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Work package 2 - Best available practices and on-site techniques for environmental site assessment and soil recovery

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Executive summary

This document presents the development strategy and action plan for the rehabilitation and productive use of areas affected by former clay mining activities, using the Ormož pilot site as an example. The Ormož site is a former clay-extraction area impacted by long-term soil disturbance and reduced fertility. This report aims to identify the optimal non-food agricultural solution, assess its environmental and socio-economic feasibility, and outline technical steps for implementation and long-term management.

Environmental assessments within the PoLaRecCE project confirm that, despite limited organic matter, remediation is unnecessary, and the site is suitable for resilient perennial species. Comparative analysis identified a white mulberry plantation as the most sustainable option. White mulberries support soil stabilization, promote ecological recovery, and provide a foundation for modern sericulture, relevant in medical, cosmetic, and bio-based innovation.

The strategy details site preparation, planting, maintenance, and monitoring procedures for Ormož. Once established, mulberries require modest annual inputs, and their long lifespan enables stable long-term planning. The plantation contributes to erosion control, biodiversity enhancement, carbon accumulation, and fosters educational activities, community engagement, and rural development.

A financial model shows that while initial investments are high and returns delayed, the long-term value lies in durability, low maintenance, and potential local value chains. The project aligns with municipal priorities, promoting sustainable land use, circular economy principles, and innovative non-food agriculture.

The Ormož pilot site serves as a replicable model for transforming degraded post-industrial land into a productive and ecologically meaningful landscape. Through mulberry-based sericulture, the site offers a pathway to environmental restoration, community development, and regional leadership in sustainable bio-based innovation.

1.Background

1.1 Regional background

The Municipality of Ormož is situated within the Spodnje Podravje sub-region, part of the broader Podravska statistical region in north-eastern Slovenia — an area geographically described as sub-Pannonian Slovenia. The region is characterised by wide plains along the Mura and Drava rivers broken into vast gravel-clay terraces, and by relatively low hills with long ridges separated by slightly wider valleys. The valley bottoms consist of clay and clay-sand alluvia of Miocene and Quaternary origin, which makes them naturally moist and prone to frequent flooding (1). Unlike the heavily forested southern regions of Slovenia, the Podravska and Mura regions have the highest proportions of cropland and the lowest biocapacity per hectare of any statistical region in the country (2), indicating that the land is under sustained and intensive agricultural pressure with limited ecological reserve capacity.
The most serious and well-documented environmental problem at regional scale is the contamination of groundwater, driven primarily by intensive agriculture. For the period 2019–2024, official monitoring confirmed poor chemical status in groundwater bodies of the Savinja, Drava, and Mura basins, with nitrate identified as the primary cause and atrazine — a herbicide now banned across the EU — as an additional contaminant specific to the Drava basin (3). The Dravska kotlina alluvial plain has been specifically recognised by the Slovenian Environment Agency (ARSO) as one of the most heavily burdened groundwater zones in the country, a situation caused by the thin and highly permeable pedological cover of the alluvial plains, which accelerates the leaching of nitrates and pesticides into shallow aquifers (4). Around Ormož specifically, the influence of intensive agriculture is directly visible in the elevated atrazine content measured in the Drava River itself (1). Pesticide contamination further compounds this problem: in the Drava and Mura lowlands, certain phytopharmaceuticals persistently exceed groundwater quality standards, making north-eastern Slovenia the most pesticide-contaminated groundwater zone in the entire country (5). Surface water quality across the region is similarly poor. More than half of all water bodies in the Drava and middle Sava catchment areas fail to achieve good ecological status, with hydromorphological changes, nutrient loading, and general degradation identified as the principal causes (6). The natural self-cleaning capacity of the Drava has been substantially reduced by a chain of hydroelectric power plants in its upper course, and water quality deteriorates progressively towards the Slovenian-Croatian border (1).
Soil degradation represents another significant environmental concern at regional scale. The principal forms affecting the agricultural lowlands of north-eastern Slovenia include soil sealing by urban and

industrial expansion, loss of organic matter, compaction, and erosion. Between 2002 and 2007 alone, the total urbanised surface area of Slovenia increased by nearly 22.5%, predominantly at the expense of agricultural land (7). Slovenia currently has only 853 m² of arable land per capita — far below the estimated minimum of 2,500 m² per capita needed for food self-sufficiency (8). As of 2022, the national inventory of Potentially Contaminated Sites lists 671 sites representing a potential source of environmental pollution from past or present activities, with remediation considered very urgent for 196 sites and urgent for a further 35 (9). This confirms that post-industrial and post-extraction land degradation is a systemic, multi-site problem, with north-eastern Slovenia contributing a significant share. Additionally, agri-environment measures have failed to halt the loss of extensive meadows and other key semi-natural habitats characteristic of the Ormož–Ptuj area, despite protective designations established for this area as early as 1979 (10).

Land degradation associated with clay extraction for brick and tile production is not a problem confined to the Municipality of Ormož alone — it is a clearly regional phenomenon rooted in the geology and industrial history of north-eastern Slovenia. The valley bottoms and alluvial terraces of Spodnje Podravje and the neighbouring Mura sub-region consist of Miocene and Quaternary clay-sand alluvia that are geologically widespread across the entire lowland zone (1). Brick clay is listed as one of the primary mineral raw materials extracted in Slovenia under the national Mining Act (11), and annual brick clay production in Slovenia consistently reaches approximately 160,000–200,000 metric tonnes (12). The country's principal brick and tile producer, Wienerberger d.o.o., operates multiple extraction and production facilities within this north-eastern zone: brick production in Ormož, roof tile production in Boreci/Križevci pri Ljutomeru in the Mura region, and a further processing unit in Lukavci (13). The presence of these sites at multiple points across the Podravska–Mura area confirms that clay extraction and its environmental legacy are regional rather than purely local in character.

The environmental consequences of open-pit clay extraction — surface deformation, subsoil compaction, loss of organic matter, reduced biological activity, and permanent removal of productive land — recur at each of these sites across the region (14). The Ormož clay mine, with its 444,000 m² of already-exploited area as of 2025, represents one prominent example of a land degradation pattern that characterises the wider north-eastern Slovenian lowlands.

In response to these challenges, a multi-level framework of measures has been implemented. At the national level, the Resolution on the National Environmental Action Programme 2020–2030 provides overarching policy guidelines for the protection of water, soil, and biodiversity (15). Slovenia has transposed the EU Water Framework Directive into national law through the Waters Act, obliging the government to formulate a Programme of Measures every six years for all river basins including the Drava, while water protection zones defined by ministerial decrees restrict agricultural land use

around vulnerable drinking water sources (4). The EU-level ban on atrazine has already demonstrated measurable effectiveness, with concentrations of atrazine and its metabolite showing a statistically significant declining trend in the Drava basin since the ban came into force (5). For the ecological condition of the Drava corridor, the national Natura 2000 Management Programme 2023–2028 defines binding conservation objectives for all 355 Natura 2000 sites in Slovenia (16). At the regional level, the ForDrava project — a 6.1 million euro initiative led by the Regional Development Agency for Podravje-Maribor, co-funded by the European Regional Development Fund — sought to improve the conservation status of habitat types and endangered species along the Drava River between Maribor and the Slovenian-Croatian border (17). A successor project for the restoration of river and riparian habitats along the Mura and Drava rivers, with a budget of 12.2 million euros, was launched in October 2025 (18). Nevertheless, despite this framework of legislation and EU-supported programmes, the effectiveness of implemented measures remains uneven. Nitrate pollution continues to produce officially poor groundwater chemical status in the Drava basin (3), and agri-environment schemes have failed to meet biodiversity conservation objectives (10). The need for more integrated, site-specific approaches to land rehabilitation — such as that developed within the PoLaRecCE project for the Ormož pilot site — therefore remains fully justified in the regional context.

1.2. Local background

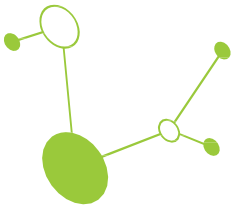
The pilot site has a rectangular layout and is situated on the peripheral zone of an active clay mine, where clay is currently extracted to produce construction bricks. The specific area in question was exploited more than 40 years ago, and all clay deposits had already been removed at that time. The distance between the pilot site and the presently active extraction area is approximately 700 m. The pilot site constitutes a degraded terrain that has been gradually undergoing natural vegetation succession. The portion selected for the implementation of the PoLaRecCE strategy covers approximately 4,000 m^2. For reference, the total area of the already exploited section of the clay mine amounts to 444,000 m^2 (as of 2025). The reclaimed mining area is planned to be designated for business and industrial functions in the forthcoming years.

This anthropogenic activity resulted in significant surface deformation, including the formation of an excavation situated in the central part of the study area. Portions of the site are characterized by steep slopes surrounding the excavation. The pilot site constitutes a degraded area undergoing gradual natural vegetation succession. The area is presently covered with naturally regenerated tree species, predominantly black locust (Robinia pseudoacacia) and goat willow (Salix caprea). Smaller populations of aspen (Populus tremula), Scots pine (Pinus sylvestris),

and silver birch (Betula pendula) are also present. The understory is composed mainly of dewberries (Rubus caesius), ferns (Dryopteris filix-mas), and various grass species. In more sun-exposed zones and along forest edges, goldenrods (Solidago spp.), greater celandine (Chelidonium majus), and wood avens (Geum urbanum) were also recorded.

The Municipality of Ormož is characterized by a temperate continental climate with warm summers and cold winters. The average annual precipitation amounts to approximately 871 millimeters, distributed over about 115 rainy days per year. The region also benefits from a relatively high level of solar irradiation, with an estimated 3,609 sunshine hours annually. Air temperature exhibits considerable seasonal variation. During winter, particularly in January, average daytime temperatures are around 3 °C, while nighttime temperatures frequently fall to approximately –2 °C. In contrast, the summer months—June, July, and August—are distinctly warm, with average daytime temperatures ranging from 26 to 27 °C and nighttime temperatures between 15 and 17 °C. The mean annual air temperature typically ranges from 8.4 to 9.1 °C. The growing season (defined as the period with average temperatures above 0 °C) lasts approximately 6.7 months, extending from early April to late October. This relatively long warm period supports agricultural activities, including viticulture and orchard cultivation, which are characteristic of this region of Slovenia.

The Ormož pilot site is situated on land previously affected by several decades of clay extraction and associated industrial operations. Although the area was not subjected to heavy industrial emissions, such as those produced by metal smelters, prolonged excavation and soil disturbance have led to significant alterations in soil structure, reduced fertility, and a general decline in organic matter content. Previous ecological assessments conducted within the PoLaRecCE project confirmed that the soil exhibits characteristics typical of former extraction zones: it is heterogeneous, compacted in deeper horizons, and composed predominantly of mineral material with low levels of biological activity.



2. Site specific actions for the municipality of Ormož

2.1 Timeline

1) Initial recognition of the environmental problem at the Ormož pilot site

- STATUS: Accomplished.
- WHO / RESPONSIBLE BODY: Municipality of Ormož.
- WHEN: Second half of 2024.
- OUTPUT: Identification of environmental challenges and initial soil sampling.
- INDICATOR: Completion of the site inspection and identification of polution related to clay mining.

2) Implementation of the environmental site assessment procedure

- STATUS: Accomplished.
- WHO / RESPONSIBLE BODY: Institute of Environmental Engineering of the Polish Academy of Sciences
- WHEN: Late 2024 to early 2025.
- OUTPUT: Detailed environmental assessment report (Deliverable D.2.2.4).
- INDICATOR: Quantified data confirming harmful subsoil compaction, low carbon stocks, and nitrogen levels below 40 kg N ha^{-1}.

3) Construction of the financial model for the investment (Milestone 1 – M1)

- STATUS: Accomplished.
- WHO / RESPONSIBLE BODY: Municipality of Ormož and project partners.
- WHEN: Finalised in late 2025.
- OUTPUT: Financial model and cost-benefit analysis for non-food agricultural production.
- INDICATOR: Integration of the site into local circular-economy value chains with a projected productive lifespan exceeding forty years.

4) Selection of the best recovery solution for the degraded soil and establishment of the plantation (Milestone 2 – M2)

- STATUS: Accomplished.
- WHO / RESPONSIBLE BODY: Municipality of Ormož (decision making), external service providers (planting), and municipal staff (maintenance and expansion).
- WHEN: January 2025 – March 2026.
- OUTPUT: Established white mulberry (*Morus alba*) plantation, educational park, and a dedicated biodiversity habitat.
- INDICATOR: Successful clearing of 4,000 m^2 of overgrown land and the planting of 660 total mulberry trees across Phase 1 and Phase 2 (including the creation of a frog habitat near the water stream).

The initial recognition of the environmental problem at the Ormož pilot site was successfully accomplished during the second half of 2024. During this phase, the Municipality of Ormož led a comprehensive site inspection with project partners to identify key environmental challenges. This effort resulted in the collection of initial soil samples and the identification of pollution related to clay mining.

The implementation of the environmental site assessment procedure was carried out by the PoLaRecCE project environmental assessment team between late 2024 and early 2025. This stage produced a detailed assessment report, which established the baseline for the site's rehabilitation. Key indicators of success for this procedure included quantified data confirming harmful subsoil compaction, low carbon stocks, and nitrogen levels below 40 kg N ha^{-1}, which necessitated the development of specific fertilisation guidelines.

In late 2025, the Municipality of Ormož and its project partners finalised the construction of a financial model for the investment, marking the completion of Milestone 1. The output of this stage was a comprehensive financial model and cost-benefit analysis specifically tailored for non-food agricultural production on degraded land. The primary indicator for this milestone was the integration of the site into local circular-economy value chains, backed by a projected productive lifespan for the white mulberry plantation exceeding forty years.

The selection of the best recovery solution led to the establishment of the plantation between January 2025 and March 2026, achieving Milestone 2. While the Municipality of Ormož acted as the decision-making body, external service providers performed the initial planting, and municipal staff handled ongoing maintenance and expansion. This phase resulted in an established white mulberry (Morus alba) plantation, an educational park, and a dedicated biodiversity habitat. Success was indicated by the clearing of 4,000 m^2 of overgrown land and the planting of 660 total mulberry trees across two phases, which included the creation of a targeted frog habitat near a water stream.

Tabel 1: Project implementation steps for the Ormož pilot site

Action	Timeline	Responsible	Expected result	Indicator
Site Inspection and Soil Sampling	10–11 October 2024	Competent institutions and partners	Identification of soil degradation levels and geogenic/anthropogenic contamination	Completion of environmental assessment; identification of "hot spots"
Land Clearing and Terrain Leveling	January – March 2025	Municipal staff / External services	Removal of overgrown vegetation (bushes, roots, trees) to restore land usability	Total area cleared (approx. 4,000 m^2) and terrain leveled for planting
Phase 1: Initial Planting	Mar-25	External service provider	Establishment of the primary plantation area as an educational park	500 white mulberry trees planted with 500 supporting poles
Monitoring and Planting Control	3–4 April 2025	Municipal staff	Verification of planting success and immediate seedling health	Completion of inspection reports and control logs
Seedling Irrigation	April – July 2025	Municipal staff / Service provider	Survival and establishment of seedlings during the dry period	12 watering sessions performed based on weather conditions
Routine Plantation Maintenance	June – September 2025	Municipal staff / Service provider	Management of natural vegetation succession and healthy tree development	Successful pruning and mowing; removal of invasive thorns and shrubs
Adaptive Management and Fertilisation	September – October 2025	Municipal staff / Service provider	Increased plantation density and remediation of low soil nitrogen levels	160 additional mulberries planted; 70 trees replaced; application of briquetted manure

Phase 2: Expansion and Ecological Enhancement	February – March 2026	Municipal services	Creation of a dedicated frog habitat near the water stream and optimal site success	125 mulberries planted in new area; 70 trees replaced in Phase 1 area; fertilization completed

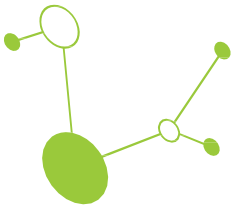
Implementation steps

The implementation began at the start of 2025 with the preparation of degraded land located next to the clay mine. The first step included the complete removal of overgrown vegetation to restore basic land usability. This was followed by mechanical land leveling to create suitable conditions for planting. Once the terrain was stabilized, the first planting phase was initiated in early March 2025 by an external service provider. During this phase, 500 white mulberry trees were planted together with 500 supporting poles to ensure stability and proper growth. After a monitoring period of six months, adaptive management measures were implemented: 160 additional mulberries were planted to increase density, and 70 non-viable trees were replaced. All planted trees received eco-friendly fertilizer to support sustainable growth. This phase concluded with the successful establishment of the primary plantation area, which is intended to function as an educational park.

The second phase focused on ecological enhancement of a smaller land patch located near a water stream. The objective of this phase was biodiversity improvement, specifically the creation of a suitable habitat for frogs. In this area, 125 white mulberries were planted, each supported by poles to ensure proper development. As in the first phase, all trees received eco fertilizer to maintain consistency in sustainable cultivation practices. Additional maintenance actions were also carried out in the first phase area, including the replacement of 70 mulberries to ensure optimal plantation success.

Milestones

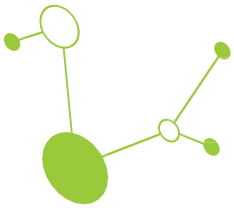
The first key milestone was the completion of land preparation, including vegetation removal and terrain leveling, which enabled the transition to planting activities. The second milestone was achieved in mid-March 2025 with the successful planting of the initial 500 white mulberries and



installation of support structures. The third milestone occurred after six months with the evaluation of plant growth, followed by reinforcement actions including additional planting and replacement of unsuccessful trees. The completion of fertilization across all planted areas marked another important milestone, ensuring ecological consistency. The final milestone of the first phase was the establishment of the educational park area. In the second phase, a significant milestone was the creation of the frog habitat zone through targeted planting near the water stream, alongside the completion of all supporting ecological measures.

Tabel 2: List of reached milestones

Number	Milestone
1	Land cleared and leveled next to the clay mine.
2	500 white mulberries and 500 support poles planted by mid-March 2025.
3	Six-month monitoring completed and corrective planting carried out.
4	160 additional white mulberries planted and 70 unsuccessful trees replaced.
5	First area completed as an educational park.
6	Second part of the pilot action near the water stream planted with 125 mulberries to support frog habitat creation.
7	Eco fertilizer applied across both areas.



Tabel 3: Assessment of soil ecosystem services for the Ormož pilot site

Service	***Service Importance Level***				
	Pivotal	***Important***	***Necessary***	***Not necessary***	***Irrelevant***
Soil forming		*White mulberries contribute to gradual soil improvement through root systems and organic matter,*			
Water retention		*The plantation, especially the second phase near the stream, support water retention and*			
Mitigating the effects of climate change	*The project directly contributes through tree planting, carbon capture, and*				
Immobilization/filtering of pollutants		*Mulberries and improved soil structure help reduce pollutant mobility, particularly*			

Nutrient cycling		*Leaf fall and organic inputs enhance nutrient cycling, supported*			
Biomass production for energy purposes				*Although possible, white mullberries are not the best fit for biomass.*	
Food production					*White mulberries which are modified for sericulture do not produce*
CO_2 sequestration	*Tree planting is a key contribution to carbon sequestration and long-term climate*				
Aesthetic, cultural and landscape functions	*Significantly improves a previously degraded area (former clay mine), transforming it into a visually attractive and*				

3.Proposed land management directions

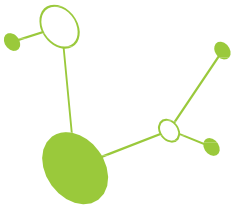
3.1 Plantation of white mulberry (*Morus alba*)

The selected land management strategy for the Ormož pilot site involves the establishment of a white mulberry (*Morus alba*) plantation. A specially grafted, low-growing variety of silkworm mulberries, intended for non-food agricultural purposes, is planned to be planted. The above-ground parts of the plants, primarily the leaves, will be utilized as feed for silkworms, which will be employed for experimental silkworm breeding. The site, covering approximately 0.4 hectares, is situated on a portion of the clay mine that was exploited more than 40 years ago. Based on environmental assessments, the soil conditions were considered suitable for non-food perennial crops. White mulberry is tolerant towards poor soil conditions, which was a necessity in this pilot action.

White mulberries are becoming a central component of Ormož's strategy for establishing a modern, sustainable sericulture model within the PoLaRecCE project. Unlike fast-growing energy crops, mulberries provide long-term ecological benefits while facilitating the revitalization of a specialized craft that is increasingly relevant in medicine, cosmetics, and bio-based innovations. Their capacity to thrive on nutrient-poor soils and to stabilize degraded land renders them an ideal crop for regions pursuing both economic diversification and environmental restoration.

In recent years, interest in natural, traceable raw materials has grown sharply across Slovenia and Europe. This creates opportunities for Ormož to position itself as a pioneer in local silk production. White mulberry plantations support a range of emerging sectors: high-quality cocoons for medical applications, research into biofibers, educational programs for schools and universities, and new eco-entrepreneurial initiatives that rely on sustainable land use.

The annual cycle of mulberry cultivation and silkworm rearing is well-aligned with the organizational capacity of rural communities. Leaf harvesting occurs in late spring and early summer, while cocoon collection takes place upon completion of the rearing cycle. This predictable schedule enables farmers and municipal services to coordinate operations, manage



labor requirements, and optimize logistics without the continuous, year-round demands characteristic of many conventional agricultural crops.

From an economic perspective, white mulberry plantations provide stability and long-term value. Although initial establishment requires several years to reach full productivity, the trees can remain productive for more than forty years. Revenue generated from the sale of cocoons and related silk products can be gradually reinvested to enhance rearing facilities, expand plantations, or involve additional families and small-scale producers within the value chain. This reinvestment cycle strengthens local entrepreneurship and promotes multi-generational engagement in the sector.

Compared to other land-use alternatives evaluated for the Ormož pilot area, white mulberry emerges as the most suitable option. Unlike fast-growing biomass crops cultivated for energy production, mulberry fulfills both ecological and economic functions, while also supplying essential raw materials for silkworm rearing. Its capacity to thrive in moderately degraded soils renders it a viable choice for landscapes transitioning from conventional agriculture to more sustainable and specialized production systems.

One of the primary advantages of white mulberries lies in their multifunctionality. The trees contribute to a more resilient rural landscape by providing long-lasting greenery, stabilizing soils, and creating conditions conducive to biodiversity. Their deep root systems help protect slopes from erosion, while the canopy improves microclimatic conditions in open areas. From a development perspective, mulberry plantations facilitate high-value silk production, educational programs, and the gradual establishment of a local supply chain based on natural materials and bio-based innovation.

Mulberries exhibit a high degree of adaptability to climatic fluctuations, tolerating summer heat, irregular rainfall, and nutrient-poor soils. Once established, plantations require relatively low maintenance and can remain productive for several decades. This longevity provides stability for long-term planning and enables communities to progressively develop knowledge and capacity in sericulture without the constraints of short rotation cycles. Moreover, their cultural and historical significance adds an additional dimension, supporting tourism, heritage education, and community identity.

Nonetheless, mulberry cultivation presents certain challenges. The establishment phase is gradual, and several years are required before leaf yields reach optimal levels for intensive silkworm rearing. Consequently, economic returns are not immediate and depend largely on the maintenance of plantation health during the early years. Mulberries do not provide rapid

biomass output is characteristic of energy crops, and initial tasks—such as soil preparation, planting, irrigation during the first seasons, and early pruning—require significant commitment from both municipal staff and farmers. Furthermore, although mulberries contribute to improving soil structure, their effectiveness in soil remediation is moderate compared to specific grass species that accumulate pollutants more rapidly.

3.2. Plantation of poplar (*Populus spp.*) for timber, biomass, and energy production - alternative option

Another land-use option considered was the cultivation of energy poplar (*Populus spp.*), a fast-growing tree species commonly employed in short-rotation coppice systems for timber, biomass, and energy production. Poplars are well-adapted to moderately degraded and moist soils and can produce substantial biomass yields within 3–5 years.

Advantages:

- Very high biomass yield (up to 10–15 tons of dry matter per hectare per year).
- Rapid growth, with harvest possible after 3–4 years.
- Effective soil remediation properties, including the absorption of nutrients and heavy metals.
- Established market demand for poplar biomass (pellets, chips, energy use).

Disadvantages:

- Requires higher soil moisture and periodic maintenance.
- Sensitive to drought and poor soil aeration.
- Short rotation cycle, necessitating replanting after 6–8 years.
- Higher planting costs compared to grass biomass e.g. Miscanthus, bamboo.

- Harvesting and transport costs are substantially higher than for Miscanthus, as specialized forestry equipment and more intensive labor are required, increasing operational expenses and reducing overall profitability, particularly on small or fragmented plots.

While popular represents a viable option for intensive biomass production, it is less durable and more management-intensive than perennial grasses. It may be utilized as a complementary species in mixed restoration systems.

3.3. Plantation of bamboo (Phyllostachys spp.) - alternative option.

The third alternative evaluated was the cultivation of bamboo (Phyllostachys spp.), a fast-growing grass species increasingly considered for biomass production and green architecture applications. Although bamboo demonstrates remarkable productivity under warmer climatic conditions, its potential in Central Europe is constrained by limited frost tolerance.

Advantages:

- Extremely rapid growth and high biomass yield under optimal conditions.
- Potential for use in bio-based construction materials.
- Provides aesthetic and ecological functions within the landscape.

Disadvantages:

- Low frost resistance, posing a risk of damage under Central European winter conditions.
- Requires careful management to prevent uncontrolled spreading due to its invasive potential.
- High initial planting costs and uncertain market value in the region.

Currently bamboo remains primarily an experimental or decorative option suitable for small- scale trials, rather than a practical large-scale solution for degraded lands in the Ormož pilot area.

3.4. Final considerations

The comparative evaluation of potential land-use strategies for the Ormož pilot site indicates that white mulberry cultivation represents the most coherent, long-term, and sustainable solution for the rehabilitation and utilization of the degraded, former clay-extraction area. While several conceptual alternatives were explored — including ecological greening measures and mixed-species tree planting — mulberries consistently emerged as the option that most effectively supports environmental recovery, economic potential, and alignment with regional development strategies.

From an environmental standpoint, white mulberries contribute significantly to soil stabilization and the gradual restoration of organic matter. Their extensive root systems help secure the fragile upper soil layers, mitigating erosion risks commonly associated with post-extraction sites. As long-lived perennials, mulberries enhance soil structure over time, promote biodiversity, and support increased carbon sequestration. White mulberry also plays an important role in climate change mitigation, contributing to the reduction of soil erosion, improvement of microclimatic conditions, and increased resilience of the area to drought and temperature extremes. Unlike fast-rotation crops that necessitate frequent soil disturbance, a mulberry plantation strengthens landscape resilience and facilitates the re-establishment of stable ecological functions.

Other evaluated approaches — such as using mulberries primarily for visual rehabilitation or integrating them into broader mixed-species plantings — provide valuable environmental benefits but do not achieve the same balance between ecological restoration and productive land use. These alternatives offer aesthetic improvements, shading, and habitat creation; however, their contribution to long-term economic development remains limited.

From an operational and developmental perspective, white mulberries provide:

- Moderate establishment costs compatible with small- and medium-sized municipal budgets,
- A very long plantation lifespan, substantially exceeding that of many alternative crops,
- Low annual maintenance requirements once the plantation is established,
- Direct integration into emerging circular-economy value chains based on sustainable silk production.

The decision to introduce white mulberry cultivation, adopted in spring 2025, represents an important strategic step by the Municipality of Ormož in the field of sustainable management of degraded land, climate resilience, and the development of bio-based solutions. The establishment of white mulberry plantations on formerly degraded areas combines ecological soil restoration,

increased biodiversity, and the development of sustainable agricultural production with high added value. At the same time, it enables the development of local bioeconomy value chains related to sustainable silk production for medical and research purposes, the use of biomaterials, and the development of innovative circular products.

Moreover, the cultivation of white mulberries directly supports the municipality's strategic objectives regarding sustainable land management, rural revitalization, biodiversity enhancement, and the development of innovative bio-based sectors. As sericulture regains relevance in medical, cosmetic, and research applications, mulberry plantations offer the region a unique opportunity to position itself as a leader in modern, environmentally responsible silk production.

The pilot site in Ormož therefore represents a good practice example of integrated post-industrial land revitalization, where environmental objectives are combined with economic development, sustainable resource management, and long-term benefits for the local community. For these reasons, the establishment of a white mulberry plantation has been identified as the most suitable and future-proof land-management strategy for the Ormož pilot site. It combines ecological benefits, long-term productive potential, community engagement, and replicability — offering a high-value model that can be successfully extended to other degraded or underutilized areas within the municipality and the wider region. Due to its transferability, the model is also relevant for other degraded areas across the wider region and supports the objectives of European policies related to climate neutrality, circular economy, and sustainable land use.

3.5. Relevance of the investment for local communities

The investment is closely aligned with the strategic priorities outlined in the development, environmental, and rural revitalization plans of the Municipality of Ormož. The establishment of a white mulberry plantation on degraded or underutilized land directly supports long-term objectives related to sustainable land rehabilitation, biodiversity enhancement, and the transformation of former extraction areas into productive green spaces. By introducing mulberries as a permanent, low-impact crop, the municipality promotes responsible land management and reinforces its commitment to climate adaptation and ecological restoration.

The project further advances Ormož’s vision of a circular, bio-based local economy. Through the revival of sericulture, the municipality obtains a renewable natural resource that can support innovative sectors, including medical and cosmetic silk applications, educational programs, and research initiatives. This approach fosters resource efficiency, reduces waste, and facilitates the

creation of new production chains based on regionally sourced, renewable materials. Additionally, the initiative enhances cooperation among farmers, municipal services, local institutions, and emerging rural enterprises. By uniting diverse community stakeholders around a shared, long-term activity, the plantation promotes participatory land management—an approach increasingly emphasized in municipal policy documents and regional development strategies.

Investment in white mulberry cultivation supports key municipal objectives by fostering sustainable development, generating opportunities for local employment and knowledge transfer, and positioning the Municipality of Ormož as an innovative leader in environmentally responsible land use and the revitalization of traditional, yet future-oriented, rural practices.

4. Description the best procedure for degraded land

4.1 Financial model for investment

Following the pre-feasibility assessment outlined in a previous Report 1.5.1, white mulberry plantation for the purpose of developing a local silk production in cooperation with associated partner Re-Use Center, has been selected as the best alternative for revitalization of the degraded land in Municipality of Ormož.

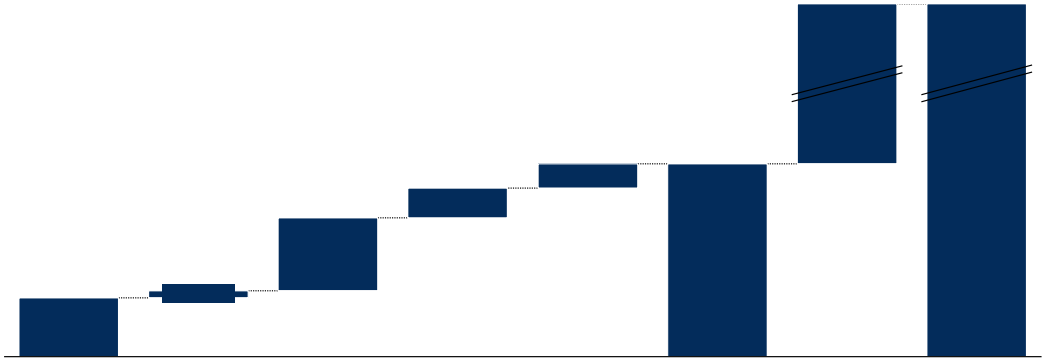
White mulberry cultivation for silk production represents a revival of historical practices in the region, with Slovenia possessing indigenous subspecies particularly suited for silk production. The project leverages the municipality's agricultural expertise whilst introducing high-value production that requires less intensive soil use compared to traditional food agriculture. Given the uncertainty around land pollution from historical industrial activity, white mulberries provide a suitable option for non-food agricultural production.

In this section we are presenting the financial model detailing the financial costs and benefits of the selected investment.

Tabel 4. Project investment costs (year 0)

Cost category	EUR
White Mulberry Plantation	12.965
Soil Preparation	3.960
Fertilisation	462
Plant Purchase	4.917
Planting Labour	1.976
Marking Poles	1.650
Production Equipment	50.000
Total Investment	62.965

Tabel 5. ***Cost calculation for white mulberry plantation (EUR 12.965,70)***



The plantation establishment represents the PoLaRecCE project scope, covering initially 730 trees white mulberry with currently 660 remaining trees planted on formerly degraded land. At EUR 19,65 per tree, the investment reflects the specialized requirements of establishing productive mulberry cultivation for sericulture purposes.

Soil preparation (EUR 3.960,00) accounts for comprehensive site preparation of the former clay pit. This substantial allocation, at EUR 6,00 per tree, recognizes the need to assess and ameliorate soil conditions following industrial use. Activities include soil testing to determine contamination levels and suitability for non-food production, mechanical

preparation to improve structure and drainage, and organic matter incorporation to establish baseline fertility. Given the site's industrial history, thorough preparation proves essential to support tree establishment.

Fertilization (EUR 462,00) provides initial nutrient application at EUR 0,70 per tree, establishing baseline fertility for root development and initial growth. The modest allocation reflects white mulberry's relatively low nutrient requirements compared to intensive horticultural crops, with slow-release formulations providing sustained availability during the establishment phase.

Plant purchase costs (EUR 4.917,00) represent the largest single component at EUR 7,45 per tree. This investment in quality planting stock proves critical, as the indigenous Slovenian white mulberry subspecies demonstrates superior characteristics for silk production. The allocation ensures procurement of certified, disease-free material from reputable sources, establishing the foundation for productive capacity over the plantation's multi-decade lifespan.

Planting labor (EUR 1.976,70) at EUR 2,995 per tree covers installation following optimal spacing requirements for leaf production, initial watering to support establishment, and mulching to conserve moisture and suppress weed competition. The allocation recognizes that proper planting technique significantly influences long-term productivity and tree health.

Marking poles (EUR 1.650,00) at EUR 2,50 per tree provide site demarcation for management purposes and tourism demonstration functions. This allocation supports both operational efficiency and the plantation's potential role as an educational and tourism destination.

Production Equipment (EUR 50.000,00)

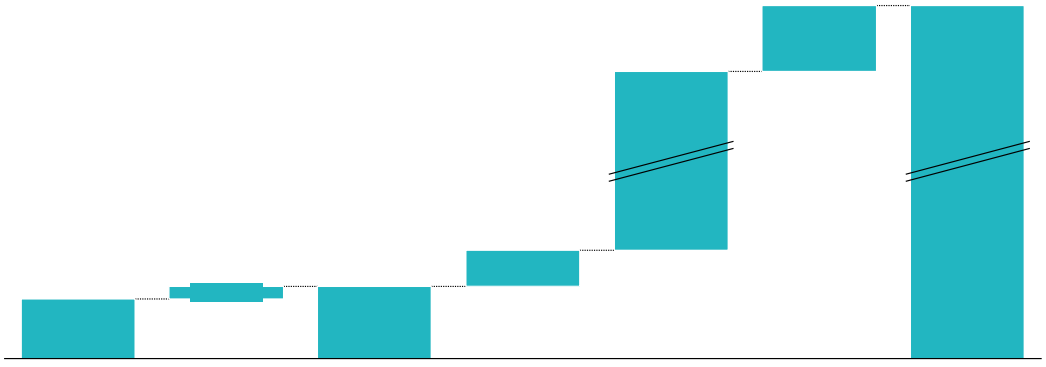
Silk production infrastructure represents 79% of total investment, reflecting the capital-intensive nature of transforming raw materials into marketable silk products. This allocation covers silkworm rearing facilities including climate-controlled environments for optimal cocoon production, silk extraction and processing equipment for transforming cocoons into raw silk thread, and basic quality control and packaging systems for market preparation.

This investment proves necessary for the complete value chain and is assumed to be covered by the Re-Use Centre or through additional funding sources.

Tabel 6. Operational costs (year 1 onwards)

Cost category	EUR
White Mulberry Maintenance*	1.000
Leaf Harvesting	200
Production Space Rent	600
Cost of silk production	10.989
Cost of sales	1.099
TOTAL	13.889

Tabel 7. Cost calculation for white mulberry maintenance (EUR 1.000,00 annually, Years 1-3, then when needed)



Tree maintenance represents 7% of Year 1 operational costs, concentrated in the establishment period. The allocation covers weed control during the critical first three years when competition significantly affects growth, minimal disease and pest management reflecting mulberry's generally robust nature, and periodic pruning to develop optimal tree structure for leaf production. Beyond Year 3, maintenance shifts to an as-needed basis, with costs incurred intermittently in Years 5, 7, 9, 12, and 15, reflecting the species' low-

maintenance characteristics once established. This cost pattern proves advantageous compared to annual crop agriculture, reducing labor requirements and operational complexity.

Leaf Harvesting (EUR 200,64 annually)

Harvesting costs account for 1% of annual operational expenditure, calculated based on productivity assumptions of 60 kg of leaves harvested per hour. With estimated annual leaf production requiring 12,16 hours plus 10% contingency (13,38 total hours) at EUR 15,00 per hour, the allocation reflects the labor-intensive nature of leaf collection. Multiple harvests throughout the growing season prove necessary to maintain leaf quality for silkworm feeding, with timing affecting nutritional content and subsequent silk quality.

Production Space Rent (EUR 600,00 annually)

Facility costs represent 4% of operational expenditure, covering rental of dedicated space for silkworm rearing and silk production activities. The Re-Use Centre's partnership structure likely enables access to suitable facilities at below-market rates, reducing this cost component. The allocation assumes basic climate-controlled space adequate for small-scale production.

Cost of silk production (EUR 10.989,00 annually)

Production constitutes 79% of operational costs, reflecting silk production's labor-intensive character. The calculation assumes 0,5 kg of raw silk produced per hour, requiring 666 hours for the projected annual output, with 10% contingency bringing total hours to 732,6 at EUR 15,00 per hour. This substantial allocation encompasses silkworm rearing through multiple lifecycle stages, careful cocoon harvesting at optimal maturity, silk extraction and initial processing, and quality control and packaging. The labor intensity, whilst creating employment opportunities, represents the primary ongoing cost driver and underscores the importance of achieving premium pricing to offset production expenses.

Cost of sales (EUR 1.098,90 annually)

Sales costs represent 8% of operational expenditure, calculated as 10% of production labor costs. This allocation covers packaging materials suitable for raw silk, logistics for market access, and participation in relevant trade events or buyer meetings. The moderate allocation reflects the project's focus on raw silk sales to established processors, minimizing marketing requirements compared to consumer-facing products.

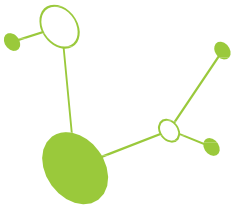
The operational cost structure demonstrates silk production's labor-intensive nature, with production labor and associated costs representing 87% of annual expenditure. Total Year 1 operational costs of EUR 13.888,54 escalate annually at 3% to reflect inflation, with the model projecting operational costs reaching EUR 21.053,04 by Year 15. This cost structure aligns with small-scale, quality-focused silk production, where labor intensity creates local employment whilst requiring premium pricing for financial viability.

Tabel 8. Revenue projections

Parameter	Value
Total Trees	660
Leaf Yield per Tree (kg)	1,125
Silk Conversion Ratio	1:2,5
Raw Silk per Tree (kg)	0,45
Year 1 Production (kg)	222
Year 2 Production (kg)	252
Year 3+ Production (kg)	297
Base Price per kg (EUR)	75
Price Escalation	3%
Year 1 Revenue (EUR)	**16.706**
Year 15 Revenue (EUR)	**33.692**

Production Ramp-Up and Yield Assumptions

Revenue generation follows a graduated maturation schedule, recognizing that white mulberry trees require establishment time before reaching full productive capacity. The model projects 75% of full production in Year 1 (222,75 kg raw silk), 85% in Year 2 (252,45 kg), and full production from Year 3 onwards (297,00 kg annually). This ramp-up pattern



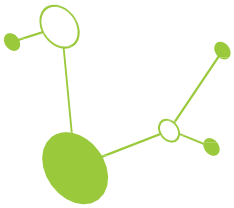
reflects industry experience with perennial tree crops, where initial yields remain below mature capacity as trees develop full canopy and root systems.

The yield assumptions derive from established parameters for white mulberry silk production. Each tree produces approximately 1,125 kg of leaves annually at maturity, supporting silkworm rearing that converts leaves to cocoons at roughly 2,5:1 ratio (accounting for silkworm metabolism and waste), with cocoons yielding approximately 20% raw silk by weight. This chain produces 0,45 kg of raw silk per tree annually, or 297 kg from the 660-tree plantation at full capacity.

Pricing Strategy

The base price of EUR 75,00 per kilogram represents a 25% premium over current Asian raw silk prices (approximately EUR 60,00/kg). This premium pricing reflects several value propositions that differentiate European production: superior quality from indigenous Slovenian white mulberry subspecies, traceable and ethical production meeting EU environmental and social standards, proximity to European processors reducing logistics costs and enabling rapid delivery, and sustainable production utilizing degraded land rather than displacing food agriculture. The premium proves justified given that Italian and other European silk processors currently pay significant logistics costs and face increasing supply chain uncertainties with Asian sources.

Price escalation at 3% annually reflects inflation rather than real price growth, acknowledging that Asian competition constrains pricing power. However, the model's conservative price trajectory does not account for potential shifts toward sustainable and traceable sourcing that could support higher premiums over time. By Year 15, the price reaches EUR 113,44 per kilogram in nominal terms, whilst maintaining constant real pricing power.



Tabel 9. *Financial assumptions*

Assumption	Value
Inflation Rate	3%
Price Escalation	3%
Discount Rate	5%
Project Horizon	15 years
Corporate Tax Rate	20%
Depreciation Period	5 years
Depreciation Method	Straight-line

The financial model incorporates several key assumptions that influence projected returns and risk assessment. The 3% inflation rate applied to operational costs reflects recent Slovenian economic conditions, with costs escalating consistently across the project horizon. Similarly, revenue price escalation of 3% maintains constant real prices, recognizing that competitive pressures from Asian production limit pricing power beyond inflation adjustment.

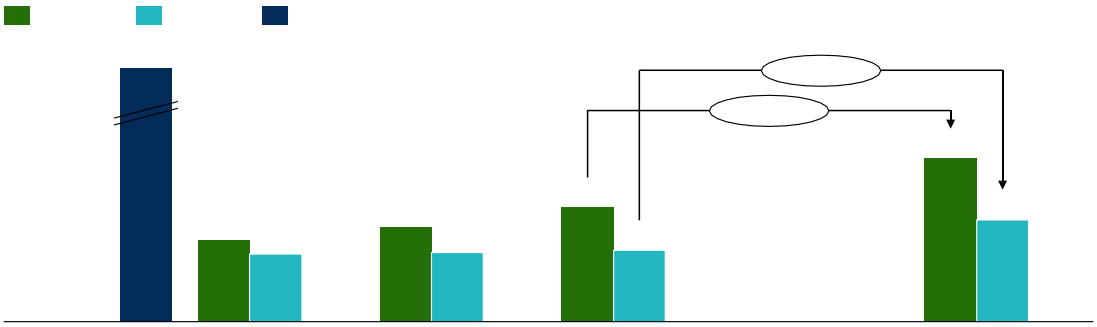
The 5% discount rate merits particular attention. Whilst the municipality serves as project sponsor, providing inherent financial stability, the operational model through the Re-Use Centre introduces performance risks typical of commercial ventures. The discount rate. Therefore, sits above typical municipal project rates (2-3%) but below purely commercial ventures (8-12%), reflecting this hybrid structure. The rate appropriately captures market risk associated with establishing novel production in an area without recent sericulture experience, price risk from Asian competition, and operational risk from the need to develop local expertise.

The 15-year project horizon proves notably conservative for perennial plantations. White mulberry trees remain productive for several decades with proper management, and silk production facilities operate beyond 15 years with routine maintenance. The truncated horizon therefore provides substantial downside protection, excluding significant value from trees' productive tail and potential facility lifetime extension. This conservative approach suits the pilot project's proof-of-concept nature, with successful implementation enabling follow-on investment decisions based on demonstrated performance.

Depreciation applies only to production equipment (EUR 50.000,00) on a straight-line basis over five years, generating EUR 10.000,00 annual expense. White mulberry trees do not depreciate under agricultural accounting conventions, as biological assets appreciating in value as they mature. The five-year depreciation period reflects expected equipment economic life, after which refurbishment or replacement investment would be required to maintain production capacity.

Assumption summary

Tabel 10. ***Forecasts of relevant project assumptions for the first 4 years, considering the expected price and cost increase due to inflation between year 4 and year 15.***



Total revenue grows from EUR 16.706,25 in Year 1 to EUR 33.692,94 in Year 15, reflecting both production maturation and price escalation. The revenue trajectory demonstrates two distinct phases: rapid growth during Years 1-3 as production reaches full capacity (increasing from EUR 16.706,25 to EUR 23.631,55), and steady 3% annual growth thereafter from price escalation. This pattern provides predictable cash flows once full production commences, supporting financial planning and enabling potential expansion investment decisions based on proven market acceptance and operational performance.

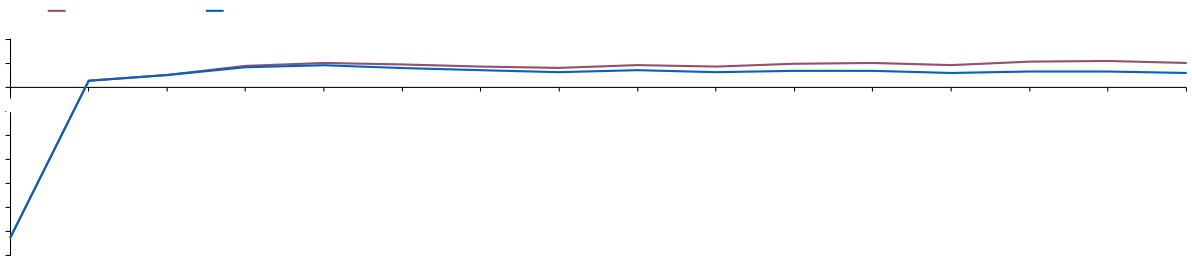
The operational costs commence in year 1 as well with EUR 13.899 and they rise steadily under assumed inflation rate reaching EUR 14.734 in year 3. It should be noted that the ramp up in production within the years 1-3 indicates that for the first three years the plantation is not generating operational profit, which changes in year 4 when the plants reach full yield. In year 15 we expect operational costs to be EUR 21.053, demonstrating the effect of compounding growth of inflation.

Investments costs are presented only in year 0 as the project does not assume any significant investments to be made after the initial set-up. Any replacement equipment and similar is funded through amortization and from operational expenses.

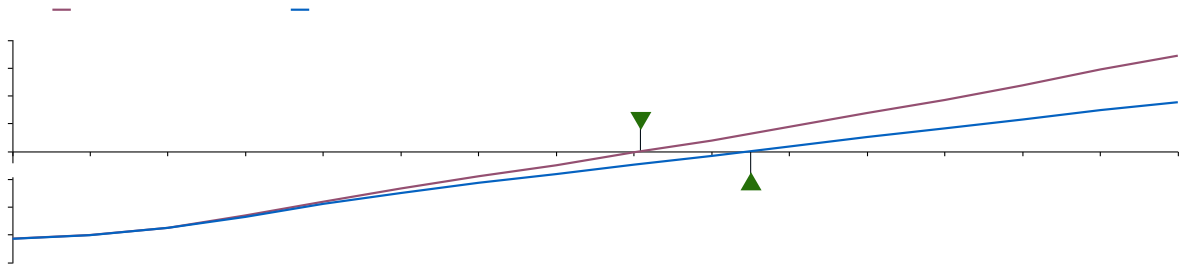
Financial model results and interpretation

Tabel 11. ***Cumulative free cash flow (red line) and discounted cumulative cash flow (blue line).***

Projected project cash flow (free and discounted)



Projected project cumulative cash flow (free and discounted)



Tabel 12. *Calculation costs of investment phase (Year 0)*

Metric	EUR
Net Present Value (NPV)	35.718
Internal Rate of Return (undiscounted)	9,75%
Internal Rate of Return (discounted)	6,11%
Money Multiple	1,79x
Payback Period (undiscounted)	8 years
Payback Period (discounted)	11 years
Total Cumulative Cash Flow (15 years)	69.936,99

The project commences with total capital expenditure of EUR 62.965,70, establishing both plantation and production capacity. This represents the point of maximum financial exposure, with no offsetting revenue.

Operational Years (Years 1-15)

Cash flow turns positive in Year 1, generating EUR 2.817,71 in pre-tax operating cash flow (EBITDA) despite below-capacity production. However, equipment depreciation (EUR 10.000,00 annually, Years 1-5) creates accounting losses in the initial period, though these represent non-cash charges that do not affect operational viability. Cash taxation commences in Year 4 once cumulative profits exceed losses, with annual tax payments of EUR 51,37 to EUR 2.756,87 thereafter.

Operating cash flow (EBITDA) demonstrates consistent growth throughout the operational period. From Year 3 onwards, when production reaches full capacity, annual EBITDA ranges from EUR 8.897,20 to EUR 12.639,90, escalating with price increases. The depreciation period conclusion in Year 6 significantly improves profitability, with net income rising from EUR 8.705,18 (Year 6) to EUR 10.111,92 (Year 15) in a steady upward trajectory.

The undiscounted cumulative cash flow analysis shows breakeven occurring in approximately Year 8, with the project generating positive cumulative returns of EUR 7.948,04 by Year 9.

By project conclusion (Year 15), cumulative undiscounted cash flow reaches EUR 68.936,99, representing 109% return on invested capital. The money multiple of 2,10x indicates that every euro invested generates EUR 2,10 in cumulative cash returns over the project horizon, excluding the substantial residual value of productive trees and operational facilities.

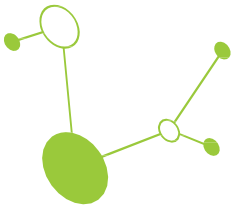
Discounted Cash Flow Analysis

The discounted analysis at 5% provides a more conservative and economically rigorous assessment. The Net Present Value of EUR 35.718,39 indicates that the project generates value significantly above the required return threshold, with total discounted cash flows of EUR 82.643,73 (money multiple of 1,79x) exceeding the initial investment by 131%. The Internal Rate of Return of 6,11% (on a discounted basis) exceeds the 5% discount rate, confirming positive risk-adjusted returns.

The discounted payback period extends to approximately Year 11, reflecting the time value of money and risk adjustment. This extended payback aligns with expectations for agricultural projects requiring establishment periods, though it remains well within the 15-year project horizon. The three-year differential between undiscounted and discounted payback illustrates the impact of the discount rate on long-term cash flow valuation.

The pre-tax IRR of 9,75% provides insight into the project's gross return potential before considering financing costs or taxation. This metric proves particularly relevant for assessing whether the underlying business model generates sufficient returns to support various financing structures or ownership arrangements that might differ from the base case assumptions.

The 15-year analytical horizon truncates value capture at an arbitrary point. Year 15 projects annual cash flow of EUR 10.111,92, suggesting ongoing operational viability far beyond the model timeframe. The plantation and production facilities retain substantial residual value: white mulberry trees continue productive for decades with mature trees increasing yield potential, production equipment, whilst fully depreciated, remains operationally capable with routine maintenance, and established market relationships and operational expertise create intangible value supporting continued operations.



A complete valuation would capitalize terminal year cash flows or establish residual asset values, potentially adding EUR 50.000,00 to EUR 100.000,00 to project NPV depending on assumed continuation parameters. The model's conservative approach of ignoring this substantial value component provides downside protection appropriate for a pilot project, whilst understanding that successful implementation would generate returns materially exceeding base case projections.

5. Cost-benefit analysis

The financial metrics demonstrate positive returns, but comprehensive project assessment requires examining broader costs and benefits beyond the direct cash flow analysis. The following sections address non-quantified benefits that strengthen the investment case whilst acknowledging potential risks and limitations.

Land revitalization and asset optimization

The former clay pit represents a non-productive municipal asset requiring ongoing maintenance expenditure with no offsetting revenue. Current maintenance costs, whilst modest, accumulate annually with no prospect of alternative use absent investment. The transformation into productive white mulberry plantation eliminates this ongoing liability whilst generating positive cash flows. Additionally, non-food agricultural production proves suitable for degraded sites with uncertain contamination, eliminating the need for expensive remediation that would be required for food production or residential development. The asset value improvement extends beyond direct cash generation. The municipality converts a derelict industrial site into a productive agricultural asset, improving land values in the immediate vicinity through demonstrated viable use.

Economic development in below-average income municipality

Ormož's below-average economic performance within Slovenia are particularly imperative for identifying new business opportunities. Traditional agriculture faces margin pressures and lacks growth potential to materially improve municipal economic standing. White mulberry silk production introduces high-value agriculture with premium pricing potential significantly exceeding conventional crop revenue per hectare.

The demonstration of successful silk production creates blueprints for expanded operations by other landowners or entrepreneurs, generating multiplier effects beyond the pilot project scope. Success could catalyze small industry cluster development, with supporting services (equipment suppliers, technical advisors, marketing cooperatives) emerging to serve multiple producers. This cluster development pattern, whilst uncertain, represents significant upside potential for regional economic impact.

The Re-Use Centre partnership additionally serves economic development objectives by building local institutional capacity for innovative production. The technical expertise and market relationships developed through pilot operations constitute durable assets supporting continued operation and potential expansion, reducing dependence on external expertise over time.

Environmental and Ethical Production Standards

Asian silk production, whilst competitively priced, generates significant environmental and social concerns. Intensive sericulture in China and India involves substantial water consumption (approximately 3.000-5.000 liters per kilogram of raw silk), widespread pesticide application to protect mulberry plantations from endemic pests, and documented labor issues including child labor in rural production regions. European processors purchasing Asian silk face increasing supply chain scrutiny and reputational risk.

The Ormož production model addresses these concerns directly. Utilizing degraded non-agricultural land eliminates displacement of food production or conversion of natural habitats. EU environmental standards govern pesticide use and water management, substantially reducing environmental footprint. Slovenian labor law compliance and transparency in production eliminate ethical concerns around labor conditions. Whilst these attributes command premium pricing, they additionally provide European processors with

ESG-compliant sourcing options increasingly demanded by downstream customers and regulatory frameworks.

Medical-Grade Silk Production Potential

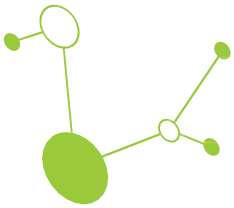
The current financial model focuses on raw silk production for traditional textile applications, but white mulberry silk possesses properties suitable for medical applications. Medical-grade silk commands premium pricing (EUR 200-500 per kilogram versus EUR 75,00 for raw silk) due to biocompatibility, strength, and controlled degradation characteristics valuable in surgical applications, wound dressings, and drug delivery systems.

Transitioning to medical-grade production requires modest additional investment in quality control and certification infrastructure (approximately EUR 20.000-30.000), with ongoing compliance costs offset by substantially higher realized prices. The pilot raw silk production establishes proof-of-concept for sericulture operations whilst building expertise necessary for medical-grade production. Successful demonstration enables follow-on investment decisions targeting medical applications, with potential to triple or quadruple per-kilogram revenue without proportional cost increases.

Tourism and Educational Opportunities

The white mulberry plantation and silk production facilities provide unique tourism and educational assets. Agritourism continues expanding in Slovenia, with visitors increasingly interested in traditional production methods and local specialty products. The site offers multiple tourism touchpoints: plantation tours explaining white mulberry cultivation and its historical significance, silkworm rearing demonstrations showing the lifecycle from egg to cocoon, and silk production workshops displaying traditional processing techniques.

Educational programming provides additional benefit streams. Schools seeking field trip destinations find agriculture and natural science educational value in observing silkworm lifecycle and plant-insect relationships. Universities researching sustainable agriculture or textile production gain access to practical demonstration site supporting academic investigations. These educational functions, whilst generating modest direct revenue, build



awareness and market access supporting core silk sales whilst contributing to community engagement objectives.

The historical context enriches tourism potential. Sericulture in Central Europe dates to the Austro-Hungarian Empire, with Slovenia participating in historical silk production before Asian imports eliminated local industry. The project's revival of traditional practice resonates with cultural tourism trends emphasizing authentic local heritage and craft traditions. This narrative dimension differentiates the production from purely commercial agriculture, supporting premium positioning and community pride in distinctive local production.

Employment and Social Inclusion

The labor-intensive nature of silk production, whilst challenging profitability, creates employment opportunities particularly suitable for certain population segments. Silk production tasks span wide range of skill levels and physical requirements, from leaf harvesting requiring mobility and stamina, to silkworm tending suitable for workers with limited mobility, to delicate cocoon processing accommodating physical limitations but requiring attention to detail.

The Re-Use Centre's mission includes social enterprise objectives, suggesting potential to structure employment supporting disadvantaged groups. Disabled workers often face barriers to conventional agricultural employment but find suitable roles in climate-controlled silk production facilities. Young families seeking flexible working arrangements benefit from seasonal labor demand patterns. The gradual scaling of production through the maturation period enables phased workforce development rather than immediate full staffing requirements.

The quantification of social benefits proves challenging, but reduced social transfer payments and increased economic activity generate fiscal benefits beyond direct project cash flows. Each FTE employment position in silk production potentially reduces municipal social expenditure whilst generating income tax and social contribution revenue, with multiplier effects from local spending by employees supporting wider economic activity.

Risk Factors and Limitations

The analysis would be incomplete without acknowledging risks tempering optimistic projections. Market risk remains substantial, with Asian production capacity able to expand rapidly should European demand materialize, potentially limiting premium pricing sustainability. The model's 25% price premium over Asian silk requires continued market acceptance of ESG and local production value propositions not yet fully validated in long-term purchasing commitments.

Operational risk reflects limited recent sericulture experience in Slovenia. Whilst historical practice provides some foundation, decades of production cessation mean limited local expertise and supply chains. The establishment of robust production protocols and supplier relationships represents learning-by-doing process with inherent risk of suboptimal outcomes during initial years. The pilot scale proves appropriate for managing this risk, but successful scaling would require continued investment in knowledge development and capacity building.

Climate risk warrants consideration. White mulberry demonstrates resilience across various conditions, but climate change introduces uncertainty around precipitation patterns and temperature extremes affecting both leaf production quantity and quality. The degraded land site selection, whilst offering revitalization benefits, potentially creates additional challenges if soil conditions prove more limiting than anticipated. The three-year production ramp-up period enables early identification of such issues whilst investment remains modest.

Figure 1. Location of the planting area

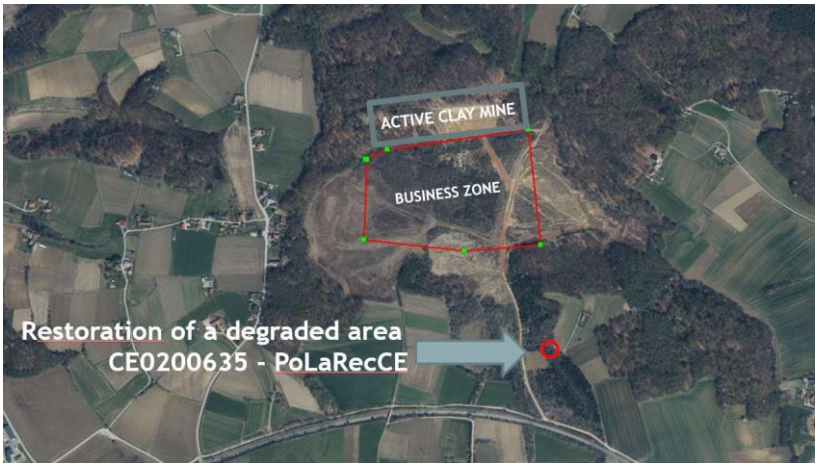


Figure 2. Picture of the plantation

Figure 3. View of the planting area from the opposite side.

6. Comprehensive upscaling plan

Across all activities, the engagement and activation of local administrations, educational institutions, and landowners were ensured through early-stage involvement, practical field implementation, demonstration-based learning, and alignment with circular economy and biodiversity principles. The transformation of degraded land near the clay mine into a mulberry-based educational and ecological park demonstrates a replicable model for sustainable land restoration. The integration of sericulture potential, ecosystem services, and social activation strengthens cooperation between research institutions, local stakeholders, and communities. This approach supports informed decision-making and enables the transfer of knowledge and practices to other regions facing land degradation, particularly within Slovenia and wider Central Europe.

Municipality of Ormož (Slovenia)— 2025 - 2026

Initial implementation and demonstration of land restoration through mulberry plantation and educational park development. Engagement of local administration and stakeholders through field visits and practical demonstration of ecological and social benefits.

Local landowners and degraded land sites in Slovenia

2025 - 2027

Transfer of knowledge through direct replication of planting methods, soil preparation techniques, and adaptive management practices. Promotion of mulberry plantations as a sustainable solution for degraded land revitalization and biodiversity enhancement while offering a way to use degraded land for economic uses – silk production.

Educational institutions (schools, universities)

2025 - 2028

Integration of the educational park into learning programs focused on circular economy, biodiversity, and sustainable agriculture. Organization of workshops, study visits, and practical demonstrations, including repair, reuse, and sericulture-related activities.

Research and development partners (national and international)

2025 - 2028

Collaboration on further development of sericulture, including extraction of silk components and innovative applications. Exchange of knowledge through EU projects and joint research initiatives, strengthening scientific validation and innovation capacity.

Local communities and vulnerable groups (social activation programs)

2025 - 2027

Involvement in planting, maintenance, and educational activities to support social inclusion and employment opportunities. Use of the site as a platform for experiential learning and community engagement.

Ecological network development (habitats and biodiversity areas)

2025 - 2027

Expansion of ecological functions through the creation of habitats such as the frog habitat near the water stream. Replication of biodiversity-supporting elements in other suitable locations.

Regional and EU-level dissemination (Interreg, Horizon, CLLD projects)

2026 - 2029

Scaling the concept through inclusion in EU-funded projects, policy alignment, and dissemination of results. Presentation of the model as a best practice for combining land restoration, circular economy, and social innovation.

Future expansion to new pilot sites

2027 - 2030

Replication of the model in other degraded areas, including agricultural and post-industrial sites, adapting the approach to local environmental and socio-economic conditions.

7. Durability plan

The long-term durability of the mulberry-based educational and ecological park is ensured through a combination of sustainable land management practices, continuous community engagement, and a clearly defined governance structure. The site has been designed not as a one-time intervention, but as a dynamic, living system that evolves over time by integrating ecological, educational, and social functions.

In terms of long-term use, the plantation of white mulberries provides a stable and low-maintenance ecological foundation. These trees are characterized by long lifespans, and, after the initial establishment period of approximately three years, maintenance is almost nonexistent. The site of the first phase will continue to operate as an educational park, hosting workshops, demonstrations, and guided visits focused on circular economy principles, biodiversity, and sustainable land use, hosted by the municipality, local social enterprises, student organizations or other interested organizations. In addition, the planned integration of sericulture creates opportunities for future economic activities, further strengthening the long-term viability and multifunctionality of the site.

Ecological durability is reinforced through biodiversity-supporting elements, such as the frog habitat located near the second-phase planting area. This contributes to ecosystem balance, increases habitat diversity, and enhances overall environmental resilience. The combination of environmental restoration, education, and the possibility of use for social purposes reduces dependence on a single function and ensures adaptability to future environmental and societal needs.

The governance structure is based on the Municipality of Ormož as the coordinating body, responsible for overall management, strategic development, and alignment with research and innovation initiatives. Community involvement plays a central role in governance, ensuring that local stakeholders, schools, and vulnerable groups actively participate in the use and development of the site. This participatory approach fosters a strong sense of ownership, increases environmental awareness, and supports long-term sustainability. Furthermore, connections with national and international project networks enable continuous knowledge exchange, access to funding opportunities and the integration of innovative practices.

From a financial perspective, the plantation represents a highly sustainable model. Once established, it requires almost no investment, as regular maintenance is very limited and no additional infrastructure

is needed. Even if sericulture activities are not immediately implemented, the location retains its full ecological and educational value. However, with the planned introduction of sericulture, the site is expected to generate additional value, further enhancing its long-term sustainability and impact.

7.1. Dissemination plan

Date of the event	Description	Responsible project partner (PP)
8th of May, 2026	WHO: Representatives of Evrosilk, the largest sericulture company in the EU, in cooperation with the Municipality of Ormož and project representatives. WHAT: Expert field visit and assessment of the established planting field, including the condition of white mulberries, planting quality, maintenance practices, and the potential for further development of sericulture activities. HOW: Evrosilk representatives will inspect the planting field on site, evaluate the work carried out, provide professional feedback, and offer free expert consultation with recommendations for possible improvements in plantation management, plant care, and future sericulture use. The visit will be organised as a public demonstration and knowledge-sharing activity. TARGET GROUP: Municipality of Ormož, local residents, farmers, landowners, tourism stakeholders, educational institutions, project partners, and all individuals interested in sericulture, white mulberries, and sustainable local development.	Municipality of Ormož

	OUTPUT: Expert assessment of the planting field, practical recommendations for improvement, increased knowledge among participants, improved visibility of the PoLaRec project, and strengthened cooperation with a leading EU sericulture company.	
9th of May, 2026	WHO: Municipality of Ormož, project representatives, local stakeholders, and invited experts in sericulture, sustainable agriculture, rural development, and tourism. WHAT: Public presentation of the project activities, achieved results, and the potential benefits of sericulture and white mulberry cultivation for the local community. HOW: The event will include a public presentation, expert explanations, discussion with participants, and presentation of the planting field as a practical example of how white mulberries can support sericulture-related activities. Special attention will be given to the opportunities that sericulture can bring to Ormož in the fields of sustainable agriculture, local economy, tourism, education, and cultural heritage preservation. TARGET GROUP: Residents of the Municipality of Ormož, local farmers, entrepreneurs, tourism providers, schools, associations, public institutions, visitors, and other stakeholders interested in the PoLaRec project and the development of sericulture. OUTPUT: Publicly presented project results, increased awareness of the benefits of sericulture and white mulberries, improved understanding of possible local development opportunities, and stronger engagement of residents and local stakeholders.	Municipality of Ormož

September, 2026 (exact date TBC)	WHO: Municipality of Ormož, project partners, local community representatives, tourism stakeholders, educational institutions, associations, and interested visitors. WHAT: Public awareness and promotional event focused on the long-term value of sericulture, white mulberries, and their possible contribution to the development of the Municipality of Ormož. HOW: The event will be organised as an open public activity combining project presentation, guided interpretation of the planting field, information sharing, and discussion with participants. The activity will present how sericulture can contribute to sustainable land use, biodiversity, local identity, educational content, tourism products, and the preservation of cultural and natural heritage. TARGET GROUP: Local residents, tourists, farmers, tourism providers, schools, youth groups, local associations, public institutions, and wider public interested in sustainable agriculture, rural tourism, and heritage-based development. OUTPUT: Increased public visibility of the project, greater awareness of the benefits of sericulture and white mulberry cultivation, stronger involvement of the local community, and identification of future opportunities for using sericulture as part of local tourism, education, and sustainable development initiatives.	Municipality of Ormož

8.Risk assessment for investment

The overall risk associated with the establishment and long-term operation of the white mulberry plantation in Ormož should be assessed as moderate, primarily due to relatively high initial investment costs and uncertainties regarding future biomass market prices. Although the crop itself is environmentally resilient and technically easy to maintain, the financial return on investment will depend on long-term market stability.

From an environmental perspective, the risks associated with establishing a white mulberry plantation in Ormož should be considered low. The species is well adapted to Central European climatic conditions and demonstrates strong tolerance to frost and drought once fully established. The period of highest vulnerability is expected during the first winter after planting, when young trees may still be sensitive to sudden temperature drops. After this initial phase, white mulberry trees typically show high resilience and can withstand dry periods due to their deep-rooting growth pattern. Minor wildlife-related damage—such as deer browsing or rodent activity—may occur, but such impacts are usually limited to the outer boundaries of the plantation and are unlikely to affect overall productivity.

Operational and economic risks are largely related to the cost of establishing the plantation. Initial soil preparation and planting require higher upfront investment compared with many traditional agricultural crops, particularly in the case of small-scale or pilot plantations. As a long-lived perennial species, white mulberry requires approximately 3–4 years to reach stable productivity suitable for regular leaf harvesting and use in sericulture. The estimated payback period of 6–8 years reflects both the gradual maturation of the plantation and the need for secure long-term planning with regard to processing capacity, partnerships, and market development.

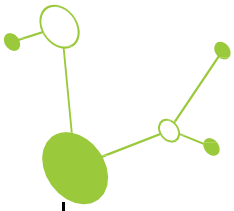
These factors introduce a degree of financial uncertainty but also highlight the long-term nature of the investment. Once established, the plantation becomes increasingly stable, productive, and inexpensive to maintain. With appropriate support measures—such as project-based funding, regional development programmes, or cooperation with research and educational institutions, the economic risks can be significantly reduced. The long operational lifespan of mulberry plantations ensures that the initial investment can be amortized over several decades of productive use, thereby improving the long-term viability of sericulture within the Municipality of Ormož. Overall, the white mulberry plantation should be considered a low-risk investment from an environmental perspective but a moderate- to high-risk investment financially, especially at smaller scales. Economic

feasibility will strongly depend on future market development, policy incentives, and available support schemes for renewable biomass cultivation. Despite these uncertainties, the plantation provides high ecological and demonstration value and serves as a practical model for sustainable land restoration.

Tabel 13. Risk assessment and mitigation measures for the establishment and long-term operation of the white mulberry plantation in Ormož

Risk	Probability	Impact	Mitigation
High initial investment costs for plantation establishment	Medium	High	Secure project-based funding, regional development support, or public co-financing. Prepare a phased investment plan and explore cooperation with research, educational, and agricultural institutions to reduce upfront costs.
Uncertainty of future biomass market prices	Medium	High	Develop long-term partnerships with biomass users, sericulture stakeholders, and potential buyers. Monitor market trends and diversify the plantation's use, including sericulture, educational activities, tourism, and demonstration purposes.
Long payback period of the investment	High	Medium-High	Plan the plantation as a long-term investment with an estimated payback period of 6–8 years. Use the long operational lifespan of white mulberry trees to amortize costs over several decades of productive use.
Delayed productivity during the first years after planting	High	Medium	Include the expected 3–4 year establishment period in the project's financial and operational planning. Avoid relying on full productivity in the early years and gradually introduce leaf harvesting and sericulture-related activities.
Sensitivity of young trees during the first winter	Medium	Medium	Apply appropriate planting techniques, winter protection where necessary, and regular monitoring during the first year. Replace damaged trees promptly to ensure uniform plantation development.
Drought stress during	Low-Medium	Medium	Ensure adequate watering and soil preparation during the first growing seasons. Once established, white mulberry trees are

establishment phase			expected to tolerate dry periods due to their deep-rooting growth pattern.
Frost damage to young trees	Low-Medium	Medium	Select suitable planting material adapted to Central European climatic conditions. Monitor weather conditions during the first winter and apply protective measures if sudden temperature drops are expected.
Wildlife damage, including deer browsing and rodent activity	Low-Medium	Low-Medium	Install protective measures where needed, especially along plantation boundaries. Regularly inspect the site and apply localised protection against deer, rodents, or other wildlife impacts.
Limited processing capacity or lack of local value chain	Medium	High	Develop cooperation with sericulture companies, biomass processors, local entrepreneurs, and research institutions. Use the plantation as a demonstration site to encourage future value-chain development in Ormož.
Insufficient stakeholder engagement	Medium	Medium	Organise public events, expert visits, educational activities, and promotional campaigns to raise awareness among residents, farmers, tourism providers, schools, and local institutions.
Limited financial feasibility at small scale	Medium-High	High	Combine economic use with ecological, educational, tourism, and demonstration functions. Seek policy incentives and support schemes for renewable biomass cultivation and sustainable land restoration.
Changes in policy incentives or funding availability	Medium	Medium-High	Diversify funding sources and align the plantation with regional development, climate adaptation, biodiversity, renewable biomass, and sustainable tourism objectives.
Overall environmental risk	Low	Low	White mulberry is well adapted to Central European conditions and has strong tolerance to frost and drought once established.



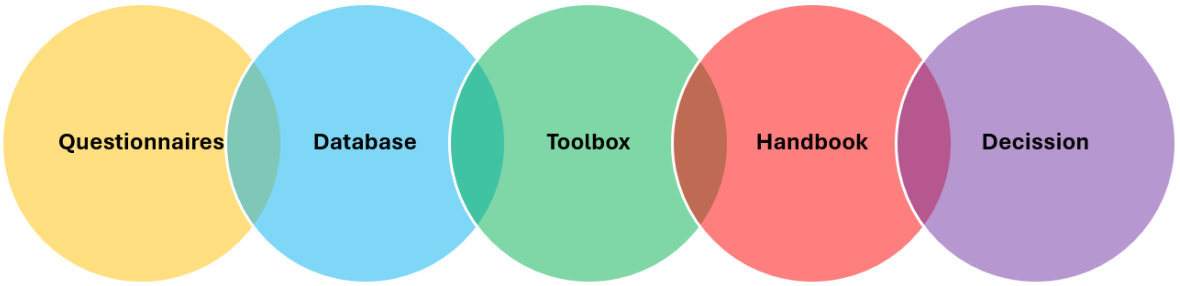
			Continue regular monitoring and apply standard plantation maintenance practices.
Overall economic and operational risk	Medium	Medium-High	Treat the plantation as a long-term strategic investment. Reduce risk through partnerships, market development, public support, phased implementation, and multifunctional use of the plantation for sericulture, education, tourism, and land restoration.

9.Policy tools/instruments

Policy Tools

To promote efficient management of degraded lands resulting from clay mining activities, the PoLaRecCE project developed a set of tools supporting strategic planning initiatives and improving multilevel governance. These tools were applied or will be applied in the context of the Ormož pilot site to address the specific challenges posed by post-extraction land rehabilitation, and together they form a coherent framework for transforming degraded former clay-mining areas into productive, ecologically valuable landscapes.

Figure 4. *Diagram showing multi-level management of degraded land as a tool developed within the framework of the PoLaRecCE Project*



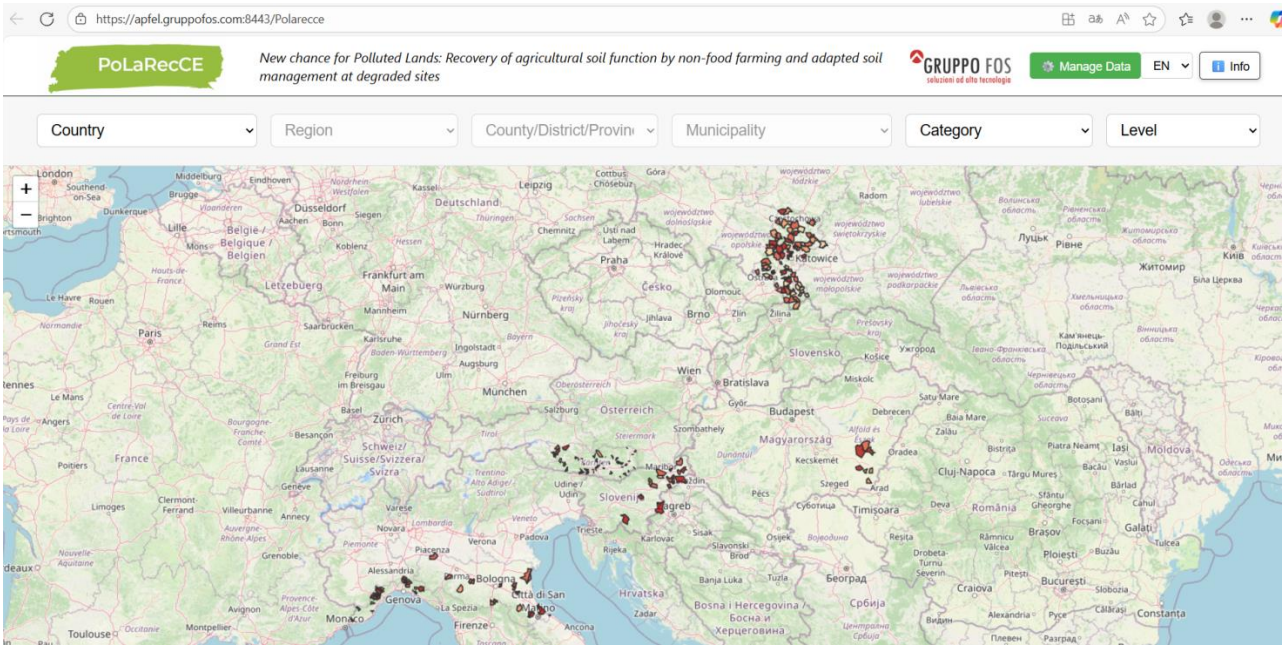
Questionnaires

Within the PoLaRecCE project, a survey was conducted to identify and assess the principal risks associated with degraded lands across the Central European region. The survey addressed 18 categories of land degradation, ranging from contamination by industrial emissions and waste disposal to physical degradation processes such as soil compaction, surface deformation, and loss of organic matter — all of which are directly relevant to the post-extraction context of the Ormož site. The primary target group comprised municipalities, specifically mayors and technical offices responsible for local planning and land management. Their responses provided essential insights into the perception and prioritisation of land degradation issues at the local level. In the case of Ormož and similar municipalities in north-eastern Slovenia, the questionnaire results confirmed that local

authorities are often unable to sufficiently recognise environmental problems related to former extraction areas due to limited environmental monitoring systems and restricted access to appropriate datasets. This finding underlines the importance of purpose-designed survey instruments as a first step in identifying the scale and nature of clay-mining-related degradation, both at the local level — within the municipality — and at the regional level, where similar degradation patterns associated with brick clay extraction sites across the Podravska and Mura regions can be identified and compared. The information obtained through the questionnaires is therefore of great importance not only from a local perspective but may also support strategic planning at the regional scale, enabling authorities to recognise clay mining degradation as a regional rather than purely site-specific challenge. **Database**

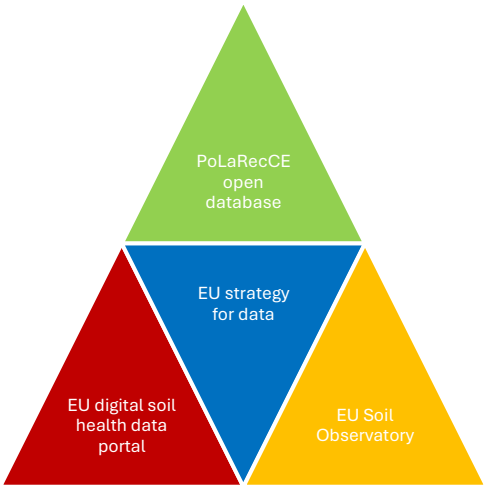
This tool has been developed in order to perform cross-regional comparison of the data obtained via survey (questionnaires).

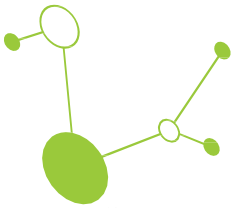
Figure 5. Map of the Central European region, showing municipalities contributing to the database on land degradation



The questionnaire-based survey feeds into an open cross-regional database developed within the PoLaRecCE project to enable comparison of land degradation data across participating Central European municipalities. This tool allows for the identification of continuous patterns as well as region-specific issues related to post-industrial and post-extraction land degradation. In the context of clay mining, the database is particularly valuable because it provides a mechanism for establishing whether the degradation associated with clay extraction in Ormož is an isolated local problem or part of a wider regional pattern — a question directly addressed in the regional background of this action plan. By aggregating data from municipalities across north-eastern Slovenia and comparable regions in Central Europe, the database makes it possible to quantify the cumulative land footprint of clay extraction operations, identify common degradation characteristics, and prioritise sites in greatest need of rehabilitation measures. The database supports various EU initiatives, including the development of an EU digital soil health data portal, the upgrading of the EU Soil Observatory, and the European strategy for data — all of which focus on making soil and land degradation information accessible to diverse stakeholders and decision-makers across administrative levels. In order to introduce the open database to Slovenian authorities and regional bodies, results and methodology developed within the PoLaRecCE project were disseminated through project events and partner meetings, supporting the integration of the Ormož case into a broader Central European evidence base on post-extraction land degradation.

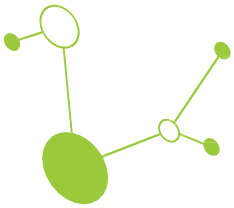
Figure 6. Diagram showing the EU initiatives supporting open access to digital information about the land degradation and soil quality





Toolbox

A key challenge in the management of degraded former clay-mining areas is the limited availability of cost-effective methods for characterising the physical and chemical condition of post-extraction soils. As demonstrated by the environmental site assessment carried out at the Ormož pilot site, soils in former clay-extraction zones are heterogeneous, compacted in deeper horizons, depleted in organic matter, and characterised by low biological activity — conditions that require targeted diagnostic approaches rather than standard agricultural soil monitoring techniques. The PoLaRecCE toolbox addresses this gap by providing a set of innovative, predominantly field-based techniques that can be used to characterise the physical and chemical properties of degraded soils, taking into account multiple degradation sources and pathways. The main advantage of the toolbox is that it includes inexpensive and easy-to-apply procedures that can be rapidly and effectively used to detect various forms of soil degradation in diverse post-extraction contexts. At the Ormož site, the toolbox was applied to confirm that concentrations of potentially toxic elements were low and did not constitute a barrier to non-food agricultural use, while also identifying the principal degradation constraints — compaction, low organic carbon, reduced nitrogen availability — that informed the choice of white mulberry cultivation as the most appropriate rehabilitation strategy. The toolbox methods are aligned with ISO standardised procedures, which is consistent with the requirements of the EU Soil Monitoring Law (Directive (EU) 2025/2360), which mandates that future soil monitoring initiatives employ methodologies certified by internationally recognised bodies such as ISO and the European Committee for Standardisation (CEN). Applied systematically across the clay-mining sites of the Podravska and Mura regions, the toolbox could provide the diagnostic foundation for a regional rehabilitation programme that goes beyond the Ormož pilot to address the full extent of post-extraction land degradation in north-eastern Slovenia.



Handbook

The final policy tool developed within the PoLaRecCE project is a handbook intended for local and regional officials, including decision-makers responsible for soil management and land-use planning. The handbook integrates the full suite of tools — questionnaires, database, and toolbox — into a practical operational document, providing criteria for selecting the most appropriate revitalization procedure for a given site, detailed instructions for conducting cost-benefit analyses for selected investment options, and guidance on governance, financing, and long-term management. For the specific context of clay-mining degradation, the handbook offers a directly applicable model: the Ormož pilot site, with its documented process of environmental site assessment, soil characterisation, comparative evaluation of land-use alternatives, and selection of white mulberry cultivation, constitutes a robust practical example that can be followed by other municipalities facing analogous post-extraction challenges. The handbook thus transforms the Ormož experience into transferable knowledge, enabling the rehabilitation approach developed here to be replicated at other degraded clay-mining sites across the Podravska region and the wider Central European territory.

Decission

Together, all four tools — questionnaires, database, toolbox, and handbook — support municipal and regional authorities in Slovenia to find answers to three fundamental questions in the context of clay-mining degradation:

- What are the main land degradation problems to be solved in our municipality as a result of clay extraction activities?
- Does clay-mining degradation affect only our local area, or is it a regional problem requiring coordinated multi-municipal action?
- What measures can be applied to restore and productively use former clay-extraction areas?

With the help of PoLaRecCE tools, strategic planning at the municipal, regional, and EU level will be better harmonised, triggering more rapid revitalization of post-extraction degraded areas and more effectively implementing the objectives of the EU Soil Monitoring Law (Directive (EU) 2025/2360), the EU Green Deal, the Circular Economy Action Plan, and national environmental programmes — all of which call for the restoration of degraded land to productive and ecologically functional use by 2050.

The Ormož pilot site, as the first documented example of PoLaRecCE tools applied to post-clay-extraction rehabilitation in Slovenia, provides a replicable and scalable model that can guide the systematic recovery of the wider regional land degradation legacy associated with brick clay mining in north-eastern Slovenia.

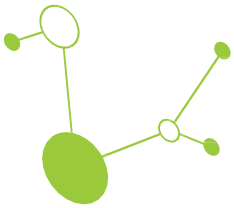
10. Final conclusions

The concentrations of potentially toxic elements at the Ormož pilot site are low and do not pose a significant environmental concern for non-food agriculture. However, long-term clay mining activities have contributed to the loss of soil organic matter and the overall degradation of soil quality. Therefore, any future soil management and land-use planning should incorporate techniques aimed at restoring both soil structure and organic matter content.

Three alternative land-use options and their related strategies were considered. The first option involved the cultivation of energy poplar (*Populus spp.*), a fast-growing tree species commonly employed in short-rotation coppice systems for timber, biomass, and energy production. The second option considered the cultivation of bamboo (*Phyllostachys spp.*), a fast-growing grass species increasingly used for biomass production and green architecture applications. The third option involved the introduction of a specially grafted, low-growing variety of silkworm mulberry (*Morus alba*) intended for non-food agricultural purposes.

Ultimately, the third option was selected, and the degraded land will be revitalized through a carefully planned approach centered on white mulberry cultivation. Although the soil exhibits characteristics typical of former extraction areas, environmental assessments confirm that it is well suited for non-food perennial species. The introduction of mulberries supports soil stabilization, encourages the gradual rebuilding of organic matter, and contributes to long-term ecological renewal, making it an appropriate and sustainable land-use strategy for the site.

The project highlights the capacity of targeted mulberry cultivation to generate multiple forms of value on a relatively small and previously underutilized area. With proper preparation, ongoing care, and systematic monitoring, the plantation enhances landscape resilience by reducing erosion, restoring structure to degraded soils, and promoting the steady recovery of ecological functions. Beyond environmental benefits, the initiative also creates opportunities for educational activities, community participation, and the reintroduction of traditional sericulture knowledge in



the region.

Overall, the Ormož pilot site provides a replicable and scalable model for transforming degraded land into a productive, low-impact resource that supports both ecological restoration and long- term community development. The approach demonstrates how a perennial, multifunctional crop such as white mulberries can serve as a foundation for sustainable land management, rural innovation, and the revitalization of local identity

Glossary

A list of notions/terms specific to this document with short explanations

Notion	Description
NUTS	nomenclature of territorial units for statistics
ETRF	European terrestrial reference frame
PTEs	potentially toxic elements
TOC	total organic carbon
SOC	soil organic carbon
ECB	European Central Bank
EBT	earnings before tax
NPV	net present value
IRR	internal rate of return
ESG	environmental, social, governance
NPK	multi-component mineral fertilizer containing nitrogen, phosphorus and potassium in various proportions

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