Interreg CENTRAL EUROPE
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PoLaRecCE

Final handbook with detailed instruction how to handle and manage the degraded land

Universal procedures for management of the degraded soils to recover and maintain their productivity

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Recovery of agricultural soil function by non-food farming and adapted soil management at degraded sites

Effective environmental site assessment procedure, analysis of potential directions of land development and ecological services

In Central Europe (CE), the sustainable management of agricultural soils contaminated by industrial and urban pollution or affected by other forms of chemical and physical degradation presents significant challenges for local administrations and communities (Annex I). Contaminated soils are typically removed from production and become wasteland, representing a substantial loss of the soil's biological potential. There is a lack of common and harmonized guidelines that could be applied across countries and administrative levels. The procedures developed within the project enable effective soil condition assessment based on innovative, predominantly field-based measurement techniques and methodologies. This makes it possible to evaluate the suitability of degraded soils for direct non-food agricultural production or to determine the need for reclamation measures aimed at restoring their biological activity and productivity.

The assumptions of the PoLaRecCE project are fully aligned with the European Union's policy on reducing environmental pollution and restoring the functional value of degraded areas. The main objective of the Soil Monitoring Law (Directive (EU) 2025/2360), as well as the PoLaRecCE strategy, is to reduce soil pollution to levels that are no longer considered harmful to human health and the environment. The practical implementation of the project strategy will contribute to the gradual improvement of soil conditions many CE regions and may be adopted in other post-industrial and highly urbanized EU regions. This project represents one of the first comprehensive attempts to improve the quality of soils degraded by industrial and urban deposition in order to achieve healthy soils by 2050, given that soils host more than 25% of global biodiversity and constitute the second-largest carbon pool on

the planet. Healthy soils, which capture and store carbon, also contribute to achieving the Union's climate objectives. The project also represents an important step toward enhancing biodiversity, ecosystem functions and services, ecological integrity, and connectivity, in line with the Convention on Biological Diversity.

Finally, the PoLaRecCE project strategy aims to develop innovative tools and approaches that support land management practices to better adapt degraded soils to the environmental, social, and economic needs of local communities. The guidelines developed within the project emphasize the need to assess soil condition before restoring its productive role in order to propose appropriate land management directions.

The guidelines and proposed procedure presented in the handbook are intended to help local administrations adapt degraded land for non-food agricultural use. Currently, these guidelines do not constitute an official standard and are not part of any legally binding regulations. Developed in cooperation with experts and practitioners involved in the PoLaRecCE project, implemented under the Interreg Central Europe Programme, these guidelines provide a practical tool for managing degraded land. They demonstrate how relatively simple and feasible measures can be applied to restore soil productivity and enable its use for non-food agriculture. This approach can create new opportunities for land that is currently unused or left fallow, as well as for areas where food production should be restricted due to soil contamination or reduced soil productivity resulting from long-term degradation caused by inappropriate agricultural practices. By applying these guidelines, local administrations can identify suitable options for bringing degraded or unused land back into productive use, while reducing potential environmental and health risks associated with its previous use or existing contamination.

The guidelines included in the handbook are intended to support local decision-making and do not replace existing national or EU legal requirements concerning soil protection, land use, and environmental safety. The suitability of degraded land for non-food agriculture should be assessed individually, taking into account the type and severity of soil degradation, the presence of contaminants, and the intended use of the biomass produced. For local administrations, this approach may provide an opportunity to improve land management, reduce the extent of unused or neglected areas, and support environmentally sustainable local development.

Environmental site assessment procedure

The first step is to identify potential environmental problems and conduct a preliminary environmental assessment of the land considered for non-food agricultural use. One internationally recognised approach is the Environmental Site Assessment (ESA), commonly used in the United States and also applied in other countries. The ESA approach is based on standards developed by ASTM International and is recognised by the U.S. Environmental Protection Agency (EPA) for specific regulatory purposes. Although similar approaches are used in Europe, ESA has not been adopted as a uniform, legally binding standard across the European Union. Instead, the assessment of contaminated land is governed primarily by national legislation and relevant EU environmental regulations.

Within the PoLaRecCE project, we propose a practical procedure consisting of the following four steps described in Figure 1.

1. Preliminary assessment

Collecting existing information on the site's history, local and regional environmental conditions, previous land use, and potential sources of land and soil degradation

2. Field investigation

Conducting field surveys and assessing soil properties, the degree of degradation, and potential contamination

3. Land suitability

Determining whether the site is suitable for non-food agricultural use and, if so, identifying the most appropriate crops

4. Management and monitoring

Selecting appropriate land management and soil restoration measures, identifying potential land-use restrictions, assessing expected ecosystem services, and establishing a monitoring plan to evaluate the effectiveness of the implemented measures

Figure 1.Practical four steps procedure

Preliminary assessment

- Collection of existing information on the site's history – reviewing local archives, internal municipal and county records, historical maps, and other available documentation to reconstruct past human activities, previous land uses, and the occurrence of natural disasters, such as floods, fires, and landslides, that may have contributed to land and soil degradation.
- Assessment of local and regional environmental conditions – collecting and analysing existing information on geological, geomorphological, pedological, hydrological, and climatic conditions. Climatic characteristics should be based on long-term meteorological records, preferably covering at least 30 years, and should include parameters such as the length of the growing season, mean annual air temperature, mean temperature and total precipitation during the growing season, and the length of the frost-free period.
- Identification of existing forms of land and soil degradation – identifying and documenting the main types and approximate extent of degradation, as well as potential historical and current sources of contamination and other degradation processes affecting the site.

Potential sources of information include:

- Municipal and county administrative records and registers including municipal archives and land-use planning documentation.;
- Historical topographic and cadastral maps, as well as aerial photographs;
- Documentation of former industrial facilities, mines, landfills, and waste storage sites;
- Previous environmental assessment reports and results of soil and groundwater analyses;
- Historical records of floods, fires, landslides, and other events that may have contributed to land and soil degradation;
- National and regional environmental databases and registers, including inventories of contaminated sites and degraded land.

Field investigation and soil assessment

Following the preliminary site assessment, based on existing information about the site's history and the identification of current and historical sources of pollution, field

investigations are necessary to assess potential soil contamination and determine the physical and chemical properties of the soil. The absence of information on contamination in historical records does not necessarily mean that a site is free from pollution. Therefore, field investigations and soil assessments based on on-site measurements and laboratory analyses of soil samples are necessary to determine the actual condition of the soil. The number of soil samples and the scope of laboratory analyses should depend on the results of the preliminary assessment and field screening using rapid, non-invasive or minimally invasive methods recommended in the PoLaRecCE Toolbox (Annex II). These methods include:

- Visual Soil Assessment (VSA) and quantification of soil organic carbon stocks;
- Soil magnetometry;
- Assessment of soil fertilisation requirements in relation to local environmental conditions.

Depending on the type and extent of land and soil degradation, these methods can help substantially reduce the number and cost of laboratory analyses by enabling more targeted soil sampling and a better selection of the chemical parameters that need to be determined in the laboratory. A cost-conscious soil investigations consist of four steps described in Figure 2.

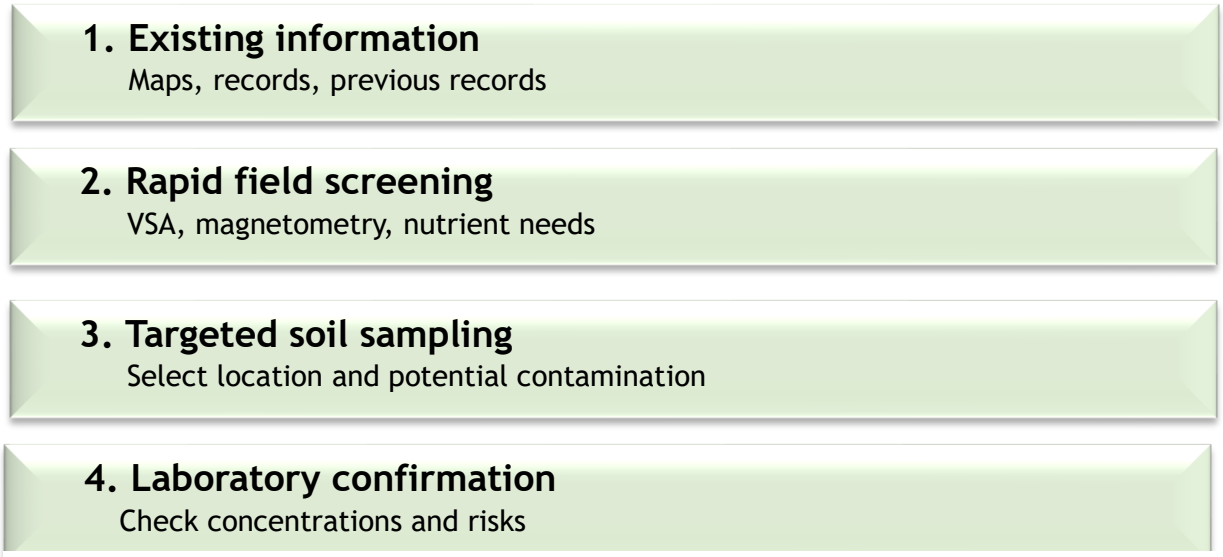


Figure 2. A cost-conscious soil investigation

Evaluation of land suitability, land management and monitoring plan, including ecosystem services

Evaluation of land suitability and land management for the proper selection of the cultivated plants

Once the preliminary assessment of the site has been completed and sufficient information has been collected on its land-use history, environmental conditions (including climate and local geology), types of land and soil degradation, basic physical and chemical soil properties, potential contamination, soil organic matter (SOM) content, and nutrient availability, the next step is to identify suitable options for non-food agriculture. At this stage, it is important to determine which non-food crops can be successfully cultivated on the degraded land and to define the main objectives of introducing non-food agriculture at the site. When selecting suitable plant species and cultivation methods, local administrations should consider the following questions to support their final decisions:

1. **Previous cultivation and local experience**: Has the proposed plant species been cultivated in the area in the past? Is there a local tradition or experience of growing this crop, or would its cultivation be a completely new activity? Is the species currently cultivated elsewhere in the municipality or surrounding region?
2. **Climatic suitability**: Are current climatic conditions and projected climate changes suitable for the selected species, and can satisfactory yields be expected? If the species was cultivated in the area in the past, have climatic conditions changed significantly since then? Do the current soil conditions, including any degradation that has occurred, still allow for its successful cultivation?
3. **Soil degradation and crop suitability**: Could the existing forms of soil degradation limit the establishment, growth, or productivity of the selected crop? Could its cultivation contribute to improving soil quality or reducing the effects of degradation?
4. **Soil fertility and organic matter**: Could the cultivation of the selected crop, combined with appropriate agricultural practices, improve soil fertility and increase soil organic matter (SOM) content?
5. **Soil and water conditions**: How could the proposed cultivation affect soil and water conditions? Could it improve soil water retention, and would additional irrigation be necessary?

6. **Compatibility with local land-use plans**: Is the establishment of the proposed plantation consistent with existing local land-use plans and the municipality's land management and development policies?
7. **Legal restrictions**: Are there any legal restrictions or specific requirements concerning the cultivation of the selected plant species or the agricultural use of the degraded land?
8. **Public acceptance and impacts on neighboring areas**: Is the proposed cultivation likely to be accepted by local residents and other stakeholders? Could the establishment and management of the plantation negatively affect neighboring areas, including the quality, use, or value of adjacent properties?
9. **Market opportunities and future development**: Are there opportunities to expand the cultivation of the selected crop within the municipality or surrounding region? Is there an existing market for the harvested biomass or other products, and what are the prospects for market development in the coming years?
10. **Infrastructure and maintenance costs**: What infrastructure and equipment would be required to establish and maintain the plantation, and what would be the associated investment and operating costs?
11. **Long-term management and sustainability**: Who will be responsible for the long-term management and monitoring of the plantation, and are sufficient financial and organizational resources available to ensure its continued operation?

The proposed checklist (Table 3) is intended to help local administrations assess the suitability of degraded land for non-food agriculture and select appropriate crops. Questions answered "No" or "Further assessment needed" should be carefully reviewed before making a final decision. It is important to note that a "No" answer does not necessarily mean that establishing a plantation is impossible. Instead, it may indicate the need to select a different plant species, modify the cultivation method, conduct additional investigations, or introduce appropriate land management measures. The checklist serves as a preliminary decision-support tool and does not replace detailed environmental assessments, where required, or the need to comply with applicable legal requirements.

Table 1. PoLaRecCE Checklist for local administration

Assessment of land suitability for non-food agriculture and selection of suitable crops
Municipality / Site: _____
Proposed crop / Species: _____
Date / Assessed by: _____
For each question, tick one response. "No" or "Further assessment needed" indicates that the issue should be reviewed before a final decision.

1. Previous cultivation and local experience

Assessment question	Yes	No	Further assessment needed
Has the proposed species been cultivated in the municipality or surrounding region?	☐	☐	☐
Is local experience or knowledge of its cultivation available?	☐	☐	☐

2. Climatic suitability

Assessment question	Yes	No	Further assessment needed
Are current and projected climatic conditions suitable for the selected crop?	☐	☐	☐
Are satisfactory yields expected under current soil and climate conditions?	☐	☐	☐

3. Soil degradation and crop suitability

Assessment question	Yes	No	Further assessment needed
Can the crop tolerate the existing soil degradation and contamination?	☐	☐	☐
Could cultivation contribute to improving soil quality or reducing degradation?	☐	☐	☐

4. Soil fertility and organic matter

Assessment question	Yes	No	Further assessment needed
Could the crop and associated agricultural practices improve soil fertility?	☐	☐	☐
Could cultivation contribute to increasing soil organic matter (SOM)?	☐	☐	☐

5. Soil and water conditions

Assessment question	Yes	No	Further assessment needed
Are soil and water conditions suitable for the proposed cultivation?	☐	☐	☐
Are water availability and any necessary irrigation measures sufficient?	☐	☐	☐

6. Compatibility with local land-use plans

Assessment question	Yes	No	Further assessment needed
Is the proposed plantation compatible with local land-use plans?	☐	☐	☐

Is it consistent with the municipality's development and land management policies?	☐	☐	☐

7. Legal restrictions

Assessment question	Yes	No	Further assessment needed
Have applicable legal restrictions and land-use requirements been identified and addressed?	☐	☐	☐

8. Public acceptance and neighboring areas

Assessment question	Yes	No	Further assessment needed
Is the proposed cultivation acceptable to local residents and relevant stakeholders?	☐	☐	☐
Can significant negative impacts on neighboring properties be avoided?	☐	☐	☐

9. Market opportunities

Assessment question	Yes	No	Further assessment needed
Is there an existing or realistically accessible market for the biomass or other products?	☐	☐	☐
Are there reasonable prospects for continued demand or future development?	☐	☐	☐

10. Infrastructure and costs

Assessment question	Yes	No	Further assessment needed
Are the required infrastructure, equipment, and services available or feasible to provide?	☐	☐	☐
Are the estimated investment and operating costs financially manageable?	☐	☐	☐

11. Long-term management and sustainability

Assessment question	Yes	No	Further assessment needed
Have responsibilities for the long-term management and monitoring of the plantation been clearly assigned?	☐	☐	☐
Are sufficient financial and organizational resources available to ensure long-term maintenance and sustainable operation of the plantation?	☐	☐	☐

Additional comments and required actions:

_____
_____
_____
_____

Note: This checklist supports preliminary decision-making. It does not replace detailed environmental assessment or applicable legal requirements.

Ecosystem services

Ecosystem services are the direct and indirect benefits that people obtain from nature and that contribute to human well-being and quality of life. These services are provided by natural ecosystems and support human health, safety, and economic activities. The concept of ecosystem services was introduced into the scientific literature in the early 1980s (Ehrlich and Ehrlich, 1981) to highlight the importance of biodiversity and the potential consequences of its loss. The concept gained wider recognition through the United Nations' Millennium Ecosystem Assessment (2005), which classified ecosystem services into four main categories described in Figure 3.

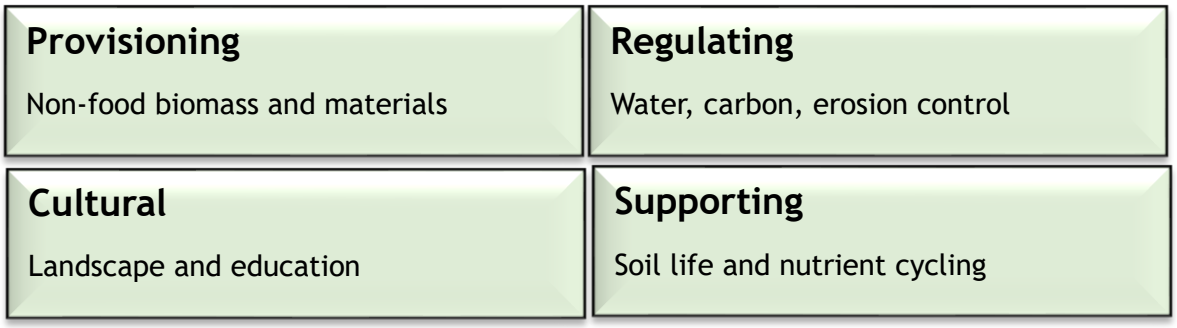


Figure 3. Four categories of ecosystem services

- Provisioning services: Products and materials obtained directly from ecosystems.
  Examples: Food, fresh water, timber, biomass for energy production, and medicinal plants.
- Regulating services: Benefits provided by natural processes that regulate environmental conditions and help maintain ecosystem stability.
  Examples: Climate regulation, carbon sequestration by vegetation and soils, flood protection, water purification, and pollination of crops by insects.
- Cultural services: Non-material benefits that contribute to people's physical and mental well-being, cultural identity, and quality of life.
  Examples: Outdoor recreation, tourism, landscape aesthetics, environmental education, and cultural or spiritual values.
- Supporting services: Fundamental ecological processes that maintain ecosystem functioning and enable the provision of other ecosystem services.
  Examples: Photosynthesis, soil formation, nutrient cycling, and primary production.

In the context of degraded land management, ecosystem services are particularly important because restoring soil functions and introducing appropriate vegetation can improve environmental conditions and provide additional benefits to local communities. These benefits may include increased carbon storage, improved water retention, reduced soil erosion, enhanced biodiversity, and opportunities for sustainable non-food biomass production.

Establishing non-food agricultural plantations, such as energy crops, fibre crops, and other industrial plants, on degraded land can provide a wide range of ecosystem services. As these crops are not intended for food production, their cultivation on land unsuitable for food crops can help reduce competition for productive agricultural land and contribute to the recovery of degraded areas. Depending on the type and degree of soil degradation, the selected plant species, and the applied land management practices, non-food agriculture can contribute to restoring or enhancing the four main categories of ecosystem services.

1. Provisioning services (Production of biomass and industrial raw materials)

Non-food agriculture can provide economically valuable products, even on land where food production is limited or unsuitable due to soil degradation or contamination.

- **Bioenergy and biofuels**: Production of biomass for renewable energy, including solid fuels such as wood chips and pellets, as well as raw materials for biofuels.
- **Fibre and industrial materials**: Production of plant fibres and other raw materials for the textile, paper, construction, and bioplastics industries.
- **Other industrial products**: Production of plant-based oils, resins, and other materials used in industrial processes.

2. Regulating services (Improvement of environmental conditions)

The cultivation of suitable non-food crops can contribute to improving soil and environmental conditions and reducing some of the negative effects of land degradation.

- **Carbon sequestration and storage**: Perennial crops can capture atmospheric carbon through photosynthesis and contribute to carbon storage in aboveground biomass, roots, and soil organic matter. The actual benefits depend on crop type, soil conditions, and management practices.
- **Soil stabilization phytostabilisation and phytoremediation**: Selected plant species can reduce soil erosion, stabilize contaminated soils, and, in some cases, contribute to the uptake or immobilization of certain pollutants. However, not all

crops are suitable for phytoremediation, and their effectiveness depends on the type and concentration of contaminants.

- **Water regulation and microclimate improvement**: Vegetation cover can reduce surface runoff, improve soil structure and water infiltration, and help regulate local temperatures. However, the effects on soil water availability depend on the water requirements of the selected crops and local climatic conditions.

3. Cultural services (Landscape improvement and social benefits)

The introduction of non-food agriculture on degraded land can improve landscape quality and create opportunities for local communities.

- **Landscape improvement**: Establishing vegetation on abandoned or degraded land can improve the visual appearance of the landscape and contribute to the regeneration of previously neglected areas.
- **Recreational and educational opportunities**: Depending on the location and type of plantation, restored areas may provide opportunities for environmental education, nature observation, and recreational activities.
- **Local identity and community involvement**: The restoration and productive use of degraded land can encourage community participation and increase public awareness of soil protection and sustainable land management.

4. Supporting services (Restoration of basic ecological processes)

Appropriately managed non-food plantations can support ecological processes that are essential for soil functioning and the provision of other ecosystem services.

- **Soil formation and nutrient cycling**: The accumulation and decomposition of plant residues, including fallen leaves and roots, can contribute to soil organic matter formation, improve soil structure, and support nutrient cycling.
- **Soil biological activity**: The development of plant root systems and the addition of organic matter can stimulate soil microorganisms and other soil organisms, contributing to the gradual recovery of soil biological functions.
- **Biodiversity and habitat development**: Plantations can provide habitats and shelter for certain plant and animal species, particularly when diverse vegetation, buffer strips, and other biodiversity-supporting measures are included. However, monoculture plantations may provide limited biodiversity benefits compared with more diverse plant communities.

In addition to providing ecosystem services, non-food agriculture can bring economic benefits to local communities by creating employment opportunities and supporting the development of local businesses and new value chains based on biomass and other non-food products. These socio-economic benefits should be considered alongside the potential environmental benefits, costs, and overall feasibility of the proposed land use.

In practice, it is often difficult or even impossible to meet all these criteria simultaneously. Therefore, when selecting land management strategies and making final decisions, local administrations should identify and prioritize the ecosystem services that are most important for the specific site and local community. This may require balancing different environmental and economic objectives and accepting certain trade-offs between ecosystem services. For example, when establishing tree plantations, a choice may need to be made between monoculture and mixed-species plantations. Monocultures can provide high biomass yields and may be easier to manage, but they often offer fewer benefits for biodiversity. In contrast, mixed-species plantations or agroforestry systems can provide greater biodiversity benefits and improve ecosystem resilience, although their productivity and management requirements may differ. Another example concerns water use. Some fast-growing bioenergy crops have high water requirements and, under certain conditions, may reduce soil water availability or groundwater recharge, particularly in dry or water-limited areas. Therefore, the selection of suitable crops should take into account local climatic conditions, water availability, and the potential impacts of cultivation on local water resources. For this reason, the selection of non-food crops and land management practices should be based not only on their economic potential but also on an assessment of the expected ecosystem services, possible trade-offs, and the specific environmental conditions and needs of the municipality.

Table 2 provides an example of a practical tool that can help local administrations assess the potential soil ecosystem services associated with the introduction of non-food agriculture on degraded land.

Table 2. Example of table for assessment of soil ecosystem services

Service	Service Importance Level				
	Pivotal	Important	Necessary	Not necessary	Irrelevant
Soil forming					
Water retention					
Mitigating the effects of climate change					
Immobilization/filtering of pollutants					
Nutrient cycling					
Biomass production for energy purposes					
Food production					
CO_2 sequestration					
Aesthetic, cultural and landscape functions					

Monitoring plan

To assess whether non-food plantations achieve their intended environmental objectives, monitoring should be carried out systematically, using measurable indicators and methods appropriate to local conditions. A practical approach is to organize monitoring into three stages: baseline assessment before plantation establishment, regular monitoring during cultivation, and periodic evaluation of environmental outcomes.

The main steps and recommended methods are described below (Figure 4).



Figure 4. Main steps and recommended methods

1. Establishing baseline conditions

Before establishing a plantation, an initial assessment of the degraded site should be conducted to document its environmental conditions. This assessment should include soil properties, the type and degree of degradation, vegetation cover, water conditions, and other parameters relevant to the planned land use. In the procedure proposed by PoLaRecCE, this assessment is carried out during the field investigation and soil assessment stage, before selecting the most appropriate land use option.

Baseline data provide a reference point for evaluating future changes and determining whether the plantation contributes to improving environmental conditions. Where possible,

measurements should be taken at clearly identified locations so that they can be repeated during subsequent monitoring.

2. Selecting key performance indicators (KPIs) related to ecosystem services

Monitoring should focus on a limited number of measurable indicators directly related to the environmental objectives of the plantation. Depending on the expected ecosystem services, the following indicators may be considered:

Climate regulation and carbon storage

- Periodic measurement of soil organic carbon (SOC) content or, preferably, SOC stocks, using comparable sampling depths and methods.
- Assessment of aboveground biomass growth and, where feasible, belowground biomass.
- Recording changes in vegetation cover and plantation productivity.

Soil restoration and water regulation

- Monitoring selected physical and chemical soil properties, such as soil pH, organic matter content, soil structure, and nutrient availability.
- Measurement of pollutant concentrations where soil contamination is present and phytoremediation or phytostabilization is among the plantation objectives.
- Assessment of soil moisture and, where relevant, groundwater levels.
- Observation and documentation of soil erosion, surface runoff, and changes in soil stability.

Biodiversity and habitat development

- Recording the presence and diversity of selected groups of organisms, such as birds, pollinating insects, and soil fauna.
- Monitoring changes in vegetation diversity and the development of habitats within and around the plantation.
- Recording the presence of selected indicator species that may reflect changes in environmental conditions.

3. Selecting appropriate monitoring tools and methods

Effective monitoring can combine simple field observations and measurements with more advanced techniques, depending on available financial resources, technical capacity, and the environmental objectives of the plantation.

Remote sensing and aerial observations.

Satellite images (e.g., Sentinel or Landsat) and drone-based surveys can be used to monitor vegetation cover, plantation development, and changes in land conditions. Vegetation indices, such as the Normalized Difference Vegetation Index (NDVI), can help identify changes in vegetation condition and growth over time. These methods are particularly useful for monitoring larger areas but should be supported by field observations where more detailed information is required.

Permanent monitoring points and field surveys

Permanent sampling points or monitoring transects should be established within the plantation to ensure that measurements can be repeated at the same locations over time. These may be used for collecting soil samples, assessing vegetation development, measuring plant growth, and recording selected biodiversity indicators.

Additional monitoring methods

Where justified, more specialized methods may be applied, including:

- Laboratory analyses of soil properties and contaminants.
- Soil moisture sensors and groundwater monitoring using piezometers.
- Camera traps or acoustic recorders for monitoring selected animal species.
- Specialized biodiversity surveys conducted in cooperation with research institutions or environmental experts.

4. Monitoring schedule, reporting, and adaptive management

The frequency of monitoring should depend on the type of indicator, expected rate of environmental change, and available resources.

- **Short-term and seasonal monitoring**: Indicators such as vegetation condition, plant survival, soil moisture, and visible erosion should be assessed during the growing season, particularly in the first years after plantation establishment.
- **Medium- and long-term monitoring**: Indicators such as soil organic carbon, soil contamination, soil structure, and biodiversity may require repeated assessments over several years. Sampling intervals should be selected according to the expected changes and monitoring objectives.
- **Reporting and evaluation**: Monitoring results should be documented and compared with baseline conditions to assess progress towards the established environmental objectives.

Monitoring should also support adaptive management, meaning that plantation management practices can be modified in response to observed environmental changes. For

example, if monitoring indicates declining soil moisture or excessive water consumption, appropriate measures may include adjusting irrigation practices, reducing planting density, or selecting plant species with lower water requirements. A monitoring programme should be realistic, cost-effective, and adapted to the technical and financial capacity of the local administration. Where necessary, cooperation with research institutions, environmental agencies, or specialized laboratories can provide additional support. Table 5 containing the recommended indicators, methods, and frequency of environmental monitoring for non-food plantations on degraded land. It can be the useful tool for the local administration in planning the monitoring strategy. Table 3 presents recommended indicators, methods, and monitoring frequencies for non-food plantations established on degraded land. It can serve as a practical tool to help local administrations develop monitoring strategies adapted to local environmental conditions and available resources.

Table 3. Recommended environmental monitoring indicators and methods for non-food plantations.

Environmental objective	Suggested indicator	Recommended method	Indicative frequency
Plantation establishment	Plant survival and vegetation cover	Field inspection	Annually, particularly in the first years
Soil quality improvement	Soil pH, SOM, soil structure	Soil sampling and field assessment	Every 2–5 years
Carbon storage	SOC stocks	Laboratory analyses and stock calculations	Every 3–5 years or longer
Water regulation	Soil moisture, visible runoff	Field observations, sensors	Seasonally
Erosion control	Visible erosion and soil stability	Field inspection, fixed photographs	Annually and after major rainfall
Pollution control	Selected pollutants and their mobility	Targeted laboratory analyses	According to site-specific risks
Biodiversity	Selected species and habitat indicators	Field surveys	Annually or at suitable intervals
Biomass production	Plant growth and biomass yield	Field measurements and harvest records	Annually or at harvest

Construction of the financial model for the investment

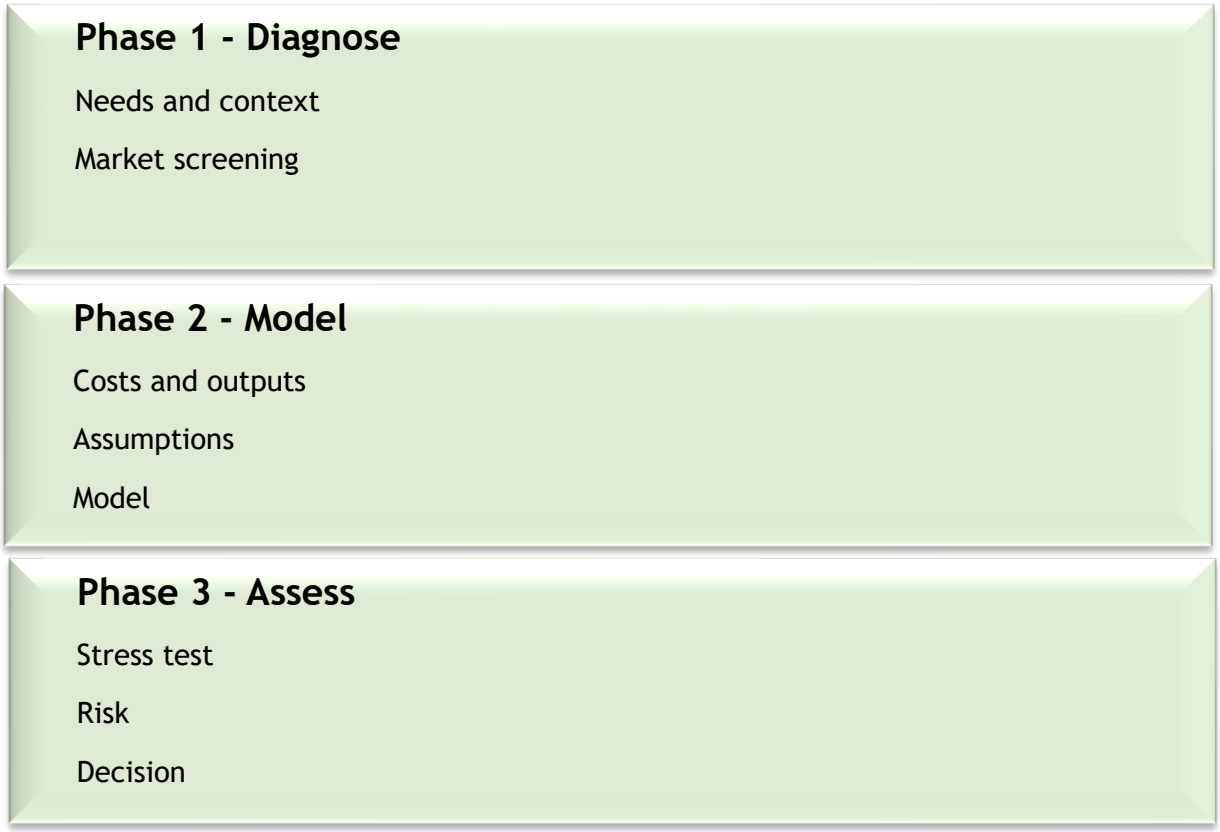


Figure 5. Financial feasibility workflow

Once the site assessment has identified the land uses that can be safely implemented, the local administration needs to assess whether the preferred land recovery solution is financially viable. A financial model supports this assessment by estimating the costs, revenues, and cash flows associated with the selected land use over the lifetime of the investment. The results are summarized using key financial indicators that help local administrations and funding institutions evaluate the financial feasibility of the proposed solution.

The procedure at a glance

The procedure consists of six steps organized into three phases (Figure 5 and 6). The first phase assesses whether the proposed investment is worth further financial analysis, the second develops the financial model, and the third tests the robustness of its results under different assumptions and translates the findings into a practical recommendation. Each step

provides the information needed for the next, ensuring a transparent and traceable process. This approach also allows the local administration to discontinue the assessment at an early stage if the proposed investment is unlikely to be financially viable.

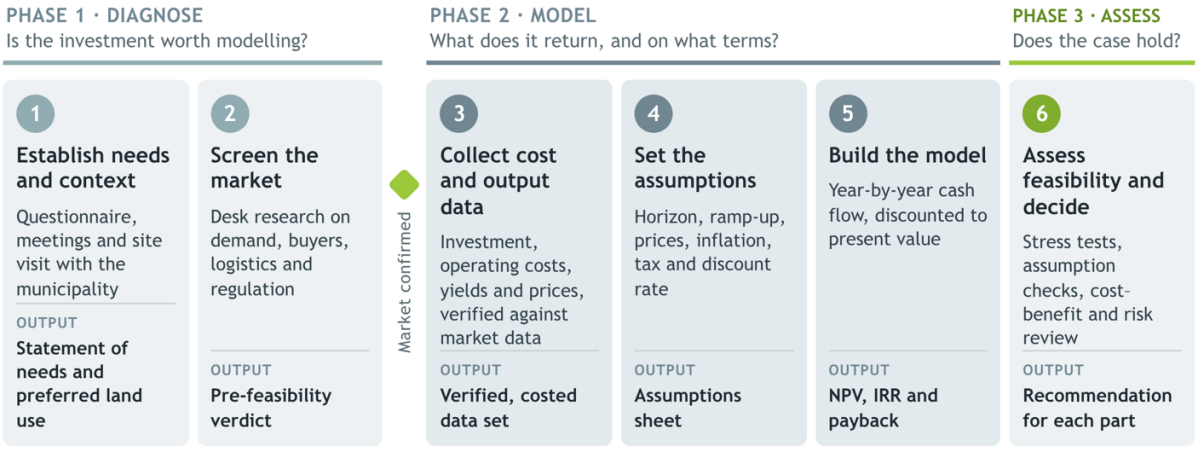


Figure 6. Six-step procedure for constructing the financial model

Phase 1: Diagnose

Step 1. Establish needs and context

Start with the objectives of the local administration rather than with a preferred crop. A questionnaire, supported by meetings and site visits, should be used to collect information in three main areas: site characteristics and the local community (plot size, previous contamination studies, soil properties, demographic characteristics, and available skills); the proposed business model (potential customers, logistics, seasonality, ownership arrangements, and required permits); and investment requirements (materials, equipment, planting material, external services, land ownership, and financing options).

Step 2. Screen the market

Before collecting detailed cost data, conduct a preliminary market assessment to determine whether there is sufficient demand for the proposed products. Consider market size and growth potential, local demand and potential buyers, logistics, seasonality, and regulatory constraints, such as land-use zoning restrictions. In the PoLaRecCE project, this assessment showed, for example, that Liguria accounts for approximately 30% of Italy's flower production and that local firewood supply in the Békés region i Hungary is insufficient to meet demand. Where the future land use has not yet been determined, as was the case in Skawina, the assessment should compare alternative options before developing a detailed financial model (Christmas trees or Miscantus).

Phase 2: Model

Step 3. Collect cost and output data

In cooperation with the local administration and the future operator, identify the initial investment costs, recurring operating costs, and expected production outputs (yields and selling prices). Whenever possible, express costs per unit, such as per tree, per hectare, or per labour hour, rather than as lump sums. In the PoLaRecCE pilot site in Ormož, establishment costs were calculated per tree, while processing costs were estimated by multiplying the required working hours by the hourly labour rate. An additional 10% contingency should be included to cover unforeseen expenses. Using unit costs makes the financial model easier to verify and adjust when the plantation area or scale of production changes.

Verify the figures you receive.

Ministries, local administrations, and operators often provide estimates of expected selling prices, crop yields, and other economic parameters. These estimates should be treated as assumptions requiring verification against independent sources, such as wholesale market prices, trade statistics, sector reports, and data from comparable producers. The sources used for verification should be documented in the model's assumptions sheet. Where estimates differ from independent evidence, conservative assumptions should be adopted to avoid overestimating revenues or underestimating costs. For example, in Gyomaendrőd, Hungary, consumer firewood prices increased by approximately 9% annually between 2000 and 2024, while the PoLaRecCE financial model assumed a more conservative annual price increase of 5%, taking into account the planned wholesale distribution of firewood.

Step 4. Set the assumptions

The assumptions used in a financial model often have a greater impact on the results than individual cost items. Therefore, all key assumptions should be clearly defined, documented in one place, and justified (Table 4). Particular attention should be paid to the discount rate, as its value can significantly affect the net present value (NPV) of an investment and may even change it from positive to negative. The discount rate should reflect the nature of the investment, its associated risks, and the applicable appraisal guidelines. In the PoLaRecCE project, discount rates ranged from 4% for a long-term municipal investment in Skawina to 8% for commercial floriculture in Cairo Montenotte. These values reflect the different assumptions adopted for public and commercial

investments. Discount rates for publicly funded projects may also be specified in national regulations or official guidelines.

Table 4. Examples of key assumptions and PoLaRecCE practice

Assumption	What it represents	PoLaRecCE practice
Project horizon	Productive life of the crop and equipment	15 years (flowers, mulberry) to 25–30 years (miscanthus, coppice)
Yield ramp-up	Years needed to reach full output	Full yield from year 3 or 4; coppice cut every 5 years, yields rising until year 15
Output price	Current sale price and its annual growth	Current wholesale prices; growth of 1–5% a year, set conservatively (e.g. 5% for firewood against 9% historically)
Cost inflation	Annual increase in operating costs	3% a year, applied to all cost lines
Discount rate	Minimum return for time and risk	4% (long-term municipal) to 8% (commercial horticulture)
Tax and depreciation	Rules applicable to the operator	National corporate tax of 9–20%; equipment depreciated over its life (5 years in Ormož)
Currency	Rate for costs in national currency	Fixed annual average, e.g. 1 EUR = 4,25 PLN in Skawina

Source: PoLaRecCE financial models for pilot sites.

Key assumptions vary considerably with the scope and size of each project and are specific to it. The values above illustrate PoLaRecCE practice and need to be adapted to any future project.

Step 5. Build the model

The financial model consists of two linked Excel worksheets (Figure 7). The assumptions sheet contains all input data, including their units and sources. The calculation sheet contains no manually entered numerical values: all calculations refer to the assumptions sheet or to other formulas, allowing each result to be traced back to its original inputs. The model calculates annual earnings before interest, taxes, depreciation, and amortisation (EBITDA), which is then adjusted for taxes, investment expenditures, and any changes in working capital to determine annual free cash flow. These cash flows are used to

calculate the net present value (NPV), internal rate of return (IRR), and payback period of the investment.

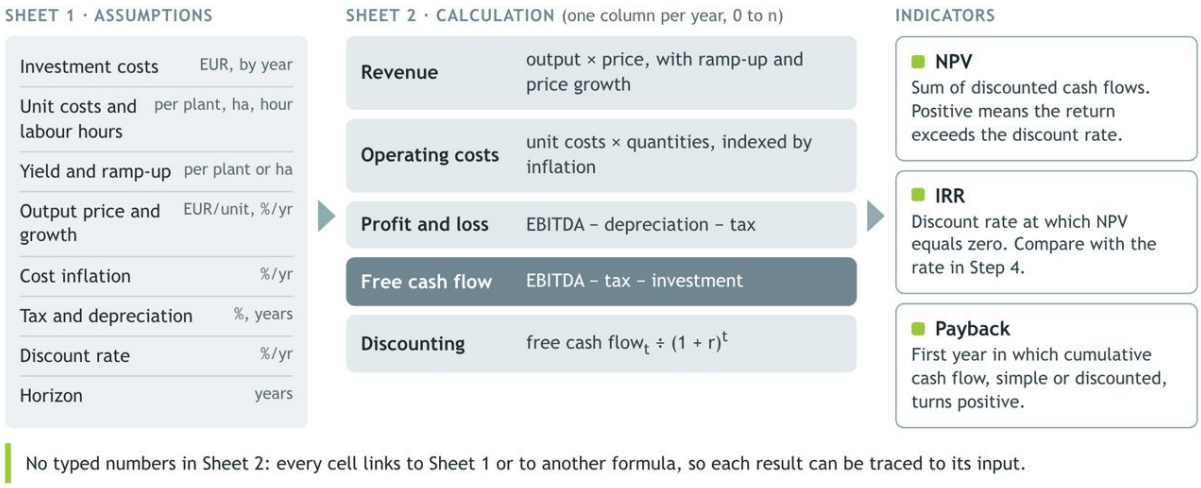


Figure 7. Structure of the financial model

Phase 3: Assess feasibility

Step 6. Assess feasibility and decide

Interpret the financial indicators in relation to the objectives of the local administration. The financial model shows the expected returns on investment under the adopted assumptions, while the feasibility assessment evaluates whether these assumptions are realistic and provides recommendations for each component of the investment (Table 5).

Stress testing. Change the key assumptions, first individually and then in combination, to assess their impact on NPV and the payback period. The main variables typically include selling prices, yields, the time needed to reach full production, cost inflation, the discount rate, and the scale of investment. The aim is to identify the conditions under which the investment becomes financially unviable and assess how likely these conditions are to occur.

Assumption check. Verify whether the assumptions that have the greatest impact on the financial results are supported by current market conditions. Consider selling prices and their trends, potential buyers and their purchasing conditions, input costs, and regulatory

requirements. Classify each assumption as confirmed, confirmed under certain conditions, or not confirmed.

Cost-benefit and risk review. Consider the environmental and social benefits not included in the financial cash flows, such as soil recovery, creation of green spaces, employment opportunities, and improved energy security. Identify and assess the main investment risks. Where financial returns are limited, these additional benefits may provide an important justification for public investment.

Table 5. Feasibility assessment in practice: examples from PoLaRecCE

Part assessed	Test or research	Finding	Recommendation
Plantation scale (Skawina)	Pilot plot compared with a 10 ha model	Pilot does not cover operating costs; 10 ha: NPV EUR 34.822, payback 14 years	**Pilot first.** Use pilot yield data to decide on 10 ha
Firewood price growth (Gyomaendrőd)	Growth cut from 5% to 3% a year	NPV stays positive; payback beyond year 20	**Proceed.** Plan for patient capital; stagger planting for yearly harvests
Raw silk price premium (Ormož)	Target price compared with Asian raw silk	EUR 75/kg is 25% above about EUR 60/kg; no purchase commitments yet	**Proceed under conditions.** Secure the premium through sales contracts and certification

Source: PoLaRecCE action plans for pilot sites.