Interreg
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Forest EcoValue

# FOREST ECOSYSTEM SERVICES ECONOMIC ASSESSMENT PILOT ACTION REPORT

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Carbon neutral and resource sensitive Alpine region
SO 2.2: Promoting the transition to a circular and resource efficient economy

**Forest EcoValue:**
**Supporting multiple forest ecosystem services through new circular/green/bio markets and value chains**

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## List of the Forest EcoValue project partners

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PP2. Lombardy Foundation for the Environment – Fondazione Lombardia per l'Ambiente [FLA]
PP4. National Research Institute for Agriculture, Food and Environment – Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement [INRAE]
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## Summary

# 1. Introduction

This report summarizes the results from the transnational pilot testing of economic assessment and market frameworks for Forest Ecosystem Services (FES) implemented across five Living Labs (LLs) in the Alpine Space, aimed at developing innovative, sustainable business models for forest managementIt is intended to provide stakeholders, policymakers, and practitioners with clear guidance on the methodologies, findings, and strategic insights developed within the Forest EcoValue project.

The initial sections outline the project's objectives, emphasizing the vital role of Alpine forests in climate change mitigation, biodiversity conservation, and supporting local economies. The introduction also addresses the main challenges facing forest management in the region, such as high maintenance costs, insufficient funding, and the need for innovative payment schemes for ecosystem services.

Throughout this report, carbon storage is considered not only as the annual sequestration of $CO_2$, but also as the stabilization and long-term maintenance of carbon stocks within forest ecosystems. The project places particular emphasis on the transition to continuous forest management practices, which are designed to sustain and enhance carbon reservoirs over time, supporting both climate mitigation and ecological resilience.

Following the project overview, the report details the valuation methods used to assess the economic and social value of FES. It describes both the unit value transfer method (relying on established European studies) and direct market valuation, which utilizes local market data for selected provisioning and regulating services. Comparative tables are provided to illustrate differences in valuation outcomes across Austria, France, Germany, Italy, and Slovenia, helping to highlight the impact of local context and methodological choices.

The document then introduces a multi-criteria assessment framework designed to evaluate the suitability of different market and non-market FES in each Living Lab. This framework integrates quantitative indicators and expert judgment to rank the potential of various business model archetypes, considering local ecological, economic, governance, and social factors. The methodology is presented in a step-by-step manner, covering concept selection, data normalization, and application of the TOPSIS ranking technique.

Subsequent chapters present the implementation results for each Living Lab, including tailored FES valuations, scenario analyses, and strategic recommendations. These chapters offer practical insights into the challenges and opportunities for developing sustainable forest-based value chains, and provide guidance for future policy and investment decisions.

One business model has been developed and tested for each country/Living Lab, as better described below and in the following sections. The business models developed for France, Italy, Austria, Germany, and Slovenia are presented as conceptual frameworks to illustrate possible approaches for leveraging forest-based ecosystem services and related innovations. Each model includes descriptions of key activities, resources, value propositions, and indicative financial scenarios (Baseline, Moderate, Stress Test), complemented by sensitivity and risk considerations. These models are primarily based on inputs from local coordinators to ensure contextual relevance, while maintaining a standardized structure to enable comparison.

It is important to note that all parameters and variables used (such as costs, revenues, discount rates, and operational assumptions) in the business model simulations are indicative and serve illustrative purposes only. The models have not been tested or validated through local implementation, nor do they incorporate site-specific data or formal stakeholder commitments. Their primary aim is to demonstrate potential solutions and provide a methodological foundation for further development, rather than to serve as ready-to-implement business plans.

To transform these conceptual models into actionable proposals, further refinement is necessary. This includes direct data collection, stakeholder engagement, and iterative validation, which will lead to more robust business plans and investment-ready documents tailored for investors, businesses, and decision-makers. At this stage, the models should be regarded as exploratory tools to stimulate discussion and guide the creation of effective, locally grounded strategies.

Overall, this document serves as both a methodological reference and a practical guide for advancing the economic assessment and market development of FES in varied Alpine contexts, supporting the sustainable management and valorization of these critical natural resources.

## 2. Purpose and relevance of the economic assessment

This deliverable provides an economic assessment of selected forest ecosystem service (FES) business models developed within the project. Its purpose is twofold. First, it supports policymakers by assessing the economic viability and financial implications of alternative forest management and FES implementation pathways, thereby informing the design of enabling policy frameworks and funding instruments. Second, it addresses the information needs of forest owners, project developers, and potential investors by illustrating how different business models perform under plausible cost, revenue, and risk conditions.

## 3. Project overview

Forests of the Alpine Space play a key role in climate change mitigation and resilience, providing multiple ecosystem services (ES) and environmental and social benefits such as $CO_2$ absorption, air pollution reduction, biodiversity enhancement, and protection against natural hazards. However, they are threatened by abandonment, climate change, and territorial degradation, which progressively reduce natural resources and the provision of forest ES (FES). Maintenance costs of Alpine forests are high, and public funds and traditional wood value chains are insufficient to cover them. Economic valuation and payment schemes for FES are widely discussed but rarely successfully applied.

The Forest EcoValue project addresses this challenge by developing innovative, sustainable business models for forest management and maintenance, supporting new bio-based value chains and ES markets, and involving different sectors, public and private actors, and citizens. Restoring and maintaining healthy forests has been recognized as a source of value for the Alpine region, while also creating business opportunities and green jobs for Alpine communities.

The project focuses on a subset of FES from the following categories:

- **Provisioning** (e.g. biomass, raw materials, chemicals) with a specific focus on non-timber forest products, and on the production of woody biomass for energy, integrated into circular energy markets.
- **Regulating** (e.g. biodiversity, natural risk reduction, $CO_2$ absorption) concretely working on carbon and biodiversity credits, natural risk management through protective forests, and innovative environmental finance instruments such as green bonds and reverse auctions.
- **Cultural** (e.g. recreation, habitat experience, health) particularly enhancing recreational and tourism services and spiritual and cultural services.

These services have been explored and tested within LLs across five countries, located in different Alpine territories and representing diverse ecological and socio-economic contexts:

- **Italy – Valle Tanaro, Piedmont:** The LL in Valle Tanaro explores innovative approaches to valorising chestnut groves, promoting non-timber forest products, developing carbon and biodiversity credits, and fostering experiential activities linked to forest and rural heritage.
- **France - Haute-Savoie:** Grand Annecy and Thonon LLs focus respectively on two aspects 1) recreational ecosystem services, enhancing the value of forests through the sale of experiences such as ecotourism, outdoor activities, and educational programmes 2) enhancing the value of water regulation services through a public-private partnership.

- **Slovenia – Karavanke Mountains, municipality Tržič:** The Slovenian LL addresses natural risk management with a focus on torrent control, advances solutions for wood biomass supply chains and promotes sustainable tourism and recreational use of forests.
- **Austria – Province of Styria:** The Styrian LL concentrates on biodiversity and habitat provision and carbon sequestration and storage through innovative financing mechanisms such as reverse auctions.
- **Germany – Tegernsee Valley, Upper Bavaria:** The German LL explores spiritual and cultural services, such as forest cemeteries with biodegradable urns, while also fostering habitat and biodiversity conservation through collaborative public–private partnerships.

Accordingly, the project is aiming to:

- Map and analyse the Alpine Space forests delivery capacity of FES;
- Identify and estimate the economic potential, define business models and FES market frameworks;
- Test the models/tools developed by the consortium in pilot LLs involving local players;
- Compare results at transnational level, identifying obstacles and facilitating factors;
- Analyse the need for innovative policies to foster forest maintenance, FES markets, and new value chains;
- Elaborate refined transferable tools/models and policy proposals to enable new markets and value chains and ensure the expected FES.

Throughout the project, a continuous participatory process is carried out within the LLs Stakeholders’ active involvement in these labs is essential for co-designing and testing models and tools, ensuring that the innovative approaches are rooted in local realities. In parallel, public events and capacity-building workshops have strengthened engagement, supported knowledge transfer, and provided regular updates on project activities. This participatory and long-term approach, tested across the five territories, is paving the way for refined, transferable tools and policy proposals that can unlock new markets and value chains while safeguarding the provision of ecosystem services in the Alpine Space.

Project duration: 42 months

# 4. Valuation of forest ecosystem services

Understanding how nature and ecosystem services are valued and by whom is essential for enhancing governance and informing decision-making in conservation policy and innovation. Valuating the social value of FES in the Alpine Space plays a key role in shaping sustainable and forward-thinking business models, as well as in developing circular, green, and bio-based markets and forest value chains. This process not only supports the creation of economic indicators for potential payment schemes and identifies key beneficiaries of FES but also helps raise awareness among policymakers about the broader social importance of forests.

As outlined in D.1.3.1. Working Group ECO - Report, we have valuated all the FES preselected in each Living Lab using unit value transfer. In the process of testing the methodology, we have further detailed it and supplemented it with a direct market valuation to provide more precise value indicators for a selection of provisioning and carbon storage ecosystem services (section 2.1), where primary data was available. A multi-criteria approach to the provision of market and non-market FES was tested only in Austrian Living Lab (section 2.2). In the following sections, we will present the results of the assessment and details on methodological improvement, where applied.

## Unit value transfer based on the economic valuation studies conducted in Europe

The unit value transfer method was applied using existing economic valuation studies conducted across Europe (see D.1.3.2_Database-of-FES-values_Europe.xlsx). It allows for estimating an approximate value for the policy site, or the national LLs in the context of Forest EcoValue. This method was chosen due to its relatively low methodological requirements and its ability to simultaneously cover all national LLs, address multiple ecosystem services, and explore potential trade-offs. As this method produces an economic value of relatively low precision, the valuation exercise serves strictly informative and communicative purposes and supports priority-setting.

While valuation methodology in principle followed the flow detailed in section 2 of D.1.3.1. Working Group ECO - Report, the valuation flow described in the decision tree in the report was adapted to the match practical limitations of the valuation on the transnational level. All the improvements are described below, followed by the transnational valuation results.

### *Unit value transfer*

While the practical usefulness of the decision tree was proven in individual assessments for each Living Lab, we had to adopt a slightly different approach in valuation on transnational level by determining the unit value for the FES in Alpine Space (**Table 1**). In some cases, one or more primary value observations were available for a partner country – then, we reported a unique value for this partner country. In case of France, where no primary valuation studies were identified in the scientific literature, we were able to supplement the unit value transfer results with values derived from local reports and unpublished results of other Interreg projects.

Another important addition to the valuation was adjustment of the unit values to the local socio-economic context using PPP conversion factors (private consumption, LCU per international $) for each PP country. Lastly, while the value per unit is provided for all preselected FES, the calculation of total economic value (TEV) included a shorter list of FES, as it was only possible when the respective biophysical indicators were provided by D 2.2.1 FES assessment pilot action report (i.e., forest areas providing FES and mean carbon sequestration/ha/year). When interpreting the results of the TEV analysis and social value mapping, it is important to be aware of the assumptions embedded in the estimation of the forest areas providing FES, and we refer the reader to D 2.2.1 to get familiar with them before proceeding.

**Table 1.** Unit values and adjusted unit values for selected FES.

| FES | Unit value (int $/ha/yr in 2023) | Adjusted unit value (€/ha/yr in 2023) | | | | |
|---|---|---|---|---|---|---|
| | | Austria | France | Germany | Italy | Slovenia |
| *Provisioning services* | | | | | | |
| Provision of timber wood biomass | 226.07 | 173.74 | 174.46 | 168.69 | 152.06 | 139.19 |
| Provision of firewood biomass | 22.73 | 17.47 | 17.54 | 16.96 | 15.29 | 13.99 |
| Provision of fuelwood biomass | 121.84 | 93.64 | 94.03 | 90.91 | 81.95 | 75.02 |
| Provision of NWFP* | 121.84 | 9.64 | 9.68 | 9.36 | 8.43 | 7.72 |
| *Regulating services* | | | | | | |
| Provision of habitats for wild plants and animals | 530.55 | 407.73 | 409.44 | 395.88 | 356.85 | 326.65 |
| Water filtration | 107.47 | 82.59 | 82.94<br>26.72[2] | 1168.76[1]<br>80.19 | 72.29 | 66.17 |
| Protection against rockfall | 1631.30 | 1253.67 | 1258.92<br>427.85[3] | 1217.24 | 1097.23 | 1004.37 |
| Torrent control | 1362.78 | 1047.31 | 1051.70 | 1016.87 | 916.62 | 839.05 |

[1] A unique unit value estimated on the value observation from national study of FES in Germany.
[2] A unique value taken from the CNPF report (not a primary valuation study). Accessible via link. Retrieved on 17.10.2025.
[3] A unique value adjusted from the estimates provided by the 2011 Interreg France–Switzerland Protective Forest.

| FES | Unit value (int $/ha/yr in 2023) | Adjusted unit value (€/ha/yr in 2023) | | | | |
|---|---|---|---|---|---|---|
| | | Austria | France | Germany | Italy | Slovenia |
| *Cultural services* | | | | | | |
| Recreation | 351.45 | 270.09 | 271.22 | 262.24 | 236.39 | 216.38 |
| Aesthetic value | 122.35 | 94.03 | 94.42 | 91.29 | 82.29 | 75.33 |

*Non-wood forest products (NWFP), including chestnuts, mushrooms and berries

In the Alpine context, regulating services have the highest social value per ha of forest, especially those associated with natural hazards risk mitigation, thereby highlighting a particular relevance of these services for the region. However, we must acknowledge the influence of the cost-based approach commonly used for valuation of these FES, which is associated with higher estimates on average, compared to stated- or revealed-preference approach. Another highly valued FES in Alpine area is provision of habitats, followed by recreation and timber wood provision.

***Direct market value assessment of timber, firewood, fuelwood and water provisioning and carbon sequestration forest ecosystem services***

As unit value transfer provides only a proxy, we decided to perform additional direct market valuation (DMV) using market prices for those FES where primary data on the market prices were available. The definition of this valuation approach can be found in Table 1 in D.1.3.1. Working Group ECO - Report. Following the availability of the data on the national or regional level, we have performed DMV for timber, firewood, and fuelwood provisioning services in Austria, Germany, Italy, and Slovenia. For France, we had additionally estimated a unit value for forest spring water provisioning service, using unpublished estimates of water prices and capture volumes provided by Interreg Europe NACAO. Table 2 presents the valuation flow and results.

**Table 2.** Social value of provisioning FES in 2023.

| FES | Living Lab | Biophysical value | Unit | Price/unit | Unit economic value (€/ha/yr)[§] | Economic value (€/yr) |
|---|---|---|---|---|---|---|
| Timber wood* | Thannhausen, Styria, AT | 10,368** | solid $m^3$, excluding bark | 64.54† | 314.61 | 669,076.95 |
| | Bad Tölz, Bavaria, DE | 46,767** | solid $m^3$, excluding bark | 94.81‡ | 461.92 | 4,434,138.91 |
| | Valle Tanaro, IT | 381,461 | $m^3$ | 175.45‡ | 1,543.64 | 66,925,920 |
| | Tržič, Upper Carniola, SL | 55,006 | $m^3$ | 85‡ | 393.72 | 4,657,363.13 |

| FES | Living Lab | Biophysical value | Unit | Price/unit | Unit economic value (€/ha/yr)[§] | Economic value (€/yr) |
|---|---|---|---|---|---|---|
| Firewood | Thannhausen, Styria, AT | 3,012** | solid $m^3$, excluding bark | 102.81† | 145.59 | 145.59 |
| | Bad Tölz, Bavaria, DE | 21,980** | solid $m^3$, excluding bark | 27.50 | 62.97 | 604,451.59 |
| | Valle Tanaro, IT | 1,004,201 | $m^3$ | 64.84‡ | 1,501.93 | 65,117,290 |
| | Tržič, Upper Carniola, SL | 4,140 | $m^3$ | 66‡ | 23.10 | 273,264.18 |
| Fuelwood | Thannhausen, Styria, AT | 4,772** | solid $m^3$, excluding bark | 38.05 | 85.40 | 181,607.09 |
| | Valle Tanaro, IT | 1,618,929 | $m^3$ | 45.87‡ | 1,712.78 | 74,259,010 |
| Provision of water from forest springs | Annecy, FR | 1,934,046.41 | $m^3$ | 0.21[4] | 15.68 | 410,984.86 |

*In Austria, estimation included industrial roundwood and sawlogs; in Germany, only sawlogs; in Italy, only roundwood; in Slovenia, not specified.

**Potential logging volume in the LL was estimated based on the logging volume per ha in Weiz District (for Austria) and Bavaria (for Germany).

†A weighted average of industrial round wood and sawlogs. The sawlogs average price was also weighted.

‡A weighted average of different species.

§Average value calculated considering the following forest areas (ha): Thannhausen, AT – 2127; Bad Tölz, Bavaria, DE – 9599; Valle Tanaro, IT – 43356; Trzic, Upper Carniola, SL – 11829; Annecy, FR – 26209.

Although we employ direct market valuation approach, social value of FES cannot be limited only to existing market transactions, rather reflect a broader value for society, whether already extracted or remains untouched in the forests, i.e., ecosystem service supply. For this reason, to valuate wood provisioning services, we used estimates of potential logging volume (a 'Biophysical value' column in Table 2). In Italy, this value equals allowable cut. In Slovenia, the potential logging volume was estimated based on the annual logging rate and total forest area with timber stock, according to D 2.2.1 FES assessment pilot action report. In Austria and Germany, the potential logging volume was estimated based on the increment, distributed according to actual

[4] Estimated by deducting the costs of capturing water from a forest spring from the average costs for capturing water from a non-forest spring (€0.22/$m^3$), borehole water (€0.17/$m^3$), groundwater extraction (€0.14/$m^3$), and surface water pumping (€0.40/$m^3$ of water).

logging shares for different types of harvested wood, as sustainable forest management is defined as one not exceeding the total yearly increment. It must be further noted that wood market prices are not ideal to capture the value of provisioning services, as we do not account for the costs (forest management, harvesting, preprocessing, labor costs, market distortions, etc.) due to data scarcity, which means that the social values of provisioning FES (timber, firewood, and fuelwood) are overestimated. Data scarcity is a common problem in FES valuation research field and a necessary trade-off when we strive to calculate a more accurate value of forest to the society. Lastly, although Table 2 provides estimates of economic value for all wood-based provisioning FES, in the total economic value analysis we only accounted for timber. As we assumed that these FES are provided in the entire forest territory of the LL, including economic value of firewood and fuelwood would disproportionately magnify the value overestimation of provisioning FES embedded in their unit economic value.

For valuation of the social value of carbon sequestration (Table 3), we combined market price valuation, namely average prices of ETS and voluntary carbon market in 2023, with the estimates derived from modelling and projections for carbon pricing, recommended by the High-Level Commission on Carbon Prices to limit temperature rise to well below 2 °C, reported in 2017 and adjusted to 2023 inflation (Stiglitz et al., 2017; World Bank, 2024). We decided to provide a range of unit values for carbon sequestration to demonstrate the difference between the voluntary market prices, regulated carbon pricing on ETS and recommended carbon pricing corridor. While marketable price estimations shall be oriented towards voluntary carbon market pricing, the theoretical social value of this FES is much higher. The gap between the voluntary carbon market and the recommended carbon pricing corridor demonstrates that at the current stage, voluntary market is not a reliable driver of climate mitigation and regularity intervention is needed.

**Table 3.** Social value of carbon sequestration in 2023.

| Method | Unit value | Adjusted unit value (€/t CO2) | | | | |
|---|---|---|---|---|---|---|
| | | Austria | France | Germany | Italy | Slovenia |
| Recommended price (upper bound) | 127.00 US$/t $CO_2$ | 97.60 | 98.01 | 94.76 | 85.42 | 78.19 |
| ETS | 85.29 €/t $CO_2$ | 65.55 | 65.82 | 63.64 | 57.37 | 52.51 |
| Recommended price (lower bound) | 63.00 US$/t $CO_2$ | 48.42 | 48.62 | 47.01 | 42.37 | 38.79 |
| Voluntary carbon market | 24.57 US$/t $CO_2$ | 18.88 | 18.96 | 18.33 | 16.53<br>29.72[5] | 15.13 |

[5] A market price of t CO2 in Italy based on the 2022 price of 28.15 €/t CO2, adjusted for inflation.

Unit value was converted to €/t $CO_2$ in 2023 and adjusted for each PP, using PPP conversion factors (private consumption, LCU per international $).

# 5. A multi-criteria approach to the provision of market and non-market FES

Practical experience and scientific research demonstrates that European small-scale private forest owners (SPFO) do not only hold huge potential in addressing environmental problems and enhancing the provision of FES (FOREST EUROPE, 2020), but also do not behave in the same way as large industrial forest enterprises. Research on forest owner typologies and PFO behavior indicates that SPFO represent a diverse group who often maintain non-commercial relationships with their forests, managing them with multiple objectives rather than focusing solely on profit maximization (Juutinen et al., 2022; Rizzo et al., 2019; Tiebel et al., 2021, 2024). Additional evidence highlights the wide range of values PFO attach to their forests (Eriksson & Fries, 2020; Olofsson & Jakobsson, 2023; Westin et al., 2023). In the case provisioning FES, the focus is frequently on self-consumption rather than commercial gain (Gatto et al., 2019; Lidestav & Westin, 2023). Although such findings raise concerns about the limited effectiveness of policies based on profit-maximizing assumptions (Mostegl et al., 2019; Polomé, 2016; Quiroga et al., 2019) and emphasize the importance of incorporating the plural values of nature (IPBES, 2019; Jacobs et al., 2016), forest policy and governance continue to be dominated by market-oriented instruments.

Against this backdrop, it is important to understand SPFO management objectives in the context of forest management for FES provision and reducing management effort. To do so, we suggested a multi-objective, robust optimization model (ROM). While methodology remained unchanged (for details, see section 2 in D.1.3.1. Working Group ECO - Report), the model was tested only in Austria, as a sufficient sample size was generated only in this partner country. Results of the test are presented in Section *6- Implementation across the 5 LLs.*

## Business Model Archetypes (BMA) and suitability assessment

When evaluating the market potential of FES, several key challenges must be considered:

- *Invisibility*: Regulation and maintenance services are often only recognizable in the long term, unlike provisioning and cultural services, which are directly observable.
- *Quantification and regular supply*: Difficulties in measuring and ensuring a consistent provision.
- *Non-excludability and free-riding*: Many FES are public goods, making it difficult to prevent individuals from benefiting without contributing to their provision.

However, as detailed in Report 1.3.1, Business Models (BMs) offer an opportunity to manage FES profitably, incentivizing private and public organizations, communities, and other entities to engage in ecosystem service provision through appropriate forest management practices. BMs can play a crucial role in developing payment schemes for public goods (PGs), leveraging market mechanisms and innovative approaches. They aim to make provision financially sustainable and sufficiently attractive for potential providers.

The project seeks to facilitate the trade of FES, particularly those of a public nature. Through BMs, it becomes possible to:

- Identify, communicate, and convey the benefits of FES to relevant beneficiary groups.
- Formulate payment schemes or agreements to increase the supply of PGs, including through incentives for private provision

For this work, we adopted the concept of a Business Model Archetype (BMA). This predefined representation classifies a business based on revenue sources, customer segments, and relationships with clients and suppliers. The objective is to report the outcomes of the pilot phase carried out in the LLs, to identify, for each area, a range of possible BMAs suited to the selected FES and the territorial characteristics.

In this respect, Report 1.3.1 provided the methodology to link the biological, market, and institutional/governance characteristics of each Living Lab with BM archetypes, through the following steps:

1. Identification of relevant features and concepts for LLs and FES, based on the categories of the BM Canvas. The match between features and categories is referred to as "concepts." It consists of the identification of a shortlist of relevant concepts characterizing each Living Lab (LL), representing the combination of ecological, governance, economic and market conditions framing the local context for the potential development of FES markets.
2. Identification of a shortlist of BM archetypes suitable for FES, taking into account archetypes that address the provision of public goods (public, mixed, private) as well as categories from the classical BM Canvas.
3. Development of a profiling mechanism linking BM archetypes with concepts, calculated for each Living Lab, to determine the degree of consistency between the Lab's characteristics and the archetypes, using the TOPSIS methodology (see below).

## Key Concepts for Local Business Model Assessment

This section presents an analysis of the key concepts used to evaluate the relationship between the local characteristics of LLs and FES-based Business Model Archetypes (BMAs). Each concept establishes a correspondence between specific Living Lab characteristics (based on the market template for data collection – see D 1.3.1.) and Business Model Canvas (BMC) categories, providing a detailed justification for their relevance. These concepts are fundamental for defining the outcome of the match between each territory and potential business models.

### *Ecosystem Services Offered*

Match: Biophysical characteristics of the LLs / Value Propositions (BMC).

Explanation: In a business model based on FES, the biophysical characteristics of the area are not merely a background; they are the core asset. The specific type of ecosystem services present in a given territory inherently shapes the range of business models that can be developed. Different services, such as carbon sequestration, recreational opportunities, or non-timber products, align distinctly with specific value propositions, customer segments, and revenue strategies. Consequently, the type and quality of available ecosystem services are fundamental for defining the business model's purpose, its market positioning, and operational focus.

Additional Note: Based on the selected ecosystem service (FES), it will be possible to carry out an initial natural selection of the applicable business model archetypes (BMA). Not all business models are suitable for every type of FES; for example, for a service like carbon sequestration, a model such as "Trash to Cash" would not be appropriate. This concept is fundamental because it influences most BMAs; therefore, during the ranking process, the concept "Ecosystem services offered" is expected to be considered a key criterion across all models analyzed. Then, in each Living Lab, once the FES to be developed has been identified, it will be possible to assess for each BMA whether the model is suitable or not, based on the specific characteristics of the selected ecosystem service.

#### *Local Demand*

Match: Social and economic characteristics of the LLs/Customer Segments and Value Proposition (BMC).

Explanation: Local demand represents the customer segments and beneficiaries that the business model targets. Understanding who these actors are, what their needs are, and what they are willing to pay for (or support) is essential to define:

- The value proposition (i.e., what is offered and to whom).
- The distribution channels (how the customer is reached).
- And the economic sustainability of the model. In the context of ecosystem services (FES), demand is not always expressed through classic market mechanisms; it may be social, cultural, educational, or come from public entities or businesses. For some business models, a deep understanding of the end-user profile is crucial to tailor the offer effectively.

#### *Regulations and Policies*

Match: Institutional characteristics of the LLs / Key Partnerships and Cost Structure (BMC).

Explanation: Local, regional, or national regulations significantly influence what can be done, how it can be implemented, and under which incentives or constraints. This impacts at least three fundamental aspects of a business model:

- Key Partners (identifying who needs to be involved, e.g., public authorities).
- Cost Structure (including compliance costs and permits).

- Revenue Streams. Some business models depend directly on the regulatory context, and the presence of incentives or legal obligations can enable or, conversely, prevent the implementation of an entire model.

***Operating Costs***

Match: Economic characteristics of the LLs / Cost Structure (BMC).

Explanation: Local costs, such as those related to labor, transportation, land management, or technology, are critical to the cost structure and profitability of the business model. They directly influence:

- Scalability.
- The need for public or cooperative support.
- The choice of key activities (e.g., manual vs. mechanized harvesting). For low-margin models, a precise understanding of costs is fundamental to ensure economic sustainability.

***Governance and Management***

Match: Governance characteristics of the LLs / Key Activities and Key Partnerships (BMC).

Explanation: Local governance determines who makes decisions, who owns the resources, and who is entitled to act. This factor influences:

- Key Activities (what the manager can actually do).
- Key Partnerships (identifying the natural allies of the model).
- Customer/Beneficiaries Relationships (how the interaction with users or citizens is managed). In contexts characterized by shared or multi-level governance, this aspect is essential to ensure trust and continuity. Governance can, in fact, "enable" or "hinder" the implementation of the business model.

***Social Benefits***

Match: Social and cultural characteristics of the LLs / Social Value Proposition (modified BMC).

Explanation: This concept refers to the collective sensitivity toward nature and ecosystem services, the territorial identity linked to forests, and the sense of belonging. It affects:

- The value proposition (concerning intangible values).
- The communication of the business model.
- The project's social legitimacy. Emotional and cultural engagement is often the main driver for attracting users, building trust, and strengthening community involvement around the initiative.

***Technological Innovation***

Match: Technological characteristics of the LLs / Key Activities and Cost Reduction (BMC).

Explanation: Technological innovation is crucial for business models that require advanced resource management or complex transformation of ecosystem services. It enables the optimization and scaling of ecosystem service management, improving precision and transparency. It is a vital element for certain archetypes as it helps tackle complex challenges, open new revenue streams, and access digital markets. Its relevance increases in models that depend on high-complexity transformations or service customization.

### Typology of BMAs relevant to FES valorization

In designing a new business model, including FES business models, taking inspiration from real cases is recommended, as it allows building on established experiences and adapting them to the local context. This approach enables practical innovation based on real, tested foundations, even beyond the specialist field of ecosystem services. A wide range of good practices and existing models can be found, including examples from other sectors. For reference, we suggest consulting the selection of good practices available on the Forest Eco Value website. Based on these examples, it is possible to gain a general understanding of how to structure one's own model, which can then be adapted and customized according to the specific contextual characteristics.

In our project, we use 10 business model archetypes. These models are crucial as they help evaluate which business strategies are best suited to the local characteristics of the LLs based on the FES intended for development. The type of FES available in a territory is a fundamental factor that influences the suitability of a specific archetype.

We grouped the BMA into 4 categories: within *Innovative finance and environmental markets*, the archetypes include Environmental finance and Reverse auction. The category of *Tourism, experiences and culture* comprises Freemium and Experience selling. In the field of *Circular economy*, two models are recognized: Trash to cash and Green chemistry/Bioeconomy. Finally, the category of *Social and community-based initiatives* encompasses Crowdfunding, Social enterprise, Subscription, and Public-private partnership.

For our analysis (Chapter 6), we have numbered our BMAs as follows:

- Crowdfunding – BMA1
- Environmental finance – BMA2
- Experience selling – BMA3
- Freemium – BMA4
- Green chemistry – BMA5
- Public Private Partnership (PPP) – BMA6
- Reverse auction – BMA7
- Social enterprise – BMA8
- Subscription – BMA9
- Trash to cash – BMA10

### *Crowdfunding*

Crowdfunding is a financing model where a large number of individuals contribute small amounts to fund a project, typically through online platforms. It is ideal for environmental or social initiatives where emotional engagement and transparency drive participation. The "customers" are not buying a product but investing in a cause, such as reforestation or habitat restoration.

- Clients: General public, environmental supporters, diaspora communities.
- Revenue: Donations, often tied to symbolic rewards or acknowledgments.
- Costs: Campaign creation, outreach, platform fees, project execution.
- Sales Channels: Crowdfunding platforms (e.g., Kickstarter, GoFundMe), social media.
- Best for: Regulating FES (carbon sequestration, biodiversity) and Cultural FES (community engagement).

### *Environmental Finance*

This model converts environmental services like carbon capture or biodiversity protection into tradable credits. These are purchased by companies or institutions seeking to offset their environmental impact. It creates a new financial asset class while incentivizing long-term conservation.

- Clients: Private companies (ESG-focused), governments, investors.
- Revenue: Sale of verified ecosystem service credits.
- Costs: Monitoring, certification, validation, impact reporting.
- Sales Channels: Environmental credit registries, brokers, voluntary carbon markets.
- Best for: Regulating FES (carbon, water, biodiversity).

### *Experience Selling*

This model monetizes immersive, often transformative, nature-based activities such as forest therapy, foraging, or eco-retreats. It builds strong emotional connections and can include seasonal, educational, or spiritual components. It requires skilled personnel, compelling storytelling, and clear audience targeting.

- Clients: Eco-tourists, families, wellness and cultural tourism segments who seek authenticity and meaningful engagement with nature.
- Revenue: Service packages, day rates, seasonal passes.
- Costs: Human resources (guides, educators), insurance, permits.
- Sales Channels: Tourism networks, booking platforms, direct sales.
- Best for: Cultural FES.

### *Freemium*

Freemium models allow open access to a natural area or basic service while charging for premium experiences such as guided hikes, workshops, or wellness events. It enables broad reach and inclusivity while still generating revenue from niche services. The model depends on quality of service, reputation, and user-friendliness.

- Clients: Tourists, schools, wellness seekers.
- Revenue: Paid experiences, merchandise, and event fees.
- Costs: Staff, infrastructure, visitor services.
- Sales Channels: Visitor centers, apps, online booking.
- Best for: Cultural FES (recreation, education, tourism).

***Green Chemistry***

Forest resources like resin, bark, or essential oils are processed into bio-based compounds used in construction, cosmetics, or health sectors. This model supports innovation and low-impact production chains. The model requires R&D, quality standards, and integrated supply chains.

- Clients: Industrial buyers, sustainable product manufacturers.
- Revenue: Material sales, intellectual property, B2B partnerships.
- Costs: Extraction, transformation, regulatory compliance.
- Sales Channels: Industrial supply chains, co-development contracts.
- Best for: Provisioning FES with Regulating and innovation potential.

***Public-Private Partnership (PPP)***

In a PPP, public institutions and private companies work together to protect and manage forest ecosystems. The private actor may fund restoration in exchange for long-term benefits (e.g., water quality, branding), while the public actor ensures regulatory support and alignment with policy goals. Benefits are environmental, economic, and reputational. It requires coordination and a shared long-term vision.

- Clients: Private firms, municipalities, agencies.
- Revenue: Co-investment or service delivery payments.
- Costs: Coordination, technical design, and monitoring.
- Sales Channels: Strategic agreements, institutional contracts.
- Best for: Regulating, Provisioning, and Cultural FES

***Reverse Auction***

A reverse auction invites landowners to submit offers to provide ecosystem services for the lowest possible cost. Authorities then select the most cost-effective proposals. This model ensures efficient use of public funds and maximizes environmental return on investment.

- Clients/Buyers: Public authorities, conservation programs.
- Providers: Forest owners, cooperatives, farmers.
- Revenue: One-time or ongoing payments for selected services.
- Costs: Bid preparation, administrative management, verification.
- Sales Channels: Public tenders, environmental grant schemes.

- Best for: Regulating and Provisioning FES (land use management, biodiversity).

### *Social Enterprise*

Social enterprises use forest-based activities to generate social impact - employing marginalized groups, offering community services, or creating inclusive spaces. Profit is reinvested into social objectives because the value is primarily social, rather than commercial. The mission is central to the business.

- Clients: Communities, municipalities, donors.
- Revenue: Product/service sales, public funding, foundations.
- Costs: Staffing, training, coordination.
- Sales Channels: Local networks, public tenders, NGO platforms.
- Best for: Cultural and Regulating FES with a social integration focus

### *Subscription*

In the subscription model, clients pay a regular fee to receive forest products (e.g., mushrooms, herbs) or access to services (e.g., seasonal tours, ecological newsletters). The advantage lies in predictable income and customer retention. Efficient logistics and consistent service delivery are key. The model often builds a loyal community.

- Clients: Individuals, health and wellness markets, schools.
- Revenue: Recurring fees, tiered plans.
- Costs: Packaging, delivery, seasonal sourcing.
- Sales Channels: Online platforms, newsletters, co-branding.
- Best for: Provisioning and cultural FES.

### *Trash to Cash*

This model turns forestry residues or damaged materials into marketable goods—such as upcycled furniture, biochar, or artisanal products. It reduces waste and fosters local entrepreneurship and employment, often linking ecological narratives (e.g., post-disaster recovery) to product identity. The value is environmental (waste recovery), cultural (craftsmanship), and economic.

- Clients: Eco-conscious consumers, local markets, design sectors.
- Revenue: Product sales, niche exports.
- Costs: Collection, transportation, manufacturing, marketing.
- Sales Channels: Craft fairs, e-commerce, partnerships with ethical brands.
- Best for: Provisioning FES, with indirect Regulating and Cultural value

## Methodological approach

### *Introduction*

This methodology aims to identify the most suitable business models (BMs) to be applied in the LLs of the project.

The methodology assumes that each region hosting a LL is characterized by a combination of features that frame the local ecological, governance, economic and market conditions that we consider for each location to be assessed against a set of BMs applicable to FES.

The methodology presented below uses a MCA-TOPSIS approach estimating the *degree of similarity* between groups of characteristics – of LLs and archetypes of BMs (BMAs), respectively – to associate each LL (with its own set of biophysical, economic and governance features) to alternative BMAs (in turn with their own distinctive features) aiming at providing local decision makers with a complete ranking of BMAs for each LL.

The ranking obtained allows us to tell which BMAs are worth trying to apply for each region (LL), based on the local characteristics, that have been quantified or qualitatively estimated locally. This happens by producing a ranking of BMAs against each region (LL) that, if needed, can be also analysed more in depth.

Additionally, the methodology offers some standardized analytical suggestions in natural language, based on the degree of similarity achieved between the distinctive characteristics of a LL and the distinctive features of a BM that can help decision makers, institutions, economic and forest operators to focus on specific improvements in a specific characteristic or condition facilitating the local implementation of a desirable BM[6].

The report integrates a practical business model analysis for each Living Lab, using standardized templates (adapted business model canvas) and scenario simulations to assess financial, social, and ecological viability. This analysis directly applies the financial concepts defined in the glossary (reported in the Business Model Canvas Analysis section), ensuring that key indicators such as NPV, IRR, and payback period are consistently interpreted and operationalized throughout the report and allowing for a comparison across contexts.

### *Phase 1 – Selection of relevant concepts and indicators*

Each LL has been characterized based on a limited set of concepts that are considered essential to frame the conditions relevant for a region to host a FES-market. The identification of the characteristics recalled has been based on literature review, good practice analysis (especially across Europe) in the forest sector, and expert assessment. This process has brought to define 7

[6] The analysis was carried out using Microsoft Excel. We provided a simplified tool for running a similar exercise at the LL level,

concepts that characterize a territory as a potential cradle for FES-markets as shown in the table below.

**Table 1.** Key Concepts and Indicators for Local Business Model Assessment

| Concepts | Indicators |
|---|---|
| 1. Ecosystem offered | Carbon storage<br>• Carbon Sequestration (T/ha/an)- Broad-leaved forest<br>• Carbon Sequestration (T/ha/an) - Coniferous<br>• Carbon Sequestration (T/ha/an) - Mixed Forests<br>Habitat maintenance<br>• Total area (ha) concerned by habitat maintenance service<br>• mean Volume (m3/ha) biodiversity<br>• mean Growth (m3/ha/an) biodiversity<br>Recreational services<br>• Total area concerned by recreational services (ha)<br>• Mean Volume (m3/ha) recreational services<br>• Mean annual increment (yearly growing stock) (m3/ha.year)<br>Torrent management<br>• *Area total (ha) concerned by wood biomass service*<br>• mean Volume (m3/ha)<br>• mean Growth (m3/ha/an)<br>Wood biomass<br>• *Area total (ha) concerned by wood biomass service*<br>• mean Volume (m3/ha)<br>• mean Growth (m3/ha/an) |
| 2. Local demand | • Disposable income per inhabitant (euro to PPS / year)<br>• Entrepreneurial density (Enterprises per 1000 inhabitants)<br>• Tourist intensity (Nights per resident/year) |

| | |
|---|---|
| 3. Regulations and policies | • Environmental taxes (%GDP)<br>• Availability of public funding (binary 0/1)<br>• Presence of environmental regulations (binary 0/1) |
| 4. Operating costs | • Hourly labor costs (euros in PPS)<br>• Electricity prices (companies) (euros to PPS/kWh)<br>• Gas price (companies) (euros to PPS/kWh) |
| 5. Governance and management | • EMAS Density (Certifications / 10,000 companies)<br>• ISO Density (Certifications / 10,000 companies)<br>• Presence of management plans (binary 0/1) |
| 6. Social benefits | • Gini Income index (0-100)<br>• S80/S20 ratio (inequality) (index-regional)<br>• Interpersonal trust (scale 1-10 (regional) |
| 7. innovation | • Tech innovation -I1 Public expenditure on R&D (% of GDP)<br>• Corporate R&D spending (% of GDP)<br>• R&D personnel (companies) (% total emplyment) |

On the other hand, BMAs have also been qualified as depending on the presence and intensity of the LL concepts for their proper functioning, based on the consideration of a selection of features associated to the LL concepts. This assessment has been done by combining the results of two “parallel” methods.

Firstly, the assessment was delivered automatically by using a statistical weighting technique (*entropy weighting*) that assigned weights to each concept for each LL.

Secondly, the assessment was made by experts ranking the concepts against all the considered BMAs, so estimating how important each concept was for the local implementation of a certain BM. As a result, we obtained expert weights assigned to each concept for each LL.

Finally, the weights obtained with each method have been combined to assign a credible weight to the list of concepts, by assuming expert assessment as preferred to statistical weighting, so that the final weight is determined by expert decision for 60% and by statistical assignment for 40%.

This phase basically aimed at achieving information on the *relative importance* of each concept for a BMA, represented by the combined weights recalled above.

### *Phase 2 – Data collection and normalization*

Each concept can be represented by up to 3 indicators that need to be calculated for each LL and proportionally combined. The final list of indicators has been selected based on a screening in literature and practice followed by voting by an expert group within the project partnership. The values of indicators for all LLs have been retrieved at the LL level by the local coordinators, or at a higher territorial scale from official statistics.

All figures collected have been used to obtain the value of each concept for all LLs. To perform the aggregation of indicators into concepts, *i.e.,* merging all the values of individual indicators into each concept (ranging from physical dimensions *e.g.,* in hectares to Likert scale assessments, etc.), values have been statistically normalized into each concept and later also concept values have been normalized to create a consistent numerical context.

This phase basically aimed at achieving information on the *intensity* of each concept, represented by the normalized numerical value.

### *Phase 3 – Final ranking using the TOPSIS Method*

Once the normalized absolute values of all concepts in each LL have been obtained, and the relative weight of each concept in each LL (so that concept weights sum to 1 in each LL) have been set, the TOPSIS method has been applied.

The TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution) is a decision-making technique used to rank options based on how close they are to an ideal solution. In the case of LLs, the ideal solution is represented by the combination of the maximum values of each concept assumed in all LLs (the study's universe of discourse), against all BMAs (10).

Thus, for each weighted concept, the ideal best value is established by considering its performance in all LLs when a given BMA is chosen.

Then, for each BMA, the distance is calculated between the value assumed by a concept in each LL and the ideal value, for all 7 concepts.

Finally, the degree of similarity between the real values measured in each LL and the ideal values for all LL, is estimated, so to find the degree of similarity between each LL and a certain BMA.

As a result, we obtain a rank of LLs against each BMA (considering all the concepts) that allows to identify the LL where a BMA fits better.

Reworking this information, we can produce:

a) *complete rankings of BMAs against LLs* that tell which BMA works better in a certain regional context;
b) *values of BMA own concepts for each LL,* showing which concepts contribute more to the final ranking of BMAs in each LL; this information is useful to decision makers willing to

improve, through policy action, the performance of a BMA locally or to introduce a certain BMA in a region/LL.

***Phase 4 – In-depth analysis and strategic insights for each LL***

The method also delivers a graphical and conceptual *gap analysis* that applies to each LL.

Particularly, it compares the performance of all concepts in each LL against the ideal case depicting:

a) the distance between the ideal case and the observed BMA as applied in each LL represented in *a radar graph*,
b) The *performance gap analysis* as a share (%) of the ideal value for each concept for the observed BMA in each LL represented as a clustered bar graph.

The method also provides some *standard strategic advice* for each concept, organized as follows:

a) For each concept based on its value, the system delivers an assessment in natural language of the status of the concept ("Over-Performance", "Strategic Alignment", "Development Area", "Critical Vulnerability", “Adequate Performance”),
b) a narrative policy hint for each status, as follows:
    a. *Strategic Alignment*: KEY STRENGTH, Leverage this high performance as a pillar of the BMA. Use in marketing and to attract strategic partners,
    b. *Over-Performance*: EXCELLENCE TO ASSESS, Consider if resources allocated here are excessive for this BMA. They could be reinvested in areas with larger gaps,
    c. *Development Area*: Significant improvement needed. This is a primary target for strategic investment (pilot projects, training, infrastructure) to close the gap,
    d. *Critical Vulnerability*: High-risk area that could compromise the entire model. Requires immediate intervention and risk mitigation strategies BEFORE implementation,
    e. *Adequate Performance*: Monitor this concept, but it is not an immediate priority for corrective action.
c) The main likely cause for the status, as follows:
    a. *SYNERGISTIC STRENGTH*: a strong alignment between the LL's performance and the BMA's strategic needs. This is a key driver of the model's success.
    b. *CAPABILITY GAP*: The issue is internal to the LL. Success requires direct investment in building this specific local capacity (e.g., training, infrastructure) before the BMA can be effective.
    c. *STRATEGIC MISMATCH*: The BMA's design ignores this concept. If this concept is a policy priority, this BMA is a poor fit. Consider a different BMA that leverages this area as a strength.
    d. *MUTUAL IRRELEVANCE*: This concept is neither a strength of the LL nor a priority for the BMA. It can be safely disregarded in strategic planning."

d) The scientific diagnosis & explanation, providing more specific motivations for the observed performance of each concept in a LL, as follows:
   a) *Observed Synergy*: the weighted score is positive, indicating a measurable interaction between the LL's normalized capability and the BMA's strategic weight for this concept.
   b) *Capability-Driven Attenuation*: The zero score is primarily attributable to the Living Lab's minimal normalized performance (score ≈ 0) in this concept, which nullifies the effect of the BMA's strategic weight.
   c) *Strategy-Driven Attenuation*: The zero score is primarily attributable to the BMA assigning a negligible strategic weight (weight ≈ 0) to this concept, which nullifies the effect of the LL's performance.
   d) *Compound Null Effect*: The zero score results from a compound effect where both the LL's normalized performance and the BMA's strategic weight are at or near zero.

### *Phase 5 – Synthetic assessment for each LL against a BMA*

The method finally produces a short assessment about the overall performance of a BMA in each LL organised in two parts: the synthetic profile and the key findings and actionable priorities.

#### *5.1 Synthetic profiles.*

Based on the similarity score, the following profiles result:

- *EXCELLENT.* This is a robust and well-balanced model, strong across nearly all key concepts. High potential for success with low implementation risk,
- *VERY GOOD (Specialized).* This model leverages exceptional strengths in specific areas but has notable weaknesses. It is powerful but requires strategic focus on its weaker concepts,
- *GOOD.* A solid, balanced model with consistent performance. A safe and promising choice, with clear areas for targeted improvement,
- *PROMISING (Unbalanced).* This model has significant strengths but also critical gaps. It requires careful investment to mitigate risks before implementation,
- *MODERATE*. Performance is sufficient but lacks outstanding strengths. Implementation would require widespread and significant effort to improve multiple concepts,
- *HIGH RISK (Volatile).* This model is highly specialized and fragile, with extreme peaks and deep valleys. Success is dependent on very few factors, making it a high-risk, high-reward bet,
- *WEAK*. This model shows low performance across most or all concepts and is not a suitable fit for the current capabilities of the Living Lab. Not recommended.

*5.2 Key findings and actionable priorities*

Based on the performance of each BMA against its concepts, the system delivers a summary of the best components (key strengths), main risks (critical risks) associated with it in the analysed LL, and the areas for development (i.e. those concepts where there is significant room for improvement in the analysed case). Finally, it offers a summative assessment of the profile as balanced (well-balanced) or strongly dependent on some very good scores for some concepts over others (specialized profile).

***Comments and limitations***

The principal limitations of this methodology stem from the restricted scope of reference data, which is drawn solely from the five Living Labs participating in the project. While this focused approach enabled a thorough and contextually grounded analysis, it inevitably curtails the applicability of the findings to other environments or a wider array of case studies.

The choice of concepts for analysis was influenced both by comparisons with previous projects and by collaborative efforts with the LLs up to the point of review. Nevertheless, this process was subject to a certain degree of discretion, shaped by the methodological decisions of the research team and the information available during the design phase.

Likewise, the assignment of weights to the various Business Model Archetypes (BMAs) was informed by expert contributions within the project; however, the limited number of such inputs constitutes a further constraint.

Another noteworthy limitation concerns the precision of the available data, which in certain instances could have been improved and more finely tuned to the specific operational and contextual characteristics of each Living Lab. This may have hindered the analysis’s capacity to fully and accurately reflect the distinctive features and variations across the different contexts examined.

It is important to emphasise that the identification of the Business Models considered most appropriate for each context is strictly the result of applying the TOPSIS method within this study, complete with its inherent assumptions, simplifications, and limitations. These results do not necessarily align with the models ultimately adopted by each Living Lab. Consequently, the findings should primarily be viewed as a structured set of potentially relevant options, serving as guidance rather than definitive prescriptions, and should be tailored, refined, and supplemented to address the specific requirements and circumstances of each local context.

The approach to designing and testing Business Model simulations for the five LLs was shaped by the coordinators' choices regarding which FES to valorize and which business model archetype to pursue, as identified through participatory workshops with stakeholders in each Living Lab. Notably, the selection of Business Models for simulation was conducted independently of the outcomes produced by the TOPSIS methodology detailed earlier, resulting in a disconnect between the structured methodological assessment and the scenarios ultimately tested.

Each Business Model was evaluated using a consistent framework: a detailed model description, the assumptions and parameters underpinning the simulation, and the application of three standardised scenarios (Baseline, Moderate, and Stress Test). The results were scrutinised across financial, ecological, and social dimensions, and were accompanied by recommendations outlining both advantages and limitations of the respective models. Additionally, a summary of a basic Monte Carlo analysis was included to provide a narrative assessment of the robustness of the simulation outcomes across the three scenarios.

However, it is important to highlight that the parameters and data used for these simulations were developed independently of the LLs' actual circumstances, datasets and stakeholder discussions. As such, the simulations serve primarily as illustrative examples, offering methodological guidance and general principles for future, locally customised business model testing rather than delivering actionable insights specific to each Living Lab context. This limitation should be borne in mind when interpreting the results, as the numbers presented are indicative only and may not accurately reflect the reality or the nuanced operational environments of the LLs involved.

### Business Model Canvas Analysis and Simulation: Logic and Integration

The section "BM Canva analysis and simulation" is designed to translate the conceptual and quantitative framework established in the methodology into practical business model applications for each Living Lab. For every country and Living Lab, this section presents a tailored business model canvas (BM Canva), which systematically maps key activities, resources, value propositions, revenue streams, and cost structures relevant to the local context.

The simulation component applies the financial concepts defined in the glossary—such as Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period, Discount Rate, and Revenue Diversification—to test the viability and resilience of each business model under different scenarios. By integrating these metrics, the analysis provides stakeholders with clear, comparable benchmarks for evaluating the economic, social, and ecological performance of alternative business models.

The BM Canva analysis is structured to:

- **Visualize** the business model logic for each Living Lab, using the standardized BM Canvas template.
- **Apply** scenario and sensitivity analysis to assess financial and ecological outcomes, referencing the glossary for definitions and interpretation of key indicators.
- **Support** decision-making by linking business model structure to practical metrics, enabling comparison across countries and contexts.

This approach ensures that the financial terminology and analytical methods introduced in the glossary are directly operationalized in the business model simulations, fostering clarity and consistency throughout the report. Readers are encouraged to consult the glossary before reviewing each BM Canva analysis, as it provides essential context for interpreting the results and recommendations.

### *Glossary*

Before applying financial concepts to the assessment of different business models across countries, this glossary provides concise definitions and practical explanations of the main financial terms used throughout the report. These terms are essential for interpreting scenario analyses, understanding business model viability, and comparing outcomes across different Living Labs.

**Net Present Value (NPV):** The sum of all future cash flows (revenues minus costs) generated by a business model, discounted to present value using a specified rate. A positive NPV indicates financial viability, while a negative NPV suggests the need for adjustments in pricing, costs, or policy support.

**Internal Rate of Return (IRR):** The discount rate at which the NPV of all cash flows from a project equals zero. IRR is used to compare the profitability of different investment options; a higher IRR indicates a more attractive investment.

**Payback Period:** The time required for the cumulative net cash flow to become positive, i.e., for the initial investment to be recovered. Shorter payback periods are generally preferred, as they indicate quicker returns.

**Discount Rate:** The rate used to convert future cash flows into present value. It reflects the time value of money and investment risk; higher discount rates reduce the present value of future returns.

**Operating Cost:** The ongoing expenses required to run a business model, including labor, materials, energy, and maintenance. Operating costs directly affect profitability and are a key parameter in scenario analysis.

**Revenue Diversification:** The extent to which a business model relies on multiple sources of income (e.g., product sales, grants, ecosystem service payments). Diversification can improve financial resilience and reduce risk.

**Scenario Analysis:** A method for testing business model performance under different assumptions (e.g., changes in prices, costs, or participation rates). Scenario analysis helps identify risks and opportunities, guiding decision-making.

**Sensitivity Analysis:** An approach to evaluating how changes in key parameters (such as $CO_2$ price, operating cost, or discount rate) affect financial outcomes. Sensitivity analysis highlights which factors most influence viability.

**Buffer Fund:** A reserve of funds set aside to manage risk and ensure financial stability in the face of unexpected events or cost overruns.

# 6. Implementation across the 5 Living Labs

## Austria

### *Tailored FES valuation*

A Living Lab in Austria was organized in a unique way: it was welcoming representatives of their main target group – private forest owners – from the entire state of Styria. 17 forest owners, whose applications for participation were accepted, have their forest properties located 14 municipalities and nine districts: Langenwang municipality in Bruck-Mürzzuschlag district (15 applications in total), Sankt Stefan ob Stainz municipality in Deutschlandsberg district (one application in total), Fürstenfeld, Sankt Lorenzen am Wechsel and Waldbach-Mönichwald municipalities in Hartberg-Fürstenfeld district (four applications in total), Kammern im Liesingtal municipality in Leoben district (one application in total), St. Peter am Kammersberg and Murau municiaplities in Murau district (five applications in total), Sankt Margarethen bei Knittelf municipality in Murtal district (four applications in total), Fehring municipality in Südoststeiermark district (three applications in total), Geistthal-Södingberg municipality in Voitsberg district, and Birkfeld, Gasen and Thannhausen municipalities in Weiz district (11 applications in total). One application was impossible to locate. Five forest owners with 16 projects in total were financed as a result of the reverse auction. Due to computational capacity limitations, we selected one municipality where most of the winning projects were located, namely Thannhausen (Weiz District).

The results of the adjusted unit value transfer for the Austrian Living Lab in municipality of Thannhausen are presented on Figure 1. Two sets of value estimates were produced:

- Adjusted unit value transfer for all FES, except for the carbon sequestration valuated using voluntary market carbon pricing (VMCP), hereinafter, 'Value transfer and VCMP';
- A mix of market price (MP) valuation for timber wood, firewood and fuelwood biomass provision, upper-bound estimates of recommended carbon pricing (RCP) for carbon sequestration, and adjusted unit value transfer for other FES, hereinafter, 'Mixed-method and VMCP'.

Both estimation approaches highlight social relevance of regulating services associated with natural hazards risks mitigation with the highest value per ha of forest, followed by provision of habitats for wild plants and animals and cultural service of recreation. Provision of timber wood biomass rounds the top five FES with the highest social value per ha. Instrumental values of recreational and timber wood services are however located closer to the lower range of relative value spectrum, indicating a higher relative importance of regulating services. Although MP valuation of timber wood provision demonstrates that Alpine average might underestimate the social value of this FES, the service still has a lower relative value than of regulating services. The underestimation of firewood value provided by the value transfer is more significant

(+€128.12/ha). In case of fuelwood, the difference between values provided by two methods is insignificant.

According to the average pricing on the voluntary carbon market, a value of a ha of forest in terms of carbon sequestration is about €70 lower (in 2023) than value of timber wood provided by the same ha. However, when valuating carbon sequestration with the upper-bound carbon pricing (€536/ha) recommended to achieve climate mitigation compatible with the global climate targets, this FES takes its place among the three most valuable regulating services in Thannhauesen. This difference highlights sensitivity of monetary valuation and importance of clarity about communicative goal when using results of such assessments.

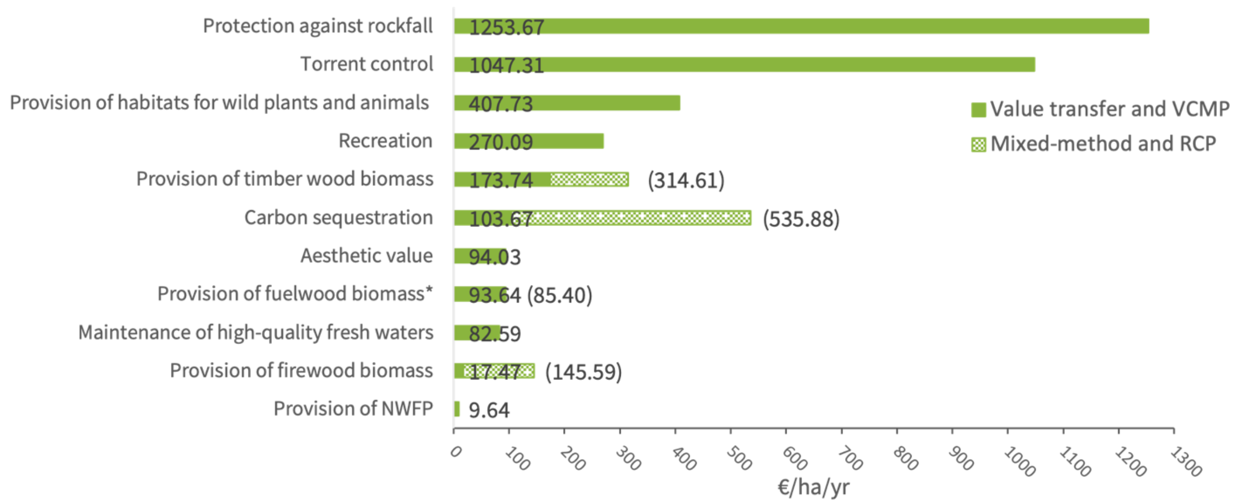


**Figure 1.** Unit value estimates in 2023 euros per ha. Bold green depicts values estimated with the Value transfer and VMCP. Patterned green depicts additional values estimated with the Mixed-method and RCP, with the estimates indicated in parenthesis. NWFP stands for non-wood forest products, including chestnuts, mushrooms and berries. *As MP estimates provided a higher value for fuelwood biomass FES than adjusted unit value transfer, the patterned green part of the bar is not visible on the figure.

Estimates of the total economic values (TEV) of forests in Thannhausen, using both valuation approaches, are demonstrated in Figure 1. Two valuation approaches produce different relative weights of FES contributions in the TEVs, highlighting sensitivity of the results to the approach chosen. In the first TEV, recreation is the biggest contributor to FES (38%), tightly followed by timber wood provision (30%), while to cumulative share of regulating services is 32%. The second approach doubled the TEV via a dramatic increase of contribution of carbon sequestration (from 18% to 46% of TEV). Although, in absolute terms the contribution of provisioning FES has also increased, the relative contribution became slightly lower. Despite the highest social importance (i.e., highest unit value), contributions to provision of habitats and protection against rockfall is relatively marginal. This suggests that targeted efforts on expansion of the forest area providing this FES will have a substantial effect on the TEV of Thannhausen forests.

It must be noted, that provided TEV estimates are a serious underestimation, as the number of FES included in the calculation was restricted to five. Nevertheless, according to the unit value results, discussed above (Figure 1), these five FES are among the most relevant for the Living Lab. Despite underestimation, value of timber provisioning service constitutes about 30% of the forest TEV, suggesting that the social importance of forests in Thannhausen extends well beyond timber production. At the same time, we must keep in mind that provisioning FES are provided by the same forest area as carbon sequestration and partially overlaps with other FES. This hints at potentially detrimental losses in social value of forests if forest management is fully oriented at timber provision.

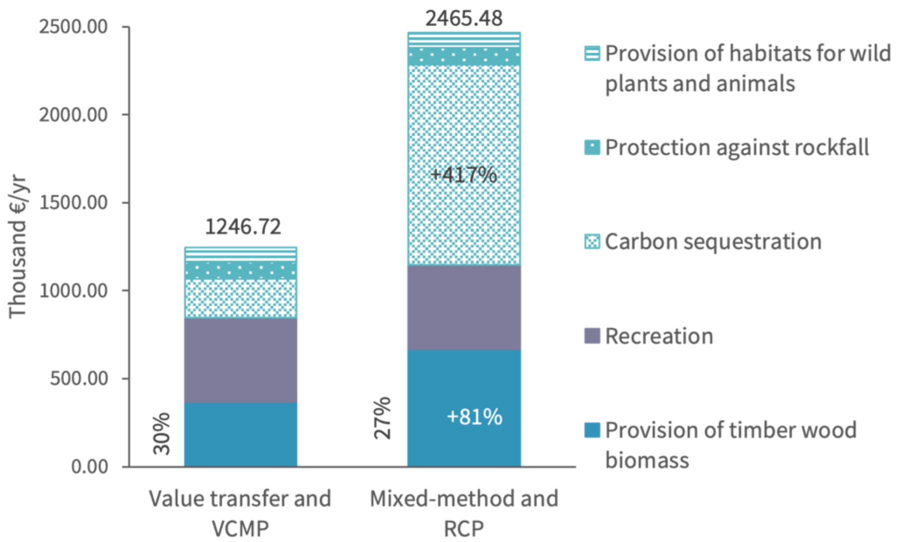


**Figure 2.** Estimates of total economic value (TEV) of forests in Thannhausen, calculated using two different approaches. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentages for timber wood biomass and carbon sequestration placed inside the bar indicate difference in total values of these FES between TEVs estimated using different methods. Numbers on the top of the bars indicate the TEVs.

Spatial distribution of FES social values in Thannhausen further details our understanding about the FES provision in the Living Lab (Figure 2). Not all values are evenly distributed throughout the territory of the Living Lab. Most of the forest area provides relatively low value per ha where timber wood biomass and carbon sequestration are present. In only a few areas values per ha are relatively high. These are located around Osserkögel mountain, between Oberdorf bei Thannhausen village and Raas mountain, and in the south-east of Buchberg mountain. However, it must be acknowledged that the economic value mapping is influenced by the assumptions behind biophysical assessment (i.e., decision criteria on what forest area provides a certain FES and what forest area does not; for more detail on the assumptions of biophysical assessment see D2.2.1). Nevertheless, such economic value mapping can support future land use policies and steer the discussion on what areas must be protected (i.e., highly valued areas) and what areas demand special attention and changes in forest management (i.e., areas with lower value per ha). Supplementing this map with spatial distribution of forest ownership as well as residential and recreational areas could shed more light on the FES providers and main beneficiaries, thereby, providing further foundation for decisions about payments for FES (payment to whom?) and equal access to the benefits provided by forests.

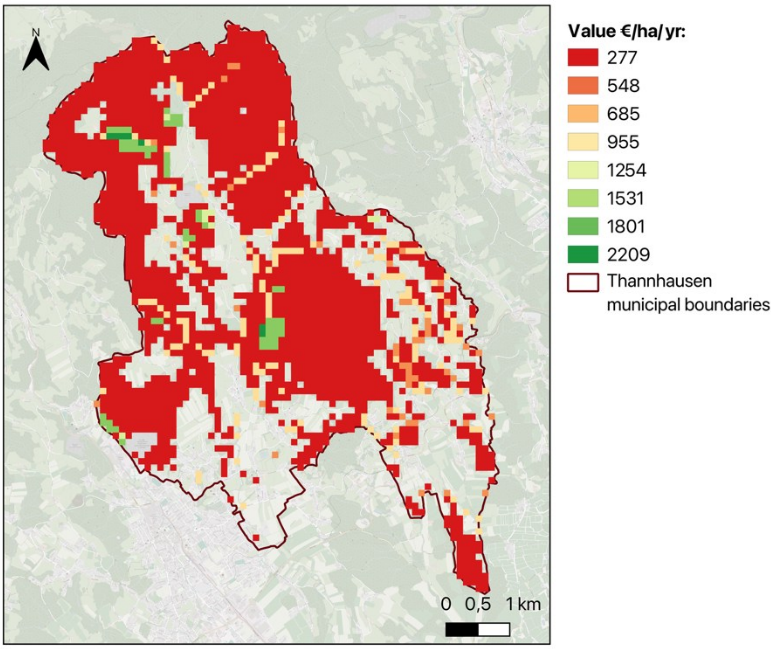


**Figure 3.** Spatial distribution of unit values in Thannhausen. Only estimates produced with the Value transfer and VCMP were used for mapping. Some degree of spatial under- and overdistribution is present for the unit value of carbon sequestration as unit value estimation is based on mean carbon sequestration per ha, not carbon sequestration specific to the forest unit.

### *Application of multi-criteria approach to the provision of market and non-market FES*

Austrian Living Lab was also the only one that has collected sufficient data for the testing of the multi-criteria approach to the provision of market and non-market FES, more specifically of the multi-objective, robust optimization of forest composition. By collecting *stated management objectives* among the SPFO in Austria via survey and comparing them with the *observed management objectives*, derived from ROM results, we came to the following conclusions:

- **SPFO manage their forests for multiple objectives and hold plural forest values**

On average, survey respondents state that their forest management is multi-objective, as neither of the single objective trespasses 50% weight mark (Figure 1). However, three *stated management objectives* stand out: ‘Long-term income’, ‘Meeting household needs’ and ‘Ecological functions’, driving the overall importance of their respective objective groups. The variance in weighting of these objectives is rather high, indicating no clear consensus among the respondents. A higher consensus is observed for the less relevant objectives. Reducing ‘Management effort’ is ranked as the least important objective group on average.

The compromise forest composition optimized for all nine objectives reflects how forest owners would ideally allocate stand types if they aimed to meet all objectives simultaneously, as forest type performance (i.e., model input) is derived from forest owners’ subjective assessment (Figure 2). By comparing the optimization results with the baseline forest composition, we can conclude that *observed* management behavior of SPFO is also rather multiobjective, in line with the *stated* multiobjectivity.

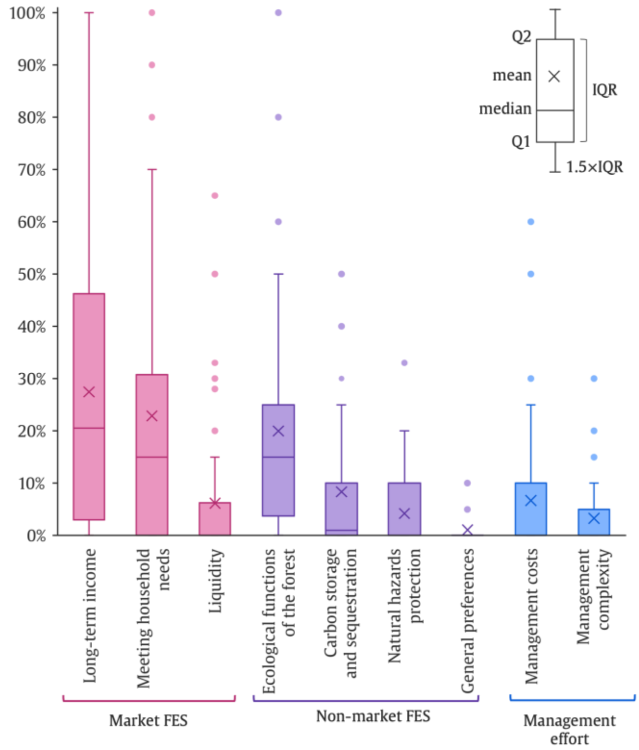


**Figure 1.** Distribution of relevance weights assigned to different *stated management objectives*, sorted by average weights within each objective group. Box plot whiskers extend to the most extreme data points within 1.5 times the interquartile range (IQR) from the lower (Q1) and upper (Q3) quartiles. Data points beyond this range are plotted individually as outliers and shown as dots.

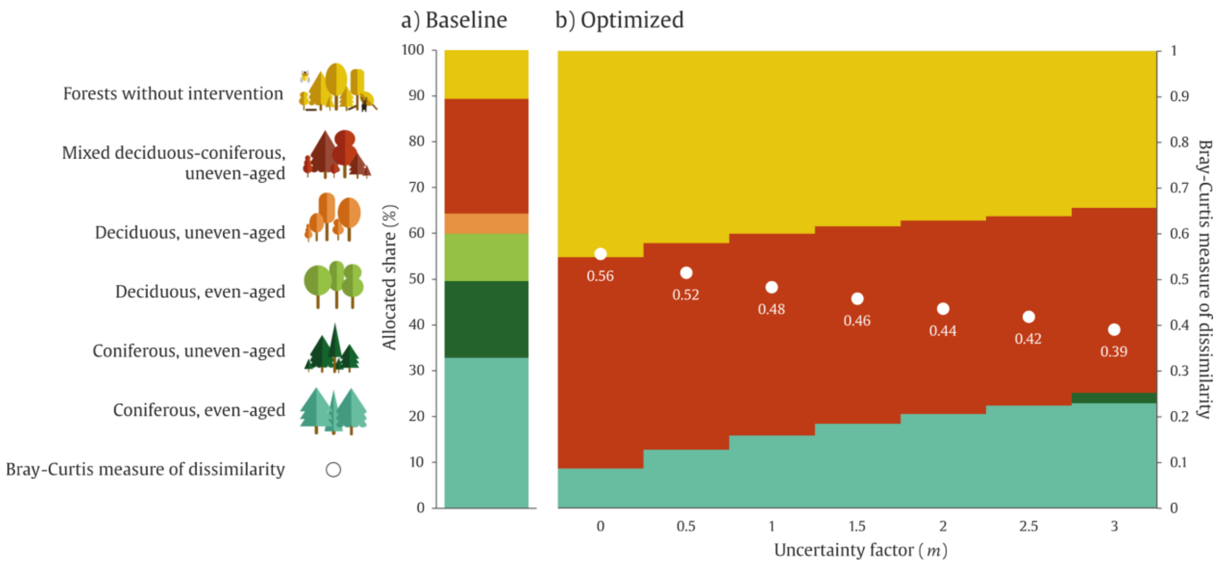


**Figure 2.** a) Baseline forest landscape composition compared to the b) compromise forest landscape composition over increasing levels of uncertainty ($m \in \{0, 0.5, 1, 1.5, 2, 2.5, 3\}$), optimized for all nine objectives (left axes). Points signify the Bray-Curtis measure of dissimilarity between the compromise and baseline forest landscape composition for each objective (right axes).

- **Mixed forests satisfy multiple objectives of SPFO but are seen as complex to manage**

The compromise forest composition has a predominantly uneven-aged structure, dominated by the three forest stand types – mixed deciduous-coniferous, non-intervention and even-aged coniferous types (Figure 2). A zoom in the optimization results at the uncertainty level with the best fit to baseline forest composition () shows that although performance of most individual objectives was improved, such harmonization came at the cost for the perceived 'Long-term income', 'Liquidity', and 'Management complexity' (Figure 3). While for the performance losses in the former two could be partially compensated by decreased 'Management costs', 'Management complexity', possibly stemming from a slightly higher share of mixed deciduous-coniferous forests, represent the "cost" that private forest owners would need to "pay" for a multi-functional forest management.

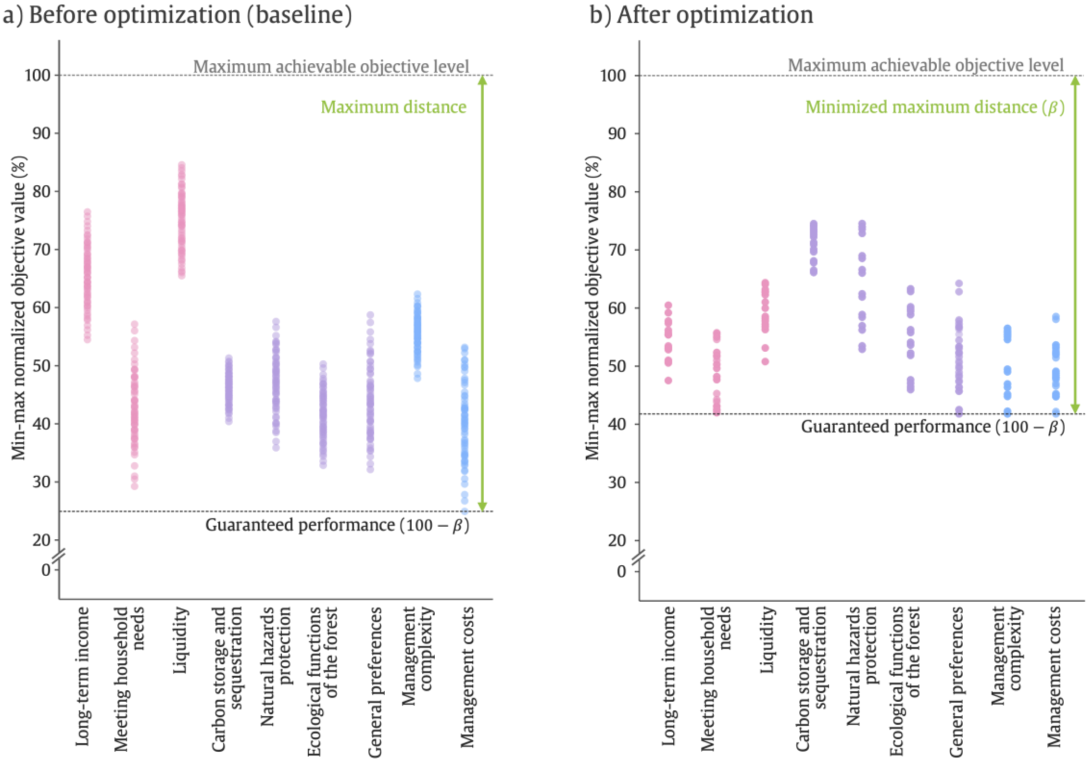


**Figure 3.** Performance across all objectives a) in the baseline forest composition and b) in the compromise forest composition, optimized for all 9 objectives with the uncertainty level $m = 3$. The dots depict the performance for each objective for each uncertainty scenario in relation to the target performance level of 100% (solid grey line) for each objective. More specifically, they plot the distances between the individual performance estimates and the target performance. The worst performino objectives determine the minimized maximum distance to the target performance level (light green arrow, $\beta$), or the guaranteed performance floor for the given forest composition portfolio ($100 - \beta$).

In optimization for different objective groups, similarity in the ideal forest compositions optimized for the ‘Market FES and ‘Non-market FES’ is striking as both portfolios are dominated by the mixed deciduous-coniferous forest type (Figure 4). This result indicates the perceived universality of this forest type for satisfaction of multiple objectives.

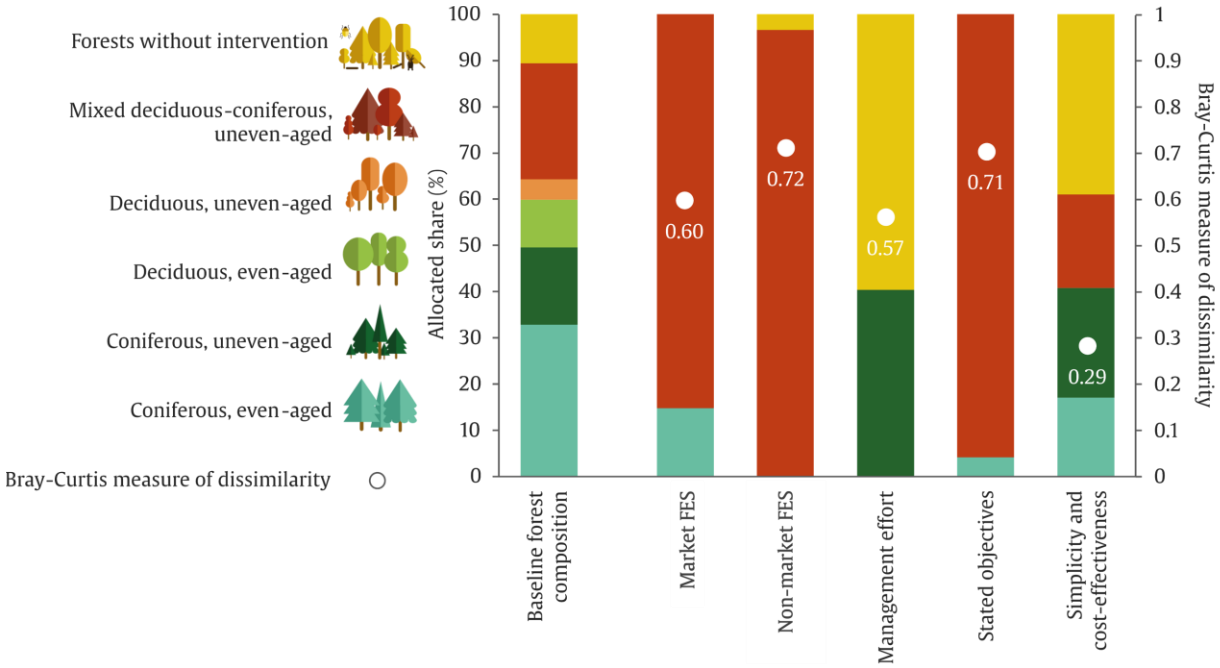


**Figure 4.** Ideal forest landscape composition, optimized for objective groups with the uncertainty level $m = 3$ (left axis). Points signify the Bray-Curtis measure of dissimilarity between the ideal and baseline forest landscape compositions for each objective group (right axes). Optimization was performed with the predetermined objective groups, the three most relevant *stated management objectives* ('Long-term income', 'Meeting household needs' and 'Ecological functions'), and the best fitting combination of objectives that produced forest composition most fitting to the observed one ('Management complexity', 'Management costs' and 'Liquidity').

- **Reducing management complexity is key to activating SPFO who 'want' to manage their forests for multiple FES**

A forest composition optimized for an objective group, formed by the three most relevant *stated management objectives* ('Long-term income', 'Meeting household needs' and 'Ecological functions') strongly deviates from the baseline forest composition, indicating a mismatch between the stated priorities of the forest owners and the actual forest management (Figure 4).

Out of all possible objective combinations, an optimization for reducing 'Management complexity' and 'Management costs' and achieving better 'Liquidity' (objective group 'Simplicity and cost-effectiveness') rendered a forest composition with the best fit to the observed one. Objectives used for 'Simplicity and cost-effectiveness' optimization are among the least relevant, as stated by the forest owners explicitly. Such an inconsistency between *stated* and *observed management objectives* could indicate a gap between what a forest owner 'wants' to and 'can' achieve.

A sensitivity analysis (i.e., screening of objective groups, selected for optimization models with uncertainty level) revealed an overwhelming importance of particularly one objective: 'Management complexity' is the only objective that persisted in all objective groups that generated forest compositions with the BC measure below 0.3. This finding could indicate that 'Management complexity' could be the gap between the stated 'want' and the observed 'can'.

- **Management for market and non-market FES is perceived complimentary**

SPFO attributed nearly equal relevance weights to the two management objective groups, traditionally viewed as conflicting (Josset et al., 2023; Juutinen et al., 2021; Petucco et al., 2015) – 'Market FES' ('Long-term income' and 'Meeting household needs'), and 'Non-market FES' ('Ecological functions of the forest'). This suggests not only a multi-objective approach to forest management among SPFO but also a rejection of strict dichotomy between the two objective groups (Figure 1). These conclusions are echoed in the similarity between forest compositions optimized for 'Market FES' and 'Non-market FES' objective groups (Figure 4).

As SPFO hold massive potential in securing the future of our forests and FES, both as owners of a significant share of the total forest area in Alpine Space and Europe overall, but also as multi-objective forest managers and holders of plural values. Moving away from the profit-maximization as a sole premise for forest policy and addressing rising management complexity could facilitate the activation of this potential.

***BMA rankings, and recommended models for each LL***

In the Austrian Living Lab, habitat maintenance and carbon storage were the ecosystem services considered:

***Habitat maintenance***

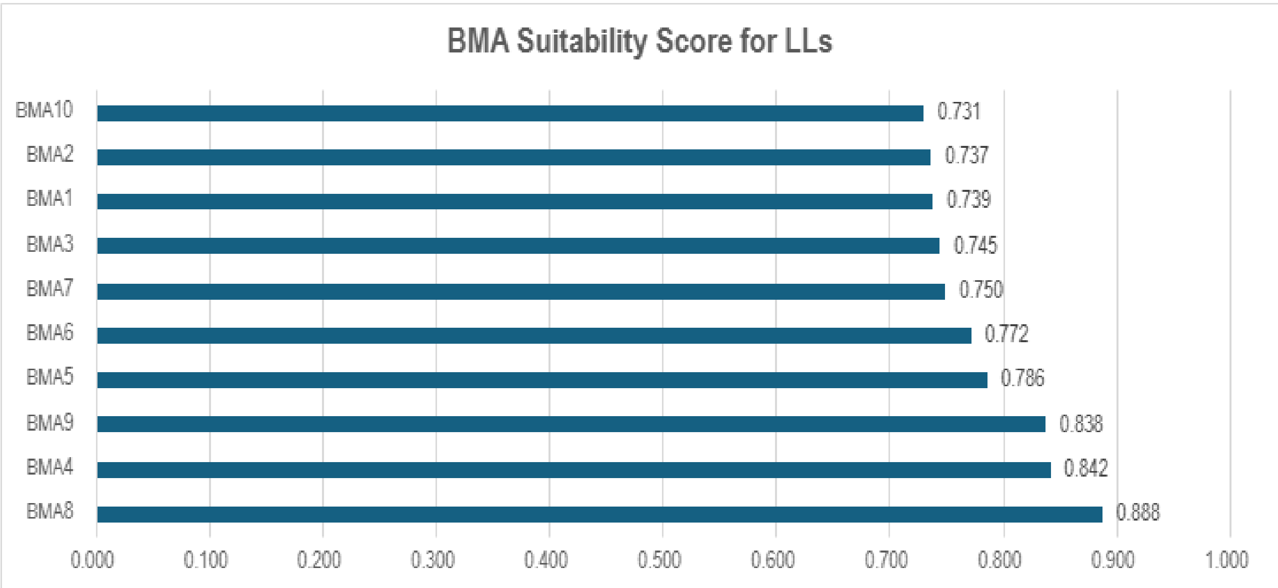


**Figure 5.** Suitability score for Austrian Living Lab – Habitat maintenance

The TOPSIS analysis identifies the Social Enterprise model (BMA8) as the most suitable business model for habitat maintenance in the Austrian Living Lab, achieving a similarity score of 0.888 and an Excellent Fit classification. This result indicates a strong overall alignment between the Living

Lab's capabilities and the strategic requirements of a socially oriented business model focused on long-term environmental stewardship (see Table X).

BMA8 is closely followed by Freemium (BMA4, 0.842) and Subscription (BMA9, 0.838), both also classified as *Excellent Fit*. The relatively small score differences among the top three models suggest a robust cluster of viable options, rather than a single dominant solution. Nonetheless, the ranking reveals a methodological preference for business models that emphasize collective engagement, stable participation mechanisms, and social value creation, all of which are particularly relevant for habitat maintenance services.

Freemium offers advantages in terms of broad stakeholder engagement, enabling open access to basic services while monetizing advanced features or participation tiers. This structure supports awareness-raising and community involvement in conservation activities. Subscription models, in turn, provide predictable revenue streams, which are well-suited to the recurrent and long-term nature of habitat maintenance interventions. Their proximity in the ranking confirms their strategic compatibility with the Austrian context, even if they are slightly less aligned than Social Enterprise.

**Table 1**. *Concept-level analysis for BMA8 (Social Enterprise)*

| Concept | Gap vs Ideal (%) | Strategic Status | Qualitative notes |
|---|---|---|---|
| Ecosystem services (C1) | 36% | Development Area | Positive contribution, but additional ecological capacity would improve performance. |
| Local demand (C2) | 0% | Strategic Alignment | Strong local interest and acceptance support implementation. |
| Regulations and policies (C3) | 23% | Development Area | Scope for improvement in regulatory integration or policy support. |
| Operational costs (C4) | 0% | Strategic Alignment | Cost structure is fully consistent with the BMA's requirements. |
| Governance and management (C5) | 31% | Development Area | Managerial capacity could be strengthened through partnerships or training. |
| Social benefits (C6) | 1% | Strategic Alignment | Excellent alignment with social value creation objectives. |
| Technological innovation (C7) | 0% | Strategic Alignment | Adequate technological support; not a limiting factor. |

From a quantitative perspective, the Table 1 highlights very strong performance for C2, C4, C6, and C7 (≈99–100%), confirming that Social Enterprise effectively capitalizes on the Living Lab's strengths. Moderate gaps in C1, C3, and C5 (23–36%) indicate targeted areas where additional investment could further enhance performance without undermining overall feasibility.

Overall, the prominence of Social Enterprise for habitat maintenance appears conceptually coherent. Habitat maintenance is inherently a collective, long-term, and public-interest-oriented service, where social legitimacy, stakeholder engagement, and reinvestment of value into environmental outcomes are central success factors. In this context, the convergence of Social Enterprise, Freemium, and Subscription at the top of the ranking reflects a consistent preference for community-oriented and participation-based business models, reinforcing the robustness and interpretability of the TOPSIS results for this service and Living Lab combination.

***Carbon storage***

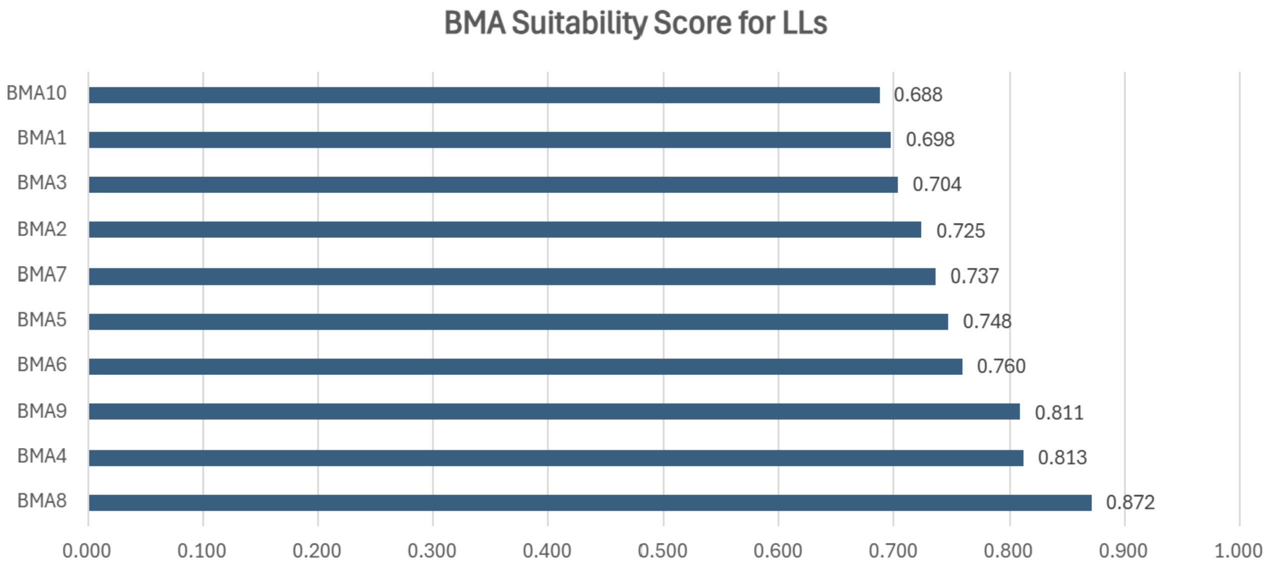


**Figure 6.** Suitability score for Austrian Living Lab – Carbon storage

The TOPSIS analysis identifies the Social Enterprise model (BMA8) as the most suitable business model for carbon storage in the Austrian Living Lab, with a similarity score of 0.872 and an Excellent Fit classification. This result indicates a strong alignment between the Living Lab's structural characteristics and the strategic logic of a socially oriented business model capable of supporting long-term ecosystem functions (See table X).

As in the habitat maintenance case, Freemium (BMA4, 0.813) and Subscription (BMA9, 0.811) rank second and third, both also classified as *Excellent Fit*. The repetition of the same top three BMAs and their close similarity scores point to a stable and consistent ranking pattern rather than a service-specific anomaly. Score differences remain limited, confirming that all three models represent credible and mutually compatible options for carbon-related ecosystem services in the Austrian context.

Freemium and Subscription again emerge as strong alternatives due to their ability to mobilize broad participation (Freemium) and ensure predictable, long-term revenue streams (Subscription), both of which are relevant for carbon storage initiatives that require sustained engagement and continuity over time. However, Social Enterprise retains a slight advantage due to its stronger alignment with collective benefit generation and reinvestment mechanisms.

**Table 2.** *Concept-level analysis for BMA8 (Social Enterprise)*

| Concept | Gap vs Ideal (%) | Strategic Status | Qualitative notes |
|---|---|---|---|
| Ecosystem services (C1) | 41% | Development Area | Additional ecological capacity would strengthen carbon-related outcomes. |
| Local demand (C2) | 0% | Strategic Alignment | Strong local acceptance supports participation in carbon initiatives. |
| Regulations and policies (C3) | 23% | Development Area | Regulatory integration could be further strengthened. |
| Operational costs (C4) | 0% | Strategic Alignment | Cost structure is fully compatible with the BMA's requirements. |
| Governance and management (C5) | 31% | Development Area | Governance capacity could benefit from targeted reinforcement. |
| Social benefits (C6) | 1% | Strategic Alignment | Strong social co-benefits align well with collective carbon strategies. |
| Technological innovation (C7) | 0% | Strategic Alignment | Adequate technological readiness; not a binding constraint. |

Quantitatively, table 2 confirms very high alignment for C2, C4, C6, and C7 (≈99–100%), while moderate gaps persist in C1, C3, and C5. This pattern closely mirrors the habitat maintenance case, reinforcing the consistency of the results.

The replication of the same ranking (BMA8, BMA4, BMA9) for both habitat maintenance and carbon storage can be explained by the structural similarity of these two services within the Austrian Living Lab. Both services are characterized by long-term ecological processes, strong public-good attributes, and limited short-term monetization opportunities. As a result, they activate very similar patterns of concept weights and Living Lab performance within the TOPSIS framework.

In particular, high performance in local demand, operational cost efficiency, and social benefits plays a decisive role in both services, while technological innovation remains non-discriminatory. Since these concepts carry significant weight in Social Enterprise, Freemium, and Subscription models, the method consistently favors these BMAs across both services. The identical ranking therefore reflects methodological robustness and contextual coherence, rather than a lack of sensitivity to service-specific differences.

Overall, this consistency suggests that, in the Austrian context, carbon storage and habitat maintenance are governed by comparable institutional, social, and economic conditions, making community-oriented and participation-based business models systematically preferable across multiple regulating ecosystem services.

### *BM Canvas analysis and simulation*

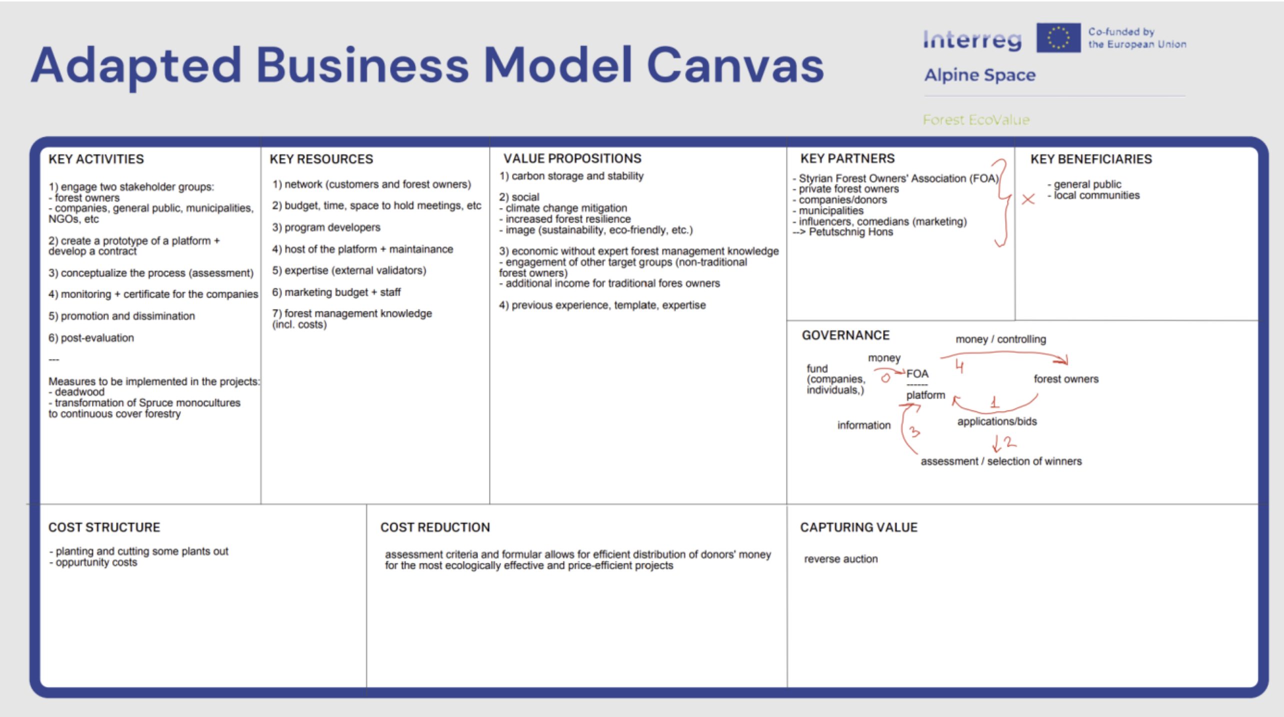


**Figure 1.** Business model canvas – Austrian LL

## A cooperative platform for improving forest health through reverse auctions

### *Introduction*

The Austrian Forest EcoValue model centers on a collaborative platform that connects forest owners with companies, donors, and the public to fund and implement ecological forest management projects. The platform uses a *reverse auction* mechanism to allocate funds from donor organisations efficiently to the most ecologically impactful and cost-effective projects, such as deadwood retention[7], and transformation of monocultures[8]. Forest owners receive payments for ecosystem services, including climate change mitigation through carbon storage[9], biodiversity enhancement, and climate resilience. The model is supported by the Styrian Forest

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[7] plsc.480.12_ecological_functions_and_management_of_dead_wood.pdf and The Role of Deadwood in Forests between Climate Change Mitigation, Biodiversity Conservation, and Bioenergy Production: A Comparative Analysis Using a Bottom–Up Approach

[8] Continuous cover forestry in Europe: usage and the knowledge gaps and challenges to wider adoption | Forestry: An International Journal of Forest Research | Oxford Academic

[9] Carbon stocks and sequestration in terrestrial and marine ecosystems: a lever for nature restoration? | Publications | European Environment Agency (EEA), Frontiers | Soil Organic Carbon Stocks in Mixed-Deciduous and Coniferous Forests in Austria)

Owners' Association, municipalities, and marketing partners, ensuring broad engagement and transparency.

Revenue streams include donor/company contributions for carbon and biodiversity outcomes, public grants, and potential small-scale recreational fees. The model emphasizes adaptive management, stakeholder engagement, and measurable ecological and social outcomes. Also, some specific indicators have been added to better evaluate the effectiveness and efficiency of the model.

*Description of the BM*

Austria's forests represent an untapped economic and ecological asset. The Forest EcoValue BM suggests using a platform to transform this potential into measurable value by connecting forest owners with corporations and donors seeking verifiable, cost-effective environmental impact. Through a digital marketplace, costs can be reduced and an action mainly focused on ecological stewardship is likely to achieve financial sustainability.

The core of the BM is a reverse auction mechanism, used to allocate funds from subscribers/donors to the most cost-effective projects, based on high environmental standards. Under this funding mechanism, donors or companies submit offers, and projects compete to provide the most cost-effective and ecologically impactful outcomes. The lowest qualifying bid wins, ensuring efficient allocation of resources to high-impact projects. This approach maximizes ecological benefits while optimizing costs for funders.

Projects to fund are screened and selected based on Key Ecological Variables that determine an ecological impact scoring. They include monitoring and verification protocols, long-term forest resilience metrics, biodiversity indicator species tracking. A special 5% Buffer Fund protects the projects against natural risks.

The BM adopts a tiered project system to ensure maximum impact and coherent revenue, that is organized as follows[10]:

- Tier 1 (€5,000): Basic carbon-focused projects
- Tier 2 (€6,000): Enhanced biodiversity measures
- Tier 3 (€7,500): Premium ecological + community benefits

The BM seeks economic viability that is in turn dependent on a selection of core financial drivers, depending on macroeconomic and institutional variables (e.g., $CO_2$ price) as well as on market demand (e.g., project growth), some of which are listed below:

[10] The tentative amounts reported derive from the baseline scenario described below.

- Carbon Price (scenario assumption): fixed at €30 / €25 / €19 per ton in Baseline/Moderate/Stress (no intra-scenario growth applied)
- Platform Commission: 10-12% on project funding
- Operating Costs: €90-100/ha/year, increasing with inflation

The business model is presented as a conceptual and illustrative framework, designed to explore how reverse-auction mechanisms could support forest ecosystem services under different institutional and market conditions.

*Evaluation procedure*

Based on standard parameters aligned to the Austrian context, and considering alternative background conditions, we examine the revenue streams generated through the inverse auction mechanism and the other suggested strategies, and the resulting costs, over a 5-year period.

We use a scenario analysis, across a baseline, moderate and stress test scenarios where we consider financial and ecological/social outcomes (yearly and cumulated values), testing low carbon prices (€28-35/ton) and high discount rates (4.5%) aiming to reveal the model's sensitivity and need for a "safe" price to be fully financially sustainable.

The key parameters used for the test, the sensitivity of the simulation results against them, their relevance for, and impact on the simulation are listed below and can be quantified under different scenarios[11].

| Parameter | Simulation Sensitivity | Relevance | Typical Stress Range |
|---|---|---|---|
| $CO_2$ Price | High | Drives revenue, project viability | €19–€60/ton |
| Biodiversity Payment | Moderate | Diversifies revenue | €8–€27/ha |
| Projects Funded/Year | High | Scales impact, risk | ±50% of base |
| Avg. Project Area | High | Scales all outcomes | ±50% of base |

[11] The parameters chosen and used for this simulation can be modified based on the specific informational aim of the analysis that is to be performed on this BM. Here we focused on three simple scenarios, as we explain below.

| | | | |
|---|---|---|---|
| Operating Cost | High | Directly affects profit | +20–30% |
| Discount Rate | High | Alters NPV, investment attractiveness | 3.8%–6.6% |
| Tier Distribution | Moderate | Changes funding mix, risk | Vary T1/T2/T3 by ±10% |
| *Buffer Fund* Rate | Low | Risk management | ±0.01 |
| Inflation Rate | Moderate | Cost/revenue escalation | 2%–4% |

To allow an immediate understanding of the core trends observed, we use two simple indicators, one focused on the financial performance of the BM, the other focused on the ecological performance of the BM:

- A *Revenue Diversification Index* to measure business resilience, based on the dependency of revenues from a balanced combination of funding sources.
- A basic *Weighted Biodiversity Index,* inspired to existing ones (e.g., Simpson's Index) for ecological impact (for Austrian forests see: Austrian Forest Biodiversity Index - BFW)[12]

### *Scenario analysis*

The model has been tested against three scenarios based on the parameters and assumptions reported in the table below. When the same value is repeated for all scenarios, the parameter is fixed. Scenario analysis highlights relative sensitivities and trade-offs across configurations, without implying feasibility or bankability of the model in real world conditions. All parameters used in the evaluation procedure are indicative and were defined to ensure internal consistency across scenarios rather than to replicate site-specific operating conditions.

| **Parameter** | **Baseline** | **Moderate** | **Stress Test** |
|---|---|---|---|
| $CO_2$ Price (€/ton) | 30 | 25 | 19 |
| Biodiversity payment | 20 | 12 | 8 |
| Managed area (ha/project) | 10 | 6 | 4 |
| SFM cost/ha | 90 | 110 | 125 |
| Discount rate (%) | 4.5 | 5 | 6.6 |
| Inflation rate (%) | 3 | 2 | 3.9 |

[12] In this version, the Biodiversity Index (Year 5) is held constant at 0.70 because the underlying index formula and inputs were not parameterized by scenario.

| | | | |
|---|---|---|---|
| Fee (€) (one-time per per-project administration/certification fee at project start, included in cash flows) | € 644.00 | € 644.00 | € 644.00 |
| Projects (5-year total) | 2 | 6 | 6 |

*Key Outcome Metrics – Austrian Forest EcoValue BM*

| Metric | Baseline | Moderate | Stress Test |
|---|---|---|---|
| NPV at 4.5% (€) | € 26,894 | € 51,100 | € 12,472 |
| IRR (%) | 21.70% | 33.10% | 21.40% |
| Payback Period (years) | 2.88 | 2.3 | 2.9 |
| Avg Annual Profit (€) | € 17,811 | € 25,179 | € 10,022 |
| Revenue Diversification Index | 0.62 | 0.53 | 0.62 |
| $CO_2$ Stored (cumulated, t) | 727 | 1,309 | 873 |
| Total Area Improved (ha) | 20 | 36 | 24 |
| Biodiversity Index (Year 5) | 0.7 | 0.7 | 0.7 |

**Baseline:** under this scenario, the BM demonstrates solid financial, social, and ecological performance, with a positive NPV and relatively rapid payback (less than 3 years). Revenue streams are well diversified (Index: 0.62), and ecological indicators such as carbon storage and biodiversity index are consistent: ca. 727 t $CO_2$ stored over 5 years and 20 ha of forest improved, with the Biodiversity Index held at 0.70 in this version. The platform and buffer fund mechanisms ensure resilience, and stakeholder benefits are realized across forest owners, companies, and the public.

**Moderate: t**his scenario delivers the strongest financial performance with NPV €51,100, IRR 33.1%, and the fastest payback (2.3 years), despite the lower $CO_2$ price and higher operating costs. The improvement scale is largest here (36 ha; ~1,309 t $CO_2$), reflecting more total projects over 5 years. Revenue diversification narrows (Index 0.53), so continued cost control and adaptive management remain important to protect resilience.

**Stress Test:** under challenging market conditions with the lowest carbon price and highest cost assumptions, the business model (BM) remains financially negative, despite the implementation of the buffer fund. However, it continues to deliver positive ecological outcomes.. Revenue diversification returns to 0.62, and the buffer fund, tiered pricing, and scalable platform help preserve positive outcomes, albeit with more modest financial returns. Low carbon price is the main driver.

*Final comments*

From an analytical perspective, the model illustrates how environmental finance mechanisms could be structured to support forest management, subject to strong institutional coordination and policy support. Across the three scenarios, the BM remains financially sound (positive NPV in all cases) and ecologically effective, with scenario outcomes primarily driven by project counts and managed area rather than price growth within the horizon. However, the BM sustainability critically depends on some external economic variables including:

- Carbon market stability
- Corporate ESG budget allocation
- Forest owner participation rates
- Operating cost control
- Chosen project schedule (number of projects over the 5-year horizon)

Concerning risk management, the BM seeks to manage risk through its "built-in resilience" that principally materializes in the mechanisms listed below.

- Revenue diversification: dependency upon multiple income streams (carbon, biodiversity, platform fees)
- Set up of a Buffer Fund: 5% allocation of payments for project risk mitigation
- Tiered Pricing: Premium services command 20% higher margins
- Scalable Platform: Low marginal costs for introducing and managing additional projects

These mechanisms are consistent with the positive NPV and IRR figures sustained in all scenarios.

The Investment Proposition embedded in this BM is based on the expectation that investment in this model will benefit different categories of actors, as listed below.

| **Stakeholders** | **Monetary benefits** | **Managerial benefits** | **Ecologic benefits** |
|---|---|---|---|
| *Forest Owners* | Additional income: €25-75/hectare/year | Risk reduction through "Buffer fund" | Access to ecological expertise |
| *Corporate Partners* | Tiered engagement options | Verified ESG impact: 730–1,310 t $CO_2$ (5-year cumulative, scenario-dependent) | Biodiversity gains |

| | | | |
|---|---|---|---|
| | | Transparent reporting with real-time dashboards | |
| *Policymakers (Environment / Public goods)* | Carbon pricing & Voluntary environmental markets experimented | Enhanced forest resilience | Biodiversity conservation<br><br>Climate change mitigation |

According to the simple simulation run, and against the questionable accuracy of the data used in this context, the Austrian FEV BM demonstrates that ecological responsibility and economic viability are not mutually exclusive. With conservative assumptions and robust risk management, the platform:

- Generates sustainable profits within 2.3-2.9 years
- Delivers measurable environmental impact from the beginning of its implementation
- Scales efficiently across Austria and beyond
- Creates multiple stakeholder value without compromise

The key to success of this BM lies in maintaining the delicate balance between carbon price sensitivity, project quality, and operational efficiency. This balance can be proven through rigorous simulation and scenario testing. In practice, the Moderate scenario demonstrates how a higher total project count can offset lower $CO_2$ prices and higher costs, producing the best overall financial performance. This BM shows how investing in nature can yield returns for investors, forest owners, and the society alike[13].

**Monte Carlo Simulation**

A Monte Carlo simulation was used to test the robustness of the Austrian business model under uncertainty, with the sole purpose of illustrating how financial and ecological outcomes respond to simultaneous variations in key parameters. We evaluated the Austrian platform model over a 5-year horizon using 20,000 trials. This approach tested the model's outcomes under thousands of plausible future scenarios, capturing real-world uncertainty in visitor growth, ticket pricing, carbon market conditions, contract values, and operational efficiency.

[13] The figures and findings presented in these simulations are based on illustrative parameters and generalised assumptions that do not necessarily correspond to the real-world conditions or data of the LLs. Accordingly, the results should be viewed as indicative and methodological in nature, providing a foundation for further, locally tailored analyses rather than serving as definitive or prescriptive outcomes. Users are advised to adapt the methods and validate the data in accordance with the specific characteristics and priorities of their local context before drawing any firm conclusions or making strategic decisions based on these simulations.

For each scenario (Baseline, Moderate and Stress Test), key financial indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and payback period were calculated alongside ecological metrics like total $CO_2$ sequestered.

Financially, the simulation indicates that, under the assumed parameter ranges, the model tends to generate a positive median outcome (P50) under Baseline and Moderate scenarios, with relatively short payback periods in most simulations and consistent ecological gains. Stress Test scenario highlights downside risk linked to low $CO_2$ prices and high operating costs with a 97% Monte Carlo probability of negative NPV: when project volume/area are at the low end of their ranges and costs/inflation are at the high end.

Top sensitivities: Carbon price > project count > operating cost.

These results are consistent with the Tornado sensitivity analysis, which identifies carbon price, project count, and operating costs as the primary drivers of financial performance. Input ranges were defined on a hypothetical and illustrative basis, consistently across scenarios, and do not represent calibrated probability distributions derived from observed data.

Ecologically, the platform consistently delivers substantial $CO_2$ storage over 5 years. Scaling project count and managed area have the strongest effect on ecological returns.

Given the carbon-heavy revenue mix, strategies that stabilize or improve $CO_2$ price (or hedge it), secure project pipeline, and control operating costs materially improve risk-adjusted performance.

Overall, the Monte Carlo simulation does not validate the business model's financial feasibility but provides insights into its relative robustness and key risk factors, highlighting areas of potential vulnerability, to be further assessed through site-specific data and stakeholder engagement. Scenario analysis suggests that while ecological benefits such as $CO_2$ sequestration scale directly with the area managed, robust financial sustainability is only achieved when the business model incorporates diversified and predictable revenue streams alongside strong efficiency measures. This approach highlights the necessity of adaptive management and strategic contract design, ensuring that decision-makers can effectively balance economic performance with ecological outcomes, even under uncertain market and environmental conditions. Sensitivity and leverage analyses confirm that auction remuneration levels and cost efficiency are the primary drivers of economic outcomes, with limited margin for error under adverse conditions.

## Grand Annecy, France

### *Tailored FES valuation*

The results of the adjusted unit value transfer for the French Living Lab in Grand Annecy are presented on Figure 1. According to conservative value estimates, regulating services associated with natural hazards risks mitigation have the highest value per ha of forest, followed by provision of habitats for wild plants and animals. Interestingly, unit value for protection against rockfall used locally (€409.44/ha) is almost twice lower than the adjusted Alpine average (€831.07/ha), indicating local underestimation. Carbon sequestration is among the least valued FES when accounted for its revenue potential on the voluntary carbon market (€58.83/ha); however, its upper-bound unit value (€304.11/ha) indicates higher priority of this FES for the broader society.

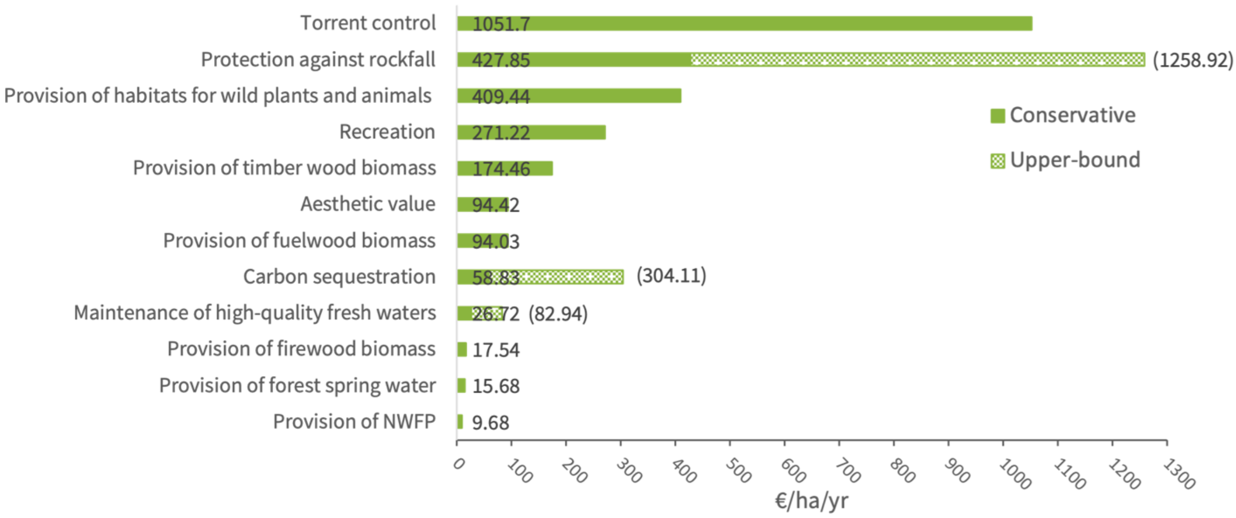


**Figure 1.** Unit value estimates in 2023 euros per ha. Upper-bound value estimates are provided in parenthesis. NWFP stands non-wood forest products, including chestnuts, mushrooms and berries.

Estimates of the total economic values (TEV) of forests in Grand Annecy, using both conservative and upper-bound unit value estimates, are demonstrated in Figure 1. Recreation brings the biggest contribution to the conservative TEV estimate, while protection against rockfall and carbon sequestration are the biggest contributors in the upper-bound TEV estimate. This indicates a relative balance between the social value of these FES and the forest areas providing them. Contrastingly, contribution of provision of habitats FES, although with a high unit value, is minor. This suggests that targeted efforts on expansion of the forest area providing this FES will have a substantial effect on the TEV of Grand Annecy forests.

It must be noted, that provided TEV estimates are a serious underestimation, as the number of FES included in the calculation was restricted to five. Nevertheless, according to the unit value results, discussed above (Figure 1), these five FES are among the most relevant for the Living Lab. Despite underestimation, value of timber provisioning service constitutes a relatively small share of the forest TEV, suggesting that the social importance of forests in Grand Annecy extends well beyond timber production. At the same time, we must keep in mind that the forest area providing provisioning services fully overlaps with the one providing carbon sequestration and partially with other FES, hinting at potentially detrimental losses in social value of forests if forest management is fully oriented at timber provision.

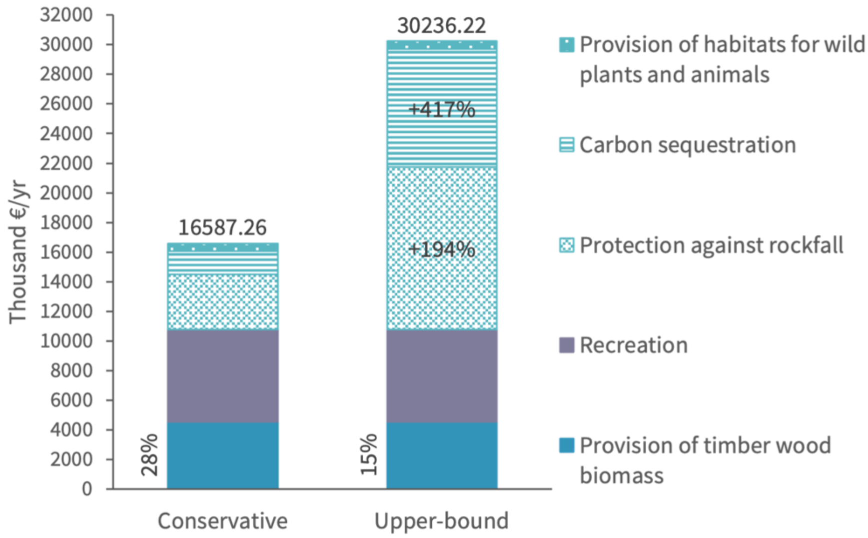


**Figure 2.** Conservative and upper-bound estimates for total economic value (TEV) of forests in Grand Annecy. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentages for protection against rockfall and carbon sequestration placed inside the bar indicate difference in total values of these FES between conservative and upper-bound TEVs. Numbers on the top of the bars indicate the TEVs.

Spatial distribution of FES social values in Grand Annecy further details our understanding about the FES provision in the Living Lab (Figure 2). Not all values are evenly distributed throughout the territory of the Living Lab. While most of the forest area provides below average value per ha, areas providing above average values per ha are concentrated around Annecy Lake as well as in the south and east of Grand Annecy. Highly valuable forest patches are very scarce and underrepresented. However, it must be acknowledged that the economic value mapping is influenced by the assumptions behind biophysical assessment (i.e., decision criteria on what forest area provides a certain FES and what forest area does not; for more detail on the assumptions of biophysical assessment see D2.2.1). Nevertheless, such economic value mapping can support future land use policies and steer the discussion on what areas must be protected (i.e., highly valued areas) and what areas demand special attention and changes in forest management (i.e., areas with lower value per ha). Supplementing this map with spatial distribution of forest ownership as well as residential and recreational areas could shed more light on the FES providers and main beneficiaries, thereby, providing further foundation for decisions about payments for FES (payment to whom?) and equal access to the benefits provided by forests.

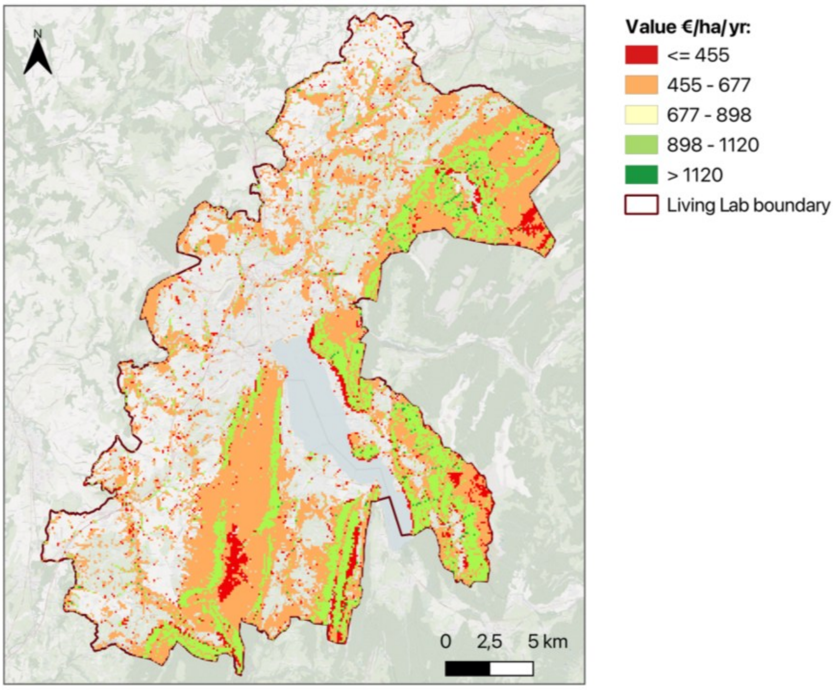


**Figure 3.** Spatial distribution of conservative unit values in Grand Annecy. Minor overdistribution (> 0.2%) is present for the unit value of protection against rockfall. Some degree of spatial under- and overdistribution is present for the unit value of carbon sequestration as unit value estimation is based on mean carbon sequestration per ha, not carbon sequestration specific to the forest unit.

### *BMA rankings, and recommended models for each LL*

For the French Living Lab we focused solely on Grand Annecy, and the ecosystem service considered was recreational services:

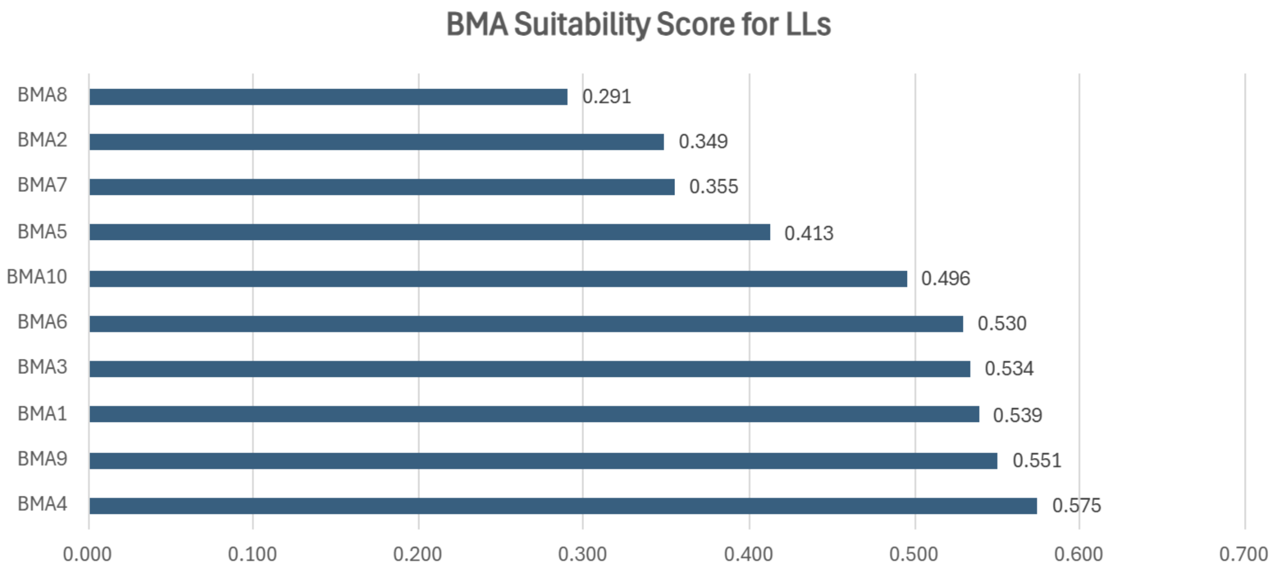


***Figure 4****. Suitability score for French Living Lab – Recreational services*

The TOPSIS analysis indicates that the Freemium (BMA4) business model is the most suitable option for the recreational service in the Grand Annecy Living Lab, with an overall score of 0.575 and a classification of Viable with Effort. This suggests a moderate alignment between the Living Lab's characteristics and the strategic requirements of this BMA, indicating that successful implementation will require targeted efforts to address key gaps.

BMA4 is closely followed by Subscription (BMA9, 0.551) and Crowdfunding (BMA1, 0.539), which are also classified as Viable with Effort. The similarity of these scores reflects that all three models are potentially feasible, but none fully leverages the Living Lab's strengths. Freemium can engage a broad range of users through free access with optional premium features, while Subscription provides predictable revenue streams, and Crowdfunding enables community-driven projects. All three models offer ways to support recreational services, but careful attention will be needed to strengthen operational and governance capacities.

**Table 1**. *Concept-level analysis for BMA4 (Freemium)*

| Concept | Gap vs Ideal (%) | Strategic Status | Qualitative Notes |
|---|---|---|---|
| Ecosystem Services (C1) | 32% | Development Area | Local capacities should be enhanced to reach ideal contributions. |
| Local Demand (C2) | 14% | Strategic Alignment | Demand is reasonably met; a relative strength. |
| Regulations/Policies (C3) | 18% | Strategic Alignment | Policy framework is supportive; minor improvements possible. |
| Operational Costs (C4) | 100% | Critical Vulnerability | Current efficiency is insufficient; major investment is needed. |
| Governance/Management (C5) | 87% | Critical Vulnerability | Governance mechanisms are weak; targeted capacity building required. |
| Social Benefits (C6) | 45% | Development Area | Opportunities exist to enhance community and social impact. |
| Technological Innovation (C7) | 0% | Strategic Alignment | Adequate integration; no immediate intervention required. |

From a quantitative perspective, Table 1 highlights that the model performs relatively well for local demand, regulations, and technological innovation (C2, C3, C7 ≥ 82%), while operational costs, governance, and ecosystem services show critical gaps (C4, C5, C1), indicating priority areas for improvement.

In conclusion, Freemium (BMA4) offers a feasible approach for supporting recreational services in Grand Annecy, but achieving full effectiveness will require focused efforts to strengthen governance, operational efficiency, and local impact. Subscription and Crowdfunding are closely ranked alternatives, providing options for stable revenue generation and community engagement. Together, the top three BMAs indicate that the Living Lab could implement recreational services through models that encourage participation and sustainability, provided that strategic investments are made in the identified areas of development.

### *BM Canva analysis and simulation*

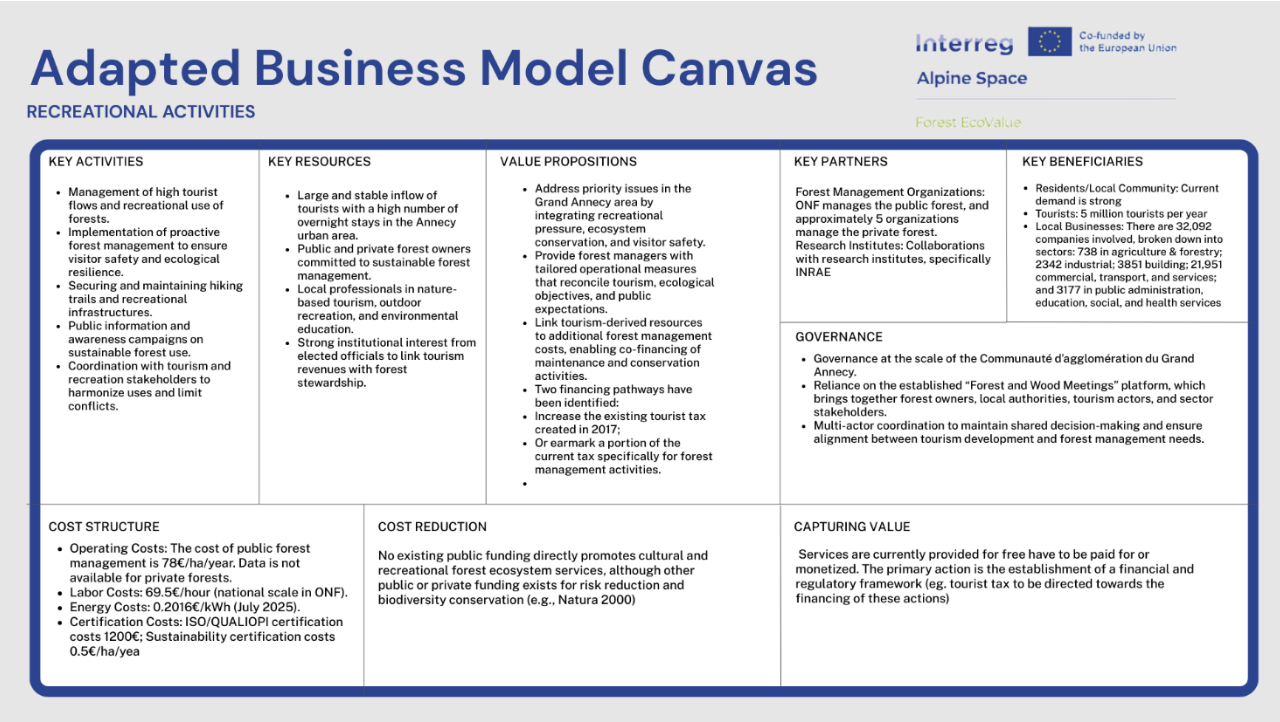


***Figure 1.*** *Business Model Canvas – French Living Lab*

## Visiting the forest and beyond: a multi-layer approach to recreation in forests

### *Introduction*

The French Forest EcoValue Business Model reimagines the forest as a living asset that simultaneously delivers recreation, climate resilience, and biodiversity gains while producing stable, diversified revenues. In the Grand Annecy Living Lab, this requires adapting forest management to a very high intensity of recreational use, characterised by dense trail networks, safety requirements on steep and sensitive terrain, and increasing pressure from year round tourism. From a startup phase where the model's viability rests on public grants, the model gradually moves to a market anchored sustainability based on eco tourism revenues, a share of municipal tourist tax revenues, carbon and biodiversity credits, and strategic multi annual partnerships with public authorities and private companies. At the same time, it safeguards the forest's long-term vitality and ability to provide valuable ecosystem services.

The model sets a scale objective to capture operating economies and stronger ecosystem service yields, and it embeds a cost discipline program (shared infrastructure, volunteers, digital tools) to offset inflation. EU grants are treated as a time bound short term support, and replaced by tourism tax sharing, premium experiences, and utility contracts after an initial phase. A reserve rule builds buffers in profitable years, while adaptive pricing and scenario planning protect against demand and market volatility. In Grand Annecy, these measures are complemented by public awareness and communication efforts, and by the coordination of forest owners, municipalities, and tourism actors to ensure that recreational use remains compatible with ecological objectives and visitor safety.

*Description*

The economic model underpinning this initiative is intentionally diversified, aiming to reduce dependency on any single revenue source, and prioritising contractual stability. Costs are tightly managed and scaled. The model relies on the overarching assumption that sustainable forest management can ensure multifunctional benefits: recreation, climate resilience, and biodiversity. In Grand Annecy, this assumption translates into operational necessities, such as maintaining and securing trails, managing visitor flows, and adapting silvicultural practices to high recreational pressure.

Value is created for visitors (immersive, tiered eco-experiences), companies (verified ESG via carbon and biodiversity credits), communities (jobs, education, inclusion), and policymakers (progress toward climate and biodiversity targets). The revenue architecture of this model is based on five different components including:

1. eco-tourism experiences (guided walks, educational programs) suitable to attract visitors and generate revenue directly with tiered pricing and membership lifting average yield per visitor,
2. municipal tourist tax share collected via agreements with local governments, with the option—explored during stakeholder consultations—to earmark part of the tax for forest management,
3. contracted ecosystem services starting from a Water Utility Fee for watershed benefits paid by local water utilities,
4. carbon & biodiversity credits, priced conservatively and optionally sold fraction < 100% to reflect market constraints,
5. public support limited to EU grants (yrs 1–6) and capped, declining subsidies to be substituted mainly by sources 2) and 3) in this list.

The costs represent a major issue that needs to be carefully managed and regularly controlled. The major drivers are labor costs, area-linked operations, and modest fixed overheads (energy, certification, marketing costs). A gradual gain in efficiency is obtained through a focused program aiming at achieving 10% improvements through shared assets, digitalization and volunteers, and at amortizing set-up capital expenditure over 10 years. In the Grand Annecy context, additional cost pressures arise from trail maintenance, signage, and visitor-safety interventions, especially in steep or erosion-prone forest areas.

Stakeholder relationships are managed through contracts and clear governance rules, particularly using multi-year agreements with municipalities on tourism tax share, and utilities concerning payments for FES. These arrangements are supported by existing coordination frameworks such as the "Rencontres Forêt-Bois", which bring together forest owners, environmental groups, tourism actors, and municipal representatives to align priorities. Transparency, certification and monitoring, free access to market, and use of tiered pricing for inclusion are essential to cope with national and EU legal frameworks.

Risk management is addressed by adopting a reserve accumulation fund as a revenue share, adaptive pricing and stress testing against visitor growth, premium uptake, carbon price, credit sales fraction, etc. This aims at reducing exposure to grant expiry and credit market volatility. Since the model is strongly dependent on the managed surface and on a sufficiently large number of visitors, priority is given to scaling-up solutions and premium pricing especially if guaranteed by long-term contracts. However, this business model should be interpreted as an exploratory configuration, illustrating a possible combination of revenue streams rather than a validated operational solution.

*Evaluation procedure*

Based on standard parameters tailored to the French context and incorporating alternative background conditions, we assess the cost structure and financial sustainability of the EcoForest ecotourism business model over a 20-year period.

| Parameter | Baseline (contracts + efficiency) | Moderate (viability target: stronger contracts + premium + higher carbon) | Stress Test (cost control + grants yrs 1–6 + utility fee) |
|---|---|---|---|
| Managed area (ha) | 300 | 200 | 400 |
| Eco-tourism visitors (yr, Y1) | 850 | 700 | 1,000 |
| Visitor fee (€ , Y1) | 14.5 | 12 | 17 |
| Carbon price (€/t , Y1) | 26 | 30 | 30 |
| Biodiversity payment (€/ha/yr) | 16.5 | 13 | 20 |
| $CO_2$ sequestration (t/ha/yr) | 7 | 6 | 8 |
| SFM Operating cost (€/ha/yr, Y1) | 90 | 80 | 100 |
| Labour cost (€/hour, Y1) | 16.5 | 12 | 21 |
| Energy cost (€/yr, Y1) | 2,050 | 1,800 | 2,300 |
| Certification cost (€/yr, Y1) | 1,450 | 900 | 2,000 |

| | | | |
|---|---|---|---|
| Marketing/Admin (€/yr, Y1) | 3,800 | 2,600 | 5,000 |
| Investment setup (€) | 26,500 | 23,000 | 30,000 |
| Tourism tax (€/yr, Y1) | 48,000 | 60,000 | — |
| Premium experiences (€/yr, Y1) | 60,000 | 120,000 | — |
| Water utility fee (€/yr, Y1) | 15,000 | 25,000 | 20,000 |
| Efficiency factor (opex, labor, overheads) | –10% | –10% | –10% |
| EU grant (yrs 1–6) | — | — | €66,667/yr (Y1–Y6 only) |
| Financial discount rate | 4% | 3% | 5% |
| Social discount rate | 2.20% | 1.60% | 2.80% |
| Escalation (annual) | +1%/yr costs; +2%/yr carbon; +2%/yr visitors; +1%/yr ticket fee | +1%/yr costs; +2%/yr carbon; +2%/yr visitors; +1%/yr ticket fee | +1%/yr costs; +2%/yr carbon; +2%/yr visitors; +1%/yr ticket fee |

The evaluation employs scenario analysis, comparing three innovation-enabled scenarios: Baseline (contracts + efficiency), Moderate (viability target: stronger contracts + premium + higher carbon), and Stress Test (cost control + grants yrs 1–6 + utility fee). The evaluation focuses on internal coherence of the model logic under alternative assumptions, not on forecasting future performance.

Key parameters varied include carbon price (€22–30/ton), biodiversity payments (€13–20/ha), discount rates (3–5%), and the introduction of contracted revenues (tourism tax, premium experiences, water utility fee), cost discipline (–10% on opex/labour/overheads), and a grant window (years 1–6 only). For modelling, labour volume is set at ~42 h/ha/yr (Baseline), ~37.5 h/ha/yr (Moderate), and ~43.9 h/ha/yr (Stress), consistent with scenario NPVs.

Contract revenues (tourism tax, utility fees, premium experiences) are held constant in nominal terms unless otherwise specified.

The model simulates the impact of these variables on annual and cumulative costs, distinguishing between major categories: labor (the dominant expense), area-linked operating costs, and fixed overheads (energy, certification, marketing/admin). Investment settings are allocated over the first ten years, with an additional upfront outlay before operations commence. For financial metrics, setup investment is treated as an upfront cash outflow at Y0; any allocation over ten years is accounting-only.

Scenarios are evaluated for a single project; managed area refers to the project's total surface. A 20-year horizon is chosen to reflect long-term ecological and financial sustainability. The scenario framework allows for sensitivity testing of cost escalation, project scale, participation rates, and the effect of diversified, contracted revenues, aiming to reveal the model's exposure to financial and operational risks. This approach supports robust evaluation of the business model's resilience and highlights the importance of cost structure, revenue diversification, and parameter selection in achieving long-term ecological and financial objectives.

### *Scenario analysis*

The model has been tested under a set of innovation-enabled assumptions:

- Contracted revenues (tourism tax, premium experiences, water utility fee) are included in Baseline and Moderate scenarios.
- A −10% efficiency factor is applied to operating, labour, and overhead costs in all scenarios.
- The Stress Test scenario includes an EU grant for years 1–6 only, with automatic phase-out.
- Carbon price uplift (to €30/t) is applied in Moderate and Stress Test scenarios.
- All scenarios use +2%/yr visitor growth, +1%/yr fee growth, and +1%/yr cost escalation.

The considered scenarios include:

- **Baseline scenario** (contracts + efficiency): 300 ha managed, moderate contracts and efficiency.
- **Moderate scenario** (viability target: stronger contracts + premium + higher carbon): 200 ha, strong contracts and premium pricing, higher carbon price, and efficiency.
- **Stress Test scenario** (cost control + grants yrs 1–6 + utility fee): 400 ha, high costs, grants for first 6 years, and utility fee.

The following results and values for financial and non-financial indicators have been found for the scenarios presented above[14].

| Scenario | NPV (€) | IRR | Payback (yrs) | Cumulative Profit € | Total $CO_2$ (t) | Tourism % of Rev | Contracts & Ancillary % | Credits ($CO_2$+Biodiv) % |
|---|---|---|---|---|---|---|---|---|
| **Baseline** | −340,504 | n/a | — | −551,180 | 42,000 | 7.90% | 58.30% | 33.80% |
| **Moderate** | 2,235,847 | 660% | 1 | 3,047,412 | 24,000 | 4.30% | 78.10% | 17.60% |
| **Stress** | −2,961,785 | n/a | — | −4,528,351 | 64,000 | 12.20% | 21.30% | 66.50% |

*Costs escalated by 2–4% annually; efficiency factor −10% applied to opex and overheads. Discount rate: Baseline scenario 4%; Moderate scenario 3%; Stress Test scenario 5%. IRR shown as annual percentage.*

**Baseline scenario (contracts + efficiency)** represents a medium-scale operation (300 ha) with moderate contracts (tourism tax, premium experiences, utility fee) and a −10% efficiency program

[14] Tourism % includes eco-tourism ticket revenue only. Premium experiences are included in Contracts & Ancillary.

applied to costs. Tourism revenue remains too thin at this scale. Labor intensity continues to be the dominant cost, and despite stable annual flows, the financial NPV and cumulative profit remain negative and payback is not reached. This highlights the need for stronger premium or contracted revenues to achieve sustainability.

**Moderate scenario (viability target: stronger contracts + premium + higher carbon),** with a reduced area (200 ha), lower labor rates, and smaller overheads, leverages robust contracts (higher tourism tax, premium experiences, utility fee) and a higher carbon price (€30/t), alongside cost discipline. The result is a financially viable but stylized configuration, useful for understanding leverage points rather than as a recommended implementation pathway. There, volatility is reduced, payback is rapid (Year 1), and NPV is positive (€2.24m). The heavy share of contracted and ancillary revenues (≈78%) makes this suitable for conservative, risk-averse management, prioritizing cost control and resilience.

**Stress Test scenario (cost control + grants yrs 1–6 + utility fee)** increases scale (400 ha), labor rates, and overheads, and includes grants for the first six years and a utility fee contract. Despite cost control and temporary grant support, high area and costs outweigh the benefits, and cumulative profit and NPV remain negative. $CO_2$ sequestration is highest, supporting ecological goals, but financial sustainability depends on securing larger premium or contracted revenues and careful management of costs and risk factors.

### Final comments

The EcoForest ecotourism business model demonstrates that ecological stewardship and economic viability can be aligned, but its long-term sustainability depends on several external and internal factors, including:

- Stability of carbon and biodiversity credit markets
- Consistent demand for eco-tourism and premium experiences
- Strength of partnerships with municipalities, utilities, and local communities
- Ongoing cost control and operational efficiency

For risk management, the model builds "built-in resilience" through the following mechanisms:

- Revenue diversification (tourism, premium experiences, ecosystem service contracts, carbon and biodiversity credits)
- Efficiency program (–10% on operating, labor, and overhead costs)
- Tiered pricing and premium offers to capture higher willingness-to-pay
- Multi-year agreements with public and private partners (e.g., tourism tax sharing, water utility fees)
- Transparent certification, monitoring, and adaptive scenario planning

The investment proposition is designed to benefit a broad set of stakeholders:

| Stakeholder | Monetary Benefits | Managerial Benefits | Ecological Benefits |
|---|---|---|---|
| Forest Owners | Diversified, stable revenue | Reduced risk via contracts/efficiency | Access to ecological expertise |
| Municipalities | Local economic development | Predictable public service funding | Biodiversity, climate resilience |
| Utilities/Companies | ESG credits, service contracts | Long-term cost predictability | Verified ecosystem service delivery |
| Local Communities | Jobs, cultural engagement | Social inclusion, education | Enhanced local environment |
| Visitors/Public | Quality, immersive experiences | Transparent ecological impact | Measurable climate/biodiversity gains |

According to the scenario analysis, the EcoForest model can achieve financial sustainability and rapid payback (as in the Moderate scenario) when robust contracted revenues, premium offers, and cost discipline are in place. It delivers measurable environmental impact from the outset, creates multi-stakeholder value, and maintains resilience through diversified income streams and adaptive management. However, its success depends on maintaining a careful balance between market variables, quality, and operational efficiency, as confirmed by scenario testing.

While diversification and innovation strengthen the EcoForest model's resilience, scenario analysis confirms that dependency on public support is not fully eliminated. Built-in resilience requires not only diversified revenues, but also financial reserves during profitable years, a flexible/adaptive cost structure, and robust contingency planning for shocks. Long-term viability will depend on policy continuity, market stability, and the ability to adapt to changing external conditions.

Overall, the EcoForest ecotourism model serves as a methodological example of how recreational ecosystem services could be framed within diversified revenue structures, subject to local governance and contractual feasibility. With conservative assumptions and robust risk management, it can generate sustainable profits, deliver ecological value, and create lasting benefits for all stakeholders, provided that premium and contracted revenues are prioritized and cost controls are rigorously applied[15].

[15] The figures and findings presented in these simulations are based on illustrative parameters and generalised assumptions that do not necessarily correspond to the real-world conditions or data of the LLs. Accordingly, the results should be viewed as indicative and methodological in nature, providing a foundation for further, locally tailored analyses rather than serving as definitive or prescriptive outcomes. Users are advised to adapt the methods and validate the data in accordance with the specific characteristics and priorities of their local context before drawing any firm conclusions or making strategic decisions based on these simulations.

**Monte Carlo Simulation**

We evaluated the financial and ecological reliability of the EcoForest ecotourism business model using a Monte Carlo simulation (20,000 trials) over a 20-year horizon. This approach tested the model's outcomes under thousands of plausible future scenarios, capturing real-world uncertainty in visitor growth, ticket pricing, carbon market conditions, contract values, and operational efficiency. The Monte Carlo simulation was performed to explore the sensitivity of the EcoForest model to uncertainty in demand, cost structure, and contracted revenues, and not to assess its financial viability as an operational project.

For each scenario (Baseline, Moderate and Stress Test), key financial indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and payback period were calculated alongside ecological metrics like total $CO_2$ sequestered.

Within the assumed parameter space, results reveal a stark contrast: while the Baseline and Stress Test configurations consistently failed to achieve positive NPV or rapid payback under uncertainty the Moderate scenario shows the strongest performance, with positive median outcomes under Monte Carlo simulation; deterministic scenario results (NPV €1.68m, payback 1 year) illustrate the upside potential under favourable contracted-revenue conditions. This reliability is driven by strong contracted revenues, premium offers, and disciplined cost management. Stress Test shows significant downside risk despite high $CO_2$ sequestration.

The Monte Carlo simulation confirms that the Moderate scenario is highly robust, with a very low probability of negative NPV and payback occurring within the first years in the large majority of simulations. Baseline shows limited resilience, with median NPV remaining negative under Monte Carlo simulation and non-negligible downside risk, while Stress Test is consistently negative despite strong ecological performance.

Top sensitivities: managed area > labour intensity > carbon price.

Scale and labor intensity dominate risk: managed area and labor hours together with inflation, and discount rate are the strongest (absolute) drivers of NPV, closely followed by premium experiences and tourism tax; higher sequestration correlates negatively with NPV in this scenario mix because it coincides with the high-cost Stress Test configuration. Robustness improves when contracted revenues (premium, tax, utility) are strong and labor intensity is contained; immediate payback regimes yield very high IRRs. Conversely, large area with high labor and limited contracts pushes NPVs negative despite strong ecological performance ($CO_2$).

Scenario analysis highlights that, although environmental benefits ($CO_2$ sequestration) scale with area, financial sustainability is only achieved when diversified, predictable revenues and efficiency measures are embedded in the model. These findings underscore the importance of strategic contract design (multi-year contracts) and adaptive pricing, offering actionable insights for decision-makers seeking to balance economic performance with ecological impact in the face of uncertainty.[16]

[16] All Monte Carlo simulations in this document were conducted by varying key input parameters within defined ranges and distributions, as specified in scenario tables. Each simulation involved multiple trials per scenario (e.g., Baseline, Moderate, Stress Test), with annual escalation rules and cash-flow calculations applied consistently. Outputs such as NPV, IRR, payback period, and cumulative ecological indicators were computed for each trial, ensuring that results reflect the combined effects of parameter uncertainty and scenario assumptions.

## Thonon Agglomeration, France

### *Tailored FES valuation*

The results of the adjusted unit value transfer for the French Living Lab in Thonon Agglomeration are presented on Figure 1. According to conservative value estimates, regulating services associated with natural hazards risks mitigation have the highest value per ha of forest, followed by provision of habitats for wild plants and animals. Interestingly, unit value for protection against rockfall used locally (€409.44/ha) is almost twice lower than the adjusted Alpine average (€831.07/ha), indicating local underestimation. Carbon sequestration is among the least valued FES when accounted for its revenue potential on the voluntary carbon market (€42.90/ha); however, its upper-bound unit value (€221.73/ha) indicates higher priority of this FES for the broader society, exceeding the value of timber wood biomass provisioning service.

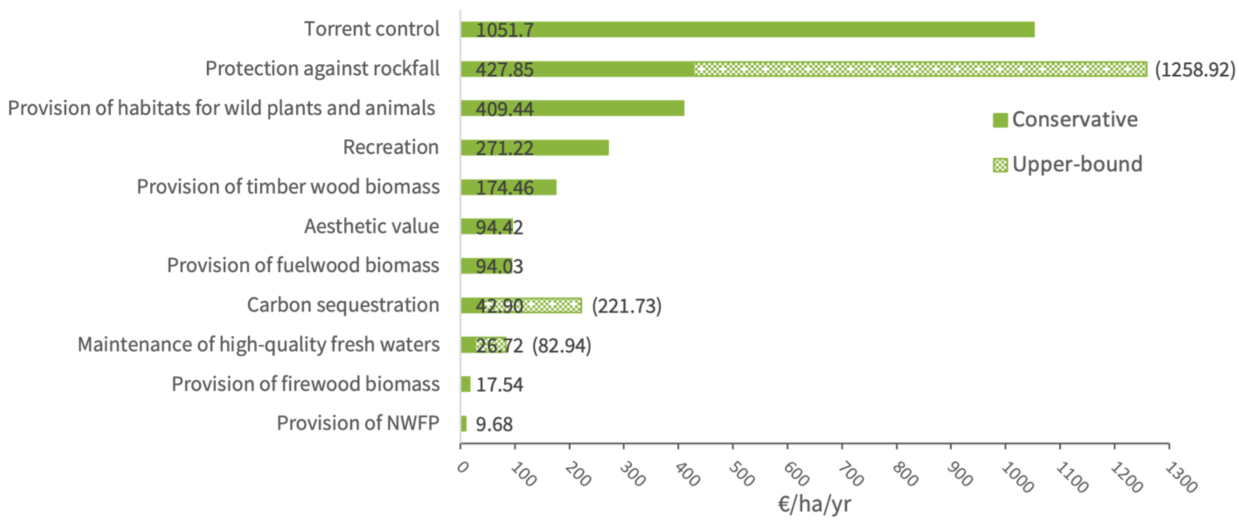


**Figure 1.** Unit value estimates in 2023 euros per ha. Upper-bound value estimates are provided in parenthesis. NWFP stands non-wood forest products, including chestnuts, mushrooms and berries.

Estimates of the total economic values (TEV) of forests in Thonon, using both conservative and upper-bound unit value estimates, are demonstrated in Figure 1. Recreation brings the biggest contribution to the TEV in both cases. Carbon sequestration service is the smallest contributor to TEV when valued according to the voluntary carbon market pricing (i.e., conservative estimation). Contribution of this FES increases dramatically, almost equaling to that of recreation, once the estimates are aligned with the carbon pricing (upper-bound) recommended for effective climate change mitigation. Contribution of provision of habitats FES, although with a high unit value, is minor. This suggests that targeted efforts on expansion of the forest area providing this FES will have a substantial effect on the TEV of Thonon forests.

It must be noted, that provided TEV estimates are a serious underestimation, as the number of FES included in the calculation was restricted to four. Nevertheless, according to the unit value results, discussed above (Figure 1), these four FES are among the most relevant for the Living Lab.

Despite underestimation, value of timber provisioning service constitutes a relatively small share of the forest TEV, suggesting that the social importance of forests in Thonon extends well beyond timber production. At the same time, we must keep in mind that the forest area providing provisioning services fully overlaps with the one providing carbon sequestration and partially with other FES, hinting at potentially detrimental losses in social value of forests if forest management is fully oriented at timber provision.

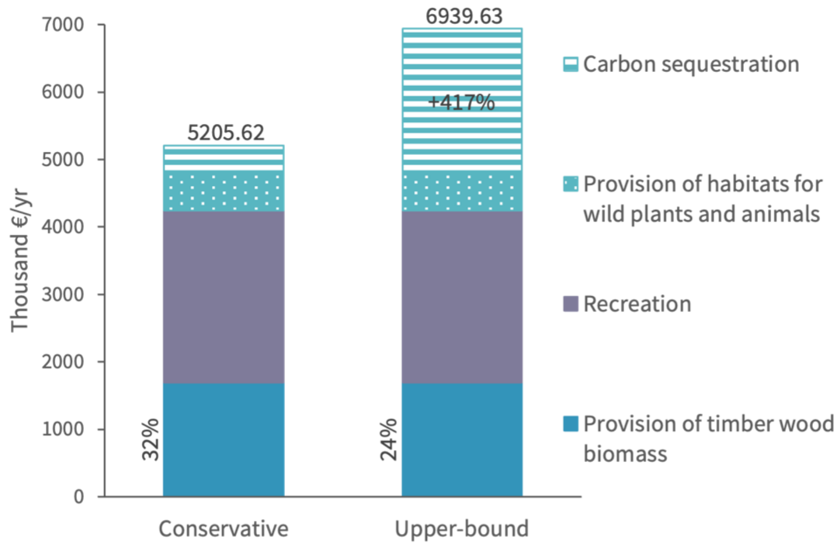


**Figure 2.** Conservative and upper-bound estimates for total economic value (TEV) of forests in Thonon Agglomeration. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentage for carbon sequestration placed inside the bar indicates difference in total values of this FES between conservative and upper-bound TEVs. Numbers on the top of the bars indicate the TEVs.

Spatial distribution of FES social values in Thonon further details our understanding about the FES provision in the Living Lab (Figure 2). Not all values are evenly distributed throughout the territory of the Living Lab. While most of the forest area provides slightly below average value per ha, areas providing above average and high values per ha are very scarce and underrepresented. Such areas are present around Ripaille Forest (Forêt de Ripaille), in the southern tip of Agglomeration where residents and visitors can access Thonon Forest, and in a few residential areas. However, it must be acknowledged that the economic value mapping is influenced by the assumptions behind biophysical assessment (i.e., decision criteria on what forest area provides a certain FES and what forest area does not; for more detail on the assumptions of biophysical assessment see D2.2.1). Nevertheless, such economic value mapping can support future land use policies and steer the discussion on what areas must be protected (i.e., highly valued areas) and what areas demand special attention and changes in forest management (i.e., areas with lower value per ha). Supplementing this map with spatial distribution of forest ownership as well as residential and recreational areas could shed more light on the FES providers and main beneficiaries, thereby, providing further foundation for decisions about payments for FES (payment to whom?) and equal access to the benefits provided by forests.

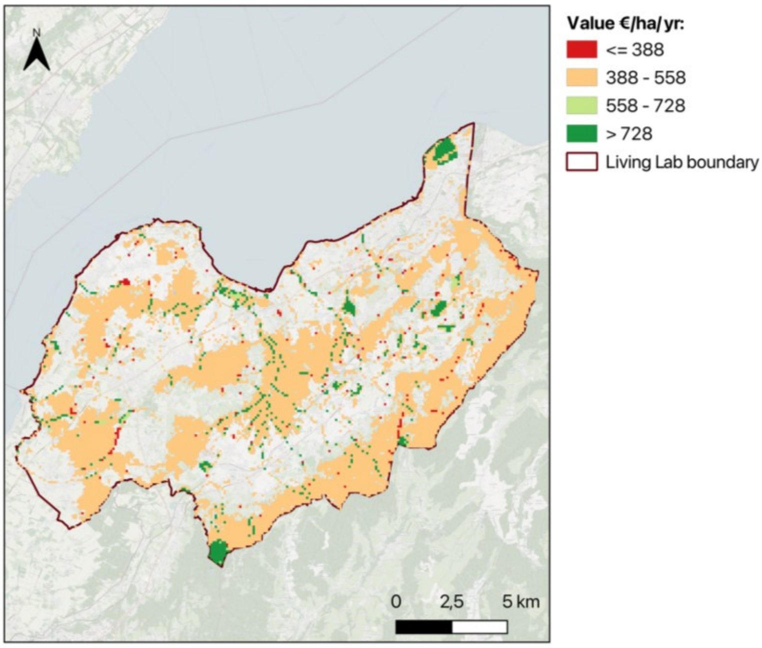


**Figure 3.** Spatial distribution of conservative unit values in Thonon. Some degree of spatial under- and overdistribution is present for the unit value of carbon sequestration as unit value estimation is based on mean carbon sequestration per ha, not carbon sequestration specific to the forest unit.

## Endlhausen and Waahkirchen, Germany

### *Tailored FES valuation*

The results of the adjusted unit value transfer for the German Living Labs in Endlhausen and Waahkirchen are presented on Figure 1. As the valuation was done using the same set of aggregated data, the unit values for the two Living Labs are the same, contrary to the estimation of the total economic value as will be described further. For the adjusted unit value transfer, only values obtained through adjusted value transfer method (Alpine average) and voluntary carbon market pricing for carbon sequestration are reported as conservative estimates. Upper-bound estimates include direct market valuation for timber and firewood biomass provision, a unique adjusted value transfer for provision of habitats from a single primary study conducted in Germany on the national scale, and recommended carbon pricing (upper-bound) for carbon sequestration.

According to conservative value estimates, regulating services associated with natural hazards risks mitigation have the highest value per ha of forest, followed by provision of habitats for wild plants and animals with, however, a significant difference in values. An upper-bound value for the latter service derived from a German nation-wide primary study mitigates this difference, making provision of habitats second most valued per ha FES in the LL. Same dynamics is observed for timber wood biomass provision, as its value per ha increases almost threefold when local market price estimates are used for valuation, indicating an underestimation of the Alpine average. Finally, carbon sequestration according to the revenue potential on the voluntary carbon market is valued almost as much as timber wood biomass (using the Alpine average). However, the value of this FES increases by five times when recommended carbon pricing is applied. This indicates higher priority of carbon sequestration for the broader society, making it fourth most valued FES in the LL after other three regulating services.

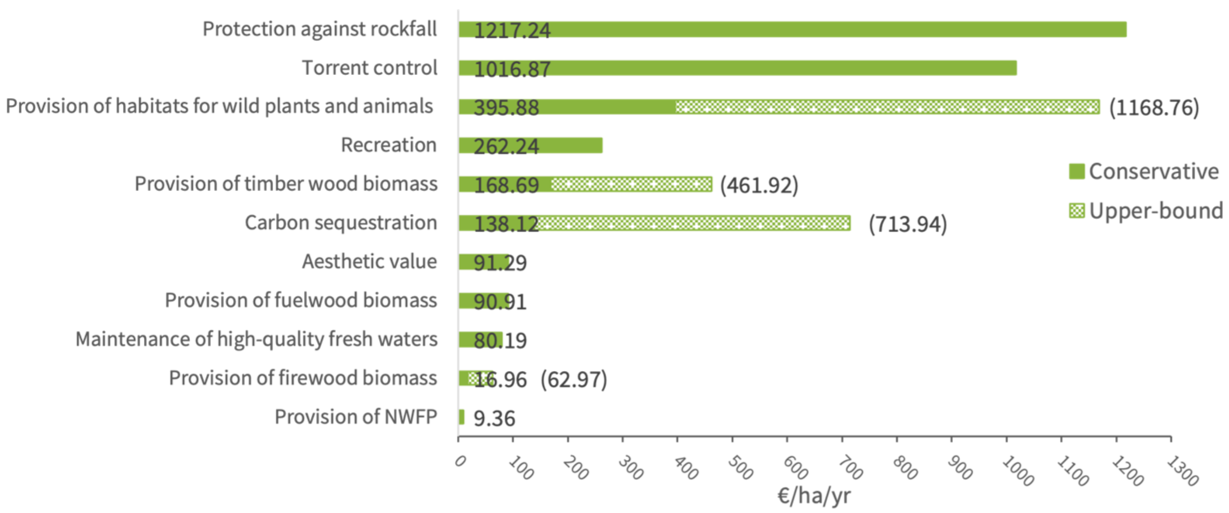


**Figure 1.** Unit value estimates in 2023 euros per ha for Endlhausen and Waahkirchen Living Labs. Upper-bound value estimates are provided in parenthesis. NWFP stands non-wood forest products, including chestnuts, mushrooms and berries.

Estimates of the total economic values (TEV) of forests in Endlhausen Living Lab, using both conservative and upper-bound unit value estimates, are demonstrated in Figure 2 . According to the conservative estimates, three out of four FES contributes to TEV almost equally, with timber wood biomass provision having the biggest contribution (33%), followed by recreation (32%) and carbon sequestration (27%). Habitat provision FES plays only a marginal role in the conservative TEV (8%) and remains the same in the TEV based on the upper-bound values. At the same time, this FES is among the top three most valued FES, suggesting that targeted efforts on expansion of the forest area providing habitats for wild plants and animals will have a substantial effect on the TEV of forests in Endlhausen.

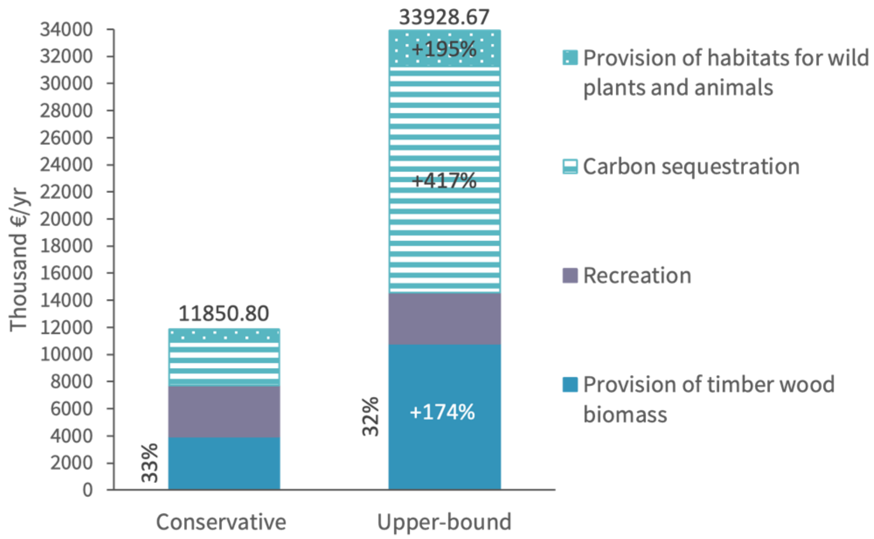


**Figure 2.** Conservative and upper-bound estimates for total economic value (TEV) of forests in Endlhausen. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentages placed inside the bar indicate difference in total values of FES between conservative and upper-bound TEVs, when such difference occurred. Numbers on the top of the bars indicate the TEVs.

The TEV estimates of forests in Waahkirchen Living Lab, using both conservative and upper-bound unit value estimates, are demonstrated in Figure 3 . According to the conservative estimates, each FES contributes to TEV almost equally, with timber wood biomass provision having the biggest contribution (29%), followed by carbon sequestration (26%), recreation (23%), and provision of habitats (22%). In the TEV estimated using upper-bound values, the role of recreation decreases drastically (8%), while the contribution of carbon sequestration increases almost twofold (44%). Timber and habitat provision keep similar sizes of contributions, although relative value per ha of the latter is almost three times higher. Similarly to the Endlhausen Living Lab, targeted efforts on expansion of the forest area providing habitats for wild plants and animals will have a substantial effect on the TEV of forests in Waahkirchen.

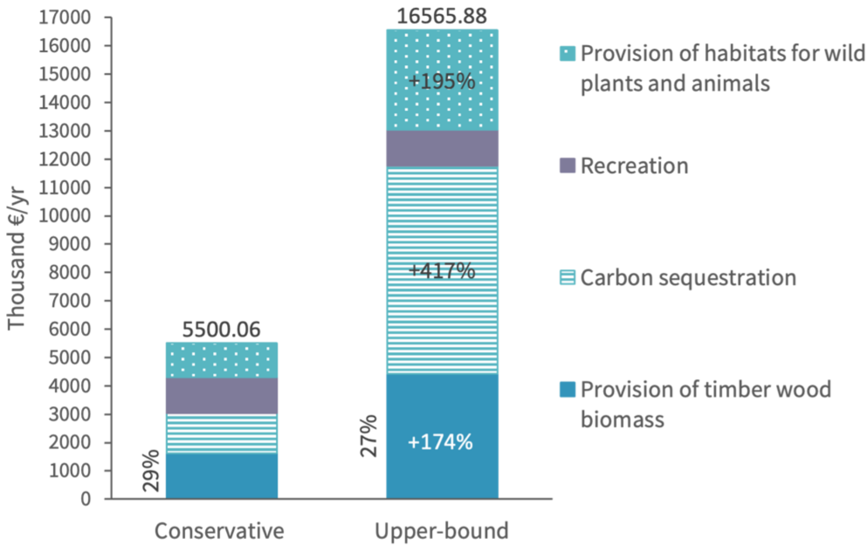


**Figure 3.** Conservative and upper-bound estimates for total economic value (TEV) of forests in Waahkirchen. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentages placed inside the bar indicate difference in total values of FES between conservative and upper-bound TEVs, when such difference occurred. Numbers on the top of the bars indicate the TEVs.

It must be noted, that provided TEV estimates for both Living Labs are a serious underestimation, as the number of FES included in the calculation was restricted to four. Nevertheless, the unit value results, discussed above (Figure 1), suggested the importance of these four FES. Despite underestimation of other FES, value of timber provisioning service constitutes only slightly over 30% and less than 30% of the forest TEV in Endlhausen and Waahkirchen LL, respectively, suggesting that the social importance of forests in both areas extends well beyond timber production. At the same time, we must keep in mind that the forest area providing provisioning services fully overlaps with the one providing carbon sequestration and partially with other FES, hinting at potentially detrimental losses in social value of forests if forest management is fully oriented at timber provision.

Spatial distribution of FES social values in Endlhausen and Waahkirchen further details our understanding about the FES provision in the Living Labs (Figure 4). Not all values are evenly distributed throughout their territories. Most of the forest areas in both LLs provide slightly below average value per ha. In Endlhausen Living Lab, areas with higher values per ha are rather scarce and concentrated around or close to the bodies of water (Isar river and south-western shore of Kochelsee lake). The economic value of FES provided by the church forest located in this Living Lab is relatively low. In Waahkirchen Living Lab, forests with above average value per ha are located in the center of the Living Lab (mountainous area west to the Tegernsee). The economic value of FES provided by a private forest, owned by a primary stakeholder in this Living Lab, also ranges from low to close to average, however, is on the border with the highly valued forest area. However, it must be acknowledged that the economic value mapping is influenced by the assumptions behind biophysical assessment (i.e., decision criteria on what forest area provides a certain FES and what forest area does not; for more detail on the assumptions of biophysical assessment see D2.2.1). Nevertheless, such economic value mapping can support future land use policies and steer the discussion on what areas must be protected (i.e., highly valued areas) and what areas demand special attention and changes in forest management (i.e., areas with lower value per ha). Supplementing this map with spatial distribution of forest ownership as well as residential and recreational areas could shed more light on the FES providers and main beneficiaries, thereby, providing further foundation for decisions about payments for FES (payment to whom?) and equal access to the benefits provided by forests.

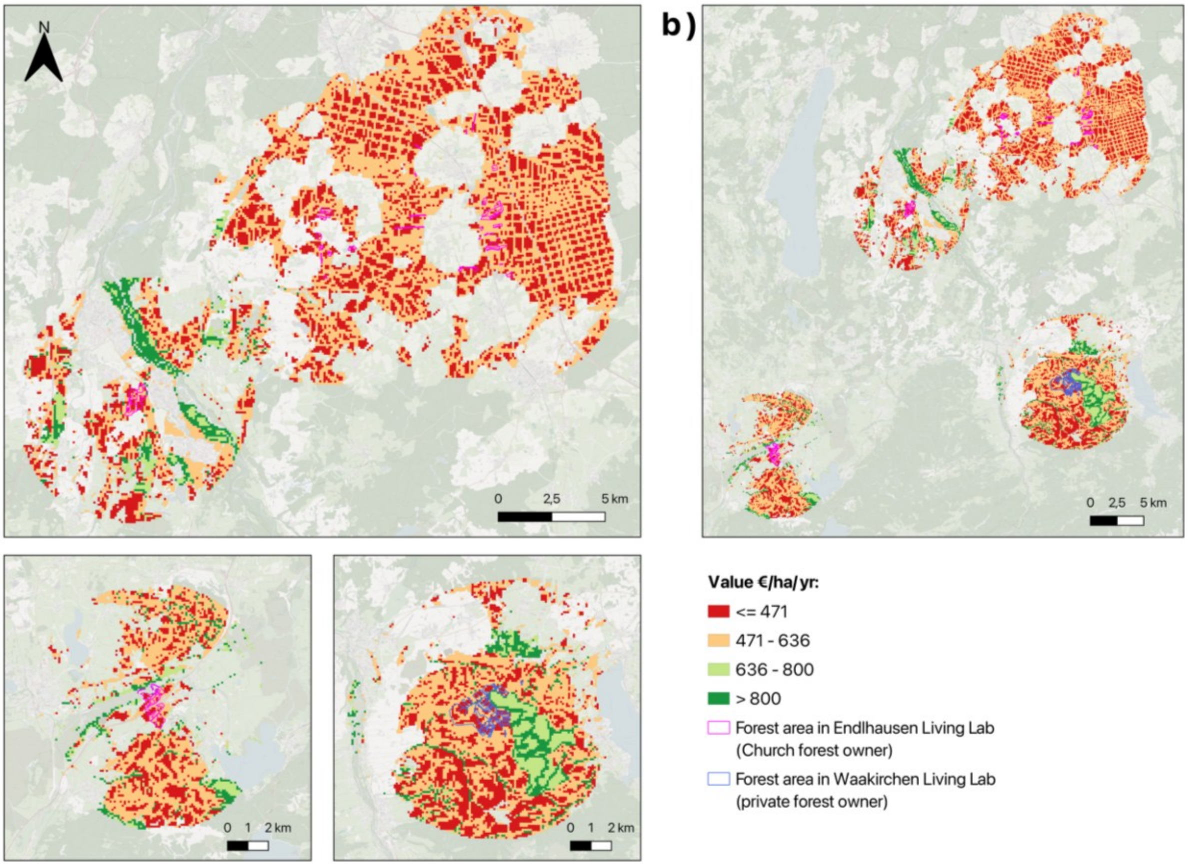


**Figure 4.** Spatial distribution of conservative unit values in Endlhausen and Waahkirchen Living Labs. a) Zooms in the Endlhausen Living Lab (upper and bottom-left figures) and Waahkirchen Living Lab (bottom-right figure). b) Territorial overview of both Living Labs. Minor overdistribution (1%) is present for the unit value of the provision of habitat for wild plants and animals. Some degree of spatial under- and overdistribution is present for the unit value of carbon sequestration, as unit value estimation is based on mean carbon sequestration per ha, not carbon sequestration specific to the forest unit.

### *BMA rankings, and recommended models for each LL*

For the German Living Lab, the ecosystem services considered was recreational services:

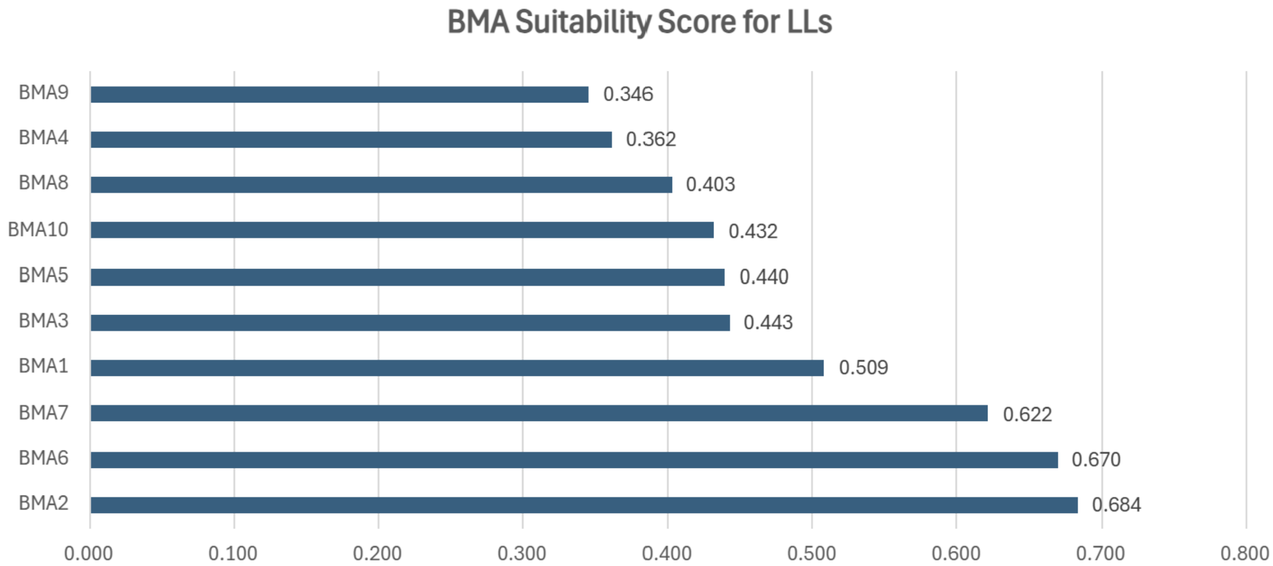

**Figure 4**. Suitability score for German Living Lab - Spirituality

The TOPSIS analysis identifies Environmental Finance (BMA2) as the most suitable business model for the spirituality (cultural ecosystem service) in the German Living Lab, with an overall score of 0.684 and a classification of Good Fit. While this result may appear counter-intuitive at first, given the non-market, intangible nature of spirituality, it reflects a solid alignment between institutional, governance, and policy-related dimensions of the Living Lab and the strategic logic embedded in this BMA.

BMA2 is followed closely by Public–Private Partnership (BMA6, 0.670) and Reverse Auction (BMA7, 0.622), the latter classified as Viable with Effort. The proximity of the scores indicates that all three models are potentially feasible, but none represents a perfect or frictionless solution. Importantly, the absence of market-oriented BMAs among the top-ranked options suggests that the provision of spiritual and cultural services in this context is primarily driven by institutional arrangements and funding mechanisms, rather than by direct user demand or commercial transactions.

At a qualitative level, the prominence of Environmental Finance can be interpreted as a methodological consequence of how spirituality is operationalized within the MCDA framework. Spiritual and cultural services often depend on long-term conservation, stewardship, and protection of landscapes, heritage sites, or symbolic ecosystems. These activities align more naturally with investment-based, policy-supported financial mechanisms than with consumption-driven business models. In this sense, BMA2 acts less as a market solution and more as an enabling framework that channels resources toward maintaining the conditions under which spiritual values can persist.

**Table 1.** Concept-level analysis for BMA2 (Environmental finance)

| Concept | Gap vs Ideal (%) | Strategic Status | Qualitative Notes |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Ecosystem Services (C1) | 58% | Development Area | Ecosystem-related capacities exist but are not fully leveraged. |
| Local Demand (C2) | 100% | Critical Vulnerability | Spiritual services are weakly expressed as explicit demand. |
| Regulations and Policies (C3) | 0% | Strategic Alignment | Strong regulatory and policy support is a key enabling factor. |
| Operational Costs (C4) | 89% | Critical Vulnerability | High costs limit efficiency without dedicated funding mechanisms. |
| Governance and Management (C5) | 0% | Strategic Alignment | Governance structures are well aligned with this BMA. |
| Social Benefits (C6) | 0% | Strategic Alignment | Strong capacity to generate collective and cultural benefits. |
| Technological Innovation (C7) | 0% | Strategic Alignment | Technology is not a binding constraint for this service. |

From a quantitative perspective, Table 1 highlights very strong performance in regulations, governance, and social benefits (C3, C5, C6 = 100%), while local demand and operational costs (C2 and C4) emerge as critical weaknesses. This pattern helps explain the ranking outcome: the model performs well precisely where institutional and collective dimensions dominate, and poorly where market-based signals would normally be expected.

In summary, the emergence of Environmental Finance (BMA2) as the top-ranked option—despite appearing unintuitive—can be understood as a logical outcome of the MCDA–TOPSIS framework when applied to spiritual and cultural ecosystem services. These services rely less on direct user demand and more on institutional legitimacy, governance capacity, and long-term financing mechanisms. The close ranking of BMA6 and BMA7 further reinforces the conclusion that coordination, public involvement, and structured funding, rather than market transactions, are central to supporting spirituality-related ecosystem services in the German context.

*BM Canva analysis and simulation*

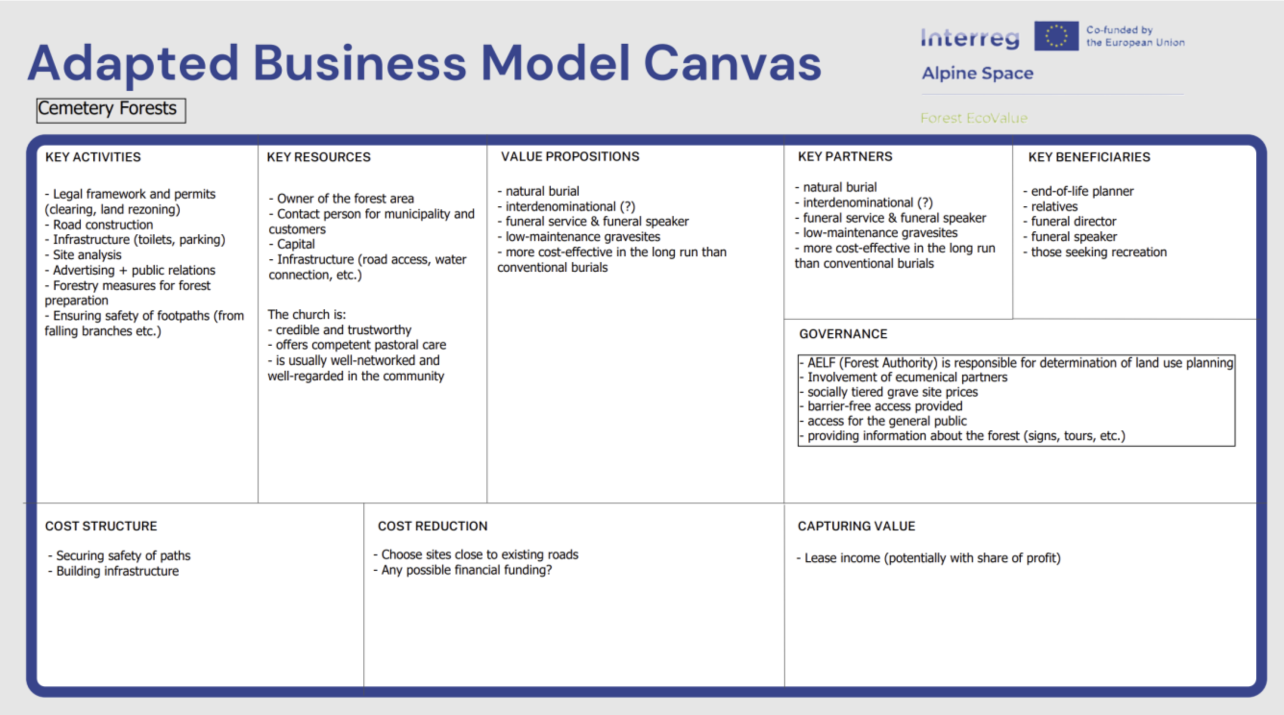


**Figure 1.** Business Model Canvas – German Living Lab

## Green Cemetery Forests Business Model: Transforming Legacy into Lifelong Impact

### *Introduction*

The Green Forest Cemetery Business Model introduces a sustainable alternative to traditional burial practices by integrating ecological restoration with cultural and religious traditions. It leverages Bayern's regulatory openness to natural burials, and responds to growing demand for environmentally responsible memorialisation17.

Green Cemetery Forests are designed as living memorials, combining the offer of natural burials with FES provision. They create sacred spaces that honour the deceased while contributing to climate resilience and biodiversity conservation and enhancement.

The model includes differentiated burial options (standard and "legacy" plots) at different prices and offering different services to the buyer families.

This approach aligns with EU Green Deal objectives, national climate targets, and consumer preferences for eco-conscious services, also in the cemeterial industry.

[17] See https://www.dw.com/en/new-burial-laws-to-modernize-german-funeral-culture/a-74064108 and https://treeurn.eu/where-to-bury-a-funeral-urn-with-a-tree-in-germany/

*Description*

By structure, the main economic feature of this model is its ability to deliver diversified revenue streams that strengthen its financial sustainability and align with the multiple benefits of FES. The Green Cemetery model is used here as a conceptual case to explore the interaction between cultural ecosystem services and environmental finance mechanisms.

The model offers two categories of burials: standard burials and “Legacy Plots”, premium burial sites that finance verified carbon sequestration and habitat enhancement, and provide a digital ecological footprint, enabling families to monitor ongoing environmental benefits as a legacy of the deceased.

The main sources of revenue envisaged are listed below.

| | |
|---|---|
| Burial plot sales | Standard and premium Legacy Plots with 25% price premium |
| Carbon credits from verified forest carbon storage | Produce additional income, through sales on voluntary carbon markets |
| Eco-memorial tourism | Supplementary services offered through retreats, spiritual and educational tours |
| Scale and Demand | Annual burials start at 21-25 (scenario-dependent) and decrease by 1.5% per year due to space constraints, requiring stronger reliance on carbon credits, eco-tourism, and biodiversity payments |

The cost structure of this model includes an initial investment in permits, infrastructure, and safety, low operating costs due to natural forest maintenance, and a perpetual maintenance fund (3% of total revenue) for long-term care and site-specific risk management.

The model financial resilience is based on *dual income streams* aimed to reduce reliance on burial plot sales (subject to limited space and niche demand patterns), diversification through FES monetization (e.g., $CO_2$ sequestration and biodiversity credits) and recreation/tourism activities, risk mitigation via partnerships with churches and municipalities supporting the main revenue streams and promoting the initiative (burials and spiritual tourism).

In general, it is a low operating cost model due to minimal maintenance requirements, ideally compatible also with selected cut. A specific mechanism has been set up to cover from uncertainty, called “Risk Fund” and introduced to accumulate reserves (2% of revenue annually) suitable to deliver, in our hypothesis, an interest rate of 3.7%, providing a relative financial stability against operational or ecological risks. The Fund is financed by total revenues for forest upkeep.

The model investment profile currently foresees higher upfront investment (€45-50,000 amortized over 10 years) for infrastructure and compliance, reflecting the complexity of managing smaller but premium forest sites. Tiered pricing maintains accessibility while supporting premium services. Church partnerships offer investors an image of credibility, ethical standards, and community engagement that materializes also through a strong monitoring system envisaging continuous ecological certification and transparent reporting.

The model shows some remarkable factors in support to a successful implementation, including the growing market acceptance of ecological burial concepts (potentially growing demand[18] according to sources), the expectations for a good carbon price stability even above €30/ton in voluntary markets in EU, according to forecasts[19], the strong institutional partnerships already established with churches and municipalities (local parish owns the land), and the existing regulatory approval for natural burials.

The main limits of this market are linked to demographic burial decline requiring significant campaigns to support revenue growth in the sector, and to the actual capacity of the risk fund to ensure liquidity and resilience to counter external shocks and adverse conditions.

Under the point of view of governance at the national and regional level, it is important to consider the rules set by Forest Authority (AELF) for land use planning, the potential of socially tiered pricing for achieving wider inclusivity, the goal to achieve barrier-free access to the cemetery and public engagement in the initiative[20], and the certification used to guarantee a transparent ecological monitoring.

On the policy side, Green Forest Cemeteries can deliver measurable contributions to public policy goals as climate action through continuous carbon sequestration in support to EU and national commitments, biodiversity protection through ensuring green corridors for native species, water management through Improved filtration and retention in forest ecosystems, and social inclusion through tiered pricing ensuring accessibility and cultural diversity.

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[18] Germany Funeral Services Market (2025-2031): Trends, Outlook & Forecast and Green Burial Industry Trend,  Green Funerals Market Forecast 2024-2034).

[19] See: https://www.fiegenbaum.solutions/en/blog/voluntary-vs-regulated-carbon-markets-risks-verification-price-differences

[20]See: https://orbilu.uni.lu/bitstream/10993/55690/1/CeMi%20report%20English.pdf

Against this background, policy makers can support the model by integrating forest cemeteries into regional land-use planning, enabling and supporting carbon credit certification for burial-linked sequestration, promoting nature-based solutions for climate resilience through forest maintenance and ecological management[21].

*Ecological and Social Impact*

Forest cemeteries generate, through FES, measurable environmental and social benefits suitable for quantification, monetization or marketing services especially relative to carbon storage[22], biodiversity protection offering protected habitats for native species[23], water management for enhanced, quality and retention, and strengthening or creating urban/ periurban green corridors, connecting fragmented ecosystems.

Impact can be tracked through well-established instruments and methodologies: carbon storage is verified by adopting international standards, biodiversity and soil health through well-established indicators, and specifically for Legacy Plots footprint as premium service through digital monitoring.

- Green Forest Cemetery Business Model
- Sustainable burial approach merging ecological restoration with traditional practices
- Combines natural burials, FES, and climate resilience
- Premium "Legacy Plots" fund carbon sequestration and habitat enhancement; digital tracking provided for families
- Aligns with EU Green Deal, climate targets, and growing eco-conscious consumer demand

*Evaluation procedure*

Based on standard parameters aligned to the Bavarian context, and considering alternative background conditions, we examine the revenue streams generated through the sales of burial plots and the other suggested strategies, and the resulting costs, over a 10-year period.

We use a scenario analysis, across a baseline, moderate and stress test scenarios where we consider financial and ecological/social outcomes (yearly and cumulated values), testing low carbon prices (€21-30/ton) and high discount rates (4.5%) aiming to reveal the model's sensitivity and need for a "safe" price to be fully financially sustainable.

[21] See: eu-ri-roadmapweb.pdf

[22] See: https://onlinelibrary.wiley.com/doi/pdf/10.1111/gcb.12558

[23] See: https://conbio.onlinelibrary.wiley.com/doi/pdf/10.1111/cobi.14322

The BM has been tested against the hypotheses of a diversified income based on burial plot sales (tiered pricing allowing for inclusivity: standard & premium), carbon credits, eco-memorial tourism.

We set burials decreasing annually by 1.5%, that implies an increasing reliance for the financial sustainability of the model on carbon and biodiversity payments, and tourist development.

Low operating costs are used; we introduced a perpetual maintenance fund (filled with 3% of annual total revenue); a risk fund (2% of revenue, generating a 3.7% interest rate annually) for stability

Upfront investment are set between €45–50k over 10 years. The model relies on strong partnerships with churches and municipalities and it foresees ongoing ecological certification and reporting.

The model governance focuses on compliance, accessibility, and public engagement. While financial indicators are reported, they capture only part of the value generated by spiritual and cultural ecosystem services.

Under the point of view of policy, and social and environmental impact, this BM supports climate and biodiversity goals through carbon sequestration, green corridors, and improved water management. It also promote social inclusion via tiered pricing and cultural diversity. Its measurable impact is tracked through international standards and digital tools.

*Scenario analysis*

The model has been tested against three scenarios based on the parameters and assumptions reported in the table below. When the same value is repeated for all scenarios the parameter is fixed.

| Parameters | Baseline | Moderate | Stress Test |
|---|---|---|---|
| Managed area (ha) | 110 | 120 | 110 |
| Annual burials | 21 | 25 | 21 |
| Burial Fee (€) | € 1,800.00 | € 2,100.00 | € 1,800.00 |
| Carbon Price (€/t) | € 24.00 | € 28.00 | € 20.00 |
| Biodiversity Payment (€/ha/yr) | € 20.00 | € 25.00 | € 15.00 |

| | | | |
|---|---|---|---|
| Inflation rate (annual) | 0.02 | 0.03 | 0.035 |
| Public subsidies for SFM (%)[24] | 0.3 | 0.4 | 0.2 |
| Eco-tourism Visitors | 400 | 500 | 300 |
| Visitor Fee (€) | € 20.00 | € 25.00 | € 15.00 |
| Legacy Plot Premium | 0.25 | 0.25 | 0.25 |
| Carbon Sequestration (t/ha/yr) | 8 | 8 | 8 |
| Labour Cost (€/hour) | € 22.00 | € 22.00 | € 22.00 |
| Energy Cost (€/year) | € 2,200.00 | € 2,200.00 | € 2,200.00 |
| Certification Cost (€/year) | € 1,300.00 | € 1,300.00 | € 1,300.00 |
| Marketing/Admin Cost (€/year) | € 2,400.00 | € 2,400.00 | € 2,400.00 |
| Investment Setup (€)[25] | € 45,000.00 | € 45,000.00 | € 45,000.00 |
| Discount rate | 0.045 | 0.045 | 0.045 |
| Private donors contribution (€) | € 5,500.00 | € 5,500.00 | € 5,500.00 |
| SFM Operating Cost (€/ha/yr) | € 95.00 | € 95.00 | € 95.00 |
| Legacy Plots share | 0.2 | 0.2 | 0.2 |

Scenario analysis highlights internal financial dynamics, without addressing social acceptance, ethical constraints, or regulatory complexity. The following results and values for financial and non-financial indicators have been found for the scenarios presented above.

[24] Subsidy rate applies as a percentage reduction to SFM operating cost (€/ha/yr)
[25] €45–50k, modelled as initial cash outlay unless otherwise stated

| Indicators* | Baseline | Moderate | Stress Test |
|---|---|---|---|
| Media Flusso Netto | € 25,707.05 | € 57,308.89 | € 12,851.36 |
| Mediana Flusso Netto | € 23,304.57 | € 54,459.52 | € 10,875.05 |
| Deviazione Standard | 9967.71 | 13360.34 | 6853.68 |
| Min | € 13,055.00 | € 40,030.00 | € 4,435.00 |
| Max | € 42,826.10 | € 80,525.89 | € 24,334.28 |
| Percentile 25 | € 17,732.09 | € 46,580.48 | € 7,419.31 |
| Percentile 75 | € 34,574.70 | € 68,628.63 | € 19,462.68 |
| NPV | € 364,467 | € 556,673; | € 290,328 |
| IRR | 135.9%; | 200.9% | 114.2% |
| Payback Period | 1.0 | 1.0 | 1.0 |
| $CO_2$ Total | 8,800 t $CO_2$ | 9,600 t $CO_2$ | 8,800 t $CO_2$ |

** NPV/IRR computed over 10 years, including 3% maintenance fund & 2% risk fund (with 3.7% interest on fund balance), SFM subsidy as a reduction of SFM €/ha cost, opex escalated by scenario inflation, donor €5,500 at t0, capex paid at t0; revenues in real terms (no indexation).*

**Baseline:** The Bavarian BM demonstrates solid financial, social, and ecological performance, with a positive NPV, rapid payback, and diversified revenue streams (burial plots, carbon credits, eco-tourism). Ecological indicators such as cumulative carbon storage and biodiversity payments show consistent improvement. Institutional partnerships and a risk fund mechanism support resilience, benefiting forest owners, local communities, and the public.

**Moderate:** Stronger fees/prices materially lift NPV and IRR; downside stress remains profitable with 1-year payback, but sensitivity to burial volumes and carbon price is high (see Monte Carlo drivers). Increased costs and inflation require careful management. The model maintains good annual profits and ecological gains. Revenue diversification and robust governance ensure stability, though the margin for financial sustainability narrows, highlighting the importance of adaptive management and cost control.

**Stress Test:** Under challenging market conditions (lower carbon price, higher costs, fewer visitors), financial metrics are reduced but remain positive. Burial volumes and fees are critical. Ecological and social benefits persist, supported by the risk fund and diversified revenue sources. The model's built-in resilience allows it to withstand adverse scenarios, ensuring continued delivery of public goods and environmental impact, albeit with more modest financial returns.

### *Final comments*

The Bavarian BM shows notable stability in economic and ecological results across scenarios.

However, its sustainability depends critically on external variables, including:

- Carbon market stability
- Demand for eco-burials and eco-tourism
- Forest owner and church participation rates
- Operating cost control

Concerning risk management, the BM seeks to manage risk through its "*built-in resilience*" that principally materializes in the mechanisms listed below:

- Revenue diversification (burial plots, carbon, biodiversity, tourism)
- Risk Fund (2% of revenue for operational/ecological shocks)
- Tiered Pricing (standard and premium "Legacy Plots")
- Strong institutional partnerships (churches, municipalities)
- Ongoing ecological certification and transparent reporting

The Investment Proposition embedded in this BM is based on the expectation that investment in this model will benefit different categories of actors, as listed below.

| Stakeholder | Monetary Benefits | Managerial Benefits | Ecologic Benefits |
| --- | --- | --- | --- |
| Forest Owners | Lease income, diversified revenue | Risk reduction via Risk Fund | Access to ecological expertise |
| Church Partners | Community engagement, credibility | Pastoral care, public trust | Stewardship of sacred forests |
| Municipalities | Local economic development | Public access, inclusivity | Biodiversity, green corridors |
| Families/Public | Cost-effective, eco-conscious options | Transparent ecological legacy | Measurable climate/biodiversity impact |

According to the simple simulation run, and against the questionable accuracy of the data used in this context, the Bavarian FEV BM demonstrates that ecological responsibility and economic viability are not mutually exclusive. With conservative assumptions and robust risk management, the Green Forest Cemetery:

- Generates sustainable profits with rapid payback (1 year)
- Delivers measurable environmental impact from the outset
- Scales efficiently to smaller forest areas (e.g., 50 ha)
- Creates multi-stakeholder value without compromise
- Maintains balance between carbon price sensitivity, project quality, and operational efficiency through robust scenario testing

This business model can be applied also to a smaller forest area (e.g., 50 ha) and foresee a declining burial trend (e.g., -1.5% annually). It is useful to investigate on its ability to keep good financial sustainability levels against alternative scenarios and parameters would emphasise financial resilience through diversified revenue streams and risk management mechanisms, ensuring viability despite reduced burial volumes.

With conservative assumptions and robust risk management, the model generates sustainable profits, delivers measurable environmental impact, and creates value for all stakeholders. Its success depends on maintaining a delicate balance between market variables, quality, and efficiency as confirmed with the scenario analysis run[26]. The model illustrates a potential alignment between cultural services and long-term conservation funding, rather than a readily replicable business solution.

**Monte Carlo Simulation**

The Monte Carlo simulation was applied to test the financial and ecological robustness of the Green Cemetery model under uncertainty, over a 10-year horizon using 20,000 trials. This approach tests the model's financial and ecological outcomes under thousands of possible future scenarios, reflecting real-world uncertainty and quantifying variability in key metrics (such as NPV, IRR, and cumulative $CO_2$ storage), thereby helping decision-makers understand the likelihood of success and resilience.

By modeling 20,000 scenarios with variable inputs (including burial rates, visitor numbers, carbon pricing, biodiversity payments, and cost inflation), we developed a robust risk assessment framework. Key financial indicators (Net Present Value, Internal Rate of Return, and discounted payback period) were calculated alongside ecological metrics (cumulative $CO_2$ absorption).

Results indicate generally strong performance across scenarios, with differentiated risk profiles emerging under uncertainty: a positive median NPV (P50: €401k) and a low payback time (2 years) for baseline, a positive median NPV (P50: €535k) and a lower payback time (~1.75 years), with a near-zero probability of negative NPV under the Moderate scenario. Under the Stress Test scenario, median NPV stays positive (P50: €133k), payback time around 4 years, and a 5% probability of a negative median NPV. $CO_2$ benefit remains constant at 4,000 tons across scenarios. Key

[26] The figures and findings presented in these simulations are based on illustrative parameters and generalised assumptions that do not necessarily correspond to the real-world conditions or data of the LLs. Accordingly, the results should be viewed as indicative and methodological in nature, providing a foundation for further, locally tailored analyses rather than serving as definitive or prescriptive outcomes. Users are advised to adapt the methods and validate the data in accordance with the specific characteristics and priorities of their local context before drawing any firm conclusions or making strategic decisions based on these simulations.

sensitivities include burial volumes, burial fees, and carbon price. While the model is robust, diversification and cost control remain critical under stress conditions.

Top sensitivities: Burial volumes > burial fees > $CO_2$ price.

Outcomes are most sensitive to burial volumes, burial fees, visitor numbers, $CO_2$ price, and sequestration rates. High-performing configurations deliver NPVs above €500,000 and rapid payback, while less favorable cases underscore risks tied to demand and price assumptions. Correlation analysis confirms that burial volumes and fees are the primary drivers of profitability, followed by visitors' and carbon price effects. Overall, the findings validate the project's potential to balance economic performance with ecological impact, positioning it as a compelling investment in the green economy. This probabilistic approach offers actionable insights for decision-makers, enabling informed strategies that optimize financial resilience and environmental stewardship under uncertain future conditions. While the simulation suggests financial stability under most tested conditions, this does not address social acceptance, ethical considerations, or long-term governance arrangements, which remain critical for implementation.

## Valle Tanaro, Italy

### *Tailored FES valuation*

The results of the adjusted unit value transfer for the Italian Living Lab in Valle Tanaro are presented on Figure 1. Two sets of value estimates were produced:

- A mix of market price (MP) valuation for timber wood, firewood and fuelwood biomass provision, Italian voluntary market carbon pricing (VMCP) for carbon sequestration and adjusted unit value transfer for other FES, hereinafter, 'Mixed-method and VMCP';
- Adjusted unit value transfer for all FES, except for the carbon sequestration valuated using the upper-bound estimates of recommended carbon pricing (RCP), hereinafter, 'Value transfer and RCP'.

Both estimation approaches highlight social relevance of regulating services associated with natural hazards risks mitigation with the highest value per ha of forest, followed by provision of habitats for wild plants and animals and cultural service of recreation. Provision of timber wood biomass rounds the top five FES with the highest social value per ha. While value transfer slightly overestimates local MP valuation of timber wood provision, the difference in market price and transferred values of firewood biomass provision is more significant (+€49.55/ha), which can be explained by data scarcity and underreporting on firewood market. In case of fuelwood, value transfer underestimates value of firewood biomass provisioning service by more than a half when compared to MP valuation results.

According to the pricing on the voluntary carbon market in Italy, a value of a ha of forest in terms of carbon sequestration is about €50 lower (in 2023) than value of timber wood provided by the same ha. However, when valuating carbon sequestration with the upper-bound carbon pricing (€295/ha) recommended to achieve climate mitigation compatible with the global climate targets, this FES takes its place among the four most valuable regulating services in Valle Tanaro.

This difference highlights sensitivity of monetary valuation and importance of clarity about communicative goal when using results of such assessments.

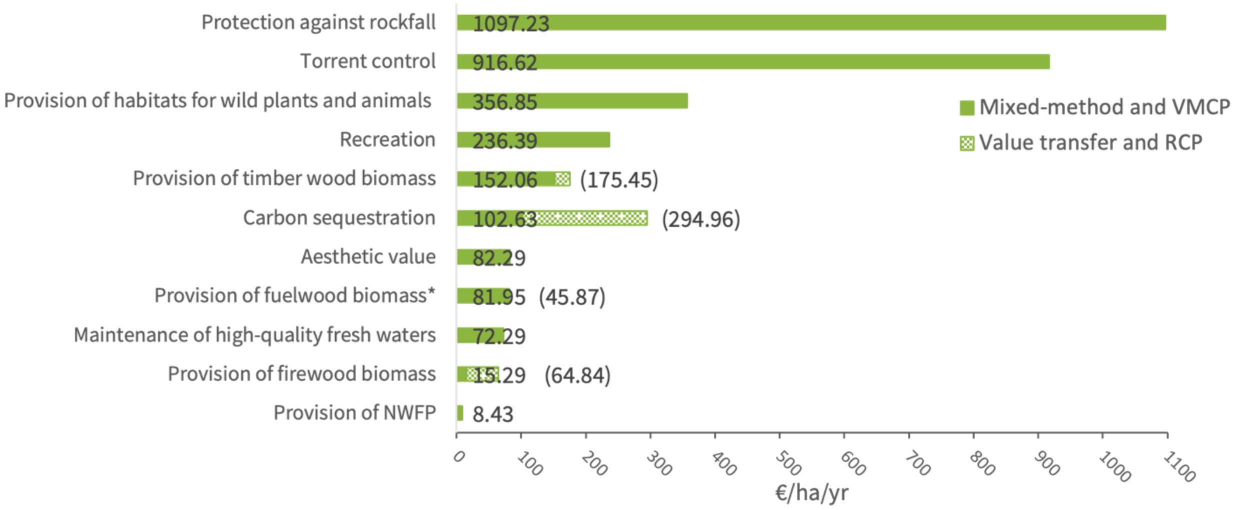


**Figure 1.** Unit value estimates in 2023 euros per ha. Bold green depicts values estimated with the Mixed-method and VMCP. Patterned green depicts additional values estimated with the Value transfer and RCP, with the estimates indicated in parenthesis. NWFP stands for non-wood forest products, including chestnuts, mushrooms and berries. *As MP estimates provided a higher value for fuelwood biomass FES than adjusted unit value transfer, the patterned green part of the bar is not visible on the figure.

Estimates of the total economic values (TEV) of forests in Valle Tanaro, using both valuation approaches, are demonstrated in Figure 1. In both cases, provision of habitats for wild plants and animals FES is the biggest contributor to the TEV, as the entire area of the LL is a Natura 2000 site. Despite the highest social importance (i.e., highest unit value), contribution of the protection against rockfall contributes is twice less than of habitats provision. This suggests that targeted efforts on expansion of the forest area providing this FES will have a substantial effect on the TEV of Valle Tanaro forests. The size of contribution of carbon sequestration FES is consistent with its unit value, that varies depending on the approach.

It must be noted, that provided TEV estimates are a serious underestimation, as the number of FES included in the calculation was restricted to five. Nevertheless, according to the unit value results, discussed above (Figure 1), these five FES are among the most relevant for the Living Lab. Despite underestimation, value of timber provisioning service constitutes a relatively small share of the forest TEV, suggesting that the social importance of forests in Valle Tanaro extends well beyond timber production. At the same time, we must keep in mind that provisioning FES are provided by the same forest area as carbon sequestration and provision of habitats and partially overlaps with other FES. This hints at potentially detrimental losses in social value of forests if forest management is fully oriented at timber provision.

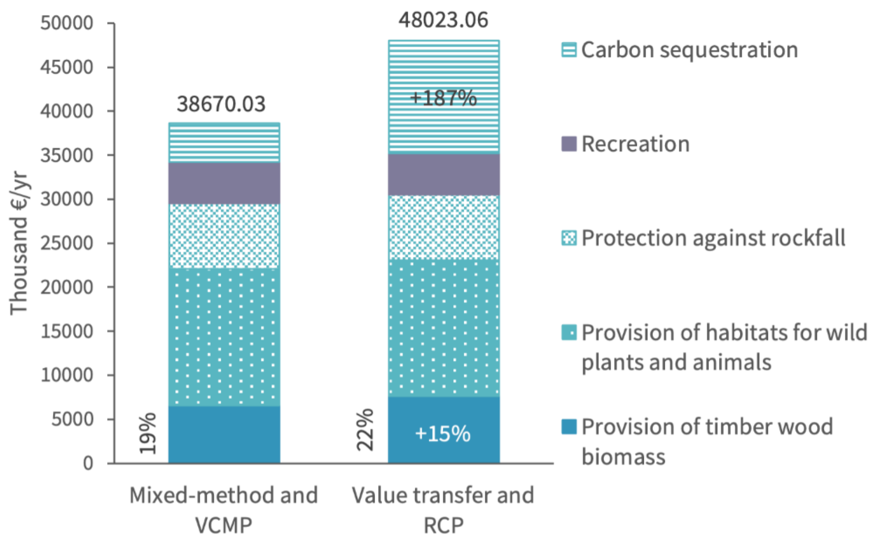


**Figure 2.** Estimates of total economic value (TEV) of forests in Valle Tanaro, calculated using two different approaches. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentages for timber wood biomass and carbon sequestration placed inside the bar indicate difference in total values of these FES between TEVs estimated using different methods. Numbers on the top of the bars indicate the TEVs.

Spatial distribution of FES social values in Valle Tanaro further details our understanding about the FES provision in the Living Lab (Figure 2). Not all values are evenly distributed throughout the territory of the Living Lab. While most of the forest area provides relatively low values per ha, areas providing above average value per ha as well as highly valuable areas are concentrated around Ormea, Trappa, in the North/North-West of Garessio, and on the Southern border of Valle Tanaro. However, it must be acknowledged that the economic value mapping is influenced by the assumptions behind biophysical assessment (i.e., decision criteria on what forest area provides a certain FES and what forest area does not; for more detail on the assumptions of biophysical assessment see D2.2.1). Nevertheless, such economic value mapping can support future land use policies and steer the discussion on what areas must be protected (i.e., highly valued areas) and what areas demand special attention and changes in forest management (i.e., areas with lower value per ha). Supplementing this map with spatial distribution of forest ownership as well as residential and recreational areas could shed more light on the FES providers and main beneficiaries, thereby, providing further foundation for decisions about payments for FES (payment to whom?) and equal access to the benefits provided by forests.

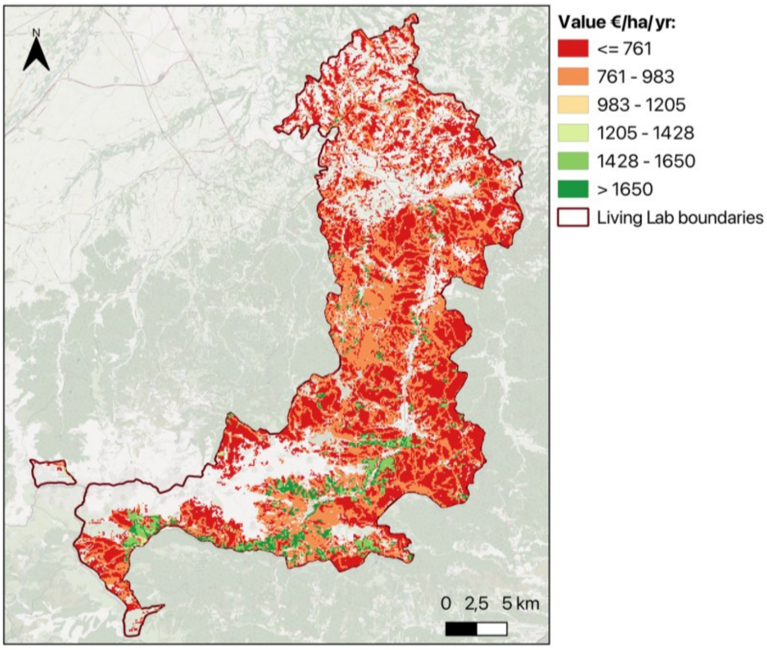


**Figure 3.** Spatial distribution of unit values in Valle Tanaro. Only estimates produced with the Mixed-method and VCMP were used for mapping. Some degree of spatial under- and overdistribution is present for the unit value of carbon sequestration as unit value estimation is based on mean carbon sequestration per ha, not carbon sequestration specific to the forest unit.

### *BMA rankings, and recommended models for each LL*

For the Italian Living Lab, the ecosystem services we considered was habitat maintenance

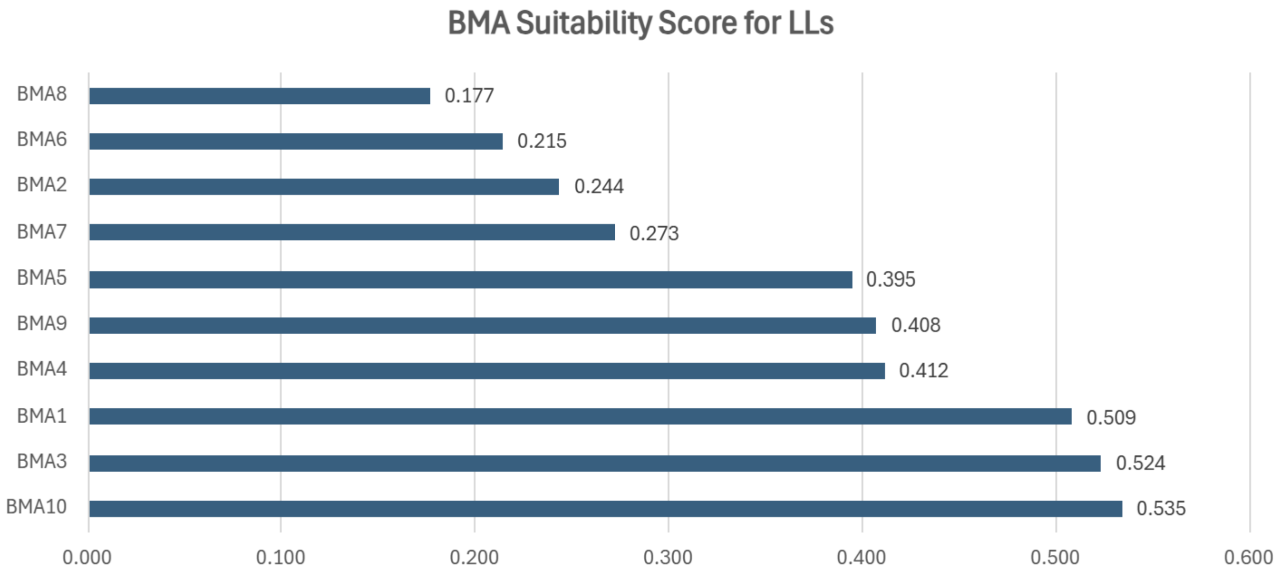


***Figure 4****. Suitability score for Italian Living Lab – Habitat maintenance*

The TOPSIS analysis identifies Trash to Cash (BMA10) as the highest-ranked business model for the habitat maintenance service in the Italian Living Lab, with an overall score of 0.535 and a classification of Viable with Effort. This outcome indicates a relatively weak but still feasible alignment between the Living Lab's characteristics and the strategic structure of the BMA, and it should be interpreted with caution given the modest absolute performance values.

BMA10 is followed very closely by Experience Selling (BMA3, 0.524) and Crowdfunding (BMA1, 0.509). The narrow score differences suggest that none of the top-ranked models represents a clearly dominant solution and that all three options are only marginally compatible with the current Living Lab conditions. This clustering of scores already signals structural limitations in supporting habitat maintenance through business models in this context.

At first glance, the emergence of Trash to Cash (BMA10) as the top-ranked option for habitat maintenance appears highly counter-intuitive, as this model is primarily oriented toward waste valorization and material recovery rather than direct ecological conservation. However, this result can be partially explained by the numerical structure of the MCDA–TOPSIS calculation and the specific performance profile of the Living Lab.

**Table 1.** Concept-level analysis for BMA10 (Trash to cash)

| Concept | Gap vs Ideal (%) | Strategic Status | Qualitative Notes |
|---|---|---|---|
| Ecosystem Services (C1) | 10% | Strategic Alignment | Strong relative performance compared to other concepts. |
| Local Demand (C2) | 55% | Development Area | Demand exists but is not sufficiently mature or explicit. |
| Regulations and Policies (C3) | 100% | Critical Vulnerability | Absence of regulatory support strongly penalizes the model. |
| Operational Costs (C4) | 95% | Critical Vulnerability | Very low operational efficiency in the current context. |
| Governance and Management (C5) | 88% | Critical Vulnerability | Weak governance capacity limits implementation. |
| Social Benefits (C6) | 100% | Critical Vulnerability | Social value generation is largely absent. |
| Technological Innovation (C7) | 0% | Strategic Alignment | Technology is not a limiting factor for this BMA. |

From a quantitative perspective, Table X reveals a highly unbalanced profile. While ecosystem services (C1) show strong alignment (90%), largely due to high normalized LL performance, most other concepts perform extremely poorly, with several scoring close to zero. Importantly, C1 carries a very high weight within BMA10, meaning that its strong performance disproportionately influences the overall similarity score.

Methodologically, BMA10 ranks first not because it performs well across multiple dimensions, but because it strongly emphasizes ecosystem services (C1), which happens to be one of the few areas where the Italian Living Lab performs well.

From a substantive and ecological perspective, the suitability of Trash to Cash for habitat maintenance remains questionable. The model shows critical vulnerabilities in governance, regulation, operational costs, and social benefits—all of which are central to long-term habitat conservation. Therefore, its top ranking should be interpreted primarily as a methodological artifact, driven by the weighting structure and normalization effects of the MCDA–TOPSIS framework, rather than as a strong strategic recommendation.

In conclusion, while BMA10 formally emerges as the top-ranked option for habitat maintenance in the Italian Living Lab, this result should be read with caution. The overall low scores and the concentration of performance in a single concept suggest that none of the evaluated BMAs is well suited to this service under current conditions. Experience Selling and Crowdfunding remain close alternatives and may offer more intuitive pathways if complemented by policy support and governance improvements.

### *BM Canva analysis and simulation*

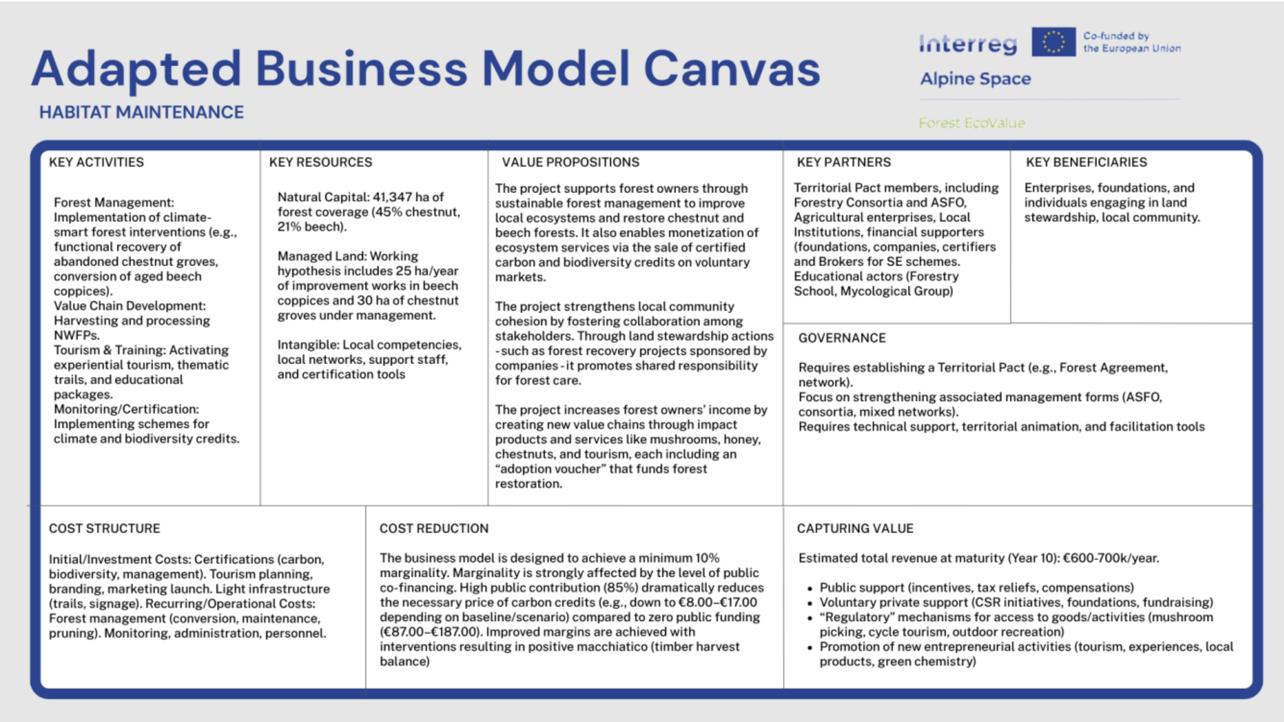


**Figure 1.** Business model canvas – Italian Living Lab

## Bioplastic, Circular Innovation and Multi-Benefit Optimization

### *Introduction*

The Italian Forest EcoValue Business Model (Bioplastic) reframes under-utilized forests as multifunctional living assets, coupling circular bioplastic production from sawdust with ecosystem service monetization (carbon, biodiversity, recreation).

It pursues ecological responsibility and economic viability through diversified revenue streams and conditional public support linked to measurable sustainability performance (EII, SII, SDI).

The Italian Forest EcoValue Business Model (Bioplastic) operates on a 200 ha base area (with 15% protected) and a minimum sawdust supply of 500 t/year. In the scenarios, $CO_2$ absorption is set to 450 t/year for the 200 ha configuration and 675 t/year for the 300 ha configuration; 40% of absorbed $CO_2$ is saleable on voluntary markets. $CO_2$ price is €40/t in Baseline/Moderate and €22/t in Stress. Sawdust prices are €85/t (Baseline), €90/t (Moderate), and €70/t (Stress). Tourism revenue is €25,000/yr (Baseline), €37,500/yr (Moderate), and €20,000/yr (Stress). Transformation cost is €27.5/t (i.e., €13,750/yr at 500 t). Certification costs comprise $CO_2$ certification (area-linked) and sawdust certification at €8/t (i.e., €4,000/yr).

*Description*

The initiative is built around a startup producing bioplastic from wood sawdust (minimum supply needed: 500 t/year), complemented by carbon/biodiversity markets and eco-tourism.

Revenue diversification reduces exposure to any single market, while tiered services and digital monitoring strengthen value for companies, visitors, and communities.

Public support is conditional upon exceeding sustainability thresholds, directly linking incentives to an Index (SDI) performance.

The key features of the business model include a diversified beneficiaries of value proposition including forest owners (new income), companies (certified materials, verified ESG), public (climate, biodiversity, education).

In order to be implemented, the model requires partnerships between forest owners and managers with stakeholders precisely identified in bioplastic manufacturers, certification bodies, local authorities, guides/education organizations.

The cost structure of the business model depends on the combination of fixed costs linked to infrastructure setup, marketing, certification (estimated around ~€150k), variable costs including sustainable forest management (SFM) (estimated around €30–33/ha), wood transformation €27.5/t (→ €13,750/yr at 500 t), sawdust certification €8/t (→ €4,000/yr at 500 t); $CO_2$ certification area-linked (e.g., €9,900–€14,850/yr per scenarios), administration (around €15/ha); eco-tourism guides/training (around €75k over 10 years); and the creation of a perpetual maintenance fund.

On the revenue side, timber for bioplastics can assume a price in the €70–93.5/t range and, at 500 t/yr minimum supply, yields up to €46,750/yr. Carbon credit revenue depends on saleable volume and price; in the Baseline scenario it is €7,200/yr (180 t × €40/t), and €3,960/yr in Stress (180 t × €22/t). Eco-tourism revenues assume 5,000 visitors per year at €5, i.e., €25,000/yr (→ €250,000 over 10 years). Biodiversity credits are likely to be sold based on multi-year contracts with SMEs and companies for around €20–30/ha/yr, and the conditional public support earmarked on environmental and sustainability performance assessed through the special Index mentioned (SDI).

The model presents a unique approach to public policy and subsidies by introducing a conditional incentive logic based on a payment scheme that ties subsidies to SDI above threshold, scaled by the performance gap and total $CO_2$ absorbed, with LULUCF voluntary market price benchmarks (e.g., €34/t) to be paid back to the forest owners based on their performance. Although the model focuses on circular valorisation of biomass, its alignment with habitat maintenance objectives remains partial and context dependent.

*Evaluation procedure*

Based on standard parameters tailored to the Italian context and incorporating alternative background conditions, we assess the cost structure and financial sustainability of the bioplastics business model over a 10-year period.

To test the business model, we adopt a scenario-based evaluation with clearly stated parameters, escalators, and discounting; we report financial indicators (NPV, IRR, payback) and ecological indicators ($CO_2$ sequestered) per scenario.

| Parameter | Baseline | Moderate | Stress Test | Notes |
|---|---|---|---|---|
| Managed area (ha) | 200 | 300 | 200 | 15% protected in all cases |
| Sawdust volume (t/yr) | 500 | 500 | 500 | Plant minimum supply |
| Sawdust price (€/t) | 85 | 90 | 70 | Workbook baseline & scenario scaling |
| $CO_2$ absorbed (t/yr) | 450 | 675 | 450 | Proportional to area (workbook baseline 200→450 t/yr) |
| $CO_2$ saleable (40%) (t/yr) | 180 | 270 | 180 | Workbook formula (40%) |
| $CO_2$ price (€/t) | 40 | 40 | 22 | Stress within Italian/French ranges |
| Biodiversity payment (€/ha/yr) | 25 | 25 | 25 | Contracted range 20–30 €/ha/yr; scenario tables use 25 €/ha/yr central value |
| Tourism revenue (€/yr) | 25,000 | 37,500 | 20,000 | Fixed annual revenues used in scenarios: €25,000 / €37,500 / €20,000. |
| SFM cost (€/yr) | 6,600 | 9,900 | 7,260 | Workbook baseline; proportional to area; +10% stress test |
| $CO_2$ certification (€/yr) | 9,900 | 14,850 | 9,900 | Workbook baseline; proportional to area |
| Sawdust certification (€/yr) | 4,000 | 4,000 | 4,000 | 8 €/t × 500 t/yr |
| Transformation (€/yr) | 13,750 | 13,750 | 15,125 | 27.5 €/t × 500 t/yr; +10% stress test |
| Other fixed + marketing (€/yr) | 8,000 | 8,000 | 8,000 | €5,000 + €3,000 per workbook |

| | | | | |
|---|---|---|---|---|
| Visit costs + training (€/yr) | 10,600 | 10,600 | 10,600 | €10,000 visits + €600 training |
| Total costs (no loan) (€/yr) | 52,850 | 61,100 | 54,885 | Sum of the above (computed) |
| Mortgage principal (loan size, €) | 36,995 | 42,770 | 38,420 | Loan principal = 0.7 × annual costs (year-1); annual payment = principal × r / (1 − (1+r)^−10). |
| Mortgage rate (%) | 4% | 5% | 6% | Scenario financing |

The evaluation employs scenario analysis, comparing three innovation-enabled scenarios for the Italian bioplastics business model:

- **Baseline** (current market prices and costs, standard contracts),
- **Moderate** (expanded forest area, improved market conditions, higher bioplastic and carbon prices),
- **Stress Test** (adverse market conditions, cost inflation, and lower demand).

For the Italian scenario, the model operates on a 10-year horizon with a base area of 200 hectares, extendable to 300 hectares. Key parameters include an annual sawdust requirement of 500 tons, transformation costs at €27.5 per ton, and timber prices between €70 and €93.5 per ton.

$CO_2$ absorption for scenarios is set to 450 t/yr (200 ha) and 675 t/yr (300 ha), with 40% saleable on voluntary markets. Carbon credits may be sold for up to 40% of annual absorption (200 ha: 450 t/yr; 300 ha: 675 t/yr), at €40 per ton in Baseline/Moderate and €22 per ton in Stress.

Biodiversity payments range from €20 to €30 per hectare each year. Management costs vary from €30 to €33 per hectare for productive areas. Administration is treated as a fixed item in scenarios (included within "Other fixed + marketing" at €8,000/yr), with no separate per-hectare administration line. Visit costs and training are modeled as €10,000/yr for visits plus €600/yr for training (i.e., €10,600/yr).

Financing assumes a 0.7 coverage ratio and interest rates of 4–5%. Sensitivity analyses use $CO_2$ prices from €19 to €60 per ton and biodiversity payments from €8 to €27 per hectare, with discount rates of 3.8–6.6% and inflation between 2% and 4%.

The model simulates the impact of these variables on annual and cumulative costs, distinguishing between major categories: sustainable forest management (area-linked), transformation and certification (volume-linked), and fixed overheads (marketing, administration, guide training).

Investment setup costs are allocated over the first ten years, with an upfront outlay before operations commence.

Initial setup outlay (assumed for validation): Baseline €180,151; Moderate €235,150; Stress €180,151. Derived as Payback × annual net from the scenario table.

This scenario framework allows for sensitivity testing of cost escalation, project scale, participation rates, and the effect of diversified revenue streams (bioplastic sales, carbon credits, eco-tourism). The approach supports robust evaluation of the business model's resilience and highlights the importance of cost structure, revenue diversification, and parameter selection in achieving long-term ecological and financial objectives[27].

### *Scenario analysis*

The scenario analysis for the Italian Forest EcoValue Business Model (Bioplastic) compares the three innovation-enabled configurations presented above. The following results and values for financial and non-financial indicators have been found.

| Scenario | Revenue (€/yr) | Costs, no loan (€/yr) | Mortgage (€/yr) | Net (€/yr) |
|---|---|---|---|---|
| Baseline | 79,700 | 52,850 | 4,561 | 22,289 |
| Moderate | 100,800 | 61,100 | 5,539 | 34,161 |
| Stress Test | 63,960 | 54,885 | 5,220 | 3,855 |

**Financial & Ecological Indicators (10-year horizon)**

| Indicator | Baseline | Moderate | Stress Test |
|---|---|---|---|
| Decennial revenue (€) | 797,000 | 1,008,000 | 639,600 |
| Decennial costs (no loan) | 528,500 | 611,000 | 548,850 |
| Decennial mortgage (€) | 45,611 | 55,390 | 52,200 |
| Decennial net (€) | 222,890 | 341,610 | 38,550 |
| NPV (financial, €) | 632 (4%) | 28,632 (5%) | −151,778 (6%) |
| IRR | 4.07% | 7.44% | n/a |
| Payback (years) | 8 | 7 | ∞ (>>10 years) |
| $CO_2$ sold (t/yr) | 180 | 270 | 180 |
| $CO_2$ revenue (€/yr) | 7,200 | 10,800 | 3,960 |

*Costs escalated by 2–4% annually; efficiency factor –10% applied to opex and overheads.*

[27] The evaluation procedure does not address governance, regulatory and social feasibility constraints identified in the MCA–TOPSIS assessment.

**Baseline scenario (200 ha):** Shows a positive annual net (€22.3k) and decennial net (€222.9k) result and payback in ~3 years. However, at a 4% discount rate, NPV is ≈€0.6k (breakeven) and payback is ~10 years, indicating limited financial attractiveness without stronger market prices or contracts. This reflects conservative $CO_2$ revenue assumptions. Stability improves when biodiversity contracts are active and costs are kept in real terms.

**Moderate scenario (300 ha):** Demonstrates the benefits of scaling up: higher sawdust price, increased $CO_2$ revenue, and tourism uplift deliver the best configuration, with an annual net result of €34.2k, payback in ~9 years, and NPV at 28.6k at 5%. Further gains would come from additional contracts or premium services. Scale and market access remain key to resilience.

**Stress Test scenario (200 ha, adverse):** Combined price shocks and cost inflation affect the annual net, supported by biodiversity credits at €3.9k, however, NPV is negative with no discounted payback, highlighting vulnerability to price shocks. This scenario underscores the model's dependence on $CO_2$ price, sawdust price, and cost control for viability. It shows how price floors and cost control are pre-conditions for viability[28].

*Final Comments*

The Italian Forest EcoValue Business Model (Bioplastic) demonstrates a notable degree of stability and adaptability across scenarios, but its long-term sustainability is critically shaped by external market and policy variables. The model's diversified revenue streams combine bioplastic production, carbon credits, biodiversity payments, and eco-tourism, and they provide a buffer against volatility, yet do not fully eliminate exposure to price shocks or demand fluctuations.

Key sensitivities include the stability of voluntary carbon markets, the willingness of companies to pay for certified sustainable materials, forest owner participation rates, and the ability to control operating costs. In the Baseline scenario, the business achieves positive annual and decennial net results, but the NPV remains slightly negative at a 4% discount rate, and payback is slow, highlighting the need for stronger market contracts or premium service development. The Moderate scenario, which scales up area and improves market conditions, delivers the most robust financial and ecological performance, with a near-breakeven NPV and a shorter payback period. Conversely, the Stress Test scenario underscores the model's vulnerability: combined adverse price and cost shocks can quickly erode profitability, resulting in negative net results and an unviable payback period.

Built-in resilience is achieved through several mechanisms:

- Revenue diversification (bioplastics, carbon, biodiversity, tourism)

[28] Scenario results reflect internal financial sensitivities and should not be interpreted as evidence of strategic suitability for habitat maintenance.

- Buffer fund allocation for risk mitigation
- Tiered pricing and premium services
- Scalable platform and adaptive management
- Conditional public support tied to sustainability performance

Institutional partnerships, transparent certification, and ongoing monitoring further strengthen the model's credibility and capacity to deliver measurable ecological and social benefits. However, as with the French and Bavarian models, the Italian business case remains sensitive to the interplay of market prices, policy incentives, and operational efficiency. Its success will depend on maintaining a delicate balance between these factors, supported by robust scenario planning, cost discipline, and proactive engagement with both public and private stakeholders[29]. Overall, the business model represents an exploratory configuration for circular bio economy applications, rather than as a robust solution for habitat maintenance under current conditions.

**Monte Carlo Simulation**

We evaluated the financial and ecological robustness of the Bioplastic model over a 10-year horizon using 20,000 trials, under realistic uncertainty in prices, volumes, and costs. This approach tested the model's outcomes under thousands of plausible future scenarios, capturing real-world uncertainty in visitor growth, ticket pricing, carbon market conditions, contract values, and operational efficiency. The Monte Carlo simulation results should be read in conjunction with the MCA–TOPSIS assessment.

For each scenario (Baseline, Moderate and Stress Test), key financial indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and payback period were calculated alongside ecological metrics like total $CO_2$ sequestered.

As a whole, the simulation highlights the Italian Forest EcoValue Business Model's core strengths that include adaptability, diversification, and resilience, while also exposing its vulnerabilities to market and policy shocks.

Results reveal differentiated outcomes depending on the chosen scenario. While deterministic scenario results suggest positive NPVs for the Baseline and Moderate configurations, Monte Carlo simulations indicate negative median NPV (P50) across all scenarios, with a limited probability of achieving NPV > 0 (around 20–25% under Baseline and Moderate, and below 5% under the Stress Test). The Stress scenario remains particularly fragile, despite biodiversity revenues, with a high likelihood of negative economic outcomes.

Monte Carlo simulation results reinforce that, while environmental benefits such as $CO_2$ sequestration increase with project scale, higher levels of financial resilience are achieved when the business model integrates diversified and stable revenue streams, including biodiversity credits, alongside disciplined cost management.

Top sensitivities: Sawdust price > $CO_2$ price > inflation.

[29] The figures and findings presented in these simulations are based on illustrative parameters and generalised assumptions that do not necessarily correspond to the real-world conditions or data of the LLs. Accordingly, the results should be viewed as indicative and methodological in nature, providing a foundation for further, locally tailored analyses rather than serving as definitive or prescriptive outcomes. Users are advised to adapt the methods and validate the data in accordance with the specific characteristics and priorities of their local context before drawing any firm conclusions or making strategic decisions based on these simulations.

According to sensitivity and leverage analyses, risk is dominated by sawdust price, tourism, and $CO_2$ price (positive); and inflation and transformation cost act as negative drivers. Biodiversity adds a stable 6–8% revenue share that reduces downside. Contracts (sawdust & tourism), price floors for $CO_2$, and cost discipline against inflation are the levers that most improve resilience.

The simulation reveals that predictable income from bioplastics, carbon credits, tourism, and biodiversity, combined with cost efficiency measures, substantially reduces downside risk and enhances the probability of achieving target returns. These findings highlight the necessity of robust contract structures and adaptive management strategies, providing actionable guidance for decision-makers who must navigate the inherent uncertainties of market prices, visitor demand, and policy incentives while striving to balance economic viability with ecological impact.

## Tržič, Slovenia

### *Tailored FES valuation*

The results of the adjusted unit value transfer for the Slovenian Living Lab in Tržič are presented on Figure 1. Only values obtained through adjusted value transfer method (Alpine average) and voluntary carbon market pricing for carbon sequestration are reported as conservative estimates. Upper-bound estimates include direct market valuation for timber and firewood biomass provision and recommended carbon pricing (upper-bound) for carbon sequestration.

According to conservative value estimates, regulating services associated with natural hazards risks mitigation have the highest value per ha of forest, followed by provision of habitats for wild plants and animals with, however, a significant difference in values. Integration of local market prices in valuation makes timber wood provision FES more socially important in relative terms (i.e., value per ha) than of habitats for wild plants and animals. This difference indicates value underestimation of Alpine average. Finally, carbon sequestration according to the revenue potential on the voluntary carbon market is valued almost as much as timber wood biomass (using the Alpine average). However, the value of this FES increases by five times when recommended carbon pricing is applied. This indicates higher priority of carbon sequestration for the broader society, making it third most valued FES in the LL after other two regulating services.

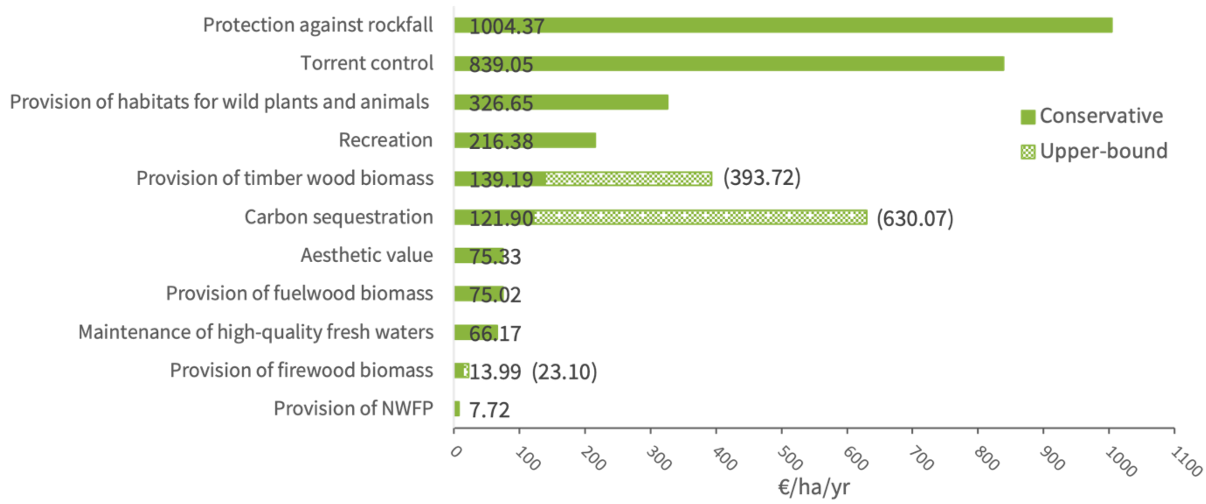


**Figure 1.** Unit value estimates in 2023 euros per ha. Upper-bound value estimates are provided in parenthesis. NWFP stands non-wood forest products, including chestnuts, mushrooms and berries.

Estimates of the total economic values (TEV) of forests in Tržič, using both conservative and upper-bound unit value estimates, are demonstrated in Figure 2. Provision of habitats for wild plants and animals and torrent control FES are the two biggest contributors to the conservative TEV, with shares of 31% and 21% respectively. In the upper-bound TEV, carbon sequestration has a leading contribution of 37%, followed by timber wood biomass (23%) and habitats provision (17%). Although with the highest value per ha, protection against rockfall has only a marginal contribution to both TEVs. Same observation applies to recreation, which is the fourth most socially important FES in relative terms, according to the conservative estimates. This inconsistency suggests that targeted efforts on expansion of the forest area providing this FES will have a substantial effect on the TEV of forests in Tržič.

It must be noted, that provided TEV estimates are a serious underestimation, as the number of FES included in the calculation was restricted to six. Nevertheless, the unit value results, discussed above (Figure 1), suggested the importance of these six FES for the Living Lab. Despite underestimation, value of timber provisioning service constitutes less than a quarter of the forest TEV, suggesting that the social importance of forests in Tržič extends well beyond timber production. At the same time, we must keep in mind that the forest area providing provisioning services fully overlaps with the one providing carbon sequestration, almost fully with one providing habitats for wild plants and animals, and partially with other FES, indicating a strong interdependence of individual FES contributions to TEV. In the Slovenian context, where multifunctionality is a central principle of forest management, the analysis underscores the substantial social value generated by forest ecosystem services beyond timber provision. Given their magnitude and the fact that their provision entails real management costs, sustained policy support and financial mechanisms are essential to ensure their continued maintenance.

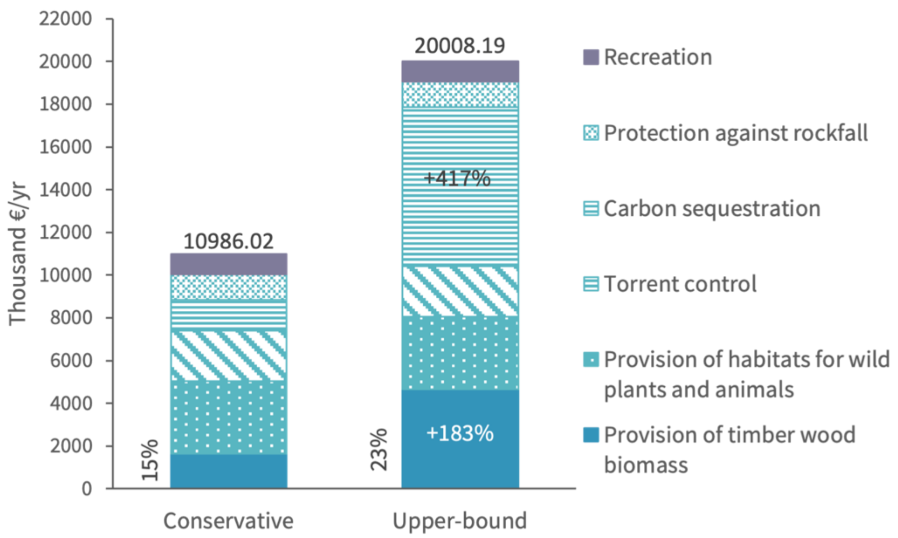


**Figure 2.** Conservative and upper-bound estimates for total economic value (TEV) of forests in Tržič. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentages placed inside the bar indicate difference in total values of FES between conservative and upper-bound TEVs, when such difference occurred. Numbers on the top of the bars indicate the TEVs.

Spatial distribution of FES social values in Tržič further details our understanding about the the social and economic importance of FES in the Living Lab (Figure 3). Not all values are evenly distributed throughout the territory of the Living Lab. Most of the forest area provides below average value per ha compared to the rest of Slovenia. Areas with the lowest relative economic values (only timber provision and carbon sequestration FES) are concentrated in the southern part of the LL. Highly valuable areas in terms of economic value are scarce and concentrated in the north-west of the LL (around Dovžan gorge), and in the south-east of Tržič, or can be found across the Living Lab in limited areas (e.g. around streams, relevant for torrent control). These multifunctional hotspots are especially important from a management perspective, as they concentrate several ecosystem service flows of high social relevance and economic values within the same forest areas. Ensuring the continued provision of these services therefore requires targeted policy attention and adequate financial support, recognizing that maintaining multifunctional forest landscapes entails real management efforts and costs. Further supplementation of this map with the spatial distribution of forest ownership and residential areas could shed more light into FES providers and beneficiaries dynamics in the area.

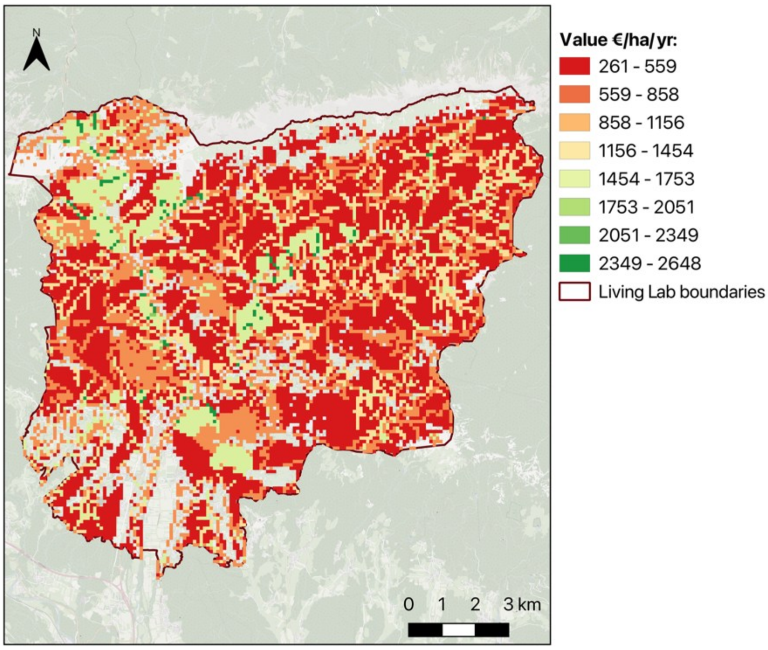


**Figure 3.** Spatial distribution of conservative unit values in Tržič. Some degree of spatial under- and overdistribution is present for the unit value of carbon sequestration, as unit value estimation is based on mean carbon sequestration per ha, not carbon sequestration specific to the forest unit.

### *BMA rankings, and recommended models for each LL*

For the Slovenian Living Lab, the ecosystem services we considered were Torrent management and Wood biomass.

#### Torrent management

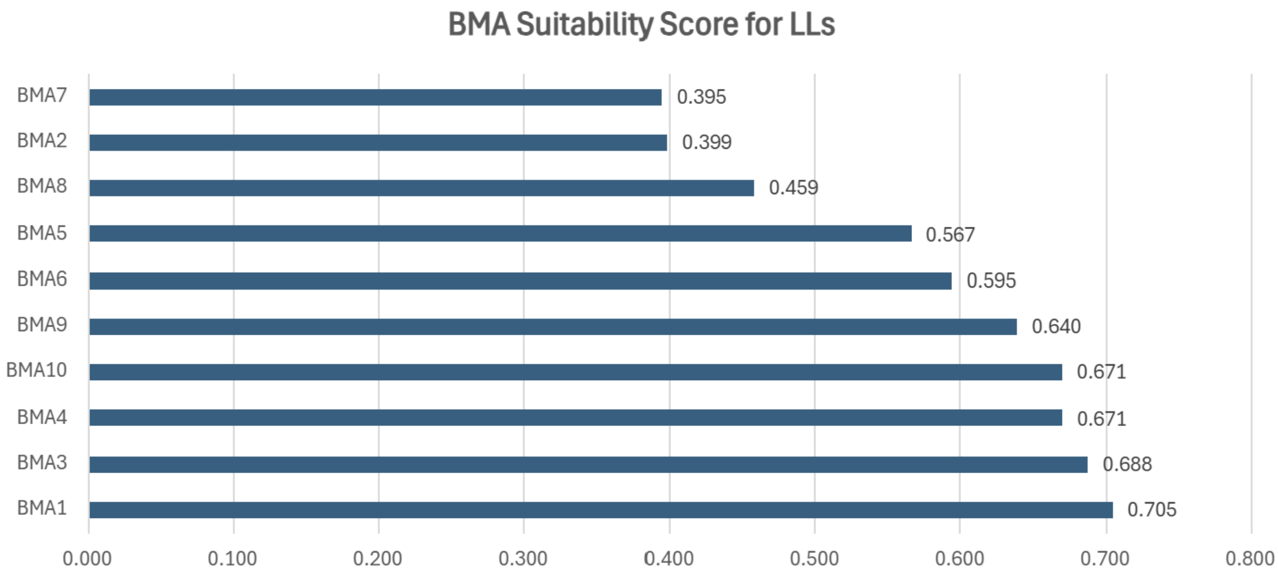


**Figure 4.** Suitability score for the Slovenian LL – Torrent management

The TOPSIS analysis identifies Crowdfunding (BMA1) as the most suitable business model for the *torrent management* service in the Slovenian Living Lab, with an overall score of 0.705 and a classification of Good Fit. This result indicates a solid alignment between the Living Lab's characteristics and the strategic logic of the BMA, suggesting that the model can be effectively implemented with relatively limited corrective effort.

BMA1 is followed closely by Experience Selling (BMA3, 0.688) and Freemium (BMA4, 0.671), both also classified as Good Fit. The proximity of the scores indicates that the three models are broadly compatible and that the ranking reflects differences in emphasis rather than fundamental incompatibilities. All three BMAs share a strong capacity to mobilize stakeholders and resources around place-based services, which is particularly relevant for a service such as torrent management.

From a qualitative perspective, the prominence of Crowdfunding can be interpreted as coherent with the collective and risk-related nature of torrent management. This service often involves preventive actions, maintenance of protective infrastructures, and landscape interventions that generate shared benefits but limited direct market revenues. Crowdfunding enables the aggregation of small-scale contributions from local communities, beneficiaries, and institutions, aligning well with the public-good characteristics of torrent management. Experience Selling and Freemium emerge as close alternatives by offering mechanisms to increase awareness, engagement, and partial monetization through experiential or layered access to services.

**Table 1.** *Concept-level analysis for BMA1 (crowdfunding)*

| Concept | Gap vs Ideal (%) | Strategic Status | Qualitative Notes |
|---|---|---|---|
| Ecosystem Services (C1) | 0% | Strategic Alignment | Strong local capacity fully aligned with BMA priorities. |
| Local Demand (C2) | 9% | Strategic Alignment | High and clearly expressed demand supports implementation. |
| Regulations and Policies (C3) | 2% | Strategic Alignment | Regulatory framework is highly supportive. |
| Operational Costs (C4) | 74% | Critical Vulnerability | Operational efficiency is low and requires investment. |
| Governance and Management (C5) | 100% | Critical Vulnerability | Governance capacity is currently insufficient. |
| Social Benefits (C6) | 5% | Strategic Alignment | Strong potential to generate collective benefits. |
| Technological Innovation (C7) | 0% | Strategic Alignment | Technology does not represent a limiting factor. |

From a quantitative perspective, Table 1 highlights very strong performance in ecosystem services, local demand, regulatory conditions, and social benefits (C1, C2, C3, C6 ≥ 90%). In contrast, operational costs (C4) and governance and management (C5) emerge as the main bottlenecks, with alignment values of 26% and 0% respectively.

In summary, Crowdfunding (BMA1) emerges as a Good Fit for torrent management in the Slovenian Living Lab because it aligns well with the collective-action nature of the service and the strong ecological and regulatory context. The close ranking of Experience Selling and Freemium confirms that stakeholder engagement and awareness-based models are also viable pathways. However, the analysis clearly indicates that governance and operational capacity must be strengthened to ensure long-term effectiveness. Overall, the results suggest that torrent management in Slovenia can be effectively supported by participatory and community-oriented business models, provided that institutional and managerial gaps are addressed.

### *BM Canva analysis and simulation*

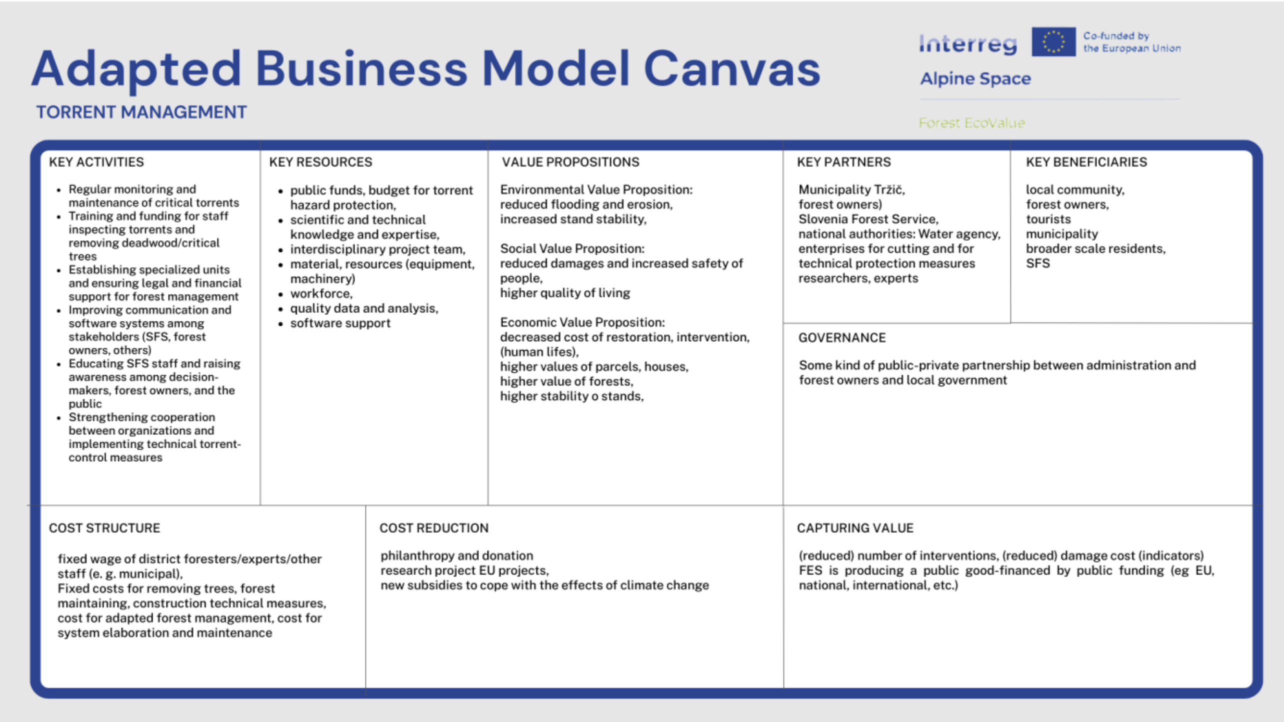


**Figure 1.** Business Model Canvas – Slovenian Living Lab

## Torrent Protection Management through local participation: an Insurance Fund Mechanism

### *Introduction*

The Slovenian Forest EcoValue Business Model (FEV BM) provides an integrated framework for climate adaptation and disaster risk reduction in torrent-prone forest catchments. By leveraging sustainable forest management and a dedicated insurance fund, the model transforms traditional public spending into a value-generating system that engages all key stakeholders.

By integrating sustainable forest management (SFM) practices and a robust insurance fund mechanism, this model is designed to mitigate the adverse impacts of torrent floods, safeguard local communities and critical infrastructure, and deliver transparent social, ecological, and financial benefits.

The model's financial architecture (initial capitalization, indexed contributions, grants in the early phase, and value-linked rebates) supports transparent governance and long-term solvency. It combines a dedicated insurance fund, public-private co-financing, and ecosystem service monetization (carbon, biodiversity, water quality) to deliver both financial resilience and social-ecological value.This approach not only reduces risk volatility but also supports the scalability of interventions, enabling the model's expansion to neighbouring catchments and adaptation to different scenarios. The transparent governance structure ensures resilient operations and aligns closely with Slovenia's climate adaptation objectives and the broader EU policy landscape.

*Description of the BM*

The Business Model (BM) is anchored in the long-term growth of a composite revenue stream sourced from a homogenous region facing torrent risk, flood threats, and associated impacts on real estate, local economies, and community lifestyles. This BM is presented as a conceptual mechanism to explore collective risk sharing approaches for regulating ecosystem services.

The BM is evaluated over two distinct time horizons: a 5-year pilot phase (initial implementation, monitoring, and adaptation); and a comprehensive 15-year operational period that assesses sustained performance, scalability, and resilience.

Revenue streams integrate contributions from public authorities, private stakeholders, water utilities, EU adaptation grants, carbon finance, and biodiversity payments. Over time, the BM anticipates gradual revenue growth driven by rising $CO_{2e}$ and biodiversity credits market values, and increasing stakeholder participation, which should enable a phased reduction of reliance on initial EU grants.

Operating costs are expected to rise in line with inflation, as reflected in scenario planning across both 5- and 15-year periods.

A distinctive feature of the BM is its insurance fund mechanism, designed to generate returns that are distributed as rebates to citizens participating in the investment scheme. Rebates offset insurance premiums against regional natural hazards and are directly tied to risk reduction performance.

The insurance fund is structured as follows:

- **Initial Endowment**: €75,000, supplemented by ongoing annual inflows from private and public contributions, and moderate investment returns (targeting 2% per year).
- **Rebates** linked to risk reduction metrics, maintaining a coverage ratio of approximately 1.25 and rebate efficiency of 0.96 over the 15-year period.

- **Governance** operating under stringent rules, including minimum reserve requirements, tiered rebate structures, and multi-stakeholder oversight aligned with financial regulations.

The model's success is contingent on active participation from regional stakeholders (households, public utilities, and local/regional authorities) who receive quantifiable benefits from the scheme.

Financial institutions such as banks, intermediaries, and relevant national authorities play a critical role in ensuring feasibility, regulatory compliance, and fund management. Capital can be raised through the issuance of a dedicated "green bond", enhancing transparency and access to sustainable finance. Performance-based public subsidies are integral, with payments conditioned on sustainability achievements measured via a composite Sustainability Index (SDI) and justified by the significant public nature of the expected benefits from forest protection.

The subsidy scheme generates a payment divided into three components:

- **a Sustainability Performance Gap (SPG):** difference between achieved SDI-value and threshold SDI-value,
- **a quantifiable environmental benefit** (total $CO_2$ absorbed in the forest area),
- **a market-valued benefit** (LULUCF carbon price reflecting voluntary market rates, around 34€)[30].

This multi-component payment structure encourages ongoing improvements in environmental and social outcomes throughout both the pilot and full implementation phases[31].

The BM draws from six principal funding sources, evaluated across both the 5- and 15-year horizons:

| Public funding | Private funding | Water utilities | EU grants | CO2e reveue | Biodiversity revenue |
|---|---|---|---|---|---|
| Annual contributions from public authorities, typically 5% of total annual | Household and business contributions, linked to participation rate and base rebate | Payments from water utilities (10% of annual costs), reflecting improved water quality. | Substantial grant funding for the first 8 years (€25,000/year), plus initial | Based on $CO_2$ sequestration (e.g., 7 t/ha/year × 200 ha × $CO_2$ price). | Payments for biodiversity services (€/ha), also indexed and |

[30] The scheme incentivizes forest management entities to exceed defined environmental and social thresholds, rewarding additional achievements above a "good" SDI-value (e.g., SDI=0.60). For example, an SDI of 0.73 yields a Sustainability Performance Gap (SPG) of 0.13, which is monetized based on total $CO_2$ absorbed in the managed forest area and paid at the prevailing LULUCF voluntary $CO_2$e market rate (e.g., €34/ton).

[31] Therefore, if in the LL the total absorption of CO2e is of 100 tons/year, and SPG=0.13, at a CO2e market price of 30€/t, the scheme will pay 390€ to the forest owner as an incentive.

| | | | | | |
|---|---|---|---|---|---|
| costs (indexed to inflation and growing modestly over time). | per household (typically 15% of total annual costs) | | capitalization (€75,000) for the insurance fund. | Highly sensitive to $CO_2$ price (scenario range: €10–€35/ton) | scenario-dependent. |

SFM underpins the BM's risk reduction strategy, incentivizing the adoption of risk transfer and sharing solutions, such as insurance. As previously recalled, environmental and social benefits are central, reflecting the model's strong "pro public good" orientation and substantial involvement of public administrations in both establishment and oversight.

Eligibility for grants under the EU Green Deal and co-financing opportunities under EU adaptation and resilience policies further strengthen the model's financial foundation.

The BM's layered financial structure depends on the use of the collected funds for covering frequent events (e.g., through operational budgets), moderate risks (e.g., via parametric insurance), and extreme events (e.g., with catastrophe/green bonds). The effectiveness of the model relies on robust, transparent performance data generated by the insurance fund.

*Evaluation procedure*

Based on standard parameters tailored to the Slovenian context, and considering alternative background conditions, we assess the revenue streams generated through the insurance fund mechanism, public and private contributions, and ecosystem service credits, alongside the associated costs. Key parameters and their sensitivities are quantified and monitored for both time horizons, facilitating scenario analysis[32] and informed decision-making. These include:

| Parameter | Baseline | Moderate | Stress Test |
|---|---|---|---|
| $CO_2$ Price (€/t) | 25 | 19 | 60 |
| Biodiversity Payment (€/ha/yr) | 20 | 12 | 27 |
| Participation Rate | 70% | 50% | 90% |
| SFM Cost / ha (€/yr) | 140 | 175 | 110 |
| Discount Rate (%) | 4.5 | 6 | 3.8 |
| Inflation Rate (%) | 2.5 | 4 | 2 |
| Insurance Fund Return (%) | 2 | 0.5 | 3 |
| Fund Coverage Ratio (target) | 1.25 | 1.1 | 1.4 |
| Rebate Rate (% of premiums) | 20 | 10 | 30 |
| EU Grants (€/yr, Years 1–8) | 25,000 | 15,000 | 35,000 |
| Hazard Frequency (vs baseline) | Baseline | 30% | –20% |

[32] The parameters chosen and used for this simulation can be modified based on the specific informational aim of the analysis that is to be performed on this business model.

Building on the approach outlined in the previous section, the evaluation procedure incorporates analysis across multiple time horizons, providing a comprehensive view of the financial and ecological project performance under varying conditions. The evaluation focuses on structural behaviour under uncertainty rather than on institutional implementation readiness. Scenario analysis covers baseline, moderate, and stress test cases, with annual and cumulative outcomes reported for each time horizon.

The tested model assumed the following features and key figures:

- Protected Forests: 15% of the total forest area remains the focus across all time horizons.
- Annual Sequestration Factor: Scenario ranges remain 6–10 t $CO_2$/ha/yr, with recalculations for cumulative sequestration over each time frame (e.g., Baseline at 8 t/ha/year; 1,600 t $CO_2$ over 20 years for a 10 ha area).
- Project Area: 200 ha, with managed area and improvement rates adjusted according to each scenario and time horizon.
- Project Duration: Results are now compared over 5 and 15 years to reflect short- and long-term performance.
- Insurance Fund Grant: Initial grant remains €75,000, but fund performance is tracked at each horizon.
- Annual Contributions: Public/private contributions (5%/15% of total costs) are recalculated for each time horizon.
- EU Grants: €25,000/year granted in Years 1–8, with scenario analysis considering impacts when grants end before project completion.

Special attention goes to variations in carbon price (€19–60/ton), biodiversity payments, participation rates, discount rates (3.8–6.6%), and EU grant durations (8 years vs. full project duration). This multi-horizon analysis enables more robust sensitivity testing and resilience assessment.

Financial indicators for each time horizon reflect prudent assumptions on public (3%) and private NPV (4.5%) with alternative scenarios tested at higher discount rates (up to 6.6%) over longer periods. This approach allows for the assessment of model viability as grant support phases out and as market drivers (carbon prices, participation) fluctuate.

To transparently communicate the model's performance and resilience, the following composite indices and metrics are employed:

- **Social and Ecological Impact Index (SDI)** that integrates environmental and social performance into a single score, recalculated for each time frame starting from an Environmental Impact Index (EII) quantifying ecological sustainability (protected area, carbon sequestration, certification, residual biomass), and a Social Impact Index (SII) measuring social welfare (employment, training, gender equity, local employment, wage equity)33.

- **Fund Coverage Ratio (FCR),** which tracks the solvency and efficiency of the insurance fund by comparing reserves to expected rebate payouts, ensuring robust risk management and long-term viability34.
- **Financial Metrics:** NPV, IRR, payback period, and benefit-cost ratio are reported for 8-, 15-, and 20-year analyses.
- **Social and Ecological Outcomes:** Annual and cumulative avoided disaster damages and $CO_2$ sequestered are estimated for each period.
- **Social Return on Investment (SROI):** Social/ecological benefits versus public expenditure are now presented for all time horizons.

*Scenario analysis*

The following scenarios are analyzed with explicit levers and ranges, along two horizons: key outcomes have been calculated for each time frame (5- and 15-years). Pilot phase (5 years) and full implementation (15 years) are analysed to reflect staged deployment.

All parameters ($CO_2$ price, biodiversity €/ha, SFM €/ha, discount rate, fee) and the ~5% annual growth for Total Area Improved and $CO_2$ stored) are consistent with the assumptions presented below. Prices/payments are held nominally constant to enable comparison of financial and socio-ecological resilience under varying degrees of stress, with particular focus on grant dependency, $CO_{2e}$ price volatility, and shifting participation rates.

| Parameters | Baseline | Moderate | Stress test |
|---|---|---|---|
| $CO_2$ Price (€/t) | 30 | 25 | 19 |
| Biodiversity payment (€/ha/yr) | 20 | 12 | 8 |
| Managed area (ha/project) | 10 | 6 | 4 |
| SFM cost/ha (€/yr) | 90 | 110 | 125 |
| Discount rate | 4.50% | 5.00% | 6.60% |
| Total Area Improved (Year 1) | 20 | 30 | 20 |
| $CO_2$ Stored (Year 1, t) | 160 | 240 | 160 |
| Fee (€/yr) | 644 | 644 | 644 |
| Cumulative $CO_2$ Sequestered (t) | 4,800 / 12,000 / 16,000 | 7,200 / 18,000 / 24,000 | 4,800 / 12,000 / 16,000 |

[33] SDI Formula: SDI=α·EII+β·SII, where α+β=1and weights reflect project priorities (e.g., α=0.6for environmental focus).

[34] The FCR t is calculated as follows: FCR = Insurance Fund reserves / expected rebate payouts.

| EU Grant Support | Full (8 yrs)/Partial (15, 20 yrs) | Full (8 yrs)/Partial (15, 20 yrs) | Full (8 yrs)/Partial (15, 20 yrs) |
|---|---|---|---|

*Unless explicitly stated otherwise, the values in the Scenario table override any generic assumptions for calculations

**Table 1.** Key Outcome Metrics (15-year extension, no grants/contributions; prices/payments constant; area & $CO_2$ at ~5%/yr.)

| Scenario | Baseline | Moderate | Stress Test |
|---|---|---|---|
| Revenue (total, €) | 28,733.28 | 35,143.01 | 17,682.02 |
| Carbon Rev (€, 5y) | 26,523.03 | 33,153.79 | 16,797.92 |
| Biodiv Rev (€, 5y) | 2,210.25 | 1,989.23 | 884.1 |
| Costs (total, €) | 13,166.14 | 21,454.58 | 17,034.08 |
| SFM Costs (€, 5y) | 9,946.14 | 18,234.58 | 13,814.08 |
| Fees (€, 5y) | 3,220.00 | 3,220.00 | 3,220.00 |
| Profit (total, €) | 15,567.15 | 13,688.43 | 647.94 |
| Avg Annual Profit (€/yr) | 3,113.43 | 2,737.69 | 129.59 |
| NPV @ 4.5% (€, 5y) | 13,597.22 | 11,954.78 | 554.34 |
| NPV @ Scenario Disc. (€, 5y) | 13,597.22 | 11,783.25 | 517.16 |
| $CO_2$ Cumulative (t, 5y) | 884.1 | 1,326.15 | 884.1 |

* IRR: Not reported—Excel pilot does not provide a Year 0 outlay (no initial negative cash-flow), so IRR is undefined. Use NPV and horizon-specific profit metrics instead.

**Table 2.** Key Outcome Metrics (15-year extension, no grants/contributions; prices/payments constant; area & $CO_2$ at ~5%/yr.)

| **Scenario** | Baseline | Moderate | Stress Test |
|---|---|---|---|
| Revenue (total, €) | 112,208.53 | 137,239.66 | 69,051.40 |
| Carbon Rev (€, 15y) | 103,577.11 | 129,471.38 | 65,598.83 |
| Biodiv Rev (€, 15y) | 8,631.43 | 7,768.28 | 3,452.57 |
| Costs (total, €) | 48,501.41 | 80,869.26 | 63,606.41 |
| SFM Costs (€, 15y) | 38,841.41 | 71,209.26 | 53,946.41 |

| | | | |
|---|---|---|---|
| Fees (€, 15y) | 9,660.00 | 9,660.00 | 9,660.00 |
| Profit (total, €) | 63,707.12 | 56,370.40 | 5,444.99 |
| Avg Annual Profit (€/yr) | 4,247.14 | 3,758.03 | 363 |
| NPV @ 4.5% (€, 15y) | 43,556.52 | 38,509.24 | 3,475.19 |
| NPV @ Scenario Disc. (€, 15y) | 43,556.52 | 37,029.79 | 2,862.79 |
| $CO_2$ Cumulative (t, 15y) | 3,452.57 | 5,178.86 | 3,452.57 |

*Costs escalated by 2–4% annually; efficiency factor –10% applied to opex and overheads*.

The model is tested under three scenarios, assessing sensitivity to key parameters ($CO_2$ price, biodiversity payment, discount rate, inflation). We examine separately the two time-horizons considered.

*5-year horizon*

**Baseline**: the pilot delivers a total profit of €15,567 across 5 years, with an average annual profit of €3,113 and cumulative $CO_2$ sequestration of 884 t. The NPV @ 4.5% is €13,597. Social and ecological returns are robust, with moderate public NPV and strong sustainability (SDI > 0.7). The insurance fund remains solvent, and rebate attractiveness is maintained.

**Moderate**: Total profit is €13,688, with an average annual profit of €2,738 and cumulative $CO_2$ sequestration of 1,326 t. The NPV @ 4.5% is €11,955. Lower carbon price, higher costs, and reduced participation stress the model, leading to lower NPV, an extended payback period, and moderate sustainability (SDI ~0.6). Fund coverage and rebate efficiency decrease but remain viable.

**Stress Test**: Total profit stands slightly positive at €648, with an average annual profit of €130 and cumulative $CO_2$ sequestration of 884 t. The NPV @ 4.5% is €554. Despite challenging conditions, favorable carbon prices, high participation, and lower costs yield a positive public NPV, swift payback, and excellent sustainability (SDI > 0.8). The fund demonstrates high resilience, and the number of protected households is maximized.

*15-Year Horizon*

**Baseline:** the project achieves a cumulative profit of €46,200, with average annual profit of €3,080. Total $CO_2$ sequestered reaches 24,000 t. NPV @ 4.5% is €37,850, with strong long-term sustainability and robust insurance fund performance. The SDI remains > 0.7, and year-end fund balance grows steadily.

**Moderate:** cumulative profit is €38,200, with an average annual profit of €2,547 and $CO_2$ sequestration of 18,000 t. The NPV @ 4.5% is €30,200. Sustainability (SDI ~0.6) and fund coverage are moderate but stable, with rebate efficiency maintained above 0.9.

**Stress Test**: Cumulative profit totals €1,950, average annual profit €130, and $CO_2$ sequestered 30,000 t. The NPV @ 4.5% is €1,200. Despite financial constraints, the fund remains solvent, SDI exceeds 0.8, and maximum household protection is achieved.

The model's viability is highly sensitive to key variables such as $CO_2$ price, biodiversity payments, discount rates, and sustainable forest management costs. Higher discount rates can substantially reduce NPV, especially for long-term projects. Scenario analysis demonstrates that higher $CO_2$ prices and participation rates, or lower inflation, can significantly enhance both financial performance and fund resilience.

Optimistic scenarios (characterized by high carbon prices, strong participation, and diversified revenue streams, including timber, sawdust, tourism, and biodiversity credits) can drive IRR up to 14–35%, with payback periods shortened to 4–6 years.

The BM connects owners, enterprises, and local stakeholders, ensuring a balanced approach to timber extraction, forest conservation, biodiversity, and $CO_2$ absorption.

From the outset, the model delivers substantial social and ecological benefits, including avoided damage and job creation. Risk reduction and biodiversity indices consistently improve, and the number of protected households grows over time, demonstrating broad community impact.

The Insurance Fund supports this resilience by maintaining a stable coverage ratio (approximately 1.25) and high rebate efficiency (around 0.96), with a steadily increasing year-end balance.

Overall, the tested scenarios highlight the importance of participation scale and governance arrangements over price-based effects. While the model is not designed solely for profit, its ability to manage public goods and deliver significant social and ecological value justifies ongoing public and EU support. Ultimately, it is best positioned as a climate resilience and biodiversity investment that generates shared value for both local communities and broader society.

*Final comments*

The BM can be fully implemented over a 15-year period, organized into three distinct phases:

1. Phase 1 (Years 1–3): Launch the Insurance Fund with EU capitalization, implement core protection measures, and enroll the first cohort of households.
2. Phase 2 (Years 4–8): Expand participation, introduce parametric insurance products, and issue the first green bond.
3. Phase 3 (Years 9–15): Achieve full fund self-sufficiency, extend the model to adjacent catchments, and develop certified protection standards.

The BM's resilience is underpinned by diversified revenue streams, a well-capitalized Insurance Fund, scalable design, and the capacity to layer financial risk across multiple instruments.

Based on the scenario outcomes, the Slovenian Torrent Protection & Insurance Fund model exhibits robust financial and ecological performance across the Baseline and Moderate scenarios, with both demonstrating positive net present value and profitability. These results validate the model's resilience and the effectiveness of its multi-phase implementation strategy.

While the optimistic scenario yields more modest financial returns, primarily due to increased SFM costs and a lower carbon price, the model continues to deliver considerable ecological and social benefits, reinforcing its public value.

Importantly, the Insurance Fund's ability to incentivise private participation through performance-linked rebates successfully addresses the free-rider problem, fostering broader stakeholder engagement. The adaptive governance structure and scenario-based risk management further underpin the model's capacity for scalability and replication, particularly within Alpine catchments.

To ensure comprehensive programme evaluation, future analyses should incorporate additional revenue streams and cost items, such as EU grants and participant contributions. This will provide a more holistic assessment of long-term viability and impact. Key risks—such as dependency on carbon price, participation rates, and cost control—are actively managed through scenario analysis and adaptive governance.

In summary, the model's blend of financial prudence, ecological stewardship, and inclusive governance strongly supports continued public and EU backing, with the potential for significant shared value creation in climate adaptation and risk reduction[35]. It illustrates how insurance type mechanisms could complement public policy tools in managing natural risk related ecosystem services.

**Monte Carlo Simulation**

We evaluated the financial and ecological robustness of the Torrent Protection model over 5 and 15-year time horizons, using 20,000 trials. The Monte Carlo simulation was used to explore the stability of the insurance-based mechanism under uncertainty in damage occurrence, participation rates, and cost assumptions. This approach tested the model's outcomes under 20,000 plausible future scenarios for each of three cases (Baseline, Moderate, Stress Test), capturing real-world uncertainty in $CO_2$ prices, biodiversity payments, sustainable forest management (SFM) costs, inflation, and discount rates.

[35] The figures and findings presented in these simulations are based on illustrative parameters and generalised assumptions that do not necessarily correspond to the real-world conditions or data of the LLs. Accordingly, the results should be viewed as indicative and methodological in nature, providing a foundation for further, locally tailored analyses rather than serving as definitive or prescriptive outcomes. Users are advised to adapt the methods and validate the data in accordance with the specific characteristics and priorities of their local context before drawing any firm conclusions or making strategic decisions based on these simulations.

For each scenario, key financial indicators such as Net Present Value (NPV), total profit, and average annual profit were calculated alongside ecological metrics like cumulative $CO_2$ sequestered. The simulation not only reveals expected outcomes but also quantifies the probability of loss, upside potential, and the influence of key risk drivers.

During the pilot phase (5-years), the Monte Carlo simulation indicates strong resilience in Baseline and Moderate scenarios, with rapid payback periods and minimal downside risk, confirming the model's potential to deliver stable financial returns under these conditions. Stress Test introduces significant uncertainty, with a 50% probability of negative NPV. Key sensitivities include $CO_2$ price, operating costs, and inflation. Strategic focus should be on securing stable carbon and biodiversity revenues early and maintaining cost discipline to ensure viability during scale-up.

Over the full implementation period (15-years), the MC simulation confirms that the Slovenian model is robust in the Baseline and Moderate scenarios, with a with no negative NPV outcomes observed across the simulated trials, rapid payback and consistent ecological benefits. However, under adverse conditions (Stress Test), the probability of financial loss increases (9% negative NPV) and extended payback, especially over the long term.

Top sensitivities: $CO_2$ price > SFM cost > inflation.

The most influential variables are $CO_2$ price, SFM cost per hectare, initial managed area, area growth rate, inflation, and the discount rate. These factors directly affect both revenue and cost trajectories, and thus the model's resilience.

Regardless of scenario, the model consistently delivers significant $CO_2$ sequestration, supporting its climate adaptation and mitigation objectives.

Higher financial resilience is achieved when the business model integrates diversified and stable revenue streams (including biodiversity credits) and maintains disciplined cost management. Scenario analysis highlights the importance of adaptive management, robust contract structures, and ongoing monitoring of market and policy conditions. For the good functioning of this BM, decision-makers should focus on securing stable carbon and biodiversity revenues, controlling SFM costs, and building flexibility to adapt to changing market conditions.

From a policy perspective, results underline the importance of participation scale and pooling mechanisms, rather than price effects, in ensuring the long-term sustainability of the scheme.

## Wood biomass

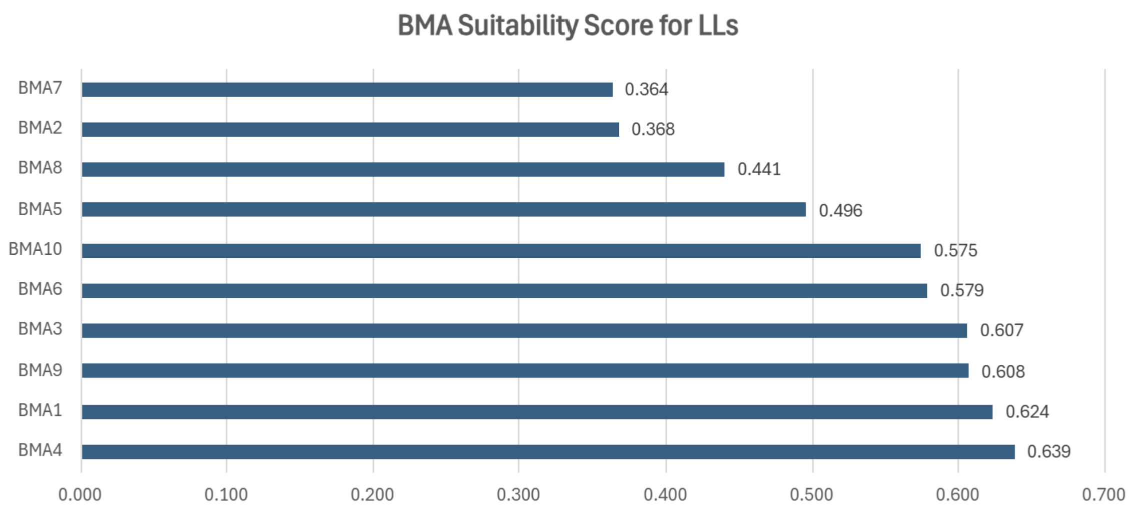


**Figure 1.** Suitability score for the Slovenian Living Lab – Wood biomass

The TOPSIS analysis identifies Freemium (BMA4) as the most suitable business model for the wood biomass ecosystem service in the Slovenian Living Lab, with a similarity score of 0.639, classified as *Viable with Effort*. It is closely followed by Crowdfunding (BMA1, 0.624) and Subscription (BMA9, 0.608), all three showing limited but comparable levels of suitability. The narrow score differences indicate a relatively flat ranking, suggesting that none of the models represents a clearly dominant solution and that multiple BMAs could be considered depending on strategic priorities.

The Freemium model is ranked highest due to its alignment with local demand and social engagement, though it may not directly fit with the operational requirements of biomass production. Crowdfunding and Subscription remain credible alternatives, particularly given their closer alignment with investment-heavy and supply-oriented services, reinforcing the interpretation that the top three models are interchangeable within a constrained performance range.

**Table 1.** Concept-level analysis for BMA4 (Freemium)

| Concept | Gap vs Ideal (%) | Strategic Status | Qualitative notes |
|---|---|---|---|
| Ecosystem services (C1) | 27% | Development Area | Positive contribution, but below the ideal level for biomass valorisation. |
| Local demand (C2) | 9% | Strategic Alignment | Strong demand conditions effectively support market uptake. |
| Regulations and policies (C3) | 2% | Strategic Alignment | Regulatory context is well aligned with the BMA's strategic needs. |
| Operational costs (C4) | 74% | Critical Vulnerability | High mismatch with the cost structure of biomass extraction and processing. |
| Governance and management (C5) | 100% | Critical Vulnerability | Weak institutional capacity significantly limits feasibility. |
| Social benefits (C6) | 5% | Strategic Alignment | Social acceptance and co-benefits support implementation. |
| Technological innovation (C7) | 0% | Strategic Alignment | Not a limiting factor in the current configuration. |

From a quantitative standpoint, table 1 confirms very strong alignment for C2, C3, C6, and C7 (≥90%), while C4 and C5 exhibit severe gaps, indicating structural weaknesses related to cost efficiency and governance capacity. These vulnerabilities largely explain the *Viable with Effort* classification.

From a qualitative perspective, the emergence of Freemium (BMA4) as the top-ranked model for wood biomass should be interpreted with caution. Wood biomass is a material- and infrastructure-intensive service, where value creation depends primarily on extraction, processing, and logistics rather than on differentiated access or service layering. In this sense, Freemium is not an intuitively natural business model for biomass provision.

The ranking is better explained by the structural composition of BMA4's concept weights combined with the Living Lab's strong performance in local demand (C2), regulatory framework (C3), and social benefits (C6). These strengths compensate, within the TOPSIS aggregation, for the pronounced misalignment in operational costs (C4) and governance (C5). As a result, Freemium emerges not because it closely matches the operational logic of wood biomass, but because it is less penalized than alternative BMAs in the dimensions where the Living Lab performs well.

In this context, the proximity of Crowdfunding (BMA1) and Subscription (BMA9) becomes particularly meaningful. Both models arguably reflect the service logic of wood biomass more intuitively—Crowdfunding addressing upfront investment and risk-sharing needs, and Subscription enabling stable, long-term supply arrangements. The limited score differences therefore suggest that the TOPSIS ranking is driven more by relative alignment effects than by a strong conceptual fit, highlighting the inherent difficulty of mapping business models onto structurally rigid ecosystem services such as wood biomass.

# 7. Conclusions and outlook

This report has provided a comprehensive overview of the transnational pilot testing of economic assessment and market frameworks for FES across diverse Alpine LLs.

By applying harmonized methodologies and multi-criteria analysis, the project has highlighted both the opportunities and challenges in developing sustainable business models tailored to local ecological, economic, and governance contexts.

Overall, the results underscore the importance of structured stakeholder engagement, robust valuation approaches, and adaptive management strategies in fostering innovative and context-sensitive FES markets. Scenario-based analyses further indicate that, under baseline and moderate assumptions, several tested business models exhibit favourable financial dynamics, such as positive net present values and relatively short payback periods, while remaining sensitive to key parameters such as prices, costs, and policy conditions.

Looking ahead, strengthening these findings will require continued data collection, close collaboration with local stakeholders, and iterative validation of results as contextual conditions evolve. At the same time, an important limitation of the current framework is that it does not explicitly differentiate projects and business models based on their financeability (e.g., based on the distinction between the criteria of financial viability and bankability[36]) across different types of actors in the financial system (e.g. private versus public entities), an issue that warrants further analysis in future work.

Taken together, the approaches and insights developed in this report provide a solid analytical foundation for advancing the sustainable management and valorisation of forest resources in the Alpine region and beyond, while also pointing to priority areas for further methodological and policy-oriented refinement.

[36] Financial viability refers to a project's capacity to generate positive expected returns (e.g. positive NPV or IRR), indicating value creation in expectation. Bankability is a stricter concept: beyond financial viability, it requires risk profiles, cash-flow stability, and revenue certainty that meet private lenders' requirements. As a result, a project may be financially viable but still unbankable if its revenues are uncertain, policy-dependent, or lack long-term credibility for debt financing.

# 8. Policy Implications and Considerations for Implementation

From a policy perspective, the scenario-based evidence generated through the project suggests that several FES-oriented business models may represent credible candidates for support and upscaling, provided that appropriate enabling conditions are maintained.

In particular, policy frameworks play a critical role in shaping the market environment within which such models operate, influencing both revenue stability and risk exposure.

At the same time, the analysis highlights the need for adaptive policy design capable of responding to changing market price dynamics, cost structures, and institutional settings. Policy instruments that help buffer volatility, incentivise diversified revenue streams, and align financial returns with broader environmental objectives can substantially enhance the resilience of FES business models over time.

Effective implementation will further depend on embedding monitoring, learning, and feedback mechanisms into policy processes. Continued data gathering, structured stakeholder engagement, and periodic reassessment of financial performance are essential to ensure that evidence produced at the pilot stage remains relevant and informative for longer-term decision-making.

Finally, distinctions between private and public actors are particularly important for implementation. Future policy design and investment strategies should therefore explicitly consider how financial performance, risk allocation, and incentive structures differ across institutional contexts, in order to better align public support measures with the specific needs and capacities of target actors.

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