D1.3 Framework for integration of ES mapping and assessment in spatial planning decisions

WP 1 Spatial Planning and Management Instruments (SP&MI)

Task 1.3 | D1.3 Framework for integration of ES mapping and assessment in spatial planning decisions (M18)

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Executive Summary

This deliverable explores how to mainstream biodiversity values into an Ecosystem Services (ES) based assessment framework designed to support spatial planning solutions that can contribute to transformative change. To achieve this highly ambitious goal, we have started by reviewing existing frameworks such as the IPBES framework for nature's value assessment, and the MAES operational framework for assessing ES in planning and policy contexts. Through this review we acknowledge the importance of applying a plural value lens to decision-making, particularly by reflecting the diversity of values of nature (intrinsic, instrumental, and relational) in the array of ES selected to be assessed (which will help decide the coverage and level of engagement required for the ES assessment), as well as defining the purpose of the ES assessment in the context of decision-making (which will help determine the depth and accuracy required for the ES assessment). We also review previous work produced within the BioValue Project, particularly D4.1 and D1.1, as well as relevant literature, to understand how ES assessments can contribute to transformative change. From our findings we propose an ES-based assessment framework (which we refer to as T1.3 Framework) with five stages: *Scoping*, *Mapping Ecosystems*, *Assessing ES*, *Results Integration*, and *Uptake of Outcomes*. We present an overview of the Framework while discussing possible methods that can be applied in each stage. The T1.3 Framework links back to the ambitions for transformative change previously defined in Task 4.1 (based on Wittmer et al., 2021). We also bring forward a set of features (which we refer to as PIECES of a transformative assessment) to guide the selection of methods and interactions to be proposed under the T1.3 Framework towards a more transformative outcome. The T1.3 Framework will be subsequently discussed with each Arena for Transformation and, through its implementation in different contexts, it will be revised, adapted and tested for its transformative potential within the goal of BioValue.

1. Introduction

The goal of task 1.3 (T1.3) within the BioValue Project is to develop a framework that summarizes the key elements for Ecosystem Services (ES) mapping and assessment to mainstream biodiversity values in spatial policy and planning, which can then be applied in Task 4.2 to support the empirical analysis in the Arenas for Implementation.

The T1.3 framework was developed around the three main approaches to ES assessment (biophysical, socio-cultural, and economic), for which the plurality of existing methods and frameworks from previous and on-going projects was reviewed and analyzed, in line with Task 1.1. Given this context, this deliverable explores which and how the elements of existing ES assessment frameworks can address the principles of transformative change.

To answer this question, we first review relevant ES and biodiversity assessment frameworks and guidelines to mainstream biodiversity values into spatial planning, dissecting concepts and structures to inspire our own assessment framework (**Chapter 2**). The reviewed sources include, first and foremost, the global assessment report (IPBES, 2019) and the assessment report on the diverse values and valuation of nature by IPBES (IPBES, 2022), the 10-steps operational framework for integrated MAES (Burkhard et al., 2018) as being developed in the SELINA project (https://project-selina.eu/); and finally, the recommendations to support the application of ES assessment methods provided by the ESMERALDA project (http://www.esmeralda-project.eu/).

Following, we identify several criteria describing key transformative features relevant to the assessment process and its outcomes. These criteria derive from the BioValue frameworks developed in Task 4.1 and Task 1.1 (**Chapter 3**) and the literature on transformative change.

In **Chapter 4**, we present the T1.3 Framework for ES assessment developed considering the insights presented in **Chapter 2**, while integrating it into the work already carried out in BioValue. We also analyze the proposed Framework against the criteria identified in the third chapter, resulting in an analysis of the transformative potential of the proposed framework.

Finally, and based on the outcomes, we present the next steps in terms of operationalization of the proposed framework in the Arenas and linkages to other tasks and work packages within BioValue (**Chapter 5**)

2. Reviewing Biodiversity and ES assessment frameworks

2.1.Brief context

As mentioned earlier, our goal in this deliverable is to understand how to mainstream biodiversity values into an Ecosystem Services (ES) based assessment framework designed to support spatial planning solutions that contribute to transformative change. This highly ambitious goal inherently comprises three different aspects (1. biodiversity/nature values, 2. ES assessments, and 3. decision-making in the context of spatial planning) that we aim to discuss in the following sections.

In regards to **biodiversity and nature values** we first and foremost refer to IPBES, the intergovernmental platform set up with a mission to *strengthen science-policy interface for biodiversity and ecosystem services for the sustainable use of biodiversity, long-term human well-being and sustainable development* (IPBES, 2013). We briefly analyze the conceptual framework for value assessment and the recent methodological report they have published in the topic (Section 2.2). As a reference for **ES assessments** in general, we have considered the widely recognized operational framework for ES assessment proposed under the MAES initiative (in its 10-step revised version being considered in the SELINA project) as well as the guidelines and recommendations on methods for ES assessments that stems from the recent ESMERALDA project. The overall structure of the proposed framework is largely inspired by these sources, and through them we discuss the many challenging aspects of successfully integrating ES assessments into **decision-making in spatial planning contexts** (Section 2.3).

To avoid ambiguity, we advance the definition of key concepts addressed in this chapter below (**Box 1**)

Box 1: Key concepts of biodiversity and ecosystem service assessments

Assessment: assembling, summarizing, organizing, interpreting and possibly reconciling pieces of new or existing knowledge and communicating them so that they are relevant and helpful to an intelligent but inexpert decision-maker (Maes et al., 2013)

Biodiversity: the variability among living organisms and the ecological complexes of which they are a part; this includes diversity within species (genes), between species and of ecosystems (UNEP 1992)

Nature: The natural world, with emphasis on the diversity of living organisms and their interactions among themselves and with their environment (Díaz et al., 2015)

Ecosystem Service (ES): the benefits human beings derive from well-functioning ecosystems (MA, 2005)

Values of nature: representations of what people and society care about and what they consider important in relation to nature. They can thus refer to nature itself (intrinsic values of nature), how nature contributes to people's quality of life (instrumental values of nature) or the way people conceive and relate to nature (relational values of nature) (Díaz et al., 2015)

Valuation of nature: The process of documenting the existence of different values of nature, identifying when and where and by whom they are expressed, that in turn allows characterizing values. This can be performed through valuation methods for eliciting and articulating the values of nature (IPBES, 2022)

Ecosystem condition (EC): the overall quality of an ecosystem measured in terms of its abiotic and biotic characteristics which underpin the ecological integrity of the ecosystem (H. Keith et al., 2020)

Ecosystem characteristic: attributes of an ecosystem describing its components, structure, processes, and functionality. The term characteristics is intended to be able to encompass all of the various perspectives taken to describe an ecosystem (Czúcz & Condé, 2017)

Indicator (of ES or a EC characteristic): a concrete quantitative metric which reflects a condition characteristic or an ecosystem service (Potschin-Young et al., 2018)

2.2. Biodiversity and the diverse values of nature

Understanding the **values of nature** (see **Box 1**) is a fundamental step to better comprehend and manage the interlinkages between people and nature, including the multiple ways in which people conceive and value nature, and how these values are accounted for in decisions towards achieving a good quality of life (Díaz et al., 2015). Notwithstanding, the wide subjectivity of the word *value* makes it is challenging to identify a practical and common definition of what the *values of nature* can be across knowledge systems, academia, and society as a whole.

In fact, the 2019 IPBES Global Assessment (IPBES, 2019) places values at the forefront of the discussion of the drivers of change in nature, and it has significantly contributed to a classification of the specific values of nature that expands from the dichotomy of **instrumental values** (*the importance of nature as a resource for humans*, more anthropocentric) vs. **intrinsic values** (*the importance of nature for its own sake, regardless of usefulness to people*, more *biocentric*) to include a third category of **relational values** (*the importance of meaningful and symbolic human-nature relationships*, more *pluricentric*) (see Figure 1).

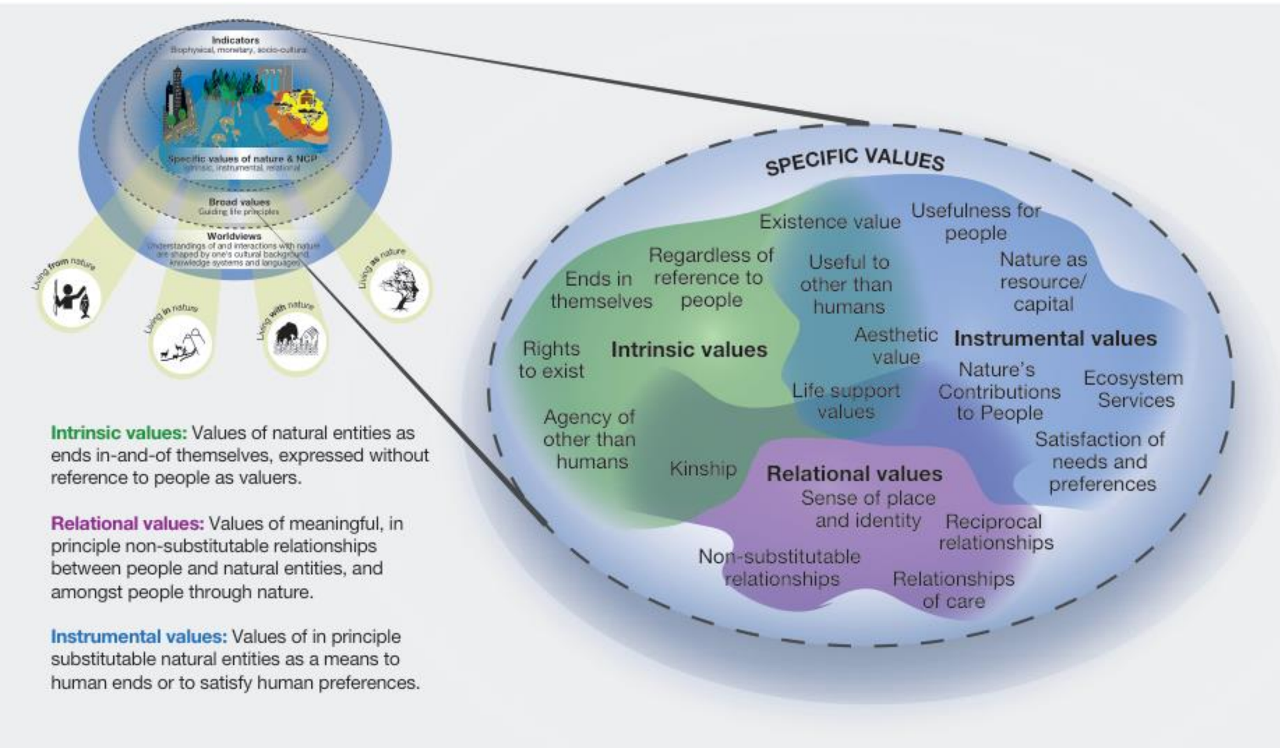

Figure 1 A general visualization of nature's multiple specific values, with core definitions, examples and fuzzy boundaries for each value type (from IPBES, 2022).

These three typologies of specific values of nature provide a conceptual framework that allows for a comprehensive understanding of the importance of nature and the different ways it relates to human preferences, perception, and experiences (Figure 2), which can also be organized by the focus of the value. The *nature* element of the framework includes **all dimensions of biodiversity** (see **Box 1** for definition), from genes to ecosystems, including ecosystem functioning, communities, biomes, Earth life support's systems, and their associated ecological, evolutionary, biogeochemical processes and biocultural diversity. The rationale for such an encompassing definition of biodiversity is based on the realization of the basic hierarchical organization of nature, and that no level of the hierarchy can exist without the support and interactions of all the other levels (Zacharias & Roff, 2001) – e.g., species cannot thrive without suitable habitats within which to live, habitats cannot exhibit any constancy of conditions without the ecosystem level processes that maintain them, etc.. The element of *Nature's contributions to people (NCP)* refers to all the contributions, both positive and negative, of nature to the quality of life of humans as individuals, societies or humanity as a whole. The range of descriptions of the human dependence of living nature contemplated in this NCP element is thus vast (embracing for instance the concept of ES, natural capital, nature's gifts, etc.). *Good quality of life* is the element related to the achievement of a fulfilled human life. It is a highly value-laden and context dependent concept comprising multiple factors such as access to food, water, health, education, security, and cultural identity, material prosperity, spiritual satisfaction, and freedom of choice.

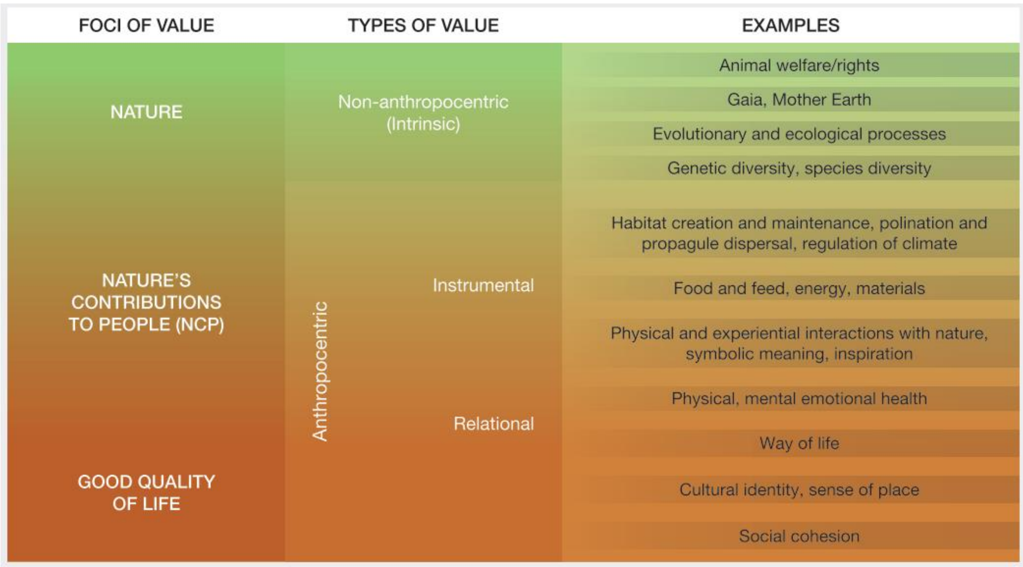

Figure 2 Diverse values related to nature, nature's contributions to people (NCP) and a good quality of life. The grading in the colors indicate that both instrumental and relational values can be ascribed to the value of NCP, and to highlight that NCP are intertwined with nature and a good quality of life (from Pascual et al., 2017).

While the *nature* element addresses mostly intrinsic values, both *NCP* and *good quality of life* encompass anthropocentric types of values, either instrumental or relational. Notwithstanding, the spectrum of nature's values is purposefully displayed as a gradient, with fuzzy boundaries between them, to highlight the fact that they do not have clear-cut limits (IPBES 2019). In fact, if we focus on the ES concept as a possible description of *NCP*, for example, we can find an array of examples that cut through these fuzzy boundaries and can also be related to a focus in nature (*intrinsic values*) - for instance maintaining nursery population and habitats (2.2.2.3[1]), and existence

[1] Codes following the CICES v5.1 ecosystem services classification

values (3.2.2.1) - or to a focus in *good quality of life* (*relational values*) – for instance sacred/religious values (3.2.2.2) and other cultural ES (3.1.2.X).

The operationalization of these multiple values into assessments to support decision-making is currently a challenging task. Among the three typologies, instrumental values are regarded as more practical to include in assessments on nature's contributions to people (which can be of material or non-material nature), including through different types of economic valuation and cost-benefit analyses, usually under the umbrella concept of ES (IPBES, 2022). They are conceptually and technically easier to quantify than other value types (De Vreese et al., 2019), and by translating the varying nature's benefits into the common language of economic benefits, they support high comparability and commensurability.

As a matter of fact, in the realm of comparability among value types, the total economic value framework (TEV) provides an established environmental economics value classification designed to include a wide range of values associated with the benefits (or detriments) of nature (Figure 3). The TEV approach distinguishes among *use values*, based on the satisfaction generated by *direct use* (consumptive or non-consumptive) of natural resources or by *indirect use* (the conditions that enable use and satisfaction), *non-use values*, and *option value* (generated by future use). *Non-use values* refer to the utility or satisfaction generated for an individual by knowing that others will have access to nature's benefits, be it other people currently living (*altruist value*) or future generations (*bequest value*), or by knowing that something exists, even if there is no direct access to or direct enjoyment of it (*existence value*) (IPBES 2022).

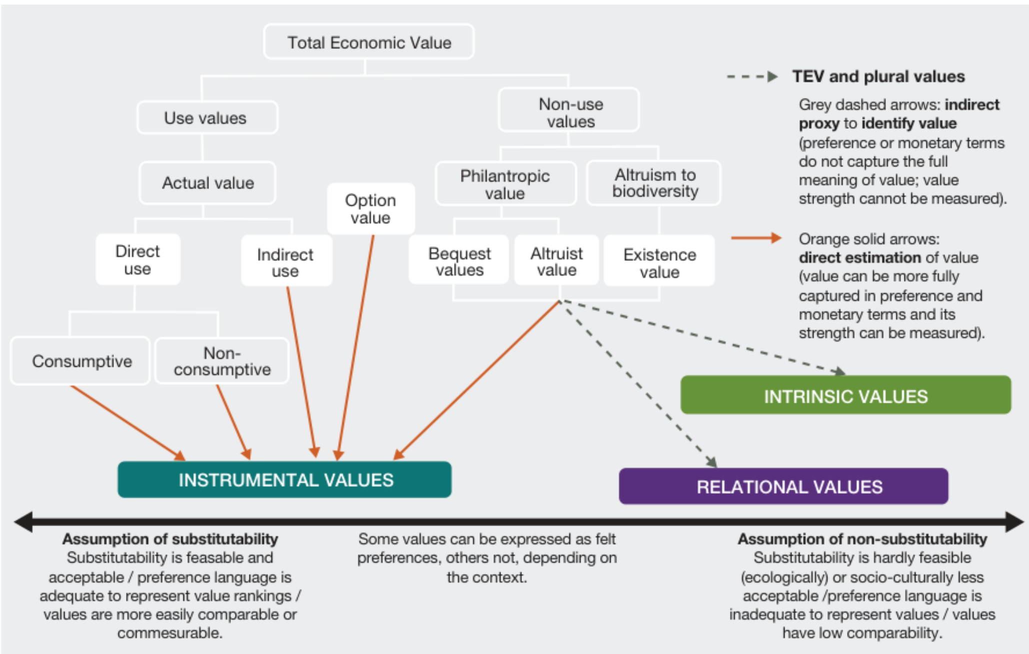

Figure 3 The Total Economic Value Framework and its direct and indirect relationships to the three specific values of nature. From IPBES (2022).

Although TEV is naturally most adequate to capture instrumental values, other value types sometimes can be indirectly identified by framing them in the language of preferences. When legitimate, a proxy can help identify that a preference for a value is present – though it cannot estimate the strength of that preference compared to others, which poses a challenge when the goal is to incorporate diverse values of nature into practical assessments to support decision-making (IPBES, 2022). This is key in the context of the present deliverable: purely instrumental approaches to valuation may obscure other value expressions, thus misrepresenting conflicts, alienating stakeholders, and removing other reasons and motivations for environmental protection out of the picture, with relevant consequences to nature conservation and social justice goals (De Vreese et al.,2019). Many environmental conflicts often arise when people implicitly or explicitly reject the reduction of values to preferences and refuse to negotiate trade-offs or compensations for their loss (IPBES 2022). For example, the TEV framework underperforms in framing intrinsic values in terms of direct, non-consumptive use-values or as individual preferences as these typically represent something that is neither negotiable nor substitutable, such as nature's sacred values (Dasgupta, 2021). Even though the intrinsic or relational values of nature could be theoretically addressed under TEV by using *existence value* as an indicator, this would not be capturing the full meaning of these non-instrumental values (see, for instance, this short essay by Baard, 2019 and the discussion in Pascual et al. 2017). The same rationale applies to the value of the ecosystem's biotic and abiotic characteristics that are key to ecosystem integrity and resilience. In these cases, non-economic indicators can replace or complement TEV (such as biophysical or social indicators) to better address environmental conflicts with clarity and justice.

The selection of valuation approaches highly influences whose values are represented in decision-making processes. Multiple valuation approaches (including methods and indicators) are needed to facilitate the visibility and expression of intrinsic, instrumental, and relational values and reconcile them in decision-making (IPBES 2022). The combination of specific methods and indicators, including deliberative valuation, economic valuation, and multi-criteria analyses, provides a good compromise to cover the spectrum of nature's values as much as possible. This facilitates the consideration of multiple values in parallel when they may not be directly comparable or made compatible (hence ranked or compensated for), e.g., through well-established and respectful deliberative discussions with affected parties (IPBES, 2022). Moreover, assessment methods can capture values understood as a *principle* (as someone's worldview in a cultural context), a *preference* (of someone over something), an *importance* (of something for itself or others), or simply a measure of something (Pascual et al. 2017). Improving analytical capacity (i.e., skills, knowledge, and tools) by bridging scientific and non-scientific knowledge plays an important role in addressing the gaps hindering the operationalization of multiple values.

In this regard, the authors of the 2022 IPBES Methodological Assessment Report advance an 8-step approach for a comprehensive valuation process and the optimization of diverse values in decision-making (Figure 4). The approach was designed to overcome the most common challenges to capturing different values of nature to this end, as evidenced in different sections of the same report, including power imbalances, resource constraints, and knowledge asymmetries. The approach is based on the valuation steps outlined by the IPBES preliminary guide on values and valuation (IPBES, 2015), the five tasks proposed by (Tengö et al., 2017), and the theoretical inputs from (Gupta et al., 2010) needed for successful collaboration, weaving, and integration of diverse knowledge systems.

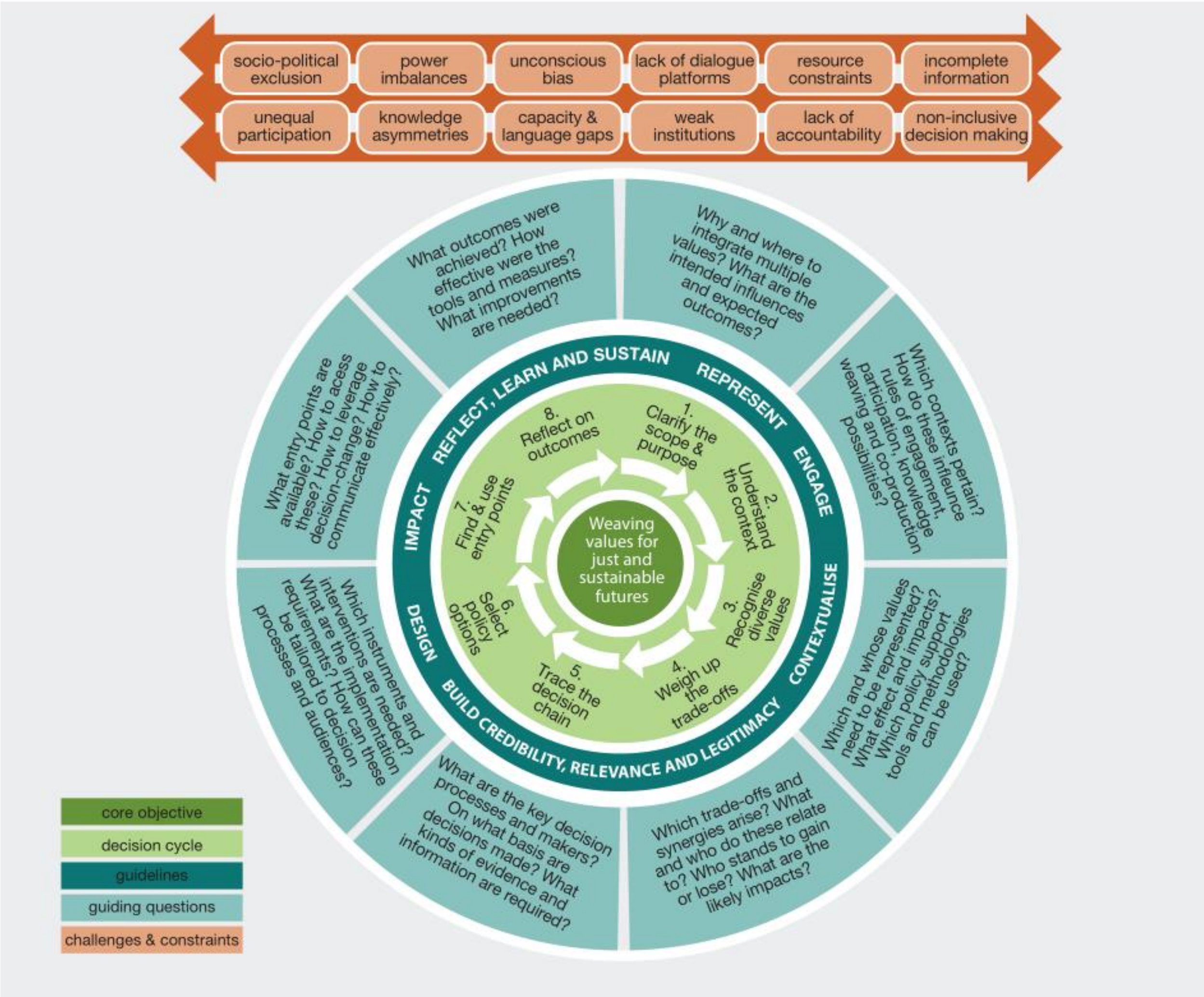

Figure 4 The operationalization of diverse values in the decision-making cycle (from IPBES, 2022).

In the context of the present deliverable, we highlight the 8-steps in this iterative approach and its related guidelines, which are highly relevant to the ES assessment framework proposed here (Table 1). The information provided in Table 1 is a re-structured summary of the contents of Chapter 6 (Section 6.5.3) from IPBES (2022).

Table 1 The 8 steps in the iterative approach to valuation and related guidelines to operationalize the diverse values of nature in decision-making (from IPBES, 2022).

	Valuation approach steps	Related Guidelines
Step 1	**Clarify the scope and purpose of the valuation** with relevant actors to support policy uptake from the beginning. This step includes answering the questions of which decision-making process it links to, what are the associated policy and management challenges, what is the purpose of the valuation (see Figure 5 below), who and what it seeks to influence, and which outcome or change it intends to set in motion. This enables the selection of the right combination of methods and the design of a feasible process considering the context and resources available, which highly influences the end results of valuation. Understanding the purpose also creates space for reflection to use appropriate policy support tools and methodologies to identify and capture different values in a specific place**. Capacities needed: motivational and analytical**	**Represent:** Ensure a fair representation of diverse worldviews and values held by relevant actors (including stakeholders, right holders, and knowledge holders, e.g., indigenous peoples and local communities, gender diversity and youth, and civil society organizations involved in conservation or development activity, among others).

	Valuation approach steps	Related Guidelines
Step 2	**Understand the context** or the specific factors and conditions that shape how and to what ends the concept of diverse values should be operationalized. This helps discover both opportunities and challenges to identify, understand, integrate, reflect and support pluralistic approaches. **Capacities needed: analytical, governance and social networking**	**Engage** interactively with the relevant actors to promote dialogue, long-term collaboration and co-creation of solutions
Step 3	**Represent diverse values** by focusing on identifying and capturing instrumental, intrinsic, and relational values of nature in the given scope and for the chosen purpose. Key questions include whose values are in place, how they will be addressed, whether all relevant actors and values are considered, and if someone is missing, how can the missed ones be brought on board? This is the stage where relevant nature's contributions to people and ES are identified and classified in relation to the management challenge, the purpose and the scope. This also implies analyzing conditions, trends, and underlying causes of degradation and unsustainable use of different ES and nature´s contributions to people, which are related to the values and worldviews held by different stakeholders. Capacities needed: **Analytical, bridging and negotiation**	**Contextualize** the entire decision-making process synchronously with the values underpinning the biophysical, social, economic, cultural and political context in the target intervention area.
Step4	**Weigh up the trade-offs** by identifying the factors that shape people's behavior and actions, understanding their motivations, and identifying synergies and trade-offs considering differences in time, location, and cost-benefit distribution. Trade-offs emerge when values and needs differ and often imply conflicts among stakeholders who can benefit and/or carry on the costs of decisions made. The ways that trade-offs are solved influence the development pathway and the well-being of stakeholders. The management of trade-offs implies balancing power asymmetries, creating the space to clarify, discuss, and recognize different perceptions and values, supporting knowledge weaving, and setting the basis for constructive negotiation. **Capacities needed: Analytical, bridging, and negotiation**	
Step 5	**Trace the decision chain** by bringing together all the information collected during steps one to four and linking them to possible policy interventions to operationalize diverse values effectively in concrete decisions and management actions. Identifying key decision processes as well as related stakeholders and actors to address trade-offs will contribute to leveraging change. Decision chains are not unitary but typically incorporate many different dimensions and are understood and experienced by different stakeholders in various ways. Therefore, a collaborative – engaging diverse stakeholders and knowledge systems – review of possible interventions according to the policy cycle can provide orientation and discover potential actions and limitations. Efforts must continue to ensure that the information being produced meets the target audience's needs and is also generated and presented in a way that is credible, relevant and legitimate in the light of these needs and interests. **Capacities needed: Analytical, bridging, negotiation and governance**	**Build credibility, relevance and legitimacy** by instilling a sense of co-ownership over valuation results by all actors who take part in the valuation process.
Step 6	**Select policy options,** moving from information gathering to a more action-oriented identification of concrete responses and measures happens. Possible interventions could range from shallow leverage points, i.e., easy actions to implement with small impacts on changes (e.g., working at municipal levels, introducing participatory planning, design and/or implementation of standards and safeguards, target investments), to deep leverage points that have a strong impact on transformative change (e.g., policy reforms that address underlying causes of degradation and unequal distribution, the establishment of new institutions for a more inclusive government, ecological fiscal reforms etc.). At this implementation stage, valuation guides how and where to implement pluralistic approaches and measures and where adjustments could be made. Additionally, valuation could contribute to monitoring the impacts of the selected policy option on the problem situation. **Capacities needed: Motivational, governance and negotiation**	**Design** decision-making processes that consider stakeholders' capacities, knowledge, and perspectives through equal, participatory, communicative, and conflict management approaches.

	Valuation approach steps	Related Guidelines
Step 7	**Find and use entry points** to integrate diverse values into decision-making. These points should be related to the drivers of change and policy options that were identified in previous steps and are windows of opportunity that allow us to place an issue on the political agenda (so they should be connected to policy issues to receive the attention of decision-makers). The valuation process can either be used as an entry point to obtain political relevancy or can also act as one since it generates knowledge and provides recommendations to improve policy **Capacities needed: motivational, governance and social networking**	**Strive for impact** by focusing on tangible results as soon as possible, fostering validation within and between knowledge systems, being coherent with the regulatory context and identifying opportunities for scaling up and out.
Step 8	**Reflect on outcomes** regarding the impacts of the different actions implemented. This step consists of evaluating the policy decision after it has been implemented. Thus, effects and changes are monitored over a given time to determine the effectiveness of the intervention, seeking adaptation. This step is related to monitoring and evaluation, supporting adaptive management to improve actions towards the desired outcomes, and observing how the situation and relationship of different actors changed and how decisions were taken and enforced. At the same time, it assesses conditions and trends of ecosystems and analyses where and how to improve. **Capacities needed: Analytical, motivational and governance**	**Reflect and learn** to ensure that decisions that impact nature and its contributions to people are aligned with the values and actions that can foster transformative change

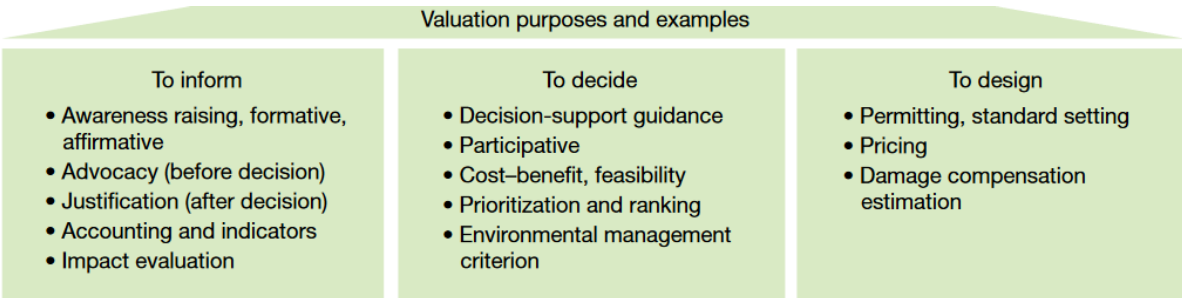

Figure 5 Examples of valuation purposes in the context of decision-making (to inform, to decide, to design). From Pascual et al. (2023).

KEY MESSAGES FOR THE TASK 1.3 FRAMEWORK

The documents analyzed in this section highlight the **plurality of nature's values** and the importance of applying a plural value lens to decision-making. This calls for understanding whether and how values can be directly compared, made compatible, or considered in parallel (through respectful deliberation processes). Mainstreaming biodiversity values into spatial planning through ES assessments is thus profoundly related to **expanding ES assessment methodologies that can elicit and articulate values** across the whole spectrum (intrinsic, instrumental, and relational values). Valuation uptake, for instance, can be improved by **increasing analytical capacities** (e.g., bridging scientific and non-scientific knowledge) and **prioritizing participatory and deliberative methods** for envisioning alternative futures inclusive of diverse worldviews, knowledge systems, and values. It is also relevant to frame the ES assessment under a **comprehensive and optimized approach**, according to the steps and the guidelines presented in the valuation assessment from IPBES (2022), which include (i) **understanding the context and purpose** of the assessment early on by ensuring a **fair representation of stakeholders, engaging iteratively**, (ii) **identifying the trade-offs** and weighting them up while tracing the decision chain, which calls for building **credibility, relevance, and legitimacy** to the process, instilling a sense of **co-ownership over the assessment and its outcomes**, and (ii) **reflecting** on the outcomes by **fostering co-learning** to ensure our actions and values are aligned with a positive transformative change.

2.3. Assessing Ecosystem Services for decision-making

In pursuing the task of understanding how biodiversity values can be mainstreamed in ES assessments, and notwithstanding the considerations regarding the diverse values of nature shared in the previous subsection, it is fundamental to refer to the most updated and comprehensive integrated operational framework for ES assessments in Europe, which stems directly from the MAES initiative (Mapping and Assessment of Ecosystem Services).

This 10-step iterative and operational framework (Figure 6) proposed by Burkhard et al. (2018) is being thoroughly reviewed in the ongoing SELINA Project, given its high potential for widespread implementation of ES assessment under different policy and planning contexts. We will briefly review the key points from each section and discuss the applicability in the context of the present deliverable.

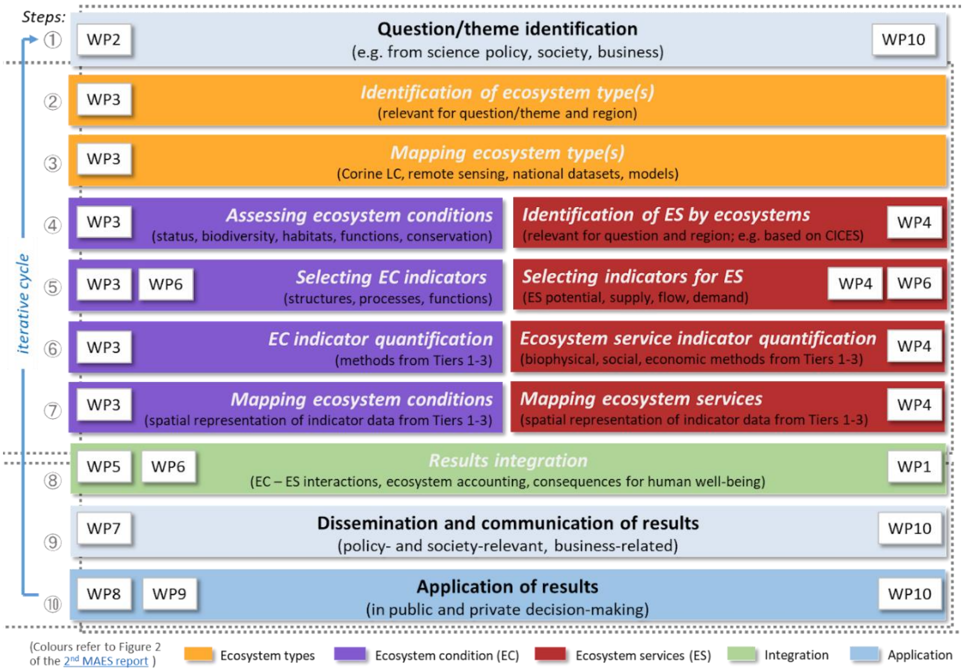

Figure 6 Integrated ES assessment framework, as being addressed in project SELINA (based on Burkhard et al., 2018). The work packages (WP) shown in the figure refer to the SELINA project and are not relevant to this deliverable.

The integrated ES assessment starts with a **relevant question** for science, policy, society or business on different levels. This serves as an entry point for the next steps of the framework and sets the **context of the assessment (step 1)**. Understanding the question(s) that will guide the assessment is key to successfully implementing the ES concept in decision-making (Rosenthal et al., 2015). The authors refer to a broad set of possible questions that can help frame the ES assessment, such as "*How do ecosystem services affect human well-being, who and where are the beneficiaries, and how does this affect how they are valued and managed?*" (broad question) or "*How can mapping and assessing ES help the design of prioritization criteria for restoration and at which scale to get significant benefits in a cost-effective way?*"(specific question) – more examples can be found in Maes et al., (2013).

A **selection of ES** to be addressed should follow the identified questions relevant to the assessment context. This ensures the relevance of the selected ES for stakeholders, policy- and decision-making, and specifically for the study area. This may require some capacity-building activities to promote stakeholders' involvement in the selection process (Rosenthal et al., 2015). Dialogues with stakeholders need to be started early and maintained throughout the process, establishing, if possible, a permanent network or platform for experts (Geneletti et al., 2020). Moreover, and tying back to the discussion on the diverse values of nature from the previous section (Section 2.2), this engagement with stakeholders should also ensure that the ES selected are able to represent all relevant perspectives over nature in that context, across the value spectrum (intrinsic, instrumental, and relational values), which requires a convergence of stakeholder's representations of nature and the ES concept (De Vreese et al., 2019). As a rule of thumb, the selection **should cover the categories** of provisioning, regulating, and cultural ES to enable the analysis of trade-offs, synergies, and interactions amongst them. Therefore, a context-specific selection of ES is of utmost importance. It is also relevant to tie the selection of ES to an **existing classification system** (e.g., CICES v5.1 from Haines-Young & Potschin-Young, 2018; or the Millennium Ecosystem

Assessment classification from the MA, 2005) as a useful entry point to retrieve scientific information, data and similar case studies. Finally, the selection of the ES to be addressed is also impacted by the availability of data, resources, and knowledge to carry out the appropriate assessment.

Once the context of the ES assessment has been set and the targeted ES identified, the assessment moves on to the second step of **identifying ecosystem types (step 2)**. Identifying ecosystem types goes beyond the identification of land cover and land-use categories. However, this information provides a promising starting point since it is readily accessible at various resolutions or scales. Relevant ecosystem typologies can be found in the literature, such as the hierarchical one advanced by the European Environment Agency (2016), the IUCN Global Ecosystem Typology (D. A. Keith et al., 2022), or the descriptive EUNIS habitat classification (Moss, 2008). Referring to existing ecosystem classification systems may bring a more ecologically accurate perspective to the ES mapping exercise – which is the next step of the framework. Notwithstanding, the type of ecosystems to be identified depends on the purpose, scale, and data available to perform the ES assessment, and in the context of this deliverable, it is considered indissociable from step 3 (mapping), which follows next.

As the following step in the MAES framework, **mapping ecosystems (step 3)** – *e.g. mapping the spatial extent of ecosystems based on their biotic and abiotic characteristics* - is quite relevant to produce outcomes that decision-makers can use for dialogues (Erhard et al. 2017). Here, land-cover cartography can be enhanced to include additional biophysical data on other relevant socio-cultural structures that might allow a spatial differentiation of ecosystems to assess better the ES they provide – for instance, by identifying service-providing units (SPUs) (Andersson et al., 2015). Additional information used to identify ecosystem typology may include satellite imagery (to identify better transition habitats, such as riparian galleries or coastal dunes, or to depict forest typology), data on current environmental zones, potential natural vegetation maps, data from local surveys and/or citizen science to identify habitat niches. Detailed information on accessibility to particular natural areas, the presence of sacred or relevant natural/cultural elements, and the presence of relevant built infrastructures (bridges, hospitals, schools) can also be considered to increase the detail of the ecosystem's typologies distinguished and selected for the assessment.

A key feature of this framework lies in the importance attributed to **mapping and assessing EC (steps 4 to 7)** prior to assessing ES *per se*. EC is defined as *the overall quality of an ecosystem measured in terms of its abiotic and biotic characteristics which underpin the ecological integrity of the ecosystem* (**see Box 1**). In the context of the MAES framework, indicators for assessing EC should be linked with the supply of the ES that are being targeted. Vallecillo et al. (2022) provide a thorough overview of EC variables that can be used for assessing conditions in the context of natural capital accounting, covering a wide array of ecosystem types (urban, agroecosystems, forest, heathlands, wetlands, freshwaters, and marine). They distinguish EC variables based on key ecosystem characteristics (see Box 1 for definition) that range from abiotic characteristics (which can be **physical** or **chemical)**, and biotic characteristics (which can be **compositional, structural,** or **functional)** to finally **landscape** characteristics (which can be either landscape or seascape addressed at a coarser scale) (Table 2). Of note, biodiversity is understood as a focal component for ecological integrity (Kandziora et al., 2013), and as such, biodiversity changes are reflected in changes in the biotic characteristics of an ecosystem (its compositional, structural, and functional state).

Table 2 EC typologies (from Czúcz et al., 2021)

Groups	Classes	Examples
Abiotic ecosystem characteristics	Physical state	Soil structure, impervious surface, water availability
	Chemical state	Soil nutrient concentration, air and water quality
Biotic ecosystem characteristics	Compositional state	Species richness, genetic diversity, presence of threatened species
	Structural state	Vegetation density, habitat structure, food chain and trophic levels
	Functional state	Productivity and decomposition processes
Landscape level characteristics	Landscape and seascape at coarse scale	Connectivity, fragmentation, ecosystem type mosaics

Navigating the relationship between these EC variables and ES supply has been a growing research field since Kandziora et al. (2013a) proposed correlation matrixes. Recent research efforts largely focus on one particular ES indicator (e.g., soil protection or flood regulation, in Rendon et al., 2020 and Vári et al., 2022, respectively), or on particular ecosystem typologies (e.g., in-land and coastal water bodies Grizzetti et al., 2019). In the context of natural capital accounting, La Notte et al. (2022) have identified a list of EC variables that directly connect with ES assessments (Table 3).

Table 3 ES, key variables for biophysical ES assessment and its connection with EC variables (from La Notte et al., 2022)

Ecosystem services (ref. INCA)	Key variables of biophysical assessment	To be flagged in condition accounts (ref. SEEA EA)
Crop provision	Share of ecological inputs	% organic farming (structural state)
Timber provision	Annual increment of biomass	% tree cover (structural state)
Crop pollination	Wild pollinator occurrences	# species richness (compositional state)
Soil retention	Cropping management and conservation practices factors	% vegetation cover (structural state)
Water purification	Nitrogen inputs	ug/m^3 nitrogen concentration (chemical state)
Flood control	Imperviousness	% soil sealed per area (physical state)
Carbon sequestration	Carbon uptakes and emissions	% tree cover (structural state)
Habitat and species maintenance	Species hotspots	# presence of top predator species (functional state)
Nature-based recreation	Urban green infrastructures	% urban green (structural state)

In the context of the present deliverable, these EC variables are examples that can be considered alongside ES mapping and assessment to foster an understanding of EC-ES relationships that is useful for decision-making, which aids in communicating our dependency on nature more clearly (Rozas-Vásquez et al., 2019) but without overwhelming the assessment process.
Notwithstanding the importance of understanding the condition of ecosystems, the main focus of the MAES framework is on **mapping and assessing ES (steps 4 to 7),** which conceptually operationalizes the whole framework. A complete understanding of the flow of ES from ecosystems to society entails a set of **ES indicators** that describes three aspects: the capacity of

ecosystems to provide services (i.e., **ES supply**), the people's demand for services (i.e., **ES demand**) and the actual use of services by beneficiaries (i.e., **ES flow**) (Burkhard & Maes, 2017). These concepts are reflected in the ES "cascade" model (Potschin-Young et al., 2018), thus directly linking back to the EC assessments discussed above. The ES flow from ecosystems to people usually requires additional investments or inputs in other forms of capital (human, financial). As such, the set of ES indicators selected can also include anthropogenic inputs (see examples in (Grunewald et al., 2017).

The methods for mapping and assessing ES have been extensively analyzed under project ESMERALDA (referenced earlier in Section 1) and can be broadly categorized into biophysical, social, and economic methods (Table 4). A brief description of each method and the resources required is presented in Annex (Table 16).

Table 4: Overview of the most widely implemented biophysical, social, and economic methods for assessing ecosystem services (adapted from Deliverables D3.3, D4.2, D4.3, and D5.4 - ESMERALDA Project)

Type of Method		Methods	Time and Resource Demand (level)	Relevance per type of ES ✔ = relevant ✔ ✔ = very relevant		
				Provisioning	Regulating	Cultural
BIOPHYSICAL	Direct measurements	Field Observations	High	✔ ✔	✔	✔
		Surveys and questionnaires	Medium	✔		✔ ✔
		Remote sensing and earth observations	Medium	✔ ✔	✔ ✔	
		Remote sensing derivatives	Medium	✔ ✔	✔ ✔	
		Statistical and socio-economic data	Low	✔ ✔		✔
	Indirect measurements	Spatial proxy (including look-up tables)	Low	✔ ✔	✔	
		Phenomenological models	Medium	✔	✔ ✔	
		Macro-ecological models	High	✔	✔ ✔	✔
		Trait-based models	High	✔	✔ ✔	
		Process-based models	High	✔ ✔	✔ ✔	
	Modelling	Statistical models	Medium	✔ ✔	✔ ✔	
		Ecological connectivity models	High	✔	✔ ✔	
		State and transition models	High		✔ ✔	
		Conceptual models	High	✔ ✔	✔ ✔	✔
		Integrated modelling frameworks	Medium	✔ ✔	✔ ✔	
SOCIAL	Socio-cultural methods	Preference assessment	Medium	✔	✔	✔ ✔
		Time-use	Medium	✔	✔	✔ ✔
		Photo elicitation surveys	High	✔	✔	✔ ✔
		Narrative assessments	Medium	✔	✔	✔ ✔
	Integrated approaches	Participatory mapping	High			✔ ✔
		Scenario Planning	High	✔	✔	✔ ✔
		Deliberative valuation	High	✔	✔	✔ ✔

Type of Method		Methods	Time and Resource Demand (level)	Relevance per type of ES ✔ = relevant ✔ ✔ = very relevant		
				Provisioning	Regulating	Cultural
ECONOMIC	Primary valuation methods	Market price	Low	✔ ✔		✔
		Public pricing	Low/Medium	✔ ✔	✔	✔
		Defensive expenditure	Low/Medium	✔	✔	✔
		Replacement cost	Low/Medium	✔	✔ ✔	✔
		Restoration cost	Low/Medium	✔	✔ ✔	✔
		Damage cost avoided	Low/Medium		✔ ✔	
		Social cost of carbon	Low		✔ ✔	
		Opportunity cost	Medium	✔	✔	✔
		Net factor income (residual value)	High	✔ ✔		
		Production function	High	✔ ✔		
		Input-Output Models	High	✔ ✔		✔
		Hedonic pricing	Medium/High		✔	✔ ✔
		Travel cost	Medium			✔ ✔
		Contingent valuation	Medium	✔	✔	✔
		Choice modelling (choice experiment)	High	✔	✔	✔
		Deliberative valuation	High	✔	✔	✔
	Value transfer methods	Unit value transfer	Low	✔	✔	✔
		Value function transfer	Medium	✔	✔	✔
		Meta-analytic function transfer	High	✔	✔	✔

Each of these methods can be applied with more or less depth and accuracy (referred to as the different *tiers* of the assessment) given the type of ES addressed, data availability, data quality, available resources, expertise, and software requirements (Table 5).

Table 5 Definition of tiers for ES assessments (adapted from Deliverable 4.2 – ESMERALDA Project)

	Accuracy	Detail	Technical Expertise	Data
Tier 1	(Usually) lower accuracy and robustness of results (suitable for awareness raising)	Lower level of detail and spatial specificity	Requires some technical expertise	Uses readily available data
Tier 2	Moderate accuracy and robustness of results (suitable for informing broad policy direction)	Moderate level of detail and spatial specificity	Requires some technical expertise across multiple disciplines	Requires processing existing data from multiple sources
Tier 3	Higher accuracy and robustness of results (suitable for informing the selection of investments)	Higher level of detail and spatial specificity	Requires high levels of technical expertise across multiple disciplines	Requires collection of detailed new data from multiple sources

Combining different tiers in the assessment, also known as a tiered approach, can be extremely helpful in overcoming data barriers (Weibel et al., 2018), along with undertaking iterative approaches by updating the assessment results when better knowledge and data become available (if applicable). In the context of this deliverable, the purpose of the assessment in terms of support to decision-making should dictate the level of depth and accuracy required, with more expedite and simplistic approaches (tier 1) being sometimes sufficient for baseline assessments or awareness raising, as opposed to more demanding and complex methods (tier 3) that are usually required if the purpose is to compare alternative development options or evaluate the impacts of implemented solutions (Grêt-Regamey et al., 2015).

Once the set of ES of interest has been assessed and mapped, and ideally related to a set of EC variables that underpin ES supply, there is a need to **integrate the results (step 8)** so that all of the information collected can be useful to support decision-making in different contexts. Several methods for results integration exist, ranging from simple overlay analysis (sums, densities, overlaps and correlations), to weighted summations and multi-criteria analysis, optimization algorithms (such as MARXAN), extended cost-benefit analysis, narrative approaches, deliberative valuation, etc. Though the selection of the best integration method is largely dependent on the different ES being addressed and the ES assessment methods selected in the previous step, a key element to keep in mind is the actual usability of the assessment outcome to support decision-making. This perspective of assessment outcomes as knowledge that is not just useful (*relevant*) but actually usable (*helpful*) to support decision-making has been already acknowledged as pivotal in environmental research (Clark et al., 2016). In fact, Dewulf et al. (2020) distinguish three different logics that are inherent to decision-making processes and what this implies in terms of (environmental) knowledge use:

- the logic of **consequentiality**, the most commonly adopted one, rooted in rational theories, in which environmental knowledge is used because of its utilitarian value (aka rational choice) [e.g.: *deciding about water conservation measures in a given wetland area in Europe by performing a cost-benefit analysis of its expected consequences for upstream and downstream stakeholders*];
- the logic of **appropriateness**, rooted in institutional theories, in which environmental knowledge is used because it fits existing rules and routines [e.g., *deciding about water conservation measures in a given wetland area in Europe by following the EU Water Framework Directive and its goals set out in target* 4]; and
- the logic of **meaningfulness**, rooted in theories of sensemaking and interpretation, in which environmental knowledge is used because it makes sense to decision-makers [e.g., *deciding about water conservation measures in a given wetland area in Europe by considering the meaning of the wetland as sources of water for cities downstream, their meaning as living space of local communities, or their meaning as hotspots of biodiversity*].

In the context of the present deliverable, we argue that ES assessment outcomes need to be integrated in a way that enables the decision-making context to expand from a rational choice logic (consequentiality) to a sensemaking logic (meaningfulness). To this end, including integration methods that go beyond financial deliberations (e.g., classic cost-benefit analysis), and are able to properly address the different values of nature (*what matters to whom, to what extent, in what manner*), seems to be essential.

Additionally, we acknowledge that the purpose of the assessment is extremely relevant to help choose the appropriate integration method. Based on a recent review in the context of (urban) spatial planning, these are the most commonly applied integration methods regarding different assessment purposes (Cortinovis et al., 2021):

- **Conducting baseline analyses**, i.e., understanding the supply and distribution of ES in the area, identifying important issues concerning ES supply and demand, and gathering baseline knowledge to support the development and assessment of alternative solutions. Analyzing ES can be useful to identify objectives and constraints of the decision-making process and to define a benchmark for comparing future scenarios and monitoring plan implementation. **Most commonly applied integration methods: simple overlays (diversity, average), and weighted summation**
- **Identifying possible actions**, i.e., using (also) ES information to identify alternative options or to develop optimal solutions (e.g., identifying priority areas for conservation or creating new green spaces, optimizing land use scenarios for multiple objectives). In this case, the inputs of the ES assessments do not include predefined alternatives but a set of constraints and/or objectives to meet. The assessment produces a single or a set of optimal decisions, together with a measure of the compliance to the constraints and achievement of the objectives**. Most commonly applied integration methods: optimization algorithms**
- **Comparing alternative options**, i.e.. using (also) ES information to compare alternative planning decisions, when more options are available and a decision must be made about which one to implement. Alternatives at different levels include, for example, alternative development patterns, alternative areas or sites where to implement certain policies, alternative site-specific nature-based solutions or management options. **Most commonly applied integration methods: efficiency indicators and multicriteria analysis**
- **Assessing the impact of decisions**, i.e., using ES information to understand/quantify the consequences on ES of the decisions made. This includes both ex-ante assessments of a specific (selected) decision as well as in-itinere and ex-post monitoring of its implementation. Assessing impacts necessarily involves a comparison with a benchmark, usually the baseline condition before the decision is/was implemented. **Most commonly applied integration methods: simple overlays (diversity, average)**

The second-to-last step of the MAES framework, dissemination **(step 9)**, refers to translating the integrated assessment outcomes into a language that can be understood by the ES community and *an intelligent but usually inexpert decision-maker*. In the context of the present deliverable, this step is indissociable from the application **(step 10)**, particularly because the proposed framework should be operationalized in the three Arenas for Transformation in close collaboration with decision-makers. These two final steps are thus highly related to how the integrated assessment outcomes will feed back into the spatial planning solutions designed in each Arena that will ultimately contribute to transformative change.

KEY MESSAGES FOR THE TASK 1.3 FRAMEWORK

Based on this brief review of the operational 10-step Framework advanced from the MAES initiative in Europe, the framework proposed in the present deliverable is guided by the relevance of the sequential steps to operationalize ES assessments and increase its uptake in the decision-making process. In this regard, our analysis acknowledges the importance of **setting the context** of the assessment and identifying the ES to be assessed as a first step, preferably promoting **knowledge sharing** and stakeholder **engagement** as early as possible. Though a key feature in the framework analyzed, the lack of robust information to depict straightforward EC-ES relationships makes it a challenge to include EC assessments in a framework that is designed to support decision-making. Notwithstanding, we refer to a limited set of EC variables that can be linked to ES supply and can be integrated into the proposed framework. Moreover, we acknowledge that selection within the multitude of **methods available to map and assess ES** (**biophysical, social, and economic**) should be guided not only by **data and resource availability** (including institutional capacity) but also by the **plurality of values** that should be reflected in the array of ES selected in that specific context (which will help decide the coverage and level of engagement required, linking back to the previous section), as well as the **purpose of the assessment** (which will help determine the necessary depth and accuracy). Finally, we acknowledge that translating the ES assessment results into a decision-support system requires **integration methods** that foster meaningful decision-making by properly addressing the different values at play and **should not be limited to economic metrics** of value and cost-benefit analyses. The operationalization of the proposed framework in the Arenas for Transformation will ideally feed back into spatial planning solutions that aim to contribute to transformative change.

3. The features of a transformative ES assessment

3.1 Introduction

In this Chapter, we aim to identify and define the relevant features that ES assessments should comply with in order to increase the transformative potential of the T1.3 ES framework, resulting from the analysis of the previous outcomes of BioValue, specifically deliverables D4.1 and D1.1, as well as literature on transformative change. The transformative potential of ES assessments in spatial planning needs to be understood from the perspective of its integration within not only the broader analytical framework for transformative change proposed in Task 4.1 but also in relation to the transformative change characteristics against which current spatial planning instruments were assessed in Task 1.1.

3.2 Overview of the analytical framework from Deliverable 4.1

In D4.1, the BioValue team has tailored the analytical framework for transformative change proposed by Wittmer et al. (2021) into the spatial planning context.

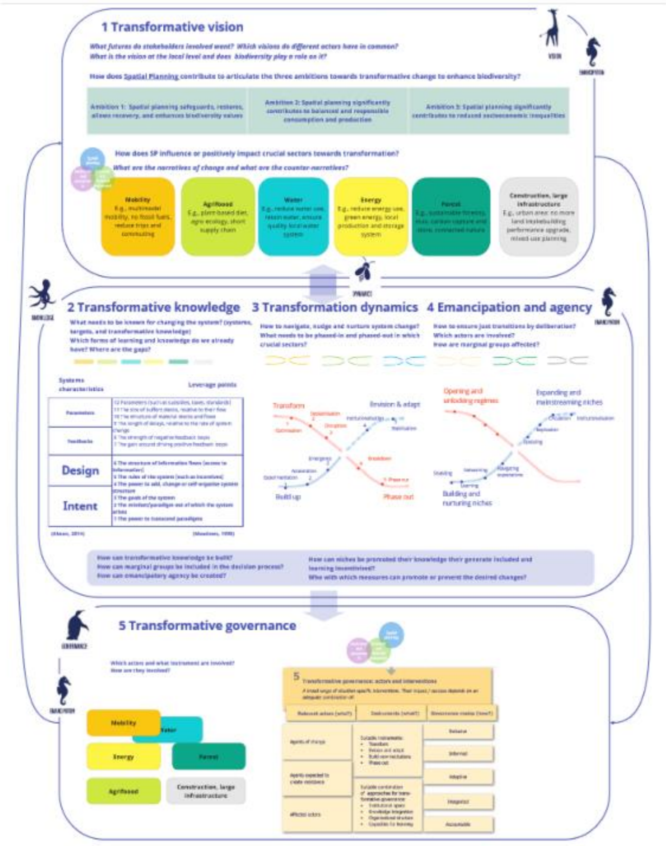

Figure 7 The Analytical Framework for Transformative Change from D 4.1 (adapted from Wittmer et al., 2021)

This consists of a 5-part analytical framework that stems from *visions* (what futures do we want?), *knowledge* (what needs to be known for a changing system?), and *dynamics* (how to navigate, nudge, and nurture system change?), which leads to *emancipation and agency* (how to open spaces for deliberation, inclusion, and emancipation?) and, finally, *governance* (which represents an adequate combination of actors, instruments, and modes).

In tailoring this analytical framework to the spatial planning context, the team has subsumed the ambitions proposed in *visions* into three:

- **Ambition 1**: **spatial planning safeguards, restores, allows recovery and enhances biodiversity**. As is emphasized in target 1 of the *Kunming-Montreal Global Biodiversity Framework*, inclusive spatial planning should be ensured to bring the loss of areas of high biodiversity importance, including ecosystems of high ecological integrity, close to zero by 2030. Here, spatial planning usually operates in direct ways by reducing or enhancing certain uses in certain areas. Examples of approaches that significantly contribute to this ambition are Nature-based solutions and ES.
- **Ambition 2: spatial planning significantly contributes to balanced and responsible consumption and production without external social and environmental costs**. Here, the effects of spatial planning can induce more balanced, sustainable territorial relations between urban, peri-urban and rural communities. Examples of approaches to contribute to this ambition are reducing (and stopping) land take and land consumption and urban food system production.
- **Ambition 3: spatial planning significantly contributes to reducing socioeconomic inequalities**, for example, in the context of urban areas, which is reflected, e.g., in unequal access to transport, housing, among others that primarily affect the integration of marginalized communities, migrants, youth, and disadvantaged groups.

As such, the transformative potential of a spatial planning instrument towards a sustainable management of biodiversity can be understood as its potential to contribute to these three ambitions, i.e., (i) it safeguards, restores, allows recovery and enhances biodiversity as global commons (e.g., NbS), (ii) it promotes balanced and responsible consumption and production (e.g., stopping or reducing land take), (iii) it reduces socioeconomic inequalities.

The five building blocks from WP4 framework can highlight the most relevant features of transformative change, as shown (**Error! Reference source not found.**).

Table 6 The five building blocks for transformative change in the context of ES assessments (based on Deliverable D4.1 -BioValue Project)

BUILDING BLOCKS FOR TRANSFORMATIVE CHANGE	Definition
VISION	Narratives conducive to global commons; addressing biodiversity but also economic and social concerns and inequalities
KNOWLEDGE	Context-based, pluralistic, and goal-oriented information
DYNAMICS	Replacing and systematically phasing out unsustainable practices
EMANCIPATION AND AGENCY	Achieve value change and finding ways for a good life and decent livelihood for all humans without degrading global commons
GOVERNANCE	Redirecting finance, changing incentives, mandatory supply legislation and extending rights-based approaches

The team has also presented different pathways for achieving each of the ambitions defined, which is briefly summarized by its entry points below (Table 7).

Table 7 Entry points of the pathways of impact for each Ambition, derived from D4.1

	PATHWAYS OF IMPACT THROUGH SPATIAL PLANNING INSTRUMENTS
AMBITION 1	PROACTIVELY ENHANCE BIODIVERSITY RESTRIC OR PROHIBIT CERTAIN USES
AMBITION 2	ALLOCATING AREAS AND INCENTIVES MIXED-USE PLANNING
AMBITION 3	PLANNING INSTRUMENTS THAT CONTROL PEOPLE'S ACCESS TO HOUSING, JOBS, TRANSPORT, GREEN AND BLUE AREAS

KEY MESSAGES FOR THE 1.3 FRAMEWORK

Based on this brief analysis, and to weave the Framework proposed in the present deliverable into the broader analytical framework for transformative change from D4.1, it is necessary to ensure that (1) **the ES assessment is set out in a context that addresses at least one of the three ambition**s that define the *visions* for transformative change, and (2) **the ES assessment can provide material support to the spatial planning instruments** (or other planning solutions) **that lead to the pathways of impact** for each of the three ambitions.

3.3 Overview of the transformative change potential of planning instruments

In D1.1, the BioValue team addressed challenges and barriers to biodiversity inclusion in spatial planning systems. Building on the work of Fedele et al. (2019), the team assessed several spatial planning instruments against four transformative characteristics described for (i) the governance of spatial planning systems, (ii) the implementation of the mitigation hierarchy, (iii) the spatial planning provisions for different sectors, and (iv) biodiversity and ES. For a matter of relevance to this deliverable, the transformative characteristics are reported as follow for the first two elements of analysis.

- **Re-structuring:** Overall, it encompasses changes concerning the structure and components of a given system. For the governance of spatial planning systems, it refers to the reorganization of planning instruments, regulations, and simplification of planning procedures, for instance, to favor stakeholders' involvement and instruments homogenization to provide more speedy and robust decisions. In the context of the mitigation hierarchy, it promotes the full and right order of implementation of the avoidance, minimization, restoration and offsetting levels.
- **Path-shifting:** Generally speaking, it is described as a redirection of the principles that govern a system. For the governance of spatial planning systems, path-shifting entails adopting an inclusive, adaptative and pluralist approach. For the mitigation hierarchy, the T1.1 deliverable describe a path-shifting change whenever planning instruments reflect a shift from a reactive planning approach of observed/foreseen changes to proactive approach for biodiversity enhancement, which include preparation for unexpected events.

- **Innovative:** innovative planning instruments are those that use new knowledge, e.g., derived from bottom-up grassroot initiative of NbS implementation, to delineate novel planning visions, strategies, and actions. It can be represented using NbS for meeting mitigation hierarchy goals.
- **Multiscale:** the multiscale characteristic captures those vision, strategies and actions of plans that support the involvement of actors and stakeholders from the public and private realm and civil society and create synergies between several spatial and temporal scales (e.g., accounting for the needs of future generations, and the spatial transboundary impacts of planning interventions). In the context of the MH, it entails coordinating mitigation hierarchy goals and requirements across spatial planning scales.

Distilling these transformative criteria can highlight the most relevant features of transformative change in the context of ES assessments to inform spatial planning decisions (Table 8).

Table 8 Distilling the criteria for transformative change from Task 1.1 in the context of ES assessments (based on Deliverable D1.1 – BioValue Project).

CRITERIA FOR TRANSFORMATIVE SPATIAL PLANNING SYSTEMS (T.1.1)	Distilled features in the context of ES assessments
RE-STRUCTURING	Reorganizing and integrating current steps in traditional ES assessment frameworks, including changing those traditionally involved in the ES assessment process (both institutional representatives and stakeholders)
PATH-SHIFTING	Capturing changes in vision/strategies/actions that shift the values at stake in ES assessments in order to embrace adaptation (i.e., implementing iterative learning processes) and pluralisms (i.e., accounting for diverse sources of knowledge as well as values).
INNOVATIVE	Eliciting context-based, pluralistic, and goal-oriented information through ES-assessments in novel ways, including diverse knowledge systems specifically to allow the inclusion of the different perspectives and values of nature that are present among those involved in the process and to identify ES promoters and beneficiaries correctly
MULTISCALE CHANGES	Performing ES assessments in such way that it contributes to an understanding of the possible changes in ES supply and demand across different spatial and temporal scales (e.g., through scenarios analyzes), including identifying synergies and trade-offs between actors

KEY MESSAGES FOR THE TASK 1.3 FRAMEWORK

Based on these criteria, it is necessary to ensure that the ES assessment framework brought forward in this deliverable can contribute to the design and implementation of spatial planning instruments that will ultimately solidify re-structuring, path-shifting, innovative and multiscale systems. Practically speaking, **the ES assessment should be suited to somehow address the criteria** of a transformative spatial planning system, by at least **taking into consideration the distilled features** of each criterion here presented to contribute to its end goal.

3.4 Elements of transformative change for ES assessment from relevant literature

In addition to the work already developed within BioValue, we have reviewed a number of reference documents that approach elements, criteria, guidelines and recommendations for transformative change in different contexts (policy making, governance, planning, and value assessment), to better understand how to increase the transformative potential of an ES-based assessment. This review is intended to provide additional support to the principles already discussed in Task 1.1 and Task 4.1 (as per the previous sections).

Key elements for transformative social change (Naito et al., 2022)

Though the authors present a slightly different framework for transformative change than the one from our WP4, it is relevant to highlight the set of key criteria for transformative change that the authors provide within the necessary structural transformation processes, in order for social transformation to occur. These key elements include (non-exhaustive list):

- institutional capacity for monitoring and responding to environmental change (**adaptive capacity**)
- promoting **knowledge sharing**
- constructing a **shared vision**
- addressing **power dynamics**

Collaborative pathways in sustainability transitions (Chambers et al., 2022)

To navigate the tensions (which they call *rigidities*) that may emerge in the processes (i.e., collaborative weaving of research and practice by diverse societal actors) towards sustainability transitions, Chambers et al. (2022) identify four pathways at the science-policy-society interface to foster agility (as opposed to rigidity) and potentiate transformative change, which can be relevant to help navigate the challenges of mainstreaming biodiversity values in ES assessments:

- **Elevating marginalized agendas** by **supporting marginalized actors** to elevate their own perspectives and claims in ways that maintain their integrity while broadening struggles for justice. There is a need to **incorporate a variety of knowledge systems** and carefully consider the inclusion of marginalized perspectives alongside prevailing mainstream and dominant paradigms

- **Questioning dominant agendas:** by deeply **engaging actors** who hold stakes in dominant systems by reflecting on their agendas and exploring more inclusive actions. There is a need **to mobilize people** to act towards a collective good.

- **Navigating conflicting agendas** by embracing the political aspect of brining actors together to decide upon and undertake transformations to interlinked paradigms, relations, practices, policies, and institutions. There is a need **address power lock-ins and power relations** currently hindering the capacity for change (or identify those power relation possibly enabling it).

- **Exploring diverse agendas** by connecting actors through exploratory processes that do not aim to empower any particular agenda, but rather foster mutual understanding and respect for a plurality of perspectives. There is a need to foster **iterative collaboration for learning, sharing experiences and perspectives**.

IPBES guidelines for value assessment to overcome uptake challenges (IPBES, 2022)

As mentioned earlier in Chapter 2 (2.2) the IPBES methodological assessment report (IPBES 2022) brings forward a guideline to operationalize the diverse values of nature into decision-making processes, which include:

- **Contextualize** the entire decision-making process in synchrony with the values that underpin the biophysical, social, economic, cultural and political context in the target intervention area.
- **Design tailored decision-making processes** that take into account capacities, knowledge and perspectives of stakeholders through equal, participatory, communicative, and conflict management approaches
- **Ensure a fair representation of diverse worldviews** and values held by relevant actors (including stakeholders, right holders and knowledge holders e.g., indigenous peoples and local communities, gender diversity and youth, civil society organizations involved in conservation or development activity among others).
- **Engage interactively with the relevant actors** to promote dialogue, long-term collaboration and co-creation of solutions.
- **Strive for impact and legitimacy** by instilling a **sense of co-ownership** over valuation results by all actors who take part in the valuation process.
- **Reflect and learn** to ensure that decisions that impact nature and its contributions to people are aligned with the values and actions that can foster transformative change.

As this guideline is set within a step-wise, iterative valuation approach, they were designed to help overcome the challenges that hinder uptake of valuation results in decision-making, which is a relevant consideration for transformative processes (Fedele et al., 2019).

Transformative governance of biodiversity: insights for sustainable development (Visseren-Hamakers et al., 2021)

Taking from the findings in Chapter 6 of the IPBES Global assessment report, which aimed at operationalizing the concept of transformative governance, these authors focus on biodiversity-related issues to draw broader lessons for sustainability debates. The authors hypothesize that governance will only become transformative when it addresses indirect drivers underlying sustainability issues and is simultaneously:

- **Integrative:** operationalized in ways to ensure local solutions also have **sustainable impacts at other scales, on other issues, and in other places and sectors**
- **Inclusive:** in ways that **empower those whose interests are currently not being met** and **represent values embodying transformative change** for sustainability
- **Adaptive:** since transformative change and governance, and our understanding of them, evolve over time, so governance needs to enable **learning, experimentation, reflexivity, monitoring and feedback**
- **Pluralist:** recognizing and incorporating **different scientific and societal knowledge** systems

Planning for transformational change (Linnenluecke et al., 2017)

Planning for transformational change is based on the belief that actors at multiple levels within society (individuals, organizations, government) need to: **co-create future plans** and generate value, with an external focus of planning; engage in actions at a high-levels to shape the future; and **collaborate broadly with non-traditional stakeholders**. This approach also features prominently in the assessment document of the Intergovernmental Panel on Climate Change (i.e., IPCC, 2012; which is outside the scope of this review). Planning for change recognizes that environmental challenges present opportunities for private sector organizations, and also for entire systems, that must undergo significant changes to address future challenges associated with protecting planetary boundaries, as well as the unmet needs of those marginalized voices. Planning for change draws on stakeholder management to **collaborate with a wide range of stakeholders**. Traditionally, many of these stakeholders, including scientific, policy and community representatives have not been included in planning processes. Nevertheless, they do have an interest in the future outcome of the transformation. Those advocating for transformational change argue that this approach has the **potential to develop more inclusive, robust solutions to sustainability challenges because it involves stakeholders and bases that involvement on principles of self-organization**. Planning for change is also meant to foster efficient communication channels through social networks and **trust-building dialogues**.

3.5 The transformative potential of ES assessments

Based on the previous literature, we extracted five key transformative features that can be applied to ES assessment (see also Table 9):

- **Pluralizing:** The ES assessment has transformative potential if it ensures the co-existence of diverse knowledge and (conflicting) perspectives throughout the various phases of the assessment process, ideally as early as possible. This includes capturing the different values of nature (intrinsic, instrumental and relational), which should be reflected in the ES being assessed.

- **Impacting:** The ES assessment has transformative potential if it ensures the assessment process uptake by applying feasible methods to elicit (derive information) and articulate (analyze and interpret information) ES, and linking back the outcomes of the assessment to the ambitions for transformative change.

- **Empowering:** The ES assessment has transformative potential if it ensures not only a timely fair representation of all relevant actors (as part of Pluralizing), but if it applies integration methods that enable clearly identifying and weighting off synergies and trade-offs across beneficiaries in ways that do not trump dominant values and perspectives over marginalized ones.

- **Contextualizing:** The ES assessment has transformative potential if it ensures a process that is in synchrony with the values that underpin the context to which it is applied, and by eliciting and articulating context-specific and goal-oriented information with the span, depth, and accuracy required to support decision-making given the specific purpose of the assessment.

- **Engaging:** The ES assessment has transformative potential if it promotes high levels of engagement with the purpose of triggering processes of social learning that can raise awareness among stakeholders (formative purpose) and reshape planning decisions through a reflect and adapt approach (adaptive co-learning), increasing ownership over its process and outcomes.

- **Scaling:** The ES assessment has transformative potential if it enables a clear understanding of the possible changes in ES supply and demand across different spatial and temporal scales (e.g., through scenarios analysis, back-casting and forecasting, etc).

These features (abbreviated as *PIECES*) are not a comprehensive set but merely a combination of the most prominent criteria that emerged from our review and that can be applied to the ES assessment framework in the context of the present deliverable. It is thus not intended to fully capture the whole concept of transformative change and its nuances, but rather to guide the selection of methods and interactions to be proposed under the T1.3 Framework towards a more transformative outcome.

Table 9 The possible PIECES of a transformative assessment: description and links with the contents from Section 3.4.

PIECES OF A TRANSFORMATIVE ASSESSMENT	SHORT DESCRIPTION	Links with previous BioValue outcomes (D4.1 and D1.1) and the literature reviewed (section 3.4)	
		From BioValue	From the literature
PLURALIZING	The ES assessment ensures co-existence of diverse knowledge and (conflicting) perspectives	D4.1 VISION building block: Narratives conducive to global commons; addressing biodiversity but also economic and social concerns and inequalities D1.1 PATH-SHIFTING criteria: Capturing changes in vision/strategies/actions (...) embracing pluralisms (i.e., accounting for diverse source of knowledge as well as values).	Co-create future plans by collaborating with a wide range of stakeholders, including non-traditional (Linnenluecke et al., 2017) "(...) recognizing and incorporating different scientific and societal knowledge systems" (Visseren-Hamakers et al., 2021) Ensure a fair representation of diverse worldviews and values held by relevant actors (IPBES 2022) "(...) incorporate a variety of knowledge systems" (Chambers et al 2022). Constructing a shared vision (Naito et al 2022)
IMPACTING	The ES assessment ensures the feasible methods to facilitate uptake in a transformative spatial planning process	D4.1: KNOWLEDGE: (...) goal-oriented information D 4.1: AGENCY: Achieve value change and finding ways for a good life and decent livelihood for all humans without degrading global commons	Design tailored decision-making processes (...) striving for impact and legitimacy (IPBES 2022)
EMPOWERING	The ES assessment ensures the application of integration methods to identify and weigh off synergies and trade-offs across beneficiaries, tackling positions of power.	D1.1: MULTISCALE: Performing ES assessments in such way that it contributes to identifying synergies and trade-offs between actors	"(Working)... in ways that empower those whose interests are currently not being met and represent values embodying transformative change for sustainability" (Visseren-Hamakers et al., 2021) (..) address power lock-ins and power relations (...) supporting marginalized actors" (Chambers et al., 2022) addressing power dynamics (Naito et al., 2022)

PIECES OF A TRANSFORMATIVE ASSESSMENT	SHORT DESCRIPTION	Links with previous BioValue outcomes (D4.1 and D1.1) and the literature reviewed (section 3.4)	
		From BioValue	From the literature
CONTEXTUALIZING	The ES assessment ensures synchrony with the purpose and the values that underpin the context to which it is applied	D4.1 KNOWLEDGE: context-based, pluralistic, and goal-oriented information D1.1: INNOVATIVE: Eliciting context-based, pluralistic, and goal-oriented information through ES-assessments in novel ways, including diverse knowledge systems specifically to allow the inclusion of the different perspectives and values of nature that are present among those involved in the process and to correctly identify ES promoters and beneficiaries	Contextualize the entire decision-making process in synchrony with the values that underpin the biophysical, social, economic, cultural and political context in the target intervention area. (IPBES 2022)
ENGAGING	The ES assessment ensures high levels of engagement with processes of social learning and adaptive co-learning, increasing ownership over its process and outcomes	D1.1 PATH SHIFTING: Capturing changes in vision/strategies/actions that shift the values at stake in ES assessments, in order to embrace adaptation (i.e., implementing iterative learning processes)	"(...) enable learning, experimentation, reflexivity, monitoring and feedback" (Visseren-Hamakers et al., 2021) Engage interactively with the relevant actors (...) and instill a sense of co-ownership over valuation results (IPBES 2022) Reflect and learn to ensure that decisions that impact nature and its contributions to people are aligned with the values that shape transformative change (IPBES 2022) "(...) iterative collaboration for learning, sharing experiences and perspectives" (Chambers et al., 2022) Adaptive capacity (...) promote knowledge sharing (Naito et al., 2022)
SCALING	The ES assessment ensures a clear understanding of the possible changes in ES supply and demand across different spatial and temporal scales	D1.1 MULTISCALE: an understanding of the possible changes in ES supply and demand across different spatial and temporal scales	(...) ensure local solutions also have sustainable impacts at other scales, on other issues, and in other places and sectors" (Visseren-Hamakers et al., 2021)

4. The T1.3 Framework

4.1.Introduction

The information analyzed in the previous chapters culminated in this ES assessment framework to mainstream biodiversity values into decision making in the context of spatial planning (aka The T1.3 framework). This is hence a framework that aims to provide guidance (including methods for biophysical measurements, social and economic information, as analyzed in Section 2.3) for approaching the importance of nature from different perspectives (as analyzed in Section 2.2, including intrinsic, instrumental, and relational values), framed by its transformative potential (as given by its connection with the WP4 framework analyzed in Chapter 2 as well as the PIECES of a transformative assessment from Chapter 3). We will next present the T1.3 framework, providing an overview of the stages that comprise it, and finalize this chapter with a section analyzing its transformative potential.

4.2. An overview of the T1.3 Framework and its operational stages

The T1.3 Framework is presented in Figure 8, being framed by transformative change by considering a link with the three ambitions from the WP4 Framework directly in the first stage of the framework, and also linking the uptake of the assessment results (last stage) into the pathways for impact from the WP4 Framework as well, which in turn feeds back into the ambitions. Additionally, the whole framework and its operationalization can foster transformative change by complying with the transformative elements of a transformative assessment (PIECES), as from Section 3.5. We will briefly go through each of the stages to operationalize this Framework.

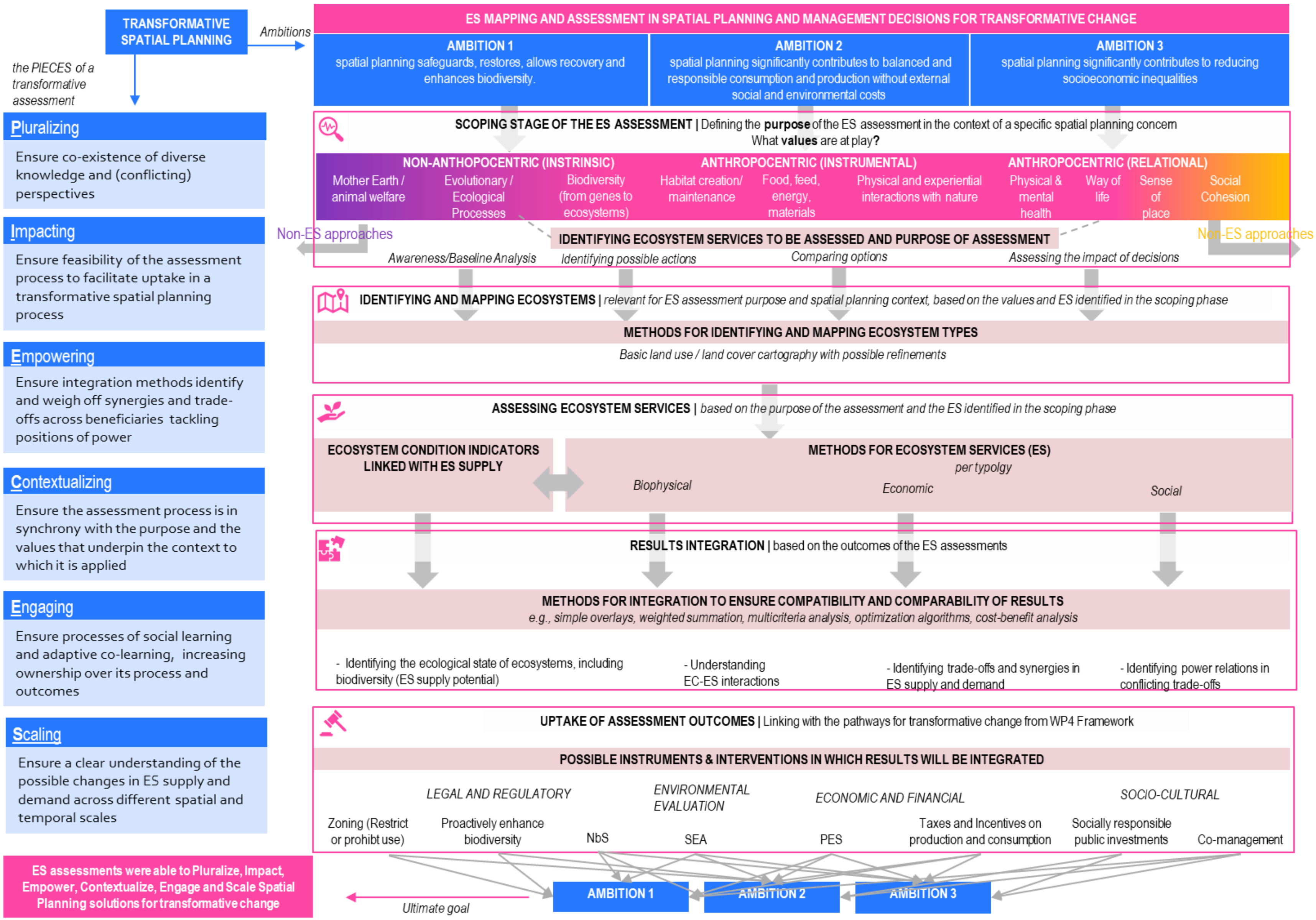

Figure 8 An overview of the T.13 Framework

STAGE 1: SCOPING

Scoping is the first stage of this Framework, though it is already embedded within the spatial planning process, in the frontier **between VISION and TERRITORIAL MODEL** (see the spatial planning process scheme developed for BioValue in Annex - Figure 10). As such, it is preceded by the identification of the problems (i.e., the spatial planning issue(s) being addressed), as well as the identification of all relevant actors that should be involved in the process.

The scoping stage refers back to the *first step* of the MAES operational framework (*theme identification*, see Section 2.3), and also to the *first three steps* of the value assessment framework from IPBES (see Table 1 in Section 2.2) and so for the purpose of the present deliverable we acknowledge that the entry point at this stage should be composed of two key elements:

- Identifying the **purpose of the assessment**, based on possible planning and context-specific questions and issues to be addressed (linking back to the discussions in Section 2.3)
- Identifying the **values of nature** that are at play in this decision-making context (Section 2.2) to help guide the **selection of ES** that will be targeted

Identifying the purpose of the assessment will dictate the level of depth and accuracy that should be brought to the assessment process and consequently will affect the selection of methods and indicators to assess ES in the following stages of the framework. In this regard, we illustrate potential assessment purposes based on possible end goals (i.e., ways in which the assessment can support decision-making in the context of spatial planning), based on the discussion from Section 2.3 (Table 10).

Table 10 Examples of possible purposes for performing ES assessments in the context of Spatial Planning (adapted from Cortinovis et al., 2021 and Pascual et al., 2023).

PURPOSE OF THE ASSESSMENT			
Raising awareness / Conducting baseline assessments	**Identifying possible actions**	**Comparing alternative options**	**Assessing the impact of decisions**
Map supply and demand Identify important issues (providers vs beneficiaries) Illustrate potential benefits and costs of alternative solutions Define a benchmark for future scenarios and impact assessment	Identify alternative development options Develop optimal solutions (e.g., identifying priority areas for conservation, new green infrastructure, mixed-use planning)	Compare alternative planning decisions Alternatives at different levels – i.e., alternative development patterns, alternative areas or sites where to implement certain policies, alternative site-specific nature-based solutions or management options	Understand/quantify the consequences on ES of the decisions made Comparison with a benchmark (baseline condition)

Ideally, the identification of the values of nature (as analyzed earlier in Section 2.2) is to be performed through meaningful stakeholder participation, to ensure all the preferences, perspectives, and judgments that are relevant to this particular decision-making context are considered. At this stage it is also essential to frame and contextualize the values identified within the ambitions for transformative change in spatial planning (as discussed in Section 3.2). The selection of ES naturally derives from the values identified, and they will be the focus of the subsequent stages of the Framework. As already discussed in Section 2.2, we acknowledge at this stage the importance of translating the diverse values of nature into the concept of ES. With the goal of mainstreaming biodiversity values into this assessment, we bring forward possible connections that will help promoting a plural lens to the proposed framework (Figure 9).

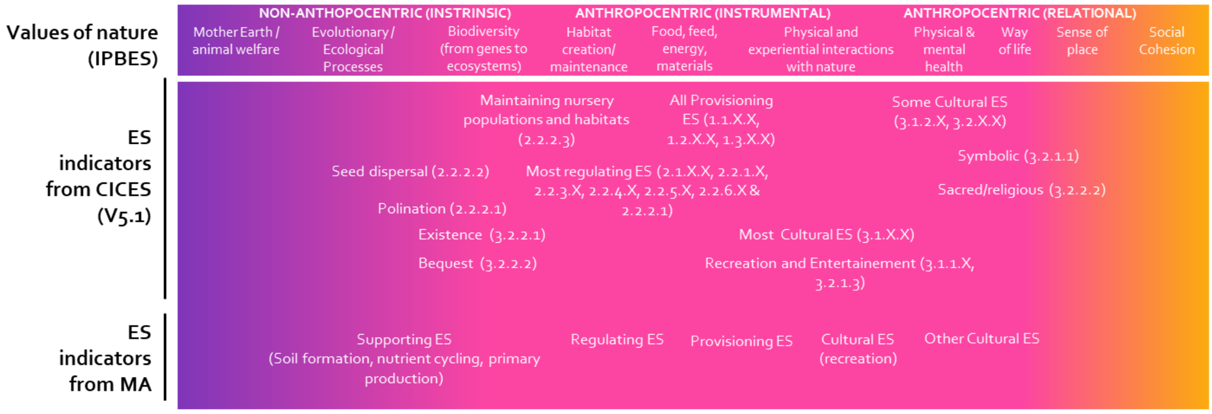

Figure 9 Examples of how ES indicators can reflect the diverse values of nature (intrinsic, instrumental, and relational). ES indicators from the CICES classification (V5.1) and from the Millenium Ecosystem Assessment (MA).

Methods that can be employed at this scoping stage can range anywhere in between a more formal and complying approach with a top-down, *ad-hoc* definition of the assessment purpose and selection of values/ES to be addressed, performed by the entity(ies) responsible for the spatial planning process (though this accrues little transformative potential to the assessment process - as per the PIECES presented in Section 3.5), to a compromise approach with a top-down pre-selection of assessment purposes and potential values and ES to be analyzed, made by the responsible entity(ies) and later discussed with a selected group of stakeholders or even a more holistic, bottom-up and meaningful participation approach where the assessment purpose and the values/ES to be addressed are collectively selected.

STAGE 2: IDENTIFYING AND MAPPING ECOSYSTEMS

The second stage of this Framework concerns identifying and mapping the ecosystems of interest to the assessment. This stage refers back to the *steps 2* and *step 3* of the MAES assessment framework (Section 2.3).

The purpose of the assessment and the ES identified in the previous stage will dictate the information required here. We acknowledge that the basic input of spatial information for identifying and mapping ecosystem types is land-use/land-cover cartography that might be readily available for the study area, at the highest resolution possible. Depending on the purpose of the assessment and the data availability, this can be used as a proxy for the types of ecosystems of interest by itself.

However, context-specific refinements involving relevant stakeholders or field experts are highly advised to increase the assessment's accuracy and consequently improve uptake and increase the ES assessment's transformative potential. Refinements can include using additional biophysical information or data on sociocultural structures that might be relevant to the specific planning context. Methods for performing spatial refinements in identifying ES types can include highly technical and expert-based data approaches or locally produced datasets (collected through field surveys, social media, citizen-science datasets, consultation of relevant groups, or participatory through participatory approaches).

STAGE 3: MAPPING ECOSYSTEM SERVICES (AND CONDITION)

The third stage of this Framework consists of assessing the ES selected in stage 1, based on the ecosystem types mapped in stage 2. This stage refers back to *steps 4 to 7* from the MAES operational framework (Section 2.3) and *step 4* from the IPBES value assessment framework (Section 2.2). The spatial component of ES assessments (i.e., mapping) is essential in the context of decision-making for spatial planning, and as such we refer here to assessments by implying mapping *and* assessment.

Ideally, and as discussed in Section 2.3, the condition of ecosystems (EC) would be the entry point for this stage, where, for instance, the potential supply of certain ES can be linked with specific EC indicators (which can be indicators of the chemical/physical state of ecosystems, of their functional, structural, or compositional state, or even of mosaic/diversity at the landscape level). Notwithstanding, we acknowledge at this stage that, since EC-ES relationships are a complex topic still prematurely depicted in the literature, within the context of an ES assessment to support decision-making, they might bring additional complexity and uncertainty to the process. To this end, we expand on a few well-established EC-ES relationships and advance here possible EC indicators that can be assessed in the present Framework, which can be useful to the context of the assessment – i.e., considering the assessment purpose and also the ES selected in the first stage (Table 11). Methods for assessing EC through these or other robust indicators usually require expert-derived data or technical expertise.

Table 11 Examples of EC indicators and their potential use in the context of the T1.3 Framework (based on Vallecillo et al., 2022). The list is non-exhaustive.

Type of EC Indicator	**Variable**	**Unit**	**Usefulness in the context of ES assessment (ES interaction or EC assessment for planning outcome)**
Physical/Chemical State	Normalized Difference Moisture Index (NDMI)	Dimensionless	Indication of water stress in vegetated patches (crops, fields), proxy for Water Flow Regulation ES Demand Can be used as EC assessment to identify vegetation areas in need of restoration (combined with other indicators)
	Sealed soil cover	%	Indication of imperviousness, can be used as variable in runoff models for flood control ES potential supply
	Nitrogen inputs (concentration)	µg/m³ of N	Indication of water quality, can be used as variable in water quality models to determine ES potential supply Can be used as EC assessment to identify areas of water purification ES demand
Compositional State	Species richness (bumblebees)	# of species	Indicator of wild pollinator occurrences, proxy for pollination ES Services supply as a variable in species distribution models.

Type of EC Indicator	Variable	Unit	Usefulness in the context of ES assessment (ES interaction or EC assessment for planning outcome)
			Can be used as EC assessment to identify biodiversity hotspots (combined with other indicators)
Structural State	Tree cover	%	Indicator of annual biomass increments, can be used as a proxy for timber provision ES supply
	Vegetation cover	%	Indicator of crop management and conservations practices (in rural landscapes), can be used as a proxy for soil retention ES supply as variable in spatial RUSLE models
Functional State	Presence of top predator species	# of species	Indicator of species hotspots, can be used as proxy for habitat maintenance ES supply

As for the ES assessment *per se*, which is logically a central piece in this Framework, a few considerations from the discussion in Section 2.3 have to be covered. First, the selection of methods to assess ES is highly dependent on the data, resources and capacities available. Secondly, we acknowledge that, to overcome limitations, tiered approaches combining different methods and indicators are highly advised. Thirdly, the selection of ES from stage 1 will also dictate the best methods to be applied in this stage, determining the span of methods and indicators to be considered. Finally, the purpose of the assessment defined in stage 1 will also dictate the best methods to be applied, determining the appropriate level of depth and accuracy that is required.

Based on these considerations, we bring forward possible methods that can be applied considering the ES selected and the purpose of the assessment (Table 12). A brief description of the methods and the resources required is presented in Annex (Table 16).

Table 12 Examples of possible methods for ES assessment to be applied given the typology of ES and the purpose of the assessment (inspired by Cortinovis et al. 2021 and based on Deliverables D3.3, D4.2, and D4.3 from the ESMERALDA project).

Type of ES	PURPOSE OF THE ASSESSMENT			
	Raising Awareness/ Conducting baseline assessments	Identifying possible actions	Comparing alternative solutions	Assessing the impact of decisions
Provisioning ES	Spatial proxies (look up tables) Statistical data Remote sensing derivatives Market price	Statistical models Integrated models frameworks Field Observations Opportunity cost		Field Observations Input/Output models Production function
Regulating ES	Spatial proxies (look up tables) Remote sensing derivatives Avoided or restoration cost (benefit transfer) Social cost of carbon	Remote sensing Process-based models Phenomenological models Opportunity cost		State and transition models Macro-ecological models Connectivity models Avoided or restoration cost (value functions)
Cultural ES	Spatial proxies (look up tables) Surveys & questionnaires Statistical and social economic data Benefit transfer	Preference assessments Time-use assessments Travel cost Contingent valuation	Participatory mapping Deliberative valuation Scenario planning Photo-elicitation surveys Hedonic pricing	Deliberative valuation Narrative assessments

We acknowledge the importance of assessing both ES supply and demand at this stage, to enable the identification of synergies and trade-offs not only from the supply side but also the demand (beneficiaries), as well as considering spatial and temporal changes in ES supply and demand, by prioritizing methods that allow generating and comparing different scenarios.

STAGE 4: RESULTS INTEGRATION

The fourth stage of the Framework consists of integrating the outcomes assessed in stage 3, specifically by combining (articulating, making comparable, ranking, etc.) all information regarding the ES (and possibly EC) to support decision-making. This stage refers back to *step 8* from the MAES operational framework (Section 2.3).

The integration stage is the **central stage** of the assessment, where potential trade-offs and synergies can be identified and weighted up. Overall, the methods for integration will heavily depend on the type of assessment carried out in the previous stage. For instance, the outcomes of ES assessments elicited (and valued) through economic methods can be integrated via economic assessments such as an extended Cost-Benefit Analysis (CBA). Results integration can also be performed using simple spatial overlays where densities or averages are calculated, or applying more complex methods such as optimization algorithms, efficiency indicators, or Multi-Criteria Decision Analysis (MCDA) (Cortinovis et al., 2021). However, and as discussed in Section 2.3, methods for integration that encourage an equal treatment to all the diverse values of nature being addressed as well as the different preferences and perspectives of actors (e.g., addressing power asymmetries), should be prioritized, as they help set a more *meaningful* logic to the decision-making (linking back to the logics of decision-making discussed in Section 2.3). Given the challenges associated with economic valuation methods in capturing intrinsic or relational values, MCDA (with weighting through participatory approaches) and deliberative valuations foster a more comprehensive and meaningful integration of diverse values if fitting to the purpose of the assessment and the ES being addressed (Table 13).

Table 13 Examples of possible methods for ES assessment integration given the purpose of the assessment (based on Cortinovis et al. 2021).

PURPOSE OF THE ASSESSMENT			
Raising Awareness/ Conducting baseline assessments	Identifying possible actions	Comparing alternative solutions	Assessing the impact of decisions
Simple spatial overlays (density, average) Weighted summation	Optimization algorithms Deliberative valuation	Efficiency indicators Multi-Criteria Decision Analysis (MCDA) Extended Cost-benefit Analysis	Simple spatial overlays (density, average)

Possible outcomes from this integration phase will mostly vary depending if EC was assessed in the previous stage. For instance, if the focus of the assessment in stage 3 was solely on ES supply and demand, then the integrated assessment can provide information on **trade-offs and synergies in ES supply and demand**, as well as identifying **power relations** that may exist in conflicting trade-offs. On the other hand, if EC was also assessed, then on top of the outcomes listed above the integrated assessment can also provide information on the **ecological state** of ecosystems and identification of areas in need of restoration, **biodiversity level** and identification of sensitive areas, as well as proxy information for **ES supply potential** (based on condition level). Ultimately, an integrated assessment that includes EC indicators will also shed light on the EC-ES relationships found in the study area.

STAGE 5: UPTAKE OF OUTCOMES

The fifth and final stage of the Framework is given by the uptake of the assessment's outcomes into the most fitting spatial planning instrument or other relevant instruments, given the purpose of the assessment defined earlier. This stage relates to the *final step* of the MAES operational framework (Section 2.3).

Based on the outcomes of the previous integration stage, the results of the assessment can help inform different spatial planning instruments in different ways. At this stage, we bring forward the relevance of each possible outcome from the integrated assessment to inform different spatial planning instruments (Table 14).

Table 14 Relevance of possible assessment outcomes and its uptake in different spatial planning and policy instruments (o = slightly relevant; ✔ = relevant; ✔ ✔ = very relevant). This list is non-exhaustive.

POSSIBLE INSTRUMENTS FOR UPTAKE OF ASSESSMENT OUTCOMES	POSSIBLE ASSESSMENT OUTCOMES (from stage 4)				
	Identifying ecological state of ecosystems, including biodiversity		Understanding EC-ES relationships	Identifying trade-offs and synergies in ES supply and demand	Identifying power relations in conflicting trade-offs
ENVIRONMENTAL EVALUATION					
Strategic Environmental Assessment (SEA)	✔ ✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔
LEGAL AND REGULATORY					
Zoning (restrict or prohibit use)	✔ ✔	✔ ✔	✔	✔	✔ ✔
Proactively enhance biodiversity	✔ ✔	✔ ✔	✔	✔	✔
Nature-based solutions	✔ ✔	✔ ✔	✔	✔ ✔	✔ ✔
ECONOMIC AND FINANCIAL					
Payment for Ecosystem Services schemes (PES)	o	o	✔	✔ ✔	✔ ✔
Taxes and incentives on production and consumption	o	o	✔	✔ ✔	✔ ✔
SOCIO-CULTURAL					
Socially responsible public investments	✔	✔	✔ ✔	✔	✔ ✔
Co-management	✔	✔	✔ ✔	✔ ✔	✔ ✔

The implementation of these instruments is expected to contribute directly to one or more of the ambitions for a transformative spatial planning process. This connection is made possible through the pathways for transformative change defined in WP4 framework (Section 3.2), and it allows feeding back into the ambitions for transformative change. We acknowledge the relevance of integrating this Framework within the spatial planning process depiction from BioValue (shown in Annex - Figure 10), as this will enable validation upon the outcomes of the instruments, and promote opportunities for reflection upon the assessment results in this regard (in the loop cycle indicated in the scheme).

4.3.The transformative potential of the T1.3 Framework

The Framework here presented will be further developed in the remainder of the BioValue project, as it will be tailored for implementation in the Arenas for Transformation (as part of Task 4.2), and hence its potential to elicit transformative change will be tested in practice. Notwithstanding, by linking back to the PIECES of a transformative assessment defined in Section 3.5, we anticipate some elements from the proposed Framework that can be operationalized in this regard, including not only the methods that can be applied in each stage but also its implementation as a whole (Table 15). These elements are still under discussion and are expected to evolve as the Framework is operationalized in the Arenas.

Table 15 Understanding the transformative potential of the T1.3 Framework and its operational stages (for details on the stages see previous section - 4.2). The elements here presented are not exhaustively listed.

PIECES OF A TRANSFORMATIVE ASSESSMENT	T1.3 FRAMEWORK	T1.3 FRAMEWORK STAGES				
		SCOPING	MAPPING ECOSYSTEMS	ASSESSING ES (AND EC)	INTEGRATION	UPTAKE
PLURALIZING	Ensures the co-existence of diverse knowledge and (conflicting) perspectives throughout the ES assessment process	Defining the purpose of the assessment and ES to be assessed through bottom-up approaches, including relevant actors across different sectors	Revising and refining existing spatial information on ecosystems to identify relevant areas of potential ES supply and demand	Prioritizing assessment and valuation methods and approaches that account for the plurality of nature's values		
IMPACTING	Prioritize adequate and feasible methods throughout the ES assessment process to facilitate uptake within the end goal of a transformative spatial planning process				Prioritizing integration methods that produce relevant information to support decision making and adequately meets the purpose of the assessment	Ensuring integrated results are fed back into instruments that lead to the pathways of impact, linking back to the ambitions
EMPOWERING	Prioritize integration methods in the ES assessment to identify and weigh off synergies and trade-offs across beneficiaries, tackling positions of power, clearly identifying winners vs losers etc.			Prioritizing assessment and valuation methods that help clearly identifying promoters and beneficiaries across different sectors	Prioritizing integration methods that help identify synergies and trade-offs in ES supply and demand across different sectors, without favoring dominant values	
CONTEXTUALIZING	Prioritize context-specific information and promote adaptive co-learning and formative interactions among relevant actors to ensure the values that underpin the context of the ES assessment are synchrony with transformative change	Defining the purpose of the assessment and ES to be assessed through bottom-up approaches, including relevant actors across different sectors			Prioritizing integration methods that allow for deliberation and knowledge sharing among relevant actors	Ensuring integrated results are supporting decision making in the context of the specific spatial planning process in which it is embedded

PIECES OF A TRANSFORMATIVE ASSESSMENT	T1.3 FRAMEWORK	T1.3 FRAMEWORK STAGES				
		SCOPING	MAPPING ECOSYSTEMS	ASSESSING ES (AND EC)	INTEGRATION	UPTAKE
ENGAGING	Promote meaningful engagement and interaction throughout the ES assessment process as early on and as much as possible	Favor stakeholder interactions as early as possible in the assessment process	Favor refinement of spatial information with relevant actors	Favor assessment methods that allow including or at least interacting with relevant actors	Favor integration methods that foster interaction with relevant actors	
SCALING	Prioritize methods and approaches for the ES assessment that allow a clear understanding of the possible changes in ES supply and demand across different spatial and temporal scales			Prioritize assessment methods that capture changes in ES supply and demand across different spatial and temporal scales		

5. Future directions

The T1.3 ES assessment Framework and its transformative potential will be discussed with each Arena for Transformation in *Year 2*, in order to revise and adapt it to be operationalized in different contexts, as part of Task 4.2, which will result in Deliverable D4.3 (Month 32) (*Progress report II - final report - of the case-studies development following the application of the analytical framework and reflexive analysis*). In its implementation, the elements presented in Table 15 will also be explored to understand and optimize the overall contribution of this Framework to Transformative Change.

In this regard, the first step forward will consist of carrying out individual meetings with the three Arenas in the first quarter of 2024. As of now, preliminary meetings with the Trento Municipality in late November 2023 have already taken place and resulted in minor changes to an earlier version of the Framework here presented.

Additionally, other workflows within BioValue will also benefit from the operationalization of the Framework here proposed, such as D4.4 *Recommendations for policy mixes combining instruments from SP&MI, EAI and E&FI across governance levels drawing on the respective transformative potential (M34)* and D4.5 *Assessment of the applicability of proposed improvements in other EU Member States (M34) Note on the assessment of the proposals being generated in WP4 for scaling purposes in terms of their realistic application to other spatial planning contexts for EU Member States.*

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Annexes

In this Annex we present a table with a full description and additional information on each of the ES assessment methods discussed in the deliverable (Table 16) as well as the schematic representation of the spatial planning processes as advanced by the BioValue team (Figure 10).

Table 16 Brief description and data requirements for all the methods for ES assessment mentioned. Based on Deliverables D3.3,D4.2, and D4.3 – ESMERALDA Project.

Method	Description	Data requeriments and additional info
Biophysical		
Spatial proxy methods	Spatial proxy methods are derived from indirect measurements which deliver a biophysical value in physical units but this value needs further interpretation, certain assumptions or data processing, or it needs to be combined in a model with other sources of environmental information before it can be used to measure an ecosystem service. In many cases, variables that are collected through remote sensing qualify as indirect measurement. Examples for terrestrial ecosystems are land surface temperature, NDVI, land cover, water layers, leaf area index and primary production.	Data: Empirically measured data/ expert scoring/statistics for indicators Land cover data (GIS layers): terrain, vegetation, soil, bathymetry, habitat distribution etc. Software: Statistical software, spreadsheet, GIS software, Independent modelling tools
Phenomenological models	The phenomenological models describe empirical relationships between biodiversity or ecosystem components and ecosystem services. They are based on the understanding that biological mechanisms underpinning ES supply.	Data: Information from other studies/ meta-analysis Land use or land cover (GIS data), soil conditions, climatic conditions, accessibility Software: Statistical software, GIS software, Independent modelling tool
Macro-ecological models (includes habitat models)	Models that assess ES supply based on the presence (or abundance) of specific components of biodiversity, referred to as Ecosystem Service Providers (ESP) or Service Providing Units (SPU), depending on their geographic distribution. The contribution of e.g. different species or functional groups to the ES of interest is assessed based on specific traits (e.g. trophic guilds) or expert knowledge.	Data: Species distribution data (e.g. Atlases, in-situ data) inventories Habitat / land cover data (GIS data), additional parameters: soil, climate, land use etc. Remote sensing to derive environmental variables and processes to be coupled with models. Software: Statistical software, GIS software, Independent modelling tool
Trait-based models	There is increasing evidence for relationships between traits of organisms and ES supply. Trait-based models quantify ES supply based on (statistical) relationships between functional traits of Ecosystem Service Providers (ESP) and ecosystem properties considered either by experts or by stakeholders to support a given ecosystem service.	Data: Observational or empirical data on functional traits, plant traits, traits of soil microorganisms Explanatory variables: land use/ land cover, soil variables, climate variables Software: Statistical software, GIS software, Independent modelling tool
Process-based models (includes: landscape function models)	Process-based models rely on the explicit representation of ecological and physical processes that determine the functioning of ecosystems. They provide functional means of plant and ecosystem processes that are universal rather than specific to one biome or region. One purpose of such models is to explore the impact of perturbations caused by climatic changes and anthropogenic	Data: High-quality data on climate, atmospheric CO_2 concentrations, land use conservation, sequestration Note: Process-based models require very good expertise to

Method	Description	Data requeriments and additional info
	activity on ecosystems and their biogeochemical feedbacks. Many process-based models allow the net effects of these processes to be estimated for the recent past and for future scenarios. In terms of ecosystem services, these types of models are most widely applied to quantify climate regulation, water supply from catchments, food provision but also in the wider frame of habitat characterisation.	use the models properly
Statistical models	Statistical models are mathematical models that measure the attributes of a certain population using a representative sample as measuring the whole population is usually not possible. In statistical models ecosystem services are estimated based on explanatory variables such as soils, climate, etc., using a statistical relation.	Data: Environmental variables Software: Statistical software (e.g. R, SPSS, MatLab) Visualisation could be done separately in GIS software.
Ecological Connectivity models (to include methods/softwares such as Zonation, MSPA, MatrixGreen, TerrSet (former IDRISI), FunCon, etc.)	Ecological connectivity models are used to evaluate the structural and/or functional degree to which the landscape facilitates or impedes movement of different ecological processes. Connectivity of the landscape (e.g. urban green) promotes the provision potential of many ecosystem services as connectivity is fundamentally linked to the ecological processes providing these services. Structural connectivity models usually use LULC data derived, for example, from remote sensing as a basis to generate the geometry of the landscape elements and perform connectivity or fragmentation analysis. The latter are used to define the spatial pattern of the services providing units and their capacity to provide services. Functional connectivity models use data of the species dispersal in addition to physical attributes of the landscape.	Structural connectivity Data: Land cover or land use data, habitat data, features restricting movements, e.g. road and rail networks Functional connectivity Data: Species/ habitats distribution data, species suitability data, land cover or land use data, habitat data, features restricting movements, e.g. road and rail networks Software: Conefor (also plugin for Qgis or ArcGis available), Guidos, Fragstats, MatrixGreen, FunCon, GraphHab. Many calculations could be done separately in GIS softwares
State and transition model	State and transition models (STM) assume there are a number of states in which a system can exist, but there are specific conditions that can drive the system between states. The main focus of these models is the threshold point that separates one state from another and marks the transition between them. STMs are developed using information from a combination of sources including expert knowledge, historical observations, monitoring, and controlled experiments. They can be a good tool for examining natural systems by providing managers with better ways of understanding and communicating changes in the ecosystem as well as to provide broad predictive capabilities to assess and estimate potential future changes, given certain management and environmental conditions. The combination of STM with ecosystem services approach is useful for identifying multiple functions and benefits directed to improve decision making.	Data: Temporal land use data, remote sensing data, Software: GIS-softwares, RS softwares
Conceptual model	Conceptual models of ecosystem services describe systemic interactions between nature and people. They are, for instance, illustrations of ecosystem structures and functions, or impact of drivers and pressures on state variables. Conceptual models can also describe complexity of various approaches in the quantification of ecosystem services.	Data: Information from other studies Software: Visualisation tools
Integrated modelling framework	This group includes modelling tools designed specifically for ecosystem services modelling and mapping that can assess tradeoffs and scenarios for multiple services. They integrate various methods for different services which are usually organized in modules each of them designed for a particular service. The integrated modelling frameworks utilize GIS software as a means to operate with spatial data and produce maps. They can work as extensions of commercial or open-source software packages, stand-alone tools or web-based applications. They are designed to help researchers in ES assessment and enable decision makers to assess quantified tradeoffs associated	Data: Land cover data (GIS layers): terrain, vegetation, soil, bathymetry, habitat distribution etc.. environmental statistics Software: GIS-softwares, stand-alone tools e.g. InVEST

Method	Description	Data requeriments and additional info
	with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation.	
Field Observations	The elemental approach of natural sciences has always been making observations in nature and taking direct measurements (based on physical units). This should not be forgotten when considering mapping and assessing of the ecosystem services. In a sophisticated form field observations can be part of national or regional sampling systems, such as national forest inventories, biodiversity surveys, or LUCAS land cover measurements in the EU. Moreover, all kinds of in situ and citizen science observations, whose importance is increasing a lot, belong to this group. The value of the field observations is that they are spatially explicit and when stored in GIS databases they can be used to validate and calibrate results of the other methods.	Data: In-situ measurements Software: GPS, basic maps, online maps (e.g.google earth)
Surveys and questionnaires	This is a method class that is used often to get a quick overview of the studies phenomenon, and perhaps assist in selecting which other more appropriate models can be used in mapping and assessment. Surveys and questionnaires can provide expert information on ecosystem services, but they can be also used to evaluate uncertainties of other methodologies. Their role in ecosystem assessment and decision-support is important.	Data: Online questionnaires, expert interviews Software: Online tools e.g. Harava, Maptionnaire
Remote sensing and earth observations	The role of novel Earth observation techniques and data sets is becoming increasingly important in environmental monitoring, both for biodiversity (Vihervaara et al. 2017b), and for ecosystem services (Cord et al. 2017). Satellite Earth observation as well as airborne and drone observations have huge potential to improve quantification, mapping and assessment of ecosystems and their services. Optical, radar and LiDAR data can be used for direct measurements, or to gather information that feeds in the models.	Data: Satellite images, airborne images, LIDAR points Software: Remote sensing softwares e.g. Erdas Imagine, ENVI, GIS softwares and tools e.g. QGIS, ArcGIS, TerraScan, LasTools, FUSION
Remote sensing and earth observation derivatives (NDVI, land cover, surface temperature)	Remote sensing and Earth observation can be used also indirectly to get derivatives for ecosystem services. Examples of such measurements are, for instance, NDVI, land cover and surface temperature. Alone they are not directly reflecting to ecosystem services, but they can be used as important indirect proxies for them, or they can also feed in the models.	Data: Land cover data (GIS layers): terrain, vegetation, soil, bathymetry, habitat distribution etc. Software: Remote Sensing software e.g. ENVI, Erdas Imagine, GIS software e.g. ArcGIS
Use of statistical and socio-economic data	Sometimes data from socio-cultural or economic methods can be used as proxy data for ecosystem services. These data are seldom spatially-explicit, but they can be collected from wider regions, such as governance units (e.g. NUTS, municipalities, counties) or from national statistics. Interaction with national statistics can be also bi-directional, because on the one hand there are already many useful statistics collected which can help in mapping and assessing ecosystem services, but on the other hand there is also urgent need to get improved statistical information of ecosystem services (see KIP-INCA – Integrated Natural Capital Accounting – project, and SEEA-EEA – System for Environmental-Economic Accounts – Experimental Ecosystem Accounting).	Data: Population data, statistics Software: Statistical software e.g. R, SPSS, GeoDa
Economic		
Market price	Prices for ES that are directly observed in markets. Very often such prices need to be adjusted for market distortions.	Easy to collect and adjust data. Market prices can be distorted e.g. by subsidies. Most ES are not traded in markets
Public pricing	Public expenditure or monetary incentives (taxes/subsidies) for an ES is used as a proxy of the value of the ES.	No direct link to preferences of beneficiaries
Defensive expenditure	Expenditure on the protection of ecosystems and ES is used as a proxy of the value of ES.	Only applicable where direct expenditures are made for environmental protection related to provision on an ES. Provides lower bound estimate of ES benefit

Method	Description	Data requeriments and additional info
Replacement cost (Alternative cost method)	The cost of replacing an ES with a man-made service is used as a proxy of the value of the replaced ES.	No direct relation to ES benefits. Over- estimates value if society is not prepared to pay for man-made replacement. Under-estimates value if man-made replacement does not provide all of the benefits of the original ecosystem.
Restoration cost	Estimates the cost of restoring degraded ecosystems to ensure provision of ES as a proxy of the value of the ES.	No direct relation to ES benefits. Over- estimates value if society is not prepared to pay for restoration. Under- estimates value if restoration does not provide all of the benefits of the original ecosystem.
Damage cost avoided	Calculates the damage costs that are avoided due to the regulation of environmental flows by ecosystems (e.g. flood attenuation, storm buffering).	Difficult to quantify changes in risk of damage to changes in ecosystem quality.
Social Cost of Carbon	The monetary value of damages caused by emitting one tonne of CO_2 in a given year. The social cost of carbon (SCC) therefore also represents the value of damages avoided for a one tonne reduction in emissions, in other words, the benefit of a CO_2 reduction. SCC is a specific application of the "damage cost avoided" method.	SCC is a specific application of the "damage cost avoided" method. SCC is characterised by high modeling uncertainties and partial coverage of climate change impacts.
Opportunity cost	The next highest valued use of the resources used to produce an ecosystem service. As an economic method for quantifying value, the opportunity cost is the monetary value of the foregone alternative use of resources. For example, the opportunity cost of ecosystem services from a natural ecosystem might be the value of agricultural output if the land is converted to agricultural instead of conserved in a natural state.	Measures the cost of providing ecosystem services instead of the benefit
Net factor income (residual value method)	Revenue from sales of a marketed good to which the ES is an input, minus cost of other inputs.	Tendency to over-estimate values since all normal profit is attributed to the ES
Production function	Statistical estimation of a production function to quantify the contribution of an ecosystem input in the production of a marketed good. Cost function and profit function methods follow a similar approach and form of analysis.	Technically difficult. High data requirements
Hedonic pricing	A revealed preference method that estimates the influence of environmental characteristics on the price of marketed goods to identify the marginal willingness to pay for changes in those environmental characteristics	Requires substantial data on ecosystem- economy linkages to parameterise connections between sectors
Travel cost	A revealed preference method that estimates a demand function for recreational use of a natural area using data on the observed costs and frequency of travel to that destination.	Technically difficult. High data requirements. Limited to ES that are spatially related to property locations.
Contingent valuation	A stated preference method that uses survey approaches to ask respondents how much they are willing to pay (or accept) for specified changes in the provision of ES.	Technically difficult. High data requirements. Limited to valuation of recreation. Complicated for trips with multiple purposes or to multiple sites.
Choice modelling (choice experiment, discrete choice modelling)	A stated preference method that uses surveys to ask respondents to make trade-offs between ecosystem service provision and payments to elicit willingness to pay for changes in ES.	Expensive and technically difficult to implement. Risk of biases in design and analysis
Group / participatory valuation	A stated preference method that asks groups of stakeholders to state their willingness to pay for specified changes in the provision of ES through group discussion	Expensive and technically difficult to implement. Risk of biases in design and analysis
Input-Output analysis	Quantifies the interdependencies between economic sectors in order to measure the impacts of changes in one sector to other sectors in the economy. Ecosystems can be incorporated into input-output models as distinct sectors.	Risk of biases due to group dynamics

Method	Description	Data requerments and additional info
Value transfer (benefit transfer)	The use of research results from existing primary studies at one or more sites or policy contexts ("study sites") to predict welfare estimates or related information for other sites or policy contexts ("policy sites"). Can be applied through 3 different approaches: **Unit value approach:** a constant value per unit of ecosystem service is applied to estimates of supply (or a constant value per unit area of ecosystem is applied to the area of ecosystem as a proxy of supply). Thus, variations in ecosystem service value across space result only from variations in supply. Values can also be adjuested accross spatial units to account for spatial variations in value (population density, income levels or price levels). **Value function approach:** estimates spatially variable unit values across the study area using a value function, which may contain multiple spatial variables (e.g. income, household size, distance to ecosystem). A value function is typically estimated from a single primary valuation study, which may be conducted within the mapped study area (subsequent use for mapping involves spatial extrapolation of results) or outside of the mapped study (in which case the mapping involves value transfer in a strict sense). **Meta-analytic value function transfer approach:** also enables the estimation of unit values that vary across spatial units within the study area by applying a value function containing multiple spatial variables.	Unit values can be obtained from existing applications of the primary valuation methods. Adjustments to unit values, if possible, should account for the number of beneficiaries of an ecosystem service, the effect of income levels on willingness to pay, and differences in price levels. They are simple but Unlikely to be able to account for all factors that determine differences in values between study and policy sites. Value information for highly similar sites is rarely available Value functions can be obtained from a number of primary valuation methods including hedonic pricing, travel cost, production function, avoided damage cost, contingent valuation and choice experiment methods. Parameter values for each spatial unit in the study area are plugged into the value function to estimate unit values vary across spatial units. Value fucntions allows differences between study and policy sites to be controlled for (e.g. differences in population characteristics), but requires detailed information on the characteristics of the policy site. Meta-analytic funcitons are estimated from the results of multiple primary valuation studies, which increases the scope for including additional spatial variables that might not be feasible within a single primary valuation study (e.g. crowdedness, accessibility, fragmentation, scarcity). Meta analytic functions allow differences between study and policy sites to be controlled for (e.g. differences in population characteristics, area of cosystem, abundance of substitutes etc.). They can be practical for consistently valuing large numbers of policy sites. However, they require detailed information on the characteristics of policy site(s) and are analytically complex
Cost-Effectiveness Analysis (CEA)	An evaluation method that involves identifying the least cost option that achieves a specific goal.	Used for identifying lowest cost policy options to achieve a given objective. Does not require assessment of benefits and is analytically relatively straightforward. Limited applicability to ecosystem services given complex and multi-functional nature of ES provision; and the absence of single quantified policy targets
Cost-Benefit Analysis (CBA)	An evaluation method that involves summing up the value of the costs and benefits of an investment/policy/project and comparing options in terms of their net benefits (the extent to which benefits exceed costs).	Used to estimate the economic performance of investments and policies. Provides a measure of how much an investment or policy contributes to societal wellbeing. Requires that all costs and benefits are quantified in monetary terms; can result in omission of important effects.

Method	Description	Data requeriments and additional info
Multi-Decision Criteria Analysis	An appraisal of the status and trends in the provision of ecosystem services in a specified geographic area. The general aim of an ecosystem service assessment is to highlight and quantify the importance of ecosystem services to society. Ecosystem service assessments are multidisciplinary in nature, applying and combining biophysical, social and economic methods	Used to rank alternative investments and policies. Allows the inclusion of effects that cannot be expressed in monetary terms. Heavily reliant on the subjective judgement of the analytical team (bias can be reduced if weighting factors are assessed via deliberative methods)
Social		
Preference assessment	Preference assessment is a direct and quantitative method to demonstrate the social importance of ecosystem services by analysing social motivations, perceptions, knowledge and associated values of ecosystem services demand or use	
Time-use assessment	This method estimates the value of ecosystem services by directly asking people how much time they are willing to invest (WTT) for a change in the quantity or quality of a given ecosystem service or conservation plan	
Photo-elicitation surveys	It is a quantitative method, based on the simple idea of inserting a photograph into a research interview. It can be used to assess a range of landscape views at the same time. Respondents specify the principal ecosystem services provided by each landscape from a list of potential services provided by the area.	
Narrative assessment	Narrative methods aim to understand and describe the importance of nature and its benefits to people with their own words. By using narrative methods we allow the research participants (residents of a certain place, users of a certain resource, or stakeholders of an issue) to articulate the plural and heterogeneous values of ecosystem services through their own stories and direct actions (both verbally and visually).	
Participatory GIS	Evaluates the spatial distribution of ecosystem services according to the perceptions and knowledge of stakeholders via workshops and/or surveys. PGIS allows for the participation of various stakeholders in the creation of an ES map in the identification of ES 'hotspots' on a map, and integrates their perceptions, knowledge and values in the final maps of ecosystem services	
Participatory scenario planning	Participatory scenario planning applies various tools and techniques (e.g. brainstorming or visioning exercises in workshops, often complemented with modelling) to develop plausible and internally consistent descriptions of alternative future options	
Deliberative assessment	Deliberative methods are an umbrella term for various tools and techniques engaging and empowering non-scientist participants. These methods ask stakeholders and citizens to form their preferences to ecosystem services together in a transparent way through an open discourse	

Figure 10 The schematic representation of Spatial Planning Processes used in BioValue. From our partners in IST (Portugal).