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Conservation and Human Use Index: A Practical, Multi-Parameter Assessment Tool to Identify and Track Conflicts and Synergies in Conservation Area Management

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Abstract

Natural resource management and area-based conservation are increasingly recognised as outcomes of complex interactions between ecological conditions and social systems, shaped by local knowledge, governance arrangements, and environmental pressures. The Social-Ecological Systems Framework (SESF), developed by Elinor Ostrom, provides a comprehensive framework to analyse these dynamics; however, most applications remain context-specific, limiting cross-site comparability. This study introduces the Conservation and Human Use Index (CHUI), a standardised diagnostic tool that operationalizes SESF principles for comparative analysis across conservation-important areas. CHUI comprises 134 qualitative questions structured across four equally weighted dimensions: (i) Natural Values and Ecosystem Services, (ii) Threats and Pressures, (iii) Governance, and (iv) Social Perceptions. Using an ordinal 0–3 scale with a "Not Applicable" option, the Index enables consistent, flexible application through both desk-based assessments and participatory processes. It generates aggregate and disaggregated outputs that help identify pressure hotspots, governance gaps, and conservation-use synergies. CHUI's primary innovation lies in translating SESF into a pragmatic and participatory instrument that supports real-world decision-making. Rather than replacing detailed ecological or socio-economic assessments, it functions as a collaborative diagnostic compass to guide targeted investigation and intervention. Its participatory design fosters shared learning, transparency, and co-production of context-specific management pathways, supporting adaptive stewardship and community empowerment. Developed within the Horizon Europe PRO-COAST project and tested across ten European coastal case studies, CHUI advances both the operationalization of SESF and the practice of inclusive, adaptive conservation management.

Keywords: social-ecological system; area-based conservation; biodiversity; governance; Ostrom's diagnostic approach; human-nature interaction; management effectiveness; protected area; diagnostic tool

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1. Introduction

The Social-Ecological Systems Framework (SESF), developed by Nobel Laureate Elinor Ostrom [1–3], offers a comprehensive approach to understanding the complex interactions between ecological and social components in resource governance. Understanding human–nature interactions is essential for advancing both human well-being and biodiversity conservation [4–9].

Recognising that neither natural nor human systems operate in isolation, Ostrom's SESF identifies a set of four core variables—resource systems, resource units, governance systems, and actors—that interact dynamically within a broader socio-political and ecological context [1,10]. By structuring analyses around these subsystems and their interlinkages, the SESF supports comparative studies across diverse resource settings, from forest to coastal floodplains management and from fisheries to agricultural irrigation systems, enabling a deeper understanding of the conditions under which collective action and sustainable management are most likely to emerge [3]. A key strength of the SESF is its ability to treat social and ecological components with equal analytical depth [11]. Specifically, the subsystems resource systems and resource units represent the ecological components, while the subsystems governance systems and actors represent the social component. As such, the framework has become a foundational tool in interdisciplinary research on sustainability and adaptive governance [12]. Recent reviews indicate that social-ecological systems research continues to expand rapidly, with increasing emphasis on integrated evaluation frameworks, system dynamics, and the translation of theory into management-relevant tools [13].

The operationalisation of the SESF in the literature is predominantly context-specific, often focusing on individual case-study areas, specific resource management situations, or single SESF subsystems [4,14–20]. For example, prior applications of SESF include indicator-based quantitative assessment for small-scale fisheries in Mexico [15], localised conservation and management policies for multiple resources and users in Punta Allen coastal community in Mexico [20] and assessment of temporal and spatial variations in coastal floodplain management in the Ganges-Brahmaputra delta [4]. Even though some studies applied the SESF approach across various types of area-based conservation for multiple case studies, they often emphasise particular dimensions (e.g., governance), limiting broader comparability [14,20–22].

At the same time, recent studies highlight that many SES applications still rely on relatively static assessments and insufficiently capture trajectories, shocks, and multi-scalar dynamics, underscoring the need for repeatable and structured diagnostic tools that can support longitudinal analysis and adaptive management [23].

In parallel, emerging empirical work increasingly integrates ecological processes, governance systems, and stakeholder perceptions within resilience-oriented frameworks, reinforcing the importance of holistic, multi-dimensional approaches to SES analysis [24,25].

Thus, although the SESF provides a valuable diagnostic tool for analysing natural resource management within complex social-ecological systems, operationalising it for multiple resource units or across different case-study areas remains a challenging task [8,22,26]. The Conservation and Human Use Index (CHUI), addresses this limitation by being applicable across a wide range of socio-ecological settings. CHUI does not modify or replace the SESF; rather, it is explicitly grounded in its core structure. CHUI operationalises the key SESF variables through a structured set of indicators and guiding questions that make the framework applicable in a transparent and comparable manner across diverse socio-ecological settings. In this way, CHUI contributes methodological clarity and practical usability, while remaining conceptually anchored in Ostrom's original framework.

The CHUI was developed under the HORIZON project PRO-COAST, titled "A PROactive approach for COmmunities to enAble Societal Transformation" (2023–2026). The project aimed to empower local communities to take an active role in restoring and protecting biodiversity and ecosystem services across Europe's coastal regions. It promoted inclusive environmental governance by integrating local knowledge into decision-making and equipping ecosystem managers and local society with the tools needed to make informed, biodiversity-conscious decisions. To address the complex dynamics of coastal

social ecological systems, PRO-COAST applied Ostrom's SESF and tested its application across ten representative Case Study (CS) areas, covering all five European coastal regions. Each CS addresses specific conservation challenges and engages local stakeholders through participatory methodologies.

In this context, the CHUI offers a practical tool for identifying both conflicts and synergies between biodiversity conservation and human use in areas with significant ecological and/or social importance. It supports future action aligned with PRO-COAST's commitment to societal transformation, through inclusive and informed stewardship. Although CHUI was originally developed to address the specific challenges of coastal systems, subsequent improvements have enhanced its flexibility and adaptability, allowing implementation across a wide range of coastal and terrestrial settings; however, application outside the initial European context requires contextual adjustment and further validation. Inspired by the foundational work of Elinor Ostrom and the SESF, the Index addresses the complexity of human–environment interactions by considering environmental, governance, and social dimensions in CS areas. By combining the SESF approach with the CHUI, the Index helps illuminate strengths and weaknesses in governance structures, ecological conditions, and societal relationships [27,28].

The Index enables conservation practitioners, area managers, local authorities, stakeholders and actors to conduct a structured and rapid assessment of strengths and weaknesses in governance, ecological conditions, and societal interactions within a given area. Its participatory and flexible nature allows for use across a wide range of geographic and social settings and supports collaborative, informed decision-making. The engagement of diverse stakeholders through well-designed collaborative processes is especially effective in addressing highly complex and multifaceted socio-ecological dynamics [4]. The Index is user-friendly, requiring minimal training, and can be used either as a desk-based review or in participatory workshops. It was tested within the ten diverse PRO-COAST CS areas and based on their feedback it was further calibrated.

The CHUI is designed for periodic use (Section 3.3), particularly when evaluating the effectiveness of past management efforts or identifying new challenges. By evaluating multiple dimensions, such as Natural and Ecosystem Service Values, Threats and Pressures, Governance, and Social Perceptions, the Index also serves as a long-term monitoring tool, helping to track progress and inform conflict resolution strategies over time.

This paper explores the conceptual foundations of the tool and highlights its methodological contribution. Its objectives are to: (1) describe the conceptual design requirements and the translation of SESF components into a practical set of indicators and guiding questions; (2) explain the scoring and interpretation logic that enables repeated assessments and structured comparison within a site over time; and (3) outline how CHUI can be used to support stakeholder dialogue and the co-design of management responses. CHUI does not propose a new theoretical SES framework; rather, it operationalises SESF-aligned dimensions into a consistent, user-guided assessment format that can be adapted to different socio-ecological contexts with appropriate calibration and documentation of assumptions.

2. Materials and Methods

2.1. Conceptual Design Requirements and Challenges

The conceptual design of the Conservation and Human Use Index was shaped by the need to address multiple, sometimes competing, requirements. To ensure its relevance, utility, and broad applicability, the Index had to meet the following key criteria:

- Theoretical grounding: The Index aimed to be grounded in the principles of the SESF, translating this theoretical foundation into a practical, operational tool capable of integrating a wide range of relevant parameters.

- Generality and flexibility: The Index needed to be sufficiently broad, flexible, and generic to be applicable across all PRO-COAST CS areas. At the same time, it was essential for the tool to be scalable and adaptable for use in a wide range of socio-ecological settings beyond the PRO-COAST context—ensuring its relevance to society at large.
- Context-specific relevance: The Index needed to generate meaningful, context-sensitive, and meaningful insights. This required it to be specific enough to identify and assess the strengths and weaknesses of individual CS areas effectively.
- Geographic versatility: While initially designed for use in coastal regions, the Index is also suitable for application in inland areas, thereby broadening its geographic applicability.
- Practicality and efficiency: It was essential that the Index functions as a rapid assessment tool, capable of being completed within a single day. This demanded a design that is user-friendly, simple to apply, practical in real-world contexts, efficient in execution, and easily adaptable.
- Simplicity and adaptability: The tool had to be relatively straightforward to complete, allowing users to work with varying levels of data availability. Its design also needed to accommodate diverse conditions without compromising usability.

The development process of the CHUI took the above considerations into account and followed a structured, iterative approach, beginning with a comprehensive review of SESF applications, the conservation governance literature, as well as similar tools.

2.2. SESF Variables and Indicators into the Conservation and Human Use Index

The SESF includes four main variables: Resource Systems (RS), Resource Units (RU), Governance Systems (GS), and Actors (A). In addition, it includes two exogenous variables: Related Ecosystems (ECO) and Social, Economic, and Political Settings (S) and the focal action situation, which includes Interactions (I) and Outcomes (O) [3] (Figure 1).

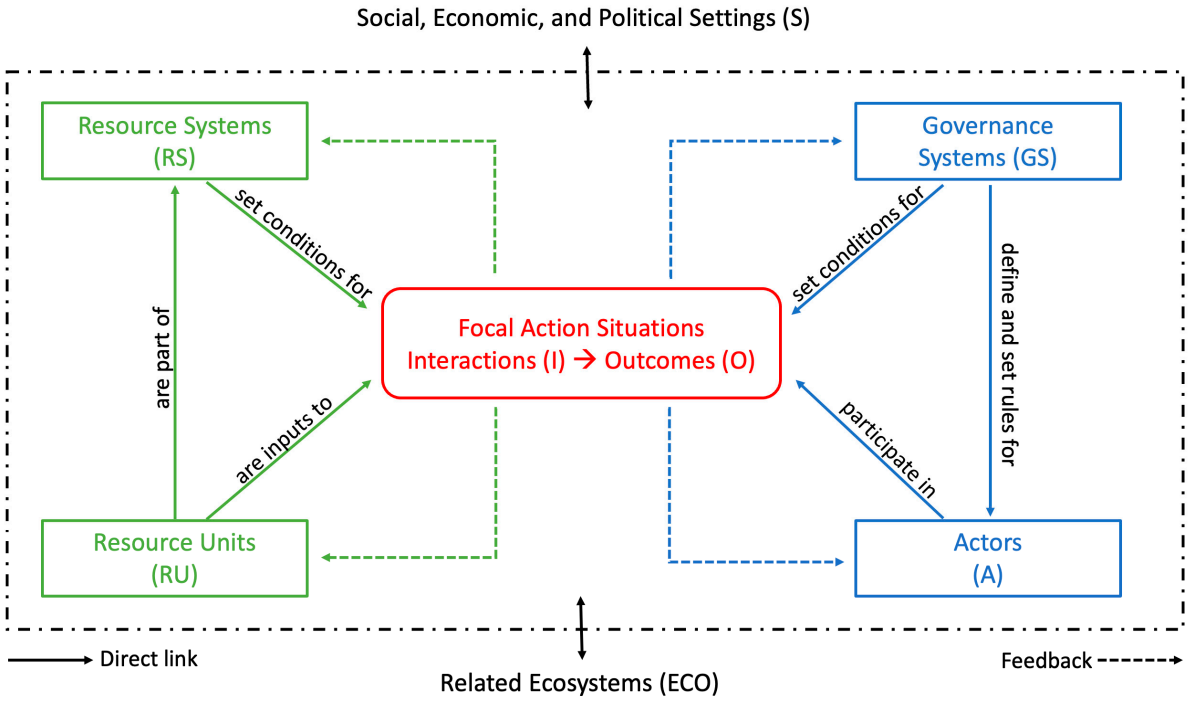

Figure 1. Revised Social-Ecological System Framework (SESF) with multiple first-tier components (source [3]).

Following the development of the SESF, Hinkel et al. [29] and Schlüter et al. [18] suggested that Resource Units (RU) is an attribute of Resource Systems (RS) and the exogenous variables, Social, Economic, and Political Settings (S) and Related Ecosystems (ECO), are attributed and included in the concept "Environment" as they are external to the focal Social-Ecological System (SES) being analysed.

To incorporate the principles of the SESF into the Conservation and Human Use Index, we adopted these recommendations, leading to the identification of four key SESF variables: Resource Systems (RS), Environment (E), Governance (G), and Actors (A) (Figure 2).

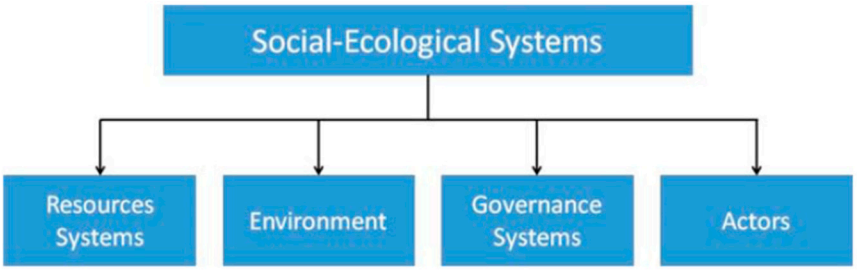

Figure 2. Revised Social-Ecological System Framework based on Hinkel et al. [29] and Schlüter et al. [18] (Source [4]).

Subsequently, specific indicators were identified for each of these four key SESF variables, and a set of qualitative questions was developed to assess each indicator (Table 1). The indicators and the detailed questions per indicator were selected based on a combination of the scientific literature and existing similar assessment tools, as well as the authors' own experience in the protection, management, and governance of protected areas (Table 2).

Within the Resource Systems indicators, those of which relate to ecosystem services, were informed by the IUCN Protected Areas Benefits Assessment Tool + (PA-BAT+) [30]. The Governance-related indicators were derived from the Elinor Index [21], which is an open-source tool that helps users gather, store, share, and assess data on equitable management and governance to support more effective area-based conservation. Additionally, the indicators related to Actors, which are expressed through social perception aspects in the Index, were shaped by studies on the social impacts of European Protected Areas and policy recommendations by Jones et al. [31]. These sources were further complemented by real-world experience and insights from conservation areas' practitioners, sociologists, and ecologists to ensure that the questions developed were both contextually grounded and broadly applicable across diverse case studies.

A key priority in developing the CHUI was to strike a balance between robustness and usability. It was designed to be user-friendly, requiring minimal training, adaptable to both facilitated discussion groups and desk-based applications, and applicable in both data-rich and data-poor contexts. Questions were carefully selected to equally represent both ecological, governance, and social aspects, while keeping the language simple and the scoring intuitive.

Table 1 presents the SESF variables, the Indicators for each variable and the number of questions per indicator, as well as per SESF variable, within the CHUI.

The detailed questions per indicator and per SESF Variable are presented in the Supplementary Materials as follows: (a) the Conservation and Human Use Index Excel Tool file [32] and (b) the Conservation and Human Use Index—User Manual [33].

Table 1. Indicators used in the Conservation and Human Use Index for each of the four key SESF variables.

SESF Variables	Indicators	No of Questions per Indicator	No of Questions per SESF Variable
Resource Systems (RS)	Key natural values of the Case Study area (i.e., in terms of natural landscapes and biodiversity: flora and fauna species and habitats)	5	33
	Status of natural values in the Case Study area	5	
	Ecosystem Services Values	23	
Environment (E)	Primary threats—pressures impacting the overall conservation status of the Case Study area	12	39
	Primary challenges or impacts affecting the overall conservation status of the Case Study area	3	
	Degree to which ecosystem services are affected by the pressures and threats in the Case Study area	24	
Governance Systems (GS)	Management mechanism overview	2	27
	Existence of (a) Management Plan(s) and its implementation procedure for the Case Study area	1	
	Existence of monitoring programmes or initiatives in place in Case Study area	3	
	Operational capacity—Allocation of resources	5	
	Regulations and enforcement	6	
	Diversity of expertise	1	
	Coordination and collaboration	4	
	Transparency and accountability	3	
	Perceived environmental outcomes	1	
	Perceived social outcomes	1	
Actors (A)	Well-being and health	4	37
	Human rights and access to resources	4	
	Knowledge and education	4	
	Livelihoods and economic impacts	4	
	Local culture and values	4	
	Social relations	4	
	Social equity (inclusion and empowerment)	4	
	Diversity	9	

Table 2 shows the main sources behind each CHUI indicator group and how they were adapted into practical questions and a consistent scoring system.

Table 2. Primary sources informing CHUI indicator groups and main adaptations.

CHUI Indicator Group	Primary Source(s)	Adaptations for CHUI
Natural values and status (landscapes, habitats, flora/fauna)	Protected-area assessment practice; expert input	Reframed into rapid, qualitative questions suitable for desk-based or workshop completion; emphasis on site-specific reference points.
Ecosystem services values	IUCN PA-BAT+ (PA-BAT+) [30]	Ecosystem Service categories as in IUCN PA-BAT+, but simplified to a consistent 0–3 scale; guidance added to distinguish 'Absent' vs. 'Not applicable'.
Threats and pressures/impacts on services	Conservation pressure/threat typologies; PRO-COAST case- study experience	Question wording harmonised; response options include 'Absent' and 'N/A' to avoid scoring irrelevant items.

Table 2. *Cont.*

CHUI Indicator Group	Primary Source(s)	Adaptations for CHUI
Governance mechanisms, capacity, enforcement, collaboration	Elinor Index [21]; expert input; PRO-COAST case-study experience	Based highly on Elinor Index governance dimensions, which also were streamlined by expert input and PRO-COAST case- study experience; response options include 'Absent' and 'N/A' to avoid scoring irrelevant items.
Social perceptions (well-being, rights, culture, equity, relations, diversity)	Jones et al. (social impacts of PAs) [31] and related social-science literature	Converted to structured questions and prompts for dialogue; response options include 'Absent' and 'N/A' to avoid scoring irrelevant items.
Scoring and grading logic	Value-function/ordinal scoring approaches [34]; Elinor Index [21]; management effectiveness literature	Uniform 0–3 scoring across questions; equal weighting across dimensions to retain balanced interpretation. In addition, the "suggested action" categories in the final scoring are based on the Elinor Index.

2.3. Assessing Performance for the Selected Indicators

The questions that feed into the Index assessment are presented in multiple-choice format, i.e., the respondent selects one—or in a few cases more than one—answer from a list of provided options. The selection is made by marking the suitable answer with an "X". In order to compare and summarise the performance of all the questions and indicators, the qualitative values are converted into a comparable scale using the value function approach.

Value functions are mathematical tools that enable systematic and transparent comparisons across different attributes of human judgement. They make it possible to incorporate people's values and perceptions explicitly, logically, and consistently, even when the underlying data are subjective or perception-based [34]. This approach has also been adopted in recent studies [4,35] and tools, such as the Elinor Index [21], which employs an ordinal scoring scale to assess the strength of governance and management arrangements in conservation areas.

In this context, the value-related questions included in the CHUI build on insights generated within the PRO-COAST project, where participants' values are measured using an established short scale based on Schwartz's value framework [36]. Given the complexity of value structures in this model, PRO-COAST captures multiple value dimensions to better understand how they influence behavioural intentions and environmental decision-making. Preliminary findings from this work informed the development of the CHUI value items, strengthening their empirical grounding and analytical relevance.

Using this normalisation approach, all assessed questions of the CHUI are scored using a 0–3 value function scale, allowing qualitative judgements to be captured in a comparable and systematic way. Each indicator and respective question are scored from 0 (indicating the worst performance) to 3 (representing the best performance). The intermediate values 1 and 2 refer to low and moderate performance, respectively [35].

This approach allows for the rapid assessment of complex features in a standardised yet accessible format, ensuring that stakeholder perspectives and expert insights are captured in a logically structured, mathematically tractable, and scalable way for future comparisons. At the same time, the scoring design enables practitioners to easily interpret results, monitor changes over time, and communicate findings effectively in both technical and non-technical contexts.

2.4. Digitalisation and Online Platform

In addition to the Supplementary Materials provided with this article, i.e., the CHUI MS Excel Tool [32] and the User Manual [33], CHUI has been digitalised into a free, open-access, web-based platform available at: https://chui.pro-coast.eu/ (accessed on 4 March 2026).

The online version maintains the same structure, dimensions, indicators, and scoring logic described above, while offering enhanced usability, automated calculations, and real-time visualisation of results. The platform is designed to facilitate standardised data entry, streamline the assessment process, and support repeated applications across different case-study areas.

3. Results

3.1. Index Structure, Dimensions and Scoring System

3.1.1. Background Information

Before beginning the scoring sections, the Index includes a set of 19 non-mandatory background questions related to the CS area. These background information questions cover general CS area characteristics, such as the site name, size of the area, existing management frameworks and conservation goals, and who is conducting the assessment. They provide essential contextual information that helps interpret the results and support future comparisons over time, but are not included in the scoring, as they do not represent performance-based criteria. This is because their purpose is not to evaluate performance or outcomes, but to ensure that assessments are grounded in a shared understanding of the CS area current situation.

3.1.2. Assessment Dimensions

The Index is based on four key dimensions, adapted from the SESF. Each of these dimensions is assessed through a series of structured questions designed to evaluate both current conditions and stakeholder perceptions.

The total number of assessed questions is 134. All questions are mandatory; however, if a particular question is not relevant or applicable to the CS area, the option "Not Applicable" may be selected and this question will not be included in calculating the relevant scores.

Each question belongs to one of the following four dimensions (referred to as "attributes" within the Index):

1. Resource System (R), which within the Index refers to "Natural Values and Ecosystem Services Values". This dimension assesses the ecological significance and value of the CS area, including important landscapes, flora species, fauna species, and habitats, their status and the value of the area in terms of ecosystem services [total number of questions: 33].
2. Environment (E), which within the Index refers to "Threats and Pressures". This dimension assesses the degree that different types of human activities, environmental factors, or natural phenomena negatively impact the ecosystem, biodiversity, and sustainability of the CS area [total number of questions: 39].
3. Governance System (G), which within the Index refers to "Governance". This dimension assesses the effectiveness of policies, regulations, processes, and practices through which decisions about the management and conservation of the CS area are made and implemented, such as decision-making, stakeholder participation and inclusion, social justice and transparency [total number of questions: 27 (25 of these being scored)].
4. Actors (A), which within the Index refers to "Social Perceptions". This dimension assesses the views, values, attitudes, and level of engagement of local communities

and other interested stakeholders regarding the management, accessibility, social justice, diversity, benefits, and challenges of the CS area [total number of questions: 37].

3.1.3. Scoring System

I. Scoring Scale (Individual question marking scale)

Each question is scored on a 0 to 3 scale as follows:
0 = Least desirable outcome;
1 = Somewhat undesirable outcome;
2 = Moderately desirable outcome;
3 = Most desirable outcome.

If a question is irrelevant to the specific context of the CS area, an 'N/A' (Not Applicable) option can be selected. When a question is marked as N/A, it is excluded from the scoring calculations, and the system automatically adjusts the maximum possible score for that variable to ensure the final percentage remains accurate.

II. Variable and Overall Score Calculation (How the overall Index is scored)

Each variable score is calculated as a percentage of its maximum possible score, based on the number of questions answered (excluding any marked as N/A). This percentage is then multiplied by 25, since each variable represents 25% of the total score. With four variables in total, this results in a final percent score out of a maximum of 100.

All variables are equally weighted to ensure a balanced evaluation across all dimensions. This equal weighting prevents any single aspect from disproportionately influencing the overall result and supports a holistic understanding of the CS area.

3.1.4. Assessment Questions

In the CHUI User Manual [33] (refer to Supplementary Material), each question of the Index is explained in detail and guidance is provided on how to answer each question.

The responses provided in the Index are based on the knowledge, perceptions, and experiences of the individuals or groups completing the assessment. As such, answers are inherently subjective and may vary depending on the respondent's role, familiarity with the CS area, and comparison with other areas. This relativity is considered a valuable component of the assessment, as it captures diverse perspectives that can help identify knowledge gaps, management blind spots, or areas of consensus. Participants are encouraged to answer as honestly and reflectively as possible, using their own understanding and context as reference.

Moreover, most questions allow the selection of the option 'Not Applicable' (N/A), which should be used only when the question or feature does not genuinely apply to the CS area, such as for geographical, legal, or contextual reasons. In contrast, the 'Absent' option is selected when a relevant feature, mechanism, or condition is expected, but is currently missing from the CS area. Selecting 'Not Applicable' (N/A) ensures that the scoring remains fair and is not influenced by elements that are irrelevant to the specific context of the CS area.

Indicative examples on the distinction between 'Not Applicable' and 'Absent' are as follows:

- If a threat such as agriculture activities is relevant to the type of CS area (e.g., a terrestrial or coastal site), but is not currently present or observed, then the selection is "Absent." However, if the threat is entirely irrelevant—such as agriculture in a fully marine protected area—then the selection is "Not Applicable (N/A)."
- If the CS area is officially recognised and would normally be expected to have a managing authority, but no such authority exists, then the selection is "Absent."

Conversely, if the area is used informally, with no legal or policy requirement for management, or if it lacks ecological significance and does not require management, then the selection is "N/A".

- If environmental education programmes are relevant but are entirely missing, then the selection is "Absent." However, if the CS area has no resident or visiting population, making such programmes unnecessary, then the selection is "N/A".

3.2. Interpretation of Results

After completing the assessment, results are produced for each one of the four main variables, as well as an overall score for the CS area. This allows users to gain both a broad overview and a detailed breakdown of where strengths and weaknesses lie.

In addition to the main four variables, the Index also provides individual scores for three sub-variables under the "Natural Values & Ecosystem Services" (R) variable:

I. The ecological significance and value of the CS area, including important landscapes, flora, fauna, and habitats (R1).
II. The overall status of landscapes, species, and habitats within the area (R2).
III. The ecosystem services value, reflecting the importance of the area in providing provisioning, regulating, cultural, and supporting services that benefit human health, biodiversity, productivity, and well-being (R3).

3.2.1. Individual Variable Grading Interpretation

In the Index [32] (refer to the MS Excel file of the Supplementary Material), each variable and sub-variable score is automatically assigned a colour-coded range (red, orange, yellow, or green) corresponding to the grading levels shown on Table 3. These categories correspond to narrative descriptions that are automatically generated in the CHUI Excel tool and the online CHUI platform (respective file of the Supplementary Material for full descriptions).

Table 3. Four-level grading of Individual Variables according to performance.

Score Range	Performance Level	Colour Code
0–6.25%	Minimal	Red
6.26–12.50%	Low	Orange
12.51–18.75%	Moderate	Yellow
18.76–25%	High	Green

Some examples of the above grading:

I. A Minimal score in Overall Status of landscapes, flora species, fauna species and habitats in the CS area indicates the area has highly degraded biodiversity, with severely impacted natural values. Urgent and significant intervention is needed to address the critical ecological decline.
II. A Moderate score in Governance may reflect that governance is operational, but could benefit from improvement. Conservation policies are in place, and enforcement is moderate, though management effectiveness can be strengthened. Addressing minor gaps would enhance the overall governance framework.
III. A High score in Social Perception shows support and trust in conservation efforts. Stakeholders actively participate in governance, view policies as beneficial, and contribute to sustainable practices. Ongoing communication and monitoring are essential to maintaining high levels of social perception and engagement with CS area management.

3.2.2. Overall Index Grading Interpretation

The final score, calculated out of 100, assigns the CS to one of four broader categories, each of which is associated with a corresponding recommended course of action (Table 4). The "suggested action" categories are based on the Elinor Index [21]. All scores, colour grading, and narrative descriptions in the CHUI Excel Tool and the online CHUI platform are generated automatically (refer to Supplementary Material). The online CHUI platform additionally provides visual representation of scores in the form of balance chart across attributes.

This structured scoring system, paired with colour codes, balance chart and tailored descriptions, enables clear, consistent interpretation of both strengths and weaknesses. It also ensures that results can be easily communicated to stakeholders and actors, managers, and policymakers.

The final score, expressed on a scale from 0 to 100, assigned the CS area into one of four broader categories, each linked to a corresponding recommended management pathway (Table 4): Plan, Build, Strengthen, or Maintain. These "suggested action" categories are based on the Elinor Index [21]. All numerical results, colour gradings, and narrative interpretations are generated automatically in both the CHUI Excel Tool and the online CHUI platform (Supplementary Material). In addition, the online platform provides a visual representation of performance across the four dimensions through a balance (radar) chart.

This structured scoring system and visuals—combining percentage scores, colour codes, graphical outputs, and tailored descriptions—support clear and consistent interpretation of results. They both facilitate effective communication with stakeholders, managers, and policymakers. Importantly, the overall score should not be interpreted as a definitive judgement or absolute measure of performance. Rather, it serves as a diagnostic indication, highlighting areas that may require closer attention, targeted improvement, or sustained effort over time.

Table 4. Overall index grading.

Final Score (0–100)	Interpretation	Suggested Action
0–25%	Plan (red colour)	Urgent action needed to develop foundational governance and conservation responses
26–50%	Build (orange colour)	Initial efforts exist, but major gaps need addressing. Engage stakeholders to strengthen responses.
51–75%	Strengthen (yellow colour)	A functioning system is in place; focus on refining and improving weak areas.
76–100%	Maintain (green colour)	Strong performance; maintain momentum through ongoing monitoring and early response to emerging risks.

3.2.3. Illustrative Application Example: Comino Island (Malta)

The practical interpretability of the scoring system and the operational workflow of the CHUI, was tested across ten CS sites of the PRO-COAST project, representing diverse coastal socio-ecological contexts across Europe. These applications aimed to evaluate the functionality, usability, and transferability of the tool in real-world conditions. The case study of Comino Island (Malta) is presented, as an example.

Comino Island is a small Mediterranean coastal and marine protected area characterised by rocky coastlines, cliffs, and ecologically important habitats, including garrigue vegetation and *Posidonia oceanica* seagrass meadows. Despite its designation under the Natura 2000 network, the area is subject to significant anthropogenic pressures. The most

prominent pressure is mass tourism, with high visitor numbers during peak seasons leading to habitat degradation, trampling of vegetation, marine disturbance from boating and anchoring, and increased waste generation. Additional pressures include invasive species, limited enforcement of environmental regulations, and fragmented governance arrangements.

The CHUI assessment was conducted as a desk-based exercise by the NGO Friends of the Earth Malta (FoE). The assessment followed the standard CHUI workflow, whereby responses to the 134 structured questions were assigned scores on a 0–3 scale and aggregated across the four dimensions. The results indicated that most variables ranged between low and moderate performance levels. For each variable, the CHUI provided interpretative guidance to support understanding of the results. The overall CHUI score for the case study was 39.8%, placing the site within the "Build" category, suggesting that while some governance structures and conservation efforts are in place, significant gaps remain, and further improvements are required to enhance socio-ecological performance. A visual representation of Comino Island's performance across the four dimensions through a balance (radar) chart (Figure 3) also depicts that the area holds a notable importance in terms of natural values that are however affected by anthropogenic pressures. Efforts are needed to improve governance in the area, as well as improve stakeholder involvement and trust.

Feedback collected from FoE highlighted the practical usability of the tool; the assessment was completed within approximately two hours, and the tool was considered easy to understand and apply. Also, the results were perceived as reasonably reflective of on-the-ground conditions, while the accompanying CHUI manual was identified as particularly useful in guiding interpretation and ensuring consistency in scoring.

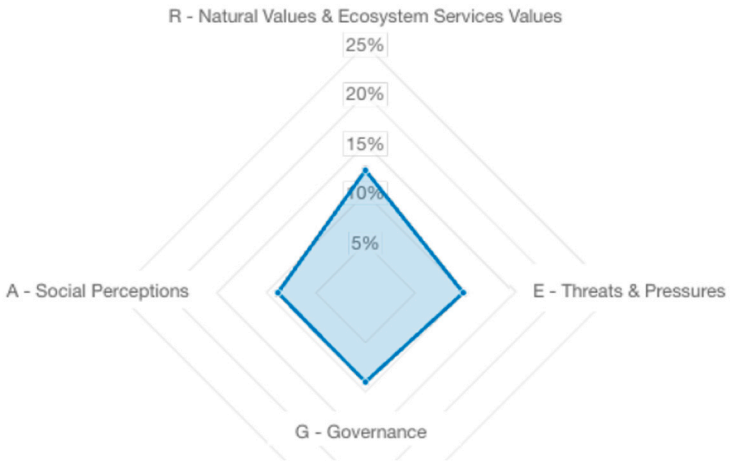

Figure 3. CHUI-generated balance chart across the four dimensions for Comino Island (Malta).

3.3. Assessment Frequency

The Index is intended for periodic use—ideally annually or at multi-year intervals—depending on the context, the pace of ecological or social change, and the management cycle of each CS area. Regular reassessment is crucial because social-ecological systems are dynamic: governance arrangements evolve, environmental pressures shift, and human activities or priorities may change over time. This repeated-use logic is increasingly recognised in SES research, which has highlighted the need to move beyond static snapshots and better capture system trajectories, and long-term dynamics across multiple scales [23]. By applying the Index repeatedly, practitioners can:

- Monitor and compare changes over time: Detect trends, emerging risks, or improvements in governance, management effectiveness, and human–nature interactions. This long-term perspective helps distinguish short-term fluctuations from meaningful structural change.
- Revisit earlier assessments and evaluate progress: Comparing new scores with previous rounds supports reflection on what has improved, what remains stagnant, and what may have deteriorated. It also helps validate whether past decisions produced the intended outcomes.
- Adjust management actions based on evolving needs and feedback: Regular updates provide an evidence base for adaptive management. Managers can refine strategies, allocate resources more effectively, and respond proactively to new challenges or opportunities identified through the completion of the Index.

3.4. Assessment Procedure

The CHUI can be completed using one of three methods or a combination of them, depending on available resources, timing, access to stakeholders, as well as what is more suitable to the conditions of the CS area.

3.4.1. Desk-Based Assessment

The desk-based assessment method is carried out by a knowledgeable individual, typically the area manager or a conservation practitioner, using available data, official reports, and expert knowledge and insights. This approach is especially useful when stakeholder access is limited or when a preliminary overview of the situation is needed. While it may not capture the full range of stakeholder perspectives, it enables a quick, informed assessment and can lay the groundwork for a more participatory process in the future. The estimated time for completion is around 3 h depending on the availability of background data, familiarity with the CS area, and how well the available documentation is organised. A desk-based assessment is the quickest option, using existing reports, data, and expert knowledge, and is ideal when time or stakeholder access is limited.

3.4.2. Combined Desk-Based Assessment by Multiple Stakeholder Groups

When multiple perspectives are needed but people cannot meet together, this method involves distributing the Index individually to representatives of various stakeholder groups (e.g., local communities, NGOs, government agencies, experts), who complete the assessment independently, based on their own knowledge and perspective. Once all responses are received, a coordinating individual, typically the CS area manager or a conservation practitioner, consolidates the results into one overall Master Index Assessment.

The Master Index Assessment is created by assigning numerical values to each answer category and calculating the mean score for each question across all stakeholder responses. The average is then rounded to the nearest whole number and converted back into the corresponding category. This process reflects the overall perception across groups, while maintaining transparency and comparability. This scoring approach ensures all inputs are equally weighted and allows practitioners to later explore the range of opinions in more detail if needed.

The estimated time for completion is around 3 days, depending on the number of stakeholder groups, which includes 3 h for each stakeholder representative to complete the Index and approximately 2 days for the coordinator to collect inputs and compile the Master Index.

3.4.3. Facilitated Focus Group Discussion

Facilitated focus groups are ideal in cases where dialogue and trust-building are priorities. This method brings together representatives from different stakeholder groups to collaboratively complete the assessment. The session is facilitated by two trained facilitators, one to guide the discussion and one to record responses. Each stakeholder group completes one version of the Index, reflecting their collective perspective. Once all groups have completed their assessments, mean scores are calculated and entered into the Master Index for interpretation. The method for combining multiple responses is the same as outlined in the Combined Desk-Based Assessment by Multiple Stakeholder Groups section.

Focus groups are encouraged, as they offer first-hand insights from those directly involved with the CS area. This approach provides a balanced overview by integrating diverse viewpoints and also allows practitioners to revisit individual group assessments for a deeper understanding of differing perceptions. Additionally, focus groups enable stakeholders to hear each other's perspectives directly, fostering more informed dialogue, increased mutual understanding, and the identification of shared priorities and common ground that can guide future decision-making and collaboration. Sharing the Index with participants in advance can further enhance the quality of the discussion by allowing time for reflection and preparation.

The estimated time for completion is approximately 1 day, depending on the number of stakeholder groups, how familiar participants are with the area/issues and the discussion flow.

3.4.4. Combined Approach

The combined approach builds on the focus group method, with the added value of a desk-based assessment conducted in advance. This preparatory step helps provide background context, including the area size, ecological features, policy landscape, and historical management actions. This information supports facilitators in framing the discussion and helps participants engage more meaningfully with the questions. While the process is still driven by stakeholder dialogue, the desk-based input complements it by grounding the discussion in documented knowledge. Together, these elements produce a richer, more robust assessment. The estimated time for completion is 1–2 days depending on time spent on the desk-based preparation and then facilitating the focus group.

4. Discussion

The development and application of the Conservation and Human Use Index demonstrate the feasibility and importance of translating the Social-Ecological Systems Framework into a practical, multi-parameter diagnostic tool. The Index responds to a recognised need in SESF operationalisation: the challenge of applying a holistic framework across multiple resource systems, governance settings, and social contexts in a consistent yet adaptable manner. The results from its implementation in the ten PRO-COAST case studies highlight both the potential and limitations of this approach, and situate CHUI within broader efforts to support inclusive and collaborative evidence-based area management.

4.1. Methodological Considerations

As with many participatory and perception-based tools, the CHUI inherently incorporates a level of subjectivity. Responses reflect how individuals interpret governance effectiveness, environmental conditions, social values, and pressures in relation to their own knowledge, experience, and expectations. Such subjectivity is not considered as a flaw but as a feature, as it reveals differences in how various stakeholder groups understand the same landscape and differences that may indicate governance blind spots, diverging priorities, or unequal access to information [37,38]. Nevertheless, the variation in expertise

among respondents—ranging from area managers and scientists to local residents—may influence scoring outcomes. This highlights the importance of carefully selecting participants, documenting respondent characteristics, and encouraging mixed-method assessment approaches that combine participatory inputs with expert-led desk-based review. At the same time, as with any participatory or perception-based tool, responses may be influenced by common survey and group-process dynamics (e.g., halo effects, anchoring on recent events, dominance in discussions, or varying familiarity with the site). To enhance reliability and transparency, the CHUI User Manual recommends combining desk-based evidence with facilitated stakeholder workshops, documenting respondent profiles, and triangulating findings with monitoring or ecological data, where these are available. In group settings, structured facilitation techniques—such as pre-scoring, moderated rounds, and recording dissenting views—can further support balanced participation.

The standardised scoring scale (0–3), enabled by value-function normalisation, ensures comparability across questions and case studies. However, the translation of qualitative judgements into discrete numerical values inevitably simplifies complex realities. The Index does not aim to capture every nuance of social-ecological dynamics, but rather to provide a structured diagnostic overview that can trigger more in-depth analysis and discussions where needed. Future versions may benefit from enhanced guidance for ambiguous cases, as well as clearer decision rules for distinguishing between "Absent" and "Not Applicable" categories, which play a significant role in shaping final scores.

It is also important to recognise the contextual foundations of the CHUI. The Index was developed within a European policy and governance setting and empirically tested in the framework of a Horizon Europe project, across ten diverse PRO-COAST coastal CS areas, spanning different European biogeographic regions. While this provided a robust basis for refinement and calibration, its initial development was nevertheless shaped by European conservation frameworks, institutional arrangements, and data availability conditions. Application beyond the EU context therefore requires careful contextual calibration. To ensure meaningful interpretation across different biogeographic and governance settings, questions, particularly those related to ecological status, species condition, and ecosystem services, should be assessed relative to locally appropriate baselines, such as national or regional Red Lists, habitat condition assessments, existing monitoring schemes, or comparable protected areas within the same ecological region. Similarly, governance and social perception items must be interpreted in light of local institutional structures, customary rights systems, levels of decentralisation, and socio-economic realities. Without such contextual anchoring, cross-regional comparisons may risk oversimplification. Future applications across non-European contexts will be essential to further validate threshold interpretations, refine guidance notes, and enhance cultural and ecological sensitivity, thereby strengthening the Index's global robustness while preserving its structured and comparable design.

4.2. Added-Value and Strengths Compared with Existing Tools

Compared with other existing assessment methods in conservation governance and social-ecological diagnostics, the CHUI offers several distinctive strengths that make it both conceptually robust and practically versatile. Existing tools such as the governance-focused Elinor Index [21] and the benefits-oriented PA-BAT+ [30] address specific components of area-based conservation, while CHUI which builds on insights from both, provides a more holistic, SESF-aligned diagnostic across multiple dimensions. Table 5 summarises the key characteristics, scope, and limitations of CHUI in comparison to existing assessment tools (Elinor Index and PA-BAT+).

Table 5. Comparative overview of CHUI and selected existing assessment tools: Elinor Index and PA-BAT+.

Feature	CHUI	Elinor Index	PA-BAT+
Primary focus	Integrated socio-ecological assessment (environment, governance, social)	Governance and management effectiveness	Ecosystem services and benefits
SESF alignment	Yes (operationalised across all dimensions)	Focus on governance	Focus on ecosystem services
Dimensions covered	Environment, Governance, Social (Actors), Resource systems	Primarily Governance and Management assessment	Primarily Environment and Resource systems (Ecosystem services)
Type of data	Qualitative	Qualitative	Qualitative
Time required	~2–4 h or 1–2 days depending on assessment procedure	<1 day	1–2 days
Key limitation	Perception-based; simplified aggregation of complex dynamics	Limited integration of environmental and social dimensions	Limited integration of governance and social dimensions

First, the Index provides equal weighting across the four SESF-aligned dimensions—resource systems, environment, governance, and actors. Treating all pillars as equally important reflects the SESF's fundamental premise that ecological processes, social dynamics, governance arrangements, and environmental pressures are deeply interconnected. CHUI's balanced structure promotes transparent, holistic assessment across ecological and social dimensions, ensuring that no single component disproportionately drives the final evaluation.

In addition, the Index is multi-parameter yet simple and flexible, integrating a broad range of ecological, governance, and social parameters, without requiring advanced statistical expertise, specialised models, or extensive datasets. Its non-technical design makes it accessible to practitioners with diverse backgrounds—including community actors, site managers, policymakers, conservation practitioners and researchers— while its qualitative–quantitative hybrid structure enables meaningful assessments in both data-rich and data-poor contexts, expanding its applicability beyond well-studied and only data-rich areas. This accessibility also strengthens the tool's capacity to promote transdisciplinary environmental management, consistent with the principles of the SESF.

A further advantage is the tool's intended transferability. While originally developed for coastal systems, the Index was structured to be adaptable to terrestrial, freshwater, protected, and other multi-use landscapes through (i) generic question wording, (ii) the use of 'Absent' versus 'Not Applicable' options, and (iii) guidance in the user manual. Also, its architecture allows consistent use across micro (site), meso (area), and macro (regional) scales, enabling comparisons within and across different governance regimes and ecological settings. However, transferability should not be assumed as a given: applying CHUI in markedly different governance regimes or livelihood contexts (e.g., highly resource-dependent communities) requires calibration of context-sensitive thresholds, documentation of assumptions, and ideally triangulation with biophysical and socio-economic data.

CHUI also distinguishes itself through its user-friendly format. Its clear structure and straightforward scoring system make it easy to use in participatory settings, encouraging active engagement from diverse groups of stakeholders/ actors. It functions as a rapid diagnostic tool, enabling practitioners to quickly identify pressure hotspots, governance weaknesses, social concerns, and priority areas requiring intervention. The tool's visual outputs, which translate scores into intuitive colour-coded diagrams, support immediate interpretation and effective communication, even for audiences without technical expertise.

Equally important is CHUI's role in strengthening participatory management. The structured scoring process supports transparent dialogue among stakeholders, fosters shared understanding, and creates a safe space for discussing differing perceptions. Its simple and visual outputs facilitate immediate communication of results across audiences with varying technical backgrounds. This participatory logic positions the Index not only as an assessment mechanism, but also as a platform for collaborative learning, consensus-building, and conflict identification, helping stakeholders jointly interpret results and co-develop management responses [39,40].

The CHUI complements, rather than replaces, related SESF-inspired approaches and tools, such as the Elinor Index [21]. Elinor played a pivotal role in shaping the development of CHUI, particularly its governance pillar. Its clear logic, structured assessment of institutional arrangements, and strong emphasis on equity, transparency, and accountability provided an essential foundation for designing a robust and meaningful governance component within CHUI.

However, CHUI adopts a broader SESF perspective, integrating ecological conditions, environmental pressures, social perceptions and governance, rather than focusing the assessment most strongly towards the governance dimension. By explicitly addressing social equity, local values, cultural relationships, and ecosystem-service dependencies, CHUI provides complementary insights that enrich and contextualise governance and social findings [41–44].

4.3. Future Improvements and Research Needs

The development of the CHUI within the PRO-COAST project drew upon the expertise and feedback of a multidisciplinary team that included ecologists, sociologists, researchers, conservation practitioners, and civil society. This process ensured that the tool reflected real-world management needs and incorporated diverse insights on social-ecological dynamics.

The Index was subsequently tested across the ten PRO-COAST CS areas, and the lessons emerging from these applications were directly integrated into the tool's structure, leading to its further refinement and calibration. Feedback was systematically collected from all CS leaders following the application of CHUI Excel tool. Overall, the tool was assessed as easy to use, with an average completion time of approximately 4.4 h. The results were considered reasonably reflective of on-the-ground conditions, while the accompanying manual was consistently identified as very helpful in supporting the assessment process. To identify areas for improvement, the feedback was analysed and several recurring themes emerged. With regard to answer options and scoring, users noted inconsistencies between the CHUI Excel tool and the user manual, which were subsequently aligned to improve clarity and consistency. In terms of terminology and wording, certain concepts were perceived as too broad, leading to refinements and the inclusion of clearer contextual guidance. Within the governance dimension, some response categories were considered overly simplified, prompting further refinement. Technical and usability-related feedback also contributed to improvements, including minor enhancements to the CHUI Excel interface and functionality to improve user experience. In addition, suggestions related to practical application and communication emphasised the need for clearer guidance and illustrative examples, particularly for non-expert users, which were incorporated into the revised manual. Overall, these iterative refinements, directly informed by CS leader feedback, contributed to improving the clarity, consistency, and practical applicability of the CHUI tool.

Looking ahead, several directions for improvement and expansion have been identified.

Beyond methodological refinements, further development of CHUI could include a more explicit process-oriented guidance chapter within the User Manual, outlining how the

tool can support the co-creation of management strategies. While CHUI already structures dialogue through its participatory scoring design, its potential extends beyond assessment. The sequential examination of ecological status, pressures, governance arrangements, and social perceptions naturally guides stakeholders from diagnosis to prioritisation and action planning. For example, discrepancies between governance scores and social perception scores may signal trust gaps requiring institutional reform or improved communication, while strong ecological values combined with high pressure scores may point to urgent regulatory or enforcement measures. In facilitated settings, the collective interpretation of results can be followed by structured exercises that identify priority interventions, assign responsibilities, and agree on monitoring indicators for subsequent assessment cycles. In this sense, CHUI can function not only as a diagnostic instrument but as a deliberative platform that supports shared learning, joint problem framing, and adaptive co-management. Future iterations of the manual and online platform could strengthen these steps, providing templates for translating assessment results into collaboratively designed management roadmaps.

Moreover, applying CHUI in a wider range of ecological and governance contexts—both within and beyond Europe—will enable a more robust evaluation of its transferability, cultural relevance, and sensitivity to institutional diversity. Such applications would also support more rigorous analyses of score distributions and variability across respondent groups, further strengthening methodological reliability.

Finally, targeted refinements to certain indicators, particularly those perceived as time-consuming, could streamline the assessment process and enhance usability without compromising the diagnostic depth that makes the CHUI a valuable socio-ecological management tool.

5. Conclusions

Overall, the CHUI demonstrates how SESF principles can be operationalised into a pragmatic and participatory tool capable of supporting real-world management. By integrating ecological conditions, environmental pressures, governance arrangements, and social perceptions, the Index generates a structured diagnostic profile that helps identify pressure hotspots, governance gaps, and opportunities for strengthening human–nature synergies. Importantly, it is noted that CHUI is not intended to replace detailed ecological surveys, economic valuation studies, or formal governance audits. Rather, it functions as a collaborative diagnostic compass that guides where deeper investigation and targeted interventions are most urgently needed. Through its participatory design, the Index creates space for shared learning, transparent dialogue, and the co-creation of context-specific management pathways. In doing so, it supports adaptive stewardship and aligns with community empowerment and societal transformation.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su18094197/s1. These are: (a) the Conservation and Human Use Index Excel Tool file [32], which aims to identify conflicts and synergies between biodiversity conservation and human use in areas with significant ecological and/or social importance and (b) the Conservation and Human Use Index-User Manual [33], which provides step-by-step guidance on all aspects of the Conservation and Human Used Index. Finally, CHUI has been digitalised into a free, open-access, web-based platform available at: https://chui.pro-coast.eu (accessed on 4 March 2026).

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Abbreviations

The following abbreviations are used in this manuscript:

CHUI	Conservation & Human Use Index
CS	Case Study
N/A	Not Applicable
PRO-COAST	A PROactive approach for COmmunities to enAble Societal Transformation
SESF	Social-Ecological Systems Framework

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