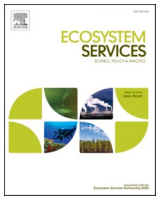
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Full Length Article

Towards a holistic approach to natural capital accounting: The CAN – Complementary Accounting Network- for marine and coastal resources

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ABSTRACT

The System of National Accounts (SNA) and the System of Environmental Economic Accounting Ecosystem Accounting (SEEA EA) frameworks have advanced efforts to integrate environmental information into economic measurement. Yet both remain limited by the principle that all measures must be expressed in monetary exchange (market) value terms, thereby overlooking other forms of values (e.g. ecological, socio-cultural, welfare). To address this gap, we operationalise the Complementary Accounting Network (CAN) framework as a parallel system that combines economic, ecological, and socio-cultural indicators over a common timescale. We illustrate the CAN using marine natural capital data at national (Italy) and regional (Sardinia) scales, including the marine habitat of *Posidonia oceanica* meadows. The illustration highlights CAN's strengths in accommodating non-monetary values and complementing SEEA EA, while also identifying limitations related to data availability and indicator harmonisation. Overall, CAN promises a more inclusive approach to capturing nature–economy interactions.

1. Introduction

In their historical evolution, national accounts have always reflected a degree of pragmatism, and scholars have argued that this implies that what is included or excluded from the accounts remains open to debate (Lepenies, 2016). Recent developments have sought to extend the System of National Accounts (SNA) to encompass natural capital, most notably through the System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA, United Nations et al., 2024). The SEEA EA provides a comprehensive set of ecosystem accounts, which are divided into stock and flow accounts. While stock accounts record ecosystem assets' extent (quantity) and condition (quality) and track their changes over time, flow accounts measure the flow of ecosystem services (ES) in both physical and monetary terms. Finally, the monetary ecosystem asset account records the net present value of each ecosystem asset (United Nations et al., 2024).

While the SEEA EA represents a powerful tool for integrating nature into accounting systems, further improvements are still needed, particularly in refining monetary valuation methods for ES (Fenichel et al., 2024; Markandya et al., 2022; UNCEEA, 2024) and strengthening the links between SEEA accounts and policy or management processes (Vardon et al., 2025). Building on this reasoning, we argue that ongoing development of the SEEA EA should continue in the medium to long term to further refine methodologies, improve data availability, and ensure broader adoption across different national contexts. At the same time, we reflect on the limitations imposed by the requirements to just use exchange prices in reporting ecosystem assets and flow of services in monetary terms. This requirement practically excludes the full value of some ES, failing to capture ecological and welfare dimensions, as well as the holistic role played by biodiversity in sustaining these services. Given the increasing pressures on the natural environment and the commitments outlined in the Global Biodiversity Framework (CBD, 1992; CBD, 2022) and the need for nations to move beyond GDP (Stiglitz et al., 2018; UN Statistics Division, 2026), we argue for the urgent development of a more comprehensive set of indicators to track ecosystems and biodiversity changes. Rather than pursuing only the integration of environmental data into the SNA, we operationalise a more pragmatic approach, i.e., the establishment of protocols such as a Complementary Accounting Network (CAN) (Turner et al., 2019), designed to operate alongside the economic accounts and on

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comparable timescales.

Fig. 1 illustrates the complementary roles of the CAN framework for the SEEA EA. The CAN needs to be populated by a broad set of information, building on SNA and SEEA EA accounts (extent, condition, ES in physical and monetary terms, and monetary stock accounts). While the monetary SEEA EA accounts are fully aligned with the SNA (as they both adopt the exchange value), the CAN offers a pragmatic way forward, avoiding adjustments to core SNA measures of production, consumption, income, and asset values. To accomplish this, the CAN includes a more comprehensive set of indicators, based on welfare, ecological, and socio-cultural dimensions (e.g., bequest, altruistic or existence value, mental well-being, landscape/scenic, sense of community), thereby capturing and plural values that are still missing from the SNA/SEEA EA but considered essential by the IPBES (Diaz et al., 2015). All measures should be consistent in spatial and temporal scale, ideally with time series for each selected indicator.

While Turner et al. (2019) introduced the CAN framework conceptually, our paper presents its first empirical application at both national and regional scales. We provide an illustration of the CAN framework applied to a marine ecosystem (including *Posidonia oceanica* meadows) in Italy and Sardinia and widen our understanding of using complementary reporting system to United Nations Sustainable Development frameworks.

Our illustration includes SNA-compliant indicators, such as GDP, monetary SEEA ecosystem accounts alongside cultural and ecological indicators. We also include methods for valuing multiple ecosystem services, including recreation, tourism, fisheries provisioning, and carbon sequestration. Finally, we demonstrate how CAN can complement existing SEEA Ecosystem Accounts by offering practical guidance for integrating monetary (e.g. welfare value) and non-monetary indicators (e.g. ecological and socio-cultural), which are currently not fully accounted for in existing SEEA EA. In doing so, we show how CAN offers the prospect of an operational indicator dashboard tool for policy-relevant decision making.

A number of established frameworks propose indicators and dashboards to measure the three pillars of sustainability (economy, society and environment), each grounded in different conceptual background. For example, target-based framework such as the United Nations' Sustainable Development Goals (UN DESA, 2016; UN DESA, 2025), structured around 17 goals, 169 targets and a large set of indicators (e.g. Goal 14 Life Below Water tracks marine pollution and protected areas), and the Planetary Boundaries framework (Rockström et al., 2009; PBS, 2025), focused on nine ecosystem processes (e.g. ocean acidification), define environmental targets or limits to be pursued. Another important framework is the Environmental Sustainability Gap (ESGAP), a strong-sustainability based framework to measure the distance between the actual status of natural resources and its scientific reference standard (Usubiaga-Liaño and Ekins, 2021). However, these are largely non-monetary and rely on predefined goals, targets, and indicators.

From an accounting perspective, the System of Environmental-Economic Accounting Central Framework (SEEA CF, UN et al., 2014) and the System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA, UN et al., 2024) extend the System of National Accounts by integrating natural capital into national accounts. They provide stock and flow reported in both physical and monetary terms, but their monetary valuation is restricted to exchange values. In the marine domain, Ocean Accounts (Barzuna et al., 2025) builds on SEEA EA principles, proposing ecological, social, and economic indicators for ocean systems; however, it inherits the same constraint of limiting monetary valuation to exchange values.

The CAN framework offers a more explicit and comprehensive conceptual structure for valuation and indicator selection. Unlike previous frameworks, it clearly distinguishes between multiple value domains—exchange, welfare, ecological, and socio-cultural—and provides transparency on which type of value is being estimated. The CAN is positioned as an umbrella framework designed for usability: it does not prescribe the use of one value concept but instead allows policymakers to select the proxy-value indicators according to their context, priorities and ethics. In other words, the CAN framework can be understood as an overarching "container" that integrates and organises insights from existing sustainability frameworks into a coherent structure for assessment and decision-making.

Frameworks such as the SDGs, the Planetary Boundaries, and the ESGAP can feed into CAN by providing science-driven indicators, while accounting-based systems like the SEEA CF, the SEEA EA, and Ocean Accounts contribute structured physical and monetary data. Rather than replacing these approaches, CAN acts as a unifying/networking architecture that absorbs their respective indicators and outputs, aligns them within a transparent valuation logic (exchange, welfare, ecological, and socio-cultural), and translates them into an integrated dashboard. This allows diverse evidence streams to be combined consistently, while leaving room for policymakers to determine priorities and weights, ultimately enhancing both interpretability and policy relevance.

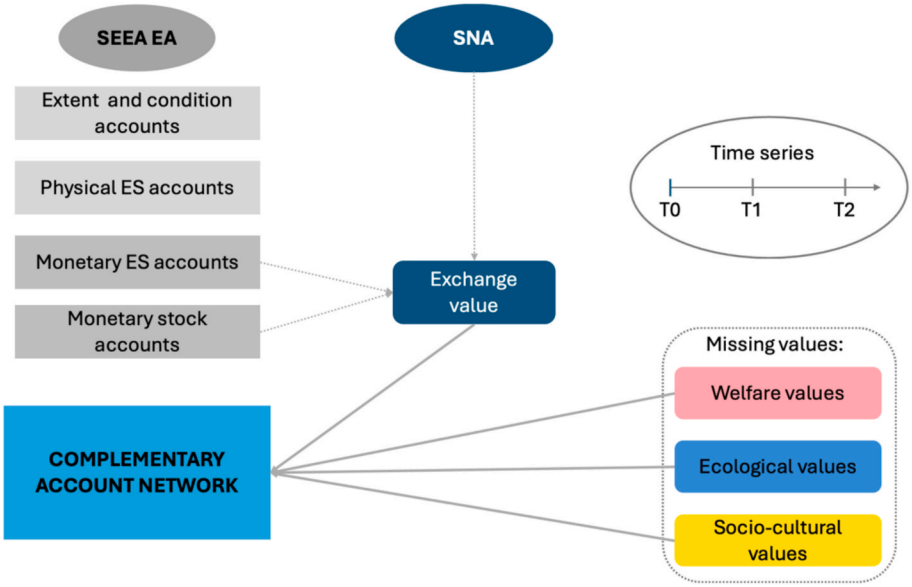


Fig. 1. Complementary Accounting Network setting.

2. The Complementary Accounting network (CAN)

The CAN is fundamentally a *network* framework, conceptualised as a set of interconnected accounting components (nodes) that link economic, ecological, and socio-cultural dimensions, as illustrated in Fig. 2. It should consist of a network of relevant nodes, each encompassing a set of indicators and metrics, but all consistently measured over a same temporal and spatial period/area. The green node, representing ecosystem health, forms the foundation for all other nodes, as the status of an ecosystem underpins its capacity to provide a sustainable flow of ES (La Notte et al., 2022). Ecosystem health is described by measurable ecological indicators, such as biodiversity or resilience. Other nodes may contain standard SNA or SEEA EA accounts (based on the exchange value concept), shown in dark blue and dark orange, respectively. Here, we find standard economic indicators such as the gross or net domestic product (GDP/NDP), gross value added (GVA), savings, and the monetary SEEA ecosystem accounts. Additional nodes may include welfare indicators (pink), such as ES monetary indicators based on willingness to pay (WTP) estimates, and ecological indicators (blue) such as SEEA extent and condition accounts as well as socio-cultural indicators (yellow) that are not fully captured by the recreation costs data in the SEEA EA cultural ecosystem services (Shellock et al., 2025). We use the blue flag status award information as an example of a cultural indicator. While the SEEA EA provides a comprehensive list of cultural ecosystem services to be evaluated, the exchange value only prevents the incorporation of related non-use and welfare values. These are particularly important for non-marketed services such as regulating services or open-access recreation (Fenichel et al., 2020), for which welfare-based values can be substantial (e.g., Christie et al., 2015; Fezzi et al., 2023).

The interconnections between nodes, indicated by the dashed circle that unifies all the nodes, highlights: (i) the diverse information required to compile a comprehensive CAN, (ii) the complementarity of different valuation frameworks, and (iii) the CAN's ability to systematise relationships among them. Such relationships are sometimes more direct, as in the case of ecological indicators directly informing the SEEA EA extent and condition accounts (represented by the dashed arrow). Finally, all accounts, indicators, and metrics within each node should be standardised in terms of temporal coverage. Stock metrics, such as extent and condition accounts, should report both opening and closing values, while flow-related measures should be reported annually as time series data.

The CAN aims to set up the dashboard and network, which are the operational and visual tools, respectively, used to present the indicators corresponding to the different components. Such a structure could serve to organise indicators in a systematic and policy-relevant manner. The establishment of robust baselines for the monitoring of environmental change and its consequences can also encourage greater stakeholder engagement in contexts where competing interests often emerge (Admiraal et al., 2013; Turner 2016).

3. A preliminary approach to CAN

We use Italy and Sardinia as national and regional case studies, providing a simplified arrangement of CAN indicators using a four-cell matrix, shown in Fig. 3. We present a categorisation of the indicator groups in Fig. 1, in terms of the different dimensions of nature's plural values. Each dimension (matrix cell) encapsulates different types of value and related valuation methodologies.

In the first cell (upper left), we report an SNA-compliant indicator: the GDP over time. In the second cell (upper right), we present monetary SEEA Ecosystem Accounts, showing ecosystem contributions to the economy. In our example, we focus on *Posidonia oceanica,* an endemic seagrass of the Mediterranean Sea, which provides key ecosystem services and is crucial for marine biodiversity conservation (Addamo et al., 2025; Bartolini et al., 2024; Leduc et al., 2023). However, increasing anthropogenic pressures are causing its decline (Hinz et al., 2024), highlighting the importance of continuous monitoring and assessment to maintain the stability of Mediterranean ecosystems. Following Addamo et al. (2025), we consider four marine ES provided by *P. Oceanica*, namely fish provisioning, carbon sequestration, daily recreation and marine-based tourism, which were monetised and included as SEEA-EA initial ES measures. The third cell (bottom right) contains biophysical change indicators (non-monetary) capturing variations in both the extent and quality of a range of marine ecosystems. As an illustrative example, findings on *P. oceanica* shoot density (shoots/m^2) derived by Bartolini et al. (2024) were employed as indicators. Meadow density serves as a measure of the condition and ecological health of this key habitat (Romero et al., 2007). The fourth cell (bottom left) contains cultural indicators (non-monetary). The number Blue Flag certification[1] was used as it is an internationally recognised eco-label awarded to beaches and marinas that meet stringent environmental, educational, safety, and accessibility criteria.

4. Results

This section feeds each of the CAN matrix four cells (Fig. 3) with our empirical results. Results provide one indicator for each of the matrix cell, each reported for the same time period (2014–2020). Fig. 4 displays cell 1 (financial-monetary SNA INDICATORS) of the CAN matrix, showing GDP for Italy and Sardinia from 2014 to 2020. The trend over time highlights a similar pathway for both regional and national economies.

Moving to cell 2 (monetary EXTENDED SNA/SEEA-EA) of the CAN matrix, Fig. 5 shows a series of line graphs illustrating the economic value of selected ecosystem services (recreation, tourism, fisheries provisioning, and carbon sequestration). In the ES accounts, while the value of daily recreation remains relatively flat, fish provisioning and tourism recreation show a decline from 2014 to 2020, a trend seen in both Italy and Sardinia. This aligns with the decreasing condition trend of *P. oceanica* observed in the same period of time, which is linked with ES supplied.

Fig. 6 presents cell 3 (non-monetary – ECOLOGICAL INDICATORS) of the CAN matrix. It shows ecological data through two-line graphs, focusing on a key indicator of a good health status of the ecosystems for Italy and Sardinia: *Posidonia oceanica* density. We build on findings from Bartolini et al. (2024) who report a decline in *Posidonia oceanica* density, from around 150 shoots/m^2 in 2014 to below 100 shoots/m^2 in 2020 in Italy, and an even steeper drop in Sardinia, from approximately 240 shoots/m^2 to about 140 shoots/m^2. This decline is ecologically significant, as *Posidonia oceanica* plays a vital role in stabilizing the seabed, sequestering carbon, and supporting biodiversity. The sharper drop in Sardinia may reflect stronger localised environmental pressures.

Lastly, cell 4 (non-monetary – SOCIO-CULTURAL INDICATORS) is showed in Fig. 7. It presents two-line graphs tracking the number of Blue Flag certifications from 2014 to 2020 in Italy and Sardinia. One of the key criteria for obtaining a Blue Flag is the active engagement of local communities and their efforts to manage coastal and marine environments. Additionally, the Blue Flag program encourages respect for and learning about valuable cultural sites and local communities through

[1] Administered by the Foundation for Environmental Education (FEE), the program seeks to promote a balance between tourism development and the preservation of coastal and marine ecosystems, which are increasingly vulnerable to pollution, overexploitation, and climate change. By incentivizing local authorities and stakeholders to adopt best practices, the Blue Flag certification not only enhances environmental quality and resilience but also contributes to the economic and social sustainability of coastal communities through the promotion of eco-conscious tourism. Data available from the Italian Institute for Environmental Protection and Research at https://indicatoriambientali.isprambiente.it/it/turismo/bandiere-blu-spiagge-e-approdi-turistici [last access 18/09/2025].

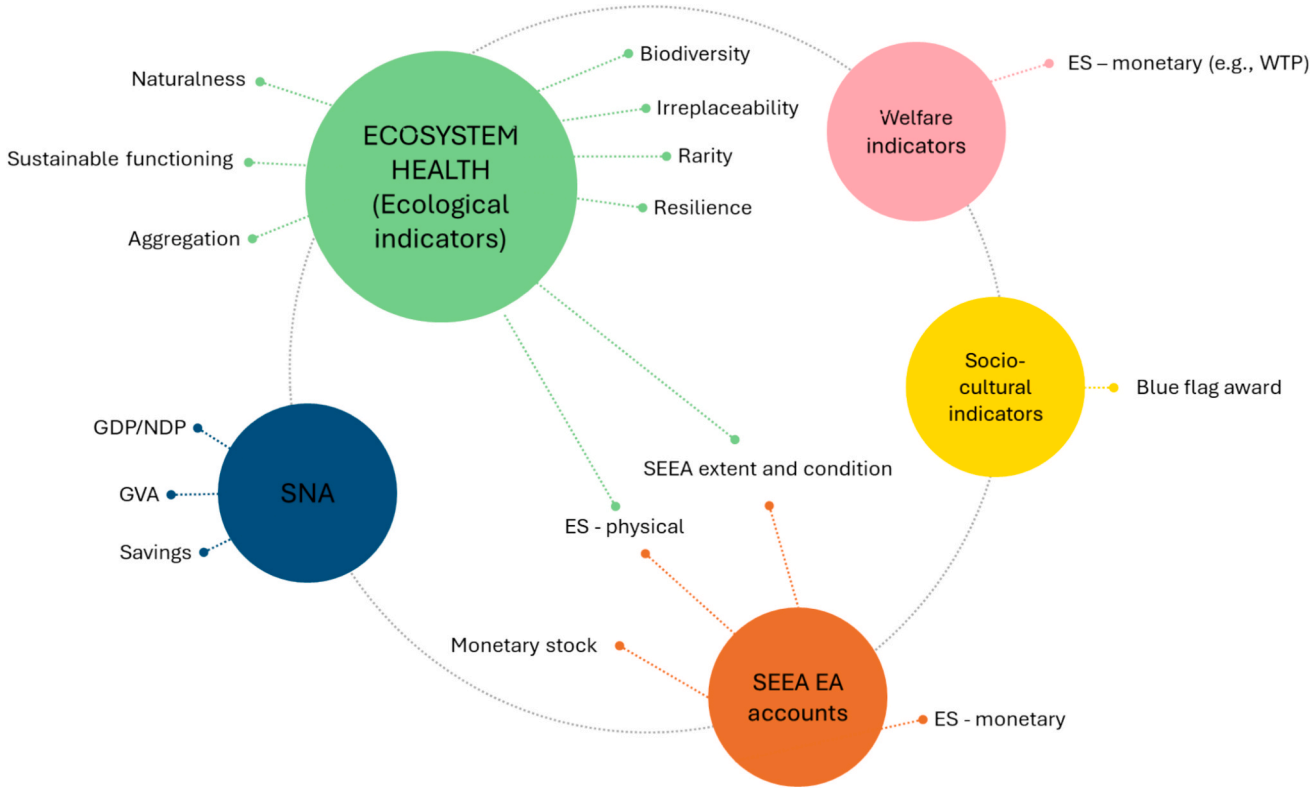


Fig. 2. Complementary Accounting Network (CAN) and information nodes The network structure shows that certain indicators provide inputs to multiple information nodes, thereby creating interconnections between them (for example, ecological indicators supplying information for the extent and condition components of SEEA EA).

MONETARY

SNA INDICATORS (national/regional) • GDP	**EXTENDED SNA/ SEEA-EA** (national/regional) • Ecosystem Services/Monetary Accounts • Extended Genuine Savings
CULTURAL INDICATORS (national/regional) • Blue Flag award	**ECOLOGICAL INDICATORS** (national/regional) • SEEA EA/Physical Accounts • Sea turtle nests

NON-MONETARY

Fig. 3. CAN matrix.

information displays and environmental-cultural education initiatives targeted at diverse user groups. Italy shows a consistent increase in Blue Flag certifications, rising from approximately 140 in 2014 to over 195 by 2020. This upward trend indicates an expanding national commitment to maintaining high standards in coastal and marine environmental management, safety, water quality, and public environmental education. Sardinia also experiences growth, although on a smaller scale. The number of certifications increases from around 6 in 2014 to 14 by 2020 The progression is not as linear as in the national trend, with plateaus observed around 2019 and 2020, suggesting

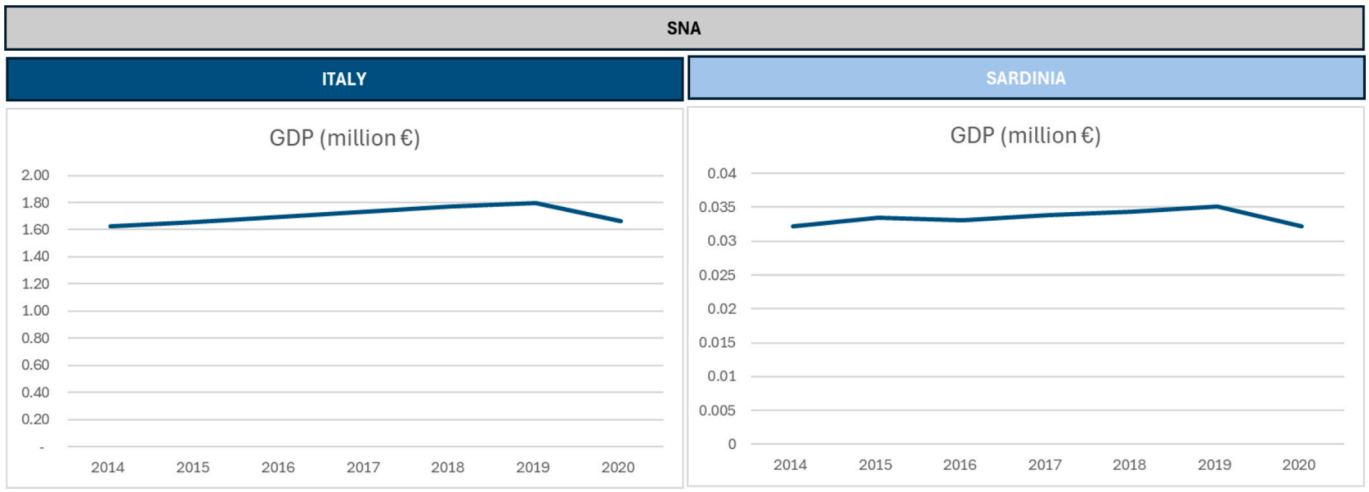


Fig. 4. CAN matrix – cell 1.

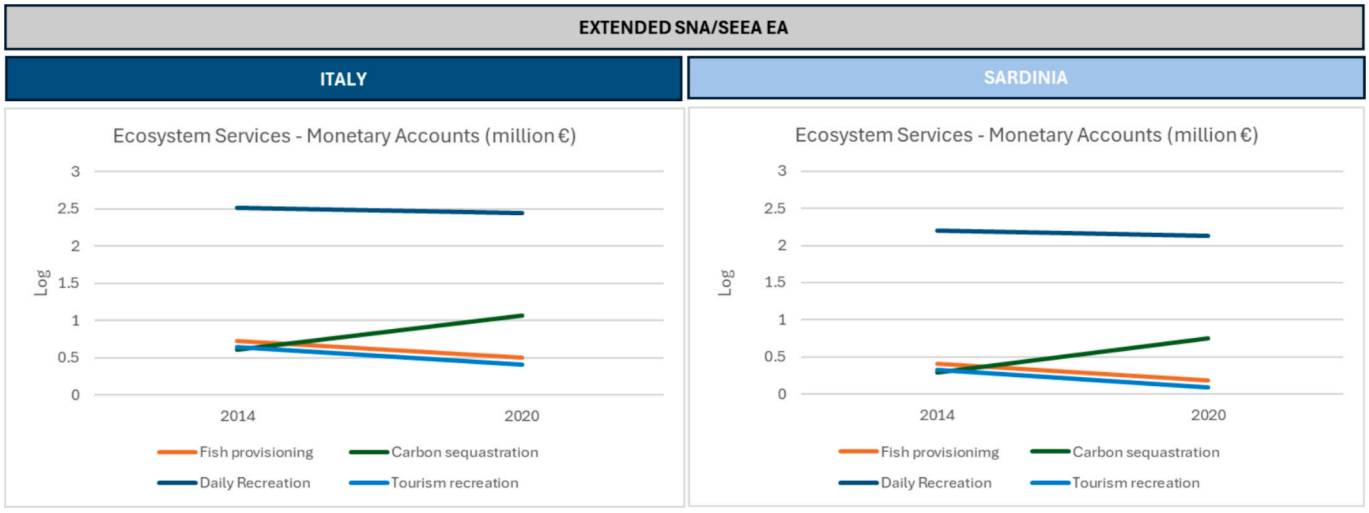


Fig. 5. CAN matrix – cell 2.

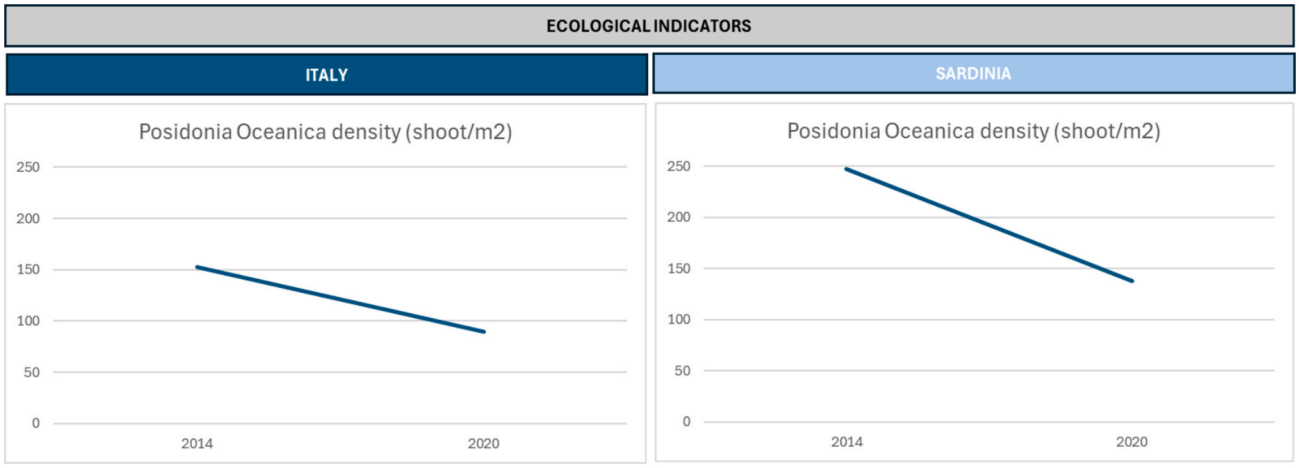


Fig. 6. CAN matrix – cell 3.

periods of consolidation or challenges in meeting criteria. Overall, the data suggests that national and regional efforts to improve coastal and marine environmental standards have been broadly successful.

Finally, Fig. 8 presents the output of CAN in the form of a dashboard designed to provide key decision-makers with essential information for further analysis and decision making. The dashboard serves to

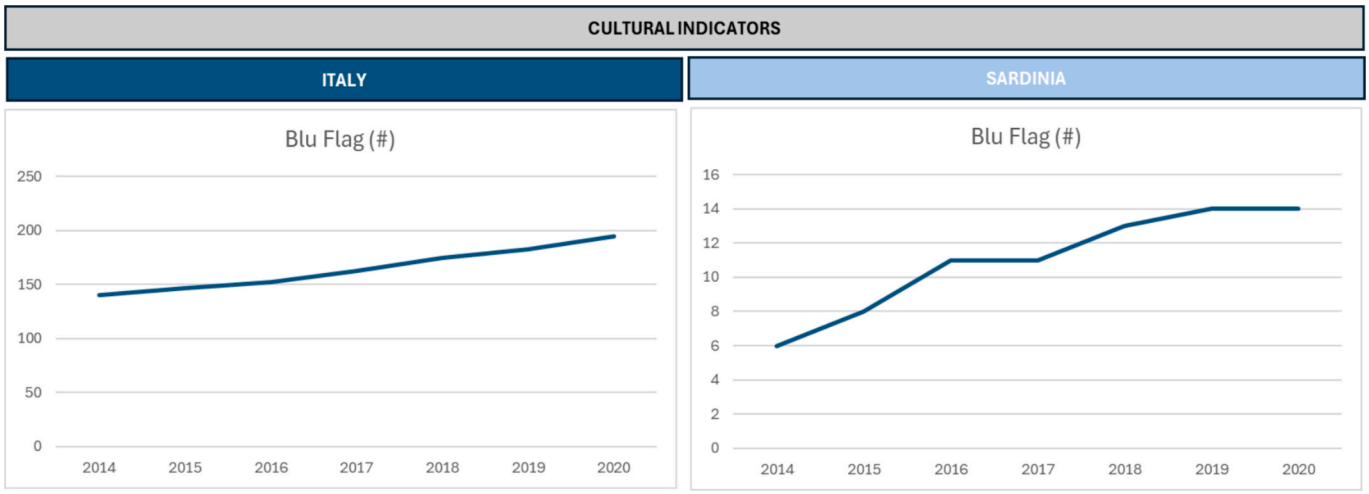


Fig. 7. CAN matrix – cell 4.



Fig. 8. CAN dashboard – full matrix.

communicate complex concepts in a clear and visually accessible format, thereby facilitating more informed decision-making processes. A key strength of the CAN lies in its inherent flexibility, as it can accommodate indicators from diverse frameworks in order to align with varying policy demands. In the example presented, one indicator for each dimension of the matrix—namely, SNA, monetary, ecological, and cultural—is included; however, the CAN framework readily allows for the integration of additional indicators.

5. Concluding remarks

This paper shows that the Complementary Accounting Network (CAN) could represent a comprehensive framework for reporting the diverse values derived from the environment by moving toward a pluralistic approach while building on SEEA EA accounts. Beyond the SEEA EA, CAN also accounts for socio-cultural values, capturing the non-financial benefits people derive from natural capital.

When the CAN is implemented empirically, the *network* framework presented in Section 2 (Fig. 1) is operationalized as a *matrix*, in which each cell comprises a set of *indicators* (Fig. 3), with the resulting output presented in the form of a dashboard (Fig. 8).

The CAN framework further enhances its policy relevance by enabling the integration of diverse international frameworks, including the Global Biodiversity Framework (CBD, 2022), IPBES (Diaz et al., 2015), and the SEEA CF (United Nations et al., 2024) and EA (United Nations et al., 2024). This capacity ensures that the dashboard can respond in a unified and coherent manner to a wide range of policy needs, thereby providing decision-makers with a versatile tool that aligns with multiple governance contexts. CAN provides the basis for systematically organizing and reporting data, thereby transforming different data into meaningful information.

In practice, compiling a comprehensive, meaningful, and reliable set of nodes to populate a CAN requires both biophysical and economic data consistent over time and space. However, the pilot application on marine and coastal resources revealed that data availability remains a critical challenge, as integrating biophysical and economic dimensions is often constrained by gaps and inconsistencies. In particular, the framework depends on time series data with a consistent temporal coverage, yet such data are frequently incomplete or incompatible across sources.

As data availability improves, the CAN may be further expanded to incorporate additional dimensions, such as extended genuine savings

proposed by Di Gennaro et al. (2025), which integrates environmental, social, and inequality aspects, or ecological indicators derived from the ES GAP framework (Usubiaga-Liaño & Ekins, 2024). The inclusion of such indicators would enhance both the analytical scope and policy relevance of the dashboard, while addressing existing gaps in the SNA and SEEA EA concerning the interconnections between natural capital, inequality, and well-being.

Another aspect of potential expansion relates to the biodiversity, which represent a key node in the CAN, as it underpins the resilience of ecosystem service delivery at larger scales health and ability to deliver services and preserve natural functioning (Folke et al., 2004; Oliver et al., 2015). At the same time, developing biodiversity indicators can be particularly challenging due to the extensive biophysical data required on species (Ferrier, 2011), and further research is needed to explore links between biodiversity and ecosystem services (King et al., 2021).

Expanding the CAN framework to integrate the above-mentioned dimensions would not only enrich its analytical capacity but also align it more closely with global priorities for inclusive and sustainable development.

CRediT authorship contribution statement

R. Kerry Turner: Writing – original draft, Supervision, Funding acquisition, Conceptualization. **Valentina Di Gennaro:** Writing – review & editing, Visualization, Investigation, Formal analysis, Data curation. **Alice Bartolini:** Writing – review & editing, Visualization. **Silvia Ferrini:** Writing – , review & editing, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

References

Addamo, A.M., La Notte, A., Ferrini, S., Grilli, G., 2025. Marine ecosystem services of seagrass in physical and monetary terms: the Mediterranean Sea case study. Ecol. Econ. 227, 108420.

Admiraal, J.F., Wossink, A., de Groot, W.T., de Snoo, G.R., 2013. More than total economic value: how to combine economic valuation of biodiversity with ecological resilience. Ecol. Econ. 89, 115–122.

Bartolini, A., Di Gennaro, V., Reas, V., Mascolo, R.A., La Notte, A., Capriolo, A., Ferrini, S., 2024. Ecosystem accounting for marine-based tourism provided by Posidonia oceanica in Italy. One Ecosyst. 9, e129751.

Barzuna, C., Haugan, P., Barbière, J., Swift, A., Khan, M., Ansong, J.O., James, P.A.S., Scherer, M., Thiele, T., von Schuckmann, K., Abramic, A., Barrowclough, D., Cisneros-Montemayor, A., Girón, A., Heaps, L., Koirala, S., Lyons, M., Paul, K., Priyanto, A.T., Randone, M., Rosado, S., Santos, C.F., Savoldelli, C., Spalding, A.K., Strand, M., Sumaila, U.R., Swaddling, A., Turner, J., Vestergaard, O., Yulianto, I., 2025. Handbook on Sustainable Ocean Plans: A practitioners' guide. Washington, DC: World Resources Institute. https://oceanpanel.org/publication/SOP handbook/ DOI: https://doi.org/10.69902/8a3c346d.

Christie, M., Remoundou, K., Siwicka, E., Wainwright, W., 2015. Valuing marine and coastal ecosystem service benefits: Case study of St Vincent and the Grenadines' proposed marine protected areas. Ecosyst. Serv. 11, 115–127. https://doi.org/10.1016/j.ecoser.2014.10.002.

Convention on Biological Diversity, 1992. *Text and Annexes.* Secretariat of the Convention on Biological Diversity, United Nations, 5 June 1992. https://www.cbd.int/convention/text/ Convention on Biological Diversity+1.

Convention on Biological Diversity CBD, 2022. The Kunming-Montreal Global Biodiversity Framework, available at: https://www.cbd.int/doc/c/e6d3/cd1d/daf663719a03902a9b116c34/cop-15-l-25-en.pdf.

Diaz, S.; Demissew, S., Carabias, J., Eyzaguirre, P., et al., 2015. The IPBES Conceptual Framework — connecting nature and people. Current Opinion in Environmental Sustainability 14 p. 1-16 ISSN: 1877-3435, available at: https://hdl.handle.net/10568/70608 DOI https://doi.org/10.1016/j.cosust.2014.11.002.

Di Gennaro, V., Ferrini, S., Turner, R.K., 2025. Extending the Genuine Savings estimates with natural capital and poverty at the regional and national level in Italy. Ecol. Econ. 228, 108433.

Fenichel, E., Obst, C., Wentland, S.A., 2024. Minding ps and qs of natural capital accounting: Sorting out prices and sustainability concepts.

Ferrier, S., 2011. Extracting more value from biodiversity change observations through integrated modeling. Bioscience 61 (2), 96–97.

Fezzi, C., Ford, D.J., Oleson, K.L., 2023. The economic value of coral reefs: climate change impacts and spatial targeting of restoration measures. Ecol. Econ. 203, 107628. https://doi.org/10.1016/j.ecolecon.2022.107628.

Folke, C., Carpenter, S., Walker, B., Scheffer, M., Elmqvist, T., Gunderson, L., Holling, C. S., 2004. Regime shifts, resilience, and biodiversity in ecosystem management. Annu. Rev. Ecol. Evol. Syst. 35 (1), 557–581.

Hinz, H., Terrados, J., Moranta, J., Reñones, O., Ruiz-Frau, A., Catalán, I.A., 2024. A risk-based approach to the analysis of potential climate change effects on fish communities associated to Posidonia oceanica in the Mediterranean. Mar. Environ. Res. 199, 106618. https://doi.org/10.1016/j.marenvres.2024.106618.

King, S., Vardon, M., Grantham, H.S., Eigenraam, M., Ferrier, S., Juhn, D., Turner, K., 2021. Linking biodiversity into national economic accounting. Environ. Sci. Policy 116, 20–29.

Leduc, M., Abadie, A., Viala, C., Bouchard, A., Iborra, L., Fontaine, Q., Lepoint, G., Marengo, M., Pergent, G., Gobert, S., Lejeune, P., Monnier, B., 2023. A multi-approach inventory of the blue carbon stocks of *Posidonia oceanica* seagrass meadows: Large scale application in Calvi Bay (Corsica, NW Mediterranean). Mar. Environ. Res. 183, 105847. https://doi.org/10.1016/j.marenvres.2022.105847.

Lepenies, P., 2016. *The power of a single number: a political history of GDP*. Columbia University Press.

La Notte, A., Cźucz, B., Vallecillo, S., Polce, C., Maes, J., 2022. Ecosystem condition underpins the generation of ecosystem services: an accounting perspective. One Ecosyst. 7, e81487. https://doi.org/10.3897/oneeco.7.e81487.

Markandya, A., Barton, D. N., Caparŕos, A., Edens, B., Grammatikopoulou, I., Harris, R., Obst, C., 2022. Monetary valuation of ecosystem services and ecosystem assets for ecosystem accounting: Interim version 1st edition. NCAVES and MAIA projects. Available at: https://seea.un.org/sites/seea.un.org/files/techreportvaluationv15_final_21072022.pdf.

Oliver, T.H., Heard, M.S., Isaac, N.J., Roy, D.B., Procter, D., Eigenbrod, F., Bullock, J.M., 2015. Biodiversity and resilience of ecosystem functions. Trends Ecol. Evol. 30 (11), 673–684.

Planetary Boundaries Science (PBScience). 2025. Planetary Health Check 2025, edited by Kitzmann, N.H., Caesar, L., Sakschewski, B. and Rockström, J. with contributions from Sakschewski, B.*, Caesar, L.*, Andersen, L. S., Bechthold, M., Bergfeld, Beusen, A., L., Billing, M., Bodirsky, B. L., Botsyun, S., Dennis, D. P., Donges, J. F., Dou, X., Eriksson, A., Fetzer, I., Gerten, D., Häyhä, T., Hebden, S., Heckmann, T., Heilemann, A., Huiskamp, W., Jahnke, A., Kaiser, Kitzmann, N.H., J., Krönke, J., Kühnel, D., Laureanti, N. C., Li, C., Liu, Z., Loriani, S., Ludescher, J., Mathesius, S., Norström, A., Otto, F., Paolucci, A., Pokhotelov, D., Rafiezadeh Shahi, K., Raju, E., Rostami, M., Schaphoff, S., Schmidt, C., Steinert, N. J., Stenzel, F., Virkki, V., Wendt- Potthoff, K., Wunderling, N., Rockström, J. Potsdam Institute for Climate Impact Research (PIK), Potsdam, Germany. https://planetaryhealthcheck.org *equal contributors to this work and designated as co-first authors DOI: 10.48485/pik.2025.017.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin III, F.S., Lambin, E., Foley, J., 2009. Planetary boundaries: exploring the safe operating space for humanity. Ecol. Soc. 14 (2).

Romero, J., Martínez-Crego, B., Alcoverro, T., Pérez, M., 2007. A multivariate index based on the seagrass Posidonia oceanica (POMI) to assess ecological status of coastal waters under the water framework directive (WFD). Mar. Pollut. Bull. 55, 196–204. https://doi.org/10.1016/j.marpolbul.2006.08.032.

Stiglitz, J., Fitoussi, J., Durand, M., 2018. Beyond GDP: Measuring What Counts for Economic and Social Performance, OECD Publishing, Paris, https://doi.org/10.1787/9789264307292-en.

Shellock, R.J., Thoms, R.E., James, P.A.S., Loureiro, T.G., Rosado, C., Swaleh, M., Cappabianca, R., 2025. Social Accounts for the ocean: a path to inclusive and equitable ocean decision-making. Environ. Sci. Policy 173, 104221. https://doi.org/10.1016/j.envsci.2025.104221.

Turner, R.K., 2016. The 'Balance Sheet' Approach within Adaptive Management for Ecosystem Services. In *Routledge handbook of ecosystem services*. Routledge, pp. 289–303.

Turner, K., Badura, T., Ferrini, S., 2019. Natural capital accounting perspectives: a pragmatic way forward. Ecosyst. Health Sustainability 5 (1), 237–241.

United Nations Department of Economic and Social Affairs, 2016. The sustainable development goals report 2016. Available at: https://unstats.un.org/sdgs/report/2016/the%20sustainable%20development%20goals%20report%202016.pdf.

UNCEEA, 2024. Report of the 19th meeting of the un committee of experts on environmental economic accounting.

UN, European Commission, FAO, IMF, OECD, & World Bank, 2014. System of Environmental Economic Accounting 2012—Central Framework. http://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf.

United Nations et al, 2024. System of Environmental-Economic Accounting: Ecosystem Accounting (SEEA EA). Available at: https://seea.un.org/ecosystem-accounting.

United Nations Department of Economic and Social Affairs, 2025. The sustainable development goals report 2025. Available at: https://unstats.un.org/sdgs/report/2025/The-Sustainable-Development-Goals-Report-2025.pdf.

United Nations Statistics Division, 2026. High-Level Forum on Official Statistics: Beyond GDP: Rethinking Progress in a Changing World, Report on the fifty-seventh session (3–6 March 2026). Available at: https://unstats.un.org/UNSDWebsite/statcom/documents/57.

Usubiaga-Liaño, A., Ekins, P., 2024. Methodological choices for reflecting strong sustainability in composite indices. Ecol. Econ. 221, 108192. https://doi.org/10.1016/j.ecolecon.2024.108192.

Usubiaga-Liaño, A., Ekins, P., 2021. Time for science-based national targets for environmental sustainability: an assessment of existing metrics and the ESGAP framework. Front. Environ. Sci. 9, 761377. https://doi.org/10.3389/fenvs.2021.761377.

Vardon, M.J., Le, T.H.L., Martinez-Lagunes, R., Pule, O.B., Schenau, S., May, S., Grafton, R.Q., 2025. Accounting for water: a global review and indicators of best practice for improved water governance. Ecol. Econ. 227, 108396. https://doi.org/10.1016/j.ecolecon.2024.108396.