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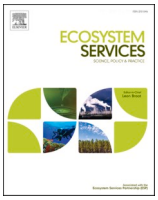

Full Length Article

Designing effective environmental policy mixes in the UN Decade on ecosystem restoration

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ABSTRACT

The 2020s are starting under challenging circumstances. The impact of COVID-19 recovery plans and the realignment of geopolitics with energy provisioning will be crucial for meeting global environmental policy targets, such as those exemplified by the recently launched United Nations Decade on Ecosystem Restoration. How to build a more ecologically viable society, however, remains a contested issue. Several scholars are also highlighting the importance of complexifying environmental policy beyond individual instruments centred on the limiting paradigm of economic growth. Drawing on these considerations, we make a case for Environmental Policy Mixes (EPMs), which can better accommodate a diversity of institutional arrangements, contextual power dynamics, and a multiplicity of environmental targets. In this paper, we first present a database of 146 environmental policy instruments (provided in the annexe) that we collected through a survey of the literature. Second, we develop an EPM framework based on a set of 14 criteria that we then test with a selected group of experts in the field, both academics and business practitioners, through structured interviews and card sorting. Following, we present an adjusted final version of the framework and conclude with two illustrative examples of how to apply it. The first one is a case study of the environmental trade-offs in a natural UNESCO World Heritage Site, and the other investigates how to align COVID-19 stimulus packages with the objectives of the UN Decade on Ecosystem Restoration. The decade ahead is going to be critical for reaching global environmental targets. The EPM framework can facilitate policy discussions and guide decision-makers in tackling the environmental policy challenges of the 2020s and beyond.

1. Introduction

The 2020s are going to be a critical decade for global environmental policy. In 2020, the UN underwent the first comprehensive review of the Sustainable Development Goals (SDGs), five years after their official adoption. Yet, pandemic and geopolitics related instabilities are jeopardising the (already meagre) achievements of the recent past, "further delaying the urgent transition to greener, more inclusive economies" (UN, 2021, p. 2). The year 2020 also ended the UN Decade on Biodiversity, which was followed by the presentation of a post-2020 plan by the International Union for Conservation of Nature (IUCN) to curb biodiversity loss by 2030 and achieve complete restoration by 2050. To reach these goals, the IUCN suggests resorting to innovative policy instruments to increase financial resources for conservation (IUCN, 2021). Likewise, in its post-2020 strategy framework the Convention on Biological Diversity (CBD) asked to speed up and advance policy action to reverse biodiversity loss by the end of the decade (CBD, 2021). The recently launched United Nations (UN) Decade on Ecosystem Restoration summarises these calls for building back a "greener" world. Between 2021 and 2030 the UN aims at restoring globally an area of land roughly the size of China. But while the environmental policy objectives are set, what instruments will deliver them? New frameworks and guiding principles may be needed to identify and design policy mixes that respond to the environmental and economic challenges of the 2020s.

The SDGs, which are commonly held as the gold standard of global environmental policy, are however yet to keep up with the expectations that followed their introduction in 2015. The hype with which they are celebrated in academic and policy circles is seldom substantiated with an adequate appraisal of the contextual trade-offs swathing SGD targets

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in the neoliberal global economic order (Katila et al., 2019). While credit must be given to the several contributions of the SDGs, the UN's policy framework seems to be stuck within outdated conceptions of development centred on economic growth (Hickel, 2019; Menton et al., 2020). Menton and co-authors (2020) believe that this narrow focus on income-based metrics masks the complexity of the multi-dimensional nature of human well-being. On the contrary, they suggest, the SDGs should "address the power dynamics and structural conditions that impede environmental and social justice" and move towards a post-growth environmental policy (Menton et al., 2020, p. 1626). Similarly, the CBD is also placing greater emphasis on the transition to a "2050 Vision of living in harmony with nature" that implies "making use of biodiversity in […] 'green infrastructure'", reducing global resources consumption, and overall "steering away from the current limited paradigm of economic growth" (CBD, 2020, p. 182).

A similar approach, argue Hickel and colleagues (2021), should be extended also to post-growth climate action and mitigation scenarios of the United Nations Framework Convention on Climate Change (UNFCCC). In 2021, Nationally Determined Contributions have been reviewed at the COP26 for the first time since the Paris Agreement of 2015. Nevertheless, the COP26 has not met the expectations of the scientific community and civic society (Masood and Tollefson, 2021). For instance, high-income countries (responsible for most historical emissions of greenhouse gases) have yet again failed to mobilize a constant stream of climate finance.[1] This lack of coordination over funding mechanisms is particularly concerning also for other environmental targets, including those set by the new UN Decade on Ecosystem Restoration launched in the summer of 2021. As outlined by the United Nations Environment Programme (UNEP), this will require increasing the amount of finance for restoration – starting from COVID-19 recovery packages. Effective ecosystem restoration relies on the development of "instruments and mechanisms to ensure that finance flows support – and do not compromise –" environmental action (UNEP, 2021, p. 4). Along these lines, the UN, CBD, IUCN and other international organisations call for redesigning subsidies and fiscal policy in the 2020s to boost restoration efforts (CBD, 2020; O'Callaghan and Murdock, 2021).

There is widespread and growing international consensus about the need to support "transformative change" and a "low-carbon circular economy", yet these horizons are ill-defined and potentially contradictory (Vezzoni, 2023). To enable a transition from a destructive energy-intensive economy to a sustainable post-growth society, the scientific community is called to inform the policy-making process with robust analytical tools and engaged scholarship (Banerjee et al., 2020; Gardner et al., 2021). However, how to achieve the vision set by the UN Decade 2021–2030 remains an open-ended question. The challenge ahead is not so much in the objectives, but in the means to reach them. What policy instruments can secure enough financial resources for tackling climate change, biodiversity loss and unsustainable pollution levels? The solution is unlikely to rest on individual policy items. This is reminiscent of Ostrom's (2007) warning against single-policy panacea, and in support of multitier frameworks for socio-ecological systems. Indeed, the increasing complexity of global environmental issues, and the related social change, ask for advancing the study of policy mixes. Prioritising the analysis of policy mixes also adds realism to the scientific inquiry, as in practice environmental policy instruments most often build on previous measures and a multiplicity of regulatory schemes (Ring and Barton, 2015). So how to classify and then design environmental policy mixes? What standards have been proposed so far and how to update and improve them?

[1] Already in 2009, at the COP15 in Copenhagen, high-income countries promised to raise 100 billion US$ of climate funding for the rest of the world each year by 2020. The promise has been reiterated on several other occasions (e.g., at COP21, at the G7 summit in Cornwell 2021, in the U.S. Build Back Better), yet to date, in 2023, it is still to be delivered.

In this paper, we use the environmental policy mixes (hereafter, EPMs) as an umbrella term to identify all combinations of environmental policy instruments that make use, directly or indirectly, of economic theory, regulatory schemes, or information-based tools. In the reminder of the paper, we first present an overview of the concept of EPM. This is followed by a description of the literature review and structured interviews that we used to compile a database of 146 environmental policy instruments. Third, drawing on these insights, we advance a preliminary framework based on a set of 14 criteria, which is then revised by our interviewees, who have been ranking the list of criteria, grouping them, and suggesting amendments. Fourth, we present a final framework for the analysis of EPMs. Following, in the discussion we illustrate how to use it for EPM design with the help of our database of 146 instruments. Some concluding reflections and suggestions for further research avenues end the paper.

2. Environmental policy mixes (EPMs)

The academic literature on instruments for environmental policy is largely dominated by the concept of payments for ecosystem services (PES) (Schomers and Matzdorf, 2013; Perevochtchikova et al., 2021). Wunder (2005) provides one of the most used definitions of PES, as (1) a voluntary transaction where (2) a well-defined ES (3) is being "bought" by a buyer (4) from a provider, (5) on the conditional case that the ES provider can secure ES provision. However, since these ideal conditions are seldom encountered in the real world, PES should include a wider array of transactions between users and providers of environmental services (Wunder and Vargas, 2005; Pirard, 2012). In other words, understanding PES and their impacts requires thorough contextualisation (Barton et al., 2014; Gómez-Baggethun and Muradian, 2015; Bauchet et al., 2020). For these reasons, Barton and colleagues (2017) tried to adapt Ostrom's Institutional Analysis and Development (IAD) framework to the study of the structural and functional characteristics of PES. Accordingly, the authors explicitly define PES as a policy mix rather than an individual instrument, since PES schemes "have resulted from processes of adaptation and co-evolution with the existing policy mixes" (Barton et al., 2017, p. 406).

PES are often exemplified as market-based instruments, but wrongly so according to Gómez-Baggethun and Muradian (2015), for the trade component is completely missing in most PES schemes. Along these lines, Hahn et al. (2015) suggest that new policy frameworks should pay more attention to the actual institutions and performance of policy instruments. Given the large and still growing array of policy items and the lack of a common lexicon (Pirard, 2012), environmental policy is becoming ever more sophisticated. It is not only the increasing number and types of instruments that are adding intricacy to the field, but also the pursuit of multi-faceted environmental goals, responding to the emergent properties of planetary ecosystems.

Multiple policy targets, therefore, often call for policy mixes instead of individual instruments, as suggested by the now famous "Tinbergen Rule": the achievement of n policy targets requires at least the same number of independent policy instruments (Tinbergen, 1952). Yet, definitions, categories, and contexts of implementation of environmental policy instruments are frequently ambiguous, and the ideal of the Tinbergen Rule may be difficult to apply in practice (OECD, 2007; Pirard, 2012; Engström et al., 2020). Nevertheless, in face of the complexity and scale of the planetary breakdown, the focus of environmental policy is moving from single instruments to policy mixes (Ring and Schröter-schlaack, 2011; Barton et al., 2014, 2017; Ring and Barton, 2015; Young and Castro, 2021).

Several authors have attempted to introduce more clarity in the study of EPMs. A common approach is to focus on individual environmental targets, like protected areas (Emerton et al., 2006; Busch et al., 2021), biodiversity (Vatn et al., 2011; Parker et al., 2012; Seidl et al., 2020), waste management (Dubois et al., 2015), greenhouse gas emissions (Donofrio et al., 2019; Ramstein et al., 2019), or ecosystem

services more in general (Ring and Schröter-schlaack, 2011; Vatn et al., 2014; Keenan et al., 2019). Alternatively, others have differentiated economic instruments based on their geographical scope, time frame, or geopolitics – e.g. a recurrent focus is on the so-called developing countries (Gutman and Davidson, 2007; Resende et al., 2021). However, in order to find effective context-dependent mixes of policy items instead of a single silver bullet measure, it is important to look at the nature of different instruments, in combination, and in comparison, to each other. There is, in other words, a need to systematize the description and design of structured policy mixes (Ekvall et al., 2016). The term EPM can be used regardless of the geographical scope, time span and nature-related field of the instruments under scrutiny. Considering this heterogeneity, environmental policy would benefit from new frameworks to characterise and effectively design EPM. The pressing global environmental targets of the 2020s represent a challenge for EPMs, but also a source of innovation and increasing diversity, as we shall explore in the next session.

3. Materials and methods

3.1. Literature review

As a starting point, we analysed the scientific and grey literature on environmental policy instruments using Web of Science,[2] whose database well covers the multidisciplinary character of our field of study. After iteratively testing and perfecting it, we used the following formula of search terms:

$$(TS = (\text{"}environmentalpolicy\text{"})ANDTS = (\text{"}policyinstrument*\text{"}or\text{"}policymechanism*\text{"})ANDTS = (review*ORlist*ORcriteri*))$$

Where TS stands for Topic Search: "Searches title, abstract, author keywords, and Keywords Plus."

The query resulted in 101 publications since 1993, half of which were published after 2015. Most of them are scientific articles (94%), of which 39% are in environmental sciences and 31% in economics. The materials have been individually scrutinised, together with their most relevant references (i.e. additional 18 manuscripts were added), to create an extensive database of 389 instruments, subsequently refined into 146 policy instruments (provided in the annexe). The sources analysed suggest several criteria to characterise and compare policy instruments. These criteria are derived from core theoretical notions, insights from policy negotiations, or the impacts on certain environmental fields or economic sectors (Parker et al., 2012; OECD, 2016). The principles according to which we selected the criteria for our Environmental Policy Mixes framework are threefold. First is *general applicability*, which refers to the universality of the criterion (e.g. filtering out criteria relevant only to specific fields of application). Second is *recurrence*, namely how often the same concept, which underpins a specific criterion, is proposed in the various sources. Third is *multidisciplinary coverage*, which responds to the need for embracing the totality of the aspects covered by different disciplines and not simply focusing on either economic or environmental characteristics. These guiding principles led us to select a set of 14 criteria, as further explained in Table 1 in section 4.1: *Nature, Activity, Ownership, Time, Availability, Approval, Economic Theory, Category of Market-Based Instruments (MBIs), Relation to Markets, Economic Value, Payer, Source, Currency,* and *Investment Spectrum*.

3.2. Structured interviews

To refine and validate our results from the literature review, a set of structured interviews was carried out with six experts in the field from four European countries: three business professionals and three academics. The interviews lasted between 45 and 90 min, and have been carried out between December 2019 and May 2020. The three business practitioners come from the financial sector: two are bank executives (Belgium, Netherlands) and one is an impact finance journalist (Italy). They have been approached during a conference of the UNEP Finance Initiative held in Luxembourg, in November 2019. Concerning the academics, the interviewees are senior scientists, with a high profile in their research field. We covered the core elements of sustainability studies, economic, environmental and socio-cultural aspects, with an environmental scientist (University of Groningen), a socio-cultural sustainability scientist (Natural Resources Institute Finland), and an environmental economist (Vrije University of Amsterdam).

To start with, the interviewees are asked to report their experience in sustainability-related disciplines in terms of years spent working in the field, both for the individual and the institution. The average experience of the individuals interviewed is 20 years, 24 for the institutions. The interviews continue with an in-depth introduction to the list of criteria for the framework. We asked interviewees to familiarise themselves with the content of the questionnaire and then answer six questions. The first question (Q1) assessed the experience and background of the interviewees. Q2 asked to order the set of criteria according to their relevance. Q3 asked for modifications to each criterion. Then Q4 presented the categorisation of criteria into four groups: nature, planning, economics and financial aspects. The respondents could approve of the categorisation or suggest alternatives. Q5 asked if there is any criterion that the interviewee would like to remove from the list. Finally, Q6 invited the respondents to propose additional criteria to be added to the

Table 1
The set of criteria of the EPM framework designed from the survey of the literature.

Group	Criterion	Short Description
Natural Resource (NR)	Nature	According to the MEA Framework (2005), which are the ecosystem services addresses by the instrument?
	Activity	Which type of activity will be funded through the instrument?
	Ownership	According to the "subtractability – excludability" matrix (Ostrom, 2005), which type of natural resource is the object of the conservation effort, and who owns it?
Planning (P)	Time	How old is the time series for the instrument?
	Availability	When will the funding be available?
	Approval	Who is in charge of approving the delivery of the funding?
Economics (E)	Economic Theory	According to which economic principles is the instrument better than simple direct funding?
	Category of Market-Based Instruments (MBIs)	To which category of MBIs (Pirard, 2012) does the instrument belong?
	Relation to Markets	Where does the invested capital come from?
	Economic Value	Which economic values compose the total economic value and therefore illustrate the relationship with the natural resource?
	Payer	Which agents will be providing the capital for the instrument?
Finance (F)	Source	How are the funds raised and used with the instrument?
	Currency	In which currency is denominated the invested capital?
	Investment Spectrum	Where do the investors targeted by the financial instrument fall in a standard investment spectrum typology (Bridges Ventures, 2012)?

[2] The survey of the literature was finalized on December 3rd, 2019.

framework. One interview was conducted in person, but due to the outbreak of the Covid-19 pandemic, five have been carried out online. Concerning Q2 and Q4, the structured interviews have been complemented with semi-open card sorting on the Miro platform. As a research method, card sorting has been used to reveal "how participants relate and categorize concepts" (Goodman et al., 2012, p. 202). The participants have been guided in ranking the criteria and in grouping them into thematic groups. The interview format is accessible in the supplementary online material.

Structured interviews have been used to elicit new information concerning the motivations and objectives that practitioners can have for using EPM. Given the specificity of the research questions asked in this paper, the contribution of selected participants is more relevant and efficient than the adoption of a widespread survey. To test the validity of the feedback from the interviews, data have been treated using a rank-based non-parametric statistical method of variance analysis, the *method of ranks* (Friedman, 1937), also known as Friedman's test. When the assumption of normal distribution is not justified, the *method of ranks* measures whether a statistical difference exists between variables, i.e. "if they can be supposed to have all come from the same universe" (Friedman, 1937, p. 676). We applied the method to test the following null hypothesis:

H_0: there are no significant differences between the ranking values assigned to each criterion by our interviewees.

We concluded that a statistically significant difference exists between the ranking values assigned during the interviews (P value $= 0.04 < \alpha = 0.05$), and thus H_0 can be rejected ($n = 6$, $\chi^2 = 23.05$, $df = 13$). We used the feedback collected during the interviews to reach a refined version of the EPM framework, by reassessing each of the 14 criteria and each of the 4 categories. In principle, we tried to include all inputs from the specialists. Some comments, however, could not be taken into account, either for a lack of a clear proposal or because they seemed rather unrelated to the scope of this paper. We tried to accommodate also contrasting views by including additional criteria or refining their characteristics. Nevertheless, most of the comments have been successfully included in the EPM framework, as further explained in section 4.2.

4. Results

4.1. Criteria for the EPM framework from the literature review

Through our survey of the literature we searched for the key characteristics of EPMs. A few studies and sources stand out for the information provided on different policy instruments and potential criteria. Gutman and Davidson (2007), for instance, review a selection of 61 financial mechanisms for biodiversity conservation, in an attempt to list all the "innovative financial mechanisms proposed in the last decade" (Gutman and Davidson, 2007, p. 58). The report contains several other valuable references adding relevant information to our database (*such as* Gutman, 2003; Bishop et al., 2006; Emerton et al., 2006; CBD, 2007; Koch-Weser and van Lier, 2008). Vatn and colleagues (2011) too is an important source for the identification of innovative economic instruments for biodiversity, mostly under the category of PES and cap-and-trade based systems. Concerning governance structures, the authors find that the public sector often plays a key role, even in so-called market-based instruments. These economic schemes mainly depended on (i) robust regulatory regimes and (ii) support in fund-raising efforts, particularly for start-up and transaction costs. The term market-based instruments should thus be used with caution, for it does not practically imply a direct involvement of the private sector, while public authorities often have a prevailing role both in terms of regulation and economic intervention. For example, Vatn et al. (2011) find that up to 99% of funding flowing to PES comes from public sources in high-income countries.

Finally, another important source is the PINE,[3] a database of environmental policy instruments developed by the Organisation for Economic Co-operation and Development (OECD), in cooperation with the European Environment Agency. It contains more than 3200 individual policies organised into six main categories (i.e. Taxes, Fees or charges, Tradable permits, Deposit-refund schemes, Environmentally motivated subsidies, and Voluntary approaches), each of them classified by sectoral criteria. The PINE database facilitates comparative analyses between countries, including volumes, tax bases, legal frameworks, and other information from national statistical institutes. From this literature review, we created an extensive database of 146 instruments, available in the annexe.

Moreover, we created an EPM framework based on criteria that respond to the standards of *general applicability*, *recurrence*, and *multi-disciplinary coverage*, as presented in section 3. Table 1 illustrates these 14 resulting criteria. Taking inspiration from Ring and Barton (2015) who identify four evaluation criteria groups for single instruments, we have arranged the criteria identified in this study into four thematic groups: the natural resource underlying the economic investment, the planning of the EPM implementation, the economic principles underpinning the EPM, and its financial characteristics. Further details on the sources of information are illustrated in the description of each criterion.

4.1.1. Natural resource underlying the economic investment

4.1.1.1. Nature. The *Nature* criterion assesses the ecosystem services that are addressed by the financial instrument. It is drawn from the Millennium Ecosystem Assessment (MEA) report of 2005. The four classes of ecosystem services, and the sub-categories, are shown in Fig. 1. This criterion should be understood as a definition of the environmental domain which is addressed by the instrument (OECD, 2016).

4.1.1.2. Activity. The *Activity* criterion outlines the type of activities to be funded (Parker et al., 2012). These actions can be:

- Conservation actions: activities that have limited (if any) extractive use of nature, and focus on delivering ecosystem services (e.g. protected areas).
- Capacity-building: activities that focus on supporting countries and communities in their ability to carry out conservation projects (e.g. governance and policy reform).
- Sustainable use: provisioning of goods in such a manner that ecosystem services and biodiversity are maintained at high levels (e.g. agroforestry).
- Technological innovation: improvement of technical knowledge related to ecosystem conservation and the sustainable use of natural resources (e.g. scientific knowledge or optimising agroforestry).
- Networking actions: efforts put into creating stable partnerships among natural resources stakeholders (e.g. countries sharing borders along a protected area).

4.1.1.3. Ownership. The *Ownership* criterion is based on the well-known typology of goods in economics, adapted accordingly to the insights proposed by Ostrom (2005). Table 2 shows the options proposed by the "subtractability-excludability" matrix.

4.1.2. Planning of the EPM implementation

4.1.2.1. Time. The *Time* criterion assesses whether, and for how long, there has been a proven track of the implementation of the instrument or

[3] Policy Instruments for the Environment (https://pinedatabase.oecd.org/).

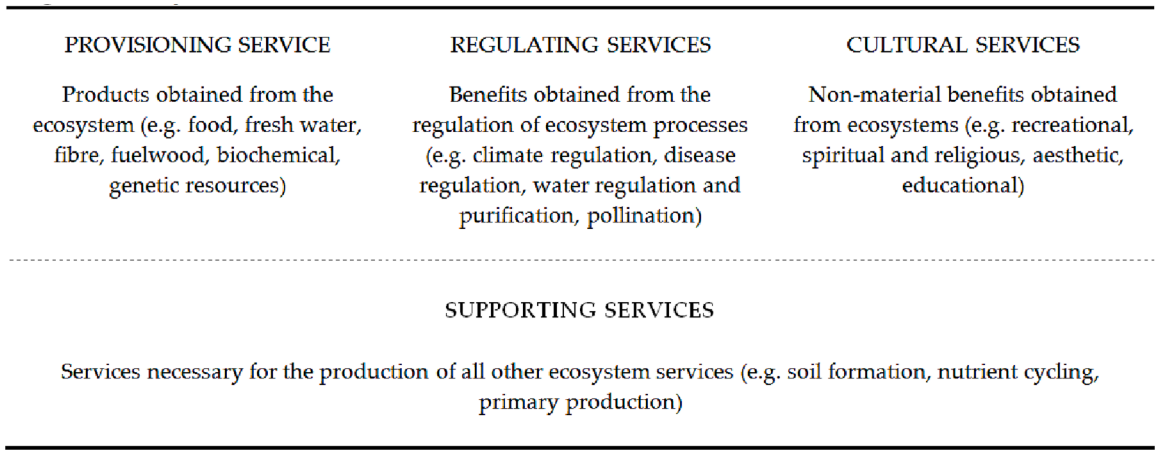


Fig. 1. Ecosystem Services framework (Millennium Ecosystem Assessment, 2005).

Table 2
Basic types of goods. .

	Subtractability		
Excludability	Public Goods	Common-Pool resources	*Low*
	Club Goods *Low*	Private Goods *High*	*High*

Adapted from Ostrom (2005)

policy mi. A lack of historical series can be a sign that further research is required, since it may be the case that a solution investigated in the past has not so far become mainstream because of adverse conditions, difficult access to key resources or impracticability. The options span from:

- *Traditional* (<50 years).
- *Well-spread* (50< years <15).
- *Ongoing* (<15 years).
- *Innovative* (few or no implementations).

4.1.2.2. Availability. The *Availability* criterion defines the convenience of implementing the financial instrument and the readiness of funding. The proposal may range from a need to reform the international monetary system, which would entail protracted negotiations, to voluntary mechanisms like joint implementation, charity lotteries, or voluntary offsets, that may need only the consent of a few parties to get them started (Gutman and Davidson, 2007).

4.1.2.3. Approval. The *Approval* criterion describes who will approve funding for nature conservation projects, programmes and activities. There are two main ways in which decisions related to the approval of funding can be made. Decision-making can either be centralised, under a national or international governing body; or decentralised, whereby individual donors or recipients make decisions on how finance is used (Parker et al., 2012).

4.1.3. The economic principles underpinning the EPM

4.1.3.1. Economic Theory. The *Economic Theory* criterion focuses on the alleged main advantages of market-based instruments: (1) improved resource allocation (cost-effectiveness rationale), (2) provision of incentives to orientate agents towards pro-environmental behaviours, and (3) creation of new or innovative sources of funding (Pirard and Lapeyre, 2014). Improved allocation of resources (1) occurs when firms equalise their marginal costs of pollution abatement by reacting to market signals (Perman et al., 2003). Since marginal costs are not explicit, market forces can reveal them, moving the focus from the individual to the aggregate cost functions (Baumol and Oates, 1988). Incentives (2) may lead to positive environmental behaviour, particularly in the presence of political instability or social constraints (Ferraro et al., 2005). Finally, market-based instruments can generate new sources of funding (3) by fixing a price for nature and fostering the establishment of ownership rights (Beder, 2001; NatureVest and EKO, 2014). Besides the conventional supposed benefits of markets, other theoretical frameworks have explained the economic theory underpinning EPMs from a different perspective. Ostrom's Institutional Analysis and Development (IAD), which looks at the institutional arrangements enabling the policy design and the "rules-in-use" that influence it, is a case in point (Ostrom, 2005; Barton et al., 2017).

4.1.3.2. Category of market-based instruments (MBIs). The *Category of MBIs* criterion is inspired by the work of Pirard (2012) and Pirard and Lapeyre (2014). The authors have tried to answer the classification

Table 3
Classification of MBIs. The first six categories are from Pirard (2012).

Category	Definition
Direct Markets	The environmental good is directly traded in a market environment, in which the approximation to an optimal market functioning depends on the degree of commodification and the assessment of property rights.
Tradable Permits	An ad hoc market is established to allow the trading of "permits" representing a specific use of a specific natural resource (in negative terms, this "permit to use" translates into a "permit to pollute"). Artificial scarcity is created by further exchange among agents participating in the market.
Reverse Auctions	The owner of a natural resource (most of the time a public authority) launches a tender for the provision of certain environmental services. The instrument is meant to be set at the lowest price offered by candidates. It is intended to reveal prices and avoid free-riding.
Coasean-type Agreements	A contractual transaction – often happening on a bilateral basis – that fixes the price in response to a common interest of the beneficiary and the provider, therefore avoiding markets. It is ideally a spontaneous transaction free of public intervention.
Regulatory Price Agreements	A pricing mechanism that leads to a modification of prices according to regulatory principles. It is based on existing markets under direct public influence.
Voluntary Price Agreements	Consists of schemes whereby environmentally driven consumers send a positive signal to producers that in turn would gain a price premium. Voluntary agreements use existing markets to identify and promote virtuous activities.
Financial Facilities	Includes instruments intended either to provide liquidity specifically for other economic mechanisms for environmental stewardship or to generate funding from adjustments in financial markets through fiscal policy and taxation.

problem, by dividing MBIs into six groups, as reported in Table 3. The classification of the instruments is based on the "intrinsic economic characteristics and the nature of their relations to markets" (Pirard, 2012, p. 64). We argue that this classification, despite proving to be an extremely valuable tool of analysis in the realm of economics, is however not enough to embrace the totality of EPMs. In our opinion, one particular relation to market principles could be added to the classification, i.e. finance. We therefore added the category called *financial facilities*. This new cluster is meant to comprehend all those economic mechanisms intended either to provide liquidity specifically for other instruments or to generate funding from adjustments in financial markets through fiscal policy and taxation.

4.1.3.3. Relation to markets. The *Relation to Markets* criterion defines the relationship with the market, industry or sector from which finance is raised (Parker et al., 2012). Invested capital could come from direct market mechanisms that create a link between the beneficiaries of ecosystem services and the providers of those services. For example, an offset market links degraders of ecosystems with protectors of other natural habitats. Alternatively, indirect market mechanisms could raise finance by implicitly linking the value of ecosystem services to more traditional markets, creating indirect markets for them (e.g. price premium). Lastly, some non-marketable sources could also generate funding without being grounded in markets (e.g. royalties for extraction of natural resources), or from a combination of commercial, public, and philanthropic sources (Rode et al., 2019).

4.1.3.4. Economic value. The *Economic Value* criterion defines the composition of the total economic value. It also illustrates the relation of the instrument with the natural resource (Plottu and Plottu, 2006), as in Fig. 2.

4.1.3.5. Payer. The *Payer* criterion indicates whether financing is generated from the beneficiary of ecosystem services or from the polluter that degrades them (Parker et al., 2012). Instruments that impose a payment on the polluter follow the "polluter pays principle". Traditionally, this happens according to some form of governmental or international regulation. Many innovative financing options are now emerging, however, that fall under voluntary arrangements driven either by increased consumer awareness, corporate social responsibility or risk mitigation strategies.

Alternatively, policy instruments following the criterion of "beneficiary-pays" are those in which revenue is generated from the beneficiary of ecosystem services. Examples of beneficiary-pays mechanisms are direct ecosystem services fees, such as global arrangements in which rich countries pay poorer ones to undertake conservation actions (Perman et al., 2003). Some instruments can raise finance indiscriminately from polluters and beneficiaries. For example, a financial transaction tax would raise finance from any financial transaction irrespective of the motivation behind it.

4.1.4. Financial characteristics

4.1.4.1. Source. The *Source* criterion describes a spectrum ranging from exogenous to endogenous sources of funding (Emerton et al., 2006; Anyango-van Zwieten, 2021). It is composed of external funding, which implies attracting and managing funds (e.g. donations and grants); market price techniques, usually based on a premium price on goods and services (e.g. resource-use fees); and self-generation of funding by internal sources (e.g. investment and enterprise funds).

4.1.4.2. Currency. The *Currency* criterion assesses whether the currency in which the invested capital is denominated and the natural resource respond to the same political, economic and legal authority. Depending on whether there is a direct linkage with a national monetary authority, monetary policies can be adopted in favour of nature conservation. Otherwise, this option needs to be discarded. Also, having a higher degree of exposure to exogenous variables, fluctuations in foreign markets may have a crucial role in determining the impact of the project. The closest the link between the natural resource and the currency (e.g. a local complementary currency in a National Park), the higher the impact that monetary policy measures have on natural resource conservation (Fonseca et al., 2019). The ability to mobilise public investments for conservation activities is indeed strictly related to financial conditions. For instance, Noy (2009) demonstrate that high reserves of foreign currency, and high levels of domestic credit, enhance the exposure of domestic markets to adverse effects due to natural disasters.

4.1.4.3. Investment spectrum. The *Investment Spectrum* criterion defines the kind of interests and motivations driving the investment. The question can be addressed by following a standard investment spectrum typology as suggested, among others, by Bridges Ventures (in UN Global Compact et al., 2015). The typology goes from investments oriented towards financial gains, defined as business-as-usual, to screening, ESG standards, themed, and impact-oriented investments. At the opposite extreme of the typology are philanthropic grants, for which the only objective is the socio-ecological impact regardless of the financial gain.

4.2. Refined framework

During the structured interview, the interviewees ranked the criteria presented in Table 1 using the method of semi-open card sorting, as explained in section 3.2. Table 4 shows the ranking of the criteria, ordered by average positioning.

As revealed by the rank-based non-parametric method of ranks conducted on our sample as (see section 3.2), this ranking of criteria according to the preferences expressed by our interviewees gives meaningful information concerning the most relevant criteria. This is shown in Table 5. The diversity of the responses provided in the structured interviews, especially in the open-ended questions, indicates that Environmental Policy Mixes may be approached from different angles. In terms of ranking, there is nevertheless a general homogeneity in the way business practitioners and academics have ordered most of the criteria, with some notable exceptions. For instance, in the case of *Activity* and *Category of MBIs* business practitioners have ranked them on average at least 4 positions higher than academics. On the contrary, *Economic Value* and *Payer* are more relevant according to academics than to business practitioners, ranking on average at least 4.5 positions

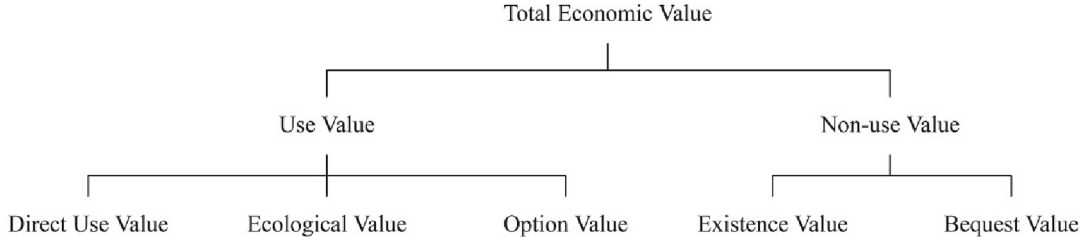


Fig. 2. Composition of the Total Economic Value (Plottu and Plottu, 2006).

Table 4
Ranking of criteria from interviews with experts in the field. The values have been assigned from 1 (=most important) to 14 (=least important).

	Business A	Business B	Business C	Academic A	Academic B	Academic C
NATURE	1	2	6	6	1	12
ACTIVITY	7	1	7	2	5	10
OWNERSHIP	4	3	5	5	4	2
TIME	14	5	13	8	7	1
AVAILABILITY	6	4	12	7	12	4
APPROVAL	9	9	3	9	6	6
ECONOMIC THEORY	13	10	10	11	10	11
CATEGORY OF MBI	12	8	2	4	11	5
RELATION TO MARKETS	11	12	1	10	8	3
ECONOMIC VALUE	2	13	14	1	3	7
PAYER	3	7	9	12	2	9
SOURCE	8	11	4	3	9	8
CURRENCY	5	14	8	13	14	14
INVESTMENT SPECTRUM	10	6	11	14	13	13

Table 5
The final ranking of criteria, based on the average preferences from the interviews (category N = Natural Resource, P = Planning, E = Economics, F = Finance).

	Criteria	Category	Average	Median	Std Dev
1	OWNERSHIP	NR	3.8	4.0	1.1
2	NATURE	NR	4.7	4.0	3.9
3	ACTIVITY	NR	5.3	6.0	3.1
4	ECONOMIC VALUE	E	6.7	5.0	5.2
5	CATEGORY OF MBIs	E	7.0	6.5	3.7
6	APPROVAL	P	7.0	7.5	2.2
7	PAYER	E	7.0	8.0	3.5
8	SOURCE	F	7.2	8.0	2.8
9	AVAILABILITY	P	7.5	6.5	3.4
10	RELATION TO MARKETS	E	7.5	9.0	4.1
11	TIME	P	8.0	7.5	4.5
12	ECONOMIC THEORY	E	10.8	10.5	1.1
13	INVESTMENT SPECTRUM	F	11.2	12	2.7
14	CURRENCY	F	11.3	13.5	3.5

higher.

The most relevant criterion is *Ownership* (avg = 3.8). Moreover, all the first positions are occupied by criteria from the Natural Resource (NR) group. The Economics (E) and Planning (P) groups share a similar relevance according to our interviewees, while criteria from the Finance (F) group close the ranking; the least relevant being *Currency* (avg = 11.3; median = 13.5). Nonetheless, the ranking above is solely based on the criteria and thematic groups that we proposed from the literature review. Therefore, a low score in the ranking could also signify that the description of the criterion should be modified or, concerning the four groups, that there may be some criteria missing. Consequently, the results shown in Table 4 and Table 5 have been complemented with qualitative open-ended answers collected during the interviews.

For instance, *business A* and *B* noted that *Economic Value* is not strictly falling only under the Economics category. Indeed, it expresses the relation of the instrument with the natural resource underpinning it, therefore it should be considered in between these two categories. *Academic B* considers that a new category, "Agency", could be added to the framework, or at least it should be considered as a cross-cutting theme for the other categories as well. *Academic C* believes that the Planning category could be better explained as "Practicalities". Far from reducing its importance, practical matters related to project management are often critical to the success of the investment. Besides these comments, overall business practitioners and academics agree with the thematic groups proposed in the original version of the EPM framework, as in Table 1.

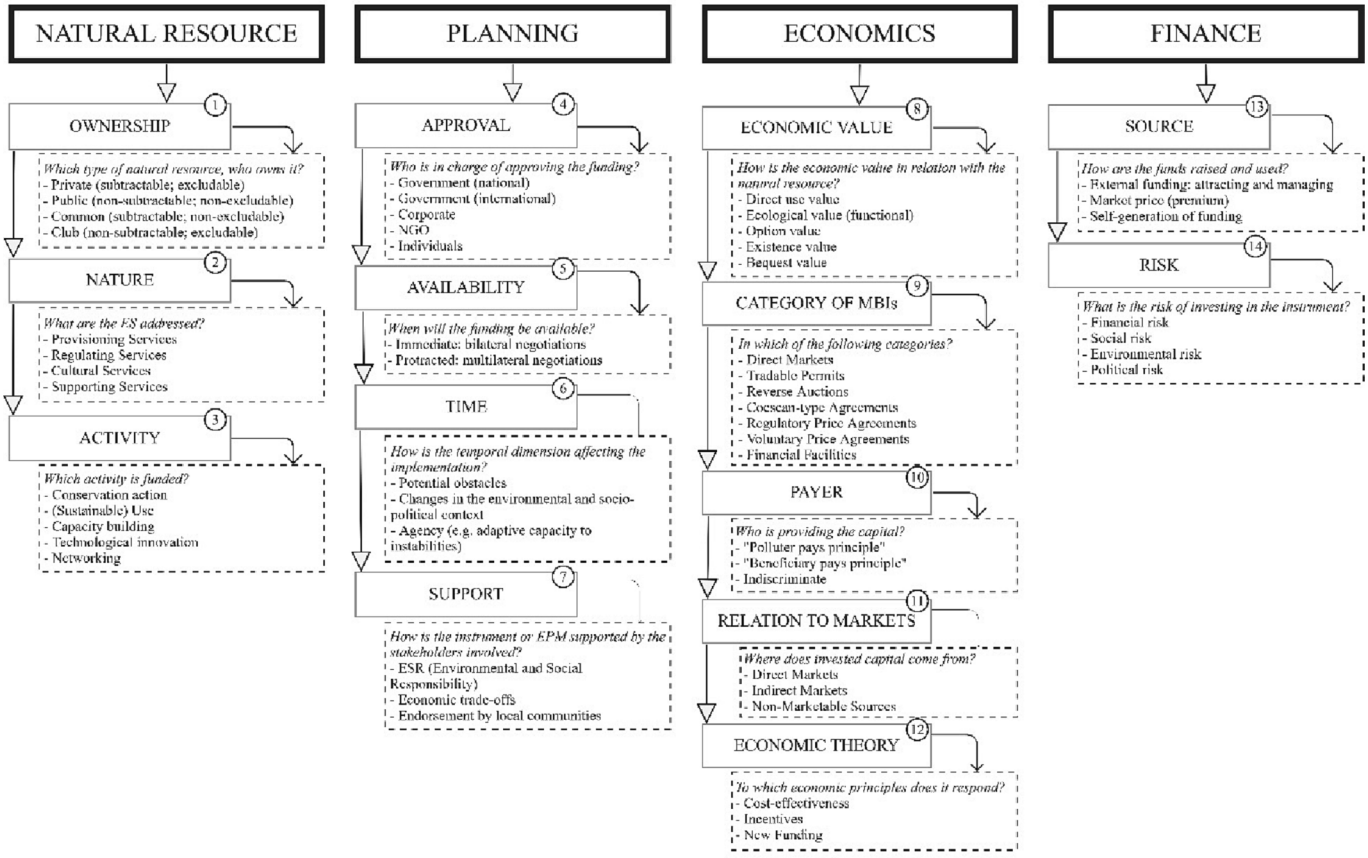
Next, our respondents had the opportunity to suggest modifications to the list of criteria. As to the *Payer* criterion, *business A* recommends that besides focusing on the dichotomy pollutant/beneficiary, the criterion should also provide options to address whether the payer is a public or a private institution. Another suggestion from *business A* is to update *Investment Spectrum* to a slightly different, but more comprehensive, categorisation published by Eurosif (2014). Moreover, *business B* suggests that *Category of MBIs* and *Relation to Markets* should be grouped in the same criteria. A similar comment is given by *academic C* about *Economic Theory*, because "it is misleading" (i.e. it does not actually refer to academic discussions or schools of thought) and perhaps should be merged with *Relation to Markets*.

Academic A and *C* consider *Time* to be a fundamental dimension underpinning all the rest of the criteria. However, they both notice that the time frame is not properly addressed in the literature and the framework presented in this paper. In fact, according to *academic A*, *Time* should address not only the seniority of the instrument but also the fluctuations, instabilities and potential changes that could happen during the lifespan of the investment. Otherwise, taking a "timeless" approach towards nature conservation would imply assuming that the key characteristics of the system will not change during the investment period.

Lastly, the interview ended by giving the possibility to introduce additional criteria or remove existing ones. Overall, most of the suggestions for additional criteria fall into the *Finance* category. *Business A* and *C*, and *academic C* suggest that more attention should be paid to the financial structure of the investment. According to *business A*, this means considering "the different types of impact measurement (from no measurement to in-depth measurement with value estimation)". *Business C* believes it can also address the agreements underpinning the financing of the project, and its composition – e.g., "are we talking about equity or debt?" As for *academic C*, it means to secure continuity of funding, since often the issue is not funding itself, but rather keeping a stable in-flow over time to build conservation strategies – "to avoid shocks, it is preferable to have less but more reliable funding".

Additionally, *business C* and *academic C* suggest adding a new criterion to the Finance category: *"Risk"*. On the founder's side, the *Risk* criterion may assess the probability of losing the invested capital. On the beneficiary side, often projects involve other forms of capital (e.g. human, natural or social capital) that may be lost in case the risk of funding is not correctly addressed. *Business C* stresses the fact that risk is not simply financial, but the social part of the investment is also crucial. In line with these comments, and considering the importance of endorsement by all the stakeholders, *academic C* proposes another criterion called *Support*. The socio-political context is a relevant additional criterion also for *academic B*, both to anticipate structural changes and recognise what is valued in society. The need for a criterion to consider the socio-ecological context of implementation is supported also by *academic A*, who suggests that this criterion could be called *Climate Change*. To conclude, *Business B* believes that *Source* is not relevant and should be removed from the list.

The feedback from the specialists we interviewed has been incorporated into the refined version of the EPM framework presented in



Ranking from interviews with experts in the field: (i) ownership, (ii) nature, (iii) activity, (iv) economic value, (v) category of MBIs, (vi) approval, (vii) payer, (viii) source, (ix) availability, (x) relation to markets, (xi) time (new criterion: "time"), (xii) economic theory, (xiii) investment spectrum (new criterion: "risk"), (xiv) currency (new criterion: "support").

Fig. 3. The final version of the EPM framework, complemented with insights from experts in the field.

Fig. 3. Some deficiencies were noticed in the Finance group. Based on these suggestions, we included two supplementary criteria – *Risk* (Finance category) and *Support* (Planning category) – as shown in Fig. 3. Instead of being added to the list, we substituted these two criteria for the two least preferred criteria: *Investment Spectrum* and *Currency*. Additionally, according to our interviewees, the *Time* criterion should be carefully reframed to include also the potential obstacles arising from changes in the environmental, social, and political context in which EPMs are implemented. In this criterion, we now also consider how the temporal dimension is affecting the implementation of the instrument. An essential component of the new *Time* criterion is the agency perspective, as "the story, conflict, power, policy learning and adaptive capacity" of agents (Driessen et al., 2012, p. 157).

5. Discussion: Working with the EPM framework

In this section, we provide two examples of practical applications of the EPM framework presented in Fig. 3. These illustrations show how to design and discuss environmental policy mixes for different policy targets. Our first case study, in section 5.1, looks at how to prevent (further) ecosystem degradation due to economic pressure in the protected area and UNESCO World Heritage site of the Wadden Sea Region. We then consider in section 5.2 a more general and broad-ranging case, in which we discuss how to align the COVID-19 stimulus packages with the objectives of the UN Decade on Ecosystem Restoration. In the following two illustrations, we use a tailored and shorter version of the EPM framework. For reasons of space, only a few criteria (one for each of the four categories) have been selected for each example, based on the most prominent ones for each case study. Moreover, we integrate the discussions on the EPM framework with instruments from the policy database that is provided as an annexe to this manuscript. Each environmental policy instrument is identified with a number (preceded by a #) as noted in the database. Fig. 4 and Fig. 5 summarise the potential policy mixes suggested for each case study.

5.1. Trade-offs in the Dutch Wadden sea

For the first case study we look at the tensions between alternative development scenarios in the Wadden Sea coastal region, which is the largest unbroken system of intertidal sand bodies in the world. In the Dutch Wadden Sea, there is a conflict between the "mere space" attractiveness related to industrial development in the region, and the "touristic space" to conserve natural areas for tourist purposes (Sijtsma et al., 2012, p. 146). In such a scenario, in which industrial development (e.g. wind farms and power plants) seems to prevail in terms of economic competitiveness (e.g. jobs) and bargaining power, policymakers could explore alternative policy measures and governance structures that consider the existence value and place attachment to the natural area (Ramirez Aranda and Vezzoni, 2022), for example harnessing the potential of ecotourism. Turning now to the EPM framework, *ecotourism price premium* (#118) is characterised as a conservation action (criterion number 3 in Fig. 3); which carries a trade-off between scenery conservation and industrial development and needs to be supported by relevant stakeholders (criterion 7); implying a non-use value of the resource (criterion 8); and which needs to raise funds through resource-use fees in established markets (criterion 13). This simplified characterisation is shown in Fig. 4.

Number	Policy Instrument	Brief Description

(*continued on next page*)

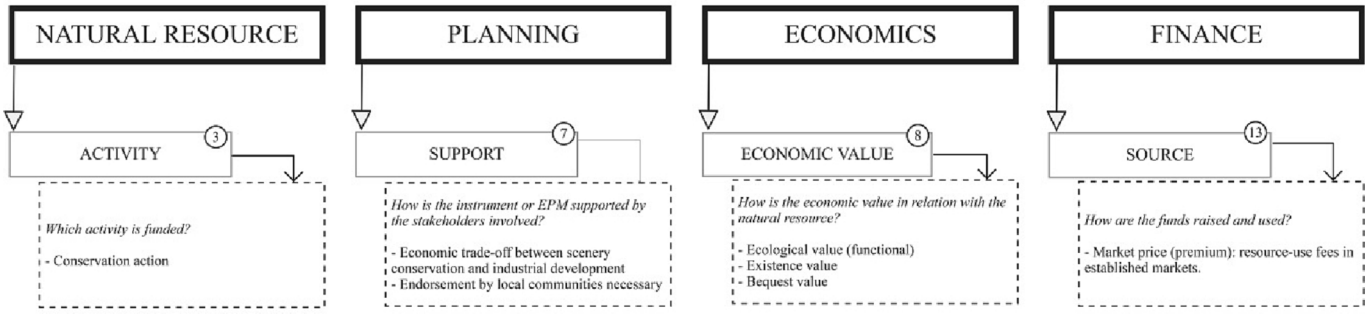


Fig. 4. The characterisation of "ecotourism price premium" applied to the Wadden area case study as suggested by the final version of the EPM framework (Fig. 3). In the top part of the figure, four criteria are selected, one for each category, with appropriate answers for the questions addressed by each criterion. The bottom of the figure shows a possible environmental policy mix for the case study of the Wadden coastal region of the Netherlands.

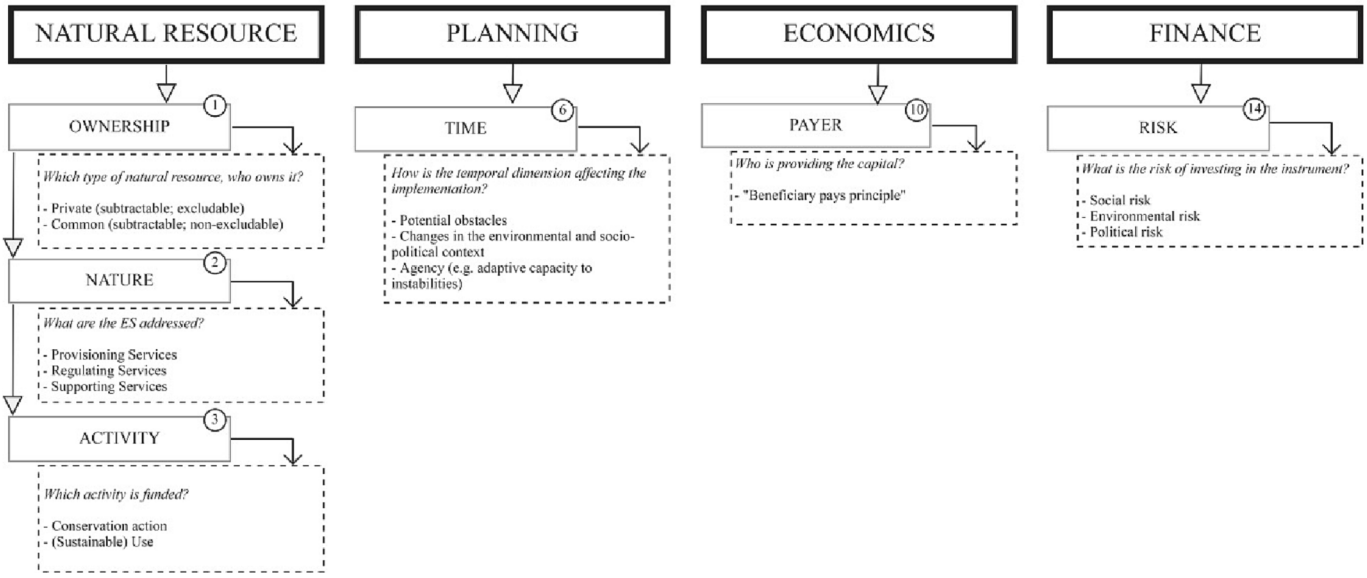


Fig. 5. Comparative analysis of green stimulus policies as suggested by the final version of the EPM framework (Fig. 3). In the top part of the figure, six criteria are selected, with appropriate answers for the questions addressed by each criterion. The bottom of the figure shows a possible environmental policy mix for aligning COVID-19 recovery packages with the UN Decade on Ecosystem Restoration.

(*continued*)

Number	Policy Instrument	Brief Description
#118	Ecotourism price premium	An additional sum is applied to the price of eco-tourism activities.
#7	One-off ecological offsets	An autonomous offsetting by the developer/ polluter.
#121	Biodiversity offsets	Companies whose activities damage biodiversity invest in biodiversity conservation elsewhere to balance or compensate for damage.
#124	Environmental credit	Preferential loans for activities with positive environmental outcomes.
#102	Eco-securitization	A securitisation process in which the financial flow is directly provided by the sustainable exploitation of a natural resource.

In the Wadden case study, the development of industry, such as wind power plants, is threatening nature protection. There is a clear trade-off between the two. In case the objective of the policymaker was to provide a substitute scenario of economic development, alternatives can be explored to test the potential of *ecotourism price premium* (#118). Otherwise, if the focus is not to prevent industrial expansion (which provides additional jobs for the area) but to compensate for nature degradation, our framework suggests a different approach. Other types of compensatory EPMs should be considered, such as *one-off ecological offsets* (#7) or *biodiversity offsets* (#121), perhaps complemented with financial facilities instruments, such as *environmental credit* (#124) or *eco-securitization* (#102).

5.2. COVID-19 recovery packages for the UN Decade on ecosystem restoration

Our second illustration demonstrates how to use the framework as a comparative tool to analyse the impact of governments' response to the COVID-19 crisis on the UN Decade on Ecosystem Restoration (UN, 2021). First, we draw on three studies – presented in Table 6 (Engström et al., 2020; Hepburn et al., 2020; O'Callaghan and Murdock, 2021) – which identify priority areas that could potentially yield the highest "double-dividend": i.e., stimulate the economy while tackling environmental degradation. Of these five policy items, number 4, which broadly represents investments in ecosystems, is particularly relevant for the 2020–2030 UN Decade.

In COVID-19 recovery discussions, ecosystems regeneration often takes the form of labour-intensive landscape management (Engström et al., 2020; Hepburn et al., 2020; O'Callaghan and Murdock, 2021), such as alternative usage of forests (*non-timber forest products*, #12). These activities require restricted access to the flow of services of a certain natural area, thus making it subtractable to alternative uses. Criterion 1 (see Fig. 5) suggests that the focus on public-common and/or

Table 6
Comparative summary of the conclusions reached by three independent studies on the most promising environmental policies for COVID-19 recovery plans.

	O'Callaghan and Murdock (2021)	Hepburn et al. (2020)	Engström et al. (2020)
1	Renewable energy	Clean physical infrastructure (e.g. to electrify the energy sector and build capacity storage)	Tax reform: carbon taxes, abolition of fossil fuel subsidies, tighter emission caps. Complemented with labour tax reduction.
2	R&D in green tech	R&D (especially for clean energy)	Clean tech R&D
3	Energy efficiency (e.g. retrofits)	Building efficiency retrofits	Small-scale infrastructure projects (e.g. retrofitting and domestic solar panels)
4	Investment in natural capital	Ecosystem resilience and regeneration (e.g. sustainable agriculture, habitat restoration)	Afforestation activities and other labour-intensive investments into natural capital
5	Sustainable transport	Education and re-training (e.g. workers from carbon-intensive to new economic sectors)	Infrastructure investments to promote active modes of transportation by discouraging cars.

public-private partnerships is justified when ownership arrangements are essentially "substractable" (Ostrom, 2005), such as common and private property of forests. Green fiscal measures should also consider the type of ecosystem services (criterion 2) as well as the activity addressed (criterion 3). For example, *agroecological schemes* (#93) and *mitigation banking for habitats* and biodiversity (#114) can sustain provisioning (e.g. food), regulating (e.g. water cycle) and supporting (e.g. soil formation) services and assure sustainable access to the natural system in the long term. Additionally, timing (criterion 6) is crucial in the recovery from the COVID-19 crisis and for limiting the already accruing consequences of ecosystem destruction. Given the current socio-political circumstances, the growing support for new environmental measures could be used to push for contentious policies, such as a *carbon tax* (#18). This should be done considering the historical struggles, power dynamics and adaptive capacity of citizens to support or oppose the policy measure (Driessen et al., 2012). The planning of the recovery packages must consider the configuration of socio-environmental-political risks which may threaten the efficacy of the measure (criterion 14). For instance, support for *community-based conservation* (#141) activities can reinforce the legitimacy of the EPM. These capital investments in ecosystems could come from public sources, or through the mobilisation of private funding compensating for direct benefits ("beneficiary pays principle", criterion 10). All in all, aligning the recovery from the COVID-19 crisis to the 2020–2030 UN agenda will require a strong focus on the context of implementation, which can be guided by our EPM framework.

Number	Policy Instrument	Brief Description
#12	Non-timber forest products	Trade of natural products other than wood derived from forests or wooded land.
#93	Agroecological schemes	The term broadly describes regulatory support for environmentally sound and regenerative agricultural practices.
#114	Mitigation banking for habitats	A natural area in which ecosystemic functions have been restored or generally enhanced in a significant and measurable manner to provide compensatory mitigation for future impacts.
#18	Carbon tax	A carbon tax is an excise tax on the producers based on the relative carbon content of the traded goods.
#141	Community-based conservation	Active involvement of local communities in conservation efforts that may directly affect them.

6. Conclusions

The Environmental Policy Mix (EPM) framework presented in this paper can support future data collection activities, assessment, and design of EPMs. The framework can facilitate policy discussions and guide decision-makers in the design of policy mixes for different environmental targets. Moreover, the framework's applicability is highly context-dependent, as illustrated in section 5. We stress the significance of the context and the researcher's subjectivity in deciding which analytical characteristics – e.g., *natural resource*, *planning*, *economics*, or *finance* – are to be prioritised.

Our study has been conducted under the "ecosystem services" paradigm. We thus took for granted questions of power, institutional relations, and political change (Fletcher and Büscher, 2017). Other studies may find these variables relevant and try to include them in the EPM framework, propose alternatives to it, or criticise it from different standpoints. The competitive principle on which market functioning is based could, for instance, be challenged by environmental policy based on notions of cooperation and reciprocity (Singh, 2015). Likewise, the institutional approach proposed by Barton et al. (2017) suggests that EPMs can be analysed based on their functional characteristics and potential interactions, as well as on their governance structures.

The 2020s are going to be a critical decade for reaching the environmental sustainability targets set by the international community. These efforts are exemplified by the recently launched UN Decade on Ecosystem Restoration, which overlaps also with commitments to curbing biodiversity loss (CBD and IUCN), halting climate change (UNFCCC) and building a more ecologically viable society after the economic destruction caused by the COVID-19 pandemic. Likewise, several scholars are highlighting the importance of complexifying environmental policy and moving beyond growth-centred accounting metrics (Menton et al. 2020; Hickel et al. 2021; Vezzoni, 2023). These multiple planetary goals are unlikely to be effectively addressed by individual instruments. We echo Banerjee and co-authors (2020), as well as Gardner and co-authors (2021), in saying that science and academics need to improve and broaden their array of analytical tools to assist and inform this transformative process. The EPM framework goes in this direction. In this paper, we have proposed a first version of it, backing it up with a database of 146 policy instruments (see annexe). We encourage further research along these lines, for advancing and perfecting environmental policy in the 2020s and beyond.

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.

Data availability

Data will be provided in a separate repository. It will also be submitted to Data in Brief.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecoser.2023.101541.

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