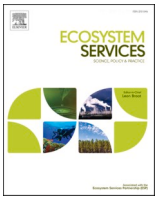
Ecosystem Services 60 (2023) 101516

Contents lists available at ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser



Full Length Article

Integrating payment for ecosystem services in protected areas governance: The case of the Po Delta Park

M. Gaglio [a], M. Lanzoni [a,*], F. Goggi [b], E.A. Fano [c], G. Castaldelli [a]

[a] Department of Environmental and Prevention Sciences, University of Ferrara, Via L. Borsari 46, 44121 Ferrara, Italy
[b] Ente di Gestione per i Parchi e la Biodiversità - Delta del Po, C.so Mazzini, 200, 44022 Comacchio, Italy
[c] Department of Life Sciences and Biotechnology, University of Ferrara. Via L. Borsari 46, 44121 Ferrara, Italy

ARTICLE INFO

Keywords:
River delta
Biodiversity conservation
Coastal wetlands
Green economy
PES
Protected areas

ABSTRACT

The effective inclusion of Ecosystem Services (ES) in the governance of Protected Areas (PAs) is a key challenge for future environmental governance. In this sense, Payments for Ecosystem Services (PES) have been conceived as instruments to internalize costs of environmental management and establish a consequential link between ES users and providers. Thus, while there is a current pressingly need for genuine PES mechanisms, in very rare cases it has been possible to satisfy this requirement. This paves the way for the study of alternative methods, such as PES-like schemes, which may be already in practice in PAs.

In order to support and discuss the feasibility of this approach, we present four successful PES-like schemes currently working in the Po River delta Park of the Emilia-Romagna region (Northern Italy). They involve traditional activities, as hunting, fishing, mushroom and truffle (M&T) picking and cultural services, coherent with the UNESCO Man and Biosphere declaration.

With the aim of using the peculiar case of the Po Delta Park as a study model, we studied services with direct market value that cover a variety of strategy cases and positive side effects typically observed in genuine PES schemes. The Park authority is a crucial actor with different roles: i) regulator/intermediator in the context of a "command" strategy (for hunting and M&T) and in a public–private partnership (for cultural services) and ii) provider in a trade context (for fishing).

Although not originally conceived under the vision of an ES approach, these practices, developed as endogenous processes, were effective in supporting conservation and ES provision. While not accounting for regulating services, PES-like schemes constitute practical evidence of broad interest concerning the role of existing, yet overlooked, mechanisms involving important ES, which could be reframed within the terminology of PES to strengthen their functioning and strategic value.

1. Introduction

Despite the growing efforts for environmental conservation spent during the last decades, anthropogenic pressures continued to cause the dramatic degradation of ecosystems and their services worldwide (Millennium Ecosystem Assessment, 2005). The critical state of ecosystems urgently calls for environmental policy measures that achieve multiple targets in the fields of nature conservation and economic development, in the light of the sustainable development goals foreseen by the Agenda 2030. The establishment of Protected Areas (PAs) was the most common measure of environmental conservation adopted during last century. Originally conceived to safeguard landscapes and wildlife, PAs have been gradually required to reach an increasing set of conservation, social and economic objectives (Watson et al., 2014). During the last two decades, environmental managers focused with growing emphasis on the functional role of ecosystems in maintaining and promoting society well-being, as fundamental assets for human prosperity (Costanza et al., 2014, 1997; Wang et al., 2021). Together with the transformation of the conservation approach, the international regulatory framework increasingly promoted the inclusion of Ecosystem Service (ES) concept within conservation policies. In particular, due to the adoption of Aichi targets of the Convention on Biological Diversity for 2011–2020 by the International Union for Conservation of Nature (IUCN) and the World Commission on Protected Areas (WCPA), the

* Corresponding author.
E-mail address: mattia.lanzoni@unife.it (M. Lanzoni).

https://doi.org/10.1016/j.ecoser.2023.101516
Received 1 August 2022; Received in revised form 10 January 2023; Accepted 21 January 2023
Available online 27 January 2023

goals of PAs have been explicitly expanded to maintain and restore ESs (Woodley et al., 2012). Later, at European level the EU biodiversity strategy for 2030 (European Commission, 2020) renewed the need for the conservation of biodiversity and halting the degradation of ESs, while aiming to expand PAs to 30 % of the EU's land and sea. Therefore, the evolution of nature paradigm required the switch on PAs vision from passive conservation instruments to active providers of ESs in a wider social-ecological system perspective (Watson et al., 2014). In terms of management strategies, this shift calls for conserving ecological functions in space and time, in addition to protect habitat and species in face of an increasing number of stressors. However, besides to conserve natural assets, an ES approach requires PAs to consider also socio-economic systems in order to capture the contribution of ecosystems for human well-being. In fact, according to the so-called "ES cascade model", ecosystem structures and processes underpin ecological functions that, in turn, deliver ESs only when meet the human demand for a benefit (Potschin and Haines-Young, 2011). The actual level of use of an ES represents the ES flow (Burkhard and Maes, 2017). In other words, an ES flow occurs when a human need intercepts a potential ES supply by an ecosystem. Unfortunately, PAs were often observed to be not effective in maintaining ES flows, either by failing to defend biodiversity (Jones et al., 2018) and/or by omitting to consider many ESs of great social and economic importance (Gaglio et al., 2019), as well as their respective drivers of change acting at wider scales (Gaglio et al., 2020). For instance, Li et al. (2020) observed notable conservation gaps for biodiversity and ESs in existing nature reserves of Tibetan Plateau. Wei et al. (2020) showed that PAs of East Africa well represented for species richness and regulating services but underrepresented for provisioning services. Similarly, Lecina-Diaz et al. (2019) found controversial outcomes in terms of ES preservation in Mediterranean PAs and further underlined the importance of integrating ESs and biodiversity to define effective conservation policies. Moreover, the Aichi target 11 concerning the establishment of effective and representative networks of PAs by 2020 was only partially met and human pressures continue to harm biodiversity (Visconti et al., 2019). ES framework is therefore still poorly integrated in the management PAs and solutions to implement ESs into policy and decision-making are urgently required (Schirpke et al., 2017).

As the research on the monetary value of ESs evolved, Payments for Ecosystem Services (PES) have been proposed as market-based instruments to create incentives for conservation (Sattler et al., 2013; Vatn, 2010). After the pioneering experience of Costa Rica national program in 1997, which aimed to tackle deforestation rates implementing mechanisms for the remuneration of ESs (Pagiola, 2008), a growing number of decision-makers attempted to adopt market-based instrument explicitly focused on ES monetarization at different administrative scales (Pirard and Lapeyre, 2014). A PES mechanism was firstly defined by Wunder (2005) as a "*voluntary transaction where a well-defined ES (or a land-use likely to secure that service) is being 'bought' by a (minimum one) ES buyer from a (minimum one) ES provider if and only if the ES provider secures ES provision conditionally*". Wunder's definition, based on the 'Coasean' conceptualization of markets, led to distinguish between "genuine PES" (or "true PES") and "PES-like" mechanisms (Muradian et al., 2010; Vatn, 2010). The latter include a large amount of non-ES labelled practices that do not satisfy-one of more conditions fixed by the above-mentioned definition. Although suggesting that such distinction may be problematic in practice, Muradian et al. (2010) enlarged the PES definition to include certain types of intervention by governments or public bodies, according to the 'Pigouvian' theory. Therefore, the PES domain encompasses a variety of practices and schemes that may involve multiple ES types, providers, users, regulators, the majority of which fall into the classification of PES-like mechanisms. In fact, only few schemes fulfill all the conditions fixed for genuine PES, being often not conceived within the ES framework (Sattler and Matzdorf, 2013). Thus, PES-like schemes are usually considered as simple conservation measures, omitting to valorize and properly manage important ESs, particularly in PAs.

Generally, while the discourse of the ESs delivery in PAs has gradually reaching a more mature stage in mountainous and marine environments (Rasheed, 2020; Schirpke et al., 2021), the role of environmental protection in supporting human well-being in transitional environments, and river deltas in particular, is still poorly clarified (Barbier, 2019). In fact, the knowledge of ecological processes and functions that underpin the supply of ESs in deltaic areas is often challenging, as combined and complex results of local variation patterns and regional conditions (Barbier, 2013). Such limits hinder the full implementation of ES knowledge in protected deltaic areas and consequently their involvement in PES schemes.

River deltas encompass aquatic and terrestrial ecosystems characterized by highly productive rates that generate important economic revenues (Gaglio et al., 2022, 2019; Tamburini et al., 2020). Nonetheless, the intensive exploitation of their land and biological resources may lead to losses in terms of biodiversity and ecosystem functionality, as well as to trade-offs among different uses (Gaglio et al., 2017; Yang et al., 2018). For these reasons, the role of PAs is strategical for environmental safeguard and for guarantying the provision of ESs over time in transitional zones.

The present study describes existing good practices adopted in the river Po delta Park (Northern Italy) that can be re-interpreted as PES-like mechanisms. The Park is a PA covering one of the most important transitional environments in Europe, where human activities intimately coexist with natural landscapes. Since the Park aims to conserve biodiversity in a highly anthropic, yet ecologically unique, transitional area, it represents an ideal case to study market-oriented mechanisms that harmonize environmental safeguard and local development. With the aim of using the particular case of the Po Delta Park as a study model, we studied four services with direct market value (i.e. hunting, mushroom and truffle picking, fishery, eco-tourism and education), which are involved in market-based mechanisms that represent unexplored examples of PES like schemes in a PA. The described ESs cover a variety of thematic areas, such as hydrological functioning, biological conservation and cultural uses, also characterized by positive side effects typically observed in genuine PES schemes. Such framework represents an ideal case for investigating the presence of well-established financial mechanisms, not originally conceived as ES-labelled schemes but involving relevant ES and functions. Although based on a single regional case, the present study provides practical evidences of broad interest about the role of existing mechanisms involving important ESs, and sheds the light on the general relevance of these practices, usually overlooked and not properly valued within the context and terminology of PES.

2. Material and methods

2.1. Study area

The delta of the Po river, the largest Italian river, is one the most environmentally important transitional areas in Europe. The ecosystems of the delta are currently under the protection of two different regional parks: the Veneto and the Emilia-Romagna Parks. The latter (herein the Po delta Park) roughly corresponds to the so—called "ancient delta" (i.e. part of the delta not subjected to coastal sediment delivery) and was selected as ideal case study to demonstrate the existence and effectiveness of PES-like mechanisms in a PA. The Po delta Park was established in the 1988 and covers an area of approximately 54,000 ha (Fig. 1), divided in six environmental districts. Each district is governed according to a specific territorial plan, which considers their peculiar environmental, ecological and cultural characteristics. Additionally, the territory is classified in areas with growing protection degrees: buffer zones, environmental protection zones, general protection zones and integral protection zones. This park has a very peculiar history as, since its creation, the shared goal of citizens and institutions has been to save

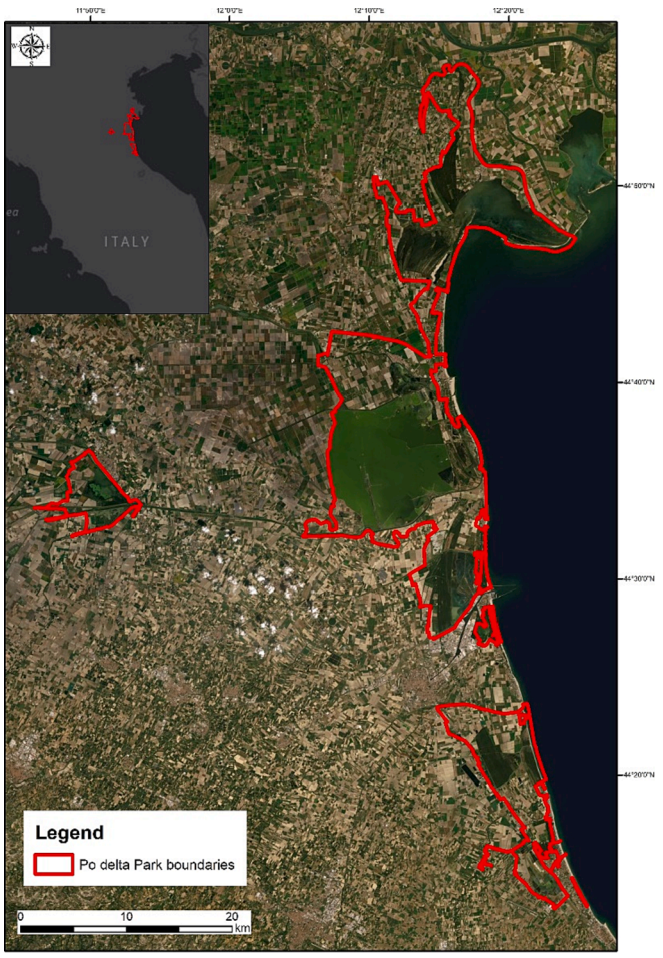


Fig. 1. Po delta Park boundaries and location in Northern Italy.

the largest coastal wetland in Italy, namely the Valli di Comacchio managed lagoon and, with it, the great historical heritage of local traditions of sustainable use of natural resources that have developed there since the late Middle Ages. One case in point is the centuries-old eel fishery that makes the Comacchio Lagoon an internationally renowned case study (Aschonitis et al., 2017). These traditional activities, such as hunting, fishing, mushroom and truffle (M&T) picking, which apparently conflict with the aims of conservation, here have found a regulation that not only coexists with, but also substantially reinforces the park's primary aims of habitat and biodiversity conservation. To them, cultural services, as eco-tourism and education, have been progressively developed in a general framework, which meet all the sustainability goals set out in the declaration for UNESCO Man and the Biosphere sites (MAB), a recognition recently obtained by the Po River Delta in 2015.

Its wetlands are the remaining heritance of an ancient water-dominated landscape that undergone important reclamation actions during last century (Cecini, 1998; Gaglio et al., 2017). Among them, Comacchio lagoon is the most extended one and includes a system of brackish water lagoons renowned worldwide for the historical tradition of extensive European eel (*Anguilla anguilla*) aquaculture (Fig. 2). Because of their unique ecological value, the ecosystems or the river Po delta Park are safeguarded by different protection measures, also including those related to the Natura 2000 network. At the same time, they are highly productive environments that support local economy by the exploitation of their biological stocks. Nonetheless, the conservation of these sensitive ecosystems requires constant human interventions to guarantee the regulation of water levels and salinity, which result in an expensive environmental management. For this reason, the Park developed endogenous financial mechanisms to partially cover the growing conservation costs. To date, being the ES approach reached a wide consensus among decision-makers, such practices could be conveniently re-interpreted within the context of PES.

2.2. PES-like mechanisms and data sources

Four PES-like schemes were identified as virtuous mechanisms currently working in the river Po delta Park, yet not conceived under an ES approach (i.e. not originally designed as PES). The four schemes are based on the following ESs: i) hunting, ii) M&T picking, iii) fishing and iv) eco-tourism and education. The analysis includes the description of scheme functioning, the identification of involved actors and positive side effects on other ESs, and the quantification of ES flows in monetary terms.

Three actors' roles were identified: providers, beneficiaries and regulators/intermediaries. Providers are defined as the owners of a resource, either a land or a biological stock; beneficiaries are individuals or communities who directly or indirectly benefit from one or more ESs delivered by providers; while regulators/intermediaries are actors who mediate between providers and beneficiaries by administering payments, monitor and/or control resource status and the ES delivery (Sattler et al., 2013).

As developed within the market context, the four considered schemes result from the match between the ES supply capacity of ecosystems and the related socio-economic demand. For this reason, their quantification was considered equivalent to ES flows in this study.

The abovementioned ESs were quantified yearly for the period 2014–2020. The latter was chosen according to the data availability for the considered ESs. Specifically, no exhaustive data were available for years before 2014, while 2021 data sources were affected by problems related to pandemic restrictions and therefore excluded by the analysis. The historical trend of ES delivery demonstrates the effects of PES-like schemes in maintaining ES flow over time. Hunting and M&T picking occur in the whole territory of the Park where these activities are not prohibited. These services were assessed by collecting data on permits and related prices. The other mechanisms involving fishing and eco-tourisms are specifically located in in two wetlands: the Comacchio lagoon and Comacchio saltwork, respectively (Fig. 2). Fishing service was evaluated considering the amount (biomass) of fishes per species sold on the market and related prices. Eco-tourism and education were respectively assessed by means of tourists and students entrances in the saltwork, and relative incomes. Data for hunting permits, M&T picking permits and fishing catches were provided by the Po delta Park offices on yearly base, while CADF *Servizio Comunicazione, Educazione e Ambiente* supplied entrance data for eco-tourism and education during the touristic season.

3. Results

The four mechanisms encompass provisioning and cultural services with direct marked values. Their functioning, the actors involved (i.e. providers, beneficiaries and regulators/intermediaries), as well as mean annual monetary flows, are summarized in Table 1. The schemes are governed according to different functioning principles. Hunting activities and M&T picking are both regulated under a command principle, based on the sale of a pre-defined number of permits and under user restrictions in space and time. Contrarily, fishing, eco-tourism and education services follow market rules.

Interestingly, the Po delta Park authority plays different roles within the mechanisms. It acts as regulator/intermediator for hunting, M&T picking and eco-tourism and education services. In particular, the Park, together with the Emilia-Romagna Region, regulates and disciplines the use of biological resources underpinning hunting and M&T picking services by the release of a restricted number of permits that are sold to the users, for which the Emilia-Romagna Region is the responsible body (i.e. the ES provider). The Park plays an intermediator role in the

Fig. 2. Comacchio lagoon,areas devoted to aquaculture (fishing) and saltwork.

Table 1
PES-like schemes considered in this study. The mean monetary flows for each schemes are intended for the period 2014–2020.

Ecosystem services	PES-like functioning	Mean monetary flows (€ yr^{-1})	Providers	Regulators/ intermediaries	Beneficiaries
Hunting	Hunters buy permits and spend time for compensation actions. Incomes are reinvested for wildlife and habitat conservation.	205,021	Regional authority	Park, Regional authority	Hunters
Mushroom & Truffle picking	Users buy permits for picking. Incomes are reinvested for habitat conservation.	9,797	Regional authority	Park, Regional authority	Pickers
Fishing	Park manages the fishing in Comacchio lagoon using traditional and extensive practices. Fish catches are sold on the market and the incomes reinvested for the lagoon management. A minor part of eel catches are directly sold to local citizens, increasing their sense of place (a side effect ES).	170,912	Park	–	Consumers, residents
Eco-tourism and education	Park grants Comacchio saltwork management to CADF that offers recreation and education experiences. Incomes are used for saltwork management. The salt produced is sold on the market (a side effect ES).	18,703	CADF	Park	Tourists, scholars, consumers

Comacchio saltwork between the CADF Company (considered as the ES provider) and users, and periodically monitors the conservation status of the area. Lastly, in the case of extensive fishery in the Comacchio lagoon, the Park is the ES provider, as fishing is carried out directly by the Park authority using ancient traditional practices. Overall, the total annual mean value of the ES involved was equal to 407,706 € yr^{-1} (472,734 US $ yr^{-1}, average exchange rate for 2014–2020: 1€ = 1.1595 US$) (Fig. 3). A general decrease of all ES monetary values was observed for 2020, due to pandemic restrictions. Detailed descriptions of each mechanism are provided in the following sections.

3.1. Hunting

The constant provision of the hunting ES requires the presence of a good number of specimens belonging to hunting species and, therefore, the conservation of their habitats in a good ecological status. In the case of the Po delta, the abundance of hunting aquatic birds (mainly ducks) depends on the ecological conditions of water bodies, such as drainage canals, lagoons and inner wetlands. The maintenance of nesting and shelter habitats (e.g. emergent vegetation) calls for the adoption of costly environmental measures within an agricultural landscape.

According to the National legislation, Regional bodies hold the normative and regulating competences in the matter of wildlife heritage.

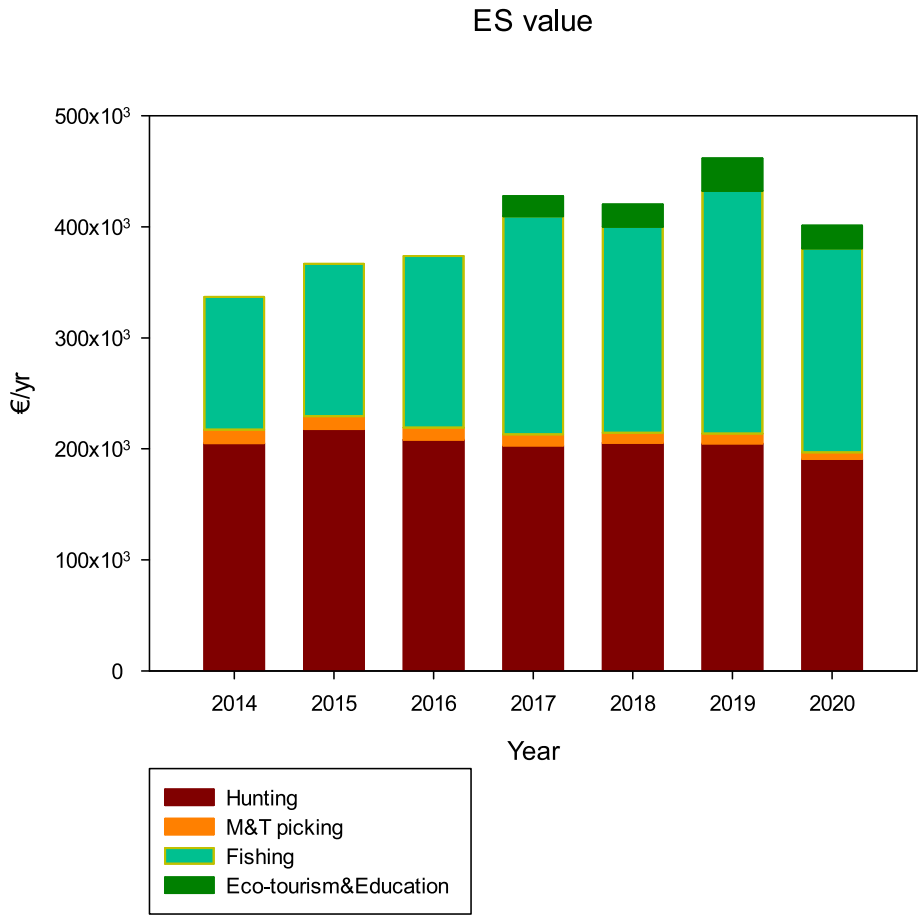


Fig. 3. Trend of annual ES values for the period 2014–2020.

For this reason, the Emilia-Romagna Region is considered both as the ES provider and regulator, together with the Park, for hunting.

Hunting activities are strictly regulated within the Park territory by a specific Regional Council Resolution, which also determinates the role of Park. Hunting is allowed only in the buffer zones of the Park, further divided in four different districts, and only to hunters with special permits (seasonal and daily permits). The Executive Board of the Park regulates the assignment of permits under a command strategy. Specifically, the number of released permits is predetermined for each district according to expert judgement based on faunal censuses, in order to maintain the hunting pressure within sustainable levels. Park manager will publish indication for demands submission each year. Moreover, the Executive Board of the Park determines further limitations and prescriptions regarding hunting pressure, periods practices, and, maintenance and compensation actions as duties for hunters. A specific article of hunting regulation document argues that the revenues derived by permits sell have to be used for the management of interested areas, including interventions for environmental conservation and restoration, prevention and control activities and farmers' compensation for wild fauna-related damages. In other words, this article establishes an intrinsic PES scheme, where the Park regulates the exploitation of a public resource on behalf of Emilia-Romagna Regional authority (i.e. providers) by hunters (i.e. users).

The mean annual incomes for the period 2014–2020 were equal to 205,021 € yr^{-1}, (237,721 US$ yr^{-1}) being the most monetary relevant among the PES-like schemes considered in the analysis. The amount of permits sold, and therefore their incomes, was maintained over time, except for a slight decrease observed for the year 2020, probably due to pandemic restrictions.

3.2. *Mushroom and truffle picking*

Being the occurrence of mushrooms and truffles associated to tree roots, their picking needs the safeguard of woodlands in good conditions, as well as to maintain their access path for fruition.

Similarly to hunting PES mechanism, M&T picking is regulated by the Park authority by means of permits release (either with daily, weekly, monthly, half-yearly and annual validity), based on a specific Regional Council Resolution. The Park authority limits the maximum number of permits (i.e. 2500 permits, regardless of their time validity), regulates picking timing and modalities and establishes no picking areas (e.g. zones "A" at integral protection and National Natural Reserves). The mean annual incomes during 2014–2020 were 9,797 yr^{-1} (11,360 US$ yr^{-1}), following a clearly declining trend from 12,112 € (1031 permits sold) in 2014 to 5,954 € in 2020 (558 permits). The trend seemed exacerbated by 2020 pandemic, when the revenues decreased from the 8872 € (812 permits) of 2019 to the 5954 € (558 permits) of 2020 (−32.9 %).

Unlike for those deriving from the sold of hunting permits, the reinvestment of picking permits revenues for environmental measures is not explicated in regulation documents. However, the Park destines such incomes to specific actions aimed to safeguard and improve the ecosystems where mushrooms and truffles are produced. The revenues were pooled together with those deriving from hunting activities and reinvested in environmental measures, as shown in Fig. 4. Details are reported in Table A1. In fact, many of the measures financed by permits incomes are beneficial for both activities, such as those for path maintenance, environmental restoration, education, monitoring and surveillance. It has to be noted that, due to the low amount of their related incomes, many activities suitable for M&T picking would not be

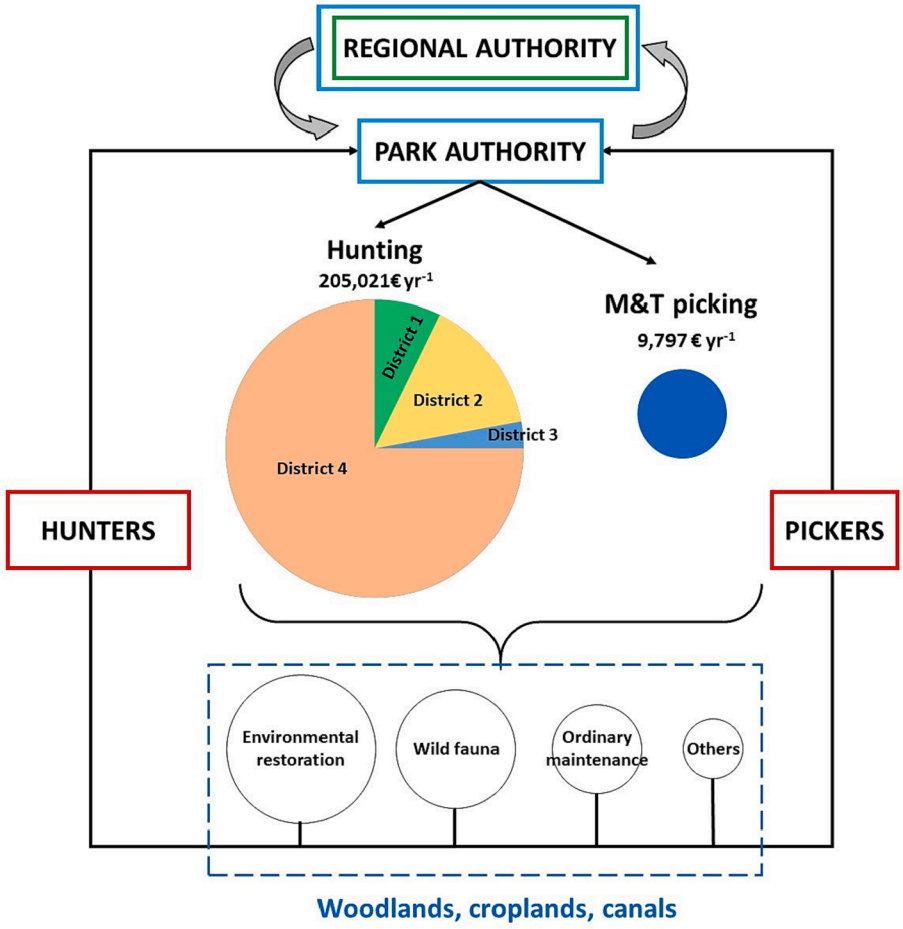


Fig. 4. PES functioning for hunting and mushroom & truffle (M&T) picking. Mean annual ES values are reported. Circle sizes are proportional to their monetary value. Red, green and blue squares respectively identify ES users, providers and regulators/intermediaries. Gray arrows denote actions taken by regulators/intermediaries. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

financed without considering their synergy with hunting.

3.3. Fishing

Fishing is a historical and economic relevant activity that supports the management of the Comacchio lagoon and constitutes an important ES for the whole river Po delta. Fishing relies on the constant availability of biological stocks over time, which, in turn, requires a sustainable exploitation that must not exceed their regeneration capacity. This is particularly evident in the case of Comacchio lagoon, where fishing depends on the conservation status of endangered species, such as European eel, and ecological conditions of a sensitive ecosystem (Aschonitis et al., 2017; Lanzoni et al., 2021). Indeed, the lagoon is connected to the sea through canals in which the water intake is artificially regulated according to environmental needs, thus allowing fish movements to and from the sea. Due to its peculiar functioning, the lagoon needs constant interventions to guarantee the hydraulic connectivity to sea that generate high maintenance costs. The fishery in Comacchio lagoon is carried out directly by the Park authority using extensive and traditional practices, i.e. by means of fishery gears named "*lavorieri*", and the catches directly sold on the local markets. The revenues are invested to finance the management of the lagoon, guaranteeing its nursery function for both commercial and protected species (Fig. 5 and details in Table A2).

This mechanism does not encompass any regulator or intermediate actor, rather the Park authority plays the role of ES provider by selling fish catches on local markets. Moreover, a minor share of European eel catches is sold directly to local citizens, thus generating an important cultural ES (i.e. heritage and identity value). In fact, eel aquaculture in Comacchio lagoon is a historical activity with high iconic value for local people, which strengthen their link with the territory. The mean annual fishing revenues for 2014–2020 were equal to 170,912 € yr^{-1} (198,172 US$ yr^{-1}) with a maximum value of 219,000 € in 2019. An increasing trend was recorded from 2014 to 2017. European eels represents the larger contributor to the total catch value, followed by anchovies, shrimps and mullets.

3.4. Ecotourism and education

Po delta wetlands, such as the case of the Comacchio saltwork, host an extraordinary biodiverse bird community, fish and plant species of conservation interest, which attract tourists for nature activities, such as birdwatching, trekking and photography, and offer opportunities for education. The abundance and presence of these species in Comacchio saltwork depend on the maintenance of adequate water and salinity levels. For instance, the Comacchio saltwork hosts the northern European community of pink flamingos (*Phoenicopterus roseus*) that appeals many tourists and schoolars. However, cultural activities require the presence of nature guides and paths, water supply and the monitor of salinity and water levels. The PES-like mechanism is based on a public–private partnership between the Park authority and a local multi-utility company, operative since 2017. The latter is a concession dealer of the Park authority, responsible for the environmental management of the saltwork, while providing guides and a range of nature

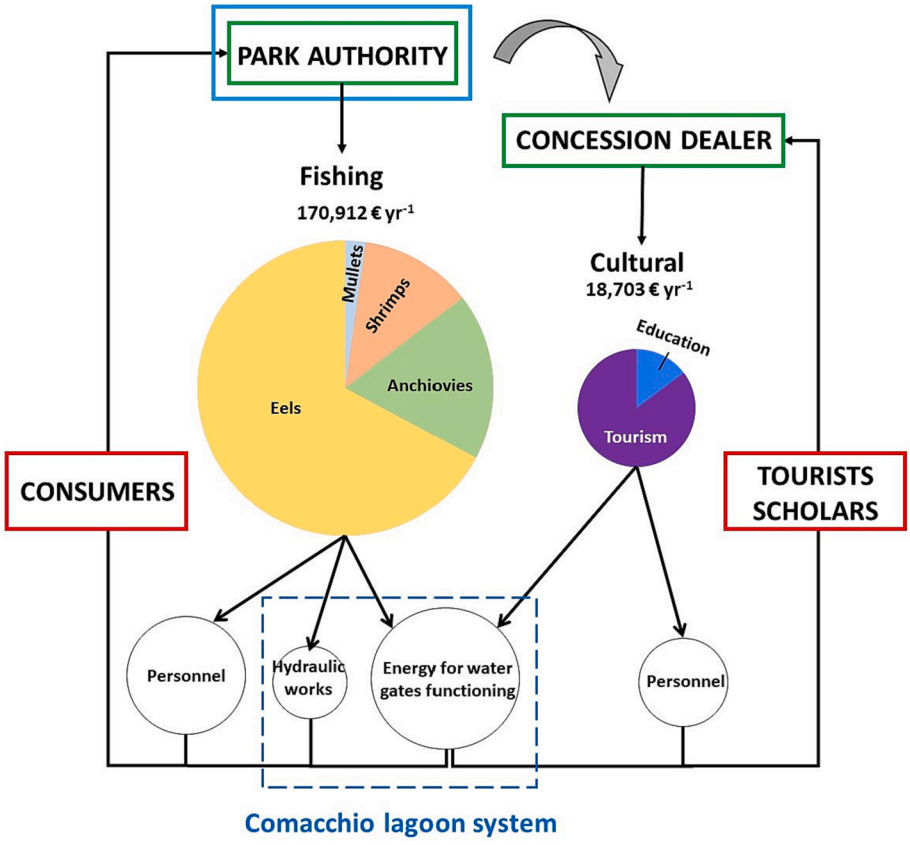


Fig. 5. PES functioning for fishing and cultural services (eco-tourism and education) in the Comacchio lagoon system. Mean annual ES values are reported. Circle sizes are proportional to their monetary value. Red, green and blue squares respectively identify ES users, providers and regulators/intermediaries. Gray arrow denotes actions taken by regulators/intermediaries. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

experiences for tourist and schools. The incomes are used to finance personnel and hydraulic management of the area. In this case, the Park can be considered as a regulator/intermediator actor that facilitates the cultural use of the saltwork and monitor the ecological status of the area, while the multi-utility is the ES provider, as suppling personnel and facilities for ecotourism and education.

The mean annual values of cultural ES in Comacchio saltwork for the period 2017–2020 were 16,224 (18,812 US$ yr^{-1}) and 2,479 € yr^{-1} (2,895 US$ yr^{-1}), for ecotourism and education, respectively. Number of yearly entrances and incomes are reported in Table A3. The effects of pandemic in 2020 reduced the number of tourist and school entrances and relative revenues, which were partially offset by the salt production restoration, representing an important "side ES" provision.

4. Discussion

4.1. PES-like importance and the role of PAs

The ES approach promises to avoid conflicts that originate when biodiversity conservation strategies do not take into account the interest of local actors (García-Llorente et al., 2018). Its implementation is therefore a challenging aspect for the sustainable development and the reach of conservation targets. Although monetary assessments are criticized for the risk of nature commodification, PES offer opportunities for active stakeholders' inclusion in nature conservation, while guarantying the delivery of ecological functions and processes to support sustainable development under the lens of ES concept.

As already existing mechanisms, the presented PES-like schemes naturally result from the match between ES supply and demand and thus overcome the difficulties related to their quantification, envisaged as one of the most challenging obstacles hindering genuine PES implementation (Schirpke et al., 2017). The four described thematic ES types demonstrate that local endogenous schemes can spontaneously arise in PAs when market dynamics intercept potential ES supply, thus providing evidences for their presence and functioning, even though missing some of the requirements of "true" PES foreseen by Wunder (2005) definition, while satisfying others. The relations between ecosystems and the ES provided, together with the adopted management measures, are clearly described. Similarly, ES users and providers (i.e. ES buyers and sellers), as well as regulators and intermediaries when present, were identified, as reported in Table 1. It worthy to be noted that conditionality occurs at different degree in the four mechanisms. It is fully satisfied in fishing and cultural services provided in the Comacchio lagoon system, where fish catches are directly sold to the market and environmental guides in the saltwork are paid only if the service is provided, while is intrinsically guaranteed in permits-based schemes. Conditionality in hunting and M&T picking works according to a feedback principle towards the provider. In fact, a predetermined number of permits can be sold irrespectively to the level of ES provision. If the latter is insufficient to meet the demand, the appeal for users will decrease together with the amount of permits sold. Although based on voluntary transactions (i.e. permits, fishes or tickets' purchase), the reinvestment of generated incomes for environmental measures is explicited (by the document rules) only in the case of hunting mechanism. In the other three schemes, the providers do not release any information to the users on the monetary flows and the environmental benefits obtained. In other words, voluntariness in these schemes occurs only from the provider side. Voluntariness condition limited to only one contractor is not rare in PES mechanisms working in market situation. Sattler et al. (2013) observed that only one third of their PES schemes dataset is completely voluntary, while another third is at least voluntary for the provider side.

The four mechanisms are structured under different principles and encompass ESs with both consumptive and non-consumptive uses of biological resources. The results suggest that the command principle better suits PES that require the exclusive use of biological resources. In

fact, a top-down approach that regulates the access or the utilization of a resource allows avoiding its exploitation over the regeneration rate, as in the case of hunting in the Po delta Park. Differently, cultural services, based on the non-exclusive use of resources, may follow market rules, at the condition of conserving ecosystems. In this sense, the monitoring role of the Park is fundamental to guarantee the conservation of Comacchio saltwork ecosystems, avoiding excessive disturbances deriving from cultural uses. This mechanism represents a successful experience of a public–private partnership in the delivery of cultural services in a sensitive ecosystem. Public-private partnerships are known as effective solutions to reach long-term financial sustainability in PES through the creation of markets for environmental goods driven by local enterprises (Aerni, 2016). However, establishing such partnerships usually require a lengthy inter-organizational working (Brewer et al., 2014) that may discourage the actors and, therefore, the role of public bodies, as Park authorities, is fundamental. Interestingly, although depending on a consumptive use of biological stocks, fishing in Comacchio lagoon is also embedded in market rules. This is possible because the Park, adopting existing traditional practices with highly sustainable characteristics, directly provides the ES, while ensuring the conservation of fish stocks in the lagoon.

Since established to safeguard ecosystem integrity and ecological functioning, PAs set the ideal conditions for the implementation of PES schemes that may effectively support nature conservation, as demonstrated by the case of Po delta Park. The involvement of PA authorities in such mechanisms, either as ES provider or as regulator/intermediator actor, contributes to foster the reliability of the mechanisms and users' trust (Wunder, 2013), important barriers to PES implementation (Asquith et al., 2008). This implicates that a large number of unknown PES-like mechanisms could be operative in PAs worldwide. Their description would contribute to the knowledge of PAs role in the delivery of ES, and their reframing under the cap of ES concept could strengthen policy coordination and efficiency.

Nonetheless, some cases of PES-like in PAs were documented in literature. For instance, Sheng et al. (2020) described horizontal eco-compensations driven by top-down policies in China, originated by extending compensation scheme from the initial forest conservation to the conservation of water resources, mineral resources and biodiversity. Other authors reported working PES affected by missing conditionality requirement. Atmodjo et al. (2017) examined two successive entrance fee systems in a Marine PA in Indonesia, observing no clear connections between the distribution of the funds and activities that improve environmental services provision. Brimont and Karsenty (2015) found that direct payments scheme in a PA in Madagascar, originally designed as PES and embedded in a command-and-control structure, produces initiatives closer to integrated conservation and development project than PES, as missing conditionality prerequisite.

In Italy, some works described PES-like schemes in Natura 2000 network areas. Schirpke et al. (2018) evaluated 50 PES cases in 21 Natura 2000 sites and detected positive socio-economic benefits, suitable for financing biodiversity conservation and sustainable development. Park authorities were involved as both intermediaries and providers in ES delivery (Schirpke et al., 2017), as also observed in this study. Interestingly, Marino and Pellegrino (2018) identified hunting and mushroom picking – related mechanisms in Natura 2000 areas, based on compensation actions by users (i.e. maintenance works and information activities), as also found in the case of the Po delta Park. Similar mechanisms could be operative in several other PAs and potentially reframed under a PES perspective. Unlike the study of Marino and Pellegrino (2018), we identified and quantified the monetary fluxes, as well as the number of users involved. This is a necessary step towards the implementation of explicit PES.

4.2. Upgrading towards genuine PES

Unlike other studies describing PES-like mechanisms inside and outside PAs, this study identifies and describes monetary flows that regulate the schemes and provide their trends over time. This knowledge represents a solid basis for the implementation of genuine PES schemes, which could potentially strengthen their functioning by: i) reinforcing local population awareness on human-nature relationship, ii) increasing credibility and trustiness of mechanisms for stakeholders by highlighting conservation outcomes, and iii) giving an added value, also in the light of market fluctuations. Genuine PES require stakeholders' information about mechanism functioning and clear delineation of payment conditionality and environmental targets. This introduces the need for a monitoring routine based on reliable indicators. Schirpke et al. (2018, 2017) proposed a monitoring founded on a set of indicators belonging to environmental, socio-economic and governance domains, to evaluate PES effectiveness in Natura2000 sites by comparing effects before and after their implementation. Moreover, the authors provided estimates of ES potential supply and users' demand. Based on these examples, which include also ES provided by faunal resources (i.e. fishing and hunting) and M&T picking, the estimates presented in this study (i.e. number of permits sold, fish catches, number of tourists and scholars) are valid indicators for PES performances in the Po delta Park. The mean economic value of the ESs involved is a suitable indicator for impacts on local economy at local scale (Schirpke et al., 2018).

The supply of side ESs is a further relevant feature observed in two of the four ESs described in the Po delta Park. The results observed in Comacchio lagoon and saltwork highlight the synergistic relation between several provisioning and cultural services in the Po delta, when environmental goods are produced through traditional and extensive practices. Contrarily, the exploitation of natural resources with an intensive approach lead to trade-off between provisioning and different regulating and cultural services (Gaglio et al., 2019). For these reasons, the design of new PES schemes in the Po delta should focus on the adoption of sustainable practices that exploit ES synergies and mitigate ES trade-offs, either be ES-oriented or based on conservation actions. Moreover, while the four mechanisms described in this study depend on commodities spontaneously traded in the market, future PES schemes are called to involve regulating services with relevant properties of public goods, which are not captured by market dynamics. For instance, the dense drainage canal network that characterizes the agricultural landscape of the Po delta has an important and underexploited potential for phytodepuration (Castaldelli et al., 2015, 2013; Pierobon et al., 2013). The large amount of nutrients leaching from surrounding and upstream croplands harms conservation of aquatic ecosystems and local economy, by causing dystrophic crisis in transitional and coastal habitats exploited for aquaculture and tourism (Gervasio et al., 2022; Marini et al., 2010; Viaroli et al., 2008). On the other hand, the quantification of biophysical and economic values of regulating services, as well as their spatial distribution, may be difficult, as require scientific knowledge of ecological processes and costly investigations.

5. Conclusions

The design of monetary instruments to reach sustainable development targets is pressingly required in PAs, where conservation costs are growing to face climate change and human pressures. By describing and comparing the four mechanisms working in the Po delta Park with other PES, this study demonstrates that successful endogenous mechanisms, yet not ES-labeled, can already be operative in PAs. The study also highlighted that Park authorities and other actors, e.g. regional administrations and private companies, may play important roles as providers, regulators and intermediaries, significantly contributing to achieving conservation goals and ES delivery.

Such PES-like schemes may be relevant for the governance of PAs and were only fragmented described in literature, particularly in deltaic areas. Their re-frame under the lens of PES theory would reinforce their functioning, with benefits in terms of ES provision and ecological conservation. Nonetheless, ESs with no direct market values, as regulating

and several cultural services, may be excluded from these practices. Additionally, their implementation in financial mechanisms could be hindered by their difficult quantification.

The Po delta, in place of a very long history of sustainable exploitation of natural resources, maintained with different purposes in the park's management, turned out to be a rich and informative case study. Moreover, the Po delta delivers a number of important regulating services that could be valorized and further improved by financial mechanisms and potentially represents an ideal research case for the implementation of future genuine PES schemes involving services with no direct market value.

Funding

This works was supported by the EU project number PGI04939 "Delta Lady-Floating cultures in River Deltas", financed by the European Interreg programme, and by the Lifeel Project - Urgent measures in the Eastern Mediterranean for the long term conservation of endangered European eel (*Anguilla anguilla*) - LIFE19 NAT/IT/000851, EU LIFE Biodiversity.

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

No data was used for the research described in the article.

Acknowledgments

The authors would like to thank Stefano Zannini and the former and present directors of the Park for encouraging and supporting this initiative, Èlena Merighi of CADF "La Fabbrica dell'Acqua" for providing the data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecoser.2023.101516.

References

Aerni, P., 2016. The historical context of payments for environmental services: A trend towards public-private partnerships. In: Aerni, P. (Ed.), The sustainable provision of environmental services. Springer Nature, Cham, pp. 1–31. https://doi.org/10.1007/978-3-319-19345-8_1/COVER.

Aschonitis, V., Castaldelli, G., Lanzoni, M., Rossi, R., Kennedy, C., Fano, E.A., 2017. Long-term records (1781–2013) of European eel (Anguilla anguilla L.) production in the Comacchio Lagoon (Italy): evaluation of local and global factors as causes of the population collapse. Aquat. Conserv. Mar. Freshw. Ecosyst. 27, 502–520. https://doi.org/10.1002/aqc.2701.

Asquith, N.M., Vargas, M.T., Wunder, S., 2008. Selling two environmental services: In-kind payments for bird habitat and watershed protection in Los Negros, Bolivia. Ecol. Econ. 65, 675–684. https://doi.org/10.1016/J.ECOLECON.2007.12.014.

Atmodjo, E., Lamers, M., Mol, A., 2017. Financing marine conservation tourism: Governing entrance fees in Raja Ampat, Indonesia. Mar. Policy 78, 181–188. https://doi.org/10.1016/J.MARPOL.2017.01.023.

Barbier, E.B., 2013. Valuing Ecosystem Services for Coastal Wetland Protection and Restoration: Progress and Challenges. Resour. 2013, 2, 213–230 2, 213–230. 10.3390/RESOURCES2030213.

Barbier, E.B., 2019. The value of coastal wetland ecosystem services, in: Perillo, G.M.E., Wolanski, E., Cahoon, D.R., Hopkinson, C.S. (Eds.), Coastal Wetlands: An integrated ecosystem approach. Elsevier, pp. 947–964. 10.1016/B978-0-444-63893-9.00027-7.

Brewer, T.R., Mant, J., Harris, J., Gill, A., Shaw, H., Burgess, P.J., Farewell, T., 2014. Improving the River Lea in Luton for the local economy, society and environment. Final Report to Defra. Cranfield.

Brimont, L., Karsenty, A., 2015. Between incentives and coercion: The thwarted implementation of PES schemes in Madagascar's dense forests. Ecosyst. Serv. 14, 113–121. https://doi.org/10.1016/j.ecoser.2015.04.003.

Burkhard, B., Maes, J., 2017. Mapping Ecosystem Services, Mapping Ecosystem Services. Pensoft Publishers. 10.3897/ab.e12837.

Castaldelli, G., Soana, E., Racchetti, E., Pierobon, E., Mastrocicco, M., Tesini, E., Fano, E. A., Bartoli, M., 2013. Nitrogen budget in a lowland coastal area within the Po River Basin (Northern Italy): Multiple evidences of equilibrium between sources and internal sinks. Environ. Manage. 52, 567–580. https://doi.org/10.1007/s00267-013-0052-6.

Castaldelli, G., Soana, E., Racchetti, E., Vincenzi, F., Fano, E.A., Bartoli, M., 2015. Vegetated canals mitigate nitrogen surplus in agricultural watersheds. Agric. Ecosyst. Environ. 212, 253–262. https://doi.org/10.1016/j.agee.2015.07.009.

Cecini, C., 1998. Physical processes and human activities in the evolution of the Po Delta, Italy on JSTOR. J. Coast. Researcg 14, 774–793.

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S., Turner, R.K., 2014. Changes in the global value of ecosystem services. Glob. Environ. Chang. 26, 152–158. https://doi.org/10.1016/J.GLOENVCHA.2014.04.002.

Costanza, R., D'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R.G., Sutton, P., Van Den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nat. 1997 3876630 387, 253–260. 10.1038/387253a0.

European Commission, 2020. EU Biodiversity Strategy for 2030. Bringing nature back into our lives.

Gaglio, M., Aschonitis, V.G., Gissi, E., Castaldelli, G., Fano, E.A., 2017. Land use change effects on ecosystem services of river deltas and coastal wetlands: case study in Volano–Mesola–Goro in Po river delta (Italy). Wetl. Ecol. Manag. 25, 67–86. https://doi.org/10.1007/s11273-016-9503-1.

Gaglio, M., Lanzoni, M., Nobili, G., Viviani, D., Castaldelli, G., Fano, E.A., 2019. Ecosystem Services approach for sustainable governance in a brackish water lagoon used for aquaculture. J. Environ. Plan. Manag. 62, 1501–1524. https://doi.org/10.1080/09640568.2019.1581602.

Gaglio, M., Aschonitis, V., Castaldelli, G., Fano, E.A., 2020. Land use intensification rather than land cover change affects regulating services in the mountainous Adige river basin (Italy). Ecosyst. Serv. 45, 101158 https://doi.org/10.1016/j.ecoser.2020.101158.

Gaglio, M., Bresciani, M., Ghirardi, N., Muresan, A.N., Lanzoni, M., Vincenzi, F., Castaldelli, G., Fano, E.A., 2022. Aquatic vegetation loss and its implication on climate regulation in a protected freshwater wetland of Po River Delta Park (Italy). Water (Switzerland) 14, 117. https://doi.org/10.3390/w14010117.

García-Llorente, M., Harrison, P.A., Berry, P., Palomo, I., Gómez-Baggethun, E., Iniesta-Arandia, I., Montes, C., García del Amo, D., Martín-López, B., 2018. What can conservation strategies learn from the ecosystem services approach? Insights from ecosystem assessments in two Spanish protected areas. Biodivers. Conserv. 27, 1575–1597. https://doi.org/10.1007/S10531-016-1152-4/TABLES/5.

Gervasio, M.P., Soana, E., Vincenzi, F., Castaldelli, G., 2022. An Underestimated Contribution of Deltaic Denitrification in Reducing Nitrate Export to the Coastal Zone (Po River-Adriatic Sea, Northern Italy). Water (Switzerland) 14, 501. https://doi.org/10.3390/w14030501.

Jones, K.R., Venter, O., Fuller, R.A., Allan, J.R., Maxwell, S.L., Negret, P.J., Watson, J.E. M., 2018. One-third of global protected land is under intense human pressure. Science (80-) 360, 788–791. https://doi.org/10.1126/SCIENCE.AAP9565/SUPPL_FILE/AAP9565_JONES_SM.PDF.

Lanzoni, M., Gaglio, M., Gavioli, A., Fano, E.A., Castaldelli, G., 2021. Seasonal variation of functional traits in the fish community in a brackish lagoon of the po river delta (northern Italy). Water (Switzerland) 13, 679. https://doi.org/10.3390/w13050679.

Lecina-Diaz, J., Alvarez, A., De Cáceres, M., Herrando, S., Vayreda, J., Retana, J., 2019. Are protected areas preserving ecosystem services and biodiversity? Insights from Mediterranean forests and shrublands. Landsc. Ecol. 34, 2307–2321. https://doi.org/10.1007/S10980-019-00887-8/FIGURES/3.

Li, S., Zhang, H., Zhou, X., Yu, H., Li, W., 2020. Enhancing protected areas for biodiversity and ecosystem services in the Qinghai-Tibet Plateau. Ecosyst. Serv. 43, 101090 https://doi.org/10.1016/J.ECOSER.2020.101090.

Marini, M., Grilli, F., Guarnieri, A., Jones, B.H., Klajic, Z., Pinardi, N., Sanxhaku, M., 2010. Is the southeastern Adriatic Sea coastal strip an eutrophic area? Estuar. Coast. Shelf Sci. 88, 395–406. https://doi.org/10.1016/j.ecss.2010.04.020.

Marino, D., Pellegrino, D., 2018. Can payments for ecosystem services improve the management of natura 2000 sites? A contribution to explore their role in Italy. Sustain 10, 665. https://doi.org/10.3390/su10030665.

Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Ecosystems. https://doi.org/10.1196/annals.1439.003.

Muradian, R., Corbera, E., Pascual, U., Kosoy, N., May, P.H., 2010. Reconciling theory and practice: An alternative conceptual framework for understanding payments for environmental services. Ecol. Econ. 69, 1202–1208. https://doi.org/10.1016/j.ecolecon.2009.11.006.

Pagiola, S., 2008. Payments for environmental services in Costa Rica. Ecol. Econ. 65, 712–724. https://doi.org/10.1016/J.ECOLECON.2007.07.033.

Pierobon, E., Castaldelli, G., Mantovani, S., Vincenzi, F., Fano, E.A., 2013. Nitrogen removal in vegetated and unvegetated drainage ditches impacted by diffuse and point sources of pollution. Clean - Soil, Air, Water 41, 24–31. https://doi.org/10.1002/clen.201100106.

Pirard, R., Lapeyre, R., 2014. Classifying market-based instruments for ecosystem services: A guide to the literature jungle. Ecosyst. Serv. 9, 106–114. https://doi.org/10.1016/J.ECOSER.2014.06.005.

Potschin, M.B., Haines-Young, R.H., 2011. Ecosystem services: Exploring a geographical perspective. Prog. Phys. Geogr. 35, 575–594. https://doi.org/10.1177/0309133311423172.

Rasheed, A.R., 2020. Marine protected areas and human well-being – A systematic review and recommendations. Ecosyst. Serv. 41, 101048 https://doi.org/10.1016/J.ECOSER.2019.101048.

Sattler, C., Matzdorf, B., 2013. PES in a nutshell: From definitions and origins to PES in practice—Approaches, design process and innovative aspects. Ecosyst. Serv. 6, 2–11. https://doi.org/10.1016/J.ECOSER.2013.09.009.

Sattler, C., Trampnau, S., Schomers, S., Meyer, C., Matzdorf, B., 2013. Multi-classification of payments for ecosystem services: How do classification characteristics relate to overall PES success? Ecosyst. Serv. 6, 31–45. https://doi.org/10.1016/J.ECOSER.2013.09.007.

Schirpke, U., Marino, D., Marucci, A., Palmieri, M., Scolozzi, R., 2017. Operationalising ecosystem services for effective management of protected areas: Experiences and challenges. Ecosyst. Serv. 28, 105–114. https://doi.org/10.1016/J.ECOSER.2017.10.009.

Schirpke, U., Marino, D., Marucci, A., Palmieri, M., 2018. Positive effects of payments for ecosystem services on biodiversity and socio-economic development: Examples from Natura 2000 sites in Italy. Ecosyst. Serv. 34, 96–105. https://doi.org/10.1016/J.ECOSER.2018.10.006.

Schirpke, U., Wang, G., Padoa-Schioppa, E., 2021. Editorial: Mountain landscapes: protected areas, ecosystem services, and future challenges. Ecosyst. Serv. 49, 101302 https://doi.org/10.1016/J.ECOSER.2021.101302.

Sheng, J., Qiu, W., Han, X., 2020. China's PES-like horizontal eco-compensation program: Combining market-oriented mechanisms and government interventions. Ecosyst. Serv. 45, 101164 https://doi.org/10.1016/J.ECOSER.2020.101164.

Tamburini, E., Turolla, E., Fano, E.A., Castaldelli, G., 2020. Sustainability of Mussel (Mytilus galloprovincialis) farming in the Po River delta, northern Italy, based on a life cycle assessment approach. Sustain. 12, 3814. https://doi.org/10.3390/su12093814.

Vatn, A., 2010. An institutional analysis of payments for environmental services. Ecol. Econ. 69, 1245–1252. https://doi.org/10.1016/J.ECOLECON.2009.11.018.

Viaroli, P., Bartoli, M., Giordani, G., Naldi, M., Orfanidis, S., Zaldivar, J.M., 2008. Community shifts, alternative stable states, biogeochemical controls and feedbacks in eutrophic coastal lagoons: A brief overview. In: Aquatic conservation: marine and freshwater ecosystems. John Wiley & Sons Ltd, pp. S105–S117. https://doi.org/10.1002/aqc.956.

Visconti, B.P., Butchart, S.H.M., Brooks, T.M., Langhammer, P.F., Marnewick, D., Vergara, S., Yanosky, A., Watson, J.E.M., 2019. Protected area targets post-2020. Science (80-) 364, 239–241. https://doi.org/10.1126/SCIENCE.AAV6886/SUPPL_FILE/PAPV2.PDF.

Wang, B., Zhang, Q., Cui, F., 2021. Scientific research on ecosystem services and human well-being: A bibliometric analysis. Ecol. Indic. 125, 107449 https://doi.org/10.1016/J.ECOLIND.2021.107449.

Watson, J.E.M., Dudley, N., Segan, D.B., Hockings, M., 2014. The performance and potential of protected areas. Nat. 2014 5157525 515, 67–73. 10.1038/nature13947.

Wei, F., Wang, S., Fu, B., Liu, Y., 2020. Representation of biodiversity and ecosystem services in East Africa's protected area network. Ambio 49, 245–257. https://doi.org/10.1007/S13280-019-01155-4/FIGURES/5.

Woodley, S., Bertky, B., Crawhall, N., Dudley, N., Londoño, J.M., MacKinnon, K., Redford, K., Sandwith, T., 2012. Meeting Aichi Target 11: what does success look like for protected area systems. Parks 18, 23–36. https://doi.org/10.2305/IUCN.CH.

Wunder, S., 2013. When payments for environmental services will work for conservation. Conserv. Lett. https://doi.org/10.1111/conl.12034.

Wunder, S., 2005. Payments for environmental services: some nuts and bolts. Payments Environ. Serv. some nuts bolts. 10.17528/cifor/001765.

Yang, W., Jin, Y., Sun, T., Yang, Z., Cai, Y., Yi, Y., 2018. Trade-offs among ecosystem services in coastal wetlands under the effects of reclamation activities. Ecol. Indic. 92, 354–366. https://doi.org/10.1016/j.ecolind.2017.05.005.