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Benefits and risks from payments for ecosystem services programs across the globe

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Introduction

Managing ecosystems for sustainability is a wicked problem (DeFries and Nagendra, 2017). Payments for ecosystem services (PES) have been seen as a promising tool (Kronenberg and Hubacek, 2013) to bring co-benefits to all stakeholders (e.g., providers and users), for both environmental and development outcomes (dual goals), in both the short-term and long-term (temporal scales), and at different spatial scales, from local to global (Le et al., 2024). Despite much controversy, the number of payments for ecosystem services programs (PESPs) globally is growing rapidly (Wunder et al., 2018; Jones et al., 2020; Le et al., 2024). The first worldwide PESP at the national scale was initiated in Costa Rica (in 1997) (Balvanera et al., 2012). After more than 2 decades, this number has increased to over 550 active PESPs (Salzman et al., 2018b). The reason for this is that PESP often promise two goals, (1) effectively managing the natural environment and (2) contributing to poverty reduction (Bulte et al., 2008; Engel et al., 2008; Muniz and Cruz, 2015; Philemon, 2021; Le et al., 2024). In other words, PESPs have created a remarkable attention called the 'fatal attraction of win-win solution' (Muradian et al., 2013). The objective of this article is to reinforce a critical message about the two opposing sides of PESPs. This is based on the perspectives of sustainability and the effectiveness of PESPs in not harming ecosystems and the services they provide in the relationship between humans and nature. Accordingly, our discussion will provide some of the latest findings concerning the dual promise of PESPs, focusing on whether either of the promises can be achieved by PESPs with a wide range of benefits/opportunities and risks/challenges, arising from a wide diversity of causal factors, societal concerns, and resultant outcomes in different places and communities (see Figure 1).

Definition of sustainability for considering and assessing PESPs

To evaluate the effectiveness of PESPs, the three-legged stool or three-pillar approach to sustainability as three intersecting circles is widely used (Börner et al., 2017; Aguilar-Gómez et al., 2020; Perevochtchikova et al., 2021). This traditional view

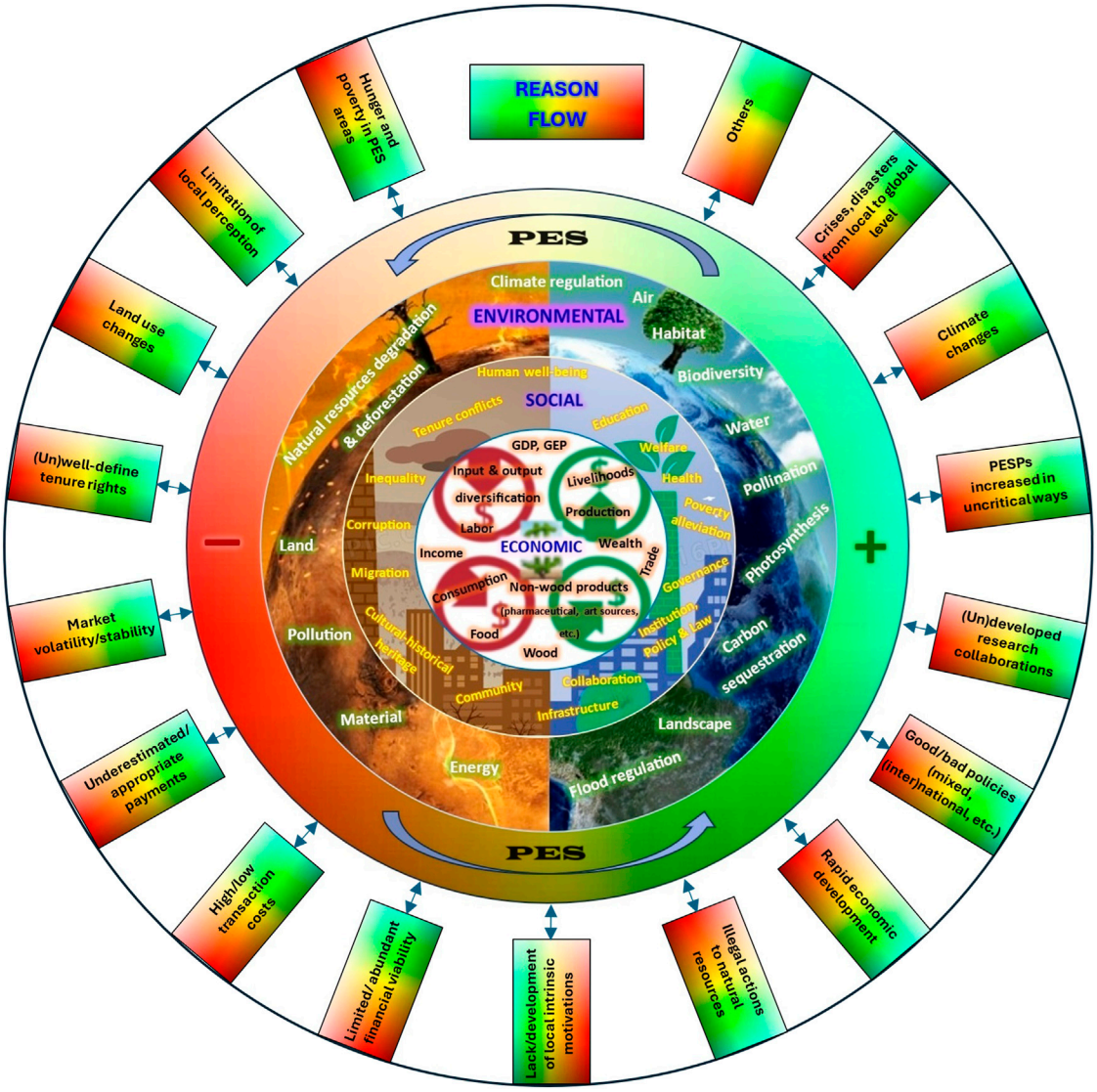

FIGURE 1
Benefits (+) and risks (–) from disseminating global PESPs [inspired from (Le et al., 2024)].

is developed from the Venn diagram of sustainability, where sustainability is created from the integration of three overlapping dimensions (economic, social and environmental) (Barbier, 1987). This traditional framework for sustainability is sometimes referred to as the 'weak sustainability' concept because it allows substitutability between the different pillars, and thereby often allows unlimited substitution of human-made capital for natural capital, even as it seeks a balance between the pillars (Ang and Van Passel, 2012; Pelenc et al., 2015). "Weak sustainability" has been criticized for being "a social construct," reflecting "how the current and future quality of the environment is subjectively valued by an individual or group" (Hueting and Reijnders, 1998, p.3), and for being an arbitrary structure in the absence of clearly defined ecological limits, as it can imply "more growth, more nature conservation, more kindergartens" (Ekardt, 2020, p.28).

However, the idea that "the schematic with the nested ellipses emphasizes a hierarchy of the dimensions, putting environment as the foundation for the other two"[a] has become more and more recommended (Wu, 2013). We basically agree with this nested approach. It implies the "strong sustainability" that natural and human-made capital are essentially complementary, not substitutes for each other (Daly, 1995). Strong sustainability demonstrates that while economic actions are part of the social domain, both economic and social activities are constrained by and dependent upon the environment (Wu, 2013). Accordingly, economic sustainability is the basic core of social sustainability and social sustainability is the basic core of environmental sustainability (Daly, 1995; Wu, 2013), as

a https://en.wikipedia.org/wiki/Sustainability

understood in the concentric ellipses or circles approach (see three inner circles, Figure 1). Developed primarily from this perspective, we propose that sustainability is more than a definition; it is not only a goal, but also a process (Kopnina and Shoreman-Ouimet, 2015). "Sustainability is normative, as it suggests a direction in terms of "good" or "bad" ways in which society and environment interact" (König, 2017, p.11) which requires us to embrace complexity and an increased responsibility towards maintaining this complexity for the goal of a stable and happy development across generations, in which economic, social, and environmental goals should never exclude or harm each other. They are always directed toward the common core goal which is to protect and sustain life in all forms by preserving the existing life-support system that is available to all living things (Sabau, 2024). This system includes dynamic and complex interactions (Wynn et al., 2022), in which some life forms are tangible and some are intangible (Sabau, 2024). Any design and implementation of PESPs should take into account both these visible and invisible aspects of sustainability. We agree that some of these aspects can be valued/measured, but some can be very difficult to value/estimate. Thus, we recommend that using the definition and aims of strong (concentric) sustainability, which is preferable to the three-pillar (weak) concept of sustainability, is necessary. However, the use of a strong sustainability definition is still not sufficient for PESPs in our opinion. Design, implementation and assessment of PESPs needs to go beyond the definition(s) of sustainability. PESPs need to consider the vital structures, functions and processes provided by 'critical natural capital' (Ekins et al., 2003; Pelenc et al., 2015) that need to be protected in practice given the diversity of socio-economic and ecological contexts in which life unfolds. The strong sustainability definition and concept (with its concentric scaffolding) offers an excellent framework and aim for PESPs, but these life-protecting sustainability features also need to be carefully considered when designing, implementing and assessing PESPs. A transdisciplinary approach has been considered essential for achieving strong sustainability, with science having the role to identify critical ecological thresholds and planetary boundaries, and social partners being involved "in a broad societal debate about (i) levels of risk acceptable to all populations (especially the most vulnerable populations) and (ii) values that underlie human development" (Pelenc et al., 2015, p.3).

PESPs bring both positive and negative outcomes

Some advocates state that PES create more boons than dangers (Schirpke et al., 2018) while others state that more disadvantages than advantages accrue from PESPs (Sorice et al., 2018; Wunder et al., 2018). We assert that PESPs, in practice, have both positive implications (e.g., enthusiasm, opportunities, benefits) and negative ones (e.g., risks/perils, challenges) (Muniz and Cruz, 2015; Blundo-Canto et al., 2018; Wunder et al., 2018; Perevochtchikova et al., 2021) in terms of socio-economic and environmental outcomes for sustainability.

PES create a diversity of impacts. Economically, PES can have many impacts across different scales and dimensions: microeconomic (e.g., household income (Hayes et al., 2017), local livelihoods (Blundo-Canto et al., 2018)), macroeconomic (e.g., local Gross Domestic Product (GDP) (Ouyang et al., 2020; Zhang et al., 2020), Gross Ecosystem Product (GEP) (Ouyang et al., 2020), global value of ES (Costanza et al., 2014)). PES can also lead to many impacts on various value types: direct value (e.g., using food, wood, other non-wood products), indirect value (e.g., trade, consumption of the ecosystem functions) (Valck et al., 2023), "existence" value and "option" value of "unspoiled natural environments" (Krutilla, 1967). Socially, PES have effects in areas such as tenure rights (Muniz and Cruz, 2015; Le et al., 2024), migration (Zhang et al., 2018), corruption (Muniz and Cruz, 2015; Thompson, 2017), and especially poverty reduction (Muradian et al., 2013; Le et al., 2024). Environmentally, the goal of conserving ecosystems is the most important and it is also the original idea in looking for a sustainability solution through PES (Pagiola et al., 2005). Environmental goals often focus on conservation domains for water, biodiversity, and forest and land-use carbon worldwide (Salzman et al., 2018b). Accordingly, three PES sectors have been identified, including: watershed PES, biodiversity and habitat PES, and forest and land-use carbon PES (Salzman et al., 2018b).

The three aspects mentioned above are based on the three-legged stool or the three-pillar approach to sustainability (with intersecting economic, social, environmental dimensions). Until now this approach has dominated assessments of PESPs in terms of sustainability goals, or at least for their effectiveness (Phan et al., 2018; Schirpke et al., 2018; Pham et al., 2020; Perevochtchikova et al., 2021; Ding et al., 2022). Unsurprisingly, assessing PESPs also often considers two parallel goals: conservation (environmental aspect) and poverty alleviation (socio-economic aspect). Although poverty reduction is not the main goal of most PESPs, it is also recognised as a necessary objective (Pagiola et al., 2005; Waage et al., 2008; Van Hecken and Bastiaensen, 2010; Kwayu et al., 2017; Xie et al., 2021). Many PESP supporters, in this view, advocated that poverty reduction is seen as secondary goal to that of ecosystem health. For instance, the report entitled "*Payments for Ecosystem Services Getting Started: A Primer*" developed by Forest Trends, The Katoomba Group, and UNEP states that "PES are not designed to reduce poverty. Rather, PES primarily offer economic incentives to foster more efficient and sustainable use of ES". Yet, the report also acknowledges that "there are, however, opportunities for designing PES which can enable low-income people to earn money by restoring and conserving ecosystems" (Waage et al., 2008, p.10), and gives examples of PESPs from Costa Rica, Ecuador, Bolivia, India, South Africa, Mexico, which may have pro-poor impacts (Waage et al., 2008). However, we consider that PESPs, at least, should be judged on the basis of their strong (concentric) sustainability impacts, as socio-economic sustainability (including the poverty reduction goal) is a core part of the overarching environmental sustainability (including the ecosystem integrity) goal. Sadly, our recent global literature review examining PESPs for sustainability did not find any evidence of the strong sustainability approach applied in the assessment of PESPs (Le et al., 2024). Is this one of the main reasons why PESPs have had more failures than successes even though PES have been popular and implemented at many scales since the 1990s until now?

In fact, with many PESPs, maximizing protection of all ES with minimal biodiversity loss is a typical goal, but socio-economic objectives are also considered a twin pillar of sustainability. This is especially emphasized in developing countries (Clements and

Milner-Gulland, 2015; Diswandi, 2017; Khuc et al., 2020; Nguyen et al., 2021; Jayachandran, 2023), as "addressing the poverty issue is also critically important to sustain the environmental benefits of a PESP" (Gauvin et al., 2010, p.489). Thus, here we consider that socio-economic and environmental goals need to be present and operate in tandem to ensure the longer-term viability and maintenance of PESPs. As Ren et al. (2020, p.1) state, "PES was perceived as an instrument to reconcile ecological conservation and poverty alleviation. Targeting the gold criteria-high ecological additionality, low opportunity costs and pro-poverty- is the key to achieving the multiple goals." PES additionality is often understood as "the direct changes in land/resource-use among participants induced by the program, compared to a baseline of no PES" (Börner et al., 2017, p.2). PES could provide different ecological additionality types, such by enhancing carbon stocks or provision of cleaner water (Fripp, 2014), or by preventing forest degradation and helping to limit small-scale and illegal deforestation (Garcia et al., 2017). This is a great aspiration given the reality of increasingly depleted global natural resources. As reported for the 40 years between 1960 and the year 2000, the world population and the global economy doubled and grew more than sixfold, respectively, and the societal demand for ES rose significantly (MA, 2005). This led to a decrease of approximately two-thirds of global ES during the same period (Engel et al., 2008). Just as the world population increased from 3.6 billion people in 1970 to more than 8.1 billion today, resource use has tripled for over the past 50 years[b]. "According to the Global Footprint Network, humanity is using up natural resources, such as food, water, land, 1.7 times faster than the planet can regenerate—the equivalent of using the resources of 1.7 earths"[b].

Yet achieving the dual goal (socio-economic and environmental), or the triple goal (economic, social, and environmental) common to many PESPs is also not automatic or universal (Deng et al., 2022). One of the explanations is that "the more successful a PESP is in encouraging a participant to undertake pro-environment behaviors, the less effective it is in improving her economic wellbeing" (Jayachandran, 2023, p.1). Indeed, the impacts from PESPs can be positive in some cases and/or in some respects, but negative in other cases or respects. For instance, in China's Sloping Land Conversion Program (SLCP - one of the largest PESPs in the world), participants' income in Changting County (of western Fujian Province of Southeast China) increased significantly between 1999–2012 with an average net income increase of 7.3 times per participant compared to an increase of 1.31 times for non-participants. Although the SLCP promoted significant benefits for participants, negative impacts were recorded for non-participants: for example, non-participants were excluded from the project and additionally denied access rights to natural resources. This negatively impacted their livelihood assets and lifeways (Wang et al., 2017). This is typical and it shows that PESPs can have positive impacts for both the economic and human wellbeing of participants but have negative or positive effects for non-participants. The SLCP's effect on ES and on the SLCP sustainability goals was not fully addressed because the program caused the exclusion of the non-participants from using some natural resources (Wang et al., 2017), which then raised issues of equity and legality (Kronenberg and Hubacek, 2013). In other localities (such as Wuqi County of Shaanxi province), the SLCP program, started in China, is considered to have had negative outcomes after two decades as "the program did not meet gold criteria, with a good targeting for ecological benefits and cost-effectiveness but still lack of equity in distribution of enrollment, benefits and rights" (Ren et al., 2020, p.1). And as "the governments' targeting strategies were more unified and stronger environmental-oriented than the landholders'. They cared more about its performance and costs for implementation and monitoring over the landholders' opportunity costs. Moreover, in governments' targeting strategies, income poverty was an obstacle to its new stage participation, although the poor participants would bring more cost-effective outcomes and favor the sustainability of the program" (Ren et al., 2020, p.1).

Negative impacts are also seen in developing countries when PESPs have deprived or reduced the rights of poor landholders and/or non-participants to access and use natural resources, thereby affecting traditional lifeways, cultural values and social identities. For example, in a PES scheme implemented in Pimampiro, Ecuador between 2000 and 2001, Rodríguez de Francisco et al. (2013) shared that the "PES scheme reinforces existing social differences, erodes community organization, undermines traditional farming practices, and perpetuates inequalities in resource access in the "working" landscape inhabited by the upstream peasant community paid for watershed management". . . and then explained that "PES schemes are thus not neutral initiatives imposed upon blank canvases, but intersect with existing development trajectories and power relations" (Rodríguez de Francisco et al., 2013, p.1217).

The case studies show that PESPs, in practice, can bring some environmental benefits, such as maintaining the existing communal forest cover in Pimampiro (Rodríguez de Francisco et al., 2013), or greening the participants' barren upland in Changting through the cultivation of orchards (Wang et al., 2017). In addition, some economic goals of PESPs can be achieved, at least for participants, such as increase in their income (Rodríguez de Francisco et al., 2013; Wang et al., 2017). Nevertheless, we also see some negative effects caused by PESPs (Rodríguez de Francisco et al., 2013; Wang et al., 2017). PESPs have the potential to negatively affect community incomes and/or their use of ES (such as the SLCP in Changting for non-participants) when compared to conditions existing before the implementation of PESPs (Wang et al., 2017). Amongst unintended consequences, PESPs can sometimes lead to increased illegal deforestation in non-PES areas—one of the main causes of natural resource loss. "PES contracts are often established on low-value lands unlikely to be converted to other uses—and leakage—that avoided deforestation in the PES area leads to increased logging in other areas" (Salzman et al., 2018a, p.221). PESPs may also provoke or escalate conflicts (especially in unequal resource allocations or with inequities in social power structures). PESPs can increase economic and political disparities between participants and non-participants, between ES sellers and ES buyers and between "external actors and members of the peasant community" (Rodríguez de Francisco et al., 2013). These social conflicts lead to significant resource depletion, which obviously not only negatively impacts current social and environmental sustainability, but also causes negative consequences for the availability of natural resources for future generations.

b *"Global resources dwindling as demand rises"* published by https://populationmatters.org/on 26 March 2024.

Notably, not all PESPs enhance the social and economic wellbeing of participants when compared to non-participants. Compared to non-participants, participants in the Anji County (one of 20 poor units in Zhejiang Province, China) Ecological Welfare Forest Program (EWFP—also known as one of the world's largest PESPs) experienced overall lower increases in human wellbeing and more unequal income between 2000 and 2016. The rapid and disproportionate increase in business income as nature-based tourism caused this gap. Geographic heterogeneity in EWFP results was also found. Improved ES in Anji County were found mainly in the south of the county, in contrast to a reduction in ES in the middle and north (Ding et al., 2022).

Importantly, PESPs should ideally aim to secure permanence of long-term benefits. Permanence here relates to how to improve or maintain success after payments cease (Wunder et al., 2008; Pagiola et al., 2016; Frings et al., 2023). PESPs' outcomes become less positive with time (Ola et al., 2019). The benefits generated during initial implementation as all benefits generated during PESPs implementation time are not guaranteed to continue when PESPs end (Wunder et al., 2008; Pagiola et al., 2016; 2020). This raises concerns about the long-term viability and success of PESPs (Wunder et al., 2008; Pagiola et al., 2016; 2020; Ola et al., 2019). This could be due to (1) lacking additionality as expected, or (2) changing to land uses with negative ES impacts or (3) "second-order impacts" or unintended consequences of PESPs that lessen, or even negate the benefits PESPs once brought (this is called PES "leakage or slippage") (Pagiola et al., 2016). From an ecological and socio-psychological perspective, PESPs can create different mechanisms that can strengthen ("crowd-in") or erode ("crowd-out") autonomous motivation (Frederick and Yasué, 2019). For instance, a Cambodian PESP started in 2006 significantly shifted perceived forest values from traditional subsistence-related values to monetary-income values (Chervier et al., 2019). As a consequence of overemphasizing monetary values, researchers determined that the program's effectiveness and benefits would likely stop because the local people said that they were likely to stop obeying conservation rules at that point (Chervier et al., 2019). This case study shows that the long-term management and preservation of ES can face more challenges after termination of a PESP than before it was even implemented.

However, in other cases, the effort to maintain and preserve ES has been found to continue to some extent even after PESPs ended. Silvopastoral projects in Quindío, Colombia (2003–2007) and in Nicaragua (2003–2008) have been assessed as successful, 4 years after the last payments stopped, although the programs were non-additional. Thanks to applying silvopastoral practices under conditions of the study sites, land owners were encouraged to adopt environmentally-beneficial practices (Pagiola et al., 2016; 2020). Furthermore, in the Quindio PESP, non-participants also had some opportunities to practice the intensive silvopastoral system during the program time, and were more likely to adopt more such practices, even though they initially lacked experience in the silvopastoral practices being promulgated by the PESP. Once groups external to the PESP recognized the profit opportunity coming from the encouraged silvopastoral practices, they were willing to apply them with learning help from the PESP participants (Pagiola et al., 2016). The ES considered by these projects are mainly those appropriated for agricultural and forest exploitation (Pagiola et al., 2016; 2020; Álvarez et al., 2023), and the number of valuable tree species is limited (Álvarez et al., 2023). Over time, 10 or 20 years after these silvopastoral programs end, further assessments will be needed to see if the positive impacts of the PESP were maintained.

Overall, there is a great diversity of PESPs in our view. There are different scales, places, and contexts. Evaluation methods are different, and the programs and outcomes are highly controversial. Nuanced, even opposing viewpoints are inevitable when both opportunities/benefits and challenges/risks are created by PESPs. The situation persists, despite the importance and potential value of the ES conservation goal and despite the tireless efforts of PESPs all over the world for the last three decades. Irrefutably, PESPs cannot easily achieve both goals (socio-economic and ecological outcomes) which are important for long-term sustainability (Alix-Garcia et al., 2015; Lokina and John, 2016) and especially for strong concentric sustainability. If PESPs bring some benefits (economic and/or social and/or environmental sustainability) for some people/communities/organizations/generations but lead to disadvantages for others in the same or different communities, or even for the entire world community and for across generations, then the broader aims of sustainability, and especially those of strong concentric sustainability are not achieved. This reinforces the idea that PESPs, despite their potential value and frequent benefits, have difficulty addressing multiple sustainability needs in one policy tool (Alix-Garcia et al., 2015; Lokina and John, 2016), whether sustainability is conceived as some appropriate balance between the three sustainability pillars or whether it is conceived as strong sustainability, i.e., a concentric scaffolding of economic, social and environmental sustainability. What matters is the direction (positive/negative/no change), magnitude (significant/insignificant/neutral) and type of changes that PESPs engender in practice.

Reasons for positive and/or negative outcomes in PESPs

On a global scale, whether applying PES is good or bad for sustainability is still controversial, for many reasons. Explanations are related to the complex causes leading to positive and/or negative outputs and outcomes (see Outer circle, Figure 1). Basically, PESPs, while being met with much enthusiasm as a promising strategy, have encountered a wide range of challenges to achieving the lofty dual goals of sustainability (Chan et al., 2017). Notably, many factors can affect or increase positive/negative PESP outcomes. These positive/negative outcomes, in turn, also change contributing factors and causal relationships. For example, land use changes due to deforestation and poorly defined land use rights have resulted in precarious and vulnerable livelihoods for many forest-based dependent peoples in tropic regions. This is just one type of socio-economic and environmental impact predicted and found from PESP implementation. Livelihoods, in terms of both economic and social benefits, are improved by PES and natural resources may be managed better (e.g., minimizing land use change and biodiversity loss). Understanding these complex causal relationships plays a vital role in considering necessary objectives and needed policies (such as improving property rights and tenure reform, enhancing financial resources, promoting stakeholders' to voluntarily contribute, etc.

(Hejnowicz et al., 2014)) which are ultimately expected to address and improve the sustainability of communities and the ecosystems they depend on (Le et al., 2024).

The fragile frontiers between positive and negative signs from the realization of PESPs

There are a series of controversies in both the theory and practice of PES that can make fragile the boundaries in recognising the positive and negative aspects of PESPs. For example, nature is priceless. Is it wrong or right to value nature to sell and buy it through PES? Some people consider that due to the pricelessness of nature, turning it into "natural capital" is wrong. The term "capital" is defined as an "asset" or "stock," and often the aim is to invest money (or value) to make more money (or value) because the typical characteristic of capital is "value in motion"[c]. In operational PESPs, natural capital (with a diversity of ES) is evaluated to allow for exchange between sellers and buyers of special green goods. If implemented as a market-based commodity, ES are subject to the law of supply and demand, which is not a characteristic for something considered "priceless"[d]. Furthermore, many precious natural resources and the ecosystem functions that they support, such as species diversity and genetic diversity may exist or have existed somewhere, but humans may not yet have discovered or named them, or saved them, so they may have completely disappeared from this world (Le, 2014). Species are lost from ecosystems in a non-random manner, since their extinction is often caused by ecosystem processes, and dominantly impacted by human activities (Duffy et al., 2012).

On the other hand, the argument is made that the pricelessness of nature needs to be appreciated, valued, and exchanged as a special commodity to enable a sustainability strategy to protect and use it; otherwise, natural resources will be destroyed by humans and/or unprotected from natural disasters. Such sensitive issues in ES have been discussed in public debates where it is increasingly believed that if the goods and ES are properly assessed, they may be valuable enough to lead to the protection of nature (Baciu et al., 2021). This can increase respect for nature. It is known that human perspectives on the value of nature are likely to change positively and significantly thanks to the enormous potential of PESPs, although many previous efforts have failed (Redford and Adams, 2009). If (1) it is believed that PESPs can provide economic incentives to promote more efficient and sustainable use of ES and/or poverty alleviation is the secondary goal of PESPs (Waage et al., 2008), and (2) it is also believed that it is inappropriate to value nature, then PES will not be expected to be beneficial in improving the strong sustainability in the management of ES. On the other hand, if it is instead believed that "PESPs have been designed with dual goals—to generate ES and to alleviate poverty" (Gauvin et al., 2010, p.489), while it may also be stated that valuing nature is inappropriate, further research and assessments will still be needed for PES to be considered a promising tool to (1) maintain and increase ES values and (2) to enhance the livelihoods of ES-dependent communities.

These two opposite arguments evoke fragility, suggesting that the concept of "nature as a bank of natural capital" (Sullivan, 2017), the valuing of natural capital, ES, and the implementation of PESPs present great and arduous trials and challenges in moving towards sustainability, and especially towards what we consider true sustainability, i.e., not damaging nature's life-support system, beyond the strong (concentric) sustainability. It has also been found that to be successful, implementing PESPs in practice means complying with many situational challenges, restrictions and regulations (Le et al., 2024). Indeed, success is not easy; and PESPs may fall into a situation of doing more harm than good. These facts have led to at least two opposite perspectives: (1) PES receive much praise and are increasingly recognized as a promising tool to "ensure the protection of global ecosystems as well as being able to help alleviate poverty in areas rich in ES" (Kronenberg and Hubacek, 2013, p.1), and (2) "PES are not the most appropriate instrument for conservation" (Muniz and Cruz, 2015, p.1).

Conclusion

In the context of the current loss of biodiversity and the increasingly unpredictable consequences of complex disasters, PESPs have a vast potential as a major social and economic tool to conserve natural resources (Redford and Adams, 2009; Chan et al., 2017). In fact, some PESPs have also attained direct positive benefits (in terms of social and economic outcomes) mainly on local scales (Le et al., 2024). Spillovers - indirect effects (positive or negative) on land/resource use and ES provision outside of contracted land could potentially be found as a result of PESP implementation (Jindal et al., 2012; Börner et al., 2017; Le et al., 2024). However, achieving wide-ranging conservation outcomes has failed for most PESPs (Sorice et al., 2018). Thus, "ES are extremely important, but need to be drawn into conservation strategies with great care" (Redford and Adams, 2009, p.787). PES should not be seen as the unique tool that can save nature and preserve ecosystems that are vital for life on Earth. Conservation should not be emphasized too much in PESPs as this ignores wider consequences (Redford and Adams, 2009). ES loss could be more severe and changes in land use trends could worsen if PESPs and the people who administer the payments focus too much on the poverty reduction goal (Wunder, 2008; Kosoy and Corbera, 2010). Conversely, an excessive focus on conservation can increase pressure on natural resources where ecosystems could be overexploited and illegally used by local people, as most of the poor across the world live in rural areas and their livelihoods depend on ecosystem resources (Gauvin et al., 2010). This suggests that PES contributions to improving sustainability still face many challenges that need to be studied more extensively. More research is needed in ecosystem science, sustainability science, and transdisciplinary approaches (Le, 2022), studying the ecosystems' complex processes, structures, mechanisms, and functions that are important for life, and the ways humans relate to ecosystems and the services they provide including through PESPs and with attention to varying contextual

c Büscher, B., and Fletcher, R (2016). Nature is priceless, which is why turning it into "natural capital" is wrong. *The Conversation, 21;* Harvey, D. (2020). Value in motion. *New Left Review*, (126), 99–116.

d Büscher, B., and Fletcher, R. (2016). Nature is priceless, which is why turning it into "natural capital" is wrong. *The Conversation, 21.*

conditions. ES may be relatively inexpensive for some countries, for example, but may be unaffordable for others or for the global community. More broadly, potential conflicts can arise, from any perspective, when implementing PESPs. Synergies and trade-offs among relevant objectives and factors need to be considered, including those involved in meeting global commitments on ecosystems conservation, climate and sustainability (Le et al., 2023; Neugarten et al., 2024). Accordingly, balancing benefits and harms or costs, maximizing the benefits that PES bring, while minimizing the risks they cause, may not be sufficient in the efforts to achieve environmental and community sustainability at a global level. After three decades, though not a new topic, PES remain a controversial tool, too blunt to address the complex, multi-faceted challenges of managing the Earth's ecosystems for sustainability. Our view is that applying the definition and aims of strong (concentric) sustainability, though preferable to the three-pillar concept of (weak) sustainability, is important, but still insufficient for PESPs design, implementation and assessments. PESPs need to go beyond general definition(s) of sustainability, and need to consider nature's vital functions, structures, mechanisms and processes that secure life in practice, given the diversity of socio-economic and ecological contexts. Although the strong sustainability definition and concept, with its concentric scaffolding, provides an excellent general framework, PESPs also need to carefully consider the specificities and process requirements for realistic local implementation. Economic, social and environmental sustainability are all part of one earth system, and the protection of this system's ability to sustain life for now and into the future should not be a means to an end, but an end in itself. This is also true when it comes to PESPs implementation. Applying the strong sustainability framework to PESPs however is still very new. Therefore, there is a need to continue the search for better practical context-sensitive solutions.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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