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What works? State-of-the-art synthesis report about best-practice design and implementation of PES and other forest IM in the European context

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Authors

Sven Wunder & Sarah Feder, EFI Mediterranean Facility – EFIMED, Sant Pau Art Nouveau Site, Sant Leopold Pavilion, St. Antoni M. Claret, 167 08025 Barcelona, Spain
Davide Pettenella & Giorgia Bottaro, TESAF Department, University of Padova, Agripolis, Viale dell'Università, 16. 35020 Legnaro (PD), Italy
Mario Torralba, Faculty of Organic Agricultural Sciences, University of Kassel, 37213 Witzenhausen, Germany

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Executive summary

Payments for ecosystem services (PES) are increasingly implemented worldwide. However, PES emergence is often limited by preconditions related to secured land rights, ES user institutions, and users' sustained willingness to pay. In Europe the prevalence of large protected areas and regulations, combinations of large state forests and fragmented private forestlands, and a vision of the state as responsible for the environment have limited PES adoption. In principle, PES are direct, flexible, and potentially effective. However, PES economic functioning is largely dependent on their design and implementation. Adverse self-selection, inadequate administrative targeting, and ill-enforced conditionality constitute three key design obstacles. Policies such as spatial targeting to service density, threats and cost levels, payment differentiation, and improved conditionality are factors that can alleviate the design challenges. Therefore, PES site selection needs to further move into high-threat areas to increase impacts. This also requires the political will to boost environmental effects.

Summary for policymakers and practitioners

Payments for environmental services (PES) (in a quasi-synonymous manner also referred to as "payments for ecosystem services") have over the last two decades become increasingly applied worldwide. However, the vast majority of these experiences have been outside of Europe. While most PES globally are forest-focussed, in Europe and other industrialized regions, agri-environmental schemes have dominated. This document draws on state-of-the-art knowledge about global PES implementation and has been reviewed through collaborative partnerships with global experts. We seek to provide a systematic, and yet accessible overview of best practices in PES and environmental impacts globally, and from that basis to tentatively examine under what circumstances PES could also be implemented more successfully in Europe.

As our organizing principle, we use of a theory of change (ToC) framework that is suited for developing stepwise, logically sequenced solutions to complex social or socioenvironmental problems. It can explain how early and intermediate accomplishments, respectively, can set the stage for longer-term results, and flag critical assumptions along the way.

1. Preconditions for PES

Why have PES emerged much more in some regions (the Americas, Australia) than in others (Europe, Africa)? Why are there also important in-country differences in PES establishment? A few explanatory PES enabling conditions stand out from our ToC:

i) Stable ES payment vehicle exists
PES financing is per definition based on voluntary willingness to pay (WTP) (cf. Sections 2.1, 2.2), as a core pillar of PES. Sufficient WTP by ES users and a pre-identified stable payment vehicle – who will make continuous contract payments? – seem to also be the main obstacles for emerging PES initiatives in Europe: in European societies, safeguarding the provision of ES is often predominantly seen as a public responsibility, which thus limits private WTP.

ii) Opportunity costs are not excessive
How much to pay is the other side of the economic equation. The opportunity costs of PES, i.e. the net incomes forgone from environmentally degrading land uses, must not be so high that the incremental value of ES falls short of covering it. That is, landowner willingness to accept (WTA) PES needs to be achievable. Notably, at the agriculture-forest frontier of many developing countries, some high-value commodities (e.g. oil palm, soybeans, perennials) may yield such large per-hectare returns that PES cannot match them. In Europe, the situation is situation-specific, depending on where ES originate, e.g. prime vs marginal agricultural lands. With much rural land abandonment and forest regrowth occurring across Europe, the opportunity costs on marginal lands are typically low.

iii) Implementing agency is seen as legitimate
First, ES users have to get their act together to engage in a user-financed PES – or alternatively, their public-sector representatives take initiative for a government-financed PES programme. The implementing institution – in Europe, typically an intermediary, or a government agency -- must

be seen especially by the to-be-contracted ES providers as legitimate. This confidence may not always pre-exist, and the process can thus entail lengthy trust-building between the parties involved.

iv) Clear property rights to land exist
Environmental service (ES) providers must have at least the right to exclude outsiders from entering or acting on their forestland in ways that might endanger ES delivery. This is a killer assumption for PES in many poorly governed developing country settings. In Europe, with more consolidated land-tenure systems, this factor plays less of a role – except perhaps for those cases with public landownership, where PES are usually not the preferred solution.

Among these four factors, preconditions about secure land rights, legality, and service users' ability to organize payments have been key bottlenecks in some developing country settings. While the PES principle may appear simple, PES is an institutionally demanding tool. This implies that, although there may be a clear economic argument for PES, in some scenarios of institutional backwardness or collective action problems, PES will not emerge.

As mentioned, Europe has also clearly been a laggard in PES implementation, but this is less explained by the institutional factors (landownership, societal organization): in that regard, Europe is much more similar to the USA and Australia – where PES indeed have been used much more. In Europe, the prevalence of large protected areas, extensive regulations, the existence of large state forests and of fragmented private forestlands, occupied often by smallholders with a large degree of absenteeism, are certainly part of the explanation. However, perhaps most central to an overall diagnosis are the economic arguments, especially insufficient private willingness to pay (i). This in turn seems related to a societal vision of generally a public responsibility for the environment and ES provision, and hence a predominant role for regulatory approaches. This societal legacy has likely limited the perceived need for, and eventual adoption of PES.

The basic economics of PES (i and ii) thus seems to constitute a hierarchically dominant precondition. When the institutional preconditions (land tenure and ES user/ intermediary institutions) are not met, PES implementation might still be enabled by supplementary actions, such as land tenure reform, contract negotiation, or institutional capacity building. In turn, when willingness to pay for and to accept PES do not match, PES will not emerge.

2. PES design and implementation

In general, three lessons stand out from our global literature review:

i) Participation is targeted to high-ES/ high-threat areas
ES distribute unequally in space, and so do the threats against them. Spatial targeting is thus the single-most important PES design issue (cf. Section 3.1). Adverse selection biases, at the level of frequent administrative targeting of projects to low-threat scenarios, as well as enrolment of predominantly non-additional landowners within programmes (i.e. those who would comply even without PES), constitute the single-most important challenge worldwide for PES programs today. Europe's performance here is probably about average: some targeting to areas with high-density

ES and/or to areas that face salient threats is clearly occurring, but there is also still much room for improvement.

ii) Cost-efficient payments
Costs of ES provision often vary much across landowners, but in ways that are not fully known by environmental agencies or ES buyers. Yet, mechanisms and proxies can be found to diversify payments to align better with the distribution of costs. Efficiency gains of moving from uniform to diversified payments (or even, inverse procurement auctions resulting in multiple payment tiers) can be massive. However, in poor countries, due to equity concerns, uniform payments remain the rule. In Europe, as in other high-income regions, some payment diversification already exists. Again, much more could still be done to increase cost efficiency.

iii*) Non-compliance is both monitored and sanctioned*
There is evidence to suggest that PES implementers around the world often shy away from sanctioning non-compliance, even when detected through monitoring. They probably often do so out of fears to lose long-established social capital with rural communities, or to lose votes when government-financed PES is concerned. De facto, conditionality as the defining feature of PES, is thus often not seriously enforced. It should not be a surprise then that PES do not work optimally. In Europe, very little is known about the degree of non-compliance and moral hazard in PES-like schemes. The matter deserves increased attention, also in Europe.

3. Contextual factors shaping impacts

Beyond design factors, many contextual conditions can influence the environmental impacts of PES:

i*) Policy mix is adequate*
PES are seldom the only game in town; they tend to be applied jointly with other environmental and non-environmental interventions that affect resource use. PES are thus not strictly an alternative to regulation and protected areas ('fortress conservation'); incentives and disincentives may well work together. In Europe, particularly the relation to the Common Agricultural Policy remains a key coordination issue for PES interventions.

ii) Motivation crowding effects are small/ reinforcing
We assume implicitly that recipients of PES will be positively motivated by the incentives they receive to carry out specific pro-environmental actions. Yet, sometimes the opposite could occur: PES could 'crowd out' intrinsic, non-monetary motivations, i.e. altruistic provision of ES from landowners who just 'want to do the right thing'. In practice, crowding neutrality is most likely; PES crowding-out is probably more exceptional.

iii) Magnet and rebound effects are small
PES interventions do affect local income generation and development dynamics. If they were to create large income gains among local ES providers, this might attract immigrants ('magnets'), and trigger additional resource consumption ('rebound'), both of which might cause environmental pressures. In Europe, this has not been the case – probably because PES has not raised rural incomes so much for the two effects to play out.

iv) Leakage effects are small/ reinforcing
Tight environmental budgets typically mean that not all targetable land areas can be PES enrolled. Pressures could thus be partially shifted from enrolled, protected areas to non-enrolled, non-protected ones. Leakage can diminish environmental impacts, and is especially relevant for globally targeted ES, such as mitigating forest-based greenhouse gas emissions, but it is also a naturally occurring reaction of rational economic agents. We do not know of any particular PES leakage studies in Europe, but we would expect the phenomenon to occur neither more nor less than anywhere else in the world.

v) Solid linkage between land-use proxy and ES
Most PES contracts are coined in terms of outcomes, i.e. land-use proxies -- such as, amount of forest cover – instead of proper impacts, such as carbon stocks or biodiversity habitat. In the longer term, linkages between proxy and ES must be verified. Sometimes, contracts can also be linked to both proxies and ES impacts, as some experiments show, also in Europe.

vi) Low transaction costs
PES systems may be fairly costly to establish (lengthy negotiation processes, possibly need for new institutions), while economic to operate once they are up and running. In Europe, many government-financed schemes seem to not have excessive transaction costs.

vii) Permanence
It is realistic to expect that land use and ES effects naturally dissipate when PES end, if the environmental problem persists: you only get what you pay for, as long as you pay. An exception would be PES designed as adoption subsidies for new technologies that, once in place, prove profitable in their own right. In Europe, particularly agri-environmental PES schemes hold examples of both transitory and permanent impacts on ES provision.

4. PES impact evaluations

The number of rigorous environmental impact evaluations conducted with a business-as-usual scenario about what would have happened without the intervention, to-date still remains limited. This is true globally, but especially so for Europe: a tradition of rigorous impact evaluations of incentive schemes has not been cultivated so far in the European context.

For PES, we found 17 rigorous impact evaluation studies for a dozen initiatives in just seven countries. A wide variation in land-use outcomes exists, even for the same PES programme applied in different regions. This underscores the importance of local contexts for environmental results. Many PES schemes have been carried out in low-threat environments, thus harvesting low-hanging conservation fruits – but when compared to matching baseline scenarios, their attributable impact is low. However, for other conservation tools, similar area selection biases prevail: PES are comparatively still doing fairly well – but not as well as they arguably could if some design errors were corrected.

Hence, PES have the potential to be direct, flexible, and effective instruments, but several flaws in PES design and implementation patterns have so far been observed. It seems PES could potentially

be upgraded in their geo-economic functioning: selection of both programme sites and in-programme contracted areas need spatial targeting to ES densities and threat levels, avoiding to predominantly pay for what would have happened anyhow. Payment differentiation and improved enforcement of conditionality with explicit sanctioning of non-compliant landowners will also help meeting design challenges. This also requires political will to boost environmental objectives, including in PES government-financed schemes that typically respond to multiple concerns.

5. European perspectives

In Europe, PES could have an alleged increased role through reforms of the Common Agricultural Policy (government-financed PES), and/ or through an increased realization on behalf of private actors that the European state regulation alone is unable to deliver the full suite of ecosystem services that service users and societies need (user-financed PES). In principle, public regulation could continue to safeguard a minimum threshold of ES delivery to society, while PES could be responsible for a 'premium ES delivery', i.e. over and above the minimum mandated by regulation. Such a sticks-and-carrot strategy could also be in the interest of landowners, who would not only have to carry the costs of basic environmental compliance, but would receive compensatory economic incentives on top, so as to make environmental protection efforts worth their while.

However, for this vision to play out, arguably a higher private willingness to pay would need to be triggered, so that the economics of PES could come to take off in Europe. We can only speculate here, but several sub-scenarios could be expected to become influential in that respect. One is that climate change would continue to increase the frequency of weather anomalies and catastrophic events, such as droughts, wildfires, stormflows and flooding, thus also increasing our societies' demand for environmental adaptation and mitigation – perhaps to an extent that sometimes financially pressurized public environmental agencies might not always be able to deliver. It would thus become increasingly clear to European citizens that they also need to privately pay for a set of ES that are crucial to their welfare.

In other words, while there are good structural explanations of the current scarcity of PES initiatives in Europe, it is also possible to imagine a series of game changers to this picture – with climate change arguably lining up as a root trigger. For forests in particular, unlike the tropical/ developing country PES focus on unanimously increasing forest cover, European forest-based, broad-scaled PES would likely be more complex. It would imply to some extent the conservation of open landscapes and mosaics, which sometimes will also imply to pay for keeping forest regrowth and biomass accumulation back from their business-as-usual expansionary forest transition path, i.e. spontaneous natural forest regeneration. More research will also be needed to determine which forest landscape reconfigurations could most effectively respond to a new set of environmental challenges, and how economic incentives can best be used to help push for the needed transformations.

Contents

Acronyms

CICES	Common International Classification of Ecosystem Services
EC	European Commission
EEA	European Environment Agency
ES	Ecosystem Services/ Environmental Services
EU	European Union
FES	Forest Ecosystem Services
IM	Innovative Mechanism
MBI	Market Based Instrument
n-MBI	Non-Market Based Instrument
PES	Payment for Ecosystem Services/ Payments for Environmental Services
SDG	Sustainable Development Goal of the United Nations
SEEA	System of Environmental Economic Accounting
SINCERE	Spurring INnovations for forest eCosystem sERvices in Europe
T	Task
ToC	Theory of Change
TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations
WP	Work Package
WTA	Willingness to Accept
WTP	Willingness to Pay

1. Introduction

As the need to adapt to a changing world draws increasing attention to the tensions between environmental degradation and development, a growing body of literature and practical experience on ecosystem services (ES) has arisen from the desire to more consciously address conservation and governance tradeoffs. The EU Horizon 2020 project "Spurring INnovations for forest eCosystem sERvices in Europe" (SINCERE) aims at developing a support structure for the development and implementation of Innovative Mechanisms (IM) in order to improve the provision of PES in Europe and to align the policy framework that encourages them.

A few decades of experience and academic literature on innovative mechanisms for setting up PES systems have laid a foundation to better understand the preconditions and variables that improve the likelihood of success in PES design and implementation. However, the vast majority of these experiences have been outside of Europe. This document draws on state-of-the-art knowledge about PES implementation from collaborative work developed through the SINCERE project, which has also been/will be featured in published articles. We have used quantitative evaluations of PES and related incentive tools, cross-sectional assessments (also known as "meta-studies"), and systematic reviews, supplemented by ad-hoc experiences of the authors, and those from selected secondary sources. We seek to provide a thorough and accessible review of best PES practices globally, and from that basis tentatively examine to what extent PES could be implemented more successfully in Europe. By reviewing the extensive literature on PES and PES-related tools, and by juxtaposing it to prevailing patterns of implementation and their environmental and welfare outcomes, we will also inform on core aspects of the future work developed by the SINCERE project.

Given the interdisciplinary nature of this project, the document aims to address diverse stakeholders from academia, policy, and practice by providing a general overview of PES, as well as other related innovative mechanisms. Chapter 1 will give an introduction as to how PES are intended to work, including as a novelty elaborating a generic theory of change for PES. Then, based on a wide body of literature worldwide, Chapter 2 explores the preconditions for PES, flagging some empirically confirmed variables influencing the emergence of PES programmes. In the following two chapters, we will deal with specific guidelines and best practices for the design and implementation of PES (Chapter 3), as well as the contextual factors that shape their impacts (Chapter 4). Chapter 5 then examines the European context through the lens of the global PES literature, best practices, and defined preconditions,. To further understand the potential impact of PES, Chapter 6 summarizes a recent systematic review to evaluate the quantitative environmental impacts of PES programmes worldwide. Finally, Chapter 7 synthesizes the conclusions from the report regarding global lessons, and looks tentatively into under what circumstances PES could be more successfully implemented in Europe.

In order for this collaborative work to be disseminated most effectively, a large part of its content has also been (or is in the process of being) made available as publications in academic journals:

- Wunder S, Brouwer R, Engel S, Ezzine-de-Blas D, Muradian R, Pascual U, Pinto R. 2018. From principles to practice in paying for nature's services. *Nature Sustainability*. 1(3): 145-150. doi:10.1038/s41893-018-0036-x
- Bösch M, Elsasser P, Wunder S. 2019. Why do payments for watershed services emerge? A cross-country analysis of adoption contexts. *World Development.* 119:111-119. doi:https://doi.org/10.1016/j.worlddev.2019.03.010
- Vaissière A-C, Quétier F, Calvet C, Levrel H, Wunder S. 2020. Biodiversity offsets and payments for environmental services: Clarifying the family ties. *Ecological Economics.* 169:106428. doi:https://doi.org/10.1016/j.ecolecon.2019.106428
- Wunder S, Börner J, Ezzine-de-Blas D, Feder S, Pagiola S. 2019. Payments for environmental services: past performance and pending potentials. *Annual Review of Resource Economics (under review)*. https://doi.org/10.1146/annurev-resource-100518-094206
- Börner J, Schulz D, Wunder S, Pfaff A. 2019. The effectiveness of forest conservation policies and programs. *Annual Review of Resource Economics (under review)*.

1.1 Payments for ecosystem services: definition and scope

Conservation practitioners worldwide are searching for more cost-effective and equitable ways of using scarce funds. Payments for Ecosystem Services (PES), also often referred to as Payments for Environmental Services, are an important attempt in this direction, having become increasingly popular over the last few decades. Following Wunder (2015), we treat the two terms in the following as quasi-synonyms. 'Ecocompensation', 'rewards', and 'conditional cash transfers' are examples of other terms being used for the same or similar environmental incentive mechanisms.

PES generally aim to incentivize landowners and other resource stewards to adopt environmentally friendly practices of protection, sustainable use, or restoration. PES are paid voluntarily by either private service users or public entities, compensating resource stewards contingent upon their contractual compliance. We can see PES as a predominantly private-lands counterpart to public protected areas, although in most countries the former is far behind the latter area-wise. "Private" would then need to be amply defined, e.g. including community lands, NGO or company-owned lands. In some cases, PES may also compensate private individuals or communities residing on public land, including protected areas or sustainable use reserves, whenever these private actors have clearly demarcated entitlements. PES contracts can range from short-term adoption of subsidies for preferable production technologies to models based on an indefinite duration of perpetual conservation easements (Kay 2016).

We define PES narrowly as voluntary transactions between service users and service providers that are conditional and based on agreed rules of natural resource management for generating offsite services (Wunder 2015). Various broader definitions exist, being more inclusive of PES-like mechanisms within the broader family of economic incentives (*ibid.*). In cases where environmental services (ES) are provided onsite (e.g. ecotourism on private lands), there are easier charging mechanisms existing than PES (e.g. site entrance fees or hedonically determined accommodation surcharges for surrounding natural beauty). Furthermore, onsite ES from which

landowners themselves benefit, such as conserving on-farm soil fertility, arguably do not need payments: landowners should be sufficiently intrinsically motivated to self-provide these ES.

PES were instead conceived for more difficult scenarios where extrinsic rewards are needed for safeguarding positive spatial externalities from landholders and resource stewards to society at large – whether near or far. Watershed protection, biodiversity conservation, and climate change mitigation are all prime examples of externality-driven ES. While these three ES types have dominated as raison d'etre behind PES, others form part of the joint motives behind public PES schemes, including the offsite visual landscape and recreational benefits.

Arguably, while some PES started as part of long-term environmental subsidy programs, such as the US Conservation Reserve Program (Claassen et al. 2008), the big push for PES in this millennium came from economists. They argued, based on the seminal work of Coase (1960), that direct payments from ES users to providers could be more cost-efficient than indirect approaches (Ferraro and Simpson 2002; Ferraro 2001; Ferraro and Kiss 2002; Simpson and Sedjo 1996; Pagiola and Platais 2002; Wunder 2005). Since then, in the context of forests most PES programs have featured forest conservation (Alston et al. 2013). Geographically, PES have been most popular in the Americas (North, South, Meso) (Börner et al. 2017; Salzmann et al. 2018; Snilsveit et al 2019).

1.2 Related innovative mechanisms

A defining feature of PES is conditionality: the *quid-pro-quo* principle of reducing or stopping payments when ES are not being adequately provided. PES thus represent a new paradigm of voluntary, contractual conservation, where ES providers choose whether or not to join a PES scheme, but ES users or funders allegedly only pay for what they get (Angelsen 2017).

However, PES are not the only innovative incentive mechanisms using conditionality.
First, forest-based climate change mitigation known as REDD+ (Reducing emissions from deforestation and forest degradation, fostering conservation, sustainable management of forests, and enhancement of forest carbon stocks) can be seen as a PES-like arrangement between industrial greenhouse gas (GHG) high-emitting countries and forest-rich countries (Wertz-Kanounnikoff and Angelsen 2009). The idea of compensated reductions in forest-based emissions that is behind REDD+ entered the international climate change negotiation at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties in Bali in 2007. Since then, hundreds of REDD+ subnational pilot projects have been carried out, though only few of them have been evaluated for their environmental impacts (Duchelle et al. 2018).

Second, green certification has also emerged as a relevant mechanism, using the labelling of commercial products as a point of leverage from the consumer side. Green certification is also a voluntary, conditional mechanism in promise of price premiums for environmentally benign production, linked to product markets (van der Ven and Cashore 2018), where PES are typically area-based, spatially specific instead. It is also a voluntary process through which a certifier, typically an independent third party, defines a set of standards to assess the quality of natural resource management and production, typically at the lower end of the value chain (Pokorny et al 2011). These standards are usually determined by a public or private certification organization to

the end of improving social and environmental practices. Although certification schemes may be reinforced or incentivized by regional government institutions, producers decide whether they will join the certification scheme, often based on financial benefits, moral priorities, and the ease of implementing the imposed requirements. Among these financial benefits is the idea that consumers will pay a premium for socially and environmentally sound production practices. As van der Ven and Cashore explain in the case of forest certification, "certification schemes attempt to steer the behaviour of consumers through the provision of information to support environmentally appropriate, socially beneficial, and economically viable forest management" (van der Ven & Cashore 2018).

Due to challenges to research design, insufficient or inconsistent data, deviations in measured outcome variables, and the ever-shifting landscape of certification standards, the existing research cannot make conclusive generalizations about the effectiveness of certification. However, many reviews provide recommendations for improving future research and broadening the scope of considered outcomes to include more easily measurable impacts. Among these impacts are the behavioural shifts expected not just among producers, but in public policy and consumer preferences. According to Gibbon et al, compliance with certification standards may also have the effect of providing producers with a set of tools and best practices to responsibly manage natural resources to achieve social, environmental, and financial goals (2011). Additionally, context-specific cases draw strong correlations between certification scheme implementation and improved social and environmental circumstances, specifically within the forest sector.

Third, ecological fiscal transfers (EFT), such as Brazil's ecological value-added tax (Grieg-Gran 2000) or India's annual 7-12 billion US$ intergovernmental pro-environmental transfers (Bush and Mukherjee 2018), represent fiscal revenues transferred conditionally from higher- (e.g. national) to lower-level government (e.g. municipalities). The amount of each transfer typically depends on the size and quality of protected areas management, or some other form of environmental protection or maintenance: a kind of PES between government bodies. This is a policy instrument designed to provide "incentives to local governments to maintain or increase biodiversity conservation activities which provide ecological benefits to society in general" (Schröter-Schlaack et al 2014). These indicators, which could be considered enabling conditions, define the sum distributed to different local governments. They have an environmental basis, such as number of hectares of protected area, or percentage of a municipality that is designated to protected areas (Ring 2008).

When EFTs are not fully conditional, they are likely to be most effective when paired with protected area policies, management best practices and guidelines, PES schemes, certification, or other governance frameworks or regulations that can more clearly lead to positive environmental and social outcomes. Then, EFTs function primarily as a funding mechanism, and can be evaluated based on clear environmental actions or expanded conservation space, rather than being measurable only in relation to the amount of pre-existing conserved area (Schröter-Schlaack et al. 2014; Droste et al. 2018). EFTs, like traditional fiscal transfers, are proven to be social and economic equalizers, successfully mitigate the economic compromise for local governments to maintain protected areas, and provide opportunities to integrate PES schemes on a trans-governmental level. An exception for this is the case of Brazil, the oldest EFT use case, as the way this transfer system was implemented also incentivized the creation of new protected areas so that

municipalities could receive increased compensation through the EFT programme (Ring 2008). Additionally, EFTs generally draw national, regional, and local policy attention to the need for economic incentives for nature conservation.

Finally, the PES principle of conditionality is also being used in other mechanisms like biodiversity offsets but, unlike for PES, here an upfront biodiversity loss from development activities is being permitted (Vaissiere et al. 2020), thus having closer ties with the environmentally regulated 'polluter pays' principle. Conversely, PES follow the 'provider gets' principle, building on different entitlements in natural resource management (Mauerhofer et al. 2013). Various cap-and-trade mechanisms around legal (or business self-imposed) environmental regulations can share some PES features, but are all focused on an initial pollution problem. Some global PES assessments are all-inclusive of these so-called 'market-based mechanisms' (e.g. Salzman et al. 2018), yet noteworthy differences in goals, functions and impacts persist.

As a novelty for this PES review, we will develop an elaborate theory of change for PES, which is an organizing principle that allows us to functionally examine the imminent strengths and weaknesses of PES, flagging key causal-chain transitions and revealing critical assumptions that are useful to evaluate their potential use, and effectiveness, in a European setting.

1.3 Theory of change: a conceptual tool

A theory of change (ToC) is an instrument for making explicit the linkages between the causal chain elements of inputs, treatments, output, outcomes, and impacts (Weiss 1997). ToC is thus a tool for developing stepwise, logically sequenced solutions to complex social or socio-environmental problems. In particular, a ToC can explain how early and intermediate accomplishments, respectively, can set the stage for longer-term results. In addition, throughout the ToC planning process, key critical assumptions about external conditions and contextual factors can be flagged. Different stakeholders can thus also clearly connect their actions to an assumedly shared, bigger, longer-term goal, and along the way identify potential risks by making explicit the underlying assumptions in each step of a logical sequence.

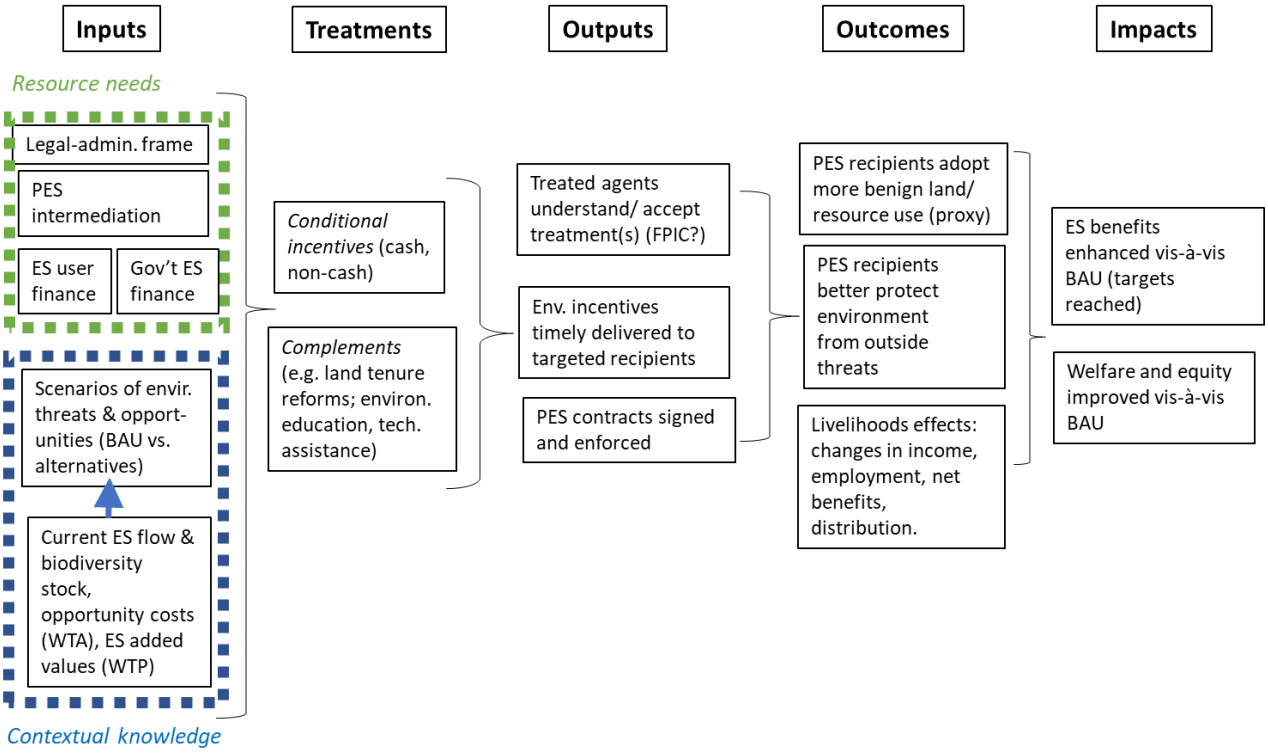
The ToC framework is especially well-suited to situations where final, long-term goals are hard to measure objectively in the short run, given their probabilistic (e.g. a more fire- or flooding-resistant landscape) and/or perceptive nature (e.g. a recreationally attractive landscape). In these situations, the ToC can help by instead designating intermediate measurable indicators that can serve as progress-tracking proxies along the way to the accomplishment of long-term, hard-to-quantify goals. These proxies may then be combined with modelling tools that can nail down additional assumptions to go from the achieved proxies to the desirable goals. A ToC is thus also a potentially important tool in guiding the process of impact evaluation.

Finally, a ToC also allows for a "backwards mapping" process in planning new interventions, where, from a pre-set bundle of long-term goals/outcomes, the planning team can normatively identify the necessary conditions and inputs to reach these goals: what would need to be done to make sequential progress in a chain of socio-environmentally interdependent actions leading to the long-term super-goal(s)?

1.4 A PES theory of change

Here we will present an integrated PES ToC, following the structure described in the previous section. In the concluding section of this document (Section 7), we will then return to the same ToC diagram, examining what were found throughout the document to be the main assumptions, in terms of PES design and implementation parameters, that are needed to make PES function properly, according to the current state-of-the-art knowledge.

Figure 1. A generic theory of change for PES



Source: (Wunder et al. 2019)

Prior to designing and implementing any PES action, typically a series of financial, legal-administrative and institutional-mediating conditions are needed, which we will describe in detail below. However, also a series of knowledge-oriented *inputs* are required: the likely economic willingness to pay (WTP) of service users, as well as the willingness to accept (WTA) of potential service providers, can be gauged through feasibility studies, allowing the implementing organization to frame the PES negotiations.

Once these inputs are in place, the PES *treatment* can be designed and executed – referring to the intervention that is meant to trigger a desirable change -- in this case, designing contracts and payment conditions. The *output* level will then tell us whether the designed treatment of paying landowners or -users conditionally was or was not effectively implemented, i.e. reaching targeted stakeholders as planned.

The *outcomes* refer to actual changes that PES is supposed to achieve on the ground, typically in targeted land-use proxies (e.g. trees planted, forest cover enhanced, habitat preserved, livelihood systems changed, etc.), thus enabling the eventual ES delivery. The ES delivery itself is described in the final level of *impacts*: given that, for instance, deforestation supposedly was halved through PES contracts, what incremental forest carbon was preserved in the entire target area? How many species could now locally survive? And, how much was drinking water quality from the watershed improved, compared to what would have happened under a business-as-usual scenario?

A key design question is the following: if PES is about conditional ES delivery, is contract conditionality then also applied at the final ES impact level, or elsewhere in the course of the ToC stages? That is, are service-providing landowners only paid to the extent that service users are receiving an actual incremental ES delivery?

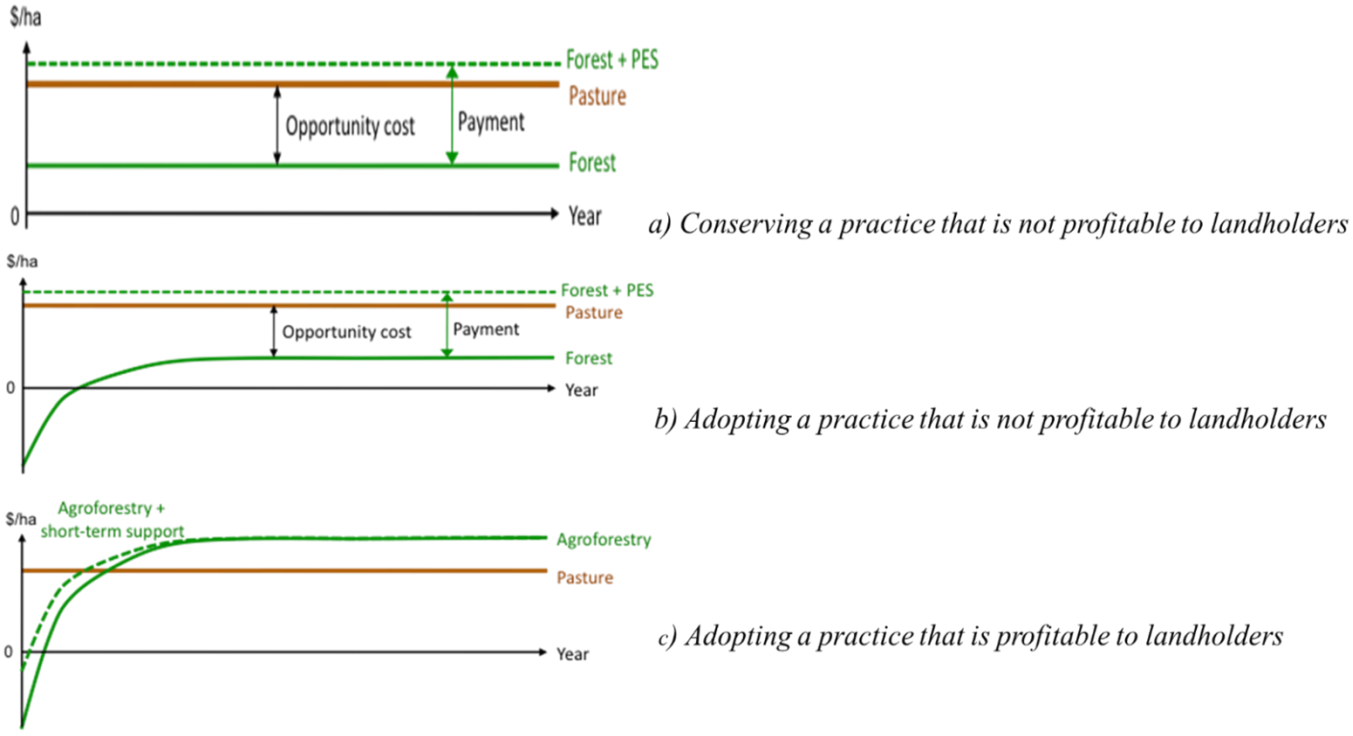
In fact, at least three different scenarios exist for when and how conditionality is applied to ES delivery: payment can happen after services are fully delivered, before any service is delivered, or based on the realization of a proxy for ES delivery. Indeed, especially in some forest carbon projects, the incremental carbon captured is measured and paid for (Tacconi et al. 2010). Conversely, other REDD+ projects using PES pilots have paid already at the input level – e.g. for communities adopting revised land-use plans featuring more forest conservation (Sills et al. 2014). Yet, the clearly most common nesting of PES conditionality occurs at the outcome level: landowners will get paid once they have complied with agreed-upon land- and resource-use proxies (e.g. protecting a certain on-farm forest area). This constitutes often a convenient Goldilocks solution between ES users having full certainty about ES delivery (impact-level payments) and ES providers assuming zero risk in ES delivery (input-based payments).

2. Preconditions

2.1 Basic economic rationale for PES

PES are based on a voluntary willingness to pay (WTP) on behalf of ES users (or their 'government-financed' representatives) and a corresponding willingness to accept (WTA) payments on behalf of ES providers. Figure 2 depicts different WTA scenarios from the ES providing landholder's perspective. Figure 2.a shows the logic of using PES for conservation, featuring landholders' net benefits undertaking a given activity, as compared to the environmental consequences of those private decisions for society, i.e. public or private external ES users. This figure does not include the benefits to downstream users or the global community of undertaking activities such as forests or agroforestry, and neither the costs imposed on others by environmentally harmful activities.

Figure 2. PES and landholder practices – profitability scenarios



Source: Wunder et al. (2019)

To give a concrete example, the environmentally damaging activity is labelled here as 'pasture' and the ecosystem to be conserved is labelled 'forest' In the example, forests assumedly generate lower benefits for landholders than pasture. Landholders thus have strong incentives to convert forests to pasture, and would bear conservation opportunity costs otherwise. PES work by sufficiently increasing the net benefits to landholders of conserving forest to equal or exceed conservation opportunity costs. Notably, landholders' incentive to conserve forest lasts only as

long as they receive payments: should payment cease, pasture would once again be more profitable, as the basic externality problem persists. To be effective, conservation payments must thus be made continuously. Real-world examples are various government-financed forest conservation PES programs, such as in Costa Rica (Pagiola 2008) or Mexico (Muñoz-Piña et al. 2008).

Figures 2.b and 2.c show the logic of two cases of using PES for restoration: one where the restored land use is also not profitable *per se* for landholders vis-à-vis current 'pasture' use (2.b), while alternatively it is profitable (2.c). In 2.b, pasture is allegedly replaced by a conservation practice ('forest'), providing superior ES but lower private returns. Changing pastures to plant forest thus carries an opportunity cost for landholders. Yet, a sufficiently large short-term subsidy might induce landholders to still adopt such practices, although a risk persists for them to abandon these in favour of the more profitable pasture once the subsidies end. The Reflorestar Program in Espírito Santo (Brazil) is one such example (Pagiola et al. 2019).

In Figure 2.c, pasture is replaced by productive yet ES friendly practices ('agroforestry') that are assumedly more profitable for landholders than pasture once established. However, switching practices involves significant outlays for initial costs (for seedlings, fertilizer, labour, etc.), while returns increase only later. If landholders are credit-constrained and/or highly risk averse, they will refrain from agroforestry adoption. Using PES here as a short-term, time-limited adoption subsidy to compensate some upfront costs might persuade landowners to establish agroforestry, and later maintain the system thanks to its superior long-term economic returns. Examples are some contracts under a trinational GEF-financed silvipastoral project (Pagiola et al. 2016, 2017) or under the Chinese Sloping Land Conversion/ 'Grain for Green' Program (Bennett et al. 2008, Fu et al. 2019).

PES thus align private land- and resource-use decisions with broader societal interests. Research and practice suggest that they have potential for direct, performance-based actions, while still facilitating fair and flexible negotiations – this unique combination has attracted attention from policymakers and conservationists (Brouwer et al. 2011). ES users typically pretend to 'rent out' certain partial land rights from landowners, e.g. the right to deforest. This only works when ES provision can be well-monitored and enforced, and when landowners can flexibly change their preferred modes of production. Otherwise, ES users might prefer to buy out environmentally sensitive lands entirely (e.g. creating municipal reserves for spring protection), although becoming responsible for land stewardship may also be costly.

The literature distinguishes between several types of PES. First and foremost, in so-called user-financed PES the ES users pay directly, while in government-financed PES a public body pays on their behalf (Engel et al., 2008). An example could be a hydroelectrical power plant that is interested in diminishing erosion and in stabilizing seasonal waterflows, and thus pays the aforementioned farmers to keep more forest (and convert less land to pasture) than they would have done otherwise. User-financed PES may often be more effective in directly overseeing contractual delivery: the direct interest means that mechanisms typically exist to monitor compliance, and thus reduce or stop payments if the contract stipulations are not being followed in a satisfactory way. However, creating a new institutional framework for PES may often be expensive in terms of start-up costs, and situations with multiple ES being provided simultaneously can be challenging to handle.

On the other hand, government-financed PES, where a government body acts as a representative of ES user interests, also has its pros and cons. The less direct ES relationship, and intertwined political interests, may mean that it is harder in those kinds of setups to stop paying in case of non-compliance. Yet, these schemes may more effectively address imminent ES free-rider problems by taxing multiple users (e.g. for biodiversity protection), and more cost-efficient in organizing payment programs at scale. They may thus exhibit a superior performance in terms of addressing ES user collective action. By being able to draw on pre-existing public regulatory bodies, government-financed schemes may also be better at keeping transaction costs at bay.

As for other typology distinctions, some PES initiatives are environmentally asset-building (e.g. planting trees), while others are activity-reducing (e.g. avoiding deforestation for conversion to alternative land uses). They thus have different implications for local livelihoods: the former may create new employment options, the latter may at least in the short run reduce those employments that were relying on environmentally degrading activities, such as unsustainable timber harvesting or agriculturally motivated forest conversion (Wunder 2005).

2.2 Binding conditions

In Figure 1 we argue that appropriate contexts for PES typically contain a mixture of factors, ranging from socioeconomic and biophysical knowledge about baseline and projected scenarios, to the presence of economic, legal-administrative, and institutional resources needed for carrying through with a PES treatment. From the literature about failed PES attempts (e.g. Wunder et al. 2008), institutional PES requirements (Farley et al 2010; Vatn 2010), critical assessments of PES processes in general (e.g. Muradian et al. 2013; Pascual et al. 2010; Wunder 2013), and our economic reasoning in the previous subsection, we can point to three preconditions of singular importance influencing whether or not a PES scheme will emerge:

i. **Economics***: User-perceived ES value exceeds landholders' expected costs of ES delivery*. This is a fundamental economic reality check for PES. Usually we know neither the precise value of the ES nor the precise cost of service provision, but we can make informed guesses – and we would expect that ES providers and users normally have a consolidated vision of their own potential gains and costs. If the expected environmental gains fail to outsize the costs in value terms, especially for the opportunity costs of service provision, PES will not materialize (Wunder et al. 2018). In other words, payment on balance needs to suffice to motivate ES providers to voluntarily and sustainably deliver more ES. Beyond alleged hard biophysical and economic facts, this also entails the right perceptions: an environmental awareness, and a vision of problems and their potential resolution is needed, especially on behalf of ES users or their government representatives. Often, this awareness is stimulated when incipient environmental problems emerge: frequent power or water cuts, inundations, or other 'small catastrophes' are often conducive to a societal alertness that favours PES development.

ii. **ES related institutions***: Stable payment vehicle(s) have been identified and the PES implementing/ intermediary institution is seen as legitimate.* Not only does there need to be a genuine economic argument for PES (cf. i.), but (sometimes multiple) ES beneficiaries also need to be able to self-organize in ways so that payments materialize (e.g. controlling ES free-riding). By far, most PES programs work with institutions

explicitly acting as intermediaries between ES providers and users (e.g. Landell-Mills and Porras 2002). Local leadership in this self-organization, on the ES user as well as the provider side, is often a key limiting factor. Whether direct implementers or intermediaries, these institutions need to be seen by ES providers as legitimate actors to enter into contractual arrangements with – which may involve lengthy negotiations and trust-building.

iii. **Land tenure***: Potential ES providers have sufficiently clear property rights to their land and resources.* Within the layered bundle of property rights to natural resources (Schlager and Ostrom 1992), potential ES providers need to have not only 'management rights' (collectively accepted rights to use and transform resources) the resource, but at least the 'rights to exclude' (keeping out externals) – which in turn needs not entail 'alienation rights' (i.e. formal land titles and rights to sell property); informally recognized but secure rights may suffice (ibid: 251). More specifically, landowners and resource stewards thus need to actually be in charge of the decision-making processes that will come to determine ES provision. In tropical forest frontiers with problematic governance (e.g. ill-defined boundaries, overlapping land claims, rural violence), this broader institutional requirement can be a killer assumption for PES.

We should probably see the first precondition as an economic *sine qua non* for PES. If ES supply costs exceed ES demand values, the very foundation for voluntary agreements will be missing – and hence the ES institutional and land tenure preconditions become obsolete. If any of the other preconditions (ES institutions or land tenure) is not met, PES implementation might still be possible if it is enabled by supplementary actions, for example, land tenure reform, contract negotiation, institutional capacity building or incentives better customized to motivations. However, these preparatory actions typically take time and resources, and might also affect subsequent PES design choices, as elaborated in Section 4. While the principle behind PES may appear simple, as a tool PES is institutionally demanding. This implies that, in practical terms, although there may be a clear economic argument for PES, in many such scenarios institutional PES will not emerge if they are accompanied by institutional backwardness.

2.3 Other PES conducive factors

Beyond these alleged primary PES-preconditioning factors, we can use meta- and cross-country studies to recognize at different aggregation levels a set factors that will co-determine the likelihood of PES schemes to emerge. To do this, in this section we will look at the presence or absence of payments for watershed service programs – the single most common type of PES (Ezzine-de-Blas et al. 2016). PES regional literature reviews, including by Ferraro (2009), Greiber (2009), Huang et al. (2009), Southgate and Wunder (2009), Tallis et al. (2009) and Stanton et al. (2010) all identified a set of national-level PES conducive variables:

a) *Legal system and property rights*

Resoundingly, the PES literature shows that an appropriate institutional environment is essential for adopting payment programs, thus reconfirming the previous subsection where the institutional setting is framed in two of the three key preconditions for PES success at the micro level. Two key

attributes of a country or region's institutional environment can help foster PES: the general legal framework and specifically land property rights regime. Having a "clear and coherent legal framework" is important for the smooth implementation of PES mechanisms; unclear or convoluted legal processes can in turn complicate, delay, and hinder the adoption of PES (Greiber 2009). Similarly, insecure property rights among landowners make these unreliable ES providers: they have no de facto control over access to (and degradation of) "their" land. This introduces risk for investments in land development or protection on the part of both PES users and providers.

b) *GDP growth*

The PES underlying resource dynamics (ES demand and supply) will be affected by a country's GDP growth and accompanying structural transformations. A growing economy would expand its 'footprint' use of natural resources, but also the availability of employment options that are not directly tied to natural resources. Willingness to pay for amenities like environmental protection might increase. Conversely, rapid GDP growth could reflect more emphasis on products that compete with or preclude the adoption of PES schemes, like high-value commodity crops or natural resource extraction (Huang et al. 2009). The variable thus seems to be important, but expectations are ambiguous.

c) *Openness to trade*

Some analysts see PES as exhibiting a strongly a market-oriented, neoliberal approach to managing socio-environmental problems (Wunder 2007; Huang et al. 2009; Muradian et al. 2010; Farley & Costanza 2010). Thus, depending on the political and ideological tradition of a given country, the market-based PES approach may be viewed as either fully in line with society's value, or alternatively as inappropriate, meeting with resistance from local populations. A country's openness to trade (measured as the sum of exports and imports as a proportion of GDP) could be linked to the positive perception and uptake of PES – given that it itself constitutes a medium of trading ES.

d) *Demographic distribution*

Commonly, forest-based ES have their origin in rural areas, while most of the demand for ES tends to come from urban areas. The distribution of a country's population could thus reasonably be expected to impact the relative scarcity of ES, and thus also the willingness to implement PES schemes. In the case of watershed services, this is perhaps most obvious: high population density downstream would stimulate aggregate WTP while, conversely, sparsely populated upstream rural populations would decrease the cost of PES implementation and compliance monitoring: there would be fewer people at the cost end of PES. A high urbanization rate would thus seem to be conducive to the emergence of PES.

In a cross-country study, we tried to econometrically explain the presence or absence of payments for watershed service programs – the worldwide single most common type of PES – in tropical developing countries (Bösch et al. 2019). Grouping countries into with and without incidence of established watershed PES schemes, we were able to use logistic regression to scrutinize factors potentially explaining the presence or absence of these PES systems.

First, the macroeconomic variables GDP growth and trade openness did not come out as significant: their impact proved to be too ambiguous. Second, we found the presence of consolidated legal and property rights systems to significantly increase the likelihood of PES emergence nationally (reconfirming our tenure precondition), but also other factors were at play: and elevated urbanization rates (relatively more downstream payers, vis-à-vis less upstream payment recipients) came out as significant explanatory variables. Third some additional biophysical factors, not considered in the previous literature, were also influential: a rugged topography (stronger upstream-downstream dimensions, such as erosion and flooding risks), and high water quality and quantity (meaning high ES were at stake to protect), proved to have significant effects. On aggregate, biophysical, socioeconomic and institutional contexts alike thus co-determined the likelihood of PES establishment.

3. Design and implementation

Although we typically do not have experimental evidence allowing us to separate out the impacts of different PES design modalities with rigorous methods, the theory about PES design (Engel 2016), case-study comparisons (Brouwer et al. 2011; Sattler et al. 2013; Wunder et al. 2008), and experiences from other incentives (Jack et al. 2008) make it increasingly clear what specific PES design and implementation features are likely to strongly influence PES outcomes and impacts. The meta-study by Ezzine-de-Blas et al. (2016) attempted a binary classification of expert-perceived environmental additionality ('significant ES impact or not?') of 55 PES cases worldwide. Three design and implementation factors stood out as significant for determining additionality (Wunder et al. 2018), to be discussed below:

i. Targeting contracts to high-ES and high-threat areas (counteracting adverse selection biases)
ii. Cost-efficient payments (aligned to provider opportunity costs and ES values), and
iii. Non-compliance monitored effectively and sanctioned (i.e. enforced conditionality)

3.1 Spatial targeting

ES are usually distributed heterogeneously in space: biodiversity hotspot areas exist, carbon densities vary across the landscape, and critical hydrological response units (high slope, erodible soils, etc.) are disproportionally important for downstream hydrological services. In short, some places are more important for conservation than other places (Wunder et al 2018). The corresponding ES peaks usually do not coincide in space, thus implying tradeoffs (Chan et al. 2006; Locatelli et al. 2014; Wünscher et al. 2008). Bundling different ES into one PES intervention requires a good understanding of the underlying ES tradeoffs (Naeem et al., 2015).

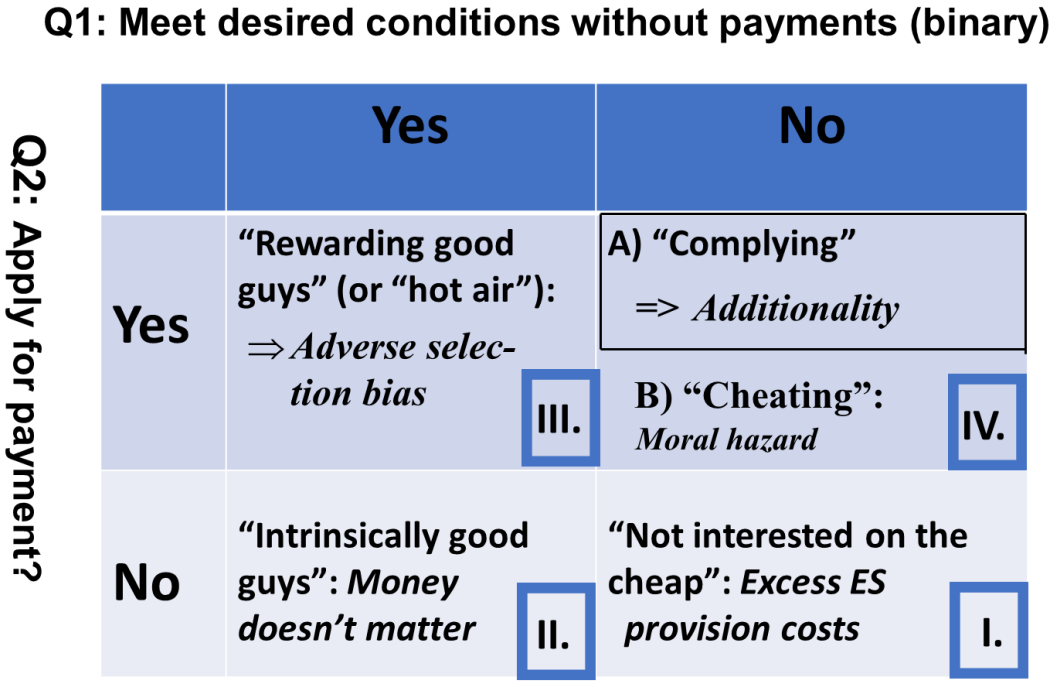
However, additionality is not only shaped by ES density, but also by the degree of environmental threat, or more generally, the ex-ante leverage of change (including also the likelihood of ES improvements to occur under a business-as-usual scenario). Threats such as deforestation or habitat degradation tend to be unevenly distributed in spatially predictable manners, e.g. near cities, roads, in areas with fertile soils, etc. (Geist and Lambin 2002). Which areas have an ex-ante potential 'to make a difference' vis-à-vis projected threats thus becomes important for PES design (Alix-Garcia et al. 2008) – or, for that sake, for any spatially explicit conservation action (Carwardine et al. 2012).

Given that investment in implementing PES projects in all places where some ES are available would be costly and require significant organizational infrastructure, it makes financial and logistical sense to focus on developing PES in target areas that have both high density of ES and face high environmental threats. Theoretically, these areas would provide significantly more benefits than a random spatial selection (Wunder et al 2018). The scarcer the PES budgets available, the less land that can be enrolled, and the more important will it be to adopt an adequate targeting approach.

Figure 3, adapted from Persson and Alpizar (2013) spells out some targeting considerations. The 2x2 table registers answers to two questions:

- **Q1**: Does the potential ES provider already (plan to) meet PES-stipulated environmental conditions (yes-no)?
- **Q2**: Does the potential ES provider apply for PES participation (yes-no)?

Figure 3. Additionality of ES providers



Source: Wunder et al. (2019), adapted from Persson and Alpizar (2013)

Going clockwise from the Southeasternmost Cell I (Q1: no; Q2: no), ex-ante non-compliant landowners that do not apply for payments often face excessive opportunity costs (alternatively, landowners could also lack confidence in PES implementers, resent the loss of autonomy/ flexibility in PES contracts, etc.): the PES offer is not attractive enough to change their pre-determined first-best, privately optimal land-use plan (cf. Section 2). Cell II (meets conditions already, but will not apply for PES) holds altruistically motivated landowners who conserve for intrinsic reasons, thus rejecting extrinsic motivations. Groups I and II thus remain outside of the PES programme.

Cell III refers to those who pre-comply and also apply for PES: a positive spin is that PES here function as rewards for good resource stewardship, allegedly persuading them to also remain so, and serving as a positive example to others. However, a negative spin is that paying this segment of landowners *per se* does not create incremental ES delivery (no land-use treatment effect on the treated): they are being paid for status quo ("hot air"). Finally, Cell IV contains the environmental impact-oriented segment of PES: those who did not comply before, but are willing to enter into PES contracts, and allegedly will change land use accordingly (IV.A). However, some will likely

continue their business-as-usual practices of non-compliance while also receiving PES, unless they get caught (IV.B). A moral hazard problem may emerge if the monitoring and sanctions system does not work adequately, implying that the overall additionality of PES will be reduced (Hart & Latacz-Lohmann 2005). It is exclusively the landowner group aligning with Cell IV.A that will produce additionality, i.e. ES provision over and above baseline.

Hence, PES contain an imminent danger of enrolling too many pre-compliant (Cell III) and too few pre-noncompliant (Cell IV) participants: the former "anyway" candidates will likely be the first ones queuing to sign up for PES, given their zero opportunity costs, and thus -- transaction costs apart -- prospects for receiving an economic rent (Ferraro 2018). This is what is referred to as *adverse self-selection bias* in the PES literature (Bottazzi et al. 2018; Burke 2016; Sims and Alix-Garcia 2017; Giudice et al. 2019): the danger of getting a structurally inadequate composition of participants in PES programmes.

How serious a problem is adverse self-selection of ES providers? We will argue below that selection biases may be the single biggest design challenge for PES implementation. It is difficult to analytically separate groups III and IV, because often (unobservable) intentions and plans for future land-use decisions are involved. Bottazzi et al. (2018) found for a regionally scaled-out watershed PES protection program in Bolivia that only 39% of contracts to exclude cattle from riparian areas, and 14% of those to prevent deforestation, appear to have been additional, according to self-stated declarations of what farmers would have done without PES.

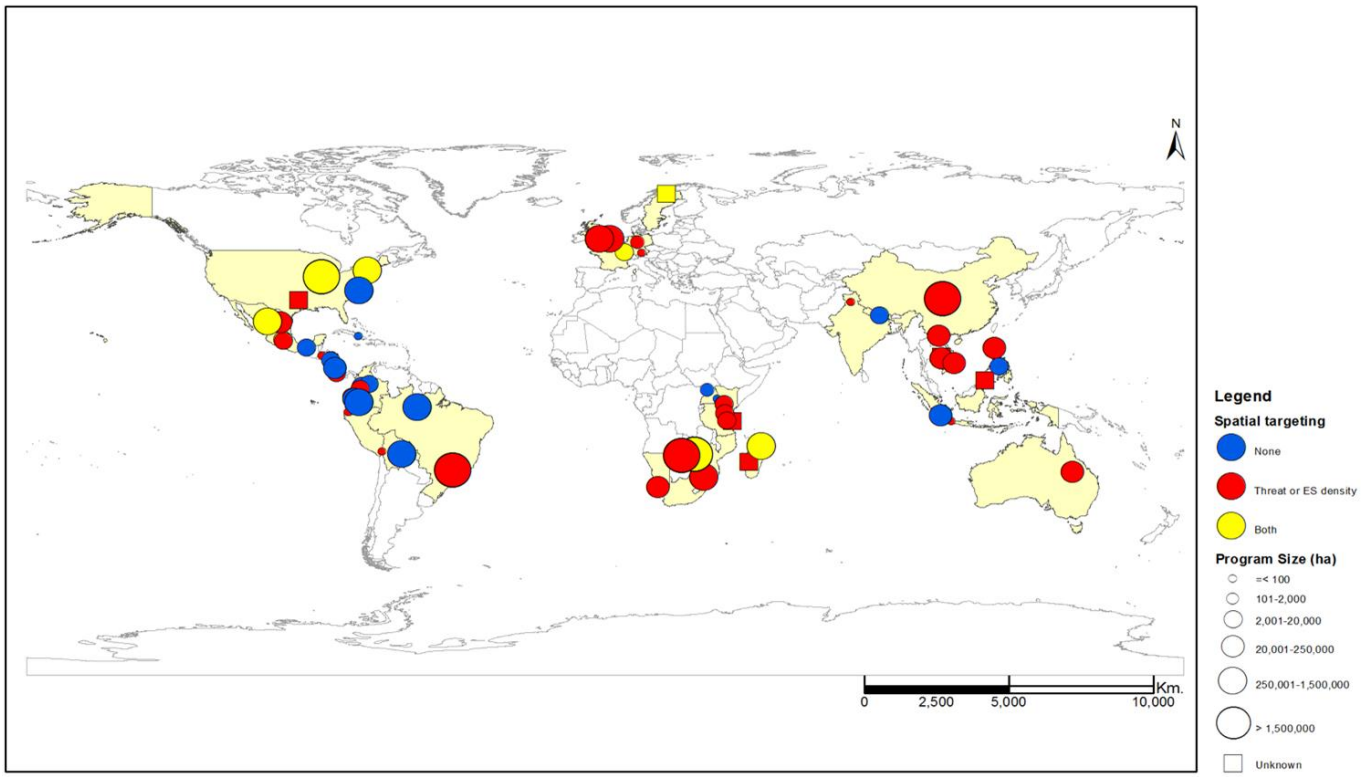
It is noteworthy that PES is not alone in facing this adverse selection challenge: any conditional instruments with voluntary agent participation (i.e. REDD+, certification, etc.) listed in Section 1 is subject to the same problem of having "anyway" participants signing up. And, whereas some observers refer to additionality as "the holy grail of PES" (Bottazzi et al. 2018: 11), additionality should be a concern for any conservation instrument – a protected area, a certification scheme, or a new forest law: how much real difference a particular instrument makes should rather be the holy grail of conservation *per se*. Active threat-oriented targeting efforts thus needed to counteract an excessive degree of adverse participant self-selection.

Drawing on a detailed PES empirical study (Wunder et al. 2018) containing 70 cases (both user- and government-financed), we show in Map 1 the degree to which these initiatives have made use of both threat and ES density-motivated targeting (yellow circles), either of these two targeting criteria (red circles), or none of them (blue circles). The size of the circles shows how large these schemes are area-wise. Around two thirds of the schemes belong to the in-between category of one targeting criterion; around 10% have used both. Size apparently does not matter for the targeting decisions. In Europe, typically some targeting efforts are made, typically also here using one criterion, but seldom both.

Finally, other targeting criteria may include proxies for provision costs, especially when budgets are scarce and provision costs heterogeneous, so that cost-efficiency becomes even more important (Engel 2016; Ferraro 2008). However, this criterion needs to be effectively overlaid with other spatial criteria, since focusing on low-cost providers alone may come to screen in precisely those providers who are *ex ante* compliant, and who, with zero opportunity costs, are willing to compete down to the lowest payment levels. For biodiversity-focused payments in particular, targeting

requirements of spatial contiguity or minimum area size may feature agglomeration bonuses for the enrolment of collective providers (Fooks et al. 2016; Jack et al. 2008; Polasky et al. 2014).

Map 1. Spatial targeting and selection of ES providers



Source: Own elaboration (with R. Pinto and R. Brouwer), based on Wunder et al. (2018)

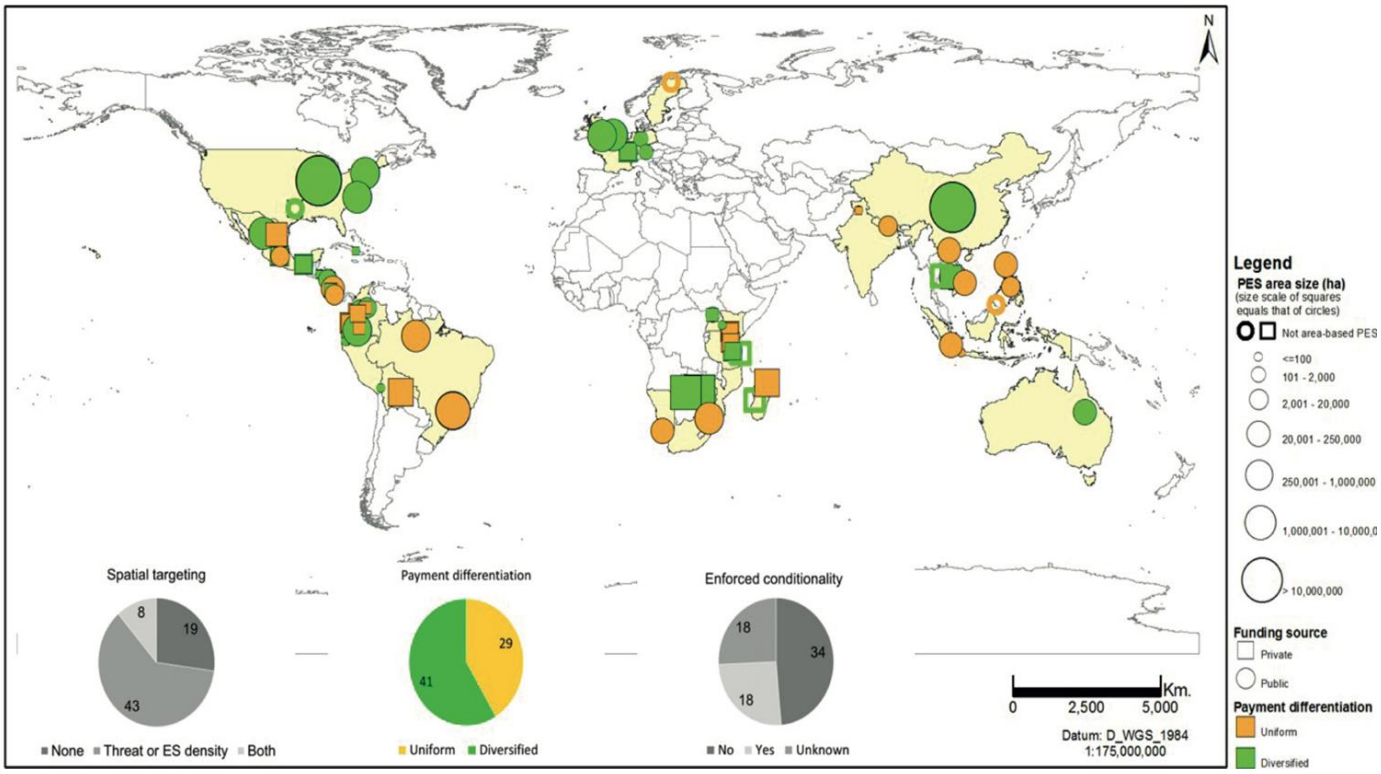
How much is spatial targeting applied in practice? In a global sample of 70 cases, half used ES-based targeting criteria, i.e. proxies for ES density – some, such as the Mexican national PSAH scheme, as a multicriteria ES function (Muñoz-Piña et al. 2008), though most targeted just a single criterion. Threat targeting was much less common (9% of cases). About one third of cases used no targeting at all; only 14% of cases combined ES density and threat in their spatial targeting (Wunder et al. 2018).

3.2 Payment differentiation

When costs of provision are heterogeneous, usually differentiated payment systems are preferable (Engel et al. 2016). This requires that cost proxies can be used to address problems of asymmetric information about these costs (Ferraro 2008), including types of agricultural or forestry producers, proximity to roads and other infrastructure, soil fertility, etc. Differentiated payments can of course also be a tool to attract high-ES providing lands, e.g. paying more for primary than for secondary forest conservation.

A particular way of aligning payments to costs are conservation tenders, i.e. inverse procurement auctions where landowners bid for and are awarded contracts according to their cost effectiveness, as specified in pre-set rules (Burke 2016; Fooks et al. 2015; Khalumba et al. 2014; Polasky et al. 2014; Whitten et al. 2017). Auctions can be complex to organize, require good ES-related information about bidders, and may thus be difficult to take to the scale of national programs. This has been done though in the US and Australia, taking advantage of rich biophysical information about land characteristics. Concerns about auctions, basically designed to minimize informational rents among ES providers, may surface on equity grounds when ES providers are predominantly poor. Auctions have thus been less applied in developing than in developed countries. Still, small-scale auctions can be optimal tools to extract ES provision cost information in PES pilot phases, defining later a few simple payment tiers (Wünscher and Wunder 2017).

Map 2. Payment differentiation



Source: Wunder et al. (2018)

In the aforementioned 70-case PES sample, half of the cases used some payment differentiation (Wunder et al. 2018). The geographical distribution is shown in Map 2. We see here a clear difference: developed countries (Europe, North America, Australia) and even high middle-income countries (China, South Africa, Mexico) are much more into differentiated payments than in lower-income countries, where uniform payments dominate – independent of the size of the PES initiatives. In poor countries, equity and poverty alleviation concerns are much more prominent for PES design choices than e.g. in Europe. The strong resistance against diversified payments in the former countries is typically based on arguments about horizontal equity, i.e. that (assumedly)

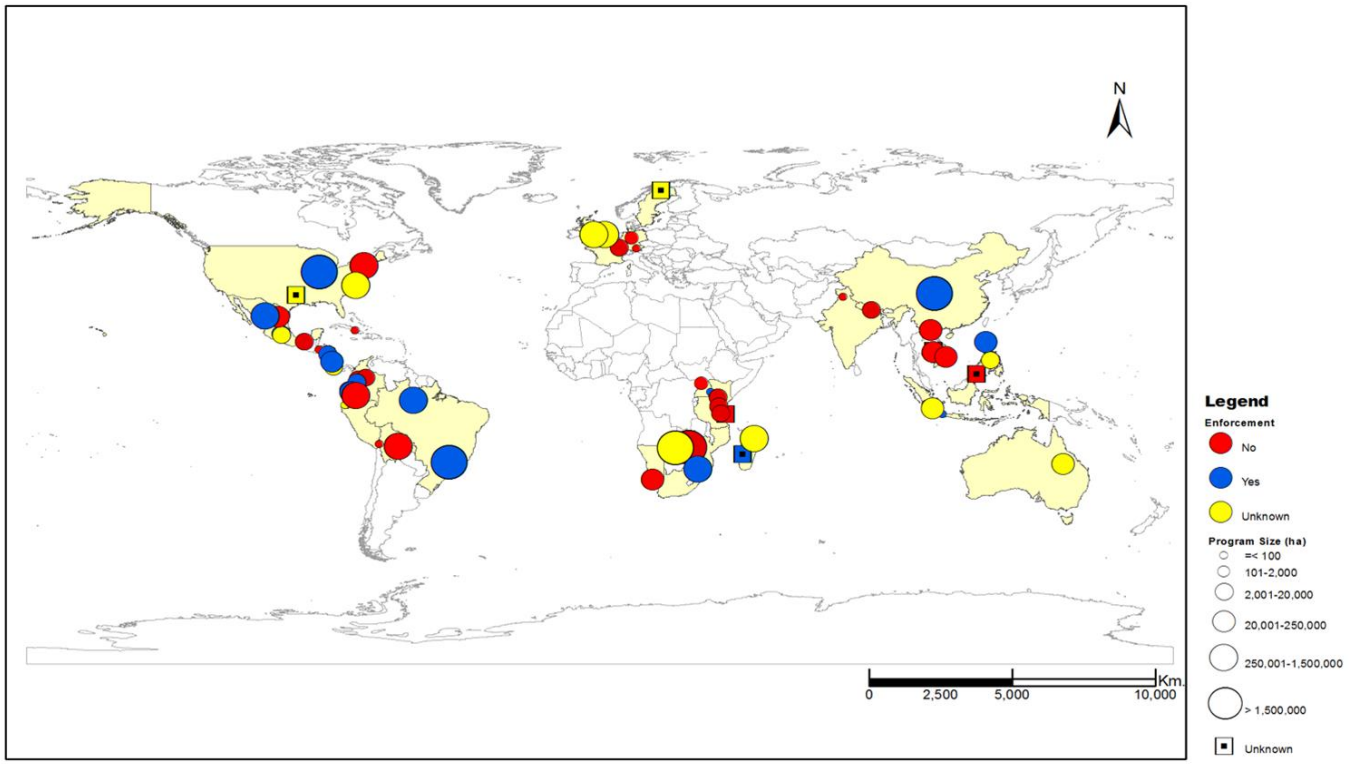
equal landowners should be treated alike (McDaniel and Repetti 1993; Pascual et al. 2014), even when their costs of provision markedly differ (McGrath et al. 2017).

3.3 Enforced conditionality

As stated in Section 1, conditionality is a key defining feature in the design of PES. However, to be credible, conditionality must also be enforced in cases of non-compliance. Enforced conditionality has two elements. First, compliance has to be monitored over time (i.e. detecting non-complying participants, typically through remote-sensing techniques and/ or on-site verification). Secondly, revealed non-compliance has to trigger sanctions, i.e. threats of, and eventually enactment of penalties, such as the partial or full discontinuation of payments (Kerr et al. 2014). Very few PES schemes are able to enact penalties that in monetary terms exceed the payment levels due for a given monitoring period. One example are the carbon forestry schemes that have made high initial investments in tree plantation, which they have to protect (in contracts with private individuals at least) through upfront bank guarantees issued by landowners (for the case of PROFAFOR, see Wunder and Alban 2008). Otherwise, if defecting on contracts are expected by contracted ES providers to be a profitable strategy, likely continuous spillover of agents from cell IV.a into IV.b (in terms of the visualization in Figure 3) will also jeopardize the environmental impact of PES.

In the global sample from Wunder et al. (2018), 63% of the investigated PES initiatives monitored compliance of service providers closely; the rest only monitored to some extent. However, only one fourth of cases (26%) had consistently sanctioned non-compliance when detected. Another 26% had occasionally applied sanctions. In turn, almost half of the cases (48%) had never sanctioned any contracted participant. Map 3 shows the corresponding geographical distribution. There is no immediately clear correlation neither with scheme size nor with region. However, we can see that for the European cases included, we typically had no information, or that sanctioning was apparently not practiced: typically, more weight is put on community internal self-control of compliance, e.g. among neighbours or landholder organizations. In contrast, it is common in PES schemes in developing countries that programme rules are being deliberately tested (Honey-Roses et al. 2009; Wunder and Alban 2008). Withholding payments to contracted participants may in such cases, however, have costs for implementers' social capital built with local people (Ferraro 2018): they may thus prefer to rather close their eyes to some degree of non-compliance (Ezzine-de-Blas et al. 2016).

Map 3. Enforcement of conditionality: monitoring and sanctioning



Source: Own elaboration (with R. Pinto and R. Brouwer), based on Wunder et al. (2018)

3.4 Other design issues

Various other practically oriented design factors are discussed by Engel (2016). For instance, duration of contracts is a recurrent issue: contracts that are too short may not be seen as worthwhile by landowners in terms of transaction costs involved. Contracts that are too long may in turn coincide with changes of opportunity costs, or be seen as a substantive reduction in the flexibility of land-use decisions. Although Ecuador's Socio Bosque program adopted a 20-year horizon, many PES programs worldwide have followed the example of the pilot Costa Rican PSA program, with a five-year duration as a Goldilocks solution (Pagiola 2008).

Cash versus in-kind payments is another frequently discussed topic. The preferences of recipients for one or the other should be the prime consideration. The cost of paying in kind also needs to be taken into account. However, if in-kind transfers form part of a more integrated 'project' activity (e.g. Asquith et al. 2008 for such a case in Bolivia), implementers should consider whether the transfer could be potentially discontinued, in case contract terms become disputed. Similarly, some Asian PES schemes have utilized the provision of conditional land rights from the state to local communities as the 'currency of payment' (Suyanto 2007; van Noordwijk et al 2012). Also here, the de facto reversibility of such conditional rights needs to be considered from a PES perspective.

4. Contextual factors shaping impacts

4.1 Motivation crowding

In our PES ToC, one crucial assumption at the impact level is that PES recipients will feel positively motivated in their environmental actions (land and resource uses) by the extrinsic PES rewards they receive. Alternatively, their aggregate environmental effort could actually go down vis-à-vis to pre-payment levels. That is because their intrinsic motivations to 'do good environmentally' are being undermined by new attitudes to 'just do it for money'.

In Figure 3 above, some landowners who already "meet desired conditions" pre-payment may shift towards the two cells where incentives are needed – whether they are receiving PES or not. This could refer both to those already 'good stewards' that accept payments (treated), and to those that were not interested in the money in the first place (non-treated), yet who might experience a 'commodification' of environmental attitudes among their PES-receiving peers, which may demotivated themselves from providing environmental efforts for the common good. When extrinsic PES incentives cause intrinsic motivations to go down, we are talking about "crowding-out"; when PES incentives conversely enhance intrinsic motivations (e.g. because landholders become more aware and/ or proud of something external agents are willing to pay for), we label it "crowding-in" effects. Motivation crowding in either direction can occur both at the individual recipient level and for collective motivations (e.g. on community lands).

By nature, motivations are physically unobservable. We have to rely on stated attitudes and reactions. Empirical tests for crowding are often done through lab-in-the-field and other framed field tests, though few of these have been experimentally designed, or have explicitly looked at motivational impacts also after PES ended (Andersson et al. 2018: SI, p.4). Existing studies thus typically conduct "payment games", rather than accompanying the impacts of real-world PES transfers. Hence, even though more case studies have recently become available, our in-depth understanding about motivation crowding remains fairly incomplete.

In a literature survey, Rode et al. (2015) found some crowding effects from economic incentives, but no significant ones in either direction for those few that related to PES specifically. Similarly, Ezzine-de-Blas et al. (2019) found in a new case collection that most PES cause no crowding effects at all: intrinsic motivations are seemingly impacted only when some specific design or contextual conditions prevail. Generally, crowding-out is only likely to occur when local people, prior to receiving PES, held strong intact environmental motivations. This is especially true in settings where no or few market transactions pre-existed (Frey 1994; Deci et al. 1999), and where small extrinsic rewards were introduced: enough to change motivational perceptions, but insufficient to change the system's economic logic (Gneezy and Rustichini 2000).

A fully intrinsically governed world is seldom relevant as backdrop to PES, which typically act in settings where markets have already exercised significant pressure on the environment. That said, contexts and design may well be taken into account by PES implementers to minimize the risk of crowding-out effects. As for contexts, crowding-out seems generally more likely when intrinsic motives and social norms were previously strong (Vollan 2008). For instance, framed agrobiodiversity-focused PES field experiments in the Andes found collective payments in

communities with strong pre-established collective conservation attitudes to cause crowding-out; in those with weak intrinsic norms payments caused crowding-in (Narloch *et al.* 2012). Correspondingly, "individual-level payments appear to stabilize conservation levels above critical thresholds by strengthening reciprocity-based behaviour, and thus crowding in pro-social dynamics" (Narloch 2011:121).

In addition to context, the design of the proper PES intervention also matters for the motivational outcomes: when interventions are perceived as "externally controlling", crowding-out is more likely than when they are seen as "locally supportive" (Andersson et al. 2018: SI, p.1). For example, ample communication and trust-building activities may enable collective PES to increase intrinsic motivations (Andersson et al., 2018; Bottazzi et al., 2018) – conversely so, when community leaders are not trusted (Costedoat et al., 2016). In this case, relying on individual PES may offer a better alternative (van Hecken et al., 2019). Inclusive participation may also favour intrinsic motivations (Dedeurwaerdere et al., 2016) while top-down conservation, applied in a market-remote setting, may favour crowding-out (Chervier et al., 2019).

In sum, we still know fairly little about the real-world motivational impact of PES schemes, especially after payments have stopped. The "ES commodification" literature had outlined motivational crowding-out as a major PES risk (Farley and Costanza 2010; Kosoy and Corbera 2010; Vatn 2010). Yet, the growing body of empirical work shows that, while both crowding-out and crowding-in are feasible, 'no effect' is the most likely scenario (Ezzine-de-Blas et al. (2019). Hence, the menace for PES to crowd out intrinsic motives has been somewhat exaggerated. Care might be taken though in non-market contexts, and with PES design modalities that may be seen as externally controlling rather than locally supportive.

4.2 Policy mixes

Economic incentives for the environment have originally been developed mainly as an alternative to a traditional regulatory approach (e.g. Hahn and Stavis 1992). Within the family of incentives, PES have been conceptualized as a direct alternative to integrated conservation and development projects (ICDP) (Simpson and Sedjo 1996; Ferraro 2001; Ferraro and Kiss 2002). Conceptually we should distinguish these tools (Börner and Vosti 2013) and evaluate their impacts separately (Börner et al., this volume), including the comparison of their impacts within the same jurisdiction (Sims and Alix-Garcia 2017).

Nevertheless, these analytical and empirical advances should not distract us from the fact that real-world conservation policies more often than not work as policy mixes, i.e. several possibly interconnected treatments are being applied simultaneously towards the same geographical sites, ecosystems, and set of agents (Bouma et al. 2019; Ring and Barton 2015). PES are no exception in that regard (Barton et al. 2017). Costa Rica's PSA program was introduced as part of a new forest law that also prohibited most land-use-changing deforestation. Politically, this move should also make the extension of Costa Rica's protected area network more palatable to society (Barton et al. 2017; Pagiola 2008; Porras et al. 2011). PSA also contains cross-compliance provisions, e.g. to the legality of land claims and social security payments for employees (Barton et al. 2017).

Similar observations apply elsewhere in Latin America. In Pimampiro (Ecuador), one of the longest-functioning municipal watershed programs, PES was introduced on top of a previously ill-enforced, but then reinvigorated forest protection law prohibiting commercial timber extraction (Wunder and Alban 2008). Similarly, in the municipal watershed program in Moyobamba (Peru), law enforcement was also strengthened simultaneously with PES (Montoya-Zumaeta et al 2019). In Brazil's oldest PES initiative, the *Bolsa Floresta* program, located in the Amazonas state, set compliance rules just marginally more restrictive than pre-existing regulations for the local sustainable development reserves, and project staff would play a role in monitoring both (Börner et al. 2013). Furthermore, all three cases also included strong ICDP components in their implementation – arguing that market-remote settings would make pure PES inviable, but probably equally reflecting a limited faith among implementers that PES would be a more adequate tool than ICDP.

In other words, rather than a switch from command-and-control policies ('sticks') to PES incentives ('carrots'), we saw more frequently that not only do sticks and carrots continue to co-exist in the same jurisdiction, but they may both simultaneously be intensified, and fine-tuned to each other – 'turning the heat on' for landowners in terms of rewards for good environmental stewardship, but also stablishing potentially higher penalties for breaking (new or pre-existing) laws. Börner et al. (2015) simulated impacts of introducing PES on top of command-and-control policies in Brazil. PES increased policy implementation cost, but also reduced income losses for those hit hardest by law enforcement – a tradeoff that varied in space according to deforestation pressures, conservation opportunity and enforcement costs.

For the infant PES impact evaluation literature, taking into account the different policy mixes of which PES forms part (heavily mixed-in regulation and ICDP) certainly multiplies the analytical challenges of attributing impacts to interventions. Important, however, for the PES ToC is it that these other policies at least remain synergistic with the basic PES objectives.

4.3 Leakage

Leakage effects refer to the impacts of a PES intervention on its target variable(s) occurring outside its predefined spatial scope. For instance, when a watershed PES enrols all the plots in the watershed into the program, then by definition there will be no leakage: the ES target area and the PES program area would fully coincide; there are no outside effects. The same cannot be said about any (however carefully delimited) forest carbon project: the ES target area for mitigating greenhouse gas emissions is, by definition, global, so any impacts occurring outside the defined project area matter. Leakage belongs under the larger umbrella of so-called 'spillover effects' of an intervention, occurring on people, places or processes other than those directly targeted – which may also contain motivation crowding (see above), as well as magnet and rebound effects (see below) (Pfaff and Robalino 2017).

The traditional PES leakage effect manifests itself from activity-reducing programs, such as forest conservation set-aside areas reducing agricultural expansion, compared to the baseline scenario. Hence, agricultural workers engage in this capped activity might move outside the PES program boundaries (i.e. spillovers to non-participants), as may also happen with mobile capital (financial, machinery, animals, etc.). This activity leakage can happen through a channel of direct input

reallocation. A complementary channel would be created through market prices for the agricultural outputs, which may rise locally due to the PES-induced supply shortfall.

How large is a leakage? Many scenarios apply depending on the size of project and its restrictions, the price elasticity on output and input markets (including land and labor), ease of access to alternative lands, etc. In general, we can identify sliding scales of economic and technological parameters determining leakage (Wunder 2008): the higher the value of the PES-restricted activity (e.g. soybeans or oil palm), and the more flexible the technological reaction to increased land scarcity, the higher leakage effects may be. For restricting access to log valuable tropical timbers in Bolivia's Noel Kempff project, leakage was estimated in the (vast) 2-42% range, depending heavily on assumptions about demand elasticities (Sohngen and Brown 2004). For the US Conservation Reserve Program (CRP), retiring marginal agricultural land for conservation purposes, leakage estimates have ranged from 4% (Fleming 2010) to 14-20% Wu (2000).

In sum, leakage is indeed a concern, but often we cannot quantify it precisely. Leakage has been a main recent argument against predominantly subnational REDD+ and other forest carbon projects to mitigate climate change, opting instead now for jurisdictional approaches that would allegedly address climate problems at larger and more holistic scales. However, as the CRP estimates indicate, for setting aside low-return agricultural or forested land, we should not expect huge leakage, and thus also not become paranoiac about leakage as a game-changing parameter. Sometimes leakage effect could notably be reinforcing the targeted ES effect: when PES programs are asset-building, e.g. a labour-demanding forest plantation projects, drawing labor out of other, potentially degrading activities could ease environmental pressures and lead to further forest gains.

Finally, a PES-specific form of on-farm leakage occurs when contracts are made for only part of a landowner's or a community's lands, so that pressures can be shifted to non-enrolled sections. This has been observed especially for community-level PES programs, e.g. in Mexico (Alix-Garcia et al. 2012) and Peru (Giudice et al. 2019). It is preferable for PES contracts to be made with agreements for the total land area (e.g. agreeing on a reduced deforestation rate) to avoid this problem.

4.4 Magnet & rebound effects

In the family of spillovers are two additional developmentally induced side-effects of higher incomes generated by PES: magnet and rebound effects. Magnet effects occur when the spending by service users/governments on PES raises incomes locally, thus attracting migrants from outside (Wittemyer et al. 2008). If PES are asset-building, e.g. for the aforementioned tree-planting example, incremental employment generation could further contribute to immigration pressures. With more people locally present, pressures on the environment may also accelerate.

A second income spillover can come in the form of rebound effects: when PES recipient households face higher net incomes (payments minus ES provision costs), the secured income flow could ease credit constraints, and expand consumption and land use. Alix-Garcia et al. (2012) found a small effect for Mexico's national watershed protection program (PSAH)– 4% for all spillover effects combined.

In practice, most PES programs do not face large magnet or rebound effects, principally because their impacts on recipient incomes is small, though typically positive. A recent impact-assessing systematic review concluded: "it is plausible [PES] led to an increase in overall household income" (Snilsveit et al 2019:iii). But what if these income gains were large instead? Alix-Garcia et al. (2013) looked at Mexico's *Oportunidades* poverty-alleviation program of conditional cash transfers, finding it had (counterfactually assessed) raised recipients' household income by one third. Household consumption of meat (+29%) and milk (+23%) rose proportionally vis-à-vis baseline in response, causing 15-33% incremental deforestation. Hence, this cautions us that PES programs with large poverty-alleviating effects could potentially also have large consumption-led rebound effects on their environmental targets.

4.5 Solid proxy-ES linkage

Ideally, ES users would pay directly for *impacts* (actual ES delivery), rather than *outcomes* (land-use proxies), cf. Figure 1. This would minimize their risk of not getting what they paid for (Ferraro 2011). But landholders often cannot manage their land in ways that guarantee ES delivery. Especially hydrological services are often enjoyed downstream at large distances from upstream management. Moreover, natural variations (e.g. fluctuating weather) make it difficult to determine the ES impacts, and attribute them duly to land management – or even to know for sure whether ES delivery has improved through PES-induced land use changes, or if observed changes simply reflect natural variability. One option is to use hydrological models such as SWAT or InVEST to simulate this linkage to water supplies (Pagiola et al., 2019).

Payments for actual service delivery may be practical for forest carbon sequestration—being proportional to biomass—and some cases of biodiversity conservation—for example, a PES program in Cambodia pays local communities to protect the nests of threatened bird species (Clements et al., 2013). Another option can be to combine impact-based (ES) with action-based payments; experiments to that end also exist in Europe (Derissen and Quaas 2013; Hanley and White 2014).

4.6 Permanence

A key concern of PES programs is whether their effects persist when the programs end—whether the effects will be *permanent* (The term "permanence" originates from the carbon sequestration literature). The logic of PES suggests that once payments cease, forests would likely no longer be conserved, as they would once again be less profitable than alternative uses (see Figure 2a in Annex). Conservation-focused PES programs try to make PES contracts renewable, yet loss of funding may cease payments. One single empirical study examined permanence from a randomized controlled trial evaluating a PES conservation program implemented in Uganda from 2011 to 2013. Jayachandran et al. (2017) had found that the program had reduced deforestation substantially. The follow-up study using satellite imagery from 2016 found that—as predicted—former PES recipients had resumed deforesting at similar rates to control group members once payments ended (World Bank, 2018).

When PES is used as an adoption subsidy for environmentally friendly practices that are profitable for landholders (Figure 2c), on the other hand, adoption should persist after payments end. Here, too, there has been a dearth of empirical studies, but some existing studies found that the

silvopastoral practices adopted thanks to PES at sites in Colombia and Nicaragua had been retained four years after payments ended (Pagiola et al., 2016, 2017).

5. The European context

Having reviewed the way PES instruments have been used worldwide, with associated opportunities and challenges, we will in this section relate our findings to the European context. Our stocktaking in previous SINCERE-WP1 deliverables revealed a relatively small amount of PES and PES-like schemes being implemented in Europe. To what extent can European structural factors explain that preconditions, enabling and design factors were perhaps less favourable towards a broad European PES strategy?

Table 1: Instruments for the provision and enhancement of PES

	Instruments	Direct costs for the public sector	Transaction costs for the public sector	Approach	Participation by the private
Passive: Command and Control	Thresholds, limitations, constraints, taxes	Relatively low	Relatively low	Top down	Compulsory
Active: voluntary participation	Tax deductions, tax exemption	Relatively high	Relatively low	Top down	Voluntary
Flat subsidies	Compensations, grants	Relatively high	Relatively low	Top down	Voluntary
Market-Based Instruments	PES schemes	Zero costs	Generally low	Bottom up	Voluntary
	PES-like schemes	Very low	Medium-low	Mixed	Sometimes compulsory
	Tradable permits (Cap and Trade schemes)	Low	Low	Mixed	Compulsory
	Certification and labelling	Zero costs (very low)	Zero costs	Bottom up	Voluntary
	Public Procurement Policy	Relatively high	Low-medium	Top down	Compulsory in pub.sector
	ES public auctions	Relatively high	Low-medium	Mixed	Voluntary
	Philanthropy	Zero costs	Zero costs	Bottom up	Voluntary
	Land acquisition	Relatively high	Low-medium	Mixed	Voluntary
Knowledge and communication	Information, technological support,provision of technical services	Relatively high	Low	Mixed	Voluntary

Source: Own elaboration

As an initial observation, about one fourth of forests in the European Union fall under special regimes of biodiversity or landscape protection, while nearly 10% are protected for soil, water and other forest ecosystem functions. Almost 35% of EU forests, presumably those with forest cover offering the highest-value ES, is thus managed under special regulatory regimes based on strict prescriptive policies. These are normally not associated with compensation measures, since command-and-control rules govern their management. That is to say, they leave little room for introducing market-based innovative mechanisms such as PES (see Table 1).

The area under special regimes of biodiversity or landscape protection has been increased by 39% in the last decade. This could be understood to suggest that, while there is increasing political attention on market-based innovative mechanisms aimed at natural resource conservation, in practice, the prevailing political instruments for conservation are still based on zoning, protected areas, and rule-definition as a passive control. This tendency is confirmed by the experience of the Natura2000 network, as well as by payments activated through rural development policy for the management of protected forests (see Table 3, to be discussed below).

Moreover, another relevant enabling factor for the development of market-based innovative instruments, and specifically of PES, is connected with the land tenure regime. About 30% of the EU forests are managed by state forest enterprises (42 million ha), with an annual harvest of 120 million m^3 – or, one third of the 400 million m^3 timber logged annually in the EU. 100,000 employees are working under the direct responsibility of the state forest enterprises. The direct control of natural resources, the mandate of using part of the profits to manage the 8.3 million ha of protected forests, the strong limitations in accessing public incentives available to forest owners defined by the EU and state legislation are all elements that discourage the delegation of management responsibilities to third parties under the use of PES schemes (EUSTAFOR 2019). Conversely, the 16 million forest owners managing approximately 60% of the EU forest area are mainly private individuals and families owning mostly small tracts of land, often not living in close proximity to their forests and, in some cases (especially in Southern Europe), not being part of associations and cooperatives. Naturally, these proportions also vary depending on specific national contexts: in various Eastern European countries, about half of national forestland is publicly owned and managed. However, for these myriad reasons, European forest smallholders may not be the best actors to become involved in PES schemes and other market-based innovative mechanisms: the transaction costs of contracting with them would be high, and their capacity to undertake tailored ES motivated changes in forest management may *de facto* be limited.

These factors help understand why PES schemes in Europe might be playing a different role compared with other regions of the world, included Western-style economies like the USA and Australia: Europe's large amount of forests already under special regulatory regimes aimed at maintaining forest ES; the presence of large, autonomous state forest enterprises and of strong public institutions with long traditions related to law enforcement; and the issue of fragmentation among private forest properties all weigh towards relatively less involvement in PES.

As for other market-based mechanisms, at least a greater degree of national enabling measures seems to have been implemented. For instance, for the European market for biodiversity offsets and related compensation mechanisms (Vaissiere et al. 2019), three major EU-level sets of regulation define a general framework for organizing a compensatory mitigation market: the Birds

and Habitats Directives, the Environmental Liability Directive, and Environmental Impact Assessment frameworks. Each are transposed into national laws by all EU Member States. In addition, 12 countries have their own national or subnational programme frameworks requiring some form of compensatory mitigation for impacts to biodiversity and the environment. A study by Bennett et al. (2017a) identified a total of 65 programmes and 180 implemented or in-development projects, most of them involving forest resources:

> "Transaction data for biodiversity offsets and compensation projects in Europe proved very difficult to collect, whether due to sensitivities around sharing financial data or difficulties on the part of projects in accurately reporting total spending and isolating costs linked to offsets or compensation from general project development costs. We documented 95.8 M€ in transactions between 1996 and 2015, and 62.7 M€ for the five-year period 2011-2015. That value is associated with 75 projects and 4,530 ha of project area, e.g., only 6% of total area reported under conservation. Thus these figures likely represent only a fraction of actual spending" (Bennett et al., 2017a:14).

Another interesting example of market-based mechanism to support ES provision is the voluntary carbon-offset market, which is only marginally influenced by state regulations and public players. In 2015, Ecosystem Marketplace (Hamrick and Goldstein, 2015) tracked European voluntary buyers purchasing 16.1 $MtCO_2e$, typically from renewable energy and forestry projects, even if projects located in Europe produced relatively few carbon offsets. More recently (Hamrick and Brotto, 2017), 59 European organizations reported transacting offsets in the voluntary market; most were for-profit (44) rather than not-for profit (15). Out of these, eight reported sales of European forestry-based carbon offsets: three in the UK, three in Italy and two in Germany. A market size of 285 $KtCO_2$, for a total value of 4.4 M€ has been recorded for the voluntary carbon offsets sold by European organizations with forest projects based in Europe (mainly afforestation and reforestation projects). Almost always the investments in forestry-based carbon offsets are associated with other market-based instruments, such as third-party certification both for accounting the carbon quotas (such as VCS, Gold Standard, Plan Vivo) and for offering a guarantee of responsible forest management (PEFC, but mainly FSC schemes).

For watershed investments, Bennett et al. (2017b) provide interesting insights into the development of initiatives connected to the implementation of EU regulations. Specifically, this refers to the EU Water Framework Directive and the regulations connected to the implementation of the so-called Pillar II of the Common Agricultural Policy, namely rural development funds associated with the EU's rural development policy Priority 4 (supporting watershed and landscape health), and Priority 5a (efficiency of agricultural water use). Table 2 gives a market overview of the value, area under management, and number of operational programmes related to watershed protection in 2015. Given that the initiatives take place at watershed scale, they involve not only forests, but also other land uses.

Table 2. Value, area under management, and number of watershed operational programmes in Europe

	Total Value, All Programmes	Total Area, All Programmes	Median Programmes Value	Median Programmes Area
Public subsidies for watershed protection	5,668 M€	12.8 Mha	77.6 M€	417,020 ha
User-driven watershed investments	39.4 M€	0.6 Mha	0.8 M€	3,500 ha
Total	5,708 M€	13.4 Mha	-	-

Source: Bennett et al. (2017b)

Many PES-like schemes and markets for selling offsets related to forest ES have been developed at the state or regional level. Some schemes have a long history, as in the case of Italy, where the use of mountain watersheds (normally characterized by large forest cover) to produce hydroelectric power took off in the last century. Payment are transferred to the local mountain authorities to be reinvested in public works, as well as in the forestry sector, especially to control soil erosion and improve rural welfare conditions (Pettenella et al., 2012). The scheme today involves almost one-fourth of Italian municipalities and 518 hydropower plants.

A clear commitment towards the implementation of PES-like schemes related to forest resources has been defined by the EU in connection to the reform of the Common Agricultural Policy and the promotion of the Rural Development Policy. For the planning period 2014-2020 under Priority 4 ('Restoring, preserving and enhancing ecosystems related to agriculture and forestry') and 5 ('Promote resource efficiency and support the shift towards a low carbon and climate resilient economy in agriculture, food and forestry sectors'), a total public expenditure of 82.3 B€ has been planned -- respectively 70.8 B€ and 11.5 B€ for the two priorities. Under Priority 4, three types of forest payments have been implemented: to support biodiversity, to improve water management and to improve soil management and/or prevent soil erosion, while under Priority 5 one type of payment has been activated, namely for supporting carbon sequestration and conservation in agricultural and forest land under special management contracts.

For each of the four payments, specific targets have been defined at EU and member state levels in terms of percentage of forest area under management contracts out of all forest cover. Table 3 (a, b) presents information on these planned targets and the progress made to achieve them by the end of 2016 (last data available based on realized expenditure).

Table 3: Active Rural Development Policy payment contracts for the forest sector

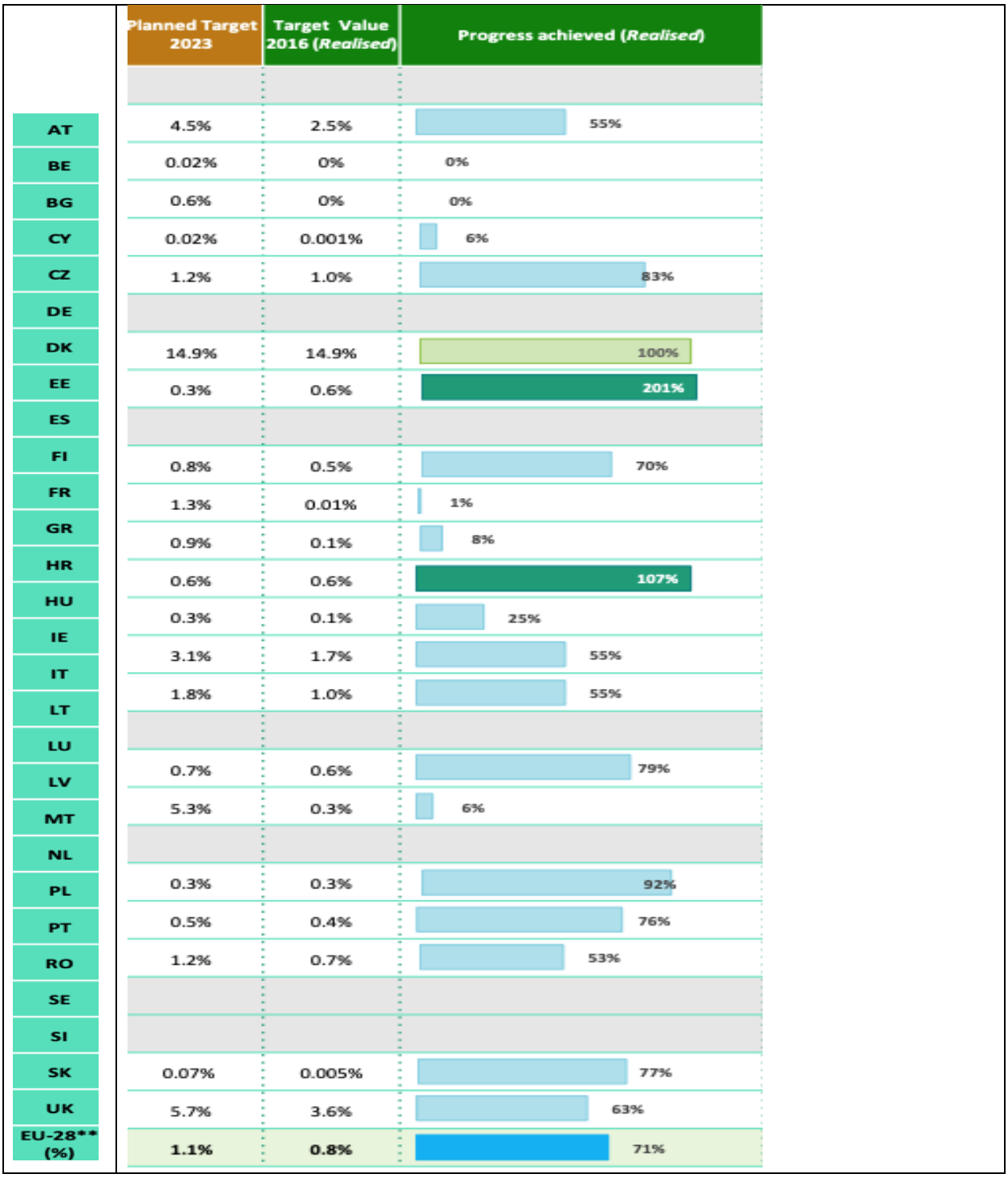
a. Forest payments under Priority 4

	Percentage of forest and other wooded land under management contracts								
	to support biodiversity (%)			to improve water management (%)			to improve soil management and/or prevent soil erosion (%)		
	Planned Target 2023	Target Value 2016 (*Realised*)	Progress achieved (*Realised*)	Planned Target 2023	Target Value 2016 (*Realised*)	Progress achieved (*Realised*)	Planned Target 2023	Target Value 2016 (*Realised*)	Progress achieved (*Realised*)
AT	0.1%	0.003%	5%				2.9%	0.1%	3%
BE	4.2%	1.8%	43%						
BG	2.6%	0%	0%				2.3%	0%	0%
CY	7.8%	0%	0%	7.8%	0%	0%	7.8%	0%	0%
CZ	0.1%	0.1%	55%				0.5%	0.1%	12%
DE	1.1%	0.4%	32%	0.4%	0.2%	48%	1.0%	0.3%	30%
DK	0.5%	2.8%	586%	0.05%	0.1%	255%			
EE	2.7%	2.5%	93%						
ES	4.9	0.2%	5%	2.0%	0.01%	0.4%	3.3%	0.3%	9%
FI									
FR	0.5%	0.3%	58%	0.08%	0%	0%	0.1%	0.0001%	0.1%
GR	0.1%	0%	0%	0.04%	0%	0%	0.8%	0%	0%
HR	0.3%	0.0004%	0.1%	0.3%	0.0004%	0.2%	0.3%	0%	0%
HU	5.1%	5.5%	109%	0.6%	0.6%	108%	0.8%	0.8%	109%
IE									
IT	3.9%	0.2%	4%	0.8%	0.2%	19%	2.7%	0.2%	6%
LT	0.4%	0.5%	111%						
LU									
LV	1.2%	1.1%	96%						
MT									
NL									
PL									
PT	1.0%	0.5%	55%	1.3%	0.03%	2%	1.3%	0.03%	2%
RO	12.2%	0%	0%				1.2%	0%	0%
SE	0.03%	0.001%	4%						
SI									
SK	2.6%	2.3%	86%	1.2%	1.3%	111%	1.2%	1.3%	111%
UK	22.1%	3.8%	17%	20.4%	3.9%	19%	18.8%	1.2%	7%
EU-28** (%)	**2.1%**	**0.3%**	16%	**0.8%**	**0.1%**	14%	**1.3%**	**0.1%**	9%

Source: ERND (2018)

b. Forest payments under Priority 5

	Percentage of agricultural and forest land under management contracts contributing to carbon sequestration and conservation



Source: ENRD (2018)

It is notable that for Priority 4, the planned target for management contracts related to biodiversity protection for forests and other wooded land (last line in Table 3a, 2nd column) was reached only for 2.1% for the EU as a whole. Meanwhile, the same target for the agricultural land was 17.9% fulfilled. These low indicators for forest biodiversity management contracts have to be analysed considering that only 0.6% of the total rural development policy expenditure has been allocated

for all the Natura2000 and biodiversity protection contracts. In light of these limitations, it is relevant to compare the realized value for 2016, which was 0.3% for forest biodiversity and 83% for biodiversity on farmlands. Seven member countries out of 28 had not activated this system of forest payments. Only three have achieved their respective 2016 target value.

The implementation of the system of payment for water management, specifically designed in order to support the EU Water Framework Directive, exhibits arguably even more discouraging results: 14% of the planned target achieved, 16 countries have not activated the measure, only two have achieved the 2016 target value. In comparison, for the same measure related to payments for farmland, the figures are: 70% achieved planned target, zero countries have not activated the measure and eight countries have achieved their target value. Similar conditions of implementation characterize payments to improve soil management and/or prevent soil erosion: 9% of the planned targets have been achieved, 13 countries are not implementing the measure, and just two have achieved the 2016 targets.

The very poor general level of implementation of forest payments, notwithstanding the non-ambitious targets in terms of land coverage, is a negative indicator of the willingness and real spending capacity of the actors of the rural development policy. Heavy bureaucratic procedures, inadequate levels of payment, high baselines and limited technical support to potential beneficiaries appear to be the most relevant factors to explain these outcomes. Towards the end of the planning period, a shift of the planned expenditure from forest payments to other measures seems more than likely.

As a general consideration, we can observe that, in contrast with many policy statements, market-based innovative mechanisms for supporting ES provision are being developed more as a result of dispersed spot initiatives than as a coordinated policy effort at a central level in the European Union. From the Inventory of Innovative Mechanisms in Europe (Deliverable D1.2), we have highlighted that the current trend in the implementation of IM for ES provision and enhancement relies mainly on incremental, rather than radical innovations, often being combined, integrated efforts. This represents the idea of 'hybrid' innovation, where bundles of different products or services, technologies, processes, actors, institutions and sources of knowledge contribute jointly-- sometimes in a random, unplanned or casual way-- to the development of innovation systems (Rametsteiner and Weiss, 2006; Edwards-Schachter, 2018).

Innovation does not only take a hybrid form, but also that of 'cascading' innovation where one type of innovation generates another, in the shape of product and/or process innovation; or, vice versa, technical or product innovation stimulates social innovation through involving new actors, establishing new networks or enlarging the scale of action.

In aggregate, the evidence suggests that PES design and implementation in Europe lags behind various other regions of the world – in particular the Americas and Australia. As mentioned above, several economic, institutional, and legal factors play a role in this lack of prevalence in a European context. One reason is that the role of PES as an instrument to promote poverty alleviation has less priority in the European socio-economic context than in developing countries with longstanding PES traditions. However, in cases more similar to the European context, like the US and Australia,

equity is also not a prominent motive, and yet both countries count on more extensive PES application than in Europe.

Another key factor points to the high level of fragmentation in European forests, coupled with the overall trend of the expansion of forested land in Europe over the past decades (Wunder et al 2018, and above). Thus, not only are forests not necessarily a threatened resource in all parts of Europe, but PES schemes can be hard to implement where land tenure across even small areas may be divided among many small private landholders. The flexible conditions of PES schemes have even led to some being carried out to prevent forest regrowth, thereby maintaining open and diverse agricultural landscape mosaics, e.g. in order to increase fire resilience or preserve cultural landscape values: whereas in many developing countries PES is almost always being used for increasing forest cover vis-à-vis business as usual, in Europe the requirements with respect to forest management are likely much more complex, and could in some cases involve reduced forest biomass and forestland cover. Overall, however, it is worth noting that there are also few PES examples in the realm of agricultural land management in Europe, which indicates that the general institutional setting would constitute the main barrier to PES implementation.

As the above exploration of forest protection policies in Europe reveals, European forests are increasingly protected by the institutional framework in the EU. While this institutional setting is a key proponent of PES schemes in other parts of the world, the European approach to ecosystem conservation seemingly retains a more regulatory emphasis, implemented through effective state policies that create a perceivably less urgent environment for PES design and implementation. However, these state policies and regulations also present gaps and implementation shortcomings – e.g. what "pollution" entitlements do landowners have – while simultaneously preventing an environment that supports PES by providing public funds for ecosystem services, and pre-empting demand from potential private users. In many European countries, environmental management is traditionally seen more as a responsibility of the state; consequently, private willingness to pay does not materialize other than in exceptional cases, such as when the ES in question is of extremely high value (e.g. the Vittel example; Perrot-Maitre 2006).

On the other hand, not all is bleak: in spite of the shortcomings, two key preconditions for PES, as identified in Section 2, are commonly fulfilled in European forests: there is a high degree of institutional stability in terms of both legal frameworks and property rights, and land tenure is in most cases well-defined. Likewise, a high rate of urbanization, corresponding to the advanced leg of the forest transition curve, implies favourable benefit-cost ratios, and thus a potential jumping-off point for increased PES implementation in Europe. Specifically, environmental factors point to some parts of Europe as areas where PES would likely be successful. For instance, Mediterranean Europe faces a set of environmental challenges, in response to which PES could play a mitigating role: wildfire risks, soil erosion, and desertification – including in adapting to climate change.

As shifting climate and social conditions worldwide motivate the implementation of innovative mechanisms for conservation and adaptation, European policy and academia are increasingly considering PES and related innovative mechanisms as tools to support these efforts. In moving forward along these lines, the existing literature on PES points to the need to carefully implement

conditionality – especially vis-à-vis sanctions – in order to ensure that these mechanisms do not echo the gaps introduced by existing forest management and rural development policies.

Looking tentatively into the future, an alleged increased role for PES in Europe could be imagined either through flexible reforms of the Common Agricultural Policy (government-financed PES), and/ or through an increased realization on behalf of private actors that the European states alone are unable to deliver through regulatory tools the full suite of ecosystem services that service users and society's need (user-financed PES). The latter would be needed to trigger a sufficient willingness to pay – a sine qua non for the economics of user-financed PES to take off.

6. Impact evaluation

6.1 Recent systematic reviews of forest impacts

Given our ToC, assumptions, and impact pathways discussed above, how well have PES programs been performing in terms of achieving their environmental targets? In this section, we concentrate on forest-cover effects, which have been by far the dominating target for PES schemes. While various PES meta-studies have been conducted in the past, only the most recent systematic reviews contain rigorously evaluated impacts. Pattanayak et al. (2010:10) could only identify six studies with rigorous forest-cover results, all from Costa Rica and Mexico, calling urgently for more impact evaluations. Samii et al. (2014) found nine studies from four PES programs that satisfied their stringent methodological criteria for rigor, again all in the same two countries. Obviously, such an extremely narrow empirical base raises serious questions about the external validity of the systematic review. Still, they concluded that PES programs had, on average, reduced annual deforestation rates by 0.21 percentage points. "The effect is modest however and seems to come with high levels of inefficiency", which, to the authors, presented one among several "troubling findings" (ibid:12).

In a recent follow-up systematic review, Snilsveit et al. (2019) extended the sample to 11 studies in eight countries, with slightly higher average effect size than Samii et al. (2014), but a large variation across cases. The conclusions remained pessimistic:

> "Despite the hundreds of millions of dollars dedicated to PES programmes over the last decades… we are unable to determine with any certainty if these are worthwhile investments. [O]ur review suggest reasons to be cautious about investing in the implementation of PES programmes… we do not know whether PES programmes do in fact achieve desired environmental…outcomes." (ibid:v-vi)

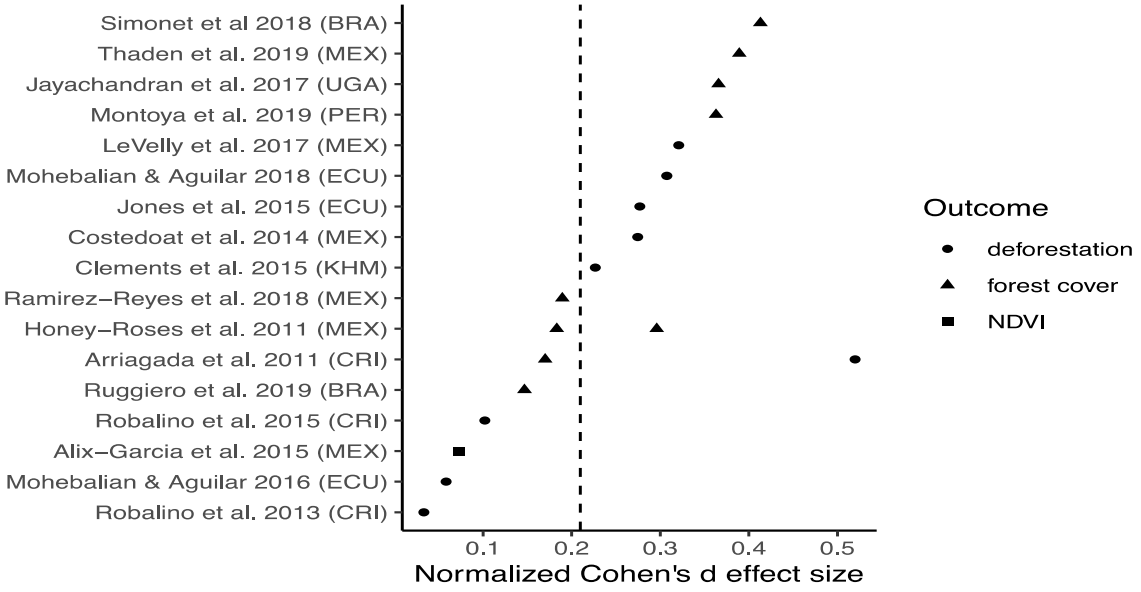
Paul Ferraro, key to theoretical PES development at the turn of the millennium, concluded in a *Conservation Biology* editorial that "greater use of PES is unwarranted unless new or expanded systems are designed explicitly to measure PES's environmental and social effects and to explore competing notions of effective contract design." (Ferraro 2011:1134). He also believed that the limited rigorous evidence may still be subject to upward (confirmation) biases, and that the methodologically most solid study (Alix-Garcia et al. 2015 on Mexico's PSAH) is the one finding close to the lowest forest impact, and correspondingly the highest poverty alleviation effect—thus reconfirming a familiar tradeoff (Ferraro 2018).

6.2 A fresh comparative look at PES forest impacts

In Figure 4, we summarize results for PES impact evaluations, as found in a new systematic literature review conducted for multiple conservation instruments (Börner et al. 2019). We show normalized effect sizes, using Cohen's D as a standardized indicator of relative impact size, and rank our 17 studies from 7 countries accordingly. The first impression is that of large variation between countries and programs, but also even within programs: while all three estimates for the Costa Rican PSA are unsurprisingly located below the overall average (vertical line), the four estimates for the Mexican PSAH are ranking from the third-lowest (Alix-Garcia et al. 2015) to the

second-highest (Thaden et al. 2019) estimate in the sample. Similarly, the three estimates for Ecuador's Socio Bosque program vary greatly, even though two of them are coming from the same analysts (Mohebalian and Aguilar 2016, 2018).

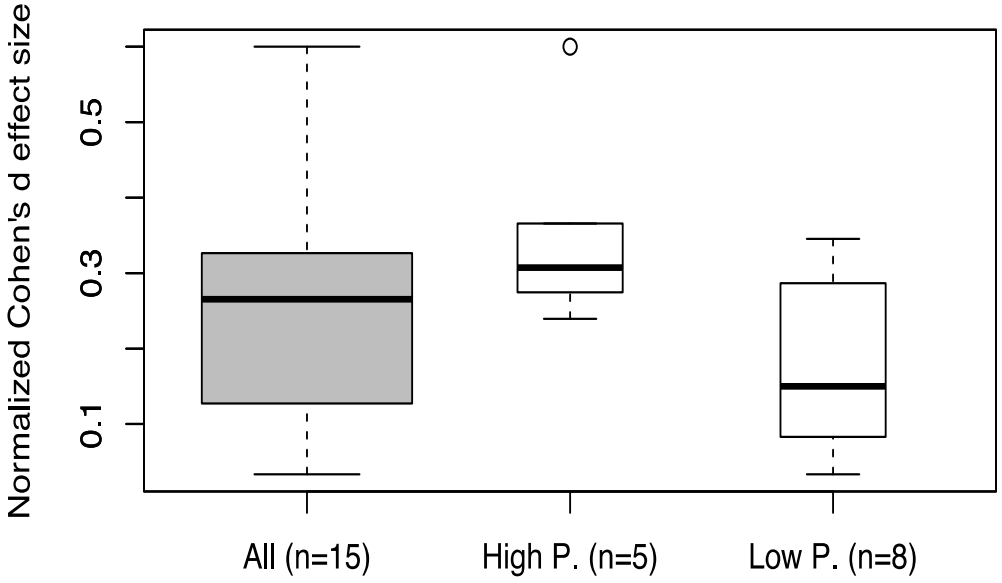
Figure 4. Forest-cover average effects of PES programs: impact evaluations compared



Source: Wunder et al. (2019)

In decomposing this variability, forest indicators used—forest cover, deforestation, Normalized Difference Vegetation Index (NDVI)—can also cause differences. Different methodologies for impact assessment can yield systematically different averages and standard deviations (Börner et al., 2019). Finally, we should remember that national and regional estimates are mixed together here, where some regions will face higher threats than others. That creates a large difference as indicated in Figure 5, which compares the results according to a source-based classification of high vs low threat scenarios (ambiguous cases apart): if there is large deforestation pressure, a PES program has 'an enemy to work against', so it becomes also easier to obtain relatively higher forest impacts. In spite of the small sample, it is noteworthy though that the count balance is tilted towards low threat (n=8), compared to high threat (n=5). Arguably, this illustrates that administrative site selection has been problematic: to date, the low-hanging fruits of low-pressure scenarios have been preferred for PES implementation.

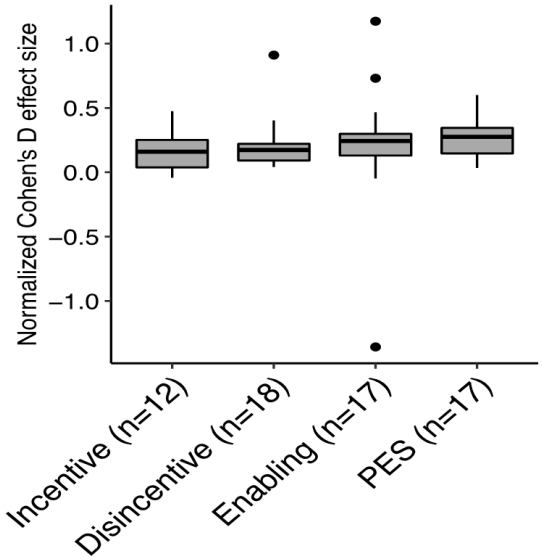
Figure 5. PES forest-cover effect sizes: high vs. low threat settings compared



Source: Wunder et al. (2019)

Finally, the Börner et al. (2019) data on other conservation tools allow us to test the statements in the beginning of this section: is there indeed shockingly little evidence about PES impacts, and the little available data compared to other conservation tools is troublingly disappointing. In Figure 6, following Börner and Vosti, (2013) for comparative purposes we grouped instruments into PES, other incentives (certification, ICDP, etc.), disincentives (protected areas, regulation), and enabling measures (e.g. decentralization, land reform, etc.).

Figure 6. Forest cover effect sizes: PES vs. other conservation instruments



Source: Wunder et al. (2019)

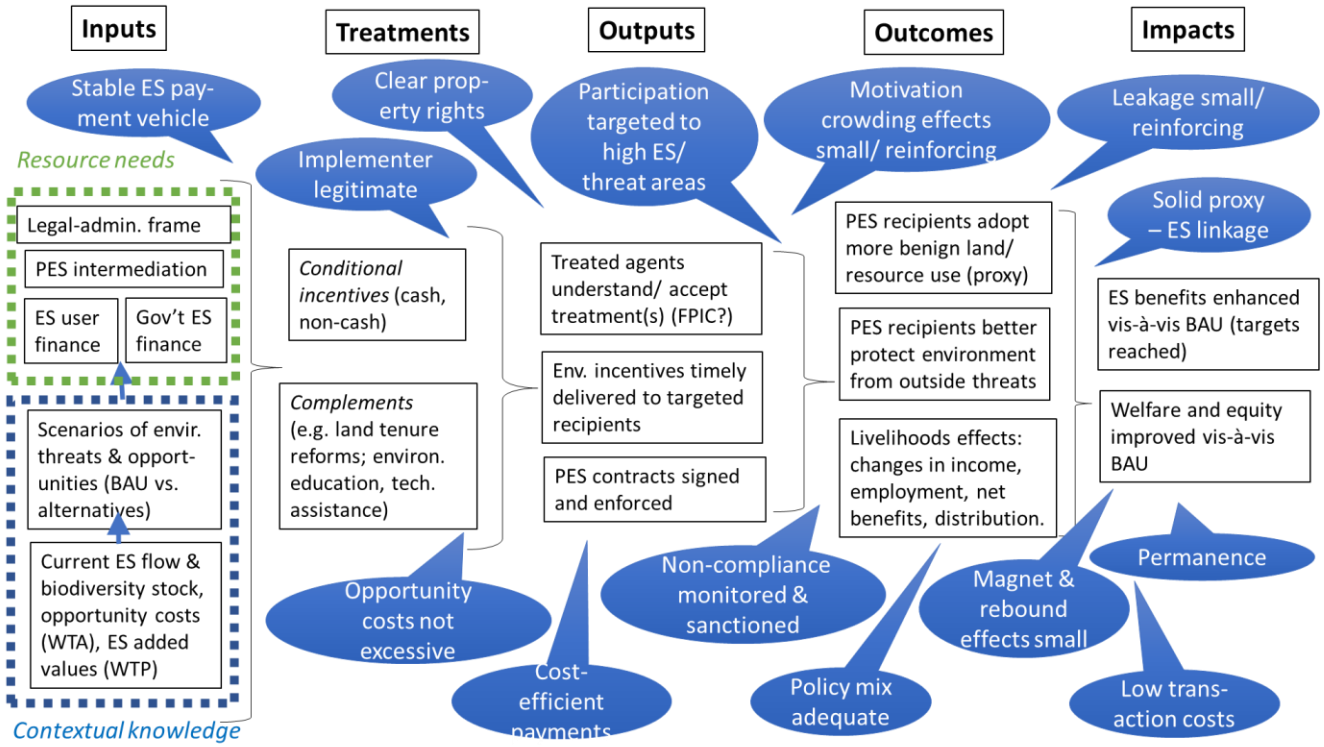
As we first can observe from the headcount, the 17 impact evaluations for the single-instrument PES ranks just behind protected areas (Börner et al., 2019), and as high as the umbrella categories disincentives and enabling measures. Looking at effect sizes, PES actually has the highest average among the four groups, although the differences are quite small, including vis-à-vis the small samples. Surely this "beauty contest" of conservation impact evaluations is also not a pretty sight in 2019, as Ferraro and Pattanayak (2006) had already warned us, but PES now might just aspire to be crowned as the least ugly of the listed candidates.

7. Conclusion and perspectives: what lessons have we learnt?

7.1. Revisiting the PES theory of change

In closing, we are returning to the theory of change (ToC) concept (introduced in Section 1), in light of our review of the preconditions and contextual factors influencing PES implementation and impacts, as well as our overview of the European context for PES. Figure 7 thus highlights some key assumptions at play for PES to reach its final objectives, and below we will discuss also their likely relevance in a European context. Moving again gradually along the ToC from inputs (left-hand side) to impacts (right-hand side), we will highlight and discuss several key assumptions that underlie the incentives to ES providers in a PES scheme.

Figure 7. PES theory of change revisited: key assumptions



Source: Wunder et al. (2019)

a) Stable ES payment vehicle exists

A fundamental economics component of the inputs for PES schemes is the prospect of continuous payment delivery, both through available financing for start-up costs, and a vehicle to enable continuous payments. PES financing is per definition based on a principle of voluntary willingness to pay (WTP), as elaborated in Sections 2.1 and 2.2, as a core pillar of PES. Sufficient WTP by ES users and pre-identified stable payment vehicles seem to also be at the heart of the obstacles

for emerging PES initiatives in Europe: in European societies, safeguarding the provision of ES is often predominantly seen as a public responsibility, which may thus limit private WTP.

b) Implementing agency is seen as legitimate
The implementing institution – in Europe, typically an intermediary, or a government agency -- must be seen especially by the to-be-contracted ES providers as legitimate. This confidence may not always pre-exist, and the process can thus involve lengthy trust-building between the parties involved. However, notwithstanding variations in the scenarios, our perception is that lack of trust and institutional confidence would not be the prime obstacle in most European settings.

c) Clear property rights exist
Second, ES providers must have clear forestland property rights, or at least the right to exclude outsiders from entering or acting on their forestland in a way that might endanger ES delivery. This is a killer assumption for PES in many developing country settings. While we can certainly recognize some differences in the clarity of land property rights across Europe, this factor plays much less of a role here – except perhaps for those cases with public landownership, where PES is usually not the preferred solution.

d) Opportunity costs are not excessive
The opportunity costs of engaging in a PES scheme must not be so high that the value of ES falls short of covering it. Conversely, potential payments must be significant enough to incentivize providers to voluntarily deliver the services. This is a major economic factor in the agriculture-forest frontier of many developing countries, in that some high-value commodities (e.g. oil palm, soybeans, perennials) are of so large a per-hectare return that forgoing their revenues simply cannot be matched by PES – while for others (e.g. slash-and-burn agriculture, itinerant pastures) harvesting returns are low enough to be 'bought out' through PES. In Europe, the situation is also situation-specific, depending on where the ES are to come from: prime vs marginal agricultural lands? Our impression is that, with much rural land abandonment and forest regrowth occurring across Europe, the opportunity cost situation is on average more relaxed than in developing countries, meaning that PES would have the potential to be competitive enough to affect land- and resource-use decisions.

e) Participation is targeted to high-ES/ high-threat areas
The spatial distribution of entire PES initiatives, as well as specific PES enrolled areas for a given scheme, is a key assumption influencing the outcomes and impacts of PES. Spatial targeting comes into play in the design of PES schemes, as elaborated in Section 3.1. Adverse selection biases, at the level of frequent administrative targeting of projects to low-threat scenarios, as well as within-project enrolment of predominantly non-additional landowners (i.e. those who would comply even without PES), constitute worldwide the single-most important challenge for PES programs today. Europe's performance here is probably about average: some targeting to areas with high-density ES and/or to areas that face salient threats is clearly occurring, but there is also still much room for improved targeting.

f) Cost-efficient payments
Costs of ES provision often vary grossly across landowners, but in ways that are not fully known by environmental agencies or ES buyers. Yet, mechanisms and proxies can be found to diversify

payments to align better with the distribution of costs. Efficiency gains of moving from uniform to diversified payments (or even, inverse procurement auctions resulting in multiple payment tiers) can sometime be massive. However, in poor countries, due to equity concerns uniform payments remain the rule. In Europe, as in other high-income regions, some payment diversification already exists. Again, much more could still be done to increase cost efficiency.

g) Non-compliance is both monitored and sanctioned
Perhaps the most important assumption related to the outcomes of PES schemes is that providers are monitored and sanctioned for non-compliance: this lies in the nature of the PES idea. Yet, there is evidence to suggest that PES implementers around the world often shy away from sanctioning non-compliance. They probably often do so out of fears to lose long-established social capital with rural communities, or to lose votes when government-financed PES is concerned. In Europe, very little is known about the degree of non-compliance and moral hazard in PES-like schemes. The matter deserves increased attention, also in Europe.

h*) Motivation crowding effects are small/ reinforcing*
As Section 4.1 illustrates, we assume implicitly that recipients of PES will be positively motivated by the incentives they receive to carry out specific pro-environmental actions. But in principle, also the opposite could occur: PES could crowding-out of intrinsic, non-monetary motivations, i.e. altruistic provision of ES from landowners who 'want to do the right thing'. Although research on motivation crowding remains incipient, it becomes increasingly clear that crowding neutrality is the most likely scenario, and that PES crowding-out, while being a factor to pay attention to in the design of PES, is in practice rather an exceptional phenomenon. No systematic evidence about motivation crowding in Europe exists that could guide our insights.

i) Policy mix is adequate
While PES remains innovative, where implemented worldwide they remain seldom the only game in town. PES interventions are often introduced on the back of (ill-functioning) regulations, protected areas, and/or (under-performing) integrated conservation initiatives, thus trying to add a new spice to a dish that was arguably lacking some flavour. The existence of simultaneous 'treatments' (i.e. interventions) makes it harder for us to later attribute impacts to singular policy components: we don't know what in particular worked, or failed to work. Yet, PES schemes may probably be strengthened by an adequate policy mix supporting environmental conservation efforts via other mechanisms, like regulations. Conversely, PES are unlikely to succeed if coupled with government regulations that under- or de-prioritize environmental results. In Europe, particularly the relation to the Common Agricultural Policy remains a key coordination issue for PES type of interventions.

j) Magnet and rebound effects are small
PES interventions do affect local income generation and development dynamics. If they create large income gains among local ES providers, this may correspondingly attract immigrants looking to get their share of the cake, which may then cause new pressures on natural resources (magnet effect). Correspondingly, households receiving additional incomes from conditional cash transfers such as PES may in part spend it on goods that leave behind environmental footprints of their own (rebound effect), examples are meat and dairy products favouring forest conversion to pastures. While there is evidence for both effects in developing countries, in Europe this is not the case –

probably because the relative size of PES in rural incomes, and thus also their derived impacts on consumption and migration decisions, have remained limited.

k) Leakage effects are small/ reinforcing
Tight environmental budgets typically mean that not all targetable land areas can be PES enrolled. Pressures could thus be partially shifted from enrolled, protected to non-enrolled, non-protected ones. Leakage can diminish environmental impacts, and is especially relevant for globally targeted ES, such as mitigating forest-based greenhouse gas emissions, but also a naturally occurring reaction of economically rational agents. We do not know of any particular PES leakage studies in Europe, but we would expect the phenomenon to occur neither more nor less than anywhere else in the world.

l) Solid linkage between land-use proxy and ES
As Section 3.5 showed, ES impacts are often not easy to measure directly. Hence, most PES contracts are coined in terms of outcomes, i.e. land-use proxies -- such as, amount of forest cover – instead of proper impacts, such as carbon stocks and biodiversity habitat. In the longer term, linkages between proxy and ES need to be verified. Sometimes, contracts can also be linked to both proxies and ES impacts, as some experiments also in Europe show.

m) Low transaction costs
PES systems may be costly to establish (lengthy negotiation processes, possibly institutional innovations), while they can in principle be administratively low-cost at the stage of recurrent payments, especially when they can be linked to government institutions, and when the actions do not have to be highly customized. In Europe, this seems to hold for many government-financed schemes, but the aforementioned private Vittel watershed programme is a contrarian example: high customization and high transaction costs were accepted, due to the high ES value.

n) Permanence
Finally, a central concern is whether the effect of PES will persist if/ when the programme ends. If PES incentivizes landowners to long-term adoption environmentally friendly practices that are privately profitable in their own right, ES permanence is achievable (see Figure 2). More common (and realistic) is it that land use and ES effects naturally dissipate when PES end, since the environmental problem persists: you only get what you pay for, as long as you pay. In Europe, particularly agri-environmental PES schemes hold examples of both transitory and permanent impacts on ES provision.

Where does all of this leave us in terms of the right-hand side of Figure 7, i.e. the outcomes and impacts? The number of rigorous environmental impact evaluations, conducted with a proper business-as-usual scenario about what would have happened without the intervention, to date still remains limited. This is true globally, but especially so for Europe: a tradition of rigorous impact evaluations of incentive schemes with explicit counterfactuals has not been cultivated so far in the European context. Most of these impact studies are also at the outcome level (land-use changes, vegetation cover), rather than the impact level (proper ES measurement).

For PES, we found 17 rigorous impact evaluation studies for a dozen of initiatives in just seven countries. A wide variation in land-use outcomes exist, even for the same PES programme applied

in different regions. This underscores the importance of local contexts for environmental results. Many PES schemes have been carried out in low-threat environments, thus harvesting low-hanging conservation fruits – but when compared to matching counterfactuals, their attributable impact is low. However, for other conservation tools, similar area selection biases prevail: PES are comparatively still doing fairly well – but not as well as they arguably could if some design errors were corrected.

7.2. Future perspectives

Payments for ecosystem services (PES) have over the last few decades become increasingly applied worldwide, but more so in some regions (the Americas and Australia) than in others (Europe, Africa). Preconditions about secure land rights, legality, and service users' ability to organize payments have been key bottlenecks in some developing country settings, e.g. in Africa. These structural-institutional factors have provided solid explanations for where PES programmes have emerged, where none of them at all have developed, and the many contexts where PES has occupied a niche in environmental policies, related specifically to private landownership with significant externality impacts on ES users, and society at large.

As mentioned, Europe has clearly been a laggard in PES implementation, but this is probably less explained by the aforementioned institutional factors (landownership, societal organization): in that regard, Europe is much more similar to the USA and Australia – where PES indeed have been used much more. In Europe, the prevalence of large protected areas and regulations, the existence of large state forests and of fragmented private forestlands, occupied often by smallholders with a large degree of absenteeism, are certainly part of the explanation. However, perhaps most central to an overall diagnosis is the lack of sufficient private willingness to pay, which in turn seems related to a societal vision of generally a public responsibility for the environment and ES provision, and hence a predominant role for regulatory approaches. This societal legacy has likely limited the perceived need for, and eventual adoption of PES.

As for the known impacts of PES worldwide, the number of rigorous impact evaluations conducted to date still remains limited, especially so for Europe: a tradition of rigorous impact evaluations of incentive schemes with explicit counterfactuals has not been cultivated so far in the European context. But from other parts of the world, we know design- and implementation-wise at this stage already quite a lot about "what works, and what doesn't".

In principle, PES as a policy tool has the potential to be direct, flexible, and effective instruments, but several flaws in PES design and implementation patterns have been observed in this initial phase of their broader-scale application. In particular, it seems clear that PES could potentially be upgraded in their economic functioning, so as to better realize their potential. The motives for this suboptimal use of the PES instrument stretches from excessive administrative simplification to multiple side-objectives and political economy factors favouring certain modes of implementation. However, the lessons towards good PES practices for environmental efficiency are quite clear: spatial targeting of contracted area selection to service density, threat (and possibly cost) levels, payment differentiation, and improved enforcement of conditionality with explicit sanctioning of

non-compliant landowners can all help to meet the design challenges. If forced to single out one policy error, PES site selection needs to further move into high-threat areas so as to increase environmental impacts, avoiding to predominantly pay for what would have happened anyhow. This also requires political will to boost environmental objectives in PES government-financed schemes that typically respond to multiple concerns.

In Europe, an alleged increased role for PES could be imagined either through reforms of the Common Agricultural Policy (government-financed PES), and/ or through an increased realization on behalf of private actors that the European states alone are unable to deliver through regulatory tools the full suite of ecosystem services that service users and society's need (user-financed PES). In principle, public regulation could continue to safeguard a minimum threshold of ES delivery to society, while PES could then be responsible for a 'premium ES delivery', i.e. over and above the minimum mandated by regulation. Such a sticks-and-carrot strategy could also be in the interest of landowners, who would not only have to carry the costs of basic environmental compliance, but would receive compensatory economic incentives on top, so as to make environmental protection efforts worth their while.

However, for this vision to play out, arguably a sufficient private willingness to pay would need to be triggered, so that the economics of PES could come to take off in Europe. We can only speculate here, but several sub-scenarios could be expected to become influential in that respect. One is that climate change would continue to increase the frequency of weather anomalies and catastrophic events, such as droughts, wildfires, stormflows and floodings, thus also increasing our societies' demand for environmental adaptation and mitigation – perhaps to an extent that the often financially pressurized public environmental agencies in Europe might not always be able to deliver: it would thus become increasingly clear to European citizens that they also need to privately pay for a set of ES that are crucial to their welfare.

As a complementary pathway, some of the costs of adaptation to natural catastrophes would also fall on insurance companies that will increasingly look to either reduce these risks at their source, but also pass on higher costs through raised insurance premiums (i.e. a disincentive), thus privatizing environmental externalities in various ways. Yet, this could also create more space for nature-based solutions to embrace PES type of solutions, where private landowners are incentivized to take actions that decrease society's exposure to environmental hazards.

Finally, as a partially alternative pathway to the envisaged privatization of societal environmental costs, a push of massive societal investments in environmental adjustments, in the spirit of a Green Deal, could also include the use of more government-financed PES to reach certain targets. In this scenario, both national governments and the EU could potentially take a leadership in providing the incentives to guide private landowners towards actions promoting the objectives of mitigation and adaptation.

In other words, while there are good structural reasons for explaining the current scarcity of PES initiatives in Europe, it is also possible to imagine a series of game changers that could alter this picture – with climate change arguably lining up as a root trigger of change. For forests in particular, unlike the tropical/ developing country PES focus on unanimously increasing forest

cover, European forest-based PES at a broader scale would likely be much more complex, implying to some extent the conservation of open landscapes and mosaics, which sometimes will also imply to pay for keeping forest regrowth and biomass accumulation back from their business-as-usual expansionary forest transition path of spontaneous natural forest regeneration. More research will also be needed here to determine which forest landscape reconfigurations most effectively could respond to a new set of environmental challenges, and how economic incentives can best be used to help pushing for the needed transformations.

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