Payments for Environmental Services (PES)

A primer on PES, common pain points, and the promise of digital technology

Climate Collective

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Executive Summary

Ecosystem services, the benefits to human wellbeing provided by nature, are the life-supporting outcomes of a healthy natural world and crucial for human existence. The exploitation of ecosystems for profit has resulted in the degradation of land and privately owned natural resources, requiring economic incentives to ensure their preservation. In this brief, **ecosystem services** refer specifically to the indirect benefits provided by nature to human wellbeing, without human interference (e.g. provision of clean air). **Environmental services** refer to the direct benefits provided as a product of human interference with natural ecosystems (e.g. activities done by people in an effort to preserve or restore specific ecosystems and their services, also sometimes referred to as nature-based solutions).

Payments for Environmental Services (PES) are a method of incentivizing the conservation of ecosystem services by rewarding land owners or stewards with subsidies, in-kind support (e.g. infrastructure provision and public services) and/or payments.

PES schemes can provide social, ecological and economic benefits, such as:

- The preservation of critical ecosystem services, including raw materials
- The assignment of economic value to critical ecosystem services
- Financial contribution and economic mobility to local stewards
- More affordable and right-fit climate change mitigation and adaptation interventions

So, why haven't these promising solutions been scaled further? PES schemes are incredibly complex and face many challenges when deployed at scale. These challenges include high transaction costs, a lack of trust between participants, inefficient and delayed monitoring, and a lack of standardized definitions and practices for impact monitoring and reporting. The application of promising emerging technologies - like AI/ML, remote sensing, blockchain, LIDAR, DNA sequencing and distributed ledger technology - is further explored in "Emerging tech for improving PES", and can help address these challenges in the following ways:

- Reducing transaction costs with fewer intermediaries and alleviated administrative costs
- Enhancing information integrity and accessibility
- Integrating, normalizing and making searchable currently disparate nature and climate datasets
- Expediting cross-border payments and increasing global access and participation
- Improving and digitizing measurement, reporting, and verification (MRV) tools
- Improving local sensing data precision, quality and accessibility
- Strengthening property rights documentation with tamper proof and blockchain-based registries
- Increasing market action by democratizing access for both communities and consumers
- Diversifying payment options for service recipients to increase market participation
- Generating more accurate and real time impact measurement
- Increasing trust in risk assessments with hyper localized and real time data

This brief touches on the applicability and importance of PES schemes for local, regional, and global ecological sustainability and climate impact, breaks down different types of PES schemes, and explores the opportunities for emerging technology solutions to scale PES scheme implementation with principles of green accountability at their core.

Introduction

This brief explores how Payments for Environmental Services (PES) can be used as an important tool for local, regional, and global ecological sustainability and climate impact. It then dives into common challenges faced and how emerging digital technologies can support more effective and scalable PES scheme implementation built around principles of green accountability.

Ecosystem vs. Environmental Services

In this brief, ecosystem services refer to the indirect benefits provided by nature to human wellbeing, without human interference (e.g. provision of clean air). Environmental services refer to the direct benefits provided as a product of human interference with natural ecosystems (e.g. activities done by people in an effort to preserve or restore specific ecosystems and their services).

Why are PES relevant today?

Ecosystem services form the foundation of human wellbeing, encompassing the clean air we breathe, the water we drink, and the fertile soil that sustains our food production, just to name a few. The exploitation of ecosystems for profitable activities, the absence of nature value, and the prioritization of individual economic gains over the preservation of the environment and the value that ecosystems provide to the global community, have led to their gradual degradation. With many natural resources privately owned, economic means are necessary to incentivize owners to choose and ensure preservation. PES schemes tackle this market failure by providing payments to internalize opportunity costs and add additional incentives to motivate eco-positive activities. PES schemes are thus a market-based approach to encourage the broader provision of ecosystem and environmental services.

What are PES schemes?

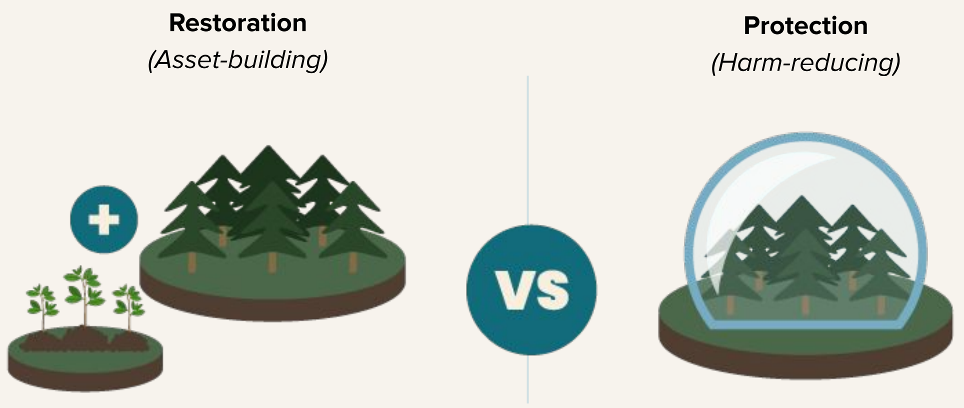
Payments for Environmental Services (PES) are widely used mechanisms for incentivizing human activities to achieve environmental goals. They alter the payment matrix for environment-related activities like conservation or regeneration actions by offsetting costs (including opportunity costs) and generating additional economic incentives for eco-positive activities. The payments can give environmental service providers the opportunity to diversify their income while reducing their dependency on extractive or environmentally harmful activities. PES schemes are particularly relevant tools to ensure the provision of public-good environmental services.

PES schemes differ from other environmental policies in that they harness economic incentives, rather than economic or legal disincentives like taxes or prohibition. Instruments such as taxes operate under the principle that polluters pay for their negative externalities, while in PES schemes, stewards are rewarded for providing positive externalities. They are a supply-side policy alternative for natural resource management with the essential characteristic that they are voluntary, and incentives are granted conditionally on the delivery of contractual agreements.

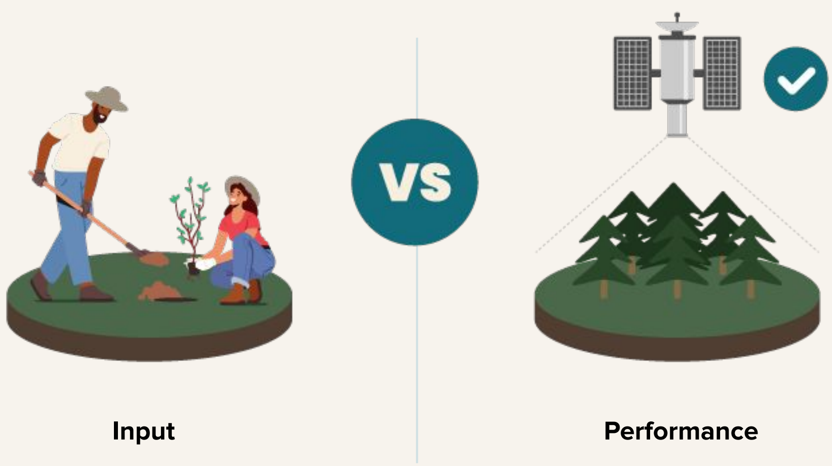
Types of PES schemes

PES schemes can be classified based on multiple criteria[1] including: the focal environmental service (e.g. carbon sequestration and storage, biodiversity protection, watershed protection); the type of activity contracted (asset building vs. harm reduction); whether it's input- or output-based, the involved stakeholder; timeframes (short- to long-term engagements); geographical extent (local to global) and others.

1. Type of Activity: One way to categorize projects is by the type of activities conducted by ES providers. Some schemes focus on *environmental asset building* (tree planting or mangrove restoration), while others target the *reduction of detrimental activities* (deforestation).



2. Input or Output based: Another classification is whether compensation is tied to *activity inputs* (maintaining biodiversity corridors in plantations) or *environmental service outputs* (the amount of species found in a plantation).

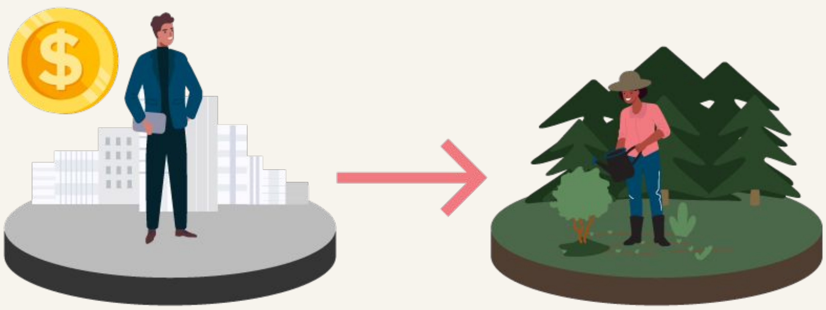


[1] Sattler, C., et al. (2013). "Multi-classification of payments for ecosystem services: How do classification characteristics relate to overall PES success?" Ecosystem services 6: 31-45.

3. Stakeholders Involved & Payment Delivery Options: Who is involved and the directness of transfer between the buyers and providers of environmental services is relevant to scheme design.

A. Direct (Coasean) transactions between ES providers and buyers occur when parties are able to easily align incentives and outcomes without the intervention of other parties. Schemes financed directly by the ES recipient are typically small and targeted.

Successful examples of Coasean PES schemes are limited (one such private example by Nestlé Vittal is described on page 9), however the increased prevalence of digital technology for both funders and service providers (including use of blockchain technologies to increase transparency and reduce administrative cost) may enable such direct schemes to be implemented more regularly.



B. Intermediated (Pigouvian) transactions include intermediary agencies like the government, NGOs, or third party project developers. Such intermediaries support by facilitating program design, offering training, supporting information exchange, building social capital and trust, or increasing preparedness. Inclusion of intermediaries also increases administrative cost and program complexity, and can lead to diversification of priorities.

Government intervention influences program success by aligning policies and public structures with environmental goals and shaping demand and supply. Government-run schemes are larger and multifaceted, with state intervention often reducing transaction costs and enabling a larger scale of success.

Social implications of PES design

The design of a PES scheme has many implications on local livelihoods. Such impact varies depending on whether a project focuses on restoration or protection activities, and whether it is input- or output-based. Restoration schemes typically generate local job opportunities, while protection activities like deforestation-avoidance might shift jobs away from a project area. For example, forestry protection may put local timber crews (as well as other members of the supply chain, like transporters and mills) out of work.

> *Participation in output-based schemes is often only tenable for larger ES providers, who can carry the risk of deferred payments pending project outcomes rather than payment for inputs. These dynamics affect the scheme's acceptance, equity, and social performance.*

Economic significance of PES

The interdependence between environmental service provision and local natural ecosystems and communities results in a variety of economic benefits.

The preservation of critical ecosystem services and raw materials. By incentivizing the protection of ecosystems, PES schemes contribute to the sustained provision of ecosystem services and essential raw materials, ensuring their availability for productive activities for current and future generations.

Solidifying the economic value of environmental and ecosystem services. By assigning market value to previously undervalued environmental and ecosystem services, PES schemes not only acknowledge their economic significance, but also foster and finance sustainable practices.

Contributing to sustainable and inclusive economic development. PES schemes have the potential to foster sustainable economic growth, particularly in small economies, by aligning conservation efforts with economic development objectives. By creating alternative income sources for service providers, PES schemes provide local communities with diversified livelihood options. These schemes can contribute to poverty reduction by extending new financial incentives to marginalized communities and driving inclusive economic growth.

Reducing climate-change mitigation and adaptation costs. PES schemes associated with carbon sequestration offer a comparatively cost-effective way to mitigate climate change. They also offer alternatives for substantially reducing expenses associated with climate change adaptation. PES providers who diligently care for their natural capital are better equipped to navigate and adapt to a rapidly changing global environment.

What makes a PES scheme successful?

The success of a PES scheme hinges on several factors, as well as the scheme's specific objectives. Key measures include:

- *Additionality,* which measures the value added by an environmental service compared to a baseline scenario (what would have happened without its implementation);
- *Permanence*, which ensures that environmental services are maintained over time;
- *Effectiveness* and *efficiency,* in terms of delivering intended environmental benefits cost-effectively;
- *Social co-objectives*, such as poverty reduction, and the equitable distribution of benefits between all participants

Deployed PES programs – a brief overview

PES schemes have been conceived and implemented by a wide array of stakeholders in various contexts, operating within diverse institutional frameworks spanning the globe. Below we include a few examples for illustration of depth and diversity.

National PES schemes

National PES strategies have received attention due to their size and impact. Several countries have implemented notable national PES programs and strategies, contributing to global efforts in ecosystem protection. Costa Rica, China, Mexico, Brazil, and Colombia are among the countries with significant PES initiatives.

Costa Rica's pioneering PES strategy, initiated in 1997, is a renowned model that rewards landowners for conserving and restoring ecosystems. Focused on reforestation and watershed protection, the program incentivizes sustainable land use by compensating landowners for vital environmental services. Centrally administered by the National Fund for Forest Financing (FONAFIFO), it employs diverse funding sources, benefiting various landowners from smallholders to larger proprietors. Projects are identified based on environmental significance and potential impact, involving collaboration between government agencies, NGOs, and local communities. The process includes technical assessments, community engagement, negotiation, and project design, with regular monitoring and adaptive management to ensure successful implementation and achievement of conservation goals. Further **examples of National PES Schemes** can be found in the Appendix.

REDD+ Projects

The REDD+ (Reducing Emissions from Deforestation and Forest Degradation, plus Conservation and Sustainable Management of Forests) program under the Kyoto Protocol has further propelled international interest in PES schemes associated with deforestation and reforestation. Due to its origins in international negotiations and global frameworks, REDD+ has been the most consistently documented PES framework in the international community. National REDD+ initiatives have gained particular attention. REDD+ plays an important role in combating climate change by tackling deforestation and forest degradation, which are major contributors to greenhouse gas emissions. The approach not only supports emission reductions, but also encourages biodiversity conservation and the sustainable management of forests.

REDD+ projects have faced criticism for inadequately involving local institutions and communities, as well as suboptimal environmental impacts observed in some projects. Regarding the latter, much of this controversy surrounds the discrepancies between projected deforestation or preservation rates and actual rates achieved, and nebulous baseline risk of deforestation. This criticism is tied specifically to the use of REDD+ as a methodology for carbon removal quantification and credit issuance. Many of these measurement and baseline discrepancy concerns can be addressed with real-time monitoring and improved modeling (discussed later in **Emerging Tech for Improving PES**).

The Forest Investment Program (FIP) is one example of a global REDD+ fund, which supports 23 developing countries' efforts to reduce deforestation and forest degradation (REDD) and promotes sustainable forest management. It provides financing to developing countries for readiness reforms and public and private investments, identified through national REDD readiness or equivalent strategies.

The Khasi Hills Community REDD+ Project is a small REDD+ scheme in Meghalaya, India. Indigenous Khasi governments across 62 villages use established forest conservation traditions to preserve and restore community forests, address poverty, and empower women through microfinance institutions. It tackles deforestation by preventing forest fires, establishing woodlots, and promoting fuel-efficient cook stoves, enhancing both ecological and socio-economic wellbeing. Funding comes from various charitable and environmental management organizations.

Savimbo, a biodiversity and forest preservation organization, uses the REDD+ grouped methodology and an indicator-species biodiversity methodology to preserve critical and biodiverse areas of forest in the Colombian and Peruvian Amazon. Their approach uses ongoing peer enrollment, which allows vulnerable smallholders and neighboring indigenous groups to safely enroll in the program as they see results from their neighbors.

A **list of national REDD+ initiatives** can be found in the appendix.

Private PES schemes

Private PES schemes mobilize resources outside of government-led programs to protect forests, offset carbon emissions, conserve biodiversity, and preserve watersheds. An example is the Nestlé Vittel Compensation Plan, which operates as a private and direct PES scheme where communities hosting the ecosystem service (Nestlé) collaborate with providers of environmental services (farmers residing in the Vittel watershed). The program aims to protect and restore the natural hydrological cycle of the Vittel aquifer by compensating landowners for implementing practices that improve water quality, reduce soil erosion, and enhance natural water infiltration. Under this scheme, Vittel directly pays participating landowners who voluntarily adopt environmentally friendly practices on their land, incentivizing them to improve water quality. Nestlé benefits as the buyer as they commercialize bottled water from the aquifer.[2]

Other notable projects

Landscape Enterprise Networks (LENS) increases infrastructure and supply chain sustainability through the purchase and sale of nature-based ecosystem improvement solutions in the UK and EU. The Outcomes Fund and Eco-harvest in the U.S. both compensate farmers for outcomes related to adopting regenerative farming practices. A more comprehensive list of PES projects, as well as links to other PES project databases, can be found in the **PES Project Database.**

[2] It's worth noting that Nestlé has been scrutinized for their disruption of the region due to over-extraction from the aquifer.

Designing PES schemes: Some considerations

When designing PES schemes, practitioners should consider a series of factors including: scheme location; payment amount; fund delivery mechanism; social elements; and impact measurement. Digital technologies can be implemented to address a number of these challenges.

Location and Spatial Targeting

Project location is critical for PES success. Location is determined with input from administrative, community and scientific groups. Spatial targeting, which requires scientific input, is more important than simple location, and includes consideration of environmental threat levels, the existence of valuable ecological features, and/or marginal ES provision costs. Other considerations include the interest of ES providers, local laws, and availability of property tenancy documentation,

Payment Amount

Payments for ES must be set in a range between the beneficiaries' willingness to pay (WTP) and the providers' willingness to accept (WTA). Aligning payments with minimum WTA values maximizes efficiency and resources for expanding ES provision, while pursuing social co-objectives (like poverty reduction) justifies higher payments. Allowing multiple providers the ability to deliver environmental services with marginal cost differentials enhances scheme efficiency and maintains balance between incentives, sustainability, and social considerations.

Fund Delivery Mechanisms

There are many ways to distribute funds, from in-kind provisions like infrastructure development to cash payments in local currency. Collective payments are recurrent options for schemes where communities, rather than individuals, provide the ES. Integration of Web3 technologies has the potential to reduce costs, streamline banking processes, facilitate global transactions, and amplify transparency in payment procedures.

Social Factors

PES operate within, and are shaped by, existing social structures. Local institutions involved in PES scheme deployment significantly shape its outcome. Understanding community and institutional motivations early on is key to designing effective incentives and preventing unintended changes to existing positive behaviors. Successful PES schemes typically consider, and even leverage, existing social structures, fairness perceptions, and traditional knowledge in their design and implementation.

Impact Measurement in PES

Impact measurement and accountability are pivotal factors in assessing the success of PES schemes; yet, impact measurements in PES schemes are sometimes inconsistent, infrequent, and retroactive. One study found that out of 70 PES schemes, only 25% had considerations for non-delivery. This was due to multiple factors, including prohibitive costs to monitor and measure payment delivery.[3]

PES Challenges

Despite the promise of PES and the examples shared earlier, many obstacles persist across PES projects which, if unaddressed, may hinder ongoing large-scale deployment of finance for this much-needed work. Some of these challenges include:

- Opaque and costly transaction flows
- Monetary incentives undermining intrinsic environmental motivations
- Uncertain ownership of environmental resources / insecure property rights
- Unintended leakage or emissions spillover beyond project boundaries to other regions
- Lack of trust between participants
- Expensive, slow and inefficient monitoring mechanisms
- Lack of arrangements in case of no delivery
- Lack of evidence for net environmental gains and additionality concerns
- Overrepresentation of participants experiencing lower environmental pressure due to self selection
- Uncertain causal links between environmental actions and environmental service provision

Addressing these challenges is crucial for successful and sustainable PES implementation. More detailed explanations of **these issues** can be found in the appendix.

Emerging technologies have the potential to entirely reshape how PES schemes are designed. Various digital Measurement, Reporting, and Verification (dMRV) tools – including satellite imagery, sensors, drones, and smartphones – enable real-time monitoring and more effective measurement of baselines, and significantly reduce data collection costs. Blockchains enable secure and transparent management of monitoring data, further strengthening accuracy and accountability of impact assessments within PES initiatives. Utilization of a public blockchain for project monitoring and corresponding financial activity permits transparency and auditability that deters misallocation of funds and makes visible the percentage of project funding that reaches local populations. Furthermore, artificial intelligence (AI) can improve the establishment of baselines and long-term modeling of forest growth and other changes in ecosystems, resulting in increased accuracy and the most current data for impact measurement.

[3] Wunder, S., et al. (2018). "From principles to practice in paying for nature's services." Nature Sustainability 1(3): 145-150.

Emerging tech for improving PES

Emerging digital technologies can bolster the implementation and effectiveness of PES initiatives, and provide innovative solutions to some of the key challenges faced in PES design and execution. These technologies include, but are not limited to: AI/ML; remote sensing; blockchains; LIDAR; DNA sequencing; and distributed ledgers. These technologies are already utilized in key climate-related services such as dMRV, greenhouse gas (GHG) accounting, and enhanced baselining and parametric insurance provision. PES schemes could see the same increased efficiency and data verification improvements through the implementation of such technologies.

1. **Enhanced Information Integrity & Accessibility:** The fragmented nature of PES schemes leads to information asymmetry across all parties - from ES buyers to providers. Blockchains can make this information publicly accessible, documenting network activities from reforestation measurements to payment disbursements, in a traceable and tamper-proof manner. New user-friendly platforms are currently being developed to provide easier access to this information on-chain. AI tools can be used to analyze this climate information to identify patterns, predict future trends, and provide effective recommendations, improving data quality over time.

   ***Example**: Open Forest Protocol tracks measurements from disparate and decentralized sources, and uses third parties to verify such measurements on a publicly-accessible digital ledger. This data is used to issue carbon credits for forestry projects.*

2. **Transaction Cost Reduction:** High transaction costs and complex transaction flows are barriers to getting direct payments into the hands of environmental service providers. Blockchains can eliminate the necessity for financial intermediaries by developing decentralized and transparent payment processing systems, thereby reducing costs across the entire financial transaction. Blockchains can also alleviate administrative costs for environmental providers and ultimately allow for more money to flow to smaller providers.

   Example: GainForest uses blockchain technology to allow donors to directly support nature projects, then uses satellite, drone, and field data to monitor and track the environmental impact of their contributions transparently.

3. **Borderless Payments and Currency Flexibility:** International currency exchange and its limitations (i.e. fees, delayed transfer times, inability to exchange with certain jurisdictions, etc.) are obstacles to facilitating cross-border PES payments. Cryptocurrencies and tokens can deliver direct, trackable, seamless, and compliant cross-border disbursements to accelerate payments and increase global participation.

   ***Example**: GoodCollective enables cross-border payments for a variety of environmental services, the only intermediary being a smart contract in which payment amounts, currencies, and conditions of payment can be configured (and are open to all to see).*

4. **Improved Monitoring and Automated Conditionality:** Accurate and timely tracking of environmental service impact is necessary to correspond program finance to climate outcomes. Digital MRV offers transparent, cost-efficient, and decentralized approaches to ensure accurate tracking of environmental service delivery. Technology-enabled dMRV allows participants to gather and compare information from disparate and unique sources, thus helping to maintain the integrity of the programs.

Tools such as smart contracts, programmable money, and escrow services enable automated conditionality enforcement; payments are triggered only upon validation of service provision, ensuring accountability and minimizing fund misappropriation. Satellite imagery and AI can also be used to evaluate how resources are invested by monitoring impacts like carbon sequestration, biodiversity protection, water regulation and landscape beauty to ensure they reach those who can effectively provide environmental services.

Example: *PlanetWatch incentivizes individuals and businesses, through a rewards system, to capture air quality data, then uses blockchain technology to store and build a global air quality monitoring network that detects pollution hotspots and provides actionable insights.*

5

Higher-fidelity networked local sensing: Understanding detailed environmental conditions (e.g., the makeup of a soil microbiome) traditionally requires expensive equipment, managed and operated by specific institutions. More robust, affordable, and, in some cases, portable sampling and sensing technologies (for example soil sampling, DNA sequencing) democratize and decentralize the measurement required for baseline-setting and ongoing monitoring of both subsequent degradation and any ecological improvements. This opens up possibilities for more accurate, robust, and frequent environmental monitoring and locally-led citizen scientific contributions.

Example: *SimplexDNA is building a Proof-of-Life protocol to incentivize the collection of environmental DNA and generate a transparent global database of biodiversity information stored on the blockchain. The protocol enables collaboration with local communities, corporations, and governments to collectively finance and share the rewards of data aggregation.*

6

Strengthened Property Rights and Incentives: Uncertain land tenure, property rights, and land ownership in some of the most ecologically critical locations can make administration of PES schemes difficult. Distributed Ledger Technology (DLT) registries host property claims and ensure that they cannot be modified or tampered with, strengthening confidence in ownership. These registries can be especially helpful in isolated areas of developing countries, where many environmental services are provided and national registries can be inconsistent or difficult to access.

Example: *The Republic of Georgia's National Agency of Public Registry (NAPR) created the first ever blockchain-based land registry system in partnership with Bitfury. using an immutable ledger to provide Georgian citizens with digital certificates of their assets to strengthen property ownership rights and trust in the government.*

7

Increase Market Liquidity: Traditionally, environmental assets and services have been difficult to trade due to their uniqueness and enormous asset size. When environmental assets are tokenized, they can be made fungible and broken down into smaller, divisible tokens, which increases accessibility to a broader range of ES purchases and allows smaller buyers to enter the market. Tokenization and other decentralized finance tools such as liquidity pools ensure transparency and traceability through immutable blockchain-based records, thereby establishing a higher level of trust among stakeholders regarding a token's history, the underlying provenance of the asset, and its eventual retirement.

Example: *Regen Marketplace lists the results of PES activities as semi-fungible assets for purchase. A recent example is Sheep Grazing credits that represent positive ecological impact of specific rotational sheep grazing practices.*

8 **Adaptive Payment Mechanisms:** The wide range of PES scheme types leads to a wide range of incentives for participants. Traditionally, payments are offered in cash or in kind, but expanding to digital wallets, tokens, and conditional payments can make a PES scheme more attractive. The ability to customize payment structure and offer a diverse array of payment options can lead to more engaged participants and better project outcomes.

> ***Example:*** *Silvi provides inputs-based micro-payments over time for tree stewardship. These payments correspond to specific milestones in stewardship activity and the tree's growth (e.g. germination).*

9 **Dynamic and Hyperlocal Baselining for Impact Measurement:** A challenge of conservation restoration and carbon markets, alike, lies in establishing accurate baseline scenarios for geographically variant sites. Past generalization of baselines has resulted in questionable projections of potential impact at project conception, and imprecise measurements that approximate change generally to large and diverse swaths of land. High-resolution remote sensing and hyperlocal machine learning models can support more accurate baselining and more nuanced projections, from which locally-specific and risk-adjusted outcome calculations can be generated.

> ***Example:*** *Pachama uses machine learning and remote sensing to create dynamic baselines that account for baseline uncertainty.*[4]

10 **Greater accuracy in risk modeling:** Modeling potential scenarios and their associated risks is a centuries-old practice. However, in a time of unprecedented environmental flux, doing so accurately is increasingly complex and, as a result, increasingly difficult. Higher fidelity and real-time remote monitoring, detailed historic data, and thousands of scientific models can now be fed into machine learning models to project and assess multiple future scenarios with greater accuracy and fidelity. This has many relevant PES applications, including providing localized projections for underwriting specific project sites.

> ***Example:*** *dClimate uses remote sensing, geospatial intelligence, and generative AI to refine its data understanding and enhance predictive capabilities over time, allowing for early risk detection and, for its parent company Arbol, more accurate parametric insurance underwriting.*

11 **Trustworthy Risk Mitigation:** Risk assessment and mitigation planning for PES projects is a significant undertaking, especially when including planning for adaptation. With the use of near real-time or real-time data indexing and smart contracts, funds allocated for risk management can be triggered and deployed specifically in the case that a catastrophic event occurs. This increases confidence in these funds, while also lowering costs of traditional insurance policies.

> ***Example:*** *Floodbase integrates satellite-based observations with hydrological and meteorological data, models, and other ground observations to generate seamless, near real-time flood maps, allowing for more accurate insurance risk assessment and payment deployment.*

Digital technologies hold immense potential to transform the landscape of PES implementation by addressing key challenges and paving the way for more effective, accountable, and sustainable PES initiatives that align with environmental and socio-economic goals. We welcome feedback, input, and further examples of successful implementations of these technologies, as well as learnings and best practices to inspire and inform the broader community in their endeavors for climate impact.

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[4] This, along with other work, has led to an updated Verra Afforestation, Reforestation and Revegetation Methodology - a significant step towards the inclusion of greater tech-based dMRV technologies in building high-integrity carbon markets.

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Appendix

PES are a relevant tool to mobilize financial resources for conservation and sustainable management of natural resources. Along with funding from the private sector (philanthropy, impact investing, and corporate social responsibility initiatives), from government budgets, and international aid agencies, PES schemes offer a strategy for fund deployment that provides pro-social benefits to pro-environmental incentives.

Formal definitions of PES

Sven Wunder[5] defined PES as "voluntary transactions where a well-defined environmental service (or a land-use likely to secure that service) is being 'bought' by an environmental service (ES) buyer from an ES provider if, and only if, the ES provider secures ES provisions." This definition is widely used in the PES space and scientific literature. Wunder[6] offers a revised definition, redefining PES as "voluntary transactions between service users and providers that are conditional on agreed rules of natural resources management for generating offsite services". This new definition emphasizes conditionality and offsite benefits as defining features of PES schemes.

Engel[7] defines PES schemes as positive economic incentives where environmental service providers can voluntarily apply for a payment that is conditional on either providing the service or engaging in an activity directly linked to its provision.

According to Muradian et al.[8], PES are schemes for transferring resources between social actors to align incentives for land use decisions with the social interest in resource management. His definition emphasizes ecological sustainability and equity rather than just economic efficiency.

Ecosystem Services and Environmental Services

The concept of ecosystem services refers to ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being. Environmental services highlight that these benefits can sometimes depend on human activities contributing to their provision.

The role of governments in PES programs

Understanding payments for environmental services (PES) schemes requires recognizing the crucial role of governmental intermediaries. Governments can fulfill different roles in PES programs, acting as legal influencers, direct market partners, or both. As a result, PES programs have been categorized as government-financed (with the state as a buyer), user-financed or Coasean (with no direct state involvement), compliant payments-based (with the state as a legal actor but not a buyer), or compensation payments-based (with the state involved as both a legal actor and buyer). The government's institutional roles directly impact the success of PES schemes, particularly when public organizational structures align with environmental goals and legislative measures influence demand or supply.

User-financed programs are typically small, strictly targeted, better monitored, and focused on single services. Government-financed programs are often larger, simultaneously aim for multiple co-objectives and benefit from established institutional structures. Large PES projects may have a higher likelihood of success when operating under state supervision due to reduced transaction costs associated with engaging government institutions.

[5] Wunder, S. (2005). "Payments for environmental services: some nuts and bolts."
[6] Wunder, S. (2015). "Revisiting the concept of payments for environmental services." Ecological economics 117: 234-243
[7] Engel, S. (2016). "The Devil in the Detail: A Practical Guide on Designing Payments for Environmental Services." International Review of Environmental and Resource Economics /9(1-2): 131-177.
[8] Muradian, R., et al. (2010). "Reconciling theory and practice: An alternative conceptual framework for understanding payments for environmental services." Ecological economics 69(6): 1202-1208.

National PES Schemes

Costa Rica's pioneering Programa de Pago por Servicios Ambientales (PPSA) program established in 1997 is widely recognized as one of the world's most successful PES programs and served as an inspiring model for other countries. The PPSA focuses on promoting conservation and sustainable management of forests, watersheds, and biodiversity through their FONAFIFO National Forestry Financing Fund. By financially compensating landowners and communities for ecosystem services like carbon sequestration, water regulation, scenic beauty, and biodiversity conservation, the PPSA has made significant contributions to forest conservation and restoration in the country thus providing a number of benefits, such as carbon sequestration, water regulation, and biodiversity conservation.

China has also implemented a number of PES schemes, including the Sloping Land Conversion Program (SLCP), which targets land degradation in rural areas by incentivizing farmers to convert erosion-prone sloping land into forests or grasslands. Other PES schemes in China include Ecological Compensation Mechanisms for protecting water resources, Forestry Carbon Sequestration Programs for afforestation and reforestation projects, and dedicated programs for wetland conservation.

Mexico's Programa Nacional de Pago por Servicios Ambientales (PNPSA) program incentivizes landowners and communities to adopt conservation practices by compensating them for the ecosystem services they provide. The program addresses a variety of environmental challenges, including deforestation, soil erosion, biodiversity loss, and water scarcity. The PNPSA operates through a decentralized approach, involving federal, state, and municipal governments, as well as local communities and civil society organizations.

Colombia's National PES program also aims to conserve forests and promote sustainable land use. The program includes payments for forest conservation, reforestation, and agroforestry practices.

These national PES schemes demonstrate the importance of integrating economic incentives, government collaboration, and community participation in achieving environmental conservation goals. They serve as inspiring models for other countries seeking to implement effective PES strategies to address pressing environmental challenges and promote sustainable development.

REDD+

REDD+ (Reducing Emissions from Deforestation and Forest Degradation) emerged from multinational negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) to combat deforestation's impact on climate change. While it gained formal recognition during COP11 in 2005 and evolved under the Bali Action Plan in 2007, its implementation faced challenges due to its top-down approach. The REDD+ program's designs, at times, did not align well with local institutional settings, resulting in difficulties in execution. PES encompasses a variety of methodologies, often designed by the scientific community in a bottom-up fashion. Successful PES schemes involve communities in their design and have proven to be better targeted and well-suited to the institutional contexts in which they operate. Although REDD+ stands as a prominent example of PES, its effectiveness has sometimes been hindered by its original top-down nature, highlighting the importance of embracing locally tailored approaches for successful implementation.

REDD+ initiatives

Some relevant REDD+ initiatives globally include:

The Amazon Fund in Brazil, is a financial mechanism established in 2010 to support initiatives aimed at reducing deforestation, forest degradation, and greenhouse gas emissions in the Amazon rainforest. Managed by the Brazilian Development Bank (BNDES), the fund attracts contributions from international donors and focuses on promoting sustainable land use practices, forest conservation, restoration, and community-based initiatives. It is currently the largest REDD+ fund in the world.

The Forest Carbon Partnership Facility (FCPF) is a financial mechanism that provides payments to countries for reducing carbon emissions through forest conservation and sustainable land use practices. It supports countries in developing and implementing their REDD+ strategies, promotes climate change mitigation and biodiversity conservation, and contributes to the sustainable development of forest-dependent communities.

The Forest Investment Program (FIP) is a multilateral REDD+ funding initiative in developing countries. It provides financial resources to countries to support their efforts in implementing climate change mitigation and adaptation activities in the forestry sector. The FIP focuses on addressing the drivers of deforestation, promoting sustainable livelihoods for forest-dependent communities, and conserving biodiversity. It operates under the strategic guidance of the World Bank and is funded by various donor countries.

The Green Climate Fund (GCF) is a global fund established under the UNFCCC to support developing countries in their climate change mitigation and adaptation efforts. The GCF provides financial assistance for projects and programs that aim to reduce greenhouse gas emissions (including REDD+), enhance resilience to climate change impacts, and promote sustainable development. It channels funds to developing countries through a variety of financial instruments and supports a wide range of sectors, including renewable energy, adaptation measures, and sustainable land use practices.

The UN-REDD Programme is a collaborative initiative between the United Nations Development Programme (UNDP), the Food and Agriculture Organization (FAO), and the United Nations Environment Programme (UNEP). It provides REDD+ technical assistance and financial support to developing countries. The programme assists countries in developing national strategies and capacities for sustainable forest management, promoting the conservation of forests and biodiversity, and enhancing the livelihoods of forest-dependent communities. The UN-REDD Programme also facilitates the coordination and exchange of knowledge among countries to support the implementation of REDD+ activities.

The BioCarbon Fund Initiative for Sustainable Forest Landscapes (ISFL) is a financial instrument under the World Bank's BioCarbon Fund that supports activities aimed at reducing greenhouse gas emissions from deforestation and forest degradation. The initiative focuses on promoting sustainable land use practices and landscape-level approaches to address deforestation drivers and enhance carbon sequestration in forests. It provides financial support to developing countries to implement projects that integrate REDD+ activities with sustainable agriculture, forestry, and other land use practices. The ISFL aims to achieve both climate change mitigation and sustainable development objectives by promoting the conservation of forests, biodiversity, and the wellbeing of local communities.

The Central African Forest Initiative (CAFI) is a regional partnership focused on the conservation and sustainable management of forests in Central Africa. It brings together Central African countries, donor countries, international organizations, and other stakeholders to address deforestation, forest degradation, and climate change in the region. CAFI aims to support participating countries in developing and implementing national strategies for forest conservation and sustainable forest management. It provides financial and technical assistance to promote sustainable land use practices, improve governance, and enhance the resilience of forest-dependent communities. Through its collaborative approach, CAFI aims to protect the rich biodiversity and ecosystem services provided by the forests of Central Africa while contributing to global climate change mitigation efforts.

The Kalimantan Forest Carbon Partnership is a collaborative initiative in Indonesia aimed at reducing greenhouse gas emissions from deforestation and forest degradation in the region of Kalimantan. It focuses on implementing activities that promote sustainable land use practices, enhance forest conservation, and improve the livelihoods of local communities. The partnership involves various stakeholders, including the Indonesian government, local communities, NGOs, and international organizations, working together to address the drivers of deforestation and support the transition to a low-carbon and sustainable economy.

The Mai Ndombe Integrated REDD+ Program is a comprehensive initiative in the Democratic Republic of Congo (DRC) that aims to reduce deforestation, promote sustainable land use practices, and improve the livelihoods of local communities. It focuses on the Mai Ndombe province, which is rich in tropical forests and biodiversity. The program combines REDD+ activities with measures to strengthen governance, protect biodiversity, and support community development. It involves collaboration between the DRC government, local communities, civil society organizations, and international partners to achieve sustainable forest management and climate change mitigation goals.

The Guyana-Norway REDD+ Partnership is a collaboration between the government of Guyana and the government of Norway to support Guyana's efforts in reducing deforestation and promoting sustainable development. The partnership focuses on financial incentives for Guyana to maintain its low deforestation rates and manage its forests sustainably. Norway provides payments to Guyana based on the country's verified deforestation and emission reductions. The partnership aims to support Guyana's transition to a low-carbon, green economy while preserving its valuable forests and ecosystem services.

Additional notable contributions to REDD+ efforts are made by Norway's International Climate and Forest Initiative (NICFI) and the German REDD Early Movers (REM) Program, which provide financial support and incentives to countries demonstrating progress in reducing deforestation and forest degradation. These initiatives collectively contribute to global climate change mitigation efforts and sustainable forest management.

Designing PES schemes: More details on considerations

When designing a PES scheme, there are multiple considerations that need to be taken into account. In direct PES schemes, project design stems from participant-driven bilateral negotiations, while multiparty arrangements often delegate scheme design to intermediaries. Government-backed PES initiatives entail design by government agencies, with monitoring activities often overseen by ES buyers or intermediaries. The following are a subset of project design criteria that are relevant to many types of PES schemes.

The location for PES programs

The location of a PES scheme is determined by various factors, including the presence of interested environmental service providers, the local legal framework, the availability of property titles, and more. Scientific studies have proposed designing PES projects based on three main spatial characteristics: the degree of environmental threat in the project area, the existence of valuable ecological characteristics, and the marginal costs of ES provisions.

The payment amount

The payment amount is generally negotiated between ES providers, ES buyers, and intermediaries. Typically, the payment amount should fall within the range between the willingness to pay (WTP) for the ES and the willingness to accept (WTA) payments for service provision. Setting payments at the minimum WTA of service providers maximizes the economic efficiency of the scheme and frees up funds for financing additional ES provision. However, other social co-objectives, such as poverty reduction, may lead to payments above the WTA. For schemes with multiple ES providers, payment differentiation based on the marginal provision costs of each provider can lead to more efficient PES outcomes. While models exist for establishing monetary valuation for ecosystem services, this valuation is rarely correlated to compensation amount to ES providers. See **more information about this**.

Social considerations

When implementing a PES scheme within an existing social structure, the project interacts with, and is influenced by, that structure. The coevolution of the scheme with the social institutions greatly shapes the outcome of the interaction. PES schemes use economic incentives to alter motivations and influence human behavior, so designing appropriate incentives requires a good understanding of how PES affects the underlying institutional setting and participants' motivations.

Successful PES schemes account for the existing social structure and participants' perceptions of equity, to avoid conflicts between ES stakeholders, suppliers, and their own values and traditions. They also encourage the utilization of traditional knowledge and creativity in solving problems related to ES provision.

Mechanisms for the delivery of funds

Payments for environmental services can be transferred in various ways, depending on the specific characteristics of the scheme. These payments can be provided as in-kind contributions, such as infrastructure development, cattle, training, and more. Alternatively, they can be granted as cash payments in the local currency. Cash payments are typically delivered directly by the environmental service buyer or through project intermediaries like NGOs or the government.

In cases where multiple stakeholders collaborate towards a common environmental goal, payments may be awarded collectively, and collective transaction mechanisms can be customized to suit the project's needs. Examples of collective payment in PES projects can be found worldwide, including in Vietnam's National Payment for Forest Environmental Services[9].

While blockchain technologies are not yet widely used for payments in PES schemes, they have the potential to reduce transaction costs, facilitate banking for participants, enable international transactions, and connect buyers and sellers on a global scale. Utilization of a public blockchain for such activities permits transparency and auditability that deters misallocation of funds and makes visible the percentage of project funding that reaches local populations.

Impact Measurement Strategies

Impact measurement mechanisms hold crucial importance within PES schemes as they provide a means to gauge the effectiveness and success of these initiatives. With clear and accurate impact monitoring, stakeholders can ascertain whether the intended environmental and socio-economic goals are being achieved. Moreover, robust impact measurement not only informs adaptive management strategies but also enhances transparency and accountability among involved parties. This data-driven approach enables evidence-based decision-making, ensuring that resources are allocated efficiently, interventions are optimized, and overall outcomes align with the objectives of PES schemes.

For many projects, it is unclear if impact monitoring occurs, and even if it does, it is typically done infrequently, retroactively (rather than real-time), and produces reports that are not publicly accessible. When done, traditional monitoring of PES schemes relies on costly on-the-ground expeditions. While these expeditions provide valuable insights into the state of ecosystems and the effectiveness of PES schemes, they are expensive and challenging to conduct, especially in large isolated areas. Technological advancements, particularly in digital Measurement, Reporting, and Verification (dMRV), have revolutionized the monitoring and evaluation of PES initiatives. Digital MRV replaces traditional methods with digital technologies like ground-truth sensing enabled by IoT devices such as smartphones, satellite imagery, sensors, drones, and artificial intelligence. These digital tools enable efficient data collection, cost reduction, and improved conditionality in PES schemes, resulting in better environmental outcomes. By utilizing smart sensors, cloud computing, and blockchain encryption, PES schemes can measure and verify their impact (and who's responsible for it) more accurately and effectively, fostering greater accountability and facilitating the achievement of environmental objectives.

[9] McElwee, P., Van Le, H. T., Nghiem, T., & Vu, H. T. D. (2022). "The challenges of collective PES: Insights from three community-based models in Vietnam. Ecosystem Services" 56, 101438.

Issues of PES implementation

Transaction Costs: Transaction costs in PES schemes encompass expenses related to negotiating contracts, calculating baselines, monitoring, and enforcement. These costs pose a significant challenge and can hinder the positive impacts of PES schemes. High transaction costs discourage participation from both buyers and providers and reduce the establishment of Coasean PES schemes. High transaction costs have negative social impacts by creating barriers to entry for smaller players and providers (e.g. smallholders), implicitly preferencing the participation of large organizations and institutions. For example, hiring legal representation and traveling to a capital city in order to register under a program and pay a central administrative fee may be untenable for small providers; in contrast, sending an SMS to register their participation or self-registration with a local authority (e.g. township office) is much more accessible.

Information Asymmetries: Incomplete contracts and information asymmetries create threats to the environmental and social objectives of PES schemes. Insufficient information among parties involved in PES transactions can lead to inadequate decision-making and a lack of trust. Monitoring mechanisms play a crucial role in reducing information asymmetries and promoting collective action in PES schemes.

Motivational Crowding Out: Refers to the displacement of intrinsic social incentives for environmental protection through economic incentives. Economic incentives provided by PES schemes are embedded within a social context and can have unforeseen effects on participants' motivations. The incentives may unintentionally crowd out intrinsic pro-environmental motivations, undermining the effectiveness of the schemes. Careful consideration of intrinsic motivations when designing PES schemes can help avoid the destruction of social pro-environmental behavior and promote sustainable outcomes. It's worth noting that there is ongoing debate whether motivational crowding-in is also possible, where actors are motivated to contribute to environmental improvement due to existing PES schemes.

Lack of Conditionality Arrangements: Payments for environmental services should only be granted if the expected services are provided in return. Payments should thus be conditioned to the delivery of results specified in the contract. If payments are conditional on ES delivery, then the consequences of non-compliance to the PES contract should be the discontinuation of payments. However, many PES schemes lack robust conditionality arrangements due to the associated monitoring and compliance costs. Weak enforcement of conditionality undermines the effectiveness of PES schemes and limits their environmental impact. In a study of 70 PES schemes, Wunder et al.[10] found that only a quarter of the schemes had mechanisms to address non-compliance with contractual agreements. Many schemes lack robust systems for ensuring conditionality due to the associated costs of monitoring and enforcement. This undermines the effectiveness of PES schemes, as difficulties in enforcing conditionality arise from social, political, financial, and technical factors. These limitations reduce the environmental impact of the PES scheme. Creating and maintaining monitoring mechanisms is costly, and implementing compliance measures, such as reducing or stopping payments for non-delivery, can be socially, politically, and economically challenging (for example, when in-kind payments are provided for building schools).

Insecure Property Rights: Unclear or absent property rights pose a challenge to the development and implementation of PES schemes. Legal uncertainty discourages investment in environmental services and hinders providers from altering activities or receiving payments. Establishing clarity and security of tenure is essential for ensuring accountability and reliable partnerships in PES transactions.

[10] Wunder, S., et al. (2018). "From principles to practice in paying for nature's services." Nature Sustainability 1(3): 145-150.

Leakage, Magnet, and Rebound Effects: PES schemes aim to provide additional environmental benefits compared to the status quo, but leakage, magnet, and rebound effects can compromise their environmental additionality. Leakage refers to "impacts of a PES intervention on its target variables occurring outside its spatial scope of action"[11] or the risk of PES leading to a displacement of the environmentally harmful activity to another place[12]. Magnet effects result from increased immigration due to improved living standards, placing additional pressure on the local environment. Rebound effects occur when increased income from PES payments leads to expenditures in environmentally harmful activities, thus resulting in fewer additional environmental gains.

Lack of Trust: Trust is a valuable and costly commodity in economic transactions. Building and maintaining trust involves significant costs, including finding suitable partners, negotiating contracts, and enforcing agreements. Establishing institutions to address bounded rationality and opportunism is necessary due to the scarcity and expense of trust. Building trust is crucial for smooth transactions without friction in the market.

Relationship between Valuation of Ecosystem Services and PES

The intricate link between valuing ecosystem services and implementing PES has long presented challenges. Although valuing ecosystem services is a longstanding practice, difficulties arise in quantifying benefits such as biodiversity preservation. Economic assessments struggle to precisely measure these benefits, often resulting in approximate calculations. Additionally, concentrating solely on a single service tends to overlook other significant attributes of ecosystems.

These valuations can incur high expenses and provide uncertain outcomes. However, there is an increasing drive to comprehensively evaluate all ecosystem services. Ecological Economics has been operating since the 1970s and attempts to value ecosystem services via techniques such as contingent value (what people say its worth), revealed preference (what people's spending shows it's worth), avoided cost (what you'll save if you do have it), and/or replacement cost (what you'd have to spend if you didn't have it). Values are more relevant to the public sector where the government ultimately foots the bill for such services or is responsible for economic growth, and therefore recognizes these broader values[13].

For example, Earth Economics uses economic valuations to assess the pre-fire value of ecosystem services from the Elephant Hill forests, grasslands, and wetlands. These assessments value an array of services, including cultural and well-being factors, contributions to biodiversity, provision of essential resources like wild foods, maintenance of water supply and purification, disaster risk reduction, carbon sequestration, and air quality enhancement. This serves as evidence of enhanced endeavors to assess the true economic value of ecosystem services[13].

[11] Wunder, S., et al. (2020). "Payments for Environmental Services: Past Performance and Pending Potentials."
[12] Engel, S. (2016). "The Devil in the Detail: A Practical Guide on Designing Payments for Environmental Services." International Review of Environmental and Resource Economics /9(1-2): 131-177.
[13] Glen Delaney, Project Manager Earth Economics & https://www.eartheconomics.org/


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