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Commission on Sustainable Agriculture Intensification

How can economic incentives designed for environmental conservation support a transition to sustainable and equitable agriculture?

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How can economic incentives designed for environmental conservation support a transition to sustainable and equitable agriculture?

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The authors
Lina Moros, Universidad de Los Andes, School of Management, Bogotá, Colombia; Sergio Puerto, Charles H. Dyson School of Applied Economics and Management, Cornell University, Ithaca NY, USA; Dayron Monroy, Universidad de Los Andes, School of Economics, Bogotá, Colombia; Josefina Achaval-Torre, Independent Consultant, Oslo, Norway; Ximena Rueda, Universidad de Los Andes, School of Management, Bogotá, Colombia.

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Executive summary

Agriculture is crucial for the livelihood of millions of people worldwide and is one of the main drivers of deforestation, biodiversity loss and resource degradation. The contribution of agriculture to these environmental problems has been exacerbated by subsidies, which constitute the dominant public policy to support farmers. At the same time, other economic instruments introducing more sustainable land-use practices and incentivizing better environmental and social outcomes are already being applied worldwide. In this report, we selected a set of these incentive-based instruments for conservation and reviewed synthesis and meta-analysis studies that offered robust evaluations and comparisons of existing research. Please note that we use conservation as a shorthand for the protection and restoration of nature, and the mitigation of the effects of climate change on the environment. Based on this review, we identify their impacts on environmental, economic, and equity outcomes and discuss the success factors and challenges in their application and design.

Overall, we find some positive effects on deforestation reduction and the protection of surface water sources, with modest impacts on mitigation of climate change via emission reductions of greenhouse gases. Moreover, economic impacts on livelihoods and distributional effects are mixed and under-studied in the literature, especially for the Global South. The evidence in the literature suggests that a crucial factor in the performance of economic instruments for conservation is a robust monitoring and sanction system based on conditional compensations. Their long-term success depends on the capacity to generate verifiable environmental benefits and the distributional impacts between winners and losers in conservation efforts.

Despite the potential of economic instruments for conservation to generate impact, significant tradeoffs remain between scalability versus efficiency, equity versus productivity and monitoring versus participation. Notably, the application of these instruments in sustainable agriculture requires tailoring their design to the local conditions of farmers, making forest conservation compatible with rural livelihoods, and balancing punishments and rewards.

Results from this review call for innovations to make these instruments useful to support the transition to sustainable agriculture. Opportunities for innovation include (i) lower access cost to smallholders, (ii) allowing mixed uses, with an emphasis on restoration, (iii) enhancing community participation in monitoring and (iv) work on spatial targeting of the most critical ecosystems with a landscape or jurisdictional approach.

1. Introduction

Agriculture is the main driver of land-use change, biodiversity loss and climate change (Benton et al. 2021, IPCC 2019). The contribution of agriculture to these problems has only been exacerbated by subsidies that constitute the dominant public policy to support producers. Input subsidies have contributed to the excessive and wasteful use of water, nutrients and pesticides (Pimentel et al. 2004, Rockström et al. 2020). In recent times, scientists have called for the repurposing of public subsidies away from inputs toward paying farmers for environmental stewardship and climate change mitigation (Rockström et al. 2020; FAO et al. 2021). Transforming agriculture to reduce its impacts on the planet will require innovations in the design and implementation of new policy tools, as well as the creation of new institutional arrangements to better govern terrestrial and marine resources.

Innovations to introduce more sustainable land-use practices are already happening in different areas of the world. Non-government organizations (NGOs), companies and governments have created different economic instruments to promote the conservation of threatened ecosystems or compensate for losses derived from economic activities (Lambin et al. 2014). These instruments have been called hybrid or market-based mechanisms, as they usually involve a combination of public and private actors, and because they tend to emulate markets (i.e., define "buyers" and "sellers" of the ecosystem service of interest). Compared to traditional policy tools designed to motivate behavioral changes among land users—such as production quotas, taxes or subsidies—hybrid instruments are being presented as alternatives to subsidies, which have shown limited success in addressing the needs of the poorer farmers. They usually end up in the hands of larger, more politically connected farmers, and are deleterious for the environment, as they tend to pursue productivity goals at the expense of water, soil and biodiversity conservation.

Many of these novel instruments have different goals: payments for ecosystem services (PES) and carbon credits, for instance, have been used primarily for water provision or carbon sequestration, while others, such as voluntary sustainability standards (VSS), have originated in agricultural supply chains with the aim of introducing more sustainable practices in food production. Such diversity of goals makes it difficult to assess their impacts on environmental conservation and poverty alleviation. An additional problem arises because many of these initiatives are often limited to the "proof of concept" phase (Bigger et al. 2021), and thus remain underfunded and insufficiently tested to provide enough evidence of their scalability.

In spite of those limitations, we find the institutional novelty of these arrangements worth understanding and therefore address the actors, relationships and domains in which these new socio-technical arrangements work (Fuenfschilling 2019) to favor better environmental and social outcomes. Given their high adoption in a small number of countries, the significant amount of research outcomes evaluating their achievements and limitations, and their adaptability to different contexts, we argue that these instruments offer an incredible opportunity to combine productive, environmental and social goals, driving a sustainable and inclusive agricultural transition.

In this paper, we selected a set of economic instruments created to incentivize environmental and social outcomes and searched for synthesis papers that offered robust evaluations and comparisons of existing case studies. We analyzed such synthesis papers in terms of economic, environmental and equity outcomes, highlighting the instruments' limitations, but also the contextual factors contributing to their success. Based on the most significant findings, we propose a series of areas for innovation to enhance their performance, in terms of both environmental and social inclusion goals, while making them more pertinent for agricultural applications.

The paper is divided into seven sections, the first of which is this introduction. In section two we present the analytical framework and, in section three, the methods and data used for the study. Section four presents the main results and section five discusses the modifications required to enhance the effectiveness of the proposed mechanisms to promote agriculture's sustainability transition. Section six presents the discussion of the study with some policy implications and section seven concludes.

2. Analytical framework

Traditionally, the public sector has designed and implemented command-and-control interventions for conservation such as the declaration of protected areas, deforestation bans and land-use zoning to sustainably manage natural resources and prevent the degradation of global and local ecosystem services. These types of interventions have had some impact. Protected areas, for example, have reduced deforestation in Brazil, Mexico and Indonesia (OECD 2020). However, regulatory instruments face limitations regarding (i) the low capacity of some governments in monitoring and enforcing regulations, which is related to (ii) the decreased power of governments to manage resource production decisions, compared to corporations, and (iii) unintended leakage effects in areas outside the control of the government (Lambin et al. 2014).

Since the end of the 1980s, the emergence of new economic instruments has created the space for the private and third sectors to actively engage in the management and governance of common goods. In this context, different actors, from governments to the private sector, have relied on economic instruments to motivate behavior change through voluntary transactions. Economic instruments are "fiscal and other economic incentives and disincentives to incorporate environmental costs and benefits into the budgets of households and enterprises" (United Nations 1997). Economic instruments can, for example, increase the cost of environmental degradation (e.g., taxes on carbon) or decrease the cost of adoption of sustainable agricultural production practices (e.g., payments for agrobiodiversity conservation services). By doing so, land users' behavior is expected to change toward more sustainable practices.

Different typologies of environmental policy instruments in the context of agriculture exist (see Annex 1). Although there has been considerable effort to categorize existing instruments, reaching a common language is difficult. Similar instruments within different typologies are frequently named differently; categories in these typologies are sometimes not mutually exclusive or exhaustive, as scientific categories need to be. Comparing typologies to each other is difficult and impedes the advancement of a common framework. The PES, for example, are included under "economic instruments" in Lockie (2020) or under "responsible market-led investments"' in FAO (2020). Exclusion criteria for categories are not completely clear.

Although it is out of the scope of this review to propose a new typology, we call on international governing bodies such as FAO to lead a task force dedicated to reaching a common framework that enables the advancement of theory and practice of environmental policy, based on a portfolio of instruments. In this context of a lack of common language, we consider it relevant to focus on those types of instruments that fall into the "gray area" of revised typologies: economic instruments that are not purely public nor purely private, instruments that are used in combination with other types of incentives and that typically overlap with or rely on regulations. We decided to adapt the FAO (2020) framework and chose five main conservation instruments to review (described in detail in the third section): (i) PES, (ii) Reducing emissions from forest Degradation and Deforestation (REDD+), (iii) VSS, (iv) carbon markets and (v) biodiversity offsets. See Table 2 for explanations of these economic instruments.

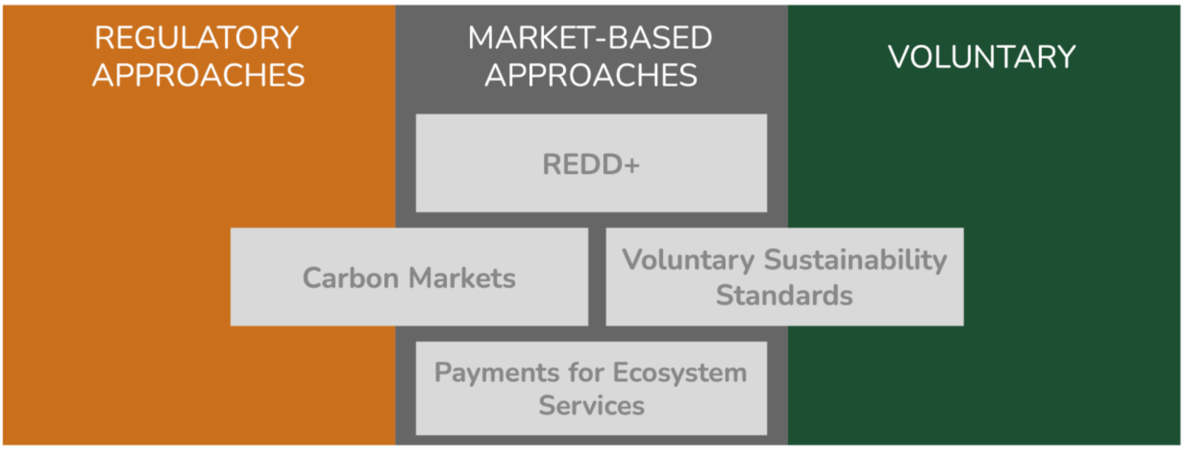

Figure 1. Typology of instruments adapted from FAO (2020).

Commonly included in these typologies are catalytic investments or blended finance instruments. These terms appeared in our searches (see below) and were suggested by experts (EDF & CFC 2020; Havemann et al. 2020). These instruments include impact investment (balancing economic and social or environmental returns) and blended finance (leveraging private funds to match concessionary funding or development assistance) also called catalytic capital. For the most part, these instruments are not true economic incentives provided to farmers for conservation purposes, but alternative ways to introduce liquidity into credit markets. For example, they often translate into micro-lending schemes. Also, they are mainly applied to financing adaptation activities to climate change impacts for agricultural producers. We were hard pressed to find data on outcomes of financing for climate change mitigation or biodiversity conservation. Nevertheless, given the interest they have generated, we included them here, noting their limitations but also the potential to repurpose some of these funds to more direct incentives that help the rural poor.

Equally challenging were the biodiversity offsets. They have been used since the 1970s as instruments to avoid the unequivocal consequences of large infrastructure projects by ensuring that there is no net loss of biodiversity (zu Ermgassen et al. 2019). These instruments are in many cases mandatory, and therefore fall under the sphere of public regulatory mechanisms. In other cases, they can be voluntary and triggered by NGOs or private companies. Although they have been applied mainly in the Global North, we think they offer great promise for countries in the Global South, where most of the global biodiversity exists and where most of the emphasis in conservation programs has been devoted to reducing tropical deforestation and securing carbon sequestration. In tropical regions, less effort has been placed in biodiversity conservation—especially in agricultural landscapes—despite having been proven to be intrinsically linked to climate change (Pörtner et al. 2021) and securing a safe operating space for humanity (Rockström et al. 2009). For many dwellers of the Global South, biodiversity is also a key factor supporting local livelihoods (Persha et al. 2011). For this reason, we included the main global evidence on their functioning and suggested ways to improve them, despite only scant evidence of their impacts in the Global South.

3. Methods

We conducted a review focusing on existing literature reviews, meta-analysis and synthesis of cases reviewing instruments and incentives for environmental conservation. We selected papers published in the last decade although the specific cases date back, for most cases, to at least 2010. We applied the following search streams in Scopus and ScienceDirect (Table 1).

Table 1. Search streams in Scopus and ScienceDirect.

Instrument (AND)	Focus (AND)	Year restriction (AND)	Type of search (AND)
PES (OR) Payment for ecosystem services	Agrobiodiversity (OR) biodiversity (OR) conservation	After 2010	Review (OR) Systematic Review Meta-analysis
VSS (OR) certification (OR) moratoria (OR) voluntary standards	Agriculture	After 2010	Review (OR) Systematic Review Meta-analysis
Carbon pricing (OR) carbon markets (OR) carbon offsets		After 2010	Review (OR) Systematic Review Meta-analysis

We used a snowball methodology to select additional papers, based on an initial search of key studies in consultation with experts[1]. The review includes papers in both the Global North and South, considering high-, low- and middle-income countries. Our study focuses on design, implementation and evaluation of outcomes in the Global South but since most of the carbon market cases came from the North, we decided to include those as well, only for that instrument. Figure 1 shows the geographical location of the revised cases. Annex 2 reports the number of cases, locations and studies we reviewed. As mentioned above, catalytic investments and blended finance were terms that appeared in our searches and were suggested by experts, so we decided to include them, noting their limitations but also their potential for a more impactful integration into financial incentives to land users.

[1] Experts included CoSAI Secretariat members and Commissioners, the Alliance of Biodiversity International and CIAT, and IUCN.

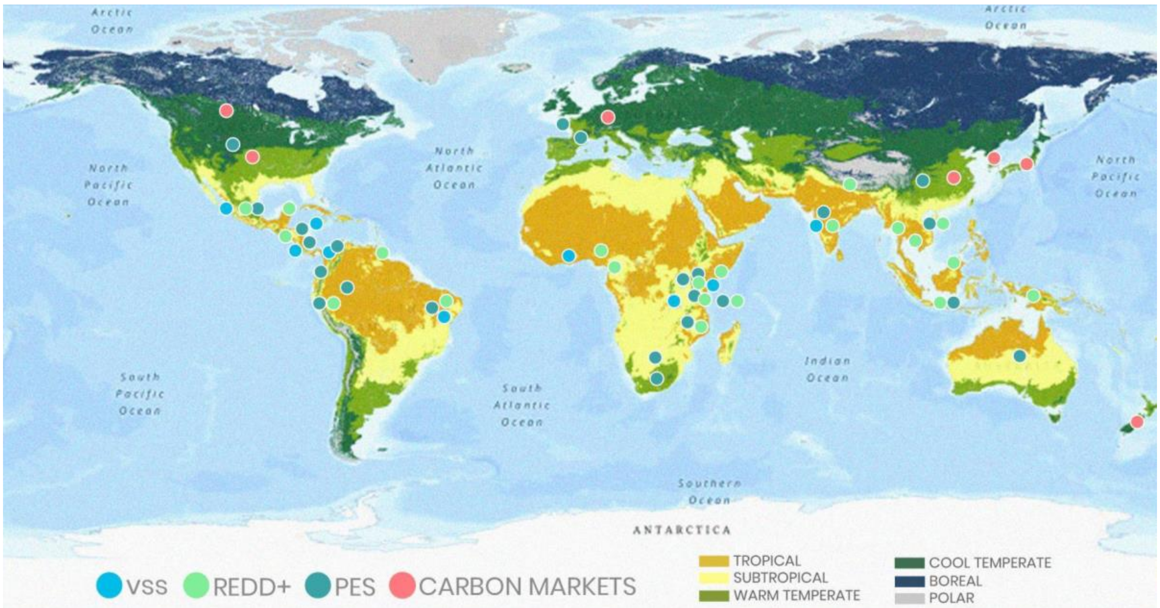

Figure 2. Location of VSS, REDD+, PES and carbon markets cases reviewed.

The selected papers are analyzed to assess four main components. First, we focus on the geographic coverage and the relevance of each instrument for the Global South. Second, we analyze each instrument design to identify whether they have been successful by measuring effects in three areas: economic (income and price) impacts, environmental impacts (including biodiversity conservation, avoided deforestation or afforestation and other sustainable land-use practices) and equity (distributive or pro-poor) impacts. Importantly, evidence needs to show additionality, meaning that the application of these instruments is conducive to true additional gains in environmental outcomes compared to reliable counterfactuals. Third, we study design, implementation and monitoring factors that explain success (or lack of). Finally, we consider what contextual and idiosyncratic factors are relevant to enable well-functioning instruments in each case.

4. Economic incentives for conservation

In this section, we describe the main results of our review. Based on the selected studies, we first describe each instrument, synthesize its main impacts in environmental, economic and equity terms, and then identify success factors and challenges in the application and design of each instrument. Table 2 presents a summary of how each of these instruments works, including a general description of the transaction between who pays and who gets paid for the conservation efforts. Table 3 presents a summary of environmental, economic and equity impacts of instruments.

Table 2. Description of economic instruments.

Instrument	Definition	Who pays?	Intermediaries	Who is paid?	What is paid for?
Payments for Ecosystem Services (PES)	Users of ecosystem services (ES) pay to providers conditional on guaranteed provision of ES	Beneficiaries of ES. Typically governments, less common citizens and the private sector	NGOs and/or local governments/community organizations that act as operators	Providers of ES. Usually forest margin land-users (either communities or individuals)	Hectares of protected forest, hectares of restored area and adoption of some sustainable agricultural practices
Voluntary Sustainability Standards (VSS)	Norms and standards to ensure that a product contributes to environmental, social and economic objectives	Governments, NGOs and companies	Certification bodies. NGOs that provide technical assistance	Producers in the Global South linked to global value chains	Adoption of sustainability standards that involve changes in productive practices
Reducing Emissions from Deforestation and forest Degradation (REDD+)	Carbon emitters buy offsets from forest margin communities supporting conservation and local communities	Carbon emitters typically in the Global North but also big companies in the Global South	Program operators (usually local NGOs or community organizations). Verification bodies	Forest margin communities or individuals in the Global South	Carbon credits

Instrument	Definition	Who pays?	Intermediaries	Who is paid?	What is paid for?
Carbon markets: emission trading systems (ETS) and clean development mechanism (CDM)	Mechanisms in which emitters (usually countries in the Global North) offset their emissions via the financing of emissions reductions in the Global South	Carbon emitters are typically in the Global North but also big companies in the Global South	Program operators (usually local NGOs or community organizations). Verification bodies	Forest margin communities or individuals, e.g., farmers in the Global South	Activities related to carbon emission reduction such as hectares of preserved forests, area of forest restoration or integrated conservation and development projects

4.1 Payments for ecosystem services (PES)

Description

As a market-based instrument for environmental conservation and sustainable land use, PES encourages landowners to maintain, restore or enhance ES via conditional economic transfers (Wunder 2015). The PES have gained traction in environmental policy because they are assumed to have more effective potential than other conservation tools, such as the declaration of protected areas, and because PES represents an alternative source of income for vulnerable communities in the Global South (Muradian et al. 2013; Pagiola et al. 2005). In these schemes, users of ecosystem services (ES) pay ES providers, conditional on the latter implementing pro-environmental actions that guarantee the provision of the ES (Ezzine-de-Blas et al. 2016). Payments could be in cash, in-kind or a mix of both and should cover the opportunity cost of alternative activities within the targeted area.

The PES could follow different environmental objectives, water protection being the most popular one, but also biodiversity protection and in some cases protection of native species and landraces used in agriculture (i.e., agrobiodiversity). The PES schemes are categorized as public or private depending on the financing source. In private schemes, ES users make a payment to ES providers in exchange for the latter to secure the provision of an ES of interest to the user. For instance, private companies participate in these schemes if the provision of the ES is closely related to the continuity of their economic operations[2] (Ezzine-de-Blas et al. 2016). In public PES, governments group the interests of ES users through taxes and fees and use the collection to pay ES providers in remote areas

[2] Including Profafor carbon PES in Ecuador (Wunder and Albán 2008), Vittel watershed scheme in France (Perrot-Maître 2006) and Simanjiro wildlife conservation scheme in Tanzania (Nelson 2008).

of national interest.[3] Either way, the key assumption is that in the absence of this payment, farmers and landowners would have not provided or preserved valuable ES.

The PES schemes targeting agriculture generally focus on dissuading farmers from transforming strategic conservation lands into farmland and encouraging the adoption of sustainable agricultural practices such as silvopastoral and agro-silvicultural systems (Ezzine-de-Blas et al. 2016; Narloch et al. 2011; Pagiola et al. 2016). We tracked 22 schemes with a farmland coverage of 16.5 million hectares, 96.5% of which are concentrated in seven schemes trying to reduce and avoid agricultural production in conservation areas.[4] In addition, three schemes in Nicaragua, Costa Rica and Colombia promoted the adoption of silvopastoral systems (Ezzine-de-Blas et al. 2016; Pagiola et al. 2016).

A particular form of PES, payments for agrobiodiversity conservation services (PACS), are designed to promote the adoption of traditional seed varieties that are better adapted to local environmental conditions. Extensive monocropping and the loss of seed diversity has put food security at risk, as varieties resilient to changing environments might be lost to higher-yielding ones. In our review, we found nine PES schemes promoting the reintroduction of 130 threatened varieties of amaranth, maize and quinoa, in more than a hundred farming communities located in Ecuador, Bolivia, Guatemala and Peru, at relatively low conservation costs (Drucker and Ramirez 2020).

Impacts

Our review of 143 cases of PES in 23 countries shows the following impacts. Environmental impacts have been typically measured in terms of reductions in deforestation rates, changes in forest cover and changes in land use. Seventeen impact evaluation studies—reviewed in Moros et al. (2020) and based on Börner et al. (2017)—and a systematic review of 44 studies and 18 unique PES programs (Snilsveit et al. 2019) show a positive impact of PES in reducing deforestation in contexts of high deforestation such as Uganda (Jayachandran et al. 2017). They have also increased forest cover, particularly in Mexico and Costa Rica, where the majority of studies have focused (Costedoat et al. 2015; Robalino and Pfaff 2013), and have promoted the adoption of sustainable cattle-ranching practices in Colombia (Pagiola et al. 2016).

The economic impacts of PES are still debatable, and more studies are needed to reach conclusive evidence. Our review shows that economic impacts have typically been measured in terms of changes in household income (Börner et al. 2017; Snilsveit et al. 2019). Studies of this type have been conducted in Costa Rica, Mexico, Mozambique and China, among others, but the evidence is of low or very low quality meaning that methodologies are questionable because of their sampling method or failure to acknowledge spillover effects (Snilsveit et al. 2019). In general, there is weak evidence of increases in total household income (Börner et al. 2020).

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[3] In cases such as the sloping land conversion program in China (Bennet 2008), Conservation Reserve Program in the USA (Claassen et al. 2008), the PES national program in Costa Rica (Pagiola 2008) and the Payments for Hydrological Services Program in Mexico (Muñoz-Piña et al. 2008).

[4] These schemes are the Los Negros scheme in Bolivia, Conservation Reserve Program and Environmental Quality Incentives Program in the US, Environmentally Sensitive Areas in the UK, Rio la Vieja scheme, Procuenca scheme in Colombia and Sociobosque in Ecuador (Ezzine-de-Blas et al. 2016).

Equity in PES is measured in terms of three dimensions: equity in access, equity in the process and equity in the results (Corbera et al. 2007). Equity impacts are usually captured in qualitative studies based on participants' perceptions. Equity in access ensures that payments do not reinforce pre-existing inequalities so that informal owners and families in vulnerable communities can also participate (Milne and Adams 2012; Rodríguez and Budds 2015). Equity in the process emphasizes that the scheme fosters inclusive decision-making mechanisms (to define payments and practices) and empowers beneficiaries in local governance processes (Wunder et al. 2018). Finally, equity in the results refers to how payments are distributed among ES providers and improve the economic income of the participants (Wunder et al. 2018). Our review shows that PES could either reinforce pre-existing inequalities (Milne and Adams 2012; Rodríguez and Budds 2015) or redistribute program benefits improving overall collective well-being (Hendrickson and Corbera 2015; van Hecken et al. 2015).

Success factors and challenges

Meta-analyses have identified three success factors of PES: spatial targeting, differentiation of payments and monitoring combined with sanctions (Ezzine-de-Blas et al. 2016; Wunder et al. 2018). Regarding spatial targeting, the literature emphasizes the need to direct PES toward areas with a higher density of ES or that are at risk of degradation or deforestation, and toward areas where the opportunity cost of preserving is low. Targeting is key to assuring additionality, which means that payments are conducive to additional gains in forest cover, for instance, compared to non-PES areas (Engel 2016). The logic of targeting resides in the fact that not all areas matter equally for conservation, i.e., there is variability in environmental benefits or risks, and budget constraints impede enrolling all potential ES suppliers (Moros 2019). The most frequent targeting strategy is to select areas based on ES density, which is based in turn on the potential provision of ES per area unit. In a recent article, Wunder et al. (2018) report that 50% of the cases revised in their study claim to target participants based on ES density.

Payments must also be differentiated with criteria of efficiency or equity, in accordance with the objectives set by the PES. Since the cost of providing an ES could differ among farmers in the same region (according to the valuation and vocation of their farm), from a cost-efficiency perspective, it is recommended that payments are proportional to the opportunity cost of preservation. Otherwise, owners of more fertile properties with easy access to agricultural markets would receive higher payments than landowners in the peripheral area with higher barriers to market access. From an equity perspective, the payment structure can be designed such that it takes into account the socio-economic vulnerability of the participants (Vorlaufer et al. 2017). In Colombia, for instance, the "Yo Protejo, agua para todos" PES scheme differentiated payments according to a national poverty index, providing higher payments to more vulnerable households (Moros 2019).

Another key internal factor in the application of PES is a robust monitoring and sanction system based on conditional compensations (Ezzine-de-Blas et al. 2016; Moros et al. 2020; Wunder et al. 2018). Progress in terms of monitoring is outstanding—almost all the PES inspected by Wunder et al. (2018) have an established monitoring system; however, the authors found that half of them sanctioned non-compliance, and only a quarter did so consistently. In 55 PES schemes analyzed by Ezzine-de-Blas et al. (2016), the degree of conditionality was 4.1 (with 9 being the maximum score). Among these programs, 12 focused on agriculture and on average yielded a lower conditionality degree (score 2.6 out of a potential 9). Almost all the schemes (focused on agriculture) monitored land use, except the Los Negros scheme in Bolivia which monitored the provision of ES (water). Eleven of them incorporated sanction mechanisms in cases of non-compliance into their design, yet only eight applied this in practice (four partially applied) and three schemes did not apply them (Ezzine-de-Blas et al. 2016).

Although studies evaluating PES overall impacts have increased over time, gaps in knowledge persist that limit the scaling up of PES in particular in agricultural landscapes. For instance, we did not find any impact evaluations of schemes aiming to promote the reintroduction of native varieties of maize, quinoa and amaranth among farmers in the South American Andes. Although available evidence is promising in terms of the potential of PES in promoting agrobiodiversity, more studies are needed in terms of evaluating the impact of this instrument for outcome variables other than forest cover, such as its impact on improving farm systems toward sustainability and climate change adaptation. In terms of income and equity impacts, quantitative studies using impact evaluation techniques are needed to assess the promises of PES in providing alternative income sources for marginalized farmers, many of them in forest frontiers.

4.2 Voluntary sustainability standards (VSS)

Description

The VSS are norms or codes of conduct that actors in a supply chain need to obey in order to sell to a specific market. These instruments were first introduced in commodity supply chains in the 1980s, with the first certification schemes in the coffee value chain (Eakin et al. 2017). The VSS encompass not only third-party certifications but also less restrictive company codes of conduct, such as the AAA program or the CAFE practices by Nespresso and Starbucks, respectively, industry roundtables, such as the Roundtable on Sustainable Palm Oil where supply actors share best practices that may lead to a certification program, and more stringent bans and moratoria—like the one established in the Brazilian Amazon to curb deforestation by excluding non-traceable suppliers from selling to international markets (Rueda et al. 2017).

Impact

A substantial number of studies have attempted to assess the environmental and livelihood impacts of these instruments. The most comprehensive and recent literature reviews are those of Garrett et al. (2021) and Meemken (2020). These two include previous research (DeFries et al. 2017; Oya et al. 2018; Tscharntke et al. 2015) so that they form the basis of the analysis undertaken here. Garrett et al. (2021) analyze 37 cases using robust methods for assessing impacts, focusing on deforestation-risk commodities (coffee, cocoa, beef, soybeans and palm oil). This excludes organic and fair-trade certifications that do not have provisions for forest conservation. Meemken (2020) analyzes 97 cases, focusing on the economic effects of sustainability standards on agricultural prices, yields, production costs, farmer profits and household income. Her analysis includes a large range of products, not only the most traded commodities, but also fruits, vegetables, spices, fibers, cereals, honey and sugar cane.

Environmental impacts show that compliance with reforestation and avoided deforestation is high in coffee in the Americas, mixed in soybeans and non-existent for cattle in the Brazilian Amazon (Garrett et al. 2021). Shade- or semi-shade-grown coffee allows for farmers to increase forest cover in their plots, which helps explain why reforestation practices were more successful in coffee than in other commodities. Improvements in conservation outcomes, including activities such as water sources protection, conservation of forest remnants and afforestation were found in 43% of all cases analyzed by Garrett et al. (2021), and were not limited to coffee.

Commodity income gains were found in 65% of the cases analyzed by Garrett et al. (2021), including certification and codes of conduct in coffee (in Latin America) and cocoa (in Ghana), and the Roundtable on Sustainable Palm Oil (in Indonesia). However, cases in Colombia, Uganda and Nicaragua found no commodity or household income improvements. Five studies analyzed simultaneous economic and conservation impacts (in coffee, cocoa and palm oil); none of them found synergistic results, and economic gains in palm oil were obtained with little conservation gain. In the other cases, conservation trumps livelihood goals, as adoption of agroforestry systems tends to reduce productivity and income, at least in the initial phases.

Using regression analysis, Meemken (2020) finds that both median and mean income increase with VSS, while effects on yields are mixed: in some cases, certification increases productivity, by helping farmers keep better records of inputs use and by improving farm practices; in others, prohibition of or reduced access to agrochemical inputs reduces yields. Finally, revenues increase for both crop and household income across certification standards, as the certified crop tends to be the main livelihood strategy for certified farmers (Rueda and Lambin 2013. The results of Meemken (2020) confirm those of previous studies that were done with smaller samples (Defries et al. 2017; Oya et al. 2018). Furthermore, none of the studies analyzed present data on differences between larger and smaller owners, thus equity considerations are not properly evaluated. Furthermore, the studies included in these reviews use propensity-score matching or other quasi-experimental design methods that control for differences in farm size and other productive assets, preventing studies from capturing possible structural differences in wealth between certified and non-certified farmers. Certification schemes have indeed been widely criticized for their lack of accessibility to smallholders. To ensure wider participation, certifying bodies have created group certifications that reduce auditing costs; they have also invited donors to help cover the cost of investments needed to reach compliance. Whether these measurements have helped close the accessibility gaps remains a field in need of further inquiry.

Success factors and challenges

What factors have contributed to the relative success of certifications, codes of conduct and moratoria? Not all studies answer this question; however, those that do, point to effective technology transfer via extension services for the adoption of better agricultural practices that reduce dependence on agrochemicals and introduce tree species into the plots, provided by the government, community organizations and donors. Strong cooperatives help improve the bargaining power of small-scale farmers and access to differentiated markets, while also ensuring the distribution of (some) economic and social benefits. Coordination and coherence between public and private policies are also crucial to ensure that social benefits are accrued (for instance by requiring that minimum living wages are paid to workers) and distributed.

Not all certification schemes offer a price premium (i.e., a price above the international price) to farmers that comply with their regulations. The UTZ certification system[5] expects that farmers increase productivity through better farming practices, thus monetizing the benefits of certification

[5] A B2B certification scheme originally from the Netherlands but currently merged with the Rainforest Alliance.

via yields but not prices. Productivity gains have indeed been observed in many certification programs. One of the studies analyzed by Garrett et al. (2022) showed that farmers certified under the Rainforest Alliance certification scheme received premia that were variable and countercyclical: increasing when the international price of coffee is low and decreasing when the price is high. Thus although farmers make an effort to adopt more sustainable practices, the market does not always recognize such efforts in the form of higher incomes.

Another limitation of certification is the lack of additionality, this is the difficulty in providing increases in forest cover, beyond what is already standing. Because of its voluntary character, adoption tends to concentrate on farmers who have already adopted better farming practices, and thus face a lower cost of entering the program. This situation tends to leave laggers behind, perhaps those that need transformations the most. Furthermore, these schemes work for highly visible, branded international commodities but for local markets in emerging or low-income economies, the market niche is very small. Also, because of its voluntary nature, VSS may have a limited landscape-level impact, as adopters and non-adopters remain interspaced in the territory, potentially canceling each other's efforts out.

For moratoria, the largest risk is leakage. As expansion into targeted natural ecosystems is banned, farmers tend to move to other ecosystems not targeted by the moratorium. This is the case with soybeans in Brazil. As the expansion is banned in the Amazon, cultivation is expanding into the Cerrado biome.

4.3 REDD+

Description

The REDD+ schemes incentivize Global South countries to implement emissions reductions activities such as keeping forests standing and sustainably managing forest and agricultural systems. The REDD+ schemes use economic compensation to forest users to discourage the felling of forests, protect carbon stocks, combined with assistance for sustainable forest management and support in alternative livelihoods among the beneficiary communities (Luttrell and Betteridge 2017; Petkova et al. 2010; Sills et al. 2015). The NGOs and private companies led the articulation of these schemes, which emerged from the international call for "demonstration activities" by the United Nations Framework Convention on Climate Change (UNFCCC) in the early 1990s (Solis et al. 2021). Currently, REDD+ schemes mostly follow a top-down approach in which resources are channeled from developed countries into projects in the Global South via multilateral institutions designed to meet the specific environmental and social goals (for example the United Nations REDD Programme). Compensation can take the form of direct payments or can be in exchange for "carbon credits," which represent reductions in greenhouse gas emissions to compensate for emissions made somewhere else.

Impact

We studied papers analyzing 85 REDD+ projects, many with the potential to alleviate poverty, empower local forest governance, conserve biodiversity and generate climate benefits (Brown et al. 2008 in Solis et al. 2021). However, an analysis of the International Database on REDD+ projects and programs shows that they primarily focus on avoiding deforestation and degradation (48.4%) and the others (37.3%) focus on afforestation or reforestation (Wunder et al. 2020). Moreover, we did not find evaluations of the impact of REDD+ on equity or the distributional effects on the communities in which these programs are implemented.

Only a few research articles focus on the main objective of REDD+, that is, changes in forest carbon and land use outcomes (Duchelle et al. 2018). For example, West et al. (2020) find that a dozen of the REDD+ projects in the Brazil Amazon reduced forest loss. However, they also find that the stated impact of these projects has been overestimated due to biased baseline estimates of the deforestation rates, such that almost half of the total carbon credits issued in these projects do not reflect true additionality gains. Duchelle et al. (2018) find similar results for the few articles studying impacts on land use and carbon sequestration.

The majority of REDD+ articles also study non-carbon outcomes such as well-being, tenure rights, biodiversity, local participation and adaptation (Duchelle et al. 2018; Wunder et al. 2020). These studies focus on small-scale agents of deforestation, for example, small farms, with limited funding flows. Wunder et al. (2020) find a net positive impact on households' perceived effectiveness of REDD+ interventions, which includes forest enhancements, environmental education and tenure clarification. In a study of 45 papers with cases in Indonesia, Kenya, Tanzania, Uganda, Mozambique, Cameroon, Brazil, Mexico, Guyana, Costa Rica and Nepal, Duchelle et al. (2017) find that forest effects are modestly positive in general. Other outcomes reveal reductions in perceived tenure security and well-being. Furthermore, REDD+ projects can affect other types of forest management and environmental collective action. For instance, Hajjar et al. (2021) find mixed effects on the resilience of community forests, such that REDD+ projects can improve participation in decision making and network connectivity, but can also negatively affect forest management by imposing restrictions on the local forest management. Similarly, Duchelle et al. (2018) find slightly positive and negative effects in articles analyzing REDD+ on non-carbon outcomes, including well-being and land tenure.

Success factors and challenges

The success of REDD+ projects depends on how well they adapt to local conditions and mitigate uncertainty while creating robust compensation schemes. For instance, the creation of local networks that actively participate in the definition of key aspects of the scheme is important to promote socio-ecological resilience in the communities, which is desirable for communities to increase their willingness to conserve and seek alternative livelihoods (Hajjar et al. 2021). Additionally, the programs and projects must mitigate the uncertainty generated by the negotiations for contract renewals and the risk of interrupting the payments, since the communities involved renounce their conventional incomes to maintain carbon stocks (Hajjar et al. 2021; Wunder et al. 2020). Some REDD+ programs started implementing conditional payments in 2017 in an effort to achieve certification and start carbon sales, which correlate with a greater commitment on behalf of landowners and implementers to carbon sequestration (Wunder et al. 2020). Further, conditional payments have been shown to be more effective when applied directly to communities, for example, via public goods like schools, education funds and wells (Duchelle et al. 2018).

The interventions promoted in these programs can also lead to unintended consequences. Similarly to PES schemes and other instruments trying to promote alternative land use via economic incentives, the design and implementation of REDD+ require a good understanding of how local conditions change. The REDD+ projects may decrease communities' resilience by restricting local forest use and introducing rigid rules that lead to conflict and greater inequalities (Duchelle et al. 2018; Hajjar et al.

2021). Also, REDD+ can contribute to communities' loss of agricultural land or grazing rights to the creation of community forests, so REDD+ can restrict food availability, lumber production and other forest resource use (Hajjar et al. 2021). The extent to which local communities adapt to these changes is still a puzzle. Duchelle et al. (2018) address that, of 45 studies, only two focused on how communities adapt to changes: one on social, ecological and agricultural adaptation, and the other on climate variability. Therefore, baseline information and a better design of counterfactuals are necessary to evaluate the progress and make better decisions around contract renewals (Duchelle et al. 2018).

Other challenges include the limited and slow funding, which makes it difficult to establish long-term commitments, the tension between REDD+ goals and the need to retain some local adaptive capacity and resilience to changes and shocks, the application of long-term rules for forest protection and restoration when livelihoods are not carefully integrated into conservation goals, gender participation and information sharing, and lack of secure land tenure (Duchelle et al. 2018; Hajjar et al. 2021; Wunder et al. 2020).

4.4 Carbon markets

Description

Since the end of the 1990s, with the signing of the Kyoto Protocol in 1997, emissions trading systems (ETS) and the clean development mechanism (CDM) have been implemented as promising mandatory mechanisms to address pollution control, tackle climate change, and redistribute the associated costs of climate action. The underlying logic of ETS is that emitters (usually developed countries in the Global North) offset their emissions via the financing of emissions reductions in low- and middle-income countries. Similarly, CDM (known as the Sustainable Development Mechanism after the 2015 Paris Accord) enables a country with an emission-reduction target to implement reduction projects in other countries, primarily low-income and developing countries, and balance out the overall level of emissions.

Impact

We reviewed papers analyzing ETS and CDM experiences worldwide. Green (2021) reviews articles since the 2000s and finds 37 peer-reviewed studies that assess the causal effects of ETS on emissions reduction. Green found a high concentration of research in the Global North, particularly in Europe and in sectors other than agriculture. Results of this analysis show that the aggregate effect on emissions is in the range of 0–2% per year and that carbon taxes are in general a better policy option in terms of cost-effectiveness than ETS. The effects of carbon pricing instruments in the developing world are yet to be fully understood. Peñasco et al. (2021) report a limited impact of greenhouse gases (GHG) allowances and similar tradable certificates on environmental effectiveness, which includes meeting targets of emission reductions and energy savings.

Despite better agricultural activities being crucial for carbon sequestration, we find no evidence of the impact of carbon pricing instruments on farm-level outcomes. A possible explanation is that key challenges still affect farmers' participation in informal and formal carbon markets, including small carbon payments, high uncertainty about the benefits of soil carbon sequestration and high transaction costs (De Pinto et al. 2010; Shames 2013). Some studies show a high mitigation potential of GHG emissions from cropland management, degraded land restoration and protection of carbon stocks (Smith et al. 2007 and 2008 in De Pinto et al. 2010). For the Global South, examples in Colombia and Peru reportedly show that coffee farmers can reduce carbon emission to the point of becoming carbon-negative (0.5 tonnes or less CO_2 equivalent per hectare) within three years of participation in a carbon market scheme designed by Rabobank, an agricultural bank, and Solidaridad, an international civil society organization (Solidaridad Network 2021). Other results show increased carbon sequestration via increased density of coffee and shade trees. Nevertheless, reports beyond incipient case studies that demonstrate impact are lacking.

In contrast to REDD+ or PES, the reviewed articles on carbon markets do not explore welfare impacts, meaning that the overall impact of carbon pricing instruments might be underestimated. This is a gap that must be bridged, in particular for agricultural landscapes in the Global South. Similarly, we did not find household- or community-level literature on the equity effects of carbon markets. However, cross-country research shows that equity impacts of carbon pricing instruments are mixed. Ohlendorf et al. (2021) re-analyze data from 53 studies on the distributional effects of carbon pricing and find that carbon pricing policies increase the likelihood of progressive outcomes (benefiting the poor more than the rich) in low- and middle-income countries, while regressive outcomes are more likely in developed countries (however, this paper does not cover the rural or agrifood sectors so it is unknown whether this conclusion is relevant). Also, they find that carbon pricing instruments do not offer additional benefits in terms of progressive outcomes compared to carbon taxes and subsidies. Other recent research shows similar null and some negative impacts for GHG trading systems (Peñasco et al. 2021).

Success factors and challenges

As in the case of the other economic incentives for conservation, the success of carbon pricing instruments depends on the capacity to produce verifiable emission reductions and other environmental benefits. It has been widely recommended that programs establish robust emissions baselines and clear targeting criteria to avoid selection bias by accounting for factors that determine program participation (Bushnell 2010; Murray and Jenkins 2010). Sequestration and emissions rates, aggregate pollution and observable individual actions are some of the measurement units that can be used to evaluate the functioning of carbon markets. Further, carbon markets produce additional benefits and costs for suppliers besides environmental benefits. These co-benefits and co-costs, as they are called, are usually unevenly distributed across geographical areas. For example, some evidence suggests that income support and higher agricultural commodities prices are among the additional benefits of carbon markets (Feng 2005).

An important challenge for carbon markets is the reallocation of emissions into non-monitored zones (leakage). To address this, policymakers could establish "leakage belts" within targeted areas and also broaden the geographical scope of the program given existing budget constraints (Murray and Jenkins 2010). Also, remote sensing, aerial photography or field inspections are monitoring strategies that support dynamic adjustment (González-Ramírez et al. 2012). Moreover, these programs require the design of pricing policies that are responsive to existing fuel prices and abatement costs, crucial factors that explain carbon market success in terms of environmental additionality (Michaelowa et al. 2019; Newell et al. 2014).

The loss of stored carbon stocks (non-permanence) is another challenge for carbon-sequestering activities. In particular, the risks of non-permanence are particularly relevant in agricultural activities that promote the temporary storage of carbon in the soil through, for example, reducing tillage. Envisioning payment strategies that account for the non-permanent nature of carbon sinks is fundamental to how these trading schemes work (García-Oliva and Masera 2004; Murray et al. 2007).

5. Other financial instruments and funding sources

According to Havemann et al. (2020), there exists a “high-level funding gap for sustainable agriculture” that cannot be met with traditional investment markets. Limited credit access is an important reason why farmers under-invest in more new agricultural technologies, including sustainable and cleaner inputs and practices. In low-income countries, formal credit and insurance institutions are usually absent or operate in a limited capacity in rural areas. Land tenure problems and uninsurable risks limit the ability of financial markets to supply the resources required for farm investments. In contrast, farmers in developed economies may have access to financial products not tailored to their specific needs, or that only respond to investments in productivity or marketing growth in traditional agricultural value chains. Therefore, financial instruments that help to solve farmers’ credit and liquidity constraints are key to the transition to sustainable agriculture.

We identified financial vehicles that can be used to support sustainability-oriented projects. It is important to note that most projects do not incorporate mitigation but focus primarily on land-use change and adaptation to climate change. The first is catalytic investments and it groups financial instruments that pool resources from several sources to fund agriculture and economic development projects with a broad scope of environmental and social objectives, for instance, to enhance conservation or reduce poverty. The second is biodiversity offsets, which are voluntary or regulatory compensations used to offset the impact of infrastructure and development projects causing environmental and social losses. In our review, we did not find independent impact evaluations or systematic assessment in the literature for either of these groups, despite some of them being frequently used. Most of the analyzed cases report results using institutional documents and for actors with specific interests in the success of each instrument. For example, private venture funds self-report the progress of sustainability goals achieved by projects in their portfolio.

The application of novel financial tools in agriculture is important because they enable investments in sustainability-oriented projects. The potential of financial tools to solve farmers’ financial constraints, and ultimately the funding gap for sustainable agriculture, relies heavily on their ability to help beneficiaries and investors manage risk more efficiently. For both of these actors, new technology may be intrinsically risky, and even riskier for projects with uncertain prospects under rapid climate change. So, financial sources from impact investment and biodiversity offsets can address these concerns by diversifying risks among several sustainability-related projects and also crowding in the support of governments and multilateral institutions. Further, a key feature of these financial tools is their potential to promote sustainable technological change without necessarily restricting land use. However, improved access to financial sources can also lead to investments in technologies with high environmental impact, highlighting the need for a robust set of principles that promote practices and inputs that help farmers balance efficiency and sustainability goals.

5.1 Catalytic investments

The group of catalytic or impact investments includes green and development bonds, institutional grants, venture capital and microcredit instruments. Sustainable and green bonds mimic the regular fixed income financial instruments, in which institutional investors fund projects and are promised a fixed rate of return after a period of time. As the name implies, sustainable and green bonds funds are used to invest in projects ranging from resilient agriculture, sanitation and education to social protection. For example, one of the largest bond issuers is the World Bank, with 75 USD billion issued in 2020 alone. The scale of this investment reportedly translated into impacts for millions of people, especially in low-income countries. In particular, the World Bank (2020) reports hundreds of thousands of farmers reached with improved agricultural technologies, assets and services by 14 projects funded worldwide. In a similar fashion, private companies issue thematic bonds, usually green bonds tied to broad environmental goals. These bonds help companies raise money to fund their activities and allow them to meet standards or regulations that are set by law or self-imposed. In most cases, the rate of return of these bonds is conditional to achieving the desired impact, so failing to do so implies a higher financing cost for companies.

Other funding sources include targeted investments from social venture capital and microfinance products. These investments work as traditional financial investments with the main difference that they narrow the scope and focus of their portfolio to channel funds toward sustainable and environmental projects. For instance, a common practice is to avoid investments related to fossil fuels while targeting renewable energy projects. In cases like these, investors benefit from the project's return on investment but also from the reputational aspects derived from targeting investment. In our review, we found that most of the impact investment funds operate in the Global North.[6] Although all cases report positive environmental and social impacts of their investments, there are no independent assessments of these results. At the same time, investment portfolios commonly combine other potential outcomes, including environmental protection with investments that are highly extractive of local natural resources, and still yield net positive results to investors.[7]

Although microcredit and similar financial products have shown mixed results, especially in poverty reduction efforts, the literature still recognizes in them great potential for impact (Hermes and Lensink 2011). In recent years, derived from the work of innovation hubs such as The Global Innovation Lab for Climate Finance, microfinance and financial products destined for sustainability projects have been implemented. An example is the Small Farmers Climate Adaptation Fund in Peru, Nicaragua, Costa Rica, Guatemala, El Salvador, Honduras and Ecuador, which enables local microfinance organizations to support farmers' climate adaptation projects (Add-Value Management 2020). In the case of Ecuador, for instance, resources are pooled from several private and institutional investors through Kiva—an NGO located in San Francisco, California—and then used to support four rural microcredit organizations that lend money to farmers to invest in water and irrigation systems, and greenhouse and organic production, among other projects.

An additional funding source is institutional grants. Examples include foundations that fund a diverse array of projects around the world, including the SWIFT, the David and Lucile Packard, and Gates

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[6] These cases include Iroquois Valley Farm Land helping small farmers convert to organic agriculture in the north-east of the USA, Climate Forest Capital offering blended financial instruments to farmers in partnership with an environmental organization in tropical forest countries and Agriculture Capital and Farmland LP investing in regenerative agriculture in the USA and Australia.

[7] As reported in the survey of investors conducted by the David & Lucile Packard Foundation, the Gordon and Betty Moore Foundation, The Nature Conservancy and JPMorgan Chase & Co. (2014).

Foundations. While these grants do not seek a financial return on the projects, they require that grantees demonstrate the impact of the investments made in terms of sustainability and development goals. An important feature of institutional grants is that funds can be allocated directly to beneficiaries.

Despite the fact that many of these instruments can be effective in allocating investments at a large scale, mostly because their design has specialized in traditional financial markets over time, their use can be limited in the developing world. These instruments match investors with far apart projects, which are often small and difficult to monitor. This greater distance implies the need for intermediaries, such as financial institutions and regulators, which in many low-income countries are deficient in the first place. As a consequence, unrestricted non-compliance can limit impact if the means of enforcing contracts are not readily available. A recent survey by the Global Impact Investing Network (GIIN 2020) shows that the main concern for impact investors is "impact washing". More than two-thirds of the sampled investor groups, particularly those in developing markets, indicated that exaggerated reporting of results was the main challenge faced by the impact investment market in the next five years. Importantly, the inability to demonstrate impact results was ranked second.

5.2 Biodiversity offsets

Biodiversity offsets (bio-offsets) are a compensatory measure that intends to compensate for unavoidable losses in biodiversity due to infrastructure or development projects. Since the end of the 1990s, bio-offsets have gained momentum among the public and private sector and the concept of "no net loss" is now increasingly being used. However, challenges exist in terms of demonstrating ecological equivalence between ecological impacts of different types that occur in distinct temporal and geographical scales. Hence, compensatory measures such as offsets should be used "only after exhausting the previous steps on the mitigation hierarchy: avoidance and minimization" (Gonçalves et al. 2015).

We did not find any review paper or meta-analysis of bio-offsetting focused in the Global South. In contrast, there is a high concentration of studies in the Global North, with the US, France, Canada and Australia leading most of the case studies. This represents an opportunity for researching countries in this region that are promoting bio-offsets through, for instance, requiring its application via legal mandates as has happened in Colombia, Brazil, Mexico and Peru. Our review also highlighted that the most commonly cited reason for off-setting success was applying high offset multipliers (i.e., large offset area relative to the impacted area) (zu Ermgassen et al. 2019). However, evidence of additionality is limited due to compliance and monitoring shortcomings of these programs (Bull et al. 2013). Also, some evidence suggests that in many cases bio-offsets policies could bring benefits at the expense of net losses in biodiversity (Curran et al. 2014).

In our review, we found that offset metrics and the scale of impact are the most reported critical issues of offsets (Gonçalves et al. 2015). Offset metrics refer to how losses are measured and are compared to gains. This issue involves a debate on whether biodiversity can be converted into a single metric and exchanged across time and space. In terms of the scale of impact, on-site offsets are those that are implemented in the vicinity of the damaged area. These types of offsets were common at the early stages of bio-offsetting under the premise that they were contributing to the restoration of the impacted area. However, more recent cases of offsets are located off-site because of their potential of constituting a source of conservation funding for other initiatives.

Table 3. Summary of environmental, economic and equity impacts of instruments.

Instrument	Environmental impacts	Economic impacts	Equity impacts	Strengths	Weaknesses
Payments for Ecosystem Services (PES)	-Reduces deforestation in contexts of high rates of deforestation -Increases forest cover -Promotes the adoption of sustainable land-use practices	-Potential for increasing household incomes	-Could reinforce pre-existent inequities in farm size and tenure -Could redistribute benefits improving collective well-being -Potential to reduce perceived land tenure insecurity	-Direct transfer from users to providers -Flexible design that allows fitting to specific contexts -Includes a wide range of activities that support ES provision (not only forest conservation)	-Risk of leakage (prohibited activities shift to non-PES areas) -Risk of elite capture -Risk of motivational crowding out
Voluntary Sustainability Standards (VSS)	-Improves tree cover in 43% of cases -Promotes the adoption of sustainable land-use practices	-Median and mean income improve with VSS -Reduced volatility -Mixed effects on yields	-Benefit early adopters (more professional and wealthier farmers) over laggers	-Links conservation to global value chains -Open new markets as long as consumers value certified products	-Risk of leakage -Farm-level focus with no guarantee of landscape-level impact -Only works in global commodity chains with reputational risk -Transition to certified products is costly

Reducing Emissions from Deforestation and forest Degradation (REDD+)	-Avoids deforestation -Increased reforestation and afforestation -Increased efforts to reduce illegal logging -Reduced biodiversity from afforestation	-Increased community physical capital and development projects -Mixed results on incomes	-Community participation in monitoring and decision making -Potentially limits communities' ability to use forest resources and adapt to change	-Connects marginalized forest communities to Global North's carbon emitters -Adheres to international standards for verification	-Only a third of REDD+ projects have sold verified carbon credits -Risk of elite capture -Risk of losing agricultural lands or grazing rights -Rigidity in land-use rules
Carbon Markets	-Very limited impact in terms of emissions reductions	-Not explored in the literature	-Not explored in the literature	Emerging results show: -Potential for lower compliance costs when measured indirectly -Co-benefits in terms of income support -Higher agricultural commodities prices	-Risk of leakage -Monitoring and verification relies on external agents

Key:

Strong positive evidence (significant differences between treatment and control groups)

Weak positive evidence (qualitative or non-comparative quantitative evidence)

Inconclusive evidence (not assessed)

6. Discussion

In this review, we focused on a sample of tools, based on economic incentives that have been used for environmental conservation, and identified their potential to support the agricultural transition toward sustainability (see a summary in Table 3). Despite their limitations, and scant independent and sound impact assessments, these instruments could tackle some of the barriers that the agricultural sector face, in particular small- and medium-scale farmers in the developing world, to engage in more sustainable, equitable and profitable practices to protect and restore nature.

The economic incentives we reviewed relate to three drivers of the transition toward sustainable agriculture. A large portion of the instruments we review create markets to change the incentives of farmers and consumers and increase or maintain sustainable practices and ES. One of the most important challenges of sustainable agriculture is that often there are no economic incentives to change undesired behaviors. As a result, farm practices with high and adverse impacts persist, despite the negative externalities they cause. Similarly, good practices are not rewarded, limiting their scalability and reducing the provision of public goods and services derived from positive externalities. In many cases, however, the key issue is not that these goods and services are not valuable, but rather that there are no mechanisms matching the supply and demand for sustainable agricultural practices, which limits the benefits they provide. The instruments we reviewed have the potential to create or promote such mechanisms: PES and REDD+ schemes facilitate a market for services otherwise neglected; VSS promote the market of good practices; and carbon pricing mechanisms potentially help to value and allocate carbon stocks more efficiently. Any market for sustainability requires monetizing aspects of the environment and thus the behavior of farmers and other resource users. Given that the value of forests and carbon stocks is not commonly incorporated in the decision making of agricultural production, REDD+ projects, PES, PACS and carbon pricing instruments can decrease the opportunity cost of conservation and reduce the pressure for land expansions in agriculture.

However, in the process of creating these markets, tensions arise, notably the tradeoffs between equity, efficiency and scale. The ability of these instruments to address these tensions seems to be modest, but more research is required to estimate their net social and economic impacts. Our discussion of all of these novel instruments helped us identify a number of areas where innovation can be promoted to enhance their performance and broaden their scope to include, for instance, not only forest remnants but the full range of agricultural practices and the biomes where they take place.

6.1 Opportunities for innovation in equity, efficiency and scalability

The success of the instruments studied depends on how well they are designed and adapted to the local conditions of farmers and beneficiaries. Both PES and REDD + can be tailored to respond to local conditions, generate trust, increase participation, democratize decision making and promote transparency (Duchelle et al. 2018; Wunder et al. 2020). Despite their potential, implementation has also shown that many challenges remain. An important example is scalability, which seems to require expanding the number of actors that mediate transactions. As the number of users and providers of ES increase, as more farmers and consumers are linked to commodity chains, as more granting institutions and grantees, or more impact investors and entrepreneurs meet, more private intermediaries and public regulators are needed to help enforce contracts, monitor progress, and estimate impacts (Huber-Stearns et al. 2013). This greater intermediation can lead to problems that can limit the efficiency of these instruments, such as corruption and elite capture, which underscores the tradeoffs between efficacy and scalability.

In terms of equity and scale, for instruments such as PES and VSS, gains in scale come at the cost of excluding smaller landholders, who are usually numerous and geographically dispersed. As transaction costs are higher when including several small-scale farmers, some programs deliberately exclude marginalized communities exacerbating pre-existent inequities. One possible manner to overcome the equity versus efficiency trade-off is to experiment with collective and/or differentiated payments by targeting larger and more dense ES areas while redistributing program benefits among more socially and economically vulnerable participants. The PES program in Selva Lacandona, Mexico, for example, lowers transaction costs by enrolling communities instead of households, favoring the scaling up of the program (Izquierdo-Tort 2020). The SocioBosque program in Ecuador, for instance, differentiates payments according to the number of enrolled hectares of forest (de Koning et al. 2011). Payments decrease as the number of enrolled hectares increase so as to not favor large landholders over small farmers. In Colombia, a public PES program incorporates social vulnerability variables into its payment structure with the objective of favoring vulnerable households that engage in conservation activities (Moros 2019).

In addition, the economic instruments we reviewed need to be redefined and adjusted for broader use in different contexts. For example, some instruments are too focused on restricting access to forest resources and limiting agricultural expansion (Ezzine-de-Blas et al. 2016). Such limitations could put livelihoods at risk. To balance equity and effectiveness, PES and REDD+ instruments can place more emphasis on the propagation of silvopastoral, agroforestry and traditional farming systems, so that rural communities in remote areas can support their livelihoods from both agriculture and environmental conservation. Silvopastoral systems funded by the Global Environment Facility in Nicaragua, Costa Rica and Colombia demonstrate this is feasible and promote farmers' engagement in conservation programs (Pagiola et al. 2004). The PES and REDD+ in degraded lands also offer an opportunity for additionality in biodiversity conservation, carbon sequestration and rural livelihoods.

The potential of carbon markets to promote land-use change and sustainable agriculture is yet to be seen because major carbon markets ignore interventions in the agricultural sector (Grosjean et al. 2016). Further, the current household- and individual-level impacts of carbon pricing seem to be limited, and there is little or no evidence for low- and medium-income countries. However, linkages between different instruments can be used to generate impact and promote sustainable agriculture. Carbon pricing schemes can be an outlet for programs that already impact agricultural and forest management. For example, the carbon stocks valuation and monitoring that REDD+ projects implement in local communities can work as the base of carbon trading systems via emission credits or green bonds.

In the case of VSS, scaling up these practices would require innovations in both supply and demand. On the supply side, investments in production technologies and extension services are needed to reduce adoption costs. On the demand side, certifications and codes of conduct need to be expanded to cover non-branded, local-market products. Public purchasing programs for schools, hospitals and other public institutions can be the pull needed to start moving local supply chains toward sustainability in the Global South markets. New financial tools such as crowd investment and other forms of democratizing funding can be directed toward strengthening VSS in local supply chains.

6.2 Opportunities for innovation in participation and monitoring

To make these instruments effective policy tools, their design needs to strike a balance between punishments and rewards. The voluntary nature of some instruments limits their design to include strict penalties. Some implementers can see these instruments as an opportunity to disseminate good practices in the hope that farmers will adopt them for their conservation motivations, rather than the existence of a conditional payment or a penalty for non-compliance. In the long run, unchecked non-compliance can undermine the functioning of any program if the stakeholders do not face any downside of negative behaviors.

Wide and effective participation of communities in the design, implementation and monitoring of compliance is another key aspect that needs to be strengthened across instruments. The REDD+ schemes, for example, have failed to include the voices of marginalized members of communities, sharpening pre-existing social conflicts or creating new ones. When asymmetries of information are high (such as in the case of carbon markets and REDD+), transparency in contracts and government support are fundamental not only to avoid undesired effects in terms of social conflict and reversal of tenure rights but to ensure the program's success over time. The role of governments is crucial to oversee and regulate private and voluntary instruments in which disparities in knowledge and power exist.

Further, land users can play more definitive roles in training and monitoring, an alternative shown to be cost-effective, at least in one case in Kenya (Duchelle et al. 2017). High dependence on extension services and external agricultural support, particularly in the short and medium terms, undermines farmers' resilience to changing environmental or market conditions. Horizontal knowledge and technology transfers appear to be a promising way to increase land-users' adaptive capacity because it decreases dependence on external agents.

6.3 Opportunities for innovation in spatial targeting

Most of the instruments studied here are voluntary in nature and only target specific ecosystems or land-covers. As a result, the landscape matrix is dotted by a few dispersed efforts for sustainability that do not add to ecosystem-wide conservation and regional sustainable livelihoods. To produce significant ecosystem-wide efforts, VSS and PES could be clustered to cover all stakeholders in a specific region, adopting what has been called jurisdictional approaches (von Esen and Lambin 2021) that address not just actors in a value chain or forest remnants in a landscape mosaic, but the entire landscape, including all land uses and users. Such approaches can also reduce the risk of leakage, as entire areas are covered by the schemes. Because most of the cases identified are in the early stages of their life cycle, evidence of their impacts is not yet available (von Ese and Lambin 2021).

Similarly, it is necessary to expand the scope of REDD+ and deliberately start covering and recognizing the existence of low-intensity agriculture within forests. Practices, such as slash-and-burn agriculture and rotation systems in forests, have been traditional for indigenous communities and could be accommodated in PES and REDD+ schemes, allowing for more flexible and adaptive use of the forest.

A more inclusive, landscape-level scale can mitigate the risk of exclusion of farmers in marginal, degraded or small plots. A combination of moratoria and PES has been proposed for the most marginalized farmers in the Brazilian Cerrado (Garrett et al. 2022) as a way of introducing more legitimacy in conservation efforts that would otherwise primarily benefit large owners. Those farmers can be given a small portion of the benefits provided by the incentives, while they work in improving their practices. Laggers and non-compliant actors should be the focus of educational campaigns, positive incentives (such as subsidized access to green equipment) and negative ones (such as limited access to credit for non-sustainable practices). Mechanisms and technologies for making PES more equitable have been recently proposed in ways that encourage larger owners to share benefits with their smaller counterparts (Bell 2021).

7. Conclusion

Agriculture is critical for the livelihood of millions of people worldwide and is one of the main drivers of deforestation, biodiversity loss and resource degradation. In this paper, we set out to comprehend how different economic instruments created to promote the conservation of strategic ecosystems can support the changes needed toward sustainable agriculture. We identified key success factors and challenges of PES, REDD+, VSS and carbon markets as well as their strengths and weaknesses based on a revision of synthesis and meta-analysis studies with a focus on the Global South. We discussed the potential and shortcomings of these economic mechanisms and identified priorities for innovation in three areas: (i) equity, efficiency and scalability; (ii) participation and monitoring; and (iii) spatial targeting. Economic instruments for conservation could support the transitions needed toward sustainable agriculture if equity considerations are incorporated from design to implementation, land users participate in different stages of program roll-out and jurisdictional approaches are implemented.

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Annex 1. Typologies of environmental policy instruments

Typology	Context	Categories
Piñeiro et al. (2020)	Incentives for adoption of sustainable agricultural practices	(i) Market-based incentives (e.g., income transfers), (ii) Regulatory measures (e.g., certifications), (iii) Cross-compliance incentives (e.g., agri-environmental payments).
FAO (2020)	incentives to improve productivity and enhance ecosystem services	(i) Purely policy-driven instruments (e.g., taxes or charges), (ii) Responsible market-led investments like bio-offsets, (iii) Voluntary investments (e.g., corporate social responsibility investments).
OECD (2020)	policy instruments to address climate change and ecosystem degradation in agriculture and forestry	(i) Command-and-control approaches such as standards and controls on the overuse of agrochemicals, (ii) Economic instruments including PES, REDD+ and tradable permits, among others, (iii) Information and other voluntary instruments that include, for example, eco-labeling and certifications, (iv) Others: R&D and technical assistance.
Lockie (2020)	Policy and regulatory instruments for agri-environmental management	(i) Self-regulation and co-regulation that includes, for instance, codes of conduct, (ii) Support and capacity building that considers, among others, technical assistance and public sector research, (iii) Information-based instruments that incorporate ecolabels and adverse publicity and the like, (iv) Economic instruments including tradable permits, conservation or agri-payments etc., (v) Direct or command-and-control regulation like restrictions and output quotas or zoning and location controls, etc.

Annex 2. Studies on economic incentives for conservation

Instrument	No. of cases	Locations	References
Payments for Ecosystem Services	143	23 countries: Australia, Bolivia, Botswana, Brazil, China, Colombia, Costa Rica, Ecuador, France, India, Indonesia, Kenya, Madagascar, México, Mozambique, Namibia, Panama, South Africa, Tanzania, Uganda, UK, USA and Vietnam	Four academic papers: Ezzine-de-Blas et al. 2016; Moros et al. 2020; Snilsveit et al. 2019; Wunder et al. 2018
Voluntary Sustainability Standards	131*	24 countries: Benin, Bolivia, Brazil, Chile, China, Colombia, Costa Rica, Dominican Republic, Ethiopia, Ghana, Guatemala, Honduras, India, Indonesia, Kenya, Laos, Mexico, Nepal, Nicaragua, Peru, Rwanda, Tanzania, Thailand and Uganda	Two academic papers: Garrett et al. 2021; Meemken 2020
REDD+	85	21 countries: Belize, Brazil, Cambodia, Cameroon, Costa Rica, Guyana, India, Indonesia, Kenya, Nepal, Madagascar, México, Mozambique, Nigeria, Perú, Philippines, Papua New Guinea, Tanzania, Thailand, Uganda and Vietnam	Two academic papers: Green 2021; Narassimhan et al. 2018
Carbon Markets	37	Six jurisdictions: country-level (Canada, China, Japan, Korea and New Zealand), Europe, OECD, and USA (national and state level)	Five academic papers: González-Ramírez et al. 2012; Green 2021; Michaelowa et al. 2019; Narassimhan et al. 2018; Newell et al. 2014
Impact Investment	20+	Australia, Brazil, Costa Rica, Ecuador, El Salvador, Ethiopia, Europe, Guatemala, Honduras, Nicaragua, Peru and USA	Three academic papers: Antarciuc et al. 2018; Havemann et al. 2020; Hermes and Lensink 2011

Instrument	No. of cases	Locations	References
			Institutional reports: GIIN 2020; World Bank 2020
Biodiversity offsets	20+	Australia, Brazil, Canada, Colombia, Finland, France, India, Madagascar, Morocco, South Africa, Sweden, Thailand, USA and Uzbekistan	Four academic papers: Bull et al. 2013; Gelcich et al. 2016; Gonçalves et al. 2015; zu Ermgassen et al. 2019

Notes: *repetition of cases is possible especially regarding coffee and cocoa cases in Latin America, India and Africa.

CoSAI
Commission on Sustainable Agriculture Intensification

The Commission on Sustainable Agriculture Intensification (CoSAI) brings together 21 Commissioners to influence public and private support to innovation in order to rapidly scale up sustainable agricultural intensification (SAI) in the Global South.

For CoSAI, innovation means the development and uptake of new ways of doing things – in policy, social institutions and finance, as well as in science and technology.

Contact us: wle-cosaisecretariat@cgiar.org

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