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The Different Dimensions of Livelihood Impacts of Payments for Environmental Services (PES) Schemes: A Systematic Review



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ABSTRACT

Through a systematic review of peer-reviewed and grey literature, this paper analyzes evidence of the livelihood impacts of Payments for Environmental Services (PES). Forty-six studies assessed PES livelihood impacts. The assessments presented more positive livelihood impacts than negative ones, focusing on financial benefits. Non-monetary and non-material impacts of PES were largely understudied. Most reviews focused on ES providers, hindering the understanding of broader societal impacts. The review yielded examples where participants lost from their participation or where improvements in one livelihood dimension paralleled deterioration in another. Consequently, we identified key research gaps in: i) understanding the social and cultural impacts of PES, ii) evaluating environmental and economic additionality from improving other ES at the expense of cultural ones, iii) and assessing PES impacts in terms of trade-offs between multiple livelihood dimensions. Moreover, increased knowledge is needed on the impact of PES on changes in household expenditure and choice, and on trade-offs between household income and inequality in ES provider communities. Finally, if PES schemes are implemented to sustainably improve livelihoods, targeting disaggregated populations, understanding equity and social power relations within and between ES providers and users, and better monitoring and evaluation systems that consider locally relevant livelihood dimensions are needed.

1. Introduction

The first experiences with Payments for Environmental Services (PES) date back to the 1990s. PES are agreements between providers and users of environmental services¹ (ES) in which users who benefit from ES compensate providers who maintain them off-site. In the agreement, ES providers must take action to maintain and improve ES provision, or reverse their degradation, to achieve conservation goals (Wunder, 2015). PES rely on the idea that positive environmental externalities can be internalized by creating appropriate markets and market instruments such as conditional rewards (Pearce and Turner, 1990). Wunder (2015) redefined PES as voluntary transactions (not necessarily market-based) between service users and providers (not limited to markets or individuals) to generate off-site services (benefits received off-site that cannot be otherwise charged). These transactions

are conditional on agreed rules of natural resource management. Other mainstreamed definitions rely on the incremental provision of environmental services (Sommerville et al., 2009; Tacconi, 2012) or on incentives to align individual/collective land-use decisions and social interest by transferring resources between social actors (Muradian et al., 2010). In practice, most PES schemes do not follow the original Coasean concept where externalities are best dealt with through private negotiations (Martin-Ortega et al., 2012; Schomers and Matzdorf, 2013). Some definitions reflect how PES were designed in practice. For example, reward-based conceptualizations include pro-poor or fairness objectives as part of the PES definition criteria (Bulte et al., 2008; Iftikhar et al., 2007; Van Noordwijk et al., 2007). This implies a synergy between socioeconomic and environmental impacts, usually assumed by nongovernmental organizations, donors, and international cooperation agencies when providing support to PES (Wunder, 2008).

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¹ The term “environmental” services is argued to include ecosystem services, as they can be considered a subcategory focusing on the human benefits derived from natural ecosystems.

However, this assumption has seldom been assessed (Pagiola et al., 2005; Pattanayak et al., 2010) nor, more in general, has the link between well-being and environmental indicators (Cruz-Garcia et al., 2017).

The effectiveness of PES in achieving multiple objectives simultaneously is debatable (Muradian et al., 2013; Wunder, 2013).

Few studies have explored or proved the synergies between PES and livelihood outcomes (Landell-Mills and Porras, 2002; Pagiola et al., 2005; Wunder, 2008; Tallis et al., 2008). Certainly, assessing the socioeconomic impacts of PES is complex and requires evaluation across a range of actors – ES providers, direct users, and beyond (Grieg-Gran et al., 2005; Hegde and Bull, 2011) – and time scales. Systematic monitoring and evaluation of PES, including their long-term environmental and livelihood effects, lag behind (Ezzine-De-Blas et al., 2016; Hejnowicz et al., 2014).

Therefore, understanding to what extent and under what conditions PES schemes have successfully improved livelihoods is urgently needed to guide future PES implementation with synergistic environmental and livelihood goals.

In this paper, we examine published evidence of the livelihood impacts of PES, based on a systematic review of peer-reviewed and grey literature available online. As different authors refer to impacts on poverty, well-being, equity, and so on, we use the term livelihoods as an umbrella definition. Using the sustainable livelihoods approach, we define livelihoods as capabilities and means of living embedded within a paradigm of equity and sustainability (Chambers and Conway, 1992). We analyze PES impacts in relation to different dimensions that contribute to sustainable livelihoods, including but not limited to financial, social, human, physical, and natural capital. Our review aims to answer two research questions: (1) what is the evidence of livelihood impacts of PES schemes evaluated in the literature? and (2) what are the current gaps in the generation of evidence of livelihood impacts of PES schemes?

2. Contextual Background

According to the literature, the positive effects of PES include increased land tenure security (Lawlor et al., 2013), financial gains, income stability, and diversification (Pagiola et al., 2005; Wunder, 2008). Additionally, PES can generate health benefits through improving and stabilizing sources of drinking water (Wunder, 2008). PES can provide recreation benefits, cultural opportunities, strengthened social networks and institutions, and economic growth (Iftikhar et al., 2007; Tacconi et al., 2013).

PES can also generate negative livelihood impacts. Constraints to resource-extractive activities may lead to lower local production, price increases, and market dependency (Pagiola et al., 2005; Wunder, 2008). Social tensions can arise from unequal benefit appropriation (Grieg-Gran et al., 2005; Wunder, 2008). PES-induced land-use restrictions can affect cultural traditions (Trac et al., 2013; Yang et al., 2013). Disbursement of payments only in the first years of PES scheme operation can affect income stability in the long term (Mahanty et al., 2013; Tacconi et al., 2013).

Previous reviews that analyzed livelihood impacts, among other aspects of PES, are available. In their review of REDD+ schemes, Lawlor et al. (2013) find that, despite the lack of robust evidence, these incentives improved land tenure security and decision-making power but provided moderate income gains. According to Leimona et al. (2009), low population density in ES provider areas and low opportunity and transaction costs determine significant effects on rural income. Tacconi et al. (2013) illustrate that several PES schemes strengthened local institutions and community engagement with local government, and expanded farmers' networks. Samii et al. (2014) reported trade-offs between conservation and poverty reduction goals, but identified only two rigorous studies on livelihood impacts of PES. Hejnowicz et al. (2014) analyzed the conditions under which PES achieved multiple

objectives. Börner et al. (2017) highlighted an important gap in the analysis of trade-offs between PES ecological performance and social outcomes.

Calvet-Mir et al. (2015) highlighted the need to generate more evidence through systematic reviews to foster comparable analyses on PES scheme design and implementation. We address this by a systematic analysis of the published evidence of livelihood impacts of PES. While previous reviews focused on defined geographic or economic areas, outcomes, types of PES, or PES features, we provide a global search of PES evaluations that report any livelihood impact. We go beyond previous reviews by focusing only on livelihood impacts and comparing positive and negative impacts on disaggregated actors. We do not use a specific definition of PES and include all PES schemes defined as such in the publications found. Our analysis addresses the gap between PES theory and practice to contribute to ongoing debates on the role of PES in livelihood improvement, and the challenges of designing PES for this purpose.

3. Methodology

We systematically reviewed peer-reviewed publications and grey literature, following the PRISMA guidelines (Moher et al., 2009). A comprehensive search for peer-reviewed studies on the livelihood impacts of PES was performed using the online SciVerse Scopus (*title*, *abstract*, and *keywords* search) and Thomson Reuter's Web of Science search engine (*title* search, *topic* search). We did not specify document type, language, year of publication, or study region. The search terms used were “payments or rewards”, AND “environmental or ecosystem services”, AND “impact*”, AND “evaluation or assessment”.

According to the [Greynet.org](http://www.greynet.org) definition, we included the following types of grey literature: institutional reports, working papers, consultant reports, non-peer-reviewed book chapters, and conference proceedings. We consulted the following databases: Agricola, 3ie, Abdul Latif Jameel Poverty Action Lab, Grey Literature Report, OpenGrey, OAIster, and Google. Given the different archiving systems of these databases, the search terms used were “payments or rewards for environmental or ecosystem services” AND “impact”.

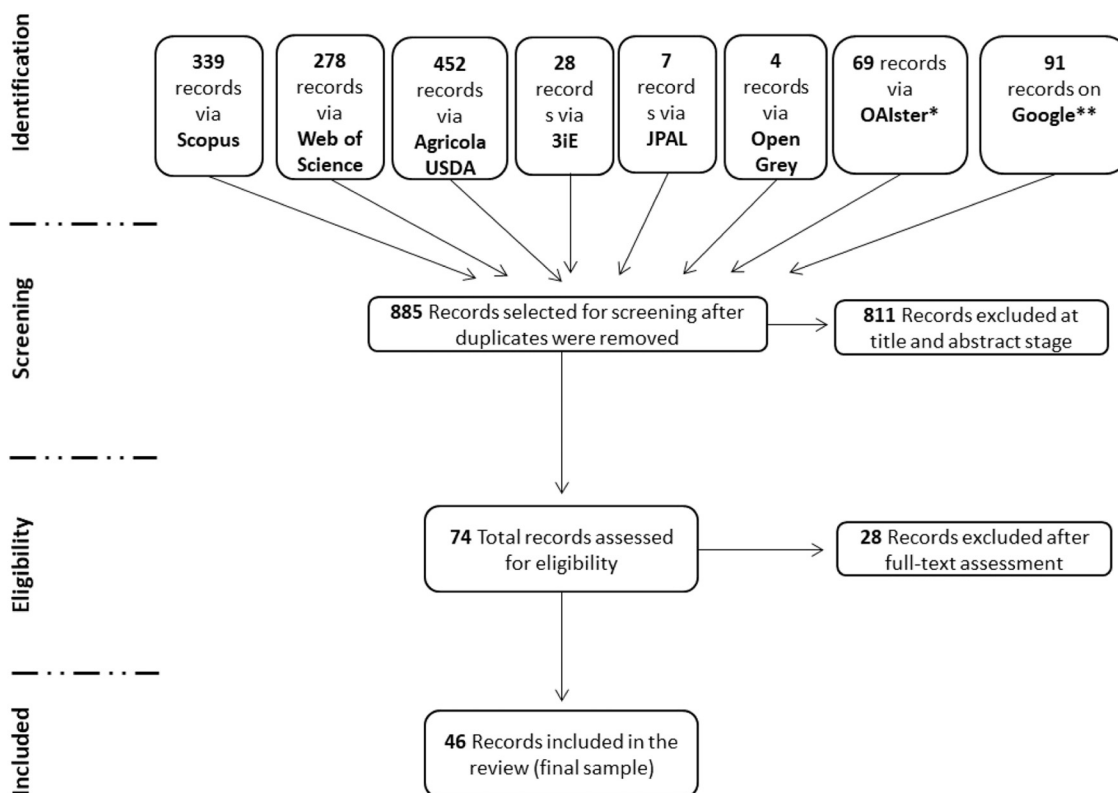
We first searched all databases in April 2016 and then reran the whole search in January 2018 to update the analysis (Appendix A).

After removing duplicates and reading through all 1268 titles, we screened 885 records, of which we identified 74 eligible for full-text assessment. We excluded studies that reported only on the environmental impacts of PES or focused on the design, planning, frameworks, and concepts related to PES or other topics. We also excluded review papers in favor of studies that provided an in-depth analysis and evaluation of the livelihood impacts of specific PES schemes. The final sample of documents eligible for full-text review had 46 publications. We analyzed them in terms of who gained and who lost from PES implementation and whether they participated (as ES providers, users, or buyers) or not in the PES. We highlighted methods to evaluate impacts and sources of data collection.

Fig. 1 shows the methodological approach, while Appendix A details the databases consulted, the search terms used per database, and the final number of records included after removing duplicates.

4. Results

We briefly overview here the general trends of the studies reviewed. Appendix B details the 46 publications, while Appendix C provides a synthetic table with the main characteristics of the PES schemes they evaluated. Appendix D provides more detail about geographical distribution of the studies, key features of the PES evaluated, and the methods used by the studies to evaluate them. Finally, Appendix E shows the positive and negative impacts of PES in the studies reviewed, the method they used to analyze them, who gains and who loses from positive and negative impacts.



* Two studies were not found directly on OAlster but as chapters of a book found through the search on OAlster

** Results from the free search with the specified terms were screened only until page 25, as they become irrelevant to the topic approximately at page 20

Fig. 1. Methodological approach.

Forty-six publications (or 5% of the publications screened) evaluated livelihood impacts. Seventy-eight percent of the publications were peer-reviewed articles; 20 publications (43%) evaluated PES schemes in Latin America, while 18 studies assessed PES in Asia (Fig. 2) and 8 in Africa.

The 46 studies evaluated 24 PES or PES-like schemes. In 17 PES schemes, the incentive mechanisms were cash transfers, followed by a combination of in-kind and cash transfer (6), and one scheme providing only in-kind compensation. ES buyers were mainly governments (62%), and ES providers were individual households (15 PES), entire communities (7), or both (2).

The studies applied mostly qualitative (43%) and quantitative methods (30%), half with counterfactuals (participants vs non-participants) (Fig. 3A and C). The most common data collection methods were surveys (63%) interviews (39%), and document reviews (36%) (Fig. 3B). Livelihood impacts were often analyzed through tests of differences (30%) and descriptive statistics (26%) (Fig. 3D).

Fig. 4 shows the number of studies that assessed each indicator and the number of impacts found for each. Seventy-eight percent of the studies, both counterfactual and non-counterfactual, focused on financial impacts of PES, followed by employment, agricultural production, and physical capital. Few publications analyzed non-monetary and non-material indicators, including social, human, and natural capital. Only 4 studies (all non-counterfactuals) assessed PES impacts in terms of cultural capital.

4.1. Livelihood Impacts

Our review found more nuanced and varied livelihood impacts than those presented in Section 2 (Appendix D). All studies except two

(Martin et al., 2014; Arriagada et al., 2018) found changes in livelihoods due to program participation. Non-counterfactual studies highlighted more negative impacts (39 impacts: 12 qualitative studies, 3 mixed methods studies) than counterfactual assessments (16 impacts: 5 quantitative studies, 1 qualitative study, 5 mixed methods studies). In total, 33 studies analyzed more than one livelihood dimension. Out of these, 10 reported only positive impacts, while 23 (9 counterfactual) reported positive impacts in certain dimensions and negative impacts in others. For instance, while PES participants derived benefits in social capital and employment, some lost benefits in another, such as income (Locatelli et al., 2008). Conversely, participants of a PES scheme in Cambodia derived benefits in multiple livelihood dimensions such as income, agricultural production, and food security simultaneously (Clements and Milner-Gulland, 2015).

4.1.1. Financial Capital and Flows

Thirty-six studies analyzed the financial impacts of PES, with mixed conclusions. Out of these, four did not find any change in financial capital or flows.

Out of the 32 studies that found any change in the financial dimension, 27 reported on variations in household income or on the share of income deriving from the PES payments. Twenty studies only found income increases due to PES implementation, while five only reported income losses. Those who gained were usually households that provided ES. Similarly, those who lost were individual providers (7) or provider communities (3). Importantly, four evaluations reported both income gains and losses, but for different types of households.

Given the predominance of assessments reporting income changes, we illustrate the heterogeneity of indicators used, methods, and findings in Appendix F. Ten papers reported the share of income from PES,

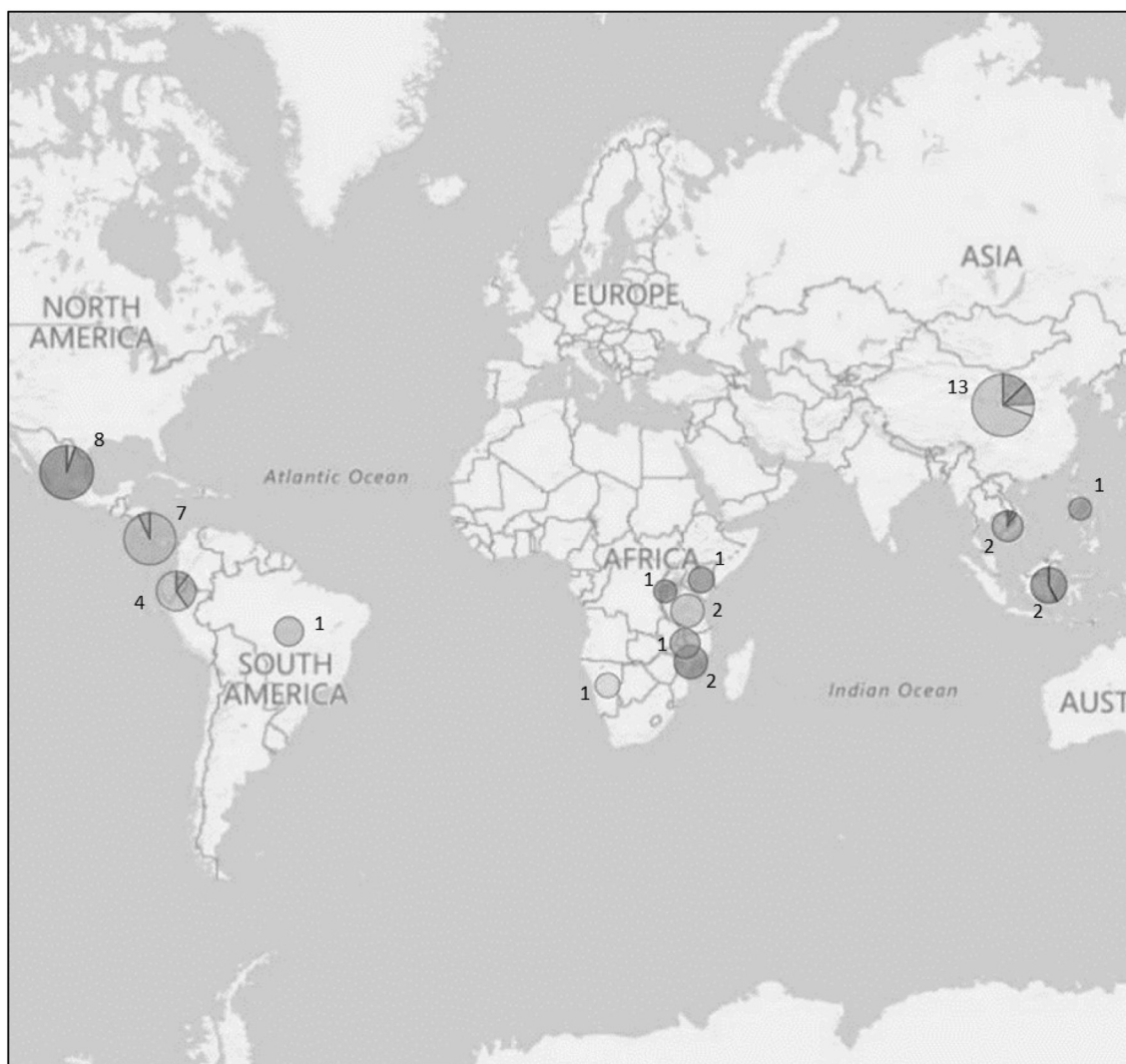


Fig. 2. Geographical distribution of publications evaluating livelihood impacts of PES schemes ($n = 46$)*.

* The circle size reflects the number of publications per country, also indicated by the numbers. The segments within the circles show the number of PES schemes evaluated by the publications.

while 12 quantify the income change due to PES. PES-induced income changes varied considerably, with income increases ranging from 14% (Miranda et al., 2003) to as much as 400% (Yang et al., 2013) and potential decreases of about 60% (Leimona et al., 2010). Overall, few studies quantified income changes. For instance, only four counterfactuals (Hegde and Bull, 2011; Liang et al., 2012; Zheng et al., 2013; Jack and Cardona-Santos, 2017) quantified PES effects on comparable income indicators (household income). All except one found significant positive effects.

As for specific PES schemes, three counterfactual studies (Li et al., 2011; Liang et al., 2012; Yin et al., 2014) attributed income increases of different intensity to the Sloping Land Conversion Program (SLCP) in China. Four non-counterfactual studies (Liu et al., 2008; Trac et al., 2013; He and Sikor, 2015; Qu et al., 2017) also reported income increases. Trac et al. (2013) reported negative impacts of the SLCP on income due to a lack of markets for promoted cash crops, while Liang et al. (2012) found income decreases for households with children but without elderly.

In the Paddy Land-to-Dry Land (PLDL) program in China, increased earnings from other sources balanced the decrease in agricultural income for participants compared with non-participants (Zheng et al., 2013).

Three non-counterfactual studies on the Natural Forest

Conservation Program (NFCP) in China presented multifaceted effects. ES providers' income increased, but whether these effects were attributable to the NFCP was unclear (Yang et al., 2013). Conversely, the NFCP did not compensate for the loss of income induced by logging and grazing bans (Cao, 2011). Moreover, while ES providers gained from additional income sources, forestry workers in provider communities, who depended on timber harvesting, suffered large economic losses (Liu et al., 2008).

In Costa Rica, two counterfactual studies reported income increases for ES providers (Cole, 2010; Miranda et al., 2003). Two non-counterfactual studies² (Locatelli et al., 2008; Porras et al., 2013) found that activities linked to reforestation helped diversify the income of participants. However, smallholders and the working class suffered negative short-term financial impacts compared with richer landowners (Locatelli et al., 2008).

Concerning the Programme for Hydrological Environmental Services (PSAH) in Mexico, one counterfactual study reported improved access to credit (Alix-Garcia et al., 2014) while a second found no improvement in the financial well-being of participants (Scullion et al.,

² Locatelli et al. (2008) reconstructed baseline information by recall by asking land-owners if and how their situation changed with the PES scheme compared to before its implementation.

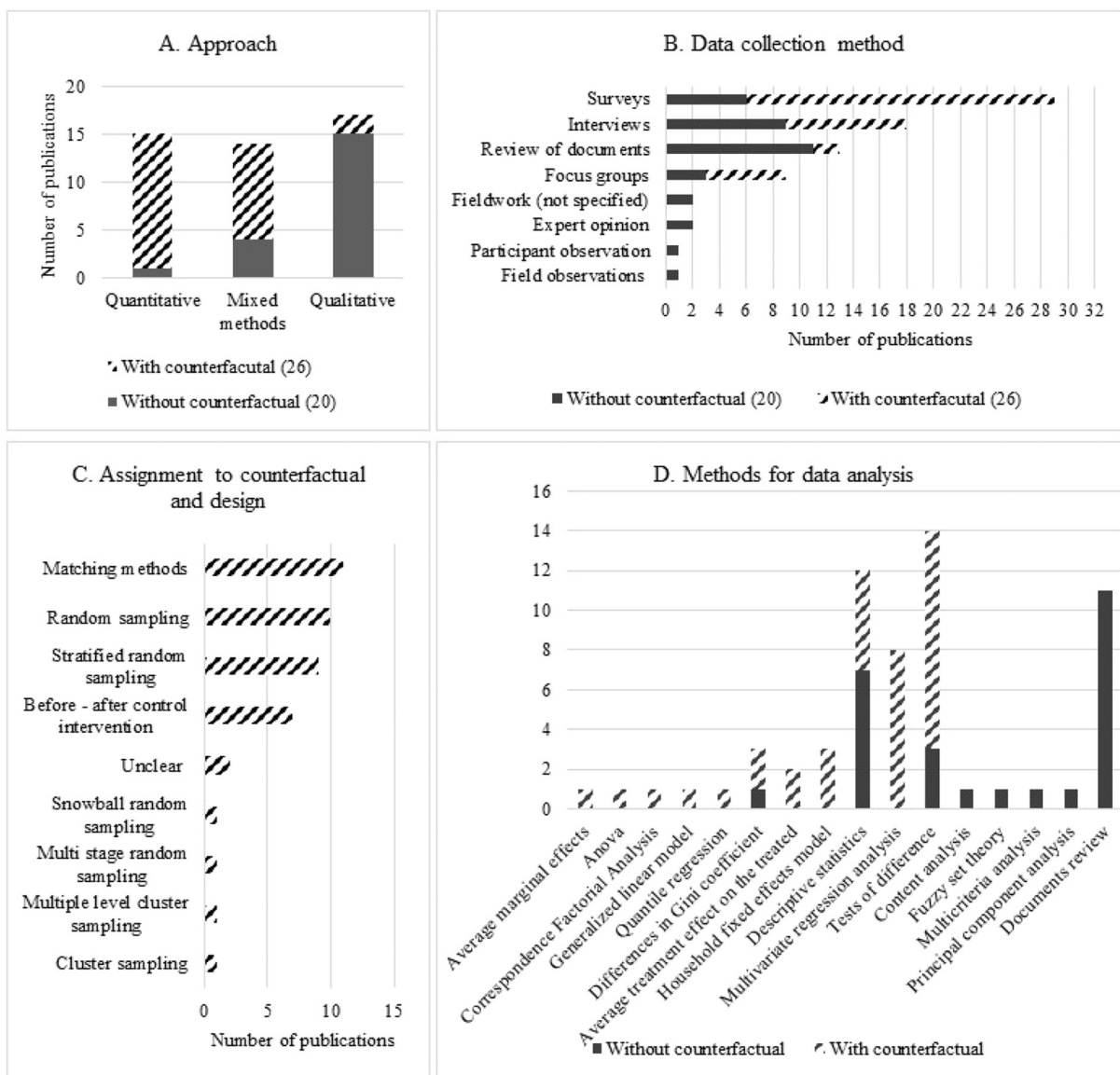


Fig. 3. Methods applied in PES livelihood evaluations (n = 46).

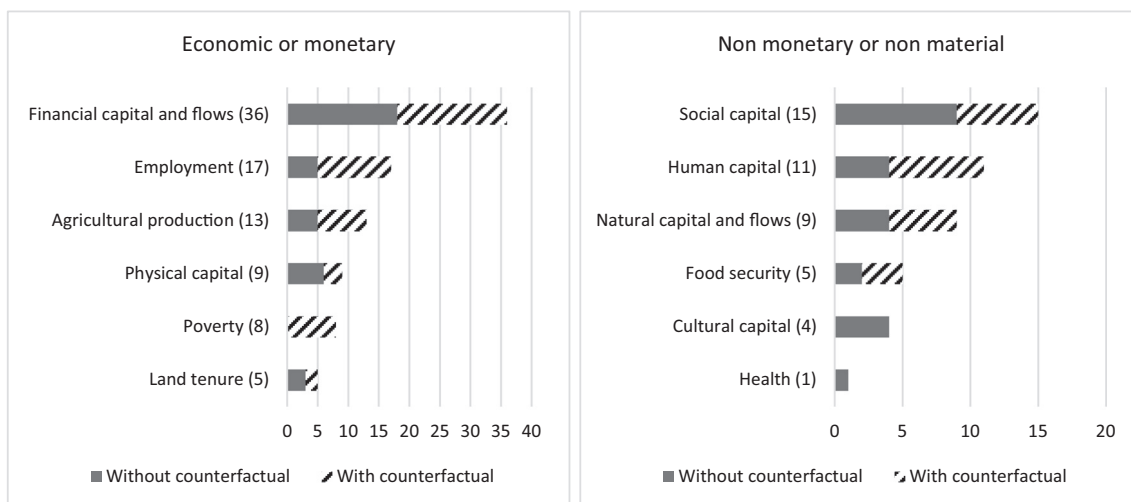


Fig. 4. Livelihood dimensions found in the PES evaluations (n = 46).

2011). Non-counterfactual studies reported mixed results. Corbera (2010) found moderate income increases for individual PSAH providers. Income inequality decreased between ES providers, although widening the poverty gap with non-providers in the same communities (García-Amado et al., 2011).

For the Socio Bosque scheme in Ecuador, a counterfactual study (Raes et al., 2014) reported income increases for individual providers, while two non-counterfactual studies reported increases especially for small landowners (Bremer et al., 2014) and income diversification at the community level (Farley et al., 2011). A non-counterfactual assessment of the Pimampiro PES in Ecuador found that powerful households gained the most, which reinforced unequal resource allocation (Rodríguez de Francisco et al., 2013).

The Olare Orok Conservancy PES in Kenya prevented a larger share of participants from slipping below the poverty line compared with non-participants, but their income sources decreased due to crowding of pastoral land (Osano et al., 2013). Additionally, payments reduced income inequality among participants, but broadened the income gap with non-participants.

Two counterfactual studies on the Nhambita Community Carbon Project in Mozambique reported income increases for ES providers (Hegde and Bull, 2011; Jindal, 2010).

A counterfactual study (Kwayu et al., 2017) of the Equitable Payments for Watershed Services (EPWS) in Tanzania reported income increases for ES providers, while an early non-counterfactual study (Lopa et al., 2012), reported that participants in the program increased 3.5 fold within the first year probably because of the financial incentives.

According to non-counterfactual studies, three PES schemes led to income losses for participants due to land-use restrictions (Rodríguez de Francisco et al., 2013; Soriaga and Annawi, 2010) and wildlife-induced damage to crops and livestock (Naidoo et al., 2011).

Four counterfactual studies reported positive impacts on household expenditure per capita of ES providers, while one reported no change. A non-counterfactual study (Ibarra et al., 2011) found that households in a Mexican community spent a larger share of their income on lower-quality food because of lower local agricultural productivity due to reduced agricultural area and shortened fallow cycles.

4.1.2. Employment

Seventeen studies, of which 12 were counterfactual, reported changes in employment due to PES implementation. Seven counterfactual studies and two non-counterfactual studies found that employment opportunities increased in ES provider communities. Two counterfactual studies (Wang et al., 2017; Uchida et al., 2009) reported increased employment opportunities for non-participants. Conversely, Jack and Cardona-Santos (2017) found that households randomly assigned to PES contracts had higher labor constraints for casual off-farm labor than those who auctioned for the contract, suggesting that the contract would have been more beneficial to self-selected households. In Mexico, labor costs of PES-induced land management changes were large compared to PSAH payments (Alix-García et al., 2014).

Yin et al. (2014) reported declining on-farm employment but increasing off-farm employment for participants of the SLCP compared with non-participants, while a non-counterfactual study (Trac et al., 2013) reported a shift to illegal timber harvesting. According to Uchida et al. (2009), the largest impact of the SLCP was increased off-farm employment of younger households or those with liquidity constrained prior to the program.

A counterfactual (Miranda et al., 2003) and a non-counterfactual study (Locatelli et al., 2008) reported increased employment related to product transportation and transformation and additional temporary labor due to the PSA in Costa Rica. Similarly, according to a non-counterfactual study, the NFPC in China resulted in a transfer of labor to other sectors and a shift from logging to forest management and plantation farming (Liu et al., 2008).

4.1.3. Agricultural Production

Twelve studies, of which seven were counterfactual, reported impacts on agricultural production. Positive impacts reported by counterfactual studies included higher crop harvests or yields (Clements and Milner-Gulland, 2015; Kwayu et al., 2017; Wang et al., 2017; Beauchamp et al., 2018), bigger cattle herds (Alix-García et al., 2014), and slight increases in commercial crops (Jindal, 2010). Non-counterfactual studies found increased grain productivity for households in SLCP communities (Cao, 2011; Liu et al., 2008) and increased investments in agricultural production for Socio Bosque participants (Bremer et al., 2014). Negative impacts in terms of reduced crop yields for participants were reported in a counterfactual study by Hegde and Bull (2011), and by two non-counterfactual studies in terms of reduced agricultural or livestock production (Molina-Murillo et al., 2014; Bremer et al., 2014).

4.1.4. Physical Capital

According to counterfactual studies, PES payments contributed to the construction of a school and clinic (Jindal, 2010), a nursery (Leimona et al., 2010), and forest road improvements (Wang et al., 2017). Non-counterfactual studies reported that PES implementation led to investments in local power grids (Yang et al., 2013), road protection from erosion (Soriaga and Annawi, 2010), greenhouses (Corbera, 2010), and community infrastructure (Molina-Murillo et al., 2014). However, according to Cao (2011) and Liu et al. (2008) (both non-counterfactual), decreased tax revenues due to logging restrictions reduced local government investment in China.

4.1.5. Poverty

Five counterfactual studies reported improvements in poverty indices for participants. The Costa Rica PSA reduced poverty among households in high-slope areas with low opportunity costs and low deforestation threat (Robalino et al., 2014), but increased poverty in low-slope areas with higher opportunity costs. The PSAH in Mexico generated significant but small poverty increases (Sims and Alix-García, 2017) in areas where larger shares of the population participated in the program, and for longer periods (Alix-García et al., 2015). The economic status (basic necessities) of ES providers in Cambodia improved compared to non-participants (Clements and Milner-Gulland, 2015; Beauchamp et al., 2018).

Three additional counterfactual studies analyzed poverty, but found no significant impacts (Arriagada et al., 2015; Diswandi, 2017; Arriagada et al., 2018).

4.1.6. Land Tenure

Two counterfactual studies reported increased security against squatters (Miranda et al., 2003) and redistribution of forestlands with long-term secure tenure (Wang et al., 2017). Non-counterfactual studies reported increased land tenure security for participants by creating communal wildlife conservancies (Naidoo et al., 2011), tenure regularization (Porrás et al., 2013), and perceived higher land security (Bremer et al., 2014).

4.1.7. Social Capital

Twelve studies, of which four were counterfactuals (i.e. Leimona et al., 2010; Miranda et al., 2003; Kwayu et al., 2017; Wang et al., 2017), reported mixed results in terms of changes in social capital. PES schemes helped to build a connection with local governments and establish agricultural cooperative organizations in China (Wang et al., 2017), while increasing trust and cohesion among participants in Tanzania (Kwayu et al., 2017). The Costa Rica PSA increased voluntary agreements, institutional dialogue, and coordination (Miranda et al., 2003), as well as inclusion of marginalized actors according to a non-counterfactual study (Porrás et al., 2013). Leimona et al. (2010) found that interactions between participants of a PES in Indonesia and external stakeholders increased, but created an exclusive group vis-à-vis

non-participants.

Non-counterfactual studies reported both positive and negative impacts on social capital. Bartels et al. (2010) found that Proambiente participants in Brazil influenced state projects through strengthened networks. The Pimampiro PES in Ecuador reinforced unequal power relations within communities and between service users and providers (Rodríguez de Francisco et al., 2013). Corbera (2010) found that the establishment of forest management groups in Mexico translated into community commitment to control damaging activities in forest areas, but created conflict between formal and informal rights holders. Locatelli et al. (2008) and Molina-Murillo et al. (2014) found that the Costa Rica PSA improved governance and increased local institutional support. Bremer et al. (2014) reported perceived improvements in community organization but potential conflicts over access to reserved land and Socio Bosque investment plans.

4.1.8. Human Capital

Out of eleven studies reporting human capital impacts, only one counterfactual study found negative impacts (Jindal, 2010), in terms of increased workloads for women. Two counterfactual studies (Miranda et al., 2003; Scullion et al., 2011) and a non-counterfactual study (Corbera et al., 2009) reported increasing environmental awareness. Other counterfactual studies reported increased knowledge and skills in agriculture and forest management (Alix-García et al., 2014; Kwayu et al., 2017; Wang et al., 2017).

4.1.9. Natural Capital and Flows

According to counterfactual studies, positive impacts of PES in natural capital (as a livelihood dimension) included increased water availability for ES users (Zheng et al., 2013), increased forest conservation linked to a conservation ethic (Scullion et al., 2011), and improved knowledge and perception of environmental services (Arriagada et al., 2018). Non-counterfactual studies reported improved perception of the environment (Locatelli et al., 2008) and of the sustainability of conservation efforts (Bremer et al., 2014), but also lower deforestation due to lower fuelwood use (Yang et al., 2013).

4.1.10. Food Security

Three counterfactual studies (Clements and Milner-Gulland, 2015; Alix-García et al., 2015; Kwayu et al., 2017) and two non-counterfactual studies (Naidoo et al., 2011; Ibarra et al., 2011) measured the effects of PES on food security, focusing on food consumption. Households participating in the Ibis Rice program were more food secure (Clements and Milner-Gulland, 2015) or had twice per person consumption (Naidoo et al., 2011) than non-participants. Alix-García et al. (2015) reported increased food consumption for poor households. Kwayu et al. (2017) found increased ability of participants to meet household food needs. Conversely, Ibarra et al. (2011) found only negative impacts, as land-use restrictions and hunting prohibitions increased market dependency.

4.1.11. Cultural Capital

Four non-counterfactual studies addressed culture-related impacts and all reported negative effects for provider communities. Forest-use restrictions affected local customs and identity (Yang et al., 2013) or hindered traditional practices (Trac et al., 2013) in China. Bans on hunting and agricultural land uses for ES providers altered traditional resource management and food systems, leading to degraded nutrition of indigenous communities in Mexico (Ibarra et al., 2011). Clearance restrictions disrupted fallow and rotation cycles, thus neglecting traditional practices and community identities in Ecuador (Rodríguez de Francisco et al., 2013).

4.1.12. Health

Only one study (non-counterfactual) discussed the health impacts of PES schemes, reporting reduced water-related diseases for households

in provider communities (Soriaga and Annawi, 2010).

4.2. Benefit Appropriation and Opportunity Costs

In four studies, poor and better-off households, smallholders, and larger landowners participated and benefited almost equally from PES schemes (Cole, 2010; Martin et al., 2014; Naidoo et al., 2011; Yin et al., 2014). Conversely, other studies found that some households had better access to PES than others. These included male-headed and richer households (Hegde and Bull, 2011; Liang et al., 2012), more food-secure or better-off households (Clements and Milner-Gulland, 2015; Beauchamp et al., 2018), or those with a certain land area (Farley et al., 2011; Lopa et al., 2012; Miranda et al., 2003; Porrás et al., 2013; Raes et al., 2014). Non-fully voluntary participation was reported in China (Li, 2009) and in Ecuador (Rodríguez de Francisco et al., 2013).

Nineteen studies discussed the opportunity costs associated with original land uses. For instance, SLCP payments were higher than the opportunity costs of retired land (Liang et al., 2012), while the payments of the PSAH in Mexico were lower than alternative incomes (Alix-García et al., 2014; García-Amado et al., 2011; Scullion et al., 2011). Martin et al. (2014) and Raes et al. (2014) reported cases in which an undifferentiated payment rate independent of individual opportunity costs was deemed the most equitable choice. Arriagada et al. (2015) found that >50% of the participants in the Costa Rica PSA mentioned that environmental protection rather than financial gain motivated them to enroll in the program.

5. Discussion

Despite the popularity of PES and the plethora of publications on the subject, this systematic review of peer-reviewed and grey literature of PES impacts found only 46 studies that assessed PES livelihood impacts, out of 885 screened. Many PES schemes have reached implementation maturity slowly, limiting evaluation opportunities. Despite the limited number of publications found, they provide nuanced evidence of the livelihood impacts of PES, and highlight PES design and evaluation gaps and opportunities.

5.1. Design of Assessments

Different methods sometimes yielded opposite or mixed results for the same PES scheme. For instance, in qualitative methods, more in-depth discussions with individual participants may yield more negative impacts as participants have the opportunity to express their discomfort about program participation or the effects on livelihood dimensions, such as social and cultural, seldom captured in quantitative assessments. Another partial explanation is that assessments from the ecological and economic literature more often use quantitative methods, focusing less on the sociological and political processes affected by PES, more often captured in the social sciences. The low use of mixed methods reduces the opportunity to understand how contextual factors, power relations, and equity issues determine multiple PES impacts for heterogeneous populations.

The choice to apply a counterfactual evaluation or not is also relevant. Evaluations based on counterfactual analysis aim to provide us with a robust understanding of the impacts of an intervention on participants compared with non-participants. This is true when the intervention is relatively straightforward, such as PES schemes based purely on cash-transfers (or only one modality of compensation) for a clearly defined and relatively homogeneous population. In the counterfactual studies reviewed, the quality of sample selection was not always clear, hindering judgment on group comparability. We found mixed results for income effects assessed with counterfactual and non-counterfactual methods for the same PES cases (e.g. in China and Mexico). Measuring income increases requires proper counterfactuals to determine the extent of income change actually attributable to PES and if this change is

significant compared to non-participants. At the same time, quantitative methods should be complemented by qualitative methods to understand contextual factors and processes that affect those changes. For instance, in Costa Rica, non-counterfactual methods were useful to understand why larger landholders benefit more from PES than smallholders (e.g. Locatelli et al., 2008). For some aspects, non-counterfactual methods that reconstruct baseline information and ask PES participants how the initial situation has changed after PES implementation can be useful to evaluate variations in dimensions such as infrastructure and land tenure security, if these were benefits clearly agreed during PES negotiation. In these cases, the causality between PES intervention and outcome is more straightforward as it is directly dependent on PES implementation and achievement of the respective commitments.

5.2. Who Benefits and How?

Our review showed that PES assessments focus on ES providers and on financial impacts. Only one study evaluated the effects on ES users. Few reported effects on non-participants, who experienced higher income inequality or lower income than PES participants, or communities suffering from reduced public investment or employment. The prevailing focus on ES providers thwarts the understanding of broader societal impacts, including on communities, non-participants, institutions, and ES buyers. In terms of “losers”, they were often ES providers experiencing income decreases due to PES-induced restrictions. However, the consequences of PES schemes cannot be fully captured in terms of income as its translation into enhanced livelihoods is not linear (Pascual et al., 2010).

This relates to another key aspect to understand how ES providers benefit from PES: in theory, if payments offset or exceed opportunity costs of conserving or better managing ES-providing areas, then PES could help to alleviate economic poverty. However, only half of the studies discussed opportunity costs, thus hampering our ability to discern the net income effects of PES (Calvet-Mir et al., 2015). Indeed, financial benefits of PES are not always the main motivation of participants. Participants enrolled in PES initiatives that were not necessarily compensating the opportunity costs (Beauchamp et al., 2018; Arriagada et al., 2015). Other non-economic reasons may explain enrollment such as conservation ethics, improvements in human and social assets, but also peer pressure or coercion (Grieg-Gran et al., 2005; Kronenberg and Hubacek, 2013).

Evidence of impacts in non-financial capital is mixed and context-dependent. For example, only a few studies reported increased land tenure security, often considered an important livelihood impact of PES (Lawlor et al., 2013). At the same time, our review yielded cases in which access rules and land-use restrictions led to segregation between powerful groups and less influential farmers, thus reducing community cohesion. Significantly, such results reflect inadequate identification of values inherent to ES, as the value system of a community might not identify with standard opportunity cost assessments.

5.3. Current Gaps

The empirical basis of the livelihood impacts of PES, although increasing, is still inadequate and seldom comparable, thus limiting the capacity of science to conclude about PES impacts under diverse socio-ecological systems.

In terms of PES design, we found key gaps for generating and assessing PES livelihood impacts. Sound monitoring and evaluation systems are urgently needed (Ezzine-De-Blas et al., 2016; Hejnowicz et al., 2014), and should aim to overcome the disconnect between short-term payments and long-term agreements (Quintero and Pareja, 2015; Tacconi et al., 2013).

Limitations in evaluation design hinder the assessment of overall and disaggregated societal benefits of PES. Sound evaluations that

complement qualitative and quantitative methods, applying rigorous counterfactuals (e.g. Gertler et al., 2016) whenever appropriate, and disentangling disaggregated PES impacts on different types of ES providers, users, and non-participants are needed. Additionally, the identification of local livelihood indicators can unearth contextual values and priorities, allowing holistic and context-relevant PES design and implementation (Blundo-Canto et al., 2016).

When counterfactual evaluation is not appropriate, fuzzy multi-criteria analysis provides meaningful results, such as those provided by Locatelli et al. (2008), although quantification might be challenging. Other approaches, such as process tracing, contribution analysis, or developmental evaluation, that take into account complexity and systemic change, can be applied (Bamberger et al., 2010; Hearn and Buffardi, 2016; Patton, 2014).

It is also important to consider contextual evolutions over the long term for counterfactual evaluation to be robust (Beauchamp et al., 2018), acknowledging that socioeconomic characteristics usually change slowly and incrementally (Arriagada et al., 2015). Analysis of past trends and evolution of key variables in the contexts analyzed can support the design of more appropriate and realistic evaluations. Moreover, PES evaluations should consider the continuity, duration, and stability of financial incentives, which shape the sustainability of economic improvements achieved through PES.

From the economic benefits perspective, our review provided insights into under-researched aspects: i) the impact of PES on changes in household expenditure and choice and ii) the trade-off between individual household income and community inequality. Some studies showed that PES were used to purchase low-quality food to substitute food formerly produced in land set aside for conservation. This type of effect deserves more in-depth studies that take into account patterns of change comparing participants and non-participants. For the second aspect, some studies showed that while PES increase income for participating households, they could exacerbate the income gap with non-participants. This trade-off deserves greater attention for assessing overall equity effects of PES.

Better economic assessment of PES impacts should increase efforts on fuller accounting of opportunity costs (Pascual et al., 2010) and understanding the rationale behind PES participation decisions, coupling economic, environmental, and cultural considerations (Corbera et al., 2007). These considerations are key when designing and negotiating PES. When opportunity costs are low and more profitable land-use alternatives are lacking, enrollment is more likely even despite low payment rates (Arriagada et al., 2009). In this respect, an opportunity exists for agricultural research in testing alternatives that increase productivity while reducing negative environmental externalities. This may reduce the negative impacts associated with reduced agricultural production reported in some of the reviewed studies. Additionally, opportunity costs should be periodically re-assessed to adapt payments to changing costs in time.

From a theoretical perspective, non-monetary and non-material livelihood aspects are understudied in PES evaluations. The few studies that reported increased food security for ES providers consider only food availability, a limited view of food security, which is multi-dimensional (FAO, 2011). The bias towards food availability rather than food quality, access, or stability reflects trends in ES research (Cruz-Garcia et al., 2016).

Our review confirms that there is little evidence of the social impacts of PES (Hejnowicz et al., 2014). Cultural impacts are almost ignored. The studies that analyzed these impacts provided a more complex picture of individual and community-level changes generated by PES. Additionally, half of the studies reviewed reported trade-offs between impacts in different livelihood dimensions, while ten reported positive increases in multiple dimensions simultaneously.

Therefore, three research areas deserve particular attention: i) understanding the social and cultural impacts of PES, ii) assessing environmental and economic additionality from improving other ES than the

expense of cultural ones, iii) and evaluating PES impacts in terms of trade-offs and synergies between multiple livelihood dimensions.

6. Conclusions

This systematic review provides empirical evidence of the livelihood impacts of PES schemes and identifies current gaps in their design and evaluation. The studies reviewed presented more positive livelihood impacts than negative ones, often focused on economic benefits for ES providers. Nonetheless, a third of the studies assessed multiple livelihood dimensions, out of each half that reported trade-offs between dimensions.

Some studies found that diverse motivations beyond economic rationale can determine the decision to participate in PES. PES design and implementation should carefully consider why and how people participate, to ensure equity and sustainability. Additionally, a better understanding of social and cultural aspects is important for PES efficiency and power-sensitive analysis (Van Hecken et al., 2015), by accounting for their institutional aspects (Corbera et al., 2009), equity considerations (Pascual et al., 2014), and non-material and non-economic benefits (Chan et al., 2012).

PES initiatives were originally designed as conservation incentives generating environmental additionality under cost-effective and economically efficient conditions (Wunder, 2015). In practice, they are often implemented to attain pro-poor impacts, while environmental objectives might be secondary (Rosa da Conceição et al., 2015). Certainly, poverty exacerbates environmental degradation and environmental degradation exacerbates poverty (Duraiappah, 1998). Therefore, environmental conservation and poverty alleviation initiatives should aim to be synergistic. Along these lines, it is necessary to ensure that PES schemes, while improving environmental service delivery, do not worsen poverty in the places where they are implemented. This has major policy implications, for instance, that could re-shape how institutions work in a way that promotes interdisciplinary interactions between policymakers and decision makers to create regulations that

address both environmental degradation and poverty, involving new ES buyers interested in societal impacts and ensuring efficient use of public funds. In terms of PES design, this would translate into better planning, monitoring, and evaluation (Le Velly and Dutilly, 2016) that respond to the objectives and inner logic of the intervention (e.g. purely environmental, purely focused on poverty alleviation, seeking to maximize both dimensions, and so on). Certainly, the effectiveness and efficiency of PES are also a result of design choices (Engel et al., 2008; Wunder, 2015).

To integrate environmental with socioeconomic and equity objectives, PES design should target disaggregated populations, looking for synergies between environmental sustainability and livelihoods (Raworth, 2012) and evaluating livelihood impacts adjusted by the stability of PES agreements. Synergies and trade-offs between, and within, livelihood and environmental dimensions should be clear when negotiating PES, enabling transparent mechanisms that distribute PES benefits equitably (Ingram et al., 2014). Assessment of power relations between ES providers and users, but also within provider communities (Tristán-Febres et al., 2018), would help avoid unequal benefit appropriation. This is seldom considered in PES design and is a significant omission in ES research (Berbés-Blázquez et al., 2016). Disaggregated assessments that account for equity and distributional effects, along with environmental and livelihood co-benefits and trade-offs, as well as understanding how local communities define their well-being to ensure locally relevant outcomes are a priority for PES research, design, and implementation that aim to achieve equitable and sustainable livelihood improvement.

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Appendix A. Search Terms and Results

Database	Search Terms	Fields	Timespan	Records identified	Records included after removing duplicates
Scopus	TITLE-ABS-KEY (payments for ecosystem servic ^a OR payments for environment ^a servic ^a AND impact ^a)	Title Abstract Keywords	05/01/ 2018	248	22
	TITLE-ABS ("payment for ecosystem service" W/5 (impact OR evaluat ^a OR assess ^a)) OR TITLE-ABS ("payment for environment ^a service" W/5 (impact OR evaluat ^a OR assess ^a))	Title Abstract	05/01/ 2018	77	7
	TITLE-ABS-KEY (reward for ecosystem servic ^a OR reward for environment ^a servic ^a AND impact ^a)	Title Abstract Keywords	05/01/ 2018	14	0
	TITLE-ABS ("reward for ecosystem service" W/5 (impact OR evaluat ^a OR assess ^a)) OR TITLE-ABS ("reward for environment ^a service" W/5 (impact OR evaluat ^a OR assess ^a))	Title Abstract	05/01/ 2018	0	0
Web of Science	"payment ^a for ecosystem servic ^a " or "payment ^a for environment ^a servic ^a " and impact ^a	Title	05/01/ 2018	249	3
	(("payment for ecosystem servic ^a " OR "payment for environment ^a servic ^a ") NEAR/5 (impact OR evaluat ^a OR assess ^a))	Topic	05/01/ 2018	29	0
	"reward ^a for ecosystem servic ^a " or "reward ^a for environment ^a servic ^a " and impact ^a	Title	05/01/ 2018	1	0
	(("reward for ecosystem servic ^a " OR "reward for environment ^a servic ^a ") NEAR/5 (impact OR evaluat ^a OR assess ^a))	Topic	05/01/ 2018	0	0

Agricola USDA	("payments for ecosystem services") OR ("payment for ecosystem services") OR ("payments for environmental services") OR ("payment for environmental services")	Keywords anywhere	07/01/2018	448	4
	(" rewards for ecosystem services ") OR (" reward for ecosystem services ") OR (" rewards for environmental services ") OR (" reward for environmental services ")	Keywords anywhere	07/01/2018	4	0
3ie	Payments for Environmental Services	-	07/01/2018	18	1
	Payments for Ecosystem Services	-	07/01/2018	8	0
	Rewards for Environmental Services	-	07/01/2018	1	0
	Rewards for Ecosystem Services	-	07/01/2018	1	0
JPAL	Payments for Environmental Services	-	07/01/2018	3	0
	Payments for Ecosystem Services	-	07/01/2018	1	0
	Rewards for Environmental Services	-	07/01/2018	0	0
	Rewards for Ecosystem Services	-	07/01/2018	3	0
OpenGrey	payment for environmental services	-	07/01/2018	1	0
	payment for ecosystem services	-	07/01/2018	2	0
	reward for environmental services	-	07/01/2018	1	0
	reward for ecosystem services	-	07/01/2018	0	0
OAIster ^a	ti:"payment ^a for environmental services" and impact	-	07/01/2018	50	6
	ti:"payment ^a for ecosystem services" and impact	-	07/01/2018	19	0
	ti:"reward ^a for environmental services" and impact	-	07/01/2018	0	0
	ti:"reward ^a for environmental services" and impact	-	07/01/2018	0	0
Google	free search: payments for ecosystem services impact	-	08/01/2018	91 (results until page 25 ^b)	3
Total					46

^a The two studies were not found directly on OAIster but in a book found in the OAIster database.

^b Results from the free search with the specified terms were screened only until page 25, as they become irrelevant to the topic approximately at page 20

Appendix B. List of the Final Sample of 46 Publications

#	Author	Title	Year	Type of document	Evaluation method ^a
1	Alix-Garcia JM, Sims KRE, Yañez-Pagans P	Only one tree from each seed? Environmental effectiveness and poverty alleviation in Mexico's Payments for Ecosystem Services Program	2015	Peer review article	Quant Count
2	Alix-Garcia, J, Aronson, G, Radeloff, V, Ramirez-Reyes, C, Shapiro, E, Sims, K, Yañez-Pagans, P	Impacts of Mexico's payments for ecosystem services program	2014	Report	Mix Count
3	Arriagada R, Villaseñor A, Rubiano E, Cotacachi D, Morrison J	Analysing the impacts of PES programs beyond economic rationale: perceptions of ecosystem services provision associated to the Mexican case	2018	Peer review article	Quant Count
4	Arriagada RA, Sills EO, Ferraro PJ, Pattanayak SK	Do payments pay off? Evidence from participation in Costa Rica's PES program	2015	Peer review article	Quant Count
5	Bartels, W, Schmink, M, Amaral Borges, E, Pereira, A, Domingos Silva dos Santos Arcos, D & H	Diversifying livelihood systems, strengthening social networks and rewarding environmental stewardship among small-scale producers in the Brazilian Amazon: lessons from Proambiente	2010	Book chapter	Qual No Count
6	Beauchamp E, Clements T, Milner-Gulland EJ		2018		Mix Count

		Assessing medium-term impacts of conservation interventions on local livelihoods in Northern Cambodia		Peer review article	
7	Bremer, LL, Farley, KA, Lopez-Carr, D, Romero, J	Conservation and livelihood outcomes of payment for ecosystem services in the Ecuadorian Andes: what is the potential for “win-win”?	2015	Peer review article	Qual No Count
8	Cao S	Impact of China's large-scale ecological restoration program on the environment and society in arid and semiarid areas of China: achievements, problems, synthesis, and applications	2011	Peer review article	Qual No Count
9	Clements T, Milner-Gulland EJ	Impact of payments for environmental services and protected areas on local livelihoods and forest conservation in northern Cambodia	2015	Peer review article	Quant Count
10	Cole RJ	Social and environmental impacts of payments for environmental services for agroforestry on small-scale farms in southern Costa Rica	2010	Peer review article	Mix Count
11	Corbera, E	Mexico's PES-Carbon Programme: a preliminary assessment and impacts on rural livelihoods	2010	Book chapter	Qual No Count
12	Diswandi D	A hybrid Coasean and Pigouvian approach to Payment for Ecosystem Services Program in West Lombok: does it contribute to poverty alleviation?	2017	Peer review article	Mix Count
13	Farley KA, Anderson WG, Bremer LL, Harden CP	Compensation for ecosystem services: An evaluation of efforts to achieve conservation and development in Ecuadorian paramo grasslands	2011	Peer review article	Qual No Count
14	García-Amado, LR	Efficiency of Payments for Environmental Services: equity and additionality in a case study from a Biosphere Reserve in Chiapas, Mexico	2011	Peer review article	Mix No Count
15	He, Jun, Sikor, Thomas	Notions of justice in payments for ecosystem services: insights from China's Sloping Land Conversion Program in Yunnan Province	2015	Peer review article	Mix No Count
16	Hegde R, Bull GQ	Performance of an agro-forestry based Payments-for-Environmental-Services project in Mozambique: a household level analysis	2011	Peer review article	Quant Count
17	Ibarra JT, Barreau A, Campo CD, Camacho CI, Martin GJ, McCandless SR	When formal and market-based conservation mechanisms disrupt food sovereignty: impacts of community conservation and payments for environmental services on an indigenous community of Oaxaca, Mexico	2011	Peer review article	Qual No Count
18	Jack BK, Cardona-Santos E	The leakage and livelihood impacts of PES contracts: a targeting experiment in Malawi	2017	Peer review article	Quant Count
19	Jindal, R	Livelihood impacts of payments for Forest Carbon Services: field evidence from Mozambique	2010	Book chapter	Mix Count
20	Kwayu EJ, Paavola J, Sallu SM	The livelihood impacts of the Equitable Payments for Watershed Services (EPWS) Program in Morogoro, Tanzania	2017	Peer review article	Mix Count
21	Leimona, B, Pasha, R, Rahadian, NP	The livelihood impacts of incentive payments for watershed management in Cidanau watershed, West Java, Indonesia	2010	Book chapter	Qual Count
22	Li J, Feldman MW, Li S, Daily GC	Rural household income and inequality under the sloping land conversion program in Western China	2011	Peer review article	Quant Count
23	Li Y	Social and ecological impact of PES program in arid region: The case from Zhang-ye in northwest China	2009	Conference paper	Quant No Count
24	Liang Y, Li S, Feldman MW, Daily GC	Does household composition matter? The impact of the Grain for Green Program on rural livelihoods in China	2012	Peer review article	Mix Count
25	Liu J, Li S, Ouyang Z, Tam C, Chen X	Ecological and socioeconomic effects of China's policies for ecosystem services	2008	Peer review article	Qual No Count
26	Locatelli B, Rojas V, Salinas Z	Impacts of payments for environmental services on local development in northern Costa Rica: a fuzzy multi-criteria analysis	2008	Peer review article	Mix No Count
27			2012	Peer review article	Qual No Count

	Lopa D, Mwanjyoka I, Jambiya G, Massoud T, Harrison P, Ellis-Jones M, Blomley T, Leimona B, Van Noordwijk M, Burgess ND	Towards operational payments for water ecosystem services in Tanzania: a case study from the Uluguru Mountains			
28	Martin A, Gross-Camp N, Kebede B, McGuire S	Measuring effectiveness, efficiency and equity in an experimental Payments for Ecosystem Services trial	2014	Peer review article	Mix Count
29	Miranda, M, IT Porras and M L Moreno	The social impacts of payments for environmental services in Costa Rica: a quantitative field survey and analysis of the Virilla watershed	2003	Report	Quant Count
30	Molina Murillo, Sergio A	Assessment of environmental payments on indigenous territories: the case of Cabecar-Talamanca, Costa Rica	2014	Peer review article	Qual No Count
31	Naidoo R, Weaver LC, De Longcamp M, Du Plessis P	Namibia's community-based natural resource management program: an unrecognized payments for ecosystem services scheme	2011	Peer review article	Qual No Count
32	Osano PM, Said MY, de Leeuw J, Ndiwa N, Kaelo D, Schomers S, Birner R, Ogutu JO	Why keep lions instead of livestock? Assessing wildlife tourism-based payment for ecosystem services involving herders in the Maasai Mara, Kenya	2013	Peer review article	Mix Count
33	Porras, I, Barton, DN, Miranda, M, and Chacón-Cascante, A	Learning from 20 years of Payments for Ecosystem Services in Costa Rica	2013	Report	Qual No Count
34	Qu M, Liu G, Lin Y, Driedger E, Peter Z, Xu X, Cao Y	Experts' perceptions of the sloping land conversion program in the Loess Plateau, China	2017	Peer review article	Qual No Count
35	Raes L, Aguirre N, D'Haese M, Van Huylenbroeck G	Analysis of the cost-effectiveness for ecosystem service provision and rural income generation: a comparison of three different programs in Southern Ecuador	2014	Peer review article	Qual Count
36	Robalino, J, Sandoval C, Villalobos L, and Alpizar F	Local Effects of Payments for Environmental Services on Poverty	2014	Discussion paper	Quant Count
37	Rodríguez de Francisco, JC, Budds J, Boelens R	Payment for Environmental Services and Unequal Resource Control in Pimampiro, Ecuador	2013	Peer review article	Qual No Count
38	Scullion J, Thomas CW, Vogt KA, Pérez-Maqueo O, Logsdon MG	Evaluating the environmental impact of payments for ecosystem services in Coatepec (Mexico) using remote sensing and on-site interviews	2011	Peer review article	Mix Count
39	Sims KRE, Alix-Garcia JM	Parks versus PES: evaluating direct and incentive-based land conservation in Mexico	2017	Peer review article	Quant Count
40	Soriaga, R, and Annawi, D	The "No-Fire Bonus" Scheme in Mountain Province Cordillera Administrative Region, Philippines	2010	Book chapter	Qual No Count
41	Trac CJ, Schmidt AH, Harrell S, Hinckley TM	Environmental reviews and case studies: Is the returning farmland to forest program a success? three case studies from Sichuan	2013	Peer review article	Qual no count
42	Uchida, E, S Rozelle, and J Xu	Conservation Payments, Liquidity Constraints and Off-Farm Labor: impact of the Grain for Green Program on Rural Households in China	2009	Peer review article	Quant Count
43	Wang, C, Pang, W, & Hong, J	Impact of a regional payment for ecosystem service program on the livelihoods of different rural households	2017	Peer review article	Quant Count
44	Yang W, Liu W, Viña A, Luo J, He G, Ouyang Z, Zhang H, Liu J	Performance and prospects of payments for ecosystem services programs: evidence from China	2013	Peer review article	Mix No Count
45	Yin R, Liu C, Zhao M, Yao S, Liu H	The implementation and impacts of China's largest payment for ecosystem services program as revealed by longitudinal household data	2014	Peer review article	Quant Count
46	Zheng H, Robinson BE, Liang Y-C, Polasky S, Ma D-C, Wang F-C, Ruckelshaus M, Ouyang Z-Y, Daily GC	Benefits, costs, and livelihood implications of a regional payment for ecosystem service program	2013	Peer review article	Quant Count

^a The method column provides a classification of the evaluation method according to the following abbreviations: Mix Count = mixed methods with counterfactual; Mix No Count = mixed methods without counterfactual; Qual Count = qualitative methods with counterfactual; Qual No Count = qualitative methods without counterfactual; Quant Count = quantitative methods with counterfactual; Quant No Count = quantitative methods without counterfactual.

Appendix C. Main Characteristics of PES Schemes Reviewed in the Studies

Country	Total*	Type of payment	Buyer	Provider	Conditionality
PES Scheme					
Brazil	1				
Proambiente	1	Cash/In Kind	Government	Farmers and forest landowners	Long term management plans and certification
Cambodia	2				
Ibis rice	2	Cash	Government	Communities in protected areas	Conservation of wildlife and natural resources
Ecotourism	2	Cash	Government	Communities in protected areas	Conservation of wildlife and natural resources
Bird Nest protection programme	2	Cash	Government	Communities in protected areas	Farming within agreed land-use plans
China	13				
Natural Forest Conservation Program (NECP)	3	Cash	Government	Forest landowners	Restore forest and vegetation cover reducing logging
Paddy Land-to-Dry Land (PLDL)	1	Cash	Government	Communities in mountainous areas	Conversion of paddy land to dryland
Sloping Land Conversion Program (SLCP)	10	Cash/In Kind	Government	Farmers in sloping cropland	Restore forest and vegetation cover reducing cropland
Changting County PES	1	Cash/In Kind	Government	Farmers	Development of orchards and production forests on hilly land or open forestland
Costa Rica	7				
Costa Rica's Payment for Environmental Services (PSA)	6	Cash	Government/ Private companies	Forest landowners	Restore forest, sustainable forest management, forest
Sistemas Agroforestales (SAF)	1	Cash	Government	Farmers	Agroforestry
Ecuador	4				
Comuna Zuleta	1	Cash	Government	Households in protected areas	Recovery of degraded páramo through burning exclusion
Pinampiro PES	1	Cash	Public water company	Landowners	Maintain vegetation cover, not felling trees, allowing natural regeneration
Socio Bosque/ Socio Páramo	3	Cash	Government	Landowners	Conservation of land
Indonesia	2				
Cidanau Watershed PES	1	Cash	Public water company	Landowners (farmer groups)	Tree planting and maintenance
West Lombok PES	1	Cash	Private water company / World Bank	Forest landowners	Watershed protection
Kenya	1				
Olare Orok Conservancy PES	1	Cash	Private companies (tourism)	Landowners (pastoral)	Conservation of wildlife through voluntary resettlement and livestock grazing exclusion
Mexico	8				
FIDECOAGUA	1	Cash	Government	Landowners	Forest protection
Mexico's Payments for Hydrological Services Program (PSAH)	8	Cash	Government	Individual and communal landowners / communities	Maintain vegetation cover, avoid land use change
Malawi	1				
Tree planting Malawi	1	Cash / In Kind	International research center	Landowners	Tree planting and maintenance
Mozambique	2				
Nhambita Community Carbon Project	2	Cash/In Kind	Private company	Individual farmers and communities	Agroforestry, no tree felling
Namibia	1				
Community-based natural resources management (CBNRM)	1	Cash	Private companies (tourism)	Communities in protected areas	Conservation of wildlife and natural resources
Philippines	1				
No fire bonus scheme	1	In Kind	Government	Communities (barangays)	Fire prevention / suppression (certificates)
Rwanda	1				
University of East Anglia PES in Rwanda	1	Cash	University	Communities in protected areas	Reduce logging, hunting, mining
Tanzania	2				
Equitable Payments for Watershed Services (EPWS)	2	Cash	Public water company / Private company/ Care International	Households in mountainous areas	Soil conservation through agroforestry, terraces

*The first row (in grey) indicates the number of publications for each country. The following rows indicate the PES schemes evaluated in each publication, per country. The values do not sum up as several PES schemes were evaluated in multiple publications.

Appendix D. Descriptive Analysis

D.1. Geographical Distribution

Most publications ($n = 36$) are peer-reviewed articles, followed by book chapters (5), reports (1), one conference paper and a discussion paper. Twenty assessments focus on PES schemes in Latin America. Eight concerned the Mexican Payments for Hydrological Environmental Services (PSAH) (Alix-Garcia et al., 2015, 2014; Corbera et al., 2009; García-Amado et al., 2011; Ibarra et al., 2011; Scullion et al., 2011; Arriagada et al., 2018; Sims and Alix-Garcia, 2017). Seven studies in Costa Rica, evaluated the national PES (PSA) (Locatelli et al., 2008; Miranda et al., 2003; Porras et al., 2013; Robalino et al., 2014; Molina-Murillo et al., 2014; Arriagada et al., 2015), and one the Sistemas Agroforestales (SAF) (Cole, 2010). In Ecuador, three studies evaluated the Socio Bosque PES scheme (Farley et al., 2011; Raes et al., 2014; Bremer et al., 2014), one the Comuna Zuleta PES (Farley et al., 2011), and one the Pimampiro PES (Rodríguez de Francisco et al., 2013). One study in Brazil evaluated the Proambiente program (Bartels et al., 2010). Thirteen publications evaluated PES schemes in China, of which nine concerned the Sloping Land Conversion Program (SLCP) (Cao, 2011; Li et al., 2011; Li, 2009; Uchida et al., 2009; Liang et al., 2012; Liu et al., 2008; Trac et al., 2013; Yang et al., 2013; Yin et al., 2014; Zheng et al., 2013; He and Sikor, 2015; Qu et al., 2017), three the Natural Forest Conservation Program (NFCP) (Cao, 2011; Liu et al., 2008; Yang et al., 2013), one the Paddy Land-to-Dry Land (PLDL) program (Zheng et al., 2013), and one the Changting County PES (Wang et al., 2017). Two studies evaluated the Nhambita Community Carbon Project in Mozambique (Hegde and Bull, 2011; Jindal, 2010), and two the Equitable Payments for Watershed Services (EPWS) in Tanzania (Lopa et al., 2012; Kwayu et al., 2017). One study assessed a Tree planting scheme in Malawi (Jack and Cardona-Santos, 2017), one the Olare Orok Conservancy PES in Kenya (Osano et al., 2013), one a PES led by University of East Anglia in Rwanda (Martin et al., 2014), and one the Community-based natural resources management (CBNRM) program in Namibia (Naidoo et al., 2011). Finally, two studies evaluated the Bird Nest protection, Ibis Rice, Ecotourism programs in Cambodia (Clements and Milner-Gulland, 2015; Beauchamp et al., 2018), one the No fire bonus scheme in the Philippines (Soriaga and Annawi, 2010), and two the Cidanau Watershed PES (Leimona et al., 2010) and the West Lombok PES (Diswandi, 2017) in Indonesia.

D.2. Buyers, Providers and Conditionality

Overall, the 46 studies evaluated 24 PES or PES-like schemes. We classified type of incentive according to the modality of payment: cash, cash with in-kind, or purely in-kind. We did not include capacity-building activities as in-kind payments unless explicitly identified as a feature of the agreement. In 17 out of these, the incentive mechanism were cash transfers, followed by a combination of cash and in-kind (6), or purely in-kind (1).

Specific in-kind compensation beyond cash payments included an annual in-kind subsidy of grain and free seedlings (SLCP); seedlings and technical assistance (Nhambita Community Carbon Project); technical assistance and long-term land use plans (Proambiente); inputs and training (Tree planting PES); green infrastructure (Changting Country PES); and timber tree planting (West Lombok PES). The “No-Fire Bonus scheme” in the Philippines only provided in-kind compensation (infrastructure).

The main ES buyers included governments (15 PES), followed by private companies (4), public water companies (3), an international research center and a university ES providers were most frequently individual households (16 PES), entire communities (5) or both (3).

Conditionality rules included conservation of wildlife (habitat protection, or relocation and exclusion of grazing) and natural resources (4), restoration or maintenance of forest or vegetation cover (4 and 3), agroforestry (3) and land use change (3).

Providers were mostly individual households (13 PES), entire communities (6) or both (2).

Conditionality rules included conservation of wildlife and natural resources (4), restoration of forest or vegetation cover (4), agroforestry (3), maintenance of vegetation cover (3), land use change (3), forest protection (2), long term management plans (2), watershed protection (1), fire prevention (1), and conservation of land (1). Wildlife conservation entailed habitat protection or relocation and exclusion of grazing. In one PES scheme, conditionality was based on voluntary settlement relocation and livestock grazing exclusion inside a conservancy reserved to high-end wildlife tourism generating the payments for grazers (Osano et al., 2013).

D.3. Environmental Services

Of the 24 PES schemes, ten focused on ES from managed forests, agro-forestry systems or forests in previous farmlands, which we categorized as agro-forestry ecosystems. Eleven PES schemes incentivized conservation of broadly defined natural forest ecosystems in areas threatened by human activities. One PES focused on High Andean grasslands (páramo), one on drylands, and one on wildlife conservancies.

The 24 PES schemes targeted different environmental services as shown in Fig. A. Hydrological services, including sediment retention by preventing soil erosion, flood mitigation, and water quality, predominate (14 PES). Eleven PES schemes aimed at improving biodiversity conservation, while nine targeted carbon sequestration. Three schemes explicitly addressed cultural services (in Namibia, in Kenya and in Costa Rica), two provisioning services, one reduced landscape flammability and one desertification protection.

Thirteen PES schemes explicitly targeted environmental services bundles. For instance, the Costa Rica PSA included hydrological services, scenic beauty, carbon sequestration, and biodiversity protection, while the PSAH in Mexico addressed hydrological services and carbon sequestration. The SLPC targeted hydrological services, desertification protection and biodiversity. Proambiente considered carbon sequestration, biodiversity, hydrological services, and landscape flammability.

D.4. Measurement of Livelihood Impacts

The studies used different methods to measure livelihoods impacts, including purely qualitative (15), purely quantitative (14) and mixed-methods (14), of which 26 compared participants' to non-participants' impacts. Most often, data collection methods included surveys (29 studies), interviews (18), document reviews (13), and focus groups (9). Seventeen counterfactual studies and two non-counterfactuals explicitly reported sample selection methods. Counterfactual assessments usually applied quantitative or mixed methods (14 and 10 publications respectively). Mixed-methods studies used qualitative data to deepen understanding of livelihood impacts measured through quantitative analysis. Martin et al. (2014), for instance, carried out interviews with participant and non-participant households in Rwanda to explore negative effects. Yang et al. (2013) conducted interviews to understand better the planning, implementation, evaluation and decision-making processes. Among qualitative studies, two

carried out in-depth interviews and focus groups with both participants and non-participants. Two non-counterfactuals mentioned fieldwork activities but provided no further specification, while assignment to counterfactual was unclear in two studies.

Seven counterfactuals analyzed data from before and after PES implementation. For instance, Yin et al. (2014) adopted a trend study approach spanning ten years; Clements and Milner-Gulland (2015) used mixed-effects models on baseline data and repeated collections after 1 to 3 years of payment disbursement.

D.5. Livelihood Dimensions and Indicators

Livelihood impacts were mainly analyzed through tests of differences (11 counterfactual, 3 non-counterfactual), descriptive statistics (5 counterfactual, 7 non-counterfactual), description of data from document reviews (11 non-counterfactual), and multivariate regression analysis (8 counterfactuals).

In 78% of studies (18 counterfactual and 18 non-counterfactual analyses), impacts of PES were assessed in terms of the financial livelihood dimension. Financial capital and flows included income (30 studies), income sources (10), income inequality (4), household expenditure (6), access to credit (6), new investments (3), and land value (1). Other studies assessed changes in employment (12 counterfactual and 5 non-counterfactual), or changes in agricultural production (8 counterfactual and 5 non-counterfactual), and physical capital (3 counterfactual and 6 non-counterfactual). Indicators for changes in agricultural production included crop yields (8), crop production (5), and livestock production (2). Eight studies, all counterfactuals, evaluated impacts in terms of poverty. Poverty indicators included a basic necessities index (2 studies), an asset index (2), a basic food basket (1), a multidimensional poverty index (1), a poverty alleviation index (1), and a welfare indicator (1).

Few publications analyzed non-monetary and non-material indicators, including social (6 counterfactual and 9 non-counterfactual), human (7 counterfactual and 4 non-counterfactual) and natural capital (5 counterfactual and 4 non-counterfactual). Only non-counterfactual studies (4) assessed PES impacts in terms of cultural capital. Two counterfactual studies assessed changes in perceived quality of

life.

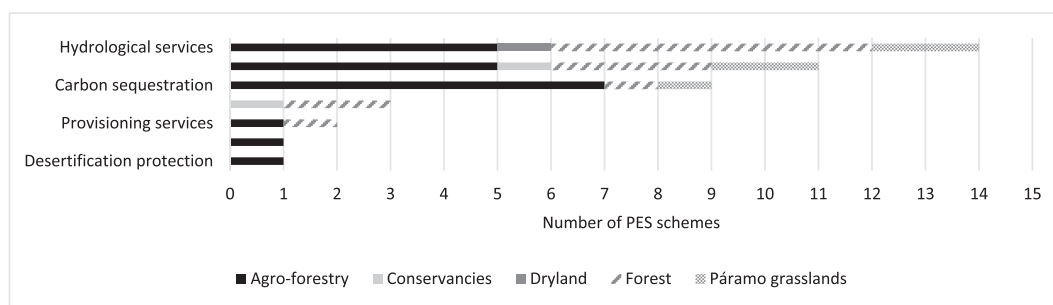


Fig. A. Environmental services by type of ecosystem (n = 24).

Appendix E. Positive and Negative Impacts of PES Reviewed

The following table shows the number of positive and negative impacts of PES in the studies reviewed for each livelihood dimension, the method used to analyze them, and who gains and who loses from positive and negative effects.

The method column provides a classification of the method according to the following abbreviations: Mix Count = mixed methods with counterfactual; Mix No Count = mixed methods without counterfactual; Qual Count = qualitative methods with counterfactual; Qual No Count = qualitative methods without counterfactual; Quant Count = quantitative methods with counterfactual; Quant No Count = quantitative methods without counterfactual.

Due to limitations of synthesizing multiple data in one table, there is no direct relationship between numbers in the method column and the columns who gains and who loses.

For clarity, we use abbreviations by type of stakeholders: P = providers; U = users; NP = non-participants.

Dimension	Positive impact	n	Method	n	Who gains	n	Negative impact	n	Method	n	Who loses	n			
Financial capital	Income increase	25	Mix Count	5	Households who provide the service (P)	18	Income decrease	9	Mix No Count	1	Households who provide the service (P)	6			
			Mix No Count	3	Households in provider communities (P)				Qual Count		1		Households in provider communities (P)		
			Qual Count	1					Qual No Count		5				
			Qual No Count	10					Quant Count		1				
	Increased household expenditure (as a proxy for higher income)	4	Mix Count	2	Households who provide the service (P)	4	Increased market dependency for food expenditure	1	Qual No Count	1	Households in provider communities (P)	1			
			Quant Count	2											
	Increased income diversification	6	Mix Count	1	Households who provide the service (P)	5	Reduced income sources	10	Mix Count	1	Households who provide the service (P)	5			
			Mix No Count	1					Mix No Count		2		Households in provider communities (P)		
			Qual No Count	2	Households in provider communities (P)				Qual No Count		5		Non-participating households in provider communities (NP)		
			Quant Count	2					Quant Count		2				
	Economic inequality decrease	3	Mix Count	1	Households who provide the service (P)	3	Economic inequality increase	3	Mix Count	1	Non-participating households in provider communities (NP)	2			
			Mix No Count	1					Mix No Count		1		Households in provider communities (NP)		
Quant Count			1		Qual No Count				1		Households in provider communities (P)				
Increased access to credit	5	Mix Count	2	Households who provide the service (P)	2	Lack of loan repayment	1	Qual No Count	1	Forest enterprises in provider communities (NP)	1				
		Quant Count	2	Households in provider communities (P)											
		Qual No Count	1												
Improved allocation of public funds	1	Qual No Count	1	Households in provider communities (P)	1										
Investments in business development	2	Qual No Count	2	Households who provide the service (P)	1	Investment in risky alternative livelihoods that do not guarantee income generation	1	Mix Count	1	Households who provide the service (P)	1				
				Households in provider communities (P)						1					
Employment	Increased off farm employment opportunities	14	Mix Count	3	Households who provide the service (P)	4	Shift of labor to more environmentally degrading practices	1	Qual No Count	1	Households in provider communities (P)	1			
			Mix No Count	2	Households in provider communities (P)				Increased costs due to additional labor		1		Mix Count	1	Households who provide the service (P)
			Qual Count	1											
			Qual No Count	2	Non-participating households in provider communities (NP)				Higher labor constraints that lead to casual work		1		Quant Count	1	

Agricultural production	Increased crop production	11	Quant Count	4	Households who provide the service (P)	7	Decreased crop production due to land use restrictions	4	Quant Count	1	Households who provide the service (P)	3	
			Qual No Count	5	Households who provide the service (P)	4							
			Quant Count	2						Qual No Count	3	Households in provider communities (P)	1
	Increased number of livestock	1	Mix Count	1	Households who provide the service (P)	1							
Physical capital	Upgrade of local power grid	1	Mix No Count	1	Households in provider communities (P)	1	Reduced investment in infrastructure due to loss of tax revenue	2	Qual No Count	2	Government in provider communities (P)	2	
			Qual Count	1	Households in provider communities (P)	1							
	Construction of nursery and community meetings building	1	Qual Count	1	Households in provider communities (P)	1							
	Community, education and health infrastructure (partially supported by PES)	2	Mix Count	1	Households who provide the service (P)	2							
	Improved access through road protection	1	Qual No Count	1	Households in provider communities (P)	1							
	Infrastructure for soil conservation	1	Quant Count	1	Households who provide the service (P)	1							
	Improved forest road	1	Quant Count	1	Households in provider communities (P)	1							
	Construction of greenhouse Radio, computer, water pump	1	Qual No Count	1	Households who provide the service (P)	1							
Land tenure	Increased land tenure security	4	Qual No Count	3	Households who provide the service (P)	3							
			Quant Count	1	Households in provider communities (P)	1							
	Security against squatters	1	Quant Count	1	Households who provide the service (P)	1							
Poverty	Poverty decrease	5	Quant Count	2	Households who provide the service (P)	3	Poverty increase	1	Quant Count	1	Households in provider communities with high opportunity costs (P)	1	
			Quant Count	1	Households in provider communities with low opportunity costs (P)	1							
			Quant Count	1	Households in provider communities (P)	1							
	Improved governance and community institutions	6	Mix No Count	1	Households who provide the service (P)	1	Lower community cohesion	2	Qual Count	1	Non-participating households in provider communities (NP)	1	
			Quant Count	2	Households in provider communities (P)	5				Qual No Count	1	Households in provider communities (P)	1

			Mix										
			Count										
			Qual	2									
			No										
			count										
	Increased interaction with external stakeholders	2	Qual	1	Households who provide the service (P)	2	Increased conflict with settlers, intermediaries and access to land	2	Qual	2	Households in provider communities (P)	2	
			Count	1			Reinforcement of power structures	2	No	2	Households in provider communities (P)	2	
			Count						Count				
	Increased participation of marginalized groups	1	Qual	1	Households who provide the service (P)	1	Reinforcement of social power structures	2	Qual	2	Households in provider communities (P)	2	
			No						No				
			Count						Count				
	Increased social networks	5	Qual	3	Households in provider communities (P)	3							
			No										
			Count	1	Households who provide the service (P)	2							
			Quant	1									
			Count										
			Mix	1									
			Count										
Human capital	Increased environmental awareness and knowledge	4	Quant	1	Households in provider communities (P)	1	Increased workload for women attending trees	1	Mix	1	Households who provide the service (P)	1	
			Count						Count				
			Qual	1	Households who provide the service (P)	3							
			Count	1									
			Qual	1									
			No										
			Count										
			Mix	1									
			Count										
	Increased capacity in forest management or agricultural practices	8	Mix	3	Households in provider communities (P)	3							
			Count										
			Qual	3	Households who provide the service (P)	5							
			No										
			Count										
			Quant	2									
			Count										
Natural capital	Improvement of forest conservation	2	Mix	1	Households who provide the service (P)	2	Reduced forest use due to restrictions	2	Mix	No	1	Households in provider communities (P)	1
			Count	1					Count				
			Qual	1									
			No										
			Count										
	Reduced time to collect fuelwood	1	Mix	No	1	Households in provider communities (P)			Qual	1	Households who provide the service (P)	1	
			Count						Count				
	Increased investments in electricity provision	1	Mix	1	Households in provider communities (P)	1							
			Count										
	Increased ES provision	4	Quant	3	Households who benefit from the service	2	Decline of sand for construction in local rivers	1	Quant	1	Non-participating households in provider communities		
			Count						Count				
					Households in provider communities (P)	2							
	Improved perception towards the environment	1	Mix	No	1	Households who provide the service (P)							
			Count										
Food security	Increased food security and to meet household food needs	2	Quant	1	Households who provide the service (P)	2	Increased consumption of foods of low nutritional quality	1	Qual	1	Households in provider communities (P)	1	
			Count	1					No				
			Mix						Count				
			Count										
	Increased consumption	2	Qual	1	Households who provide the service (P)	1	Decreased food sovereignty and food security	1	Qual	1			
			No						No				
			Count						Count				

			Quant Count	1	Poor households who provide the service (P)	1				
Cultural capital					Loss of cultural practices	3	Qual No Count	3	Households in provider communities (P) Households who provide the service (P)	2 1
					Reduced consumption of traditional foods	1	Qual No Count	1	Households in provider communities (P)	1
					Reduced cultural identity and ties	3	Mix No Count	1	Households in provider communities (P)	3
Health	Decrease in water-related diseases	1	Qual No Count	1	Households in provider communities (P)	1				
Satisfaction	Satisfaction with PES outcomes	1	Quant No Count	1	Households who provide the service (P)	1				
Quality of life	Perceived quality of life	1	Mix Count	1	Households who provide the service (P)	1				

Appendix F. Indicators, Methods and Results in Terms of Impacts on Household Income in the Studies Reviewed

Publication	Indicator	Method used to report impacts on income	Counterfactual	Proportion of income from the PES scheme	Income variation linked to the PES scheme
Arriagada et al., 2018	Household income	Matching Tests of difference	Yes		No change found
Bartels et al., 2010	Household income	Discussion from interviews and documents	No		14% increase in annual income
Bremer et al., 2014	Perceived change in household income	Descriptive statistics	No	Ranging from not critical amount to 47% of income for one participant	100% of communities; 80% of smallholders; 96% of larger landowners reported positive impacts on financial capital, through increased (or more stable) income from incentive payments, or through potential long-term income benefits from productive activities For smaller landholder individual participants the payments provide substantial income supplements The payment cannot replace the income lost by workers when their former profession was prohibited under the programs
Cao, 2011	Household income	Discussion from document review	No		78% of participants report income increase
Cole, 2010	Household income	Tests of difference	Yes		Average income of participants: US\$ 16,167 (10244) Average income of non-participants: US \$ 18,955 (7038)
Corbera, 2010	Household income	Discussion of data from	No	Ranging between 25%–50% of income	US\$ per household per year vary between 33 and 508 depending on the community

Author(s) and Year	Unit of Analysis	Methodology	Control	Findings	Notes
He and Sikor, 2015	Household income	Descriptive statistics	No	Amounting to < 8% of the average income in 2010 compared to 27% in 2001	The payments contributed to the increase in local incomes in one site, but their significance declined in later years
Hegde and Bull, 2011	Household income	Matching	Yes		Participation increases income by 266600MTS (10US\$) to 323000MTS (12US\$) depending on the model
Jack and Cardona-Santos, 2017	Household income	Matching Ordinary least squares	Yes		Random allocation of afforestation contracts did not appear to affect measures of household socioeconomic outcomes Average effect on total income from crop sales when contracts were auctioned: 86083* (48264) Non-significant effects on Household income
Jindal, 2010	Household income	Tests of difference	Yes		The average annual cash income for households with both agroforestry contracts and employment in enterprises was much higher than either non-participating households or households that hold only agroforestry contracts Annual mean income of non-participants: 12004 (142575) Participants only in payments: 143540 (195010) Participants in payment and enterprises: 14,64,590 (572452)
Kwayu et al., 2017	Household income	Matching	Yes	Payments contributed 20% of program participants' annual household cash income	
Leimona et al., 2010	Household income	Discussion of data from focus groups	Yes	The annual PES income of contributed only around 3% to PES participants' household incomes Only one group regarded PES as a primary source of income	Some participants mention that they had lost income from wood harvesting
Li et al., 2011	Household income	Multivariate Linear Regression	Yes		Positive impact upon household income, but the impact decreases from households at low income levels to those at high income levels Participation increases income by 0178*** (0066) to 0234*** (0389) depending on model
Liang et al., 2012	Household income	Ordinary least squares	Yes		Notwithstanding significant positive effects on household local wage income, participating in the program has negative effects on on-farm income, as well as migrating income Coefficient for impact of participation on total income is -1895,1 for households with children and no elderly Total income increased because of income from other sources such as tourism Forestry workers dependent on income from timber harvesting suffered big economic losses This loss pushed some local forestry workers below the poverty line Local government income decreased 28% to 15 million yuan during 1999–2001
Liu Jet al., 2008	Household income	Discussion from document review	No		Indicator impacts on short-term income was significantly negative in the whole sample and differed between upper class
Locatelli et al., 2008	Perceived change in	Multi criteria analysis	No		

	household income	Tests of difference			(null) and working class (very negative) Indicator impact on medium and long-term income differed between upper class (very positive) and three other groups: small farmers (very negative), working class (negative), and agribusinesses (negative) Farmers participating in the scheme have used the additional money to purchase clothes, assets, livestock, and to pay school fees Baseline income levels in the project area were too low to make these investments In July 2009 144 farmers had joined the scheme and were paid in May 2010 the equivalent of a total of USD 1639 as an annual payment to compensate for their efforts to improve land management, reduce erosion and improve water quality By May 2010 554 local farmers had become sellers in the scheme, increasing to 650 by November 2010 In July 2011, participating farmers were paid a total of USD 11,000 for their efforts to improve land As new people are still joining the scheme the expected payment in 2012 will be higher
Lopa et al., 2012	amount of PES payment	Discussion from document review	No		
Miranda et al., 2003	share of income	Descriptive statistics	Yes	The proportion of PES of average income for the two landowners who declared that PES represents their main activity is 37% For those who declared that PES is their second source of income the proportion is on average 12% Finally, for those who ranked PES as their third economic activity the average proportion is 18% It is worth noting that the program does not have a significant economic effect on small landowners (5% of their total income)	
Osano et al., 2013	Household income	Tests of difference	Yes		Mean gross income in 2009 in KES for participants: 363,0825 (298,8075) non-participants 184,4556 (210,7215) The US\$340 million distributed between 1997 and 2012 is probably the PES's greatest direct socio-economic benefit The direct impact is highest in remote rural areas, where PES is one of the principal sources of cash for many participants
Porrás et al., 2013	Household income	Descriptive statistics	No		The majority of the experts stated that farmers received a higher income due to the compensation given by the government and other reasons This was different from other existing studies, which found that the subsidies were a significant source of income for the participants
Qu et al., 2017	Household income	Discussion of expert interviews	No		
Raes et al., 2014	Share of income	Discussion of survey results	Yes	Ranging from <10% to >70% for one of the participants	The total profit generated through participation in for the seven households in the study area is US\$ 13,170 or US\$ 13/ha per year
Rodríguez de Francisco et al., 2013	Amount of PES payment	Discussion of data from interviews and documents	No		Payments range from US\$15 to US\$841 per year, with an average of US\$252 Almost all participants in the scheme indicated that payments were too low Based on four interviews, the income

from working their land would be much greater than the PES payments

Scullion et al., 2011	Share of income	Discussion of survey results	Yes	Of the 14 PES participants interviewed, representing 40% of the landowners paid by the PES scheme, all claimed the PES payments were < 3% of their total personal income	
Soriaga and Annawi, 2010	Village budget	Descriptive statistics	No	The scheme increased the financial capital of two villages, those with the lowest annual budgets, for 1998 by 24% and 19%, respectively In contrast, villages with the highest budgets, obtained a relatively lower proportional increase in their financial capital (18% and 20% respectively)	
Trac et al., 2013	Household income	Discussion of survey results	No		Household income was maintained or increased in one study site, decreased in another, while the change was irrelevant in the third
Wang et al., 2017	Household income	Tests of difference	Yes		Net income is 5,59 times higher for participants than for non-participants
Yang et al., 2013	Household income	Discussion of survey results	No		89% of interviewed households reported that the payments had brought more benefits (including financial) than costs to them
Yin et al., 2014	Household income	Multivariate Linear Regression	Yes	On average, a household there received an annual subsidy of up to 1929 yuan in 2006, accounting for 235% of its total income in that year In Sichuan subsidy was 767 yuan in 2006, equivalent to 9% of the total household income in that year	250% increase in total income The contributions of payment to farm, off-farm, and total income are all significantly positive, leading to a greater family income (coefficient 0029 (0001)***)
Zheng et al., 2013	Household income	Matching Tests of difference	Yes		Participant households' agricultural income decreased by around 2000 yuan relative to non-participant, presumably from converting productive rice paddies to less lucrative cornfields The decrease in agricultural income seems to be offset by an increase in migrant earnings relative to non-participants of > 3000 yuan on average Income (yuan per household): Participants 28,419 Non-participants 24,865

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