2 Payments for environmental services

We examine *payments for environmental services* (PES), an important green initiative, for its widespread applications worldwide and well-documented socioecological consequences (Naeem et al., 2015; Wunder, 2005, 2008). This book uses the term *payments for environmental services*, also termed payments for ecosystem services (Wunder, 2015). So we define payments for environmental services as payments made to restore, sustain, or improve ecosystems and the related services that benefit human beings. Payments for environmental services are one kind of essential conservation tool, which have been adopted worldwide to combat global changes that are jeopardizing ecosystem processes, functions, and services at unprecedented rates across the globe (Daily & Matson, 2008).

Under the PES framework, ecosystem service funders pay ecosystem service providers cash or in-kind incentives to change their resource-use behavior, which in turn may restore, maintain, or improve the related ecosystem services that would be unavailable without such payments (Wunder, 2015). For decades, the development and implementation of PES programs sought to combat climate change and environmental degradation (Naeem et al., 2015; Wunder, 2005, 2008). From the PES programs that are "government-financed" (Engel et al., 2008) to those broadly defined by Muradian et al. (2010), both classic and broader definitions are further summarized by Wunder (2015), who reviewed diverse definitions and debates over the past decades.

2.1 PES popularity

PES has witnessed a rapid increase in popularity over the past two decades, with more than 300 PES schemes inventoried worldwide in 2004 (Mayrand & Paquin, 2004) and at least 584 inventoried in 2016 (Ezzine-de-Blas et al., 2016). As of July 2019, the world-renowned PES program Reducing Emissions from Deforestation and Forest Degradation (REDD+) has attracted 39 developing countries to participate, covering a forest area of approximately 1.49 billion ha or 37 percent of the global forest area (Food and Agriculture Organization of the United Nations, 2019). By the end of 2018, the Conservation Reserve Program (CRP), an extensive PES program in the USA, enrolled 9.15 million ha of agricultural land for enhanced ecosystem services (United States Department

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of Agriculture & Farm Service Agency, 2019). In their systematic literature search, Ezzine-de-Blas et al. retained a subset of 55 PES programs from hundreds screened worldwide for a global PES tendency assessment (Ezzine-de-Blas et al., 2016). Even this subset covers a total of 615,746 km^2 (larger than the total area of Ukraine), accounting for an accumulated investment of more than $143.61 billion (Table 1.1). If adding China's National Forest Conservation Program (one of the most extensive PES programs in the world) to this subset, the area rises to 1,785,746 km^2, larger than the territory of Iran (~1,650,000 km^2). The popularity of PES is also evidenced by an exponential increase in PES literature (The Nature Conservancy, 2022), focusing on its conceptual frameworks, principles, design features, participation and compliance, and socio-environmental impacts and trade (Wunder et al., 2018).

Worthy of mention is an article by Wunder, Engel, and Pagiola (2008), which compares and contrasts a number of PES programs and highlights trends among the different methods of operating such projects in terms of, for example, sources of funding, geographic extent and environmental focus, and ways in which PES programs achieve and maintain effective outcomes. Another paper categorizes PES literature between 1974 and 2011, identifying the statistics of PES projects' geographic locations, their economic conceptualization, areas where additional research may benefit PES programs, and PES "types and challenges" in developing and industrialized nations (Schomers & Matzdorf, 2013).

2.2 PES concept

Under the PES concept (Naeem et al., 2015; Wunder et al., 2018), funders, beneficiaries, or representatives make payments to stakeholders to motivate pro-environmental behavior, including reducing resource use and/or pollution. Consequently, the corresponding natural structures, functions, and services are restored, maintained, or enhanced, which would otherwise be impossible (Wunder, 2015). The primary goal of PES is to protect ecosystems and their services of tremendous value to humanity (Friess et al., 2015; Wunder, 2005), including provisioning (e.g., food, water, and fiber), regulating (e.g., climate, floods, and disease), cultural (e.g., recreational, aesthetic, and spiritual benefits), and supporting (e.g., soil formation, photosynthesis, and nutrient cycling) services (Millennium Ecosystem Assessment, 2003). As pointed out earlier, global ecosystem services may have produced an annual monetary value of at least $46 trillion in 1997, and the number increased to $145 trillion in 2011 (both measured in 2007 $US) (Costanza et al., 2014).

2.2.1 Additionality

Additionality is a critical concept in PES literature, which implies that adding a payment to preserve an ecosystem service should benefit a previous baseline in terms of ecosystem services (LaRocco & Deal, 2011). Put another way, paying for an ecosystem service can have additionality if there is a noticeable difference

before and after implementation (Gillenwater, 2012). Lack of additionality happens when PES programs pay for an ecosystem service that would have been available regardless of payments, implying a waste of money for no additional ecosystem service (Engel et al., 2008). "Double-dipping" or "piggy-backing" are other terms for lack of additionality.

An excellent example of additionality is the global Reducing Emissions from Deforestation and Forest Degradation (REDD+) program, developed under the Kyoto Protocol to reduce and mitigate greenhouse gas emissions by providing local landowners incentives to protect and promote ecosystem services (UNFCCC, 2016). A common topic in REDD+ is additionality regarding whether implementing a PES contract generates additional benefits or not.

2.2.2 Concurrent PES

Many concurrent PES programs—a prominent type of concurrent green initiatives—bear spillover effects. Concurrent payments for environmental services (concurrent PES hereafter) are widespread in an era when "[t]he biosphere, upon which humanity as a whole depends, is being altered to an unparalleled degree across all spatial scales" (IPBES, 2019). Examples of concurrent PES entail communities that run two or more PES contracts simultaneously in Mexico (Ezzine-de-Blas et al., 2016); households that participate in multiple PES programs in northern Cambodia and China (Clements & Milner-Gulland, 2015; Song et al., 2018); farms funded by multiple concurrent schemes under the same PES umbrella in Costa Rica (LaRocco & Deal, 2011); and farmers' simultaneously signing-up to both the Environmentally Sensitive Area Program and Countryside Stewardship Scheme in the United Kingdom (Hodge & Reader, 2010; Lobley & Potter, 1998). The increasing debate about PES stacking and bundling (see more details in Section 2.3) has also witnessed the popularity of concurrent PES (Cooley & Olander, 2012; Motallebi et al., 2018; World Resources Institute, 2009).

In Australia, the Wet Tropics of Queensland World Heritage Area (WTWHA) was established in 1988 to protect the park area (Harrison et al., 2003). At the same time, the Community Rainforest Reforestation Program (CRRP), established in 1992, was a government-supported, small-area tree-planting program that focuses on private land bordering the WTWHA. The CRRP can complement the WTWHA substantially. Allowing substantial tree farming, the CRRP aimed to offset—likely partially—local social costs that were anticipated when the WTWHA was designated as a protected area. Furthermore, the restoration planting in the CRRP may bring in a co-benefit of enhancing biodiversity in fragmented agricultural landscapes that border WTWHA. When restoring these areas, wildlife corridors and networks—about 60% of CRRP plantings form part of a continuous vegetation corridor network—were established, enhancing the biotic viability in the Arberton Tableland that borders the WTWHA.

In Mexico, the PSA-H (Payment for Ecosystem Services–Hydrological) Program was established in 2003 to avoid the deforestation of parcels in overexploited watersheds (McAfee & Shapiro, 2010). The participants of this

program received federal funding, expecting to establish direct contacts between producers and private beneficiaries of hydrological services. The other program, PSA-CABSA (Program for the Development of Markets for the Ecosystem Services of Carbon Sequestration, the Derivatives of Biodiversity, and to Promote the Introduction and Improvement of Agroforestry Systems) was established in 2004. This PSA-CABSA program allowed local communities to develop sustainable management plans, including the production of crops (e.g., coffee, palm, cacao, vanilla, or rubber) that can be "shade grown" in the forest. Payments were made to community associations by the federal government.

Both programs ran concurrently until 2006, when they were consolidated under the larger PROARBOL program. There existed some contradictions between these two programs. For instance, debates existed about whether to promote federal bureaucratic control or to empower rural cooperative associations. The PSA-H program had strong federal control while the PSA-CABSA promoted local community stewardship of the land. In 2004–2005, PSA-H involved around 600 participants protecting over 300,000 hectares of land, while PSA-CABSA had 42 participants protecting almost 60,000 hectares of land. The greater success of PSA-H seemed to be a result of the higher amounts of federal funding. In 2004–2005, PSA-H was allocated approximately US$49 million and PSA-CABSA only an approximate US$13 million.

2.3 Classification of 55 PES programs

To determine whether each of the 55 PES programs in Table 1.1 was/is concurrent with other PES programs and the estimated level of certainty in our decision, we adopted a conservative method. First, we reviewed Ezzine-de-Blas et al. (2016), relevant journal articles, government reports or documents, book chapters, and the like with a keyword of the program name or alternative names. According to our definition, if we found at least one document providing strong evidence that the program under consideration has/had a concurrent program, this program was labeled to have a concurrent program with high certainty. We offer an example to illustrate this evaluation process: if PES programs A and B are explicitly described as being implemented in the same geographical area(s) or having payments made to the same participant(s) simultaneously, we then labeled programs A and B to be concurrent programs with a high level of certainty.

Second, we sought to rely on experts' knowledge for the programs with weak or no evidence of concurrent PES program(s). Individually, we sent email messages to the author(s) of the references we found and/or program managers and asked the following question: "Regarding the PES program in this paper, do you know whether there are other PES or PES-like programs that simultaneously targeted the same site (e.g., land parcel, watershed) and/or enrolled the same participants?" (An et al., in review). If the recipient answered yes or no with certainty, we labeled the program to have or not have a concurrent program(s) with a high level of certainty. If the recipient answered yes or no with some degree of uncertainty, then we labeled a low degree of certainty with a question mark "?".

Worthy of mention is a situation in which no evidence was found regarding a PES program's concurrency with other programs. For instance, none of the contacted experts had such knowledge (e.g., the respondent answered "I don't know"). Under such circumstances, we decided that the program was not concurrent with other programs and therefore labeled the determination with a low level of certainty. The outcome of the above determination is in Table 2.1.

Given the sites identified to have concurrent PES programs in Table 2.1, we sought to provide more information regarding the connection between the concurrent PES programs. Specifically, we reviewed relevant papers we found and provided additional information, including the name of concurrent PES programs and how they are connected. The outcome is Table 2.2. To make Table 2.2 comparable with Table 2.1, we kept all the records (i.e., PES programs) without concurrent PES programs, leaving the two columns "Program 1" and "Program 2" blank and putting the remark "No concurrent payments" in the column "Note".

We found that out of the 55 PES programs identified by Ezzine-de-Blas et al. (2016a), over half of them had concurrent programs (Table 2.2). For all the concurrent PES programs, potential spillover effects vary from site to site (An et al., in review). For instance, the Bolivia case shows that one green initiative refers to payments made by the US Fish and Wildlife Service for bird habitat protection. The concurrent green initiative represents payments for watershed conservation for downstream irrigation, which the local government funds on behalf of downstream irrigators for water stabilization. These two payments were paid to the same farmers in the same watershed (Table 2.2). For other concurrent green initiatives, we refer to Table 2.2. Regardless of differences in details, these green initiatives share the two common features we used to identify concurrent green initiatives: they either cover the same geographic area or make payments to the same recipients.

2.4 PES spillover effects

Spillover effects exist in various PES programs as in generic green initiatives. In this section, we introduce various ways that are used to package (combine) ecosystem services and sell these services as credits (Smith et al., 2015). Along this line, there exists some literature about PES packaging (including bundling and stacking), though the terminology is inconsistent in PES studies. Also, we introduce spillover effects in different regions or countries.

2.4.1 Stacking

Recently, in the USA, a concurrent PES scheme called PES stacking has emerged. However, "there are no regulations addressing stacking or any guidance documents from US federal resource agencies" (Robertson et al., 2014), nor any evidence-based guidelines about how to achieve or improve the intended ecosystem services. Primarily used in North America, stacking (also called layering) refers to providers or landowners receiving multiple payments for multiple ecosystem

Table 2.1 Determination of the 55 PES programs based on information from other sources

Id	*Label*	*Country*	*Region*[a]	*Description*	*E*[b]	*Con-PES*[c]	*Certainty*	*References*
1	NegB	Bolivia	S. America	Los Negros, Bolivia		Yes	Certain	Asquith et al. (2008), Robertson and Wunder (2005)
2	PimE	Ecuador	S. America	Pimampiro, Ecuador	√	Yes	Certain	Wunder and Albán (2008)
3	ProE	Ecuador	S. America	PROFAFOR, Ecuador		Yes?	Almost	Wunder and Albán (2008)
4	VitF	France	Europe	Vittel (Nestlé Waters)	√	No	Certain	Perrot-Maître (2005, 2006)
5	SloCh	China	Asia	Sloping Land Conversion		Yes	Certain	Bennett (2008), Xu al. (2010)
6	HydroMX	Mexico	N. America	Payment for Ecosystem Services–Hydrological (PSA-H), Mexico	√	Yes	Certain	Muñoz-Piña et al. (2008). Alix-Garcia et al. (2012), Corbera et al. (2009)
7	ConsUS	USA	N. America	Conservation Reserve Program (CRP), USA	√	Yes	Certain	Claassen et al. (2008), Leathers and Harrington (2000)
8	EnvUS	USA	N. America	Environmental Quality Incentives Program (EQIP)	√	Yes	Certain	Claassen et al. (2008), Cattaneo (2003)
9	SenUK	United Kingdom	Europe	Environmentally Sensitive Area (ESA)	√	No	Certain	Dobbs and Pretty (2008), Crabtree et al. (2000)
10	CouUK	United Kingdom	Europe	Countryside Stewardship Scheme	√	No	Certain	Dobbs and Pretty (2008), Crabb et al. (2000)

(*Continued*)

Table 2.1 Continued

Id	*Label*	*Country*	*Region*[a]	*Description*	*E*[b]	*Con-PES*[c]	*Certainty*	*References*
11	NotrG	Germany	Europe	Northeim model project	√	No?	Almost	Klimeka et al. (2008), Grolleau and McCann (2012)
12	CamZ	Zimbabwe	Africa	CAMPFIRE, Zimbabwe		No?	Almost	Frost and Bond (2008), Dunham et al. (2003), Harrison (2015)
13	LavCo	Colombia	S. America	CIPAV-Río La Vieja		Yes?	Almost	Pagiola et al. (2010)
14	ChaE	Ecuador	S. America	Chachis, Ecuador	√	Yes	Certain	Wendland and Suárez (2009), Speiser et al. (2009)
15	ChaCo	Colombia	S. America	Chaina, Colombia		No?	Unsure	Moreno-Sanchez et al. (2012), Dillaha et al. (2007)
16	ProcCo	Colombia	S. America	Procuenca, Colombia	√	No?	Unsure	Dillaha et al. (2007), Erazo and Benjumea (2004)
17	CelE	Ecuador	S. America	Celica, Ecuador	√	No	Certain	Raes et al. (2012)
18	ChacE	Ecuador	S. America	Chaco, Ecuador		Yes?	Almost	Cordero-Camacho (2008)
19	RichS	Sudáfrica	S. Africa	Richtersveld		No?	Unsure	Robinson (1998)
20	KitK	Kenya	E. Africa	Kitengela, Kenya	√	Yes?	Unsure	Yatich et al. (2008), Osano et al. (2012)
21	MenM	Madagascar	E. Africa	Menabe, Madagascar	√	No	Certain	Sommerville et al. (2010)
22	TurtT	Tanzania	E. Africa	Sea turtle nest, Tanzania		No?	Almost	Ferraro (2007), Ferraro and Gjertsen (2009)
23	BirwCa	Cambodia	Asia	Bird watch & ecotourism		Yes	Certain	Clements et al. (2010), Clements et al. (2008)
24	BirnCa	Cambodia	Asia	Bird nest protection		Yes	Certain	Clements et al. (2010), Clements et al. (2013)
25	SocE	Ecuador	S. America	Socio Bosque	√	Yes	Certain	de Koning et al. (2011), Krause et al. (2013), Holland et al. (2014)

26	JesH	Honduras	C. America	Jesús de Otoro, Honduras		No?	Almost	Kosoy et al. (2007)
27	HerCR	Costa Rica	C. America	Heredia, Costa Rica		Yes	Certain	Kosoy et al. (2007), Pagiola (2008)
28	SanNC	Nicaragua	C. America	San Pedro del Norte		No?	Almost	Kosoy et al. (2007)
29	KulN	Nepal	S. Asia	Kulekhani, Nepal	√	No	Certain	Khatri (2009), Joshi (2011)
30	DonV	Vietnam	Asia	Da Nhim PWS, Dong Nai watershed	√	Yes	Certain	To et al. (2012)
31	SonV	Vietnam	Asia	Son La PWS	√	Yes	Certain	To et al. (2012)
32	OacI	India	S. Asia	Oach Kalan-Kuhan mini micro watershed		No?	Unsure	Agarwal et al. (2007)
33	ZapMX	Mexico	N. America	Saltillo, Zapaliname		No?	Almost	Wunder and Wertz-Kanounnikoff (2009)
34	SimT	Tanzania	East Africa	Simanjiro valley	√	No	Certain	Nelson (2008)
35	BioN	Namibia	S. Africa	NRCB management	√	No	Certain	Weaver and Petersen (2008), Naidoo et al. (2016)
36	CatUS	USA	N. America	Catskills, NYC, USA	√	No?	Almost	Grolleau and McCann (2012)
37	UlgT	Tanzania	E. Africa	PWS, Tanzania	√	Yes	Certain	Lopa et al. (2012), Branca et al. (2011)
38	SilNC	Nicaragua	C. America	Silvopastoril, Nicaragua		Yes?	Almost	Pagiola et al. (2008), Pagiola et al. (2017)
39	SilCR	Costa Rica	C. America	Silvopastoril		Yes	Certain	Ibrahim et al. (2007), Pagiola (2010)
40	CidIS	Indonesia	S. Asia	Cidanau watershed PES scheme		No?	Almost	Leimona et al. (2010), Suyanto et al. (2005)
41	TreU	Uganda	E. Africa	Uganda, Trees for Global Benefits Programme	√	No	Certain	German et al. (2010), Carter (2009), Fisher et al. (2018)
42	FirPH	Philippines	A.	Philippines, No Fire Bonus Scheme	√	No	Certain	Soriaga and Annawi (2010)

(*Continued*)

Table 2.1 Continued

Id	*Label*	*Country*	*Region*[a]	*Description*	*E*[b]	*Con-PES*[c]	*Certainty*	*References*
43	TreMZ	Mozambique	E. Africa	Mozambique, carbono.	√	Yes?	Almost	Hegde (2010), Jindal (2012), Hegde et al. (2015)
44	TreMX	Mexico	N. America	Scolel Té	√	Yes	Certain	Hendrickson and Corbera (2015), Tipper (2002)
45	MonMX	Mexico	N. America	Monarch	√	Yes	Certain	Honey-Rosés et al. (2011), Honey-Rosés et al. (2009)
46	PwsG	Germany	Europe	PWS en Munich	√	No?	Almost	Grolleau and McCann (2012)
47	SumIn	Indonesia	S. Asia	Sumberjaya AF conservation auction		Yes?	Almost	Leimona et al. (2009), Suyanto (2007)
48	RefK	Kenya	E. Africa	Reforestation conservation auction		No?	Unsure	Khalumba et al. (2014)
49	FuqCo	Colombia	S. America	Fuquene, Colombia		Yes?	Almost	Quintero and Otero (2006)
50	KmpfB	Bolivia	S. America	Noel Kempff Mercado REDD+project		Yes?	Almost	Asquith et al. (2002), Pereira (2010), Grieg-Gran et al. (2005)
51	PesCR	Costa Rica	C. America	Payments for Environmental Services (PSA)		Yes	Certain	Pagiola (2008)
52	MunCo	Colombia	S. America	CIPAV- La Salvajina & PNN Munchique		No?	Unsure	CIPAV (2007)
53	MakMa	Madagascar	E. Africa	Makira WCS		No	Certain	Brimont et al. (2015)
54	LrcB	Bolivia & Peru	S. America	Landrace conservation payments	√	Yes?	Almost	Narloch et al. (2011)
55	BfeB	Brazil	S. America	Bolsa Floresta	√	No	Certain	Börner et al. (2013)

Notes:
[a] Under the column for Region, E stands for East, W for West, S for South, N for North, and C for Central.
[b] The column labeled with E stands for whether we contacted expert(s)—often the author(s) of the reference(s)—and received responses.
[c] Con-PES refers to whether there is a concurrent PES program existing with the PES program.

Table 2.2 Description of concurrent payments for the 55 PES programs

Id	*Label*	*Country*	*Program 1*	*Program 2*	*Note*
1	NegB	Bolivia	Payment for bird habitat protection	Payment for watershed conservation for downstream irrigation	Two buyers paid the same farmers in the same watershed: one is the US Fish and Wildlife Service to protect bird habitat; the other is the local government on behalf of downstream irrigators for water stabilization
2	PimE	Ecuador	Pimampiro (watershed protection)	PROFAFOR (carbon sequestration)	The same watershed was protected for both water stabilization (Policy 1) and carbon sequestration (Policy 2) through forest protection and afforestation
3	ProE	Ecuador	PROFAFOR (carbon sequestration)	Pimampiro (watershed protection)	The same watershed was protected for both carbon sequestration (Policy 1) and water stabilization (Policy 2) through forest protection and afforestation
4	VitF	France			No concurrent payments
5	SloCh	China	SLCP or GTGP (water and soil conservation)	NFCP or EWFP (water and soil conservation)	The central government paid the same households to plant trees on cropland with steeping slopes (Policy 1) and conserve natural forests (Policy 2)
6	HydroMX	Mexico	PSA-H (hydrological services)	SA-CABSA (carbon, biodiversity, and agro-forestry services)	The same recipients in the same watershed: the two PES programs were later merged into a single policy framework
7	ConsUS	USA	CRP (soil conservation)	EQIP (multiple objects beyond soil conservation)	Same recipients: an individual farmer could have some land enrolled in the CRP and other lands (or livestock) enrolled in EQIP, i.e., having contracts under more than one program

(*Continued*)

Table 2.2 Continued

Id	*Label*	*Country*	*Program 1*	*Program 2*	*Note*
8	EnvUS	USA	EQIP (multiple objects beyond soil conservation)	CRP (soil conservation)	Same recipients: an individual farmer could have some land enrolled in the CRP and other land (or livestock) enrolled in EQIP, i.e., having contracts under more than one program
9	SenUK	United Kingdom			No concurrent payments
10	CouUK	United Kingdom			No concurrent payments
11	NotrG	Germany			No concurrent payments
12	CamZ	Zimbabwe			No concurrent payments
13	LavCo	Colombia	Silvopastoral practice-1 (biodiversity conservation and carbon sequestration)	Silvopastoral practice-2 (biodiversity conservation and carbon sequestration)	Likely same households would receive multiple payments if adopting several practices such as planting trees and/or shrubs for feeding livestock and fencing as wind screens
14	ChaE	Ecuador	Payment in Gran Reserva Chachi (biodiversity conservation)	Socio Bosque (carbon storage, biodiversity protection, water provision)	Same geographic region by the local rewards for biodiversity (Policy 1) and national PES program (Policy 2)
15	ChaCo	Colombia			No concurrent payments
16	ProcCo	Colombia			No concurrent payments
17	CelE	Ecuador			No concurrent payments
18	ChacE	Ecuador	Payment for watershed conservation	Socio Bosque (carbon storage, biodiversity protection, water provision)	Possibly same watershed for water conservation (Policy 1) and other services by national program (Policy 2)
19	RichS	Sudáfrica			No concurrent payments

20	KitK	Kenya	WLP (wildlife conservation)	OOC (Olare Orok Conservancy)	Likely same geographic region: WLP for wildlife conservation later continued and expanded to cover Maasai Mara National Reserve where OOC was implemented
21	MenM	Madagascar			No concurrent payments
22	TurtT	Tanzania			No concurrent payments
23	BirwCa	Cambodia	Payment for community-based Ecotourism	Agri-environment payments and payment for bird nest protection	Same recipients in the same village by three PES programs for bird nest protection, agri-environmental conservation, and ecotourism
24	BirnCa	Cambodia	Payment for bird nest protection	Agri-environment payments and payment for community-based Ecotourism	Same recipients in the same village by three PES programs for bird nest protection, agri-environmental conservation, and ecotourism
25	SocE	Ecuador	Socio Bosque (carbon storage, biodiversity protection, water provision)	E.g., Payment in Gran Reserva Chachi (biodiversity conservation)	Socio Bosque is a national PES program, covering many geographic regions and compensating individuals participating in other PES programs
26	JesH	Honduras			No concurrent payments
27	HerCR	Costa Rica	Payment-1 for watershed conservation	Payment-2 for watershed conservation	Same watershed by two users with stacking payments: one is downstream water user; the other is a beverage company (Florida Ice and Farm Co.)
28	SanNC	Nicaragua			No concurrent payments
29	KulN	Nepal			No concurrent payments
30	DonV	Vietnam	Payment for watershed conservation	Payment for Forest Protection and Planting	There exist multiple programs in the same geographic region in Vietnamese uplands, particularly in the north-west mountainous area

(*Continued*)

Table 2.2 Continued

Id	*Label*	*Country*	*Program 1*	*Program 2*	*Note*
31	SonV	Vietnam	Payment for watershed conservation	Payment for Forest Protection and Planting	There exist multiple programs in the same geographic region in Vietnamese uplands, particularly in the north-west mountainous area
32	OacI	India			No concurrent payments
33	ZapMX	Mexico			No concurrent payments
34	SimT	Tanzania			No concurrent payments
35	BioN	Namibia			No concurrent payments
36	CatUS	USA			No concurrent payments
37	UlgT	Tanzania	PWS (watershed)	Payment for bird protection	Same watershed in Uluguru Mountains by two payments: one operated by CARE & WWF for downstream water; the other funded by UK DFID and run by the UK royal society for bird protection
38	SilNC	Nicaragua	Silvopastoral practice-1 (biodiversity conservation and carbon sequestration)	Silvopastoral practice-2 (biodiversity conservation and carbon sequestration)	Likely same households would receive multiple payments if adopting several practices such as planting trees and/or shrubs for feeding livestock and fencing as wind screens
39	SilCR	Costa Rica	Silvopastoral practice-1 (biodiversity conservation and carbon sequestration)	Silvopastoral practice-2 (biodiversity conservation and carbon sequestration)	The same households would receive multiple payments if adopting several practices such as planting trees and/or shrubs for feeding livestock and fencing as wind screens
40	CidIS	Indonesia			No concurrent payments
41	TreU	Uganda			No concurrent payments
42	FirPH	Philippines			No concurrent payments

43	TreMZ	Mozambique	Payment for carbon	Payment for biodiversity	Bundled payment model, which later might evolve to multiple payments on same geographic region or to same recipients
44	TreMX	Mexico	Payment for hydrological services (water)	Payment for forestry services (carbon sequestration)	Same participants for hydrological services (Payment-1) and forestry services (Payment-2)
45	MonMX	Mexico	MBCF (Monarch butterfly conservation Fund)	Payments for conservations ("fondos concurrentes")	In the same region of Monarch Butterfly Biosphere Reserve, other PES programs with different fund sources were operated, colloquially referred to as "fondos concurrentes"
46	PwsG	Germany			No concurrent payments
47	SumIn	Indonesia	Conditional tenures (secure tenure with forestry permits)	RiverCare (watershed functions of reducing sediment)	Likely the same watershed region under two projects: in the first project, government use secure tenure as in-kind payment for forest protection from deforestation; the second for dam functions by reducing sediment
48	RefK	Kenya			No concurrent payments
49	FuqCo	Colombia	CPWF fund for solid and water conservation	GTZ's CAP (sustainable land use for watershed)	The same watershed region with two projects
50	KmpfB	Bolivia	NKM Climate Action Project (carbon mitigation)	Payment for "bundled" biodiversity along with carbon	"Bundled" initiative combining carbon and biodiversity benefits by US Initiative on Joint Implementation and The Nature Conservancy and a consortium of US companies
51	PesCR	Costa Rica	PSA (mainly water conservation)	E.g., GEF (payments from biodiversity users)	Likely same recipients within same watersheds with multiple fund sources including fossil fuel sales tax revenues, and biodiversity users; stacking model
52	MunCo	Colombia			No concurrent payments

(*Continued*)

Table 2.2 Continued

Id	*Label*	*Country*	*Program 1*	*Program 2*	*Note*
53	MakMa	Madagascar			No concurrent payments
54	LrcB	Bolivia & Peru	PACS (agrobiodiversity conservation)	Other multiple incentives for generic diversity	Probably same site in Puro (Peru) with multiple incentives to support sustainable agricultural production for genetic diversity conservation
55	BfeB	Brazil			No concurrent payments

Note: The references are the same as those in Table 2.1.

services they supply. Unlike bundling, each ecosystem service is sold separately rather than together.

One PES program can offer both bundling and stacking options, but they cannot be performed in unison on one site because stacking requires that services become unbundled (Gillenwater, 2012). Combining payments and ecosystem services is beneficial through stacking and may be better for sellers mainly because they receive the highest amount of payments and are likely to produce the most substantial amount of ecosystem services (Gillenwater, 2012; Hejnowicz et al., 2014). Stacking payments for environmental services may also allow landowners to take on more extensive projects that would have otherwise not been economically feasible (Gillenwater, 2012; Hejnowicz et al., 2014). Another potential benefit of stacking is diversifying buyers (Hejnowicz et al., 2014). Research shows that if a landowner receives payment for only one of the ecosystem services, s/he may feel it is a financially unachievable project, but if payments could be stacked, the project might be implementable (Gillenwater, 2012).

Ecosystem services from one land parcel can be stacked and sold to more buyers. However, most literature—especially in the USA—focuses on one buyer purchasing stacked ecosystem services (often from one seller). There are three primary forms of stacking: horizontal, vertical, and temporal (Cooley & Olander, 2012). Horizontal stacking implies that when landowners participate in multiple conservation projects on different land areas, they receive a payment for each ecosystem service derived from each area of land. Vertical stacking implies when a landowner does one conservation project on one land area and receives multiple payments for the multiple ecosystem services derived from that area (Cooley & Olander, 2012). Temporal stacking is like vertical stacking, where a landowner implements only one conservation program but receives payments for different ecosystem services over time as payment programs develop. Horizontal stacking is uncontroversial, but vertical and temporal stacking has ignited debate due to their potential for "double counting" (also called "double-dipping" or "piggybacking") (Gillenwater, 2012; Hejnowicz et al., 2014; Smith et al., 2015). These terms are also more formally known as a lack of additionality.

2.4.2 Bundling

"Bundling" occurs when multiple ecosystem services generated within a land parcel are sold together as one commodity to a buyer (usually from one seller). In other words, sellers earn one payment for multiple ecosystem services (Cooley & Olander, 2012). The potential benefits of bundling are that it allows providers to receive payments for multiple ecosystem services generated as byproducts of an overarching ecosystem service. For example, by managing land to improve forest habitat for wildlife, many other ecosystem services can be created, such as carbon sequestration, scenic beauty, increased soil integrity, and water filtration.

Bundling "may be the best way of securing a sale and avoiding free-riding" (Smith et al., 2015). Bundling is desirable when the conservation goals of a PES

program are broad (Hejnowicz et al., 2014). Furthermore, bundling can potentially reduce organizational costs and increase payouts to participants (Hejnowicz et al., 2014). While proponents of bundling claim it "recognizes the interconnectedness of ecosystem services", opponents state that it may be too difficult to measure and manage multiple ecosystem services at once (Hejnowicz et al., 2014).

2.4.3 Policy implementation

PES policies—or green initiatives in a broader sense—must be designed and implemented at multiple local jurisdiction levels. However, there may exist some level of inconsistencies in this regard. Take Australia as an example. There is a federal system of urban governance in which planning legislation and policy framework are set by six states and two territories and implemented by more than 500 local governments through their land use plans. These local plans are prepared under state planning legislation. However, due to varying nomenclature, local instruments combine a mix of policy objectives with concrete provisions for spatial allocation of land uses (Gurran et al., 2015).

Australian national urban policy articulates high-level principles for settlement planning by states and territories that emphasize the need for mixed urban centers, biodiversity conservation, and sustainable design. However, there is no guarantee that state mandates for sustainability will result in local implementation through planning instruments or decisions.

An analysis was performed that focused on the plans prepared up to 2009, some of which were reaching completion in 2013. The results demonstrated considerable heterogeneity in local planning schemes, despite ongoing planning system reforms across Australia which sought to standardize local plans. Metropolitan local government areas displayed spatial differences in sustainability policy adoption (Gurran et al., 2015).

This is a fairly extensive study of the tools and conservation measures, planning approaches, land uses, and policy implementations that are used in very different ways at the local level. The main idea, as far as policy interactions, is that an umbrella policy can be implemented at the state or federal level, but can be applied very differently in different local jurisdictions.

2.5 Grand challenges

Many challenges—be they loss and fragmentation of forest areas, biodiversity loss, wildlife extinction, desertification, and the like—are jeopardizing humanity at unprecedented rates from local to global scales. Thus, they can be called grand challenges. Virtually all these grand challenges can be traced back to various human activities in the context of increasing population pressure. Humans are degrading or destroying ecosystems rapidly, threatening the very "life-support services of tremendous value" such as food, water, clean air, soil, and forests (Daily & Matson, 2008). Many protected areas—such as national parks and nature reserves—are not exempted from such degradation (Curran et al., 2004;

Liu et al., 2001). To address such challenges, the International Convention of Biological Diversity's Aichi targets (https://www.cbd.int/sp/target/) have called for protecting natural habitats (Target 5), threatened species (Target 12), and various ecosystem services from natural ecosystems (Target 14). The United Nations' 17 Sustainable Development Goals, especially Goal 15, aim to protect, restore, and promote sustainable use of terrestrial ecosystems (United Nations, 2016).

In this context, payments for ecosystem services (PES) have come into being for decades, aiming to provide incentives directly to resource users to take environmentally beneficial actions or to refrain from environmentally harmful actions in the hope of protecting ecosystems and the related services. Although PES programs have been reported to restore ecosystems and improve human well-being successfully, many challenges have surfaced in many PES programs.

First, PES programs suffer from lacking sustainability. Many participants return to their pre-PES behavioral patterns once PES payments become no longer available. This problem is widely observable globally, including both developing (Uchida et al., 2005) and developed countries (Claassen et al., 2008). Current PES research pays attention to individual factors such as farm income, land quality, land plot slope, distance from household to the land parcel, age of contract holders, labor supply, and livelihood alternatives (Adhikari & Agrawal, 2013; Engel et al., 2008; He & Sikor, 2015). These variables are primarily treated in a piecemeal manner, while the feedback loops and nonlinear relationships are largely overlooked. Also importantly, there is a dire need to measure the environmental performance of PES programs. So far, the most used measure is land use and land cover (LULC), and very few PES programs have paid enough attention to faunal and/or floral changes in responses to PES programs—there are several exceptions (e.g., Liu et al., 2008; Tuanmu et al., 2016). Therefore, PES research and implementation must consider "the complex interrelationship among socioeconomic, demography and ecological metrics" on the one hand while developing and testing more representative ecological metrics on the other hand (Lewison et al., 2017).

A critical line in PES research is to compare PES to other conservation tools such as protected areas and community-based natural resource management (Börner et al., 2017). For instance, Robalino and collaborators found that a PES program had little additionality in and around protected areas in Costa Rica (Robalino et al., 2015). A case study in Mexico found that the benefits of PES relied heavily on community training and involvement during the implementation of community forest management (Börner et al., 2017).

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