Payment for Ecosystem Services in Costa Rica: Evaluation of a Country-Wide Program

Environment, Rural Development and Disaster Risk Management Division

Juan M. Murguia
Pablo Ordoñez
Leonardo Corral
Gilmar Navarrete-Chacón

DISCUSSION PAPER Nº
IDB-DP-00950

May 2022

Payment for Ecosystem Services in Costa Rica: Evaluation of a Country-Wide Program

Juan M. Murguia
Pablo Ordoñez
Leonardo Corral
Gilmar Navarrete-Chacón

Inter-American Development Bank
Environment, Rural Development and Disaster Risk Management Division

May 2022

http://www.iadb.org

Payment for Ecosystem Services in Costa Rica: Evaluation of a Country-wide Program

Juan M. Murguia[1]

Pablo Ordoñez

Leonardo Corral

Gilmar Navarrete-Chacón[234]

Several countries have implemented payment-for-ecosystem-services (PES) programs, buoyed by the promise of these programs as a win-win strategy that would allow both the conservation of natural resources, and the reduction of poverty for rural households and communities. Our study evaluates the effect on deforestation of Costa Rica's PES program, one of the oldest country-wide programs in the world. Costa Rica approved the 1996 Forest Law (Law No. 7575), creating a PES program that compensates landowners for forest conservation. We estimate these effects using an event study design with staggered entry into treatment. Our results show a statistically significant effect for the first year with a decrease in deforestation of 0.21 ha, but not for the following years. Given that the baseline level of deforestation in our sample is low, the magnitude of the effect is large. When compared to the pre-2016 average level of within farm deforestation, our estimated effect would imply a 100% reduction in deforestation for the first year after enrollment. Given the program pays the participants for a 5-year period, and that the effect is significant only during the first year, it may be beneficial for the program to reduce its length and implement required simplified annual contract renewals or other behavioral interventions to reduce noncompliance in subsequent years.

1. Introduction

Several countries have implemented PES programs, buoyed by the promise of these programs as a win-win strategy that would allow both the conservation of natural resources, and the reduction of

[1] Juan M. Murguia, Pablo Ordoñez and Leonardo Corral are respectively Natural Resources Senior Specialist at the Environment Rural Dev & Disaster Risk Mgmt Division within the Climate Change and Sustainable Development Sector, Consultant and Economics Principal Specialist at the Strategy Development Division within the Office of Strategic Planning and Development Effectiveness at the Inter-American Development Bank.

[2] Gilmar Navarrete-Chacón is the Director of the Environmental Services Program of the National Forest Financing Fund (FONAFIFO) of Costa Rica.

[3] We are thankful to the Ministry of the Environment and Energy of Costa Rica (MINAE), and in particular to FONAFIFO for their support to design and implement this study, and to the National System of Conservation Areas (SINAC) for their technical support and discussion on MINAE prioritization criteria for PES.

[4] Funding has been provided by the Inter-American Development Bank, Economics Sector Work "Costa Rica: Impact Evaluation of Payment for Ecosystem Services Program 2010-2020" (RG-E1851).

poverty for rural households and communities. However, the evaluations of these programs have found only modest effects, with small reductions in deforestation and increases in wellbeing (Ferraro, 2017). Across different systematic reviews and studies, the average estimated effects on deforestation are small, with a ~0.2%/year reduction in the deforestation rate (Ferraro, 2017; Snilsveit et al., 2019; Wunder et al., 2020), and modest effects ranging from 2% to 14% for income, with no effects on other dimensions of human welfare (Ferraro, 2017). In contrast, Costa Rica is an example regarding forest preservation, rather than just reducing deforestation it has increased its forest coverage from 25% of its land area in 1980 to 52.4% in 2021. A possible explanation is its PES program.

Costa Rica approved the 1996 Forest Law (Law No. 7575), creating a payment-for-ecosystem-services (PES) program that compensates landowners for forest conservation. This law banned the clearing of "mature" forests in the country and established the National Forestry Finance Fund (FONAFIFO), a semi-autonomous body responsible for managing the PES program. The program is financed by a tax on fossil fuels[5] and over its lifespan has protected 2,862,747 acres (1.158.512,60 hectares) of forest through accumulated payments for US$ 565 million (approx. 815.000 annual acres (330.000 hectares) under 6,000 new contracts).

Most of the existing literature that evaluates PES programs in developing countries are from studies that use quasi-experimental methods. The possibility to use experimental methods to evaluate these programs is limited, especially when they are implemented at a national scale, and so far, the only RCT that has been done, was done at the district level in Uganda (Jayachandran et al., 2017). Most of the studies using quasi-experimental methods have focused on the programs in Costa Rica and Mexico, which were the first programs to be implemented.

Our study evaluates the effect on deforestation of Costa Rica's PES program, one of the oldest country-wide programs in the world. For this, we have data from 3,495 landowners who have applied to participate for the first time in the PES program at any point between 2016 and 2019. Participation is voluntary and participants must reach a minimum threshold on a score based on the environmental characteristics of the plot. The minimum threshold required depends on the amount of available funding each year and if they are selected, they participate in the program for 5 consecutive years. We use Hansen's et al., (2013) deforestation dataset and complement these with satellite weather data, with the monthly rainfall data from the Climate Hazards Group Infrared Precipitation with Stations (CHIRPS) dataset (Funk et al., 2015), and the monthly mean temperature from MODIS (Wan et al., 2015). We create a panel dataset, with deforestation and weather data for all these landowners, from 2012 to 2019.

We estimate these effects using an event study design with staggered entry into treatment, where the main identifying assumption is that of parallel trends between treated and untreated units. This means that in the absence of the PES program, enrolled farms would have followed a similar trend in deforestation as unenrolled ones. We believe this is a reasonable assumption in this setting, given that

[5] This source of funding might be curtailed in the future as the country moves towards decarbonization of its energy sources (IDB, 2020). Thus, it will be imperative to enhance the program's additionality.

our control group consists only of landowners who applied and were eligible to enroll but did not end up enrolling in the program. As such, we believe that our control group is comparable to the treatment group, and more importantly, we do not believe there are systematic and unobservable differences that would make the parallel trends assumptions unreasonable.

A comparison of the means for the main characteristics of both treated and untreated farms shows that both groups are comparable to each other, as we found few variables for which the difference in means are statistically significant. Results of the estimated event study design show that there is a statistically significant decrease in deforestation one year after entering the PES program. The decrease in deforestation persists up to three years after entering the program but is only statistically significant for the first year. Importantly, our estimation results provide evidence supporting the parallel trends assumption, since we find that prior to enrollment in the PES program, there is no statistically significant difference in deforestation.

We make four contributions to the existing literature. First, given the data available, we can have a control group constructed using data on actual applicants to the PES program, whereas in previous studies, the construction on the control group was done by choosing areas not enrolled in the program (R. A. Arriagada et al., 2012; Arturo et al., 2007; Robalino et al., 2021). The advantage of our data and approach, is that the control group we use in our analysis, is directly comparable to the group of enrolled farms, which in turn requires us to make less strong assumptions for our estimated effects to be considered as causal.

Second, the unit of observation in our analysis is the farm. We believe this is an important distinction from previous work, where the units are either grid cells (Arturo et al., 2007) or randomly drawn points (Robalino et al., 2021; Robalino & Pfaff, 2013). To the best of our knowledge, only one study used farms as their unit of observation, although their study focused on only one region and not the whole country (Rodrigo A. Arriagada et al., 2012). Given that the farm is the level at which decisions about land use are made, estimating effects at this level can better capture the actual effects from the program.

Third, this is the first study of the effects of the PES program in Costa Rica that has focused on the latest cohort of participants, which will allow us to understand how the effects have changed through time. Finally, given that we have data on the scores received by each application and that these scores are determined by a set of targeting criteria, we can shed some light on whether the criteria being used is targeting places where the additionality of the program is higher. We believe this is an important contribution given that it has tangible policy implications and that there is evidence of how changes in the participation criteria for the first cohorts of the program changed its additionality (Robalino et al., 2021).

The remaining of this paper is organized as follows: section 2 describes the data we use while section 3 focuses on our estimation strategies. Section 4 presents the results and discusses their significance and section 5 concludes.

2. Data

We construct a panel dataset of farms using the polygons of all the farms that have applied to the PES program in Costa Rica between 2016 and 2020. By overlapping to the polygons publicly available spatial data on deforestation, weather, terrain characteristics and accessibility we can know what happened inside each of the polygons.

For deforestation, we use Hansen's et al., (2013) deforestation dataset and the recently released dataset on deforestation and degradation in tropical moist forests (henceforth referred to as TMF) from the European Commission (Vancutsem et al., 2021). These datasets are both based on Landsat images, but the processing algorithms are different. The TMF dataset covers the following Global Ecological Zones (FAO, 2012): "tropical rain forest," "tropical moist forest," "tropical mountain system," and "tropical dry forest". These ecological zones effectively cover all the territory in Costa Rica.

We complement these information with satellite weather data, with the monthly rainfall data from the Climate Hazards Group Infrared Precipitation with Stations (CHIRPS) dataset (Funk et al., 2015), and the monthly mean temperature from MODIS (Wan et al., 2015). We also include data on the characteristics of the terrain, with data on the elevation and slope from the CGIAR STM DEM data and the potential yield for different crops from the FAO global agroecological zones (IIASA & FAO, 2012). Finally, we include a measure of proximity to markets, by including data on travel time to major cities (Nelson, 2008).

3. Empirical Strategy

Our approach to estimate the effect that the enrollment in the PES program had on deforestation is based on an event study design, where we estimate the effect of enrollment in the PES program on deforestation for the years before and after enrollment in the program. In this case, the estimating equation is:

$$FL_{it} = \sum_{j=-q}^{-1} \kappa_j PES_j + \sum_{j=0}^{m} \lambda_j PES_j + X_{it}\beta_2 + year + \alpha_i + \varepsilon_{it} \qquad (1)$$

Where *FLit* is the forest loss in hectares inside the polygon of farm *i* in year *t*. The model includes leads, which captures the of enrollment j years before the actual enrollment in the PES program, such that κ_{-2} would capture the effect of enrolling in the program, 2 years before enrollment. It also includes lags, which allow us to estimate the effect on deforestation j years after enrollment, such that λ_5 for example, would be the capture the effect from enrolling in the program, 2 years after enrollment. We also include a set of control variables *Xit* that includes rainfall, temperature and their interactions with crop suitability for different crops, elevation, slope and travel time to cities. We also include year and farm fixed effects.

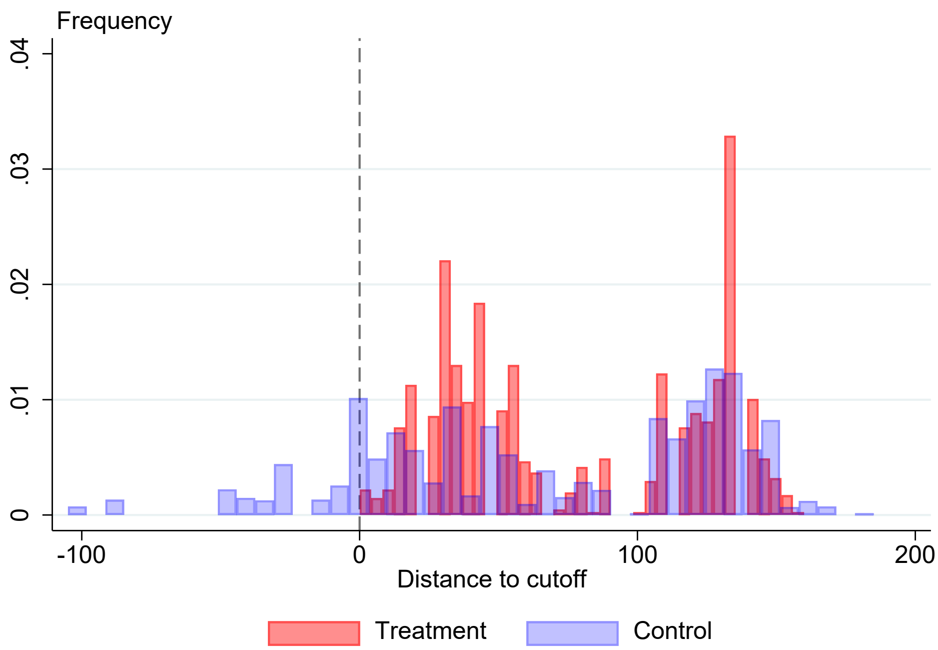
The main identifying assumption for the estimation of a causal effect from participation in the PES program is that of the parallel trends in deforestation between treated and untreated farms. In this case, this implies that the trends in deforestation that treated farms would have followed had they not been treated, would have been similar to the trend followed by the untreated farms. While this is an untestable assumption, we provide evidence that shows that the trends followed by both treated farms prior to enrollment, were similar to those followed by the untreated farms during that same period. In our setting, this would imply that the κ_{-j} coefficients are statistically equal to zero.

4. Results

We limit our sample to include only landowners who participate in the forest protection category of the PES program ("Protección de bosques"), which accounts for 74% of all the applications submitted to FONAFIFO and 69% of all the contracts signed. This excludes other categories of the PES such as agroforestry systems, reforestation and natural regeneration. Furthermore, given that the forest protection category is the one with the highest demand and that this demand exceeds the available funds every year, the applications are scored using prioritization criteria from the Ministry of the Environment and Energy (MINAE)[6]. These criteria assign a higher score for forests that are in areas considered to have a high environmental value: protected areas, indigenous territories, biological corridors, forests that provide hydrological services. Additionally, previous program participants, smallholders and those from poorer districts also receive additional points in their applications. The applications are then ranked, from the highest to the lowest score. The funds available in a given year allow the enrolment of a limited number of acres (hectares), and so the applications are selected until they reach the maximum number of hectares allowed for that year. This effectively establishes a score cutoff below which none of the applications are accepted. However, some of the applications that have a score above the cutoff do not always end up enrolling in the program even though they are given the option to do so. Thus, we limit our sample to only those applications for which the score received was above the score cutoff for the year in which they applied (all the applications to the right of the dotted vertical line in Figure 1). We believe this allows us to have a more comparable control group, given that they will have similar characteristics.

Figure 1. Histogram of the distance of the application score to the cutoff

[6] Set be decree in "Decreto Ejecutivo N 39871-MINAE"



We compare the characteristics of both participants and non-participants in our sample, to understand how different they are on average. We find that both groups have similar characteristics, with only three variables showing a statistically significant difference in the means of both groups: the application score, the proportion of the farm that has forest in 2015 and the average rainfall (Table 1). Importantly, neither the deforestation in has or as a proportion of the total farm size are statistically different between the treatment and control group.

Table 1. Summary statistics of the main characteristics by group

	Total	Control	Treatment	Difference	t-statistic
Application score	117	113	126	-13	(-12.93)***
Deforestation in ha (pre-2016)	0.209	0.208	0.209	-0.001	(-0.01)
Deforestation Rate (pre-2016)	0.13%	0.14%	0.11%	0.03%	-1.95
Forest Area 2015 (ha)	88.3	88.0	89.3	-1.3	(-0.13)
Forest Area 2015 (% of total area)	82%	81%	84%	-3%	(-3.57)***
Area (ha)	144	137	162	-25	(-0.82)
Elevation (m.a.s.l)	623	628	612	16	-0.7
Slope (degrees)	12	12	12	0	-0.04
Potential yield – Maize (kg/ha)	688	688	689	-1	(-0.04)
Potential yield – Sugarcane (kg/ha)	1,225	1,244	1,177	67	-1.69
Potential yield – Wheat (kg/ha)	15	16	13	2	-1.13
Potential yield – Citrus (kg/ha)	269	275	255	20	-1.45

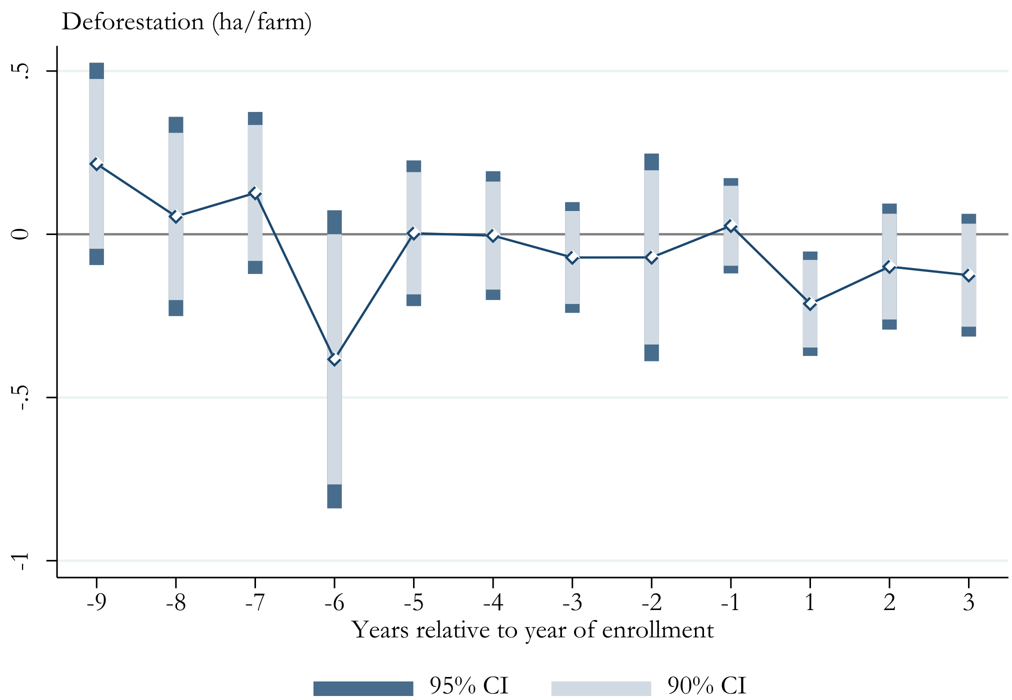
Potential yield – Coffee (kg/ha)	320	323	312	10	-0.97
Tropical moist forest (ha)	82	69	113	-44	(-1.42)
Tropical rainforest (ha)	78	81	70	11	-1.55
Travel time (min)	342	343	341	2	-0.27
Mean annual rainfall (mm)	2,871	2,892	2,820	72	(2.49)*
Mean temperature (Celsius)	26	26	26	0	(-0.08)
Obs.	3,494	2,501	993		

The main assumption for the unbiasedness of the estimated effects from our event study design, is that of the parallel trends. In this setting, this means that the trend in deforestation within each farm after enrolling in the PES program, would have been the same as the trend followed by the control group, if the enrolled farms had not participated in the program. Our belief that this is a plausible assumption in this case, comes from the fact that both groups are statistically similar in their observable characteristics (Table 1) and that both groups had the same opportunity to enroll in the program, given that their applications had scores that where above the cutoff score for the year in which they applied. As with the evaluation of other PES programs, the main concern is that due to unobservable factors, the underlying risk of deforestation is different between those who participate in the program and those who do not participate, which will ultimately violate the parallel trends assumption. We believe that the similarity in characteristics and that both groups are composed of farmers who applied to the program and were eligible to enroll, increases the probability that the underlying and unobserved deforestation risk is similar across both groups.

Our main specification is based on equation (1). For our control variables, we include rainfall and temperature for each month of the year, and interactions of yearly rainfall and temperature with elevation, slope, potential yields for the different crops, travel time and the total farm area. These last interaction terms allows us to control for the differential effects that weather conditions might have on farms of different sizes (even if the difference in the means for the two groups is not statistically significant).

Our results show that there is evidence supporting the parallel trends assumption, given that prior to the enrollment in the PES program, there is no statistically significant difference between the control and treatment farms (Figure 2). Importantly, we find that the first year after enrollment in the program, there is a decrease in deforestation of 0.21 ha. This is a statistically significant effect for the first year but not for the following years, even though the effects are still negative. Given that the baseline level of deforestation in our sample is low (which is also true for the whole country), the magnitude of the effect is large. When compared to the pre-2016 average level of within farm deforestation, our estimated effect would imply a 100% reduction in deforestation for the first year after enrollment.

Figure 2. Event study results



5. Conclusions

Costa Rica's PES program is one of the oldest country wide programs in the world. The evaluation of its effectiveness in the early years of the program showed that the program had little to no effect on deforestation (Arturo et al., 2007; Robalino & Pfaff, 2013). However, there were regions where the threat of deforestation was higher and there was active targeting of participants where the program increased forest cover (Rodrigo A. Arriagada et al., 2012), and there is also evidence showing that the effect of program on deforestation increased for the later cohorts (Robalino et al., 2021).

Ours is the first study of the latest cohort of participants of the PES program (2016-2020) and is also the first one to use actual applicants to the program as a control group. Using this control group in an event study design, we find that there is a statistically significant decrease in deforestation one year after entering the program. The decrease persists but is no longer significant for the second and third year. The magnitude of the effect during the first year is as large as possible, given the low level of baseline deforestation. Many reasons may be driving the participant's behavior in this regard. A possible explanation is that farmers comply well with the contract they sign with FONAFIFO right after they do it and less over time as they see it as a secure payment despite whether they comply compliance with the program or not; or just forget that they are receiving their payment because there is a commitment to be fulfilled. There is a body of literature on compliance reduction over time on contracts over multiperiod commitments in the field of behavioral economics, like the classic example of gym annual memberships and gym attendance. Given the program pays the participants for a 5 year period, and that the effect is significant only during the first year, it may be beneficial for the program to reduce its length, and implement required simplified annual contract renewals or other behavioral interventions to reduce non compliance in subsequent years.

Future work will focus on exploring whether there are heterogenous effects by different farms' characteristics and on understanding how effective the current targeting from the scoring criteria is at selecting those participants where the avoided deforestation would be higher.

References

Arriagada, R. A., Ferraro, P. J., Sills, E. O., Pattanayak, S. K., & Cordero-Sancho, S. (2012). Do Payments for Environmental Services Affect Forest Cover? A Farm-Level Evaluation from Costa Rica. *Land Economics*, *88*(2), 382–399. https://doi.org/10.3368/le.88.2.382

Arriagada, Rodrigo A., Ferraro, P. J., Sills, E. O., Pattanayak, S. K., & Cordero-Sancho, S. (2012). Do Payments for Environmental Services Affect Forest Cover? A Farm-Level Evaluation from Costa Rica. *Land Economics*, *88*(2), 382–399. https://doi.org/10.3368/LE.88.2.382

Arturo, G., Sanchez-Azofeifa, G. A., Pfaff, A., Robalino, J. A., & Boomhower, J. P. (2007). Costa Rica's Payment for Environmental Services Program: Intention, Implementation, and Impact. *Conservation Biology*, *21*(5), 1165–1173. https://doi.org/10.1111/j.1523-1739.2007.00751.x

FAO. (2012). *Global Agroecological Zones for FAO Forest Reporting: 2010 Update* (No. 179; Forest Resources Assessment Working Paper).

Ferraro, P. J. (2017). Are payments for ecosystem services benefiting ecosystems and people? In *Effective Conservation Science: Data Not Dogma* (pp. 159–166). Oxford University Press. https://doi.org/10.1093/oso/9780198808978.003.0025

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., Loveland, T. R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O., & Townshend, J. R. G. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science*, *342*(6160), 850–853. https://doi.org/10.1126/science.1244693

IDB. (2020). *Hacia una Economía Verde: Apoyo al Plan de Descarbonización de Costa Rica*.

IIASA, & FAO. (2012). *Global Agro-ecological Zones Model Documentation*.

Jayachandran, S., de Laat, J., Lambin, E. F., Stanton, C. Y., Audy, R., & Thomas, N. E. (2017). Cash for carbon: A randomized trial of payments for ecosystem services to reduce deforestation. *Science (New York, N.Y.)*, *357*(6348), 267–273. https://doi.org/10.1126/science.aan0568

Nelson, A. (2008). *Estimated travel time to the nearest city of 50,000 or more people in year 2000*. Global Environment Monitoring Unit - Joint Research Centre of the European Commission. https://forobs.jrc.ec.europa.eu/products/gam/

Robalino, J., & Pfaff, A. (2013). Ecopayments and deforestation in Costa Rica: A nationwide analysis of PSA's initial years. *Land Economics*, *89*(3), 432–448. https://doi.org/10.3368/le.89.3.432

Robalino, J., Pfaff, A., Sandoval, C., & Sanchez-Azofeifa, G. A. (2021). Can we increase the impacts from payments for ecosystem services? Impact rose over time in Costa Rica, yet spatial variation indicates more potential. *Forest Policy and Economics*, *132*, 102577. https://doi.org/10.1016/J.FORPOL.2021.102577

Snilsveit, B., Stevenson, J., Langer, L., Tannous, N., Ravat, Z., Nduku, P., Polanin, J., Shemilt, I., Eyers, J., & Ferraro, P. J. (2019). Incentives for climate mitigation in the land use sector—the effects of payment for environmental services on environmental and socioeconomic outcomes in low- and middle-income countries: A mixed-methods systematic review. *Campbell Systematic Reviews*, *15*(3), e1045. https://doi.org/10.1002/CL2.1045

Vancutsem, C., Achard, F., Pekel, J. F., Vieilledent, G., Carboni, S., Simonetti, D., Gallego, J., Aragão, L. E. O. C., & Nasi, R. (2021). Long-term (1990–2019) monitoring of forest cover changes in the humid tropics. *Science Advances*, *7*(10), eabe1603. https://doi.org/10.1126/sciadv.abe1603

Wunder, S., Börner, J., Ezzine-de-Blas, D., Feder, S., & Pagiola, S. (2020). Payments for Environmental Services: Past Performance and Pending Potentials. *Annual Reviews*, *12*, 209–234. https://doi.org/10.1146/ANNUREV-RESOURCE-100518-094206