Environmental Science and Policy 76 (2017) 59–69

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Using publicly available social and spatial data to evaluate progress on REDD+ social safeguards in Indonesia

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ARTICLE INFO

Keywords:
Climate change
Forests
Kalimantan
Impact evaluation
Monitoring and evaluation
Rights

ABSTRACT

Countries are grappling with how to monitor and evaluate the social impacts of reducing emissions from deforestation and forest degradation (REDD+) at national and sub-national scales as they develop REDD+ safeguard information systems (SIS). Given limited resources for social safeguard measuring, reporting and verification (MRV), and the fact that REDD+ is a performance based mechanism requiring monitoring over the medium to long-run, there is a need to develop SIS that are low cost, rigorous, and sustainable over time. Of critical importance are approaches that adequately operationalize social safeguards, provide opportunities for ongoing MRV, and are feasible in terms of within country human and financial capital. In this paper we provide an illustration of how publicly available social and spatial data can be used for the quantitative evaluation of the social impacts of early REDD+ activities using the example of Kalimantan, Indonesia.

Our analysis suggests that in the very early stages REDD+ projects are doing a reasonably good job of protecting rights (Safeguard #3), and are having a negative impact on human welfare (Safeguard #5). Other social safeguards could not be effectively evaluated due to lack of appropriate indicators in publicly available population representative datasets. Our experience suggests that there are several opportunities and challenges for countries as they move forward with REDD+ SIS. We find that for Indonesia there is sufficient data to estimate impacts for some, but not all, aspects of REDD+ social safeguards. More recently collected data have greater potential for the linking of social and spatial datasets, and fairly straight forward matching methods can be applied to construct appropriate treatment and comparison groups. Challenges include limited ability to operationalize some safeguards using existing data sources, lack of geo-referencing in several publicly available datasets, incompatibility of data layers in terms of their spatial and temporal resolution and frequency, and the complexity of generating appropriate counterfactual scenarios. Despite the limitations of existing data sources, we recommend against designing entirely new systems for REDD+ SIS. Strengthening ongoing national and sub-national data collection efforts to include appropriate geo-referenced indicators for the full range of REDD+ social safeguard indicators, and integration of carbon and social MRV systems are important avenues to explore.

1. Introduction

At the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP) 16 the Cancun Safeguards were articulated to provide guidance for national governments regarding key aspects of REDD+ implementation. REDD+ safeguards are intended to provide protections for local people regarding a variety of political, social, economic, and environmental impacts related to REDD+ policies and projects (Arhin, 2014). Importantly they provide a set of criteria by which key stakeholders can judge the performance of REDD+ (Rey et al., 2013). The Cancun safeguards (UNFCCC, 2011) are:

1. Complement national forest programs and international conventions and agreements;
2. Maintain transparent governance;
3. Respect the knowledge and rights of indigenous peoples and local communities;
4. Obtain effective participation of peoples and local communities in the design and implementation of REDD+;
5. Avoid the conversion of natural forests and ensure that activities conserve forests, biodiversity, ecosystem services, and enhance other social benefits;
6. Address risk of reversals; and

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http://dx.doi.org/10.1016/j.envsci.2017.06.006
Received 19 December 2016; Received in revised form 9 June 2017; Accepted 10 June 2017
Available online 27 June 2017

7. Reduce leakage.

Safeguards #6 and #7 fall clearly under the purview of REDD+ measuring, reporting and verification (MRV) of carbon emissions. Countries with relatively well-developed REDD+ policies have already invested heavily in developing systems for carbon MRV.

How the remaining Cancun Safeguards will be measured, reported on, and verified is an open and important question. In June 2015, the 42nd Subsidiary Body for Scientific and Technological Advice (SBSTA 42) of the UNFCCC decided that REDD+ host countries should provide information on the implementation of the Cancun safeguards in a way that ensures the reporting principles of “transparency, consistency, comprehensiveness, and effectiveness” and recognizes “national sovereignty” (UNFCCC, 2015a, 2015b). But a practical, rigorous, and cost-effective way forward remains to be articulated.

Understanding the impact of REDD+ on governance, tenure security, social welfare and other indicators is essential to ensuring that REDD+ policies and programs are designed and implemented as efficiently, effectively, and equitably as possible (Lawlor, 2013; Visseren-Hamakers et al., 2012). As reviewed by Caplow et al. (2011), in the short history of forest carbon projects there is a relatively weak evidence base evaluating social impacts. Following from that critique, we examine outcomes from REDD+ activities in Kalimantan, Indonesia and propose a relatively low cost yet rigorous approach to developing sustainable REDD+ safeguard information systems (SIS). Our objective is to provide an example of how publicly available social and spatial data can be used for the quantitative assessment of REDD+ social safeguards at national and jurisdictional scales. We also enumerate the limitations of data available for such an approach were it to be used by national governments to report on progress towards implementing the Cancun safeguards. Our aim is to demonstrate that publicly available data can be used to operationalize REDD+ social safeguards and to empirically test whether REDD+ activities have an impact on indicators of social impacts.

As we build our analysis for REDD+ social safeguard MRV we highlight five key design considerations: developing a rigorous analytical approach; articulating a theory of change; operationalization of social safeguards; confirming data availability and quality; and compiling and analyzing data. The first challenge is designing a quantitative impact evaluation of REDD+ that is sufficiently rigorous, which is important given that REDD+ is a performance-based environmental policy instrument. For several reasons, REDD+ is not generally amenable to developing reliable counterfactuals of untreated groups or to creating randomized control trials, which are considered the gold standard of impact evaluation (Sills et al., 2017; Jagger et al., 2010). First, randomly selecting REDD+ sites is difficult since they are deliberately situated in areas where reductions in deforestation and forest degradation have a high potential for mitigating climate change. Second, it is challenging to identify the precise implementation dates of REDD+ programs and projects because activities often take place according to different timelines and in sites with pre-existing conservation and development activities. Third, a rigorous quantitative impact evaluation requires baseline data, or even better historical data for a unit of observation (e.g., household, village, or group of villages), but governance and socioeconomic data are rarely collected over time for the same units (Jagger et al., 2010; Corbera and Schroeder, 2011).

A second issue for REDD+ evaluation is articulating a plausible theory of change. Rather than an approach that focuses only on the direction and size of impacts, theory of change requires thinking through causal mechanisms that may link REDD+ activities with observed changes in safeguards and other outcomes, then developing a set of testable hypotheses to evaluate those mechanisms. Developing a theory of change is additionally confounded by the complexity of REDD+ interventions which typically involve a bundle of different activities to mitigate deforestation and forest degradation (Sills et al., 2014; Jagger et al., 2010).

Third, we need to operationalize safeguards and other concepts that may be abstract and defined in relatively vague terms. This involves selecting indicators that accurately reflect the core meaning of difficult-to-measure safeguards and other outcomes (McDermott et al., 2012). Once concepts are operationalized, a fourth issue is finding actual variables that meaningfully capture those indicators. The availability of quality data may be a challenge for researchers: existing REDD+ data sources are rare given the dearth of funding for REDD+ SIS, while creating one’s own dataset is costly and resource-intensive. This may further create challenges for attribution of the observed outcomes exclusively linked to REDD+ activities.

Finally, compiling and analyzing data poses both substantive and practical challenges. Substantively, this step requires a high level of competence with remote sensing, geographic information systems, and quantitative social science including impact evaluation. Since individual researchers rarely have advanced training in all three areas, a well-trained interdisciplinary team must instead be established. We argue that, like carbon MRV, this function is best placed within a national government institution, and that social and biophysical MRV are harmonized. Other practical issues include whether or not there exists sufficient computing facilities and power; appropriate (i.e., open source) software; and administrative capacity to maintain consistent, regular schedules of measuring, reporting, and verifying the social impacts of REDD+ over time. Our study uses all the above outlined design steps to evaluate the causal impacts of early REDD+ initiatives on governance, social welfare and livelihood indicators in Kalimantan, Indonesia.

2. Materials and methods

2.1. Study design

The broad objective of this study is to provide an example of how to use publicly available social and spatial data for rigorous and sustainable REDD+ SIS. We use the case of Kalimantan, Indonesia for several reasons. First, Indonesia is recognized as a leader in REDD+, with activities taking place there since 2008, a relatively mature set of national-level policies, and a strong capacity for developing REDD+ policy and programming at the national and sub-national levels (Agung et al., 2014). Second, the polycentric nature (e.g., overlapping institutional structure) of REDD+ in Indonesia is also common in other countries with REDD+ programs (e.g., Brazil), suggesting that insights from Indonesia can be applied elsewhere (Jagger et al., 2014). Finally, relatively good spatial and social data are available for Kalimantan.

Our strategy is to use impact evaluation methods to analyze outcomes for a variety of indicators in villages (desas) with REDD+ projects or directly overlapping or adjacent to REDD+ initiatives. We then compare the outcomes to those of a matched group of non-REDD+ villages. The year 2008, when the Government of Indonesia officially sanctioned REDD+ as a national policy (Government of Indonesia, 2009), serves as the baseline year of our analysis. We consider the impact of early REDD+ activities on variables that we argue can be used to operationalize two broad categories of REDD+ social safeguards: respect for rights (safeguard#3), and social welfare and biodiversity (safeguard #5) for 18 projects situated in Kalimantan, Indonesia (Fig. 1, also see Table S1, supplemental material). Most of the projects are in the preparation phase with a wide variety of pilot activities taking place. Our list of REDD+ projects and programs in Kalimantan is not exhaustive, but includes those we were able to obtain spatial boundaries for. Some projects are spatially embedded within district-level REDD+ programs.

Because REDD+ activities take place at the sub-national and project scales in Indonesia there is the possibility of using counterfactual-based matching procedures. We argue that our approach has several advantages. It lends itself to long-term MRV and is more rigorous than most conservation and development monitoring and evaluation approaches, particularly with respect to assigning attribution of program or policy impacts (Jagger et al., 2010). We believe that by using quality data on variables that can be meaningfully used as social safeguard

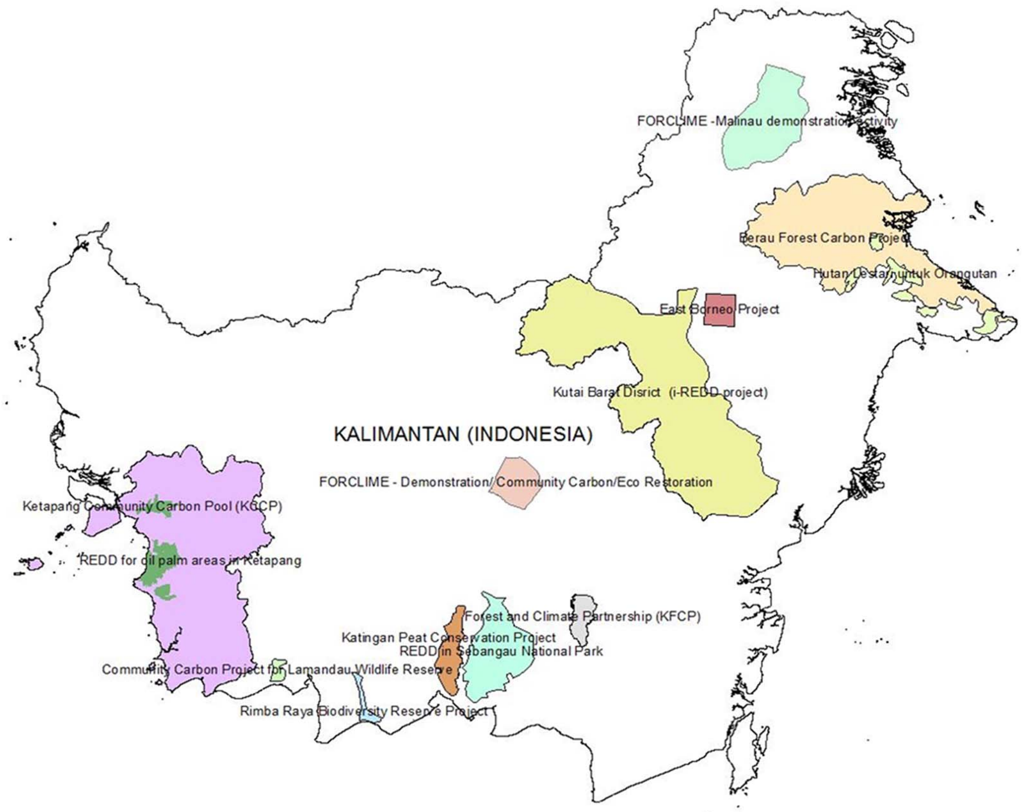

Fig. 1. Map of Kalimantan with REDD+ project boundaries (N = 18) (color).

indicators, data on other context-specific covariates and potential confounders, we may attribute the observed impacts to REDD+ program and policies. Additionally, our approach is appropriate for aggregating information across scales (i.e., it can combine project-level and sub-national initiatives), which is a considerable challenge for national-level reporting on REDD+ social safeguards or social impacts more broadly defined.

There are several caveats to our study design. First, while some REDD+ projects started in 2009, there is considerable variation among projects sites regarding when activities began in earnest. The beginning of the FPIC (free prior and informed consent) process can be considered as the commencement of REDD+, and we acknowledge that this is variable across sites. This is important because we do not expect to see impacts related to REDD+ until implementation takes place. Second, we acknowledge that even in the event of swift and effective implementation of REDD+ activities, it may be too early to see any substantive change in many governance and social welfare indicators. Third, we estimate the impact not of each individual REDD+ activity, but of the bundle of all heterogeneous activities taking place at a single REDD+ site. For example, at one project site where proponents are both establishing clear land title and increasing agricultural intensification, our analysis lumps together a variety of activities involved in those pursuits. Fourth, our study does not provide causal explanations and only provides quantitative effects of early REDD+ activities. Finally, our analysis does not explicitly address leakage or spillover effects. Instead, we focus on comparing villages directly overlapping with or adjacent to REDD+ project areas versus a statistically matched set of villages that are not spatially contiguous with REDD+ project areas.

2.2. Data

We chose the village as our unit of analysis, since it is the level at which most REDD+ interventions are implemented and, therefore, where impacts will be most easily detectable. We reviewed several datasets for suitability based on the criteria that they must:

- be publicly available;
- contain variables that effectively operationalize and measure REDD+ governance and social impacts;
- contain geo-referenced measures, or have some provision for integration with spatial data (for example, merging spatial and socioeconomic data by village name or ID);
- be available over time; and
- have the appropriate scale, with the objective of conducting our analysis at the smallest scale possible.

Our analysis required three types of data: REDD+ project boundaries; spatial data; and socioeconomic data that can be used to operationalize REDD+ social safeguards. Shapefiles for REDD+ boundaries were obtained from REDD+ project proponents. In cases where REDD+ is implemented at the district-level, we took the district boundary as the geographic boundary; in the remaining cases, we identify the number of villages falling within or adjacent to areas with early REDD+ activities. We also identified the villages that fall outside of REDD+ areas and could be used as matches. To do so, we looked for shapefiles that allowed us to overlay village boundaries on the map of REDD+ project sites. For our final analysis, we chose Jual Citra Satelit dataset as our source because it has more geographically complete boundary information than the alternatives, covering approximately 6000 Kalimantan villages and leaving us with missing boundaries for roughly 500 (or approximately 8%) of the 6451 total villages.[1]

With the village as our unit of analysis, we looked for additional spatial and socioeconomic data that was already captured at that level or could be matched by aggregating or dis-aggregating. We used open

[1] According to the Indonesian Interior Ministry there are 6451 villages in Kalimantan (Parent Code Region Data Book 2013, Kementerian dalam negeri – http://www.kemendagri.go.id/pages/data-wilayah).

source spatial data for tree cover change (Hansen et al., 2013), mean precipitation, mean temperature, and altitude (WorldClim-Global Climate Data). We obtained spatial layers of logging concessions, oil palm plantations, and wood fiber from the World Resources Institute database. And we downloaded protected shapefiles for Kalimantan from the World Database on Protected Areas. We used this data to construct variables that we assume to confound both the entry of REDD+ in a village as well as the social and ecological impacts (see Table S2). We then, use these variables to match our treated and control groups to evaluate the social impacts of early REDD+ activities.

For the operationalization of indicators of REDD+ social safeguards we reviewed a range of socioeconomic, governance, poverty and health related surveys. Possible data sources included: the Indonesia Demographic and Health Survey; the Indonesia Family Life Survey; the National Social and Economic Survey; and National Labor Force Survey. Each of these sources was reviewed and deemed unsuitable due to a variety of compatibility problems. For instance, several surveys do not cover all villages, fail to track the same households over time, lack geographic identifiers, or have spatial off-sets that make mapping the exact location of activities difficult.

Our primary data source for social safeguard indicators is the Indonesia Village Potential Statistics (PODES) survey collected by the Indonesia Bureau of Statistics (BPS) in collaboration with Rand Corporation every 3–5 years. The relevant data for our analysis were collected in 2008 and again in 2011. Data from 2008 align with our desire to reflect baseline conditions in 2008, the year REDD+ policy was enacted at the federal level in Indonesia. PODES has several socioeconomic indicators collected specifically at the village-level, some of which are well suited to analyzing the social impacts of REDD+. Notably this dataset is georeferenced, collects data for the same units over time, and has a reasonable number of variables that can be used as proxy indictors for REDD+ social safeguards. Specifically, we were able to find indicators of safeguard #3 respect for knowledge and right of indigenous peoples and local communities, and for the component of safeguard #5 that refers to enhancing social benefits. We also use forest loss estimates from the Hansen dataset as a proxy for biodiversity. After reviewing multiple rounds of that survey instrument, we concluded that we could at best operationalize only two out of the five REDD+ social safeguards. Reliable data on governance indicators, particularly those focused on natural resource management are absent from the PODES survey, and good indicators of participatory processes are also lacking.[2] A summary of our operationalization of key safeguard concepts related to safeguard #3 and safeguard #5, the variables we use for measurement, and our hypothesized relationship between REDD+ and the social safeguard indicator are presented in Table 1. We have also provided a plausible theory of change linking the variables used as proxies for measurement of safeguards to the observed outcomes. Our baseline data are from 2008, the year of REDD+ inception in Indonesia, and is also considered the year in which the treatment was implemented. We use data from 2011 to measure early REDD+ safeguard outcomes.[3]

2.3. Analysis

The first step in our analysis was mapping the boundaries of REDD+ initiatives, ranging from very small projects in specific ecological settings to wider, district-level REDD+ programs. Given our objective to evaluate the impact of REDD+ on a regional-scale, we mapped all REDD+ activities we obtained boundary data for, then overlaid the village boundaries. We had spatial data for 5991 Kalimantan villages and were able to match them with 4904 villages from PODES. We estimate that of the 4904 villages we have boundary and PODES data for, 525 are inside or adjacent to a REDD+ initiative.[4]

After evaluating our governance and socioeconomic data sources for completeness we remain with a disappointing number of villages. We have a full set of covariates for 2242 villages, including 249 of the 525 villages inside or adjacent to the boundaries of REDD+ initiatives. Because of incomplete data for a large share of villages (3749 or approximately 63%), we cannot say that our analysis is representative of Kalimantan as a whole. A visual assessment of our spatial coverage of villages suggests no reason to expect systematic bias in the villages we have complete data for (Fig. 2). To further explore potential biases we tested whether average values for variables of interest (specifically, those we match villages on) are statistically significantly different for the subset of complete data versus the full set of available data. We find that a number of variables do, in fact, significantly differ, suggesting that there may be systematic biases in our sample (Table S2, supplemental material). We have not explored this bias in depth, but speculate that some of it may originate from spatial heterogeneity in missing data. We do not address this issue in our analysis, but flag it as a limitation of our results and for future analyses that combine several different data sources which have missing observations for key variables.

To mirror randomization, our analysis relies on conventional statistical matching approaches to minimize error while achieving the best possible covariate balance between treated and control observations. The treatment effects we calculate are estimated to be the difference between each observed outcome and the counterfactuals represented by the nearest matched control unit. We estimate the average treatment effect for the treated villages (ATT)[5] (Sekhon, 2011) as:

$$ATT = E\{E(Yi \mid Xi, Ti = 1) - E(Yi \mid Xi, Ti = 0) \mid Ti = 1\}, \quad (1)$$

where

Yi is the potential outcomes for a village *i*

Ti is the treatment, 1 = village *i* receives treatment, 0 = village *i* receives no treatment

Xi depicts the observed covariates

E is the expected value

Conditional on observed covariates, ATT is the difference between the potential outcomes of village *i* when treated and the potential outcomes when not treated (control). It is calculated by taking the outer expectation over the distribution of $Xi \mid (Ti = 1)$ which represents the distribution of variables in the treated group.

We used a range of covariates for matching treated and control observations in the pre-treatment period in order to obtain a counterfactual for the treated observations. In randomized designs, randomization takes care of balance in observed and unobserved covariates. Using matching routines we can only match on observed covariates. We have used three types of covariates to achieve balance. Our first set of variables reflects past forest governance. This is important because we know that REDD+ activities often take place in areas with a history of conservation and development programs (Sunderlin and Sills, 2012) or where there is tremendous potential to prevent deforestation. We use history of protection, tree cover loss, commercial logging, wood fiber and oil palm plantations, and fires. Second, we use a number of social welfare indicators including the presence of soil roads and percent of households in agriculture as observables that need to be balanced among treated and control observations. By matching on socioeconomic indicators we ensure that our matched villages have similar

[2] Safeguard #1 "Complement national forest programs and international conventions and agreements" is best assessed using qualitative data at national scale data.

[3] The Government of Indonesia officially sanctioned REDD+ as a national policy in 2008. Many of the studied projects started within one or two years after 2008. We expect little variation in our measured social and ecological impacts due to this temporal variation in entry of REDD+ among project sites.

[4] A possible reason for the discrepancy between the number of villages we have boundaries for (5991) and the spatial overlap with PODES data is mismatch between village names or sub-divisions between the village boundary and PODES datasets.

[5] For ATT the unconfoundedness assumption can be weakened to mean independence (Heckman et al., 1998) and the complete overlap assumption may only be required for a subset of the support of X for control observations for the support of X for treated observations (Sekhon, 2011).

Table 1
Operationalizing and measuring REDD+ Social Safeguards.

	Cancun Safeguards (UNFCCC, 2011)	Operationalization	Measurement	Theory of change	Hypothesized relationship to REDD+ social safeguard
3	Respect the knowledge and rights of indigenous peoples and local communities	In the implementation of REDD+ are the knowledge and rights of local forest users being respected?	Customary land burning (*Customary land burning in the village to start agricultural business in 2011*)	Customary land burning as an agricultural practice signals respect for indigenous/local rights or the ability of local people to exercise de facto land rights OR REDD+ may limit this practice	+/−
		Do local people have secured property rights?	Secure property rights (*Change of non-agricultural lands to non-irrigated agricultural lands, extensification*)	REDD+ may increase awareness of land rights, which may lead some people to establish agricultural lands triggering expansion into forest frontier OR forest expansion may decline due to perceived security of rights over existing lands	+/−
			Secure property rights (*Change of non-irrigated agricultural lands to paddy cultivation, intensification)*	Altering land use, an expression of secure property rights will also be positively associated with REDD+	+
5	Avoid the conversion of natural forests and ensure that activities conserve forests, biodiversity, and ecosystem services, and enhance other social benefits	Has REDD+ influenced overall well-being, changed social service provision, or led to new/different economic opportunities for local people? Has REDD+ resulted in forest loss that may in turn reduce biodiversity?	Incidence of poverty (*Number of poor letters/SKTM)*	REDD+ may limit incomes from traditional livelihood activities OR REDD+ may influence access to poor letters due to increased awareness of state benefits	+/−
			Access to free health services *(Number of people receiving JAMKESMAS/JAMKESDA cards*)	Enhanced awareness due to REDD+ may also enable poor people to access free health services offered by state	+
		Has REDD+ resulted in forest loss that may in turn reduce biodiversity?	Majority of households in village using LPG as dominant fuel	REDD+ may be positively associated with access to modern energy services including LPG due to increased incomes or when REDD+ introduces interventions to reduce reliance on woodfuels	+
			Presence of mobile phone service in the village	REDD+ interventions may generate change in the economic profile of people, leading to increased demand for mobile phone and internet services	+
			Presence of internet in village		+
			Forest loss *(Average tree cover loss)*	Tree cover loss is a rough proxy for biodiversity loss. Due to the small post-treatment window after REDD+, we expect tree cover loss to be neutral or negative. For example, deforestation may occur in early years of REDD+ due to anticipation of strong legal enforcement by state agencies after REDD+ is implemented, or due to lags in setting up enforcement mechanisms	−

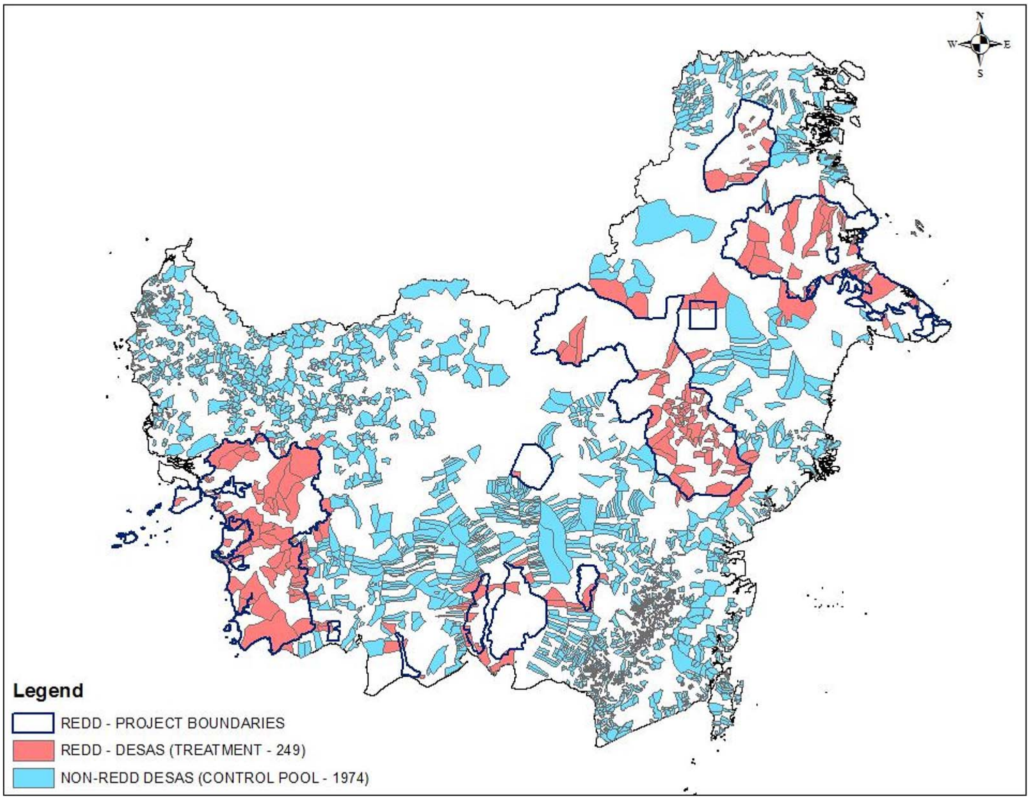

Fig. 2. Map of Kalimantan with REDD+ project boundaries; treatment (N = 249) and control villages (N = 1974) (color).

socioeconomic characteristics in the pre-REDD+ period prior to 2008. Finally, we control for important contextual or exogenous factors including past deforestation rates, market access, elevation, and size of village. We believe these factors influence various REDD+ outcomes as they determine accessibility, agricultural productivity, information flows, etc. Our assumption is that by controlling these contextual variables, we largely balance out the pre-treatment differences between the treated and the control groups that may have influenced both the entry of REDD+ project in the first place as well as the social and ecological impacts.

The propensity of each observation (i.e., village) to be assigned to REDD+ (the treatment) given a set of observed covariates was calculated in terms of a propensity score using logistic regression (Rosenbaum and Rubin, 1983). Then one-to-one matching between treated and control observations was done with replacement based on nearest propensity scores after exactly matching at provincial level. The ATT represents the difference between the average potential outcomes of REDD+ treated villages and those of control villages (in terms of our defined outcomes). Matching routines were run in R (open source software) using the Matching package (Sekhon, 2011). Detailed balance statistics for both before and after matching demonstrate balance among treated and control covariates after matching. We conducted bootstrapped Kolmogorov-Smirnov tests to explore the statistical differences among the distributions of control and treated observations. Based on the variance ratio of treatment over control (value of 1 indicates perfect balance), *t*-test of difference of means, and bootstrap Kolmogorov-Smirnov tests[6] in post-matching, we estimate the level of covariate balance achieved in our matched sets for treated and control observations. The tests indicate that the statistical differences among the distributions of control and treated observations after matching were insignificant at a 5% level of confidence after matching for all covariates (Table S3, Supplemental material).[7] To further illustrate balance, we have shown distributions of percent tree cover loss in matching treated and control observations (Fig. 3).

In addition to calculating ATE using 1:1 matching, we conducted a difference-in-difference analysis[8] in R to estimate the treatment effects of the early REDD+ interventions. We assume that the difference between the control and treatment groups, in the absence of REDD+, is constant over time. Then we calculated causal effect by estimating the difference in change of treatment and control groups with regard to governance and social indicators that we have used. Finally, we provide results for third matching approach. We used genetic matching in R to estimate average treatment effects (ATE) of early REDD+ projects in Kalimantan. Genetic matching finds optimal balance using multivariate matching wherein based on a genetic search algorithm weights are given to covariates that are used in the matching (For details, see Sekhon, 2011). Descriptive statistics for the spatial and socioeconomic data we use in our analysis are provided in Table 2.

2.4. Operationalization of safeguards

2.4.1. Cancun safeguard #3

REDD+ social safeguard #3 focuses on ensuring that REDD+ activities respect knowledge and rights of indigenous people and local communities. We operationalize respect for knowledge and rights using three variables: was customary land burning undertaken in the village to start an agricultural business; was there a change of non-agricultural lands to non-irrigated agricultural lands (extensification); and was there a change of non-irrigated agricultural lands to paddy cultivation (intensification). We feel these are important indicators of land use and allocation policies with respect to observance of local rights and broader regulatory frameworks surrounding land use in Indonesia

[6] Bootstrap tests are done with samples of 1000 for determining *p*-values. KS is a non-parametric test that compares the cumulative distribution of two datasets and explore whether they are significantly similar or different.

[7] Except for the percent involvement of people in agriculture.

[8] Due to paucity of data, we used the same matching variables (invariant, 2005 PODES) for both pre and post periods except average percent tree cover loss.

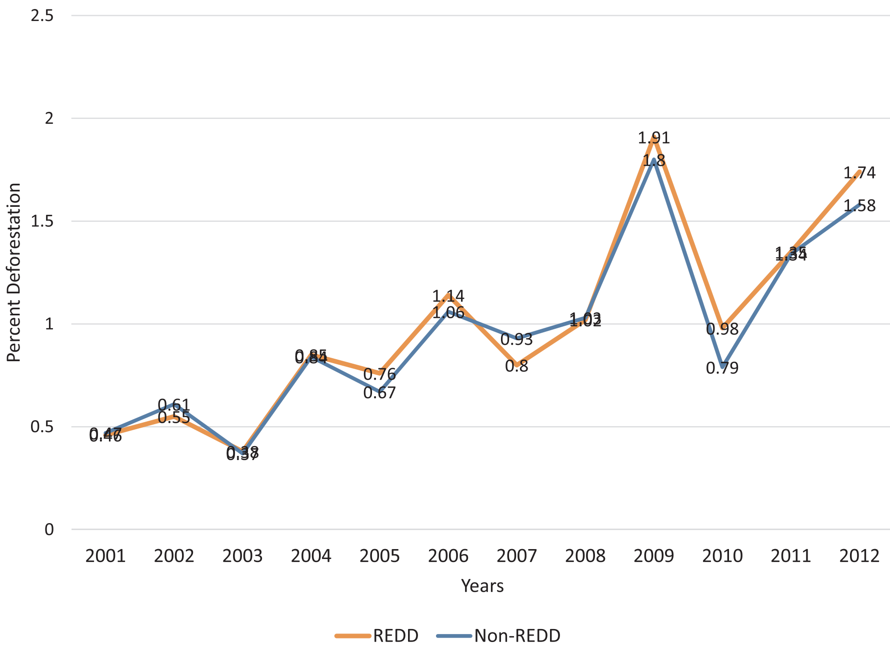

Fig. 3. Deforestation rates (2001 to 2012) in REDD+ and non-REDD+ villages (color).

Table 2
Descriptive statistics for safeguard indicators at baseline and midline.[1]

Safeguard	Indicator	Baseline (2008) Mean (st. dev.)	Baseline (2008) Range	Midline (2011) Mean (st. dev.)	Midline (2011) Range
SG#3, Respect for rights	Customary land burning in the village to start agricultural business (0 = No; 1 = Yes)	0.27 (0.44)	0 – 1	0.46 (0.49)	0 – 1
SG#3, Secure property rights	Change of non-agricultural lands to non-irrigated agricultural lands for past year (extensification) (0 = No; 1 = Yes)	NA	NA	0.09 (0.29)	0 – 1
SG#3, Secure property rights	Change of non-irrigated agricultural lands to paddy cultivation for past year (intensification) (0 = No; 1 = Yes)	NA	NA	0.08 (0.26)	0 – 1
SG#5, Human welfare	The number of poor letters/SKTM issued (past year, count)	29.31 (58.49)	0 – 707	32.5 (85.4)	0 – 1958
SG#5, Human welfare	The number of people receiving JAMKESMAS/JAMKESDA cards (past year, count)	115.05 (198.07)	0 – 3312	323.5 (733.7)	0 – 15536
SG#5, Human welfare	Majority of households using LPG as dominant fuel in a village (0 = No; 1 = Yes)	0.005 (0.07)	0 – 1	0.12 (0.32)	0 – 1
SG#5, Human welfare	Presence of mobile phone service in the village (0 = No; 1 = Yes)	0.12 (0.33)	0 – 1	0.14 (0.35)	0 – 1
SG#5, Human welfare	Presence of internet in the village (0 = No; 1 = Yes)	0.03 (0.18)	0 – 1	0.12 (0.29)	0 – 1
SG#5, Biodiversity	Tree cover loss, percent	1.03 (2.06)	0 – 26.1	1.34 (2.31)	0 – 43.5
	N	2223		2223	

[1] All variables at village-level. Sources are: Hansen et al. (2013) for tree cover, and PODES (2008, 2011)PODES (2008, 2011) for all other variables. NA = Not available.

(Brockhaus et al., 2012).

We hypothesize that if REDD+ initiatives respect rights then *de facto* rights surrounding customary land burning will be positively associated with REDD+, and altering land use, an expression of secure property rights (Galik and Jagger, 2015) will also be positively associated with REDD+. However, we note that continued land burning and extensification of agricultural lands do not support the carbon sequestration outcomes REDD+ seeks to achieve. Customary land burning as an agricultural practice signals respect for indigenous/local rights or the ability of local people to exercise *de facto* land rights. Both the Government of Indonesia and District governments have strict laws that disallow land burning in forested areas (Glover and Jessup, 2006; Tacconi and Ruchiat, 2006) by both small-scale farmers and larger-scale actors. However, swidden or slash and burn systems are the dominant form of smallholder agriculture in Kalimantan, and integral to Indonesia's shifting cultivation system. Continued use of this practice within a community suggests that local use rights are being observed, even though they may diminish the net impact of REDD+ on avoided deforestation (Kallio et al., 2016). A competing hypothesis is that land burning and shifting non-agricultural land to extensively managed systems will be negatively associated with presence of a REDD+ project. Enhanced awareness brought about by REDD+ may increase clamor about land rights, which may lead some people to establish agricultural lands triggering expansion into forest frontier, establishing new lands for agriculture.

2.4.2. *Cancun safeguard #5*

Cancun safeguard #5 calls for ensuring that REDD+ avoids the conversion of natural forests and ensures that activities conserve forests, biodiversity, and ecosystem services, while enhancing other social benefits. We focus on social benefits including indicators of general well-being, service provision, and livelihood strategies. We also use spatial data indicating percent of tree cover loss as a proxy for biodiversity. Under the basic principles of social safeguards, REDD+ should at a minimum do no harm to local populations. If REDD+ has a neutral effect on the welfare of human populations we would expect none of our models to yield statistically significant estimates. However, REDD+ is frequently touted as a poverty reduction strategy (Locatelli et al., 2010). If REDD+ is in fact having a welfare enhancing function we hypothesize it will be negatively associated with incidence of poverty and positively associated with access to free health services. We use access of local people to two kinds of social welfare programs, poverty certificates (poor letters) which are issued by village leaders to enable people to access social welfare schemes, and medical insurance cards (*Jamkesmas/Jamkesda*). We hypothesize that REDD+ to be positively associated with access to modern energy services including use of LPG in the village (particularly because use of LPG can reduce forest reliance), and presence of communication networks (mobile phone and internet services in the village). This host of welfare indicators reflect the overall well-being of people within the village. We measure the social benefits called for in Safeguard #5 as the ability of local communities to access material resources, especially those that enhance their chances of economic and social empowerment.

3. Results

3.1. Cancun safeguard #3

Our estimation of average treatment effect (ATE) suggests that REDD+ has had a positive and weakly significant impact on the prevalence of customary land burning at the village-level (Table 3(a)) . Using genetic matching with 1:1 matching we also find a positive and statistically significant effect of REDD+ on customary land burning. This effect is not robust across our different estimation strategies. For our full sample using DID estimation we find a highly significant negative effect of REDD+ on customary burning. When we decompose ATE by province (Table 3(b)) we find that in West Kalimantan the incidence of customary burning has declined, whereas in East Kalimantan it has increased. Our results may reflect different monitoring and enforcement capacity across provinces.

We consider two variables operationalizing land use change as reflective of security of property rights: transitioning non-agricultural lands to non-irrigated agricultural lands (extensification), and changing non-irrigated agricultural lands to paddy cultivation (agricultural intensification). We do not find any evidence of REDD+ impacting the transitions from non-agricultural lands to non-irrigated agricultural lands. Using genetic matching we do find that REDD+ has a positive and statistically significant effect on intensification of agricultural systems. Agricultural intensification both implies security of property rights and is a mechanism for reducing deforestation; it negates or reduces the need to convert forest to agricultural land. In our estimation of ATE, we find that in Central Kalimantan REDD+ has increased conversion from non-irrigated agricultural lands to paddy cultivation, suggesting agricultural intensification has taken place as a result of REDD+. This may suggest a positive influence of REDD+ on securing local property rights.

3.2. Cancun safeguard # 5

We find that the number of poor letters issued in REDD+ villages in Kalimantan has increased. This may suggest that either the poverty has increased or these letters have been now issued more frequently because of increased possibility of accessing services. We expect that increased awareness of rights due to the REDD+ may lead people to seek more of such cards to access state services meant for poor. Our results are fairly robust to alternate estimation strategies. When we decompose our sample by province we find that the ATE for Central Kalimantan is positive and statistically significant. We find that REDD+ has a significant and negative ATE on the availability of medical insurance cards, which grant people access to free medical services from government hospitals. As for poor letters, this finding is relatively robust to alternative estimation strategies and when we decompose the sample at the provincial level. This suggests that overall people access to health care services had declined. Next, we consider the type of cooking fuel people use, which reflects their reliance on forests for household energy as well as local supply of modern fuels (i.e., LPG); assuming type of fuel used is an indicator of wealth or overall socioeconomic status (Andadari et al., 2014), and also an indicator of reduced reliance on natural resources (Lee et al., 2015). We find that REDD+ has highly significant and negative ATE on the use of liquid petroleum gas (LPG) as cooking fuel across Kalimantan as a whole and at the provincial level. These results suggest that REDD+ has not yet led to a shift away from use of fuelwood to LPG. For communication services we use indicators of the presence of phone communication and internet in the village. We find that REDD+ villages in Kalimantan as a whole, and in East Kalimantan are significantly less likely to have access to phones and internet when compared with non-REDD+ villages. While we hypothesize that REDD+ interventions may increase incomes leading to changes in economic well-being of people, in turn leading to increased demand for mobile phone and internet services, we do not observe this in our analysis.

We consider objectively measured tree cover loss as a rough proxy for biodiversity (SG#5). Our estimates are not particularly robust, but suggest that at best REDD+ is not having a positive effect on biodiversity. Using 1 to many genetic matching we estimate a positive and statistically significant relationship between REDD+ and tree cover loss. To the extent that tree cover is a reasonable proxy for biodiversity, we find that REDD+ has a neutral or negative impact on biodiversity. REDD+ may lead to tree cover loss in its initial years due to forest conversion related to construction of office infrastructure, roads, people's reaction to scale-up of reduced deforestation activities (e.g., in anticipation of strong legal enforcement by state agencies after REDD+ etc.)

4. Discussion

Our overarching objective in this paper is to identify an approach for REDD+ SIS that is relatively low cost, rigorous, and sustainable. In the spirit of demonstrating the potential for using existing data to evaluate social impacts, we reviewed several publicly available spatial and socioeconomic datasets paying particular attention to several issues. Paramount among them is the ability to find good indicators that operationalize REDD+ safeguards. For some indicators (e.g., service provision, overall poverty status) data were readily available, whereas for others (e.g., corruption, governance, participation in REDD+ design and implementation) there were few or no easily identified indicators. We also considered other important issues including geo-referencing, scale, missing or incomplete data, etc. While publicly available data have limitations, notably the lack of representativeness after accounting for missing data, we nevertheless suggest several variables suitable for operationalizing the social safeguards articulated in Cancun.

We demonstrate the potential for impact evaluation methods to be used in the evaluation of REDD+. Impact evaluation methods are appealing because they focus squarely on attributing observed outcomes to a specific project or policy intervention. Since REDD+ implementation generally precludes the use of randomized assignment to treatment groups and, therefore, the use of randomized control trials, we advocate for the next strongest design (with respect to internal validity): a quasi-experimental design to estimate average treatment effects in villages with REDD+ activities. To establish a control group of villages that best mirrors the intervention group, we use propensity

Table 3
(a) Estimation of impact of REDD+ activities in Kalimantan.[1] (b) Average treatment effects of REDD+ activities, decomposition to provincial level.

(a)

Safeguard	Variable description	Average treatment effect (ATE)	DID[1] (T1-T0)-(C1-C0)		Genetic matching (ATE)	
		Matched sample	Full sample	Matched sample (1:1)	Full sample	Matched sample (1:1)
SG3, Respect for rights	Customary land burning in the village to start agricultural business (0 = No; 1 = Yes)	0.08*	−0.2***	−0.13	0.03	0.10***
		(0.04)	(0.05)	(0.09)	(0.02)	(0.03)
SG#3, Secure property rights	Change of non-agricultural lands to non-irrigated agricultural lands for last one year (extensively managed agriculture) (0 = No; 1 = Yes)[2]	0.02	–	–	−0.02	−0.01
		(0.03)			(0.01)	(0.02)
SG #3, Secure property rights	Change of non-irrigated agricultural lands to paddy cultivation for last one year (intensification) (0 = No; 1 = Yes)[2]	0.02	–	–	0.06***	0.04**
		(0.03)			(0.01)	(0.01)
SG#5, Human welfare	The number of poor letters/SKTM issued in past year	15.8*	14.3	24.18	13.8***	28.54***
		(8.9)	(9.79)	(18.80)	(3.8)	(6.83)
SG#5, Human welfare	Number of people receiving *JAMKESMAS/JAMKESDA* cards in past year	−95.9**	−99.34	−63.45	−108.48***	−154.68***
		(50.8)	(77.14)	(116.58)	(25.2)	(45.07)
SG#5, Human welfare	Majority of households using LPG as dominant fuel in the village (0 = No; 1 = Yes)	−0.09***	−0.006	−0.19**	−0.06***	−0.12***
		(0.03)	(0.02)	(0.03)	(0.01)	(0.02)
SG#5, Human welfare	Presence of mobile phone service in the village (0 = No; 1 = Yes)	−0.08***	−0.05	−0.07	−0.07***	−0.06***
		(0.03)	(0.04)	(0.05)	(0.01)	(0.02)
SG#5, Human welfare	Presence of internet in the village (0 = No; 1 = Yes)	−0.06**	−0.05	−0.09*	−0.05***	−0.07***
		(0.03)	(0.03)	(0.05)	(0.01)	(0.01)
SG#5, Biodiversity	Tree cover loss, percent	0.08	0.17	0.22	0.38***	0.13
		(0.7)	(0.21)	(0.32)	(0.10)	(0.19)
	Sample size	T = 249	T = 498	T = 498	T = 232	T = 249
		C = 249	C = 3948	C = 498	C = 1415	C = 249

(b)

Safeguard	Variable description	Average treatment effect (ATE)		
		West	Central	East
SG#3, Respect for rights	Customary land burning in the village to start agricultural business in 2011 (0 = No; 1 = Yes)	−0.15**	−0.02	0.28***
		(0.08)	(0.1)	(0.06)
SG#3, Secure property rights	Change of non-agricultural lands to unirrigated agricultural lands for last one year in 2011 (extensively managed agriculture) (0 = No; 1 = Yes)	−0.06	−0.08	0.07
		(0.05)	(0.08)	(0.05)
SG#3, Secure property rights	Change of non-irrigated agricultural lands to paddy cultivation for last one year in 2011 (intensification) (0 = No; 1 = Yes)	−0.04	0.17**	0.01
		(0.06)	(0.08)	(0.04)
SG#5, Human welfare	The number of poor letters/SKTM issued in 2010	15.4	30.29**	4.44
		(9.7)	(13.55)	(15.55)
SG#5, Human welfare	Number of people receiving *JAMKESMAS/JAMKESDA* cards in 2010	−249.1*	−34.96	−95.94
		(146.01)	(82.51)	(100.99)
SG#5, Human welfare	Majority of households using LPG as dominant fuel in the village in 2011 (0 = No; 1 = Yes)	−0.13**	0.05	−0.15***
		(0.06)	(0.04)	(0.06)
SG#5, Human welfare	Presence of mobile phone service in the village in 2011 (0 = No; 1 = Yes)	−0.04	0.04	−0.13***
		(0.05)	(0.06)	(0.04)
SG#5, Human welfare	Presence of internet in the village in 2011 (0 = No; 1 = Yes)	−0.03	−0.008	−0.12***
		(0.06)	(0.05)	(0.04)
SG#5, Biodiversity	Tree cover loss, percent	0.13	1.04	0.06
		(0.26)	(0.09)	(0.31)
	N	T = 74	T = 43	T = 132
		C = 74	C = 43	C = 132

[1] We assume similar pre-treatment matching variables define the trajectories of social safeguard indicators for treatment and control groups. Also, as the Early REDD+ initiatives are mostly imposed by external agents on selected villages so causal effects only corresponds to these villages. The matching variables include experience with protected area prior to 2007, average tree cover loss from 2001 to 2006, experience with logging concessions prior to 2007, experience with wood fiber plantations prior to 2007, area of the village, experienced fire from 2002 to 2005, households involved in agriculture in 2005, transportation on soil roads in 2005, mean elevation of village and distance from the capital of sub-district of the province in 2005. For details of these matching variable and their balance before and after matching, see Table S3 in Supplemental Material.

[2] Data for change of non-agricultural lands to non-irrigated agricultural lands were not available for 2008.

score matching on a number of observable covariates.

Our analysis demonstrates several limitations of this approach to evaluating social safeguards. First, scaling-up our findings is not straightforward. Due to data limitations our results are based on a limited subset of villages in Kalimantan that are by our assessment significantly different than villages we are missing data for. Second, our approach lumps all REDD+ related activities together, whereas in reality there is a high degree of heterogeneity in REDD+ interventions. Our theory of change does not have a high degree of specificity at aggregate scale. This is in part because REDD+ activities are highly varied (e.g., direct payments to households vs. in-kind investment in community infrastructure). Further, we note that we are unable to control for other development activities taking place in our study villages. While we match villages based upon variables that we believe are proxies for likely investment in development (e.g., households involved in agriculture, distance to major markets/roads) we acknowledge that we are missing a complete picture of other potential village interventions that could affect REDD+ social safeguard outcomes. Third, we assume that we have been able to control all confounders that explain the outcomes of early REDD+ activities and it is therefore, only REDD+ assignment causing the changes in observable outcomes. Fourth, our findings indicate quantitative effects of early REDD+ activities but fail to provide causal explanations. In order to fully understand the theory of change underlying observed impacts, local validation is required. For example, we are currently unable to provide a reason why there are more poverty cards issued in REDD+ villages but reduced access to free public medical care. Irrespective of the above assumptions and limitations, we contend that our study demonstrates the feasibility of analyzing the causal effects from early REDD+ initiatives on governance, social welfare, and livelihood indicators.

Finally, we address the issue of sustainability of REDD+ SIS. This is particularly important because REDD+ requires medium- to long-term agreements for reducing deforestation and forest degradation. Monitoring the social impacts of REDD+ also requires a long time frame, preferably using indicators and methods that allow impacts to be tracked consistently and at regular intervals. Creating a sustainable method of evaluation is also important given the low likelihood for sufficient REDD+ SIS funding to emerge and be maintained over time. In light of these two realities, we advocate using ongoing national-scale population representative surveys to monitor some, or even all, REDD+ social impacts. We have demonstrated the feasibility of that in Kalimantan, Indonesia. As we have noted, some surveys are not up to the task due to lack of appropriate questions, missing data, data quality etc., but there is potential. Policy makers can advocate for the inclusion of REDD+ related questions on important safeguard issues including participation, free prior and informed consent, tenure security, etc. Going a step further to integrate social safeguards MRV with carbon MRV would allow for analysis of trade-offs and synergies, a perennial concern for conservation and development projects and policies. Challenges in analyzing trade-offs and synergies in quantitative assessment of the impacts of REDD+ may include balancing the usefulness of uniform and coarse indicators of safeguard data collection at the national-level with the fine resolution and high-quality data likely required to understand causal mechanisms operating at local scale. This suggests that in order to have a common framework to track REDD+ safeguard impacts at national level, countries should invest resources to plan and implement efficient and appropriate data collection and monitoring formats. These data collection protocols should not only assist policy makers in eliciting useful estimates about the short-term and long-term impacts of REDD+, but also provide some useful information and evidence related to causal explanations and plausible theories of change by incorporating the local contextual information.

5. Conclusions

The design and implementation of SIS for REDD+ is critically important to evaluating the performance and success of forest-based climate mitigation policies and projects. We argue for the rigorous evaluation of social safeguards given their role in the wider discourse of how REDD+ is designed and legitimized (Krause and Nielsen, 2014). We used a subset of 18 early REDD+ projects in Kalimantan to demonstrate that evaluation of some rights and social impacts of REDD+ projects is possible using already available socioeconomic and spatial data. Our analysis suggests that REDD+ activities taking place in Kalimantan are doing a reasonably good job of upholding rights, and are potentially having a negative effect on human welfare. Our analysis provides an early indication of the social impact of REDD+ in Kalimantan and whether it is successfully adhering the principles of Cancun REDD+ social safeguards #3 and #5. Due to data limitations our analysis is restricted to evaluating only these two social safeguards. A comprehensive analysis of the social impacts of REDD+ should include analysis of sociopolitical impacts among others (Ghazoul et al., 2010).

We have demonstrated the operationalization of REDD+ social safeguards using publicly available social and spatial data, and used impact evaluation methods to demonstrate how REDD+ social impacts can be rigorously evaluated in a setting where REDD+ activities take place at both project and jurisdictional levels. We feel that drawing on publicly available data and using methods that seek to establish a counterfactual scenario for attributing impacts is critical for three reasons. First, the tools of impact evaluation mirror reference level or business-as-usual approaches used to attribute changes in greenhouse gas emissions to REDD+. Establishing a parallel framework to evaluate REDD+ seems like a logical approach and could possibly allow for an assessment of trade-offs and synergies between climate and welfare outcomes. Second, all indications are that very limited funds are available for the development of rigorous safeguard information systems. Designing a relatively low cost system for REDD+ SIS is critical if the social impacts of REDD+ are going to be legitimately evaluated in coming years. Third, despite limitations of our data and approach explained above, building a safeguard information system around ongoing institutionalized data collection initiatives has tremendous benefits. It ensures that REDD+ social impacts can be effectively and consistently monitored over time given appropriate data. This in turn has implications for the legitimacy and effectiveness of REDD+ (Visseren et al., 2012). The method has been demonstrated and can be applied in other sub-national and national cases. However, the main requirement in such cases is appropriate geo-referenced time-series data on a suite of indicators that can be used to meaningfully operationalize social safeguard indicators, and data on covariates and potential confounders. We emphasize that most countries building REDD+ programs have established systems of data collection on socioeconomic indicators. By making well thought out additions focused on key indicators of REDD+ social impacts a robust social MRV system for a country can be established.

An important and final point is that we do not advocate for the approach put forward in this paper to preclude other forms of data collection, monitoring, and evaluation that could be instrumental in understanding local impacts of REDD+ (see Jagger et al., 2010 and Lawlor, 2013 for overviews of monitoring and evaluation strategies). McDermott et al. (2012) correctly point out that the choice of organizations defining, funding and verifying safeguard activities are likely to influence the relative emphasis on different safeguards. Overlapping systems of social safeguard verification will ensure a robust and accountable MRV system for both social and environmental MRV. Never-the-less, we echo Caplow et al. (2011) and Corbera and Schroeder (2011) that examination of the social and environmental outcomes of REDD+ should integrate locally informed monitoring and evaluation techniques and use robust counterfactual methods.

Acknowledgements

We are grateful to the Center for International Forestry Research (CIFOR) for supporting this work. We are also grateful to the Carolina Population Center (P2C HD050924) at The University of North Carolina at Chapel Hill for general support. We also wish to thank the Indonesia Bureau of Statistics and the Duke University Library for their willingness to share the PODES data with us. We are grateful to Paul Treacy and Ryan McCord for research assistance on this project. The opinions

expressed herein are those of the authors and do not necessarily reflect the views of the sponsoring agency.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2017.06.006.

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