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LETTER

Can conservation funding be left to carbon finance? Evidence from participatory future land use scenarios in Peru, Indonesia, Tanzania, and Mexico

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Abstract

Revenues derived from carbon have been seen as an important tool for supporting forest conservation over the past decade. At the same time, there is high uncertainty about how much revenue can reasonably be expected from land use emissions reductions initiatives. Despite this uncertainty, REDD+ projects and conservation initiatives that aim to take advantage of available or, more commonly, future funding from carbon markets have proliferated. This study used participatory multi-stakeholder workshops to develop divergent future scenarios of land use in eight landscapes in four countries around the world: Peru, Indonesia, Tanzania, and Mexico. The results of these future scenario building exercises were analyzed using a new tool, CarboScen, for calculating the landscape carbon storage implications of different future land use scenarios. The findings suggest that potential revenues from carbon storage or emissions reductions are significant in some landscapes (most notably the peat forests of Indonesia), and much less significant in others (such as the low-carbon forests of Zanzibar and the interior of Tanzania). The findings call into question the practicality of many conservation programs that hinge on expectations of future revenue from carbon finance. The future scenarios-based approach is useful to policy-makers and conservation program developers in distinguishing between landscapes where carbon finance can substantially support conservation, and landscapes where other strategies for conservation and land use should be prioritized.

Introduction

Reducing greenhouse gas emissions from agriculture, forestry, and other land uses is a growing priority as part of a global strategy for mitigating climate change, particularly in the wake of the climate agreement at the December 2015 Conference of Parties in Paris. Across landscapes (defined broadly for the purposes of this article as well-defined geographic areas of various sizes with multiple land uses), decisions about land use have implications for carbon emissions and storage. Global initiatives like REDD+ (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) have explicitly sought to reward reductions in emissions from land use changes such as deforestation and forest degradation. Outside of the explicit remit of REDD+, national and voluntary carbon markets are aiming to do the same. A number of the countries that are signatories to the Paris agreement include land- and forest-based commitments in their Intended Nationally Determined Contributions (INDCs) to reductions in greenhouse gas emissions[5].

To varying degrees, individuals, organizations, and initiatives that work at the intersection of land use and climate change have favored carbon markets as critical mechanisms to support emissions reductions (Lederer 2012, Martius *et al* 2015). Proponents of carbon markets have argued that such funding is needed to sustain emissions reductions from land use, as grants or other funds will be insufficient (Angelsen *et al* 2012). Also, proponents argue, market mechanisms

[5] Information on INDCs compiled by WRI in the Climate Data Explorer: http://cait.wri.org/indc/.

are uniquely positioned to catch the eye and capture the imagination of the private sector (IETA 2014), which is required, many argue, if we hope to see a global sea change towards low-emissions land uses (de Sassi *et al* 2014). A robust and well-designed global carbon market is, according to such proponents, an optimal instrument for efficiently allocating emissions reductions from land use (and, indeed, other sectors) across private and also public actors around the world.

Criticisms of carbon markets as instruments of low-emissions development rest on multiple lines of reasoning. Some oppose the commodification of carbon altogether, considering it morally objectionable (Collard and Dempsey 2013, Leggett and Lovell 2012, Page 2013, Stephan and Paterson 2012), or believe it will lead to decisions made based on carbon, or profits, alone, without consideration of local livelihoods or equity (Benessaiah 2012, Corbera and Brown 2010, Kosoy and Corbera 2010). Others fear that market-based approaches to conservation, and especially offsets may lead to 'green-washing' with companies justifying large emissions in other sectors by marginal reductions through forestry and other land use activities (Pearse 2012, Polonsky and Garma 2008, Polonsky *et al* 2010).

Still others stress that the effectiveness of even a well-designed global carbon market is ultimately constrained by the domestic policy commitments to emissions reductions that accompany it (Green *et al* 2014). Unless countries impose serious caps on emissions that require costly compliance from their private sectors, even the most institutionally robust carbon market will not lead to the desired low-emissions development outcomes. As movement towards meaningful caps that would generate high global carbon prices has been slow, this latter line of thinking leads to the conclusion that carbon markets —and indeed all kinds of performance-based payments conditioned on carbon emissions reductions— will be inadequate to the task of meaningfully contributing to climate change mitigation.

In this paper, we assess these latter concerns about carbon markets, and performance-based payments that focus on carbon emissions reductions, by examining the potential of specific landscapes to generate carbon revenues. We ask, with the growing importance of climate change on the global agenda, should carbon now be the centerpiece of conservation initiatives? To what extent does the potential for carbon emissions reductions from land use justify the priority focus that funding from carbon markets has received in initiatives like REDD+? We address these questions by examining the impact of plausible land use futures on carbon, and by extension, the potential revenue that could reasonably be generated in landscapes under distinct, plausible but possibly extreme, future scenarios of land use. The research presented here provides preliminary answers for specific landscapes, based on eight participatory workshops undertaken in four countries (Peru, Indonesia, Tanzania, and Mexico) to explore future land use scenarios.

We first briefly discuss the workshop methodology and the landscapes that we worked in. Next, we analyze the future scenarios that emerged from the workshops, highlighting their carbon storage and emissions implications. Finally, we discuss these findings in the context of the broader carbon-market and performance-based payment agenda, finding support for the position that carbon-based payments for conservation, delivered through markets or otherwise, are likely appropriate in some places but not in others. We suggest that our workshop methodology is a useful tool for distinguishing between such landscapes, and thus for decision-making and policy. Given that some landscapes without much real potential for carbon emissions reductions have been targeted by REDD+ interventions aiming to generate revenues from carbon markets, we suggest that decision-makers have underappreciated these distinctions.

Methods

Participatory workshops

We conducted eight participatory workshops in two landscapes in each of four countries: Peru, Indonesia, Tanzania, and Mexico. In order to generate future scenarios of land use, we convened actors from multiple levels of governance and land use sectors (such as agriculture, forestry, and protected areas management) who were familiar with and active in each landscape. These landscapes were located within regions that had been studied as part of related research on multi-level governance and the politics of land use (see Ravikumar *et al* 2015 for a detailed description of this research) and were selected for the workshops because they fulfilled three main criteria: (1) they were geographically well-defined areas with known local contacts established through previous CIFOR research, (2) they had a mix of land uses, including initiatives aimed at forest conservation or sustainable forest management, as well as activities associated with deforestation and forest degradation such as oil palm, mining, or agricultural expansion, and (3) relatively current land use and carbon density data was available for these varied land use classes.

Geographical areas with a mix of land uses meant there were diverse actors with an interest in or influence over the landscapes. These included local communities, NGOs, private firms, and multiple government agencies from the local to the national level, including environment, forestry, mining, and agricultural offices. Our objective was to obtain the participation of at least one representative from each of these groups.

The two-day workshops used a participatory methodology to develop future scenarios of land use in the landscape. For further details on this approach see (Ravikumar *et al* 2014). Broadly, our approach involved the following steps[6]:

1. Prior to the workshops, generate a detailed and accurate land use map of the landscape of interest, using available data. These data were generally provided by local NGOs and partners who had conducted remote sensing studies recently.
2. During the workshops, draw on the experience of participants to construct a timeline of key events that affected land use in the landscape over the past 30 years. This served to establish a common understanding of the relevant history of the landscape, and also to identify the types of factors that have driven change in the landscape in the past. These past events informed participants' thinking about what might be important in the future. Policy changes, migratory movements, major climatic events, and commodity booms were generally important across landscapes, with different specific histories in each landscape.
3. Break up into 'homogeneous' groups, with actors from similar levels of government, sectors, or interest groups (e.g. environmental NGOs, government forestry sector officials, local community members) to identify 4–5 'factors of change'—variables that are likely to have a significant impact on the landscape in the future.
4. Collectively identify 4–5 factors that the group agrees are likely to be important—that is, to have a profound impact on land use in the landscape—and also uncertain—that is, difficult to predict into the future. Factors ranged from population growth, to migration, to commodity prices, to the future evolution of a robust global carbon market, to changes in rights and tenure regimes. Facilitators asked participants to identify potential future 'states' or directions of change for each factor. For example, if participants selected the price of an agricultural commodity as a factor, the future state of the price could be higher, lower, or similar to the current price.
5. Workshop organizers combine the factors in diverse ways to present four very general future states of the landscape that the participants need to flesh out and describe in detail. This involved selecting distinct states of each factor in a matrix, assessing holistically what a particular mix of factor states might look like qualitatively, and adjusting the states of the factors in the matrix to maximize the diversity of future scenarios. In general, among the four scenarios, the organizers sought to identify two that represented plausible extremes and one that represented 'business-as usual'. Participants provided feedback on whether or not these scenarios were internally consistent and plausible. See appendix A available at stacks.iop.org/ERL/014015/mmedia for a detailed outline of all scenarios that were elaborated across landscapes.

[6] The methodology was designed and adapted in part based on discussions with researchers from the CGIAR program on Climate Change and Food Security (CCAFS), who had used a similar methodology previously in very large multi-country regions.

The goal of constructing scenarios was to capture extreme but plausible future land use change trajectories for each landscape. Eliciting detailed feedback from the expert participants was critical in achieving this. There were three steps that we undertook to ensure that the scenarios selected for analysis did indeed represent the plausible range of future variation for the landscapes.

First, participants themselves identified plausible states for each factor of change in break-out groups within the workshops (see Step 4 above). This allowed the workshop facilitators to ascertain what each factor might look like in the future, independently, based on the input of local experts.

Second, the workshop facilitators proposed different mixes of factor states that seemed likely to produce highly *diverse* scenarios. Ultimately, the participants would determine just how diverse the land use change outcomes would be in each scenario through the subsequent analysis, but the facilitators nevertheless sought to ensure highly varied results. This was accomplished by producing a mix of states of factors that, based on experience and reviews of the literature, would likely produce high emissions and also low emissions. For example, policies favoring roads and infrastructure are known to be associated with deforestation, as are high commodity prices. Thus, one scenario might combine high commodity prices with roads and infrastructure, while another combines less support for roads and infrastructure with low commodity prices.

Third, and crucially, we solicited extended feedback from participants in plenary about these scenarios, asking them to assess (1) how plausible and coherent the mix of factors are, and (2) whether or not the scenarios seem on face to reflect the diversity of plausible scenarios for the landscape, understanding that further in-depth analysis was to emerge from the subsequent activities. In particular, we asked participants to consider critically the 'negative space' in the scenarios—that is, were there any combinations of factor states that were *not* reflected in the scenarios that we selected that *should* be included. Suggested modifications were then incorporated prior to analysis.

6. Form groups with a mix of the different stakeholder groups represented in each, with each group describing a narrative for how the landscape might reach one future state, developing a qualitatively defined 'future scenario.' See appendix B for some examples of these scenario narratives.
7. Finally, participants draw on a map to indicate how specific land uses would likely change over time. The maps were overlaid in advance with a grid, with each square of known size. The number of squares that changed from one land use class to each other land use class was counted manually by participants and double checked by facilitators within the workshops themselves. These counts were then input directly into the CarboScen tool (described below). See appendix B for examples of these maps.

To compute the carbon implications of these future scenarios we developed a carbon calculation tool called CarboScen. CarboScen calculates changes in landscape carbon storage associated with specific projected changes between different land use classes over time. The user sets the initial land areas of each land use class, and inputs the changes between land use classes based on the scenarios that emerged from the workshops. Carbon densities (Mg/ha) depend on past land use, current land use and time since land use change. Carbon densities are assumed to approach an equilibrium value asymptotically. These values are set by the user and typically vary depending on the land use. Because local information on speeds of land use changes are rarely available, these values are usually set based on studies covering larger areas (Poeplau *et al* 2011, Wei *et al* 2014). CarboScen is described in more detail in Larjavaara *et al* (2017), and further information and citation protocols are provided in appendix D.

For this study we applied the same methodology for each of the landscapes. We obtained the initial land use areas used in the workshops from the land use class maps prepared by NGOs or partners, while land use changes were obtained from the scenario-based drawings created by participants on the printed maps. To parameterize CarboScen, we compiled a dataset of carbon densities for the land use classes and set the rate at which carbon densities change as land use changes. Typically the carbon density data came from multiple previous field studies that were conducted around the landscape, from which a weighted mean was computed based on the assessed reliability and geographically relevant validity of each study.

The goal of the exercise was not to predict rigorously exactly how a particular factor will change land use in the future. Indeed, such predictions are very difficult and not necessarily useful. It would be very difficult to predict exactly how many additional hectares of Amazonian forest will be lost due to a particular increase in the global price of oil palm, for example. When other factors like conservation policies are mixed in, any quantitative modeling exercise becomes further complicated and unreliable. Thus, we leveraged the expertise of local people with experience in the specific landscape to provide an educated estimate of how different future scenarios of land use might realistically look, given the ecological, economic, political, and cultural characteristics of the landscape.

There are two important limitations of this methodology. The first limitation is related to the politics of decision-making. While this approach is effective in capturing a range of plausible future land use scenarios, it cannot capture all of them. Including a range of actors operating at different levels and in multiple sectors is beneficial in providing a diversity of perspectives on the landscapes, however, politically sensitive topics may nevertheless be subdued, even if they might have an impact on land use. For example, plausible scenarios involving massive sell-offs of land due to corruption may not arise, even if they are conceivable.

The second limitation is technical. The carbon calculator tool that was deployed is finally only as accurate as the available landscape carbon data. In many of the landscapes, rigorous studies of the carbon content of different land use classes are either very new, rather sparse, or have been carried out using very different methods. Nevertheless, we can see from a sensitivity analysis in the case of Indonesia, where carbon density estimates vary considerably between studies, that the broader conclusions of this study still hold (see appendix E).

Nevertheless, bringing this diversity of actors together in multiple landscapes around the world has produced new knowledge of what these different landscapes might look like in the future, and provided novel information about their range of plausible carbon outcomes. The data collected in the workshop allows a holistic estimation of plausible future land use changes based on deep local expertise. This permits us to examine the potential carbon benefits of different activities in these landscapes and to reflect critically on the priority given to monetizing carbon in conservation discussions.

The Landscapes

Figure 1 shows the location of the eight landscapes on the globe. The landscapes varied in terms of their size, mix and distribution of land uses, property rights and land tenure regimes, political economic characteristics, and governance dynamics. Table 1 summarizes the key aggregate characteristics of the landscapes. The main 'factors of change' that participants identified as likely to affect deforestation and land use change in the landscape are also listed, along with notes on the nature of the landscapes.

Table 1 shows the factors of change that participants agreed would be of great importance and also highly uncertain in their landscape. These factors vary considerably, ranging from fairly measurable market

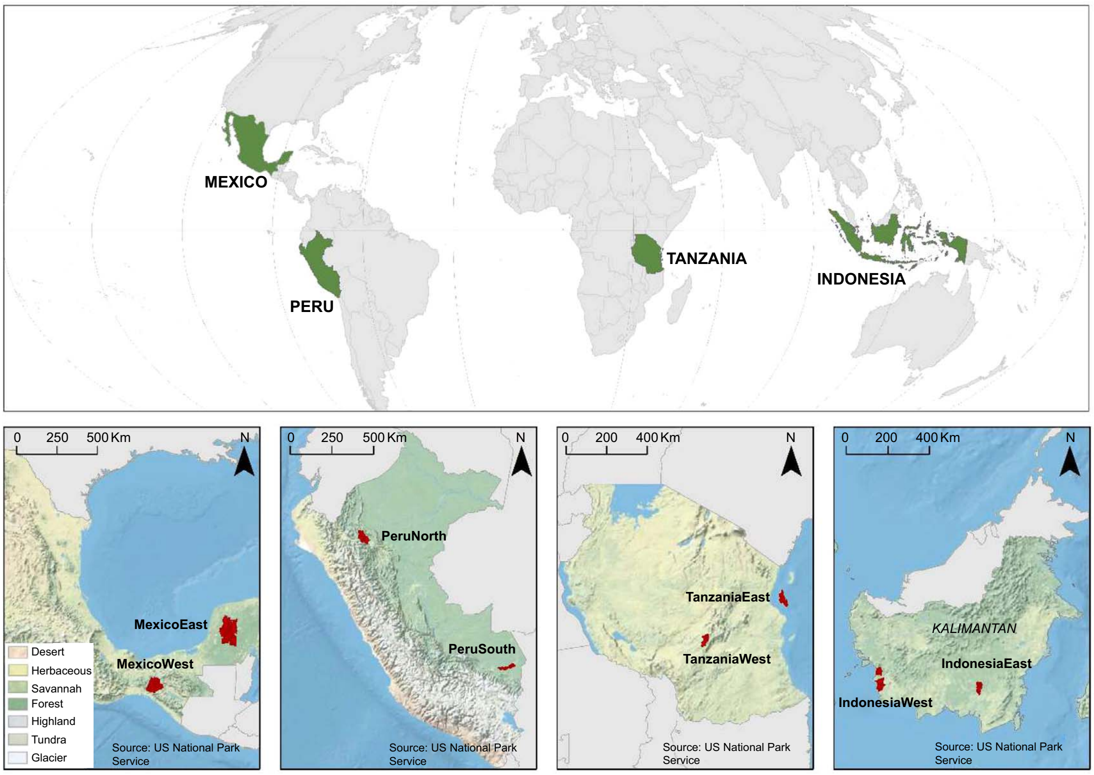

Figure 1. Location of the study landscapes on the Earth and within countries.

conditions such as specific commodity prices to factors such as regional government policies that are more complicated to characterize and measure. Nevertheless, participants had a clear view of how these factors might change over time, and what implications such changes could have for land use. For example, in the Tanzanian landscape in Iringa district, 'subsidies and policy priorities' largely referred to subsidies and support for the forestry sector. Alternative scenarios used both higher and lower levels of such subsidies.

In comparison, in the Peruvian landscape in San Martin region, 'regional government priorities' largely referred to whether the government would choose to favor cash crops and agriculture via subsidies and other policies, or conservation via engagement with REDD+, regional protected areas, and agroforestry. Again, contrasting scenarios used these opposing 'states' of change. Thus, while factors of change may appear generic in their reported formulation, the workshop methodology ensured a deeper assessment of what each factor might look like in the future in order to facilitate more rigorous scenario development.

Results

Table 2 shows the carbon content of each future scenario landscape, projected 20 years into the future, along with the change relative to the present.

The results show considerable variation across landscapes in absolute terms—some landscapes exhibit great differences in carbon storage between extreme scenarios, while others exhibit only small differences. The degree of absolute variation depends on the starting carbon density of the landscapes. Landscapes with much higher carbon densities—particularly the peatlands of Kalimantan—exhibited much greater potential losses of carbon in future scenarios. In addition, while in some landscapes scenarios ranged from net carbon emissions to net sequestration, in other landscapes—like Central and West Kalimantan—all scenarios were associated with carbon emissions, but to highly varied degrees.

In most of the study landscapes, the percent difference between extreme scenarios in terms of landscape carbon storage was relatively low, ranging from 5 to 13 percent. Madre de Dios stands out as an exception, where the most carbon-rich scenario had 63% more carbon storage than the most carbon-poor scenario. The main factor that will potentially drive deforestation in this landscape, according to participants, is gold mining (see Scullion *et al* 2014 for more information on the profound impact of gold mining in Madre de Dios). While subsequent discussions with participants suggested that the amount of forest loss to mining embedded in the first scenario was very extreme because much of the area is not actually suitable for gold mining, high losses were nevertheless considered plausible. The scenario with the next greatest carbon emissions over time, also largely due to gold mining, still reflected a 26% difference compared to the scenario with the greatest carbon storage.

At the other extreme, the Zanzibar and West Kalimantan landscapes exhibited relatively low percent

Table 1. Location, land area, carbon density (in biomass and soil to a depth of 0.3 m in mineral soils or down to mineral soil in peatlands), land use characteristics and factors of change by landscape. Factors of change were determined by the workshop participants.

Country and landscape designation (based on relative location in country)	Location/ jurisdiction where the landscape is found	Area (ha)	Avg. carbon/ ha (current)	Land use types and landscape characteristics	Factors of change identified by participants
Indonesia (East)	Central Kalimantan province	120,000	4,608	Large REDD+ projects with customary communities. Oil palm is not yet in the landscape, but has proliferated nearby.	• Government regulations • Law enforcement • Land ownership and tenure • Commodity prices • Infrastructure
Indonesia (West)	West Kalimantan province	260,217	1,934	Village forest with local forest management in a region with deforestation driven by oil palm.	• Land tenure clarity • Fire • Land management capacity • Policies and subsidies
Peru (South)	Madre de Dios region	149,637	164	Mostly pristine forest with legal, formal, and informal mining, a protected area, and agriculture. Growing population due to mining.	• Price of gold, government policy • Agricultural commodity prices • Land use rights and tenure • Migration
Peru (North)	San Martin region	280,120	163	Protected area with mostly pristine forest, indigenous communities that have rented out lands, and a REDD+ project focusing on sustainable coffee.	• Regional government policies • Agricultural commodity prices • Incentives for ecosystem services • Regional and local government budgets
Mexico (East)	Yucatan state	1,258,113	151	Mixed use landscape, both subsistence and mechanized agriculture	• Climate change • Government policy priorities • Market prices • Future of REDD+
Mexico (West)	Chiapas state	585,502	95	Protected area with mosaic of land uses, including sustainable development NGO-led projects	• Immigration • Community (*ejido*) governance and power • Decentralization • National policy, • Climate change
Tanzania (East)	Unguja region, Zanzibar (three administrative regions)	166,000	80	Urban landscape with highly developed tourism economy, protected forests, mangroves, and subsistence and commercial agriculture. Very high population density	• Economic policies and investment • Climate change, • Tourism • Population growth • Oil drilling
Tanzania (West)	Iringa district	123,169	63	Mixed-use mosaic landscape with new forest plantations and agriculture	• Population growth • Subsidies and policy priorities, • Climate change, • Commodity prices • Infrastructure • Technology

differences in carbon storage between extreme states in relative terms. However, in West Kalimantan even a small percent difference in carbon per hectare yields high differences in absolute terms due to the high carbon density of the landscape. Conversely, the variation between extreme scenarios in terms of carbon storage in Zanzibar was low in both absolute and relative terms.

Other landscapes exhibited more intermediate disparities between extreme states. As described in table 1 (above), the factors of change that participants identified varied across landscapes, albeit with some commonalities. For example, the future of tourism and urban development was important in Zanzibar, while a range of rural development issues dominated in others. Commodity prices, environmental factors, and politics were generally important, but for different reasons in different places. For example, fire and accelerated oil palm proliferation in Central Kalimantan stands to produce massive changes in landscape carbon, while the future of protected areas and indigenous territories may play a crucial role in the future of the Peruvian landscapes.

Table 2. Landscape scenarios, projected future scenario carbon stock in 30 years (tonnes/ha), and absolute and relative change compared to present day stock (Diff).

Scenario[7]	Peru North (San Martin)	Diff(%)	Peru South (Madre de Dios)	Diff (%)	Indonesia West (West Kalimantan)	Diff (%)	Indonesia East (Central Kalimantan)	Diff (%)	Tanzania East (Zanzibar)	Diff (%)	Tanzania West (Iringa)	Diff (%)	Mexico East (Yucatan)	Diff (%)	Mexico West (Chiapas)	Diff (%)
Scenario 1	156	−7 (−4%)	63	−101 (−61)	1584	−350 (−18)	3812	−795 (−17)	81	1 (1)	67	4 (.1)	149	−1.48 (−1.0)	114	−5.39 (−0.05)
Scenario 2	163	0.3 (0)	132	−32 (−19)	1669	−265 (−14)	4411	−196 (−4)	85	5 (7)	65	1 (.01)	149	−1.78 (−1.2)	119	−0.65 (−0.01)
Scenario 3	147	−15 (−9)	165	2 (−1)	1687	−247 (−13)	4353	−255 (−6)	82	2 (2)	63	0 (0)	153	2.09 (1.4)	120	0.22 (0.00)
Scenario 4	145	−17 (−11)	123	−41 (−25)	1685	−249 (−13)	4054	−554 (−12)	81	1 (2)	63	0 (0)	151	−0.10 (−0.1)	119	−0.65 (−0.01)
Difference between extremes (% difference between lowest and highest carbon scenarios)		**17.7 (11)**		**102.6 (63)**		**102 (5)**		**598.7 (13)**		**4.2 (5)**		**4.2 (7)**		**3.87 (3)**		**5.16 (4)**

[7] Scenario outlines are described in tables in appendix 1.

In Mexico, where mixed use landscapes with forests and both highly mechanized export-oriented production and subsistence agriculture intermeshed, the disparity between carbon implications of extreme scenarios was also small. Even though some scenarios involved seemingly extensive conversion of forests for agriculture, the carbon implications were limited due to relatively unimportant soil carbon density differences between the dominant land uses in the different scenarios, as a high proportion of all landscape carbon in these forests is located in soils.

In Iringa, where there is a mosaic of land uses similar to those found in the Mexican landscapes, the difference in carbon storage between likely outcomes was also limited. Here, unlike in the other landscapes, most plausible future scenarios actually involved additional carbon storage relative to the current condition of the landscape, rather than net carbon losses.

Discussion—can carbon revenues fund conservation and drive development in these landscapes?

Our results have several implications for individuals and organizations involved in decision-making around land use. Overall, we see considerable variation in the range of plausible carbon futures across landscapes. Some landscapes, like those situated over the peat soils of Kalimantan, have tremendous potential for carbon storage and, relative to what would occur if they were to be degraded, emissions reductions. Others, like Zanzibar, have far more limited potential for carbon storage and emissions reductions.

In this context, it is worth reflecting on the justifications for conservation employed in various landscapes, and considering where land use policy that turns on carbon storage makes sense. Our results suggest that conservation initiatives that depend on or plan to obtain revenues from carbon in the future are sensible in some places, but less so in others. Moreover, even if carbon storage can be monetized, whether or not such revenues can actually support conservation activities depends on a variety of political factors that we unpack below. While our results and discussion address these landscapes specifically, we argue that they also hold significance for other contexts, and for the discussion about mechanisms for conservation at the landscape scale more broadly. The approach deployed here is useful for policy makers in clarifying the potential impact of carbon finance in different landscapes.

The potential for carbon revenues to fund conservation is shaped by myriad factors and assumptions ranging from who will directly receive revenues, how they will be distributed, what time frame is being considered, the future price of carbon, and the efficiency of the market. Nevertheless, a first order approximation can be established, and for the purposes of this discussion we examine them in two very different landscapes: Zanzibar and Central Kalimantan.

In Zanzibar, one extreme emissions scenario ended with 81 tonnes per hectare in 2030 compared to 85 tonnes in the scenario at the other extreme—a relatively small difference of 4 tonnes per hectare. Using the auction price decided at the August 2015 California Air Resources Board (CARB) auction of \$12.76 USD per tonne of CO_2 equivalent (or \$46.79 USD per tonne of carbon), we can roughly assess the magnitude of carbon-based revenues that the landscape could potentially generate. In Zanzibar, at this price, the total amount of revenue is just over \$38 million USD, which would accrue over the 30 year period for which the carbon scenarios were calculated. Real potential revenue, again, depends on many factors, including the time period of accrual, and of course, the volatility of the price. In addition, how much this is in real terms depends on the discount rate, as the net present value of this stream of funding that accrues over time ought to be used to determine its real value. While there are many ways that funds might in practice be distributed among actors, depending, for example, on benefit sharing policies and land tenure arrangements, the per capita distribution of these funds among Unguja island's 896 721 million residents[8] would be a mere \$42 USD over 30 years.

When construed in this manner, the amount appears paltry and insignificant. Even if the price of carbon were higher by an order of magnitude, this would still not amount to anything approaching useful at the household level for Zanzibar's people. On the other hand, the funds could conceivably facilitate collective investment in infrastructure, such as schools and public transit, or social programs. Given that the annual budget of the government of Zanzibar is approximately \$300 million USD[9], additional revenues from monetized carbon storage could be meaningful, particularly if the price of carbon increases considerably. Although such revenues could also be shared among district and/or ward governments, the figures nevertheless suggest some idea of the magnitude or relevance that carbon income might have in Zanzibar.

The Central Kalimantan landscape presents a stark contrast with Zanzibar. There, the extreme scenarios of carbon storage came to 3 813 and 4 412 tonnes of carbon per hectare respectively, a difference of 599 tonnes per hectare. Again using the August 2015 CARB price of carbon, we see that the potential revenue is far greater: \$3.5 billion USD accruing over the course of 30 years. For comparison purposes, we consider the distribution of funds per capita. The population of the province of Central Kalimantan—an area far larger than just the

[8] www.nbs.go.tz/.
[9] http://allafrica.com/stories/201405150196.html.

considered landscape—was 2.3 million in 2011[10]. Thus, if such funds were distributed at the provincial level, it would amount to over $1 000 USD per person, again over a 30 year period. Were the price of carbon an order of magnitude higher, this would approach a significant amount on a household basis, but would still not be transformative. On the other hand $3.5 billion distributed in other ways could very imaginably support meaningful collective investment in public goods and development initiatives.

A further issue that the Central Kalimantan case highlights is, who would actually be entitled to such carbon revenues? This is both a legal and a philosophical question, and one that must ultimately be negotiated through political processes. The legal status of carbon rights in Indonesia is still being clarified, but it is likely tied to land rights, which are highly disputed in Indonesia (Myers and Muhajir 2015, Saito-Jensen and Sikor 2015). As REDD+ policy emerges in particular, there is some evidence of a move towards a national system that might allocate funds from carbon-based (Loft *et al* 2015). How this question of carbon rights, as well as land rights, is resolved will have profound implications for conservation and development. The amount of money that the study landscape might generate may seem very high if only local people in the landscape benefit from it, and quite significant if the benefits accrue at the provincial level. On the other hand, if such revenues were to be spent on projects at the national level, such that they were targeted to benefit the 250 million residents of Indonesia, the impact would likely be diluted.

Finally, the opportunity costs of land use must be taken into account. As with carbon, the prices of other commodities change over time, often unpredictably. In Indonesia, where oil palm and other agricultural conversion drives deforestation (Wijaya *et al* 2015), the price of palm oil may determine how attractive forest conversion is. If deforestation is to be substantially reduced, carbon prices per hectare may have to compete with oil palm or be coupled with regulations that bar deforestation for oil palm development. In Peru, where subsistence and larger scale agriculture has driven deforestation, prices of commodities such as oil palm and other crops, as well as gold in parts of the country (e.g. Madre de Dios), determine the opportunity costs of deforestation (see Ravikumar *et al* 2016). In Tanzania, drivers of deforestation include agriculture and charcoal production, especially for domestic urban markets, implying that demand for these products will determine incentives for deforestation (Nduwamungu *et al* 2009). And in southern Mexico, small-scale agriculture and, more recently, corn and soy expansion, have driven deforestation (Bray *et al* 2000, Radel *et al* 2010), suggesting that export markets for these crops shape opportunity costs in the region.

Indeed, these factors were explicitly highlighted by participants as critical drivers of land use change in their landscapes, suggesting that local actors and experts are keenly aware that there are opportunity costs to conservation. On the one hand, for carbon-based payments to be realized in the first place, these opportunity costs must be matched. On the other hand, the political economy of cash crops, mining, and other deforestation drivers determines the *distribution* of benefits from such activities. For example, the benefits of private oil palm plantations may accrue primarily to private interests, whereas funding from aid might support government services. It may therefore be possible to design carbon payments in such a way as to deliver benefits to a broad group of stakeholders, perhaps broader than would benefit from alternative activities like mining and oil palm. In this way, the political coalition that benefits from conservation can be expanded, and carbon finance—even if it does not exceed the gross revenues from alternative land uses—can still be a politically and economically viable approach to conservation.

Policy makers, REDD+ project proponents, and members of civil society with an interest in conservation and alternative development futures must consider not only the factors that determine the distribution of revenues from landscape carbon storage but also the extent to which they can genuinely influence the drivers of land use change. The contrast between Zanzibar and Central Kalimantan raises questions about the extent to which forest conservation activities more generally can or should be driven fundamentally by carbon-based revenues. Clearly, on the one hand, in some extreme landscapes like Kalimantan, the potential revenues from monetizing carbon storage are significant. On the other hand, in the other landscapes that we examined—and likely in many around the world—the potential for carbon-based revenues are far less. Complicating matters further, some factors of change that workshop participants identified are linked to the policy decisions of countries (such as establishing protected areas or providing payments for environmental services), while others are outside of their control (such as global commodity prices and climate-driven events). Also, some reductions in deforestation are more under the control of countries, land owners, or land users than others, this means that arguing that emissions reductions are *additional*—that is, they are the result of deliberate decisions, and would not have occurred in the absence of those decisions—is challenging. This challenge has been persistent in the design of REDD+ policies, and requires further attention as countries and other actors seek to support conservation through carbon finance.

The risk of focusing only on carbon emissions reductions, and on funding from carbon markets,

[10] www.bps.go.id/65tahun/SP2010_agregat_data_perProvinsi.pdf.

could lead to the neglect of other critical needs. There are many other reasons to conserve forests besides carbon emissions or climate change mitigation, including climate change adaptation, local peoples' livelihoods, and the provision of ecosystem services. The results presented here underscore the need for actors engaged in conservation to continue to think creatively and beyond carbon. In addition, leveraging forests for climate change mitigation itself remains important even if the direct revenues that may accrue from monetizing carbon storage are small. Payments for environmental services including but not limited to carbon sequestration and storage, policies that responsibly protect forests for conservation and sustainable uses, and, crucially, rights-based approaches to conservation all continue to hold promise (Duchelle *et al* 2014, Nolte *et al* 2013).

Policy makers and members of civil society alike should continue to think innovatively about strategies for conservation, and should do so with realistic expectations about the likely role of carbon-based revenues in supporting conservation and development.

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[11] Note: a large number of data sources were used to calculate carbon densities. These are included in appendix 3.

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