Towards a holistic assessment of national REDD+ options: Accounting for ecosystem service and biodiversity impacts

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ABSTRACT: REDD+ is an international mechanism to mitigate climate change through reducing emissions from deforestation and forest degradation, conserving and enhancing forest carbon stocks, and sustainably managing forests. Countries are faced with complex choices between a number of options of where and how to implement REDD+. Different options will deliver different combinations and levels of carbon and ecosystem and biodiversity (ESB) benefits, while also being associated with risk of environmental harms. If assessments of national REDD+ options only consider financial values of carbon benefits and the cost of its provision, REDD+ choices could be sup-optimal in so far that they do not necessarily direct investments towards those options that realize multiple benefits. Economic valuation, which evaluates impacts on ESB in monetary terms, can be an important tool to integrate ESB in cost-benefit analyses for REDD+ planning. Yet given the challenge of evaluating spatially explicit economic values of many non-carbon benefits, this paper argues not to solely rely on cost-benefit analyses. It is in this context that this paper suggests multi-criteria analyses that combine monetary and non-monetary criteria. Mapping or scoring exercises can play a key role in informing REDD+ choices. Yet REDD+ decisions would also be subject to environmental and social safeguards and to other national priorities. While optimizing environmental and social outcomes is a challenging endeavour, realizing such multiple benefits can play a key role progressing towards a green economy.

Keywords: biodiversity, cost-benefit analysis, ecosystem services, economic valuation, land use planning, multiple benefits, multi-criteria analysis, REDD+

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1. INTRODUCTION

Each year an average area of 13 million hectares of forests is lost (FAO 2010). Halting and reverting this trend could play an important role in mitigating climate change – at relatively low costs compared to many other technology-based abatement options (Stern 2007; McKinsey & Co 2009). Therefore, within the UN Framework Convention on Climate Change (UNFCCC), an international mechanism for climate change mitigation is being negotiated that would allow capturing economic values of carbon sequestration and storage (henceforth carbon benefits) from forest-based land uses. This mechanism, known as REDD+ can not only contribute to national emission reduction targets, but also serve as a catalyst for wider green economy transformations through investments in forest-based land uses (UNEP 2011b) Shukdev et al. 2011).

According to the UNFCCC COP 16 in Cancun, REDD+ consists of five activities: (1) reducing emissions from deforestation, (2) reducing emissions from forest degradation, (3) conservation of forest carbon stocks, (4) sustainable management of forest, and (5) enhancement of forest carbon stocks (Angelsen *et al.* 2009; Streck *et al.* 2009). These activities can be implemented through different actions, such as tackling the drivers of deforestation and forest degradation (including removal of forest-threatening subsidies, agricultural intensification, non-logging related income opportunities, REDD+ incentives), establishing protected areas, reducing logging intensities and the impact of logging, regeneration and restoration of native forest, and expansion of tree plantations. These actions can be undertaken in different locations depending on their suitability given environmental conditions and legal and policy contexts. Consequently, when developing national REDD+ strategies and action plans, policymakers have a choice between many different REDD+ options of where and how to implement REDD+ (Law *et al.* 2012; Stickler *et al.* 2009).

These choices can be made based on cost-benefit considerations by comparing the carbon benefits generated with the economic costs of providing them. There is growing impetus at national level to identify the most cost-effective means to reach emission reduction targets (Grieg-Gran 2006; McKinsey & Co 2009). Accordingly, a number of studies compare potential carbon revenues with opportunity costs such as foregone revenues from non-REDD+ options, such as timber or agricultural production (Bellassen and Gitz 2008; Olsen and Bishop 2009). Yet, as carbon benefits and economic costs are distributed very unevenly across spaces, spatial information is needed so as to inform decisions on where to implement REDD+. Accordingly, there is a growing number of spatially explicit cost-benefit assessments in REDD+ contexts (Boerner *et al.* 2010; Khatun 2011; Persson 2011).

These kinds of cost-benefit analyses are based on financial values associated with market benefits only. Yet land use choices can have wider impacts on non-carbon ecosystem services and biodiversity (henceforth ESB), which are not captured in market benefits. ESB underpin final ecosystem services and goods that form the base of economic activities and that give social meaning, thereby contributing to benefits for human well-being (MEA 2005). These can have high economic values reaching thousands of US$ per hectare (Balmford *et al.* 2002; Costanza *et al.* 1997; Daily *et al.* 1997; TEEB 2010; Turner *et al.* 2003). For instance, forest-based land uses support the livelihoods of people who directly depend on their resources (World Resources Institute (WRI) in collaboration with United Nations Development Programme 2008). They also contribute to water cycles and soil conservation, thereby buttressing agricultural production, hydrological power generation and transport networks that are of economic importance for countries (Naidoo *et al.* 2009; Pattanayak 2004; Ricketts *et al.* 2004). At global scale, REDD+ go hand in hand with biodiversity conservation benefits (Busch *et al.* 2010; Harvey *et al.* 2010; Phelps *et al.* 2012). It is in this context that REDD+ has often been appraised to have potential to generate additional benefits beyond carbon thereby delivering multiple benefits (Dickson and Osti 2010; UN-REDD 2009).

Nonetheless, REDD+ activities can also be associated with risks of environmental harms, for instance when it leads to the conversion of natural forests or ecosystems (Miles and Kapos 2008; Stickler *et al.* 2009). Awareness of unintended social and environmental impacts of REDD+ activities, as well as their potential to deliver multiple benefits has led to the inclusion of 'REDD+ safeguards' in the Cancun Agreements adopted at UNFCCC COP 16 in Cancun (UNFCCC/CP.16/2010/7/Add.1).

Consequently, wider environmental and socio-economic impacts of REDD+ need to be evaluated (Caplow *et al.* 2011; Corbera and Schroeder 2011). REDD+ decision-support frameworks that integrate risks factors (Law *et al.* 2012) and biodiversity benefits have been elaborated (Gardner *et al.* 2011). This paper provides a more holistic assessment framework for national REDD+ options that accounts for impacts on ESB so as to inform policy decisions on where and how to implement REDD+.

The next section starts with an analytical elaboration of how accounting for ESB impacts will facilitate economically optimal land use decisions. As discussed in section 3, given the challenges and data requirements for establishing spatially explicit economic values of ESB impacts, cost-benefit analyses should not be the only tool for assessing REDD+ options. It is in this context that section 4 argues for multi-criteria analyses, before section 5 discusses how to inform REDD+ choices based on monetary and non-monetary criteria. Section 6 then concludes with highlighting the role of economic valuation in REDD+ planning and the importance of multiple benefits for leveraging REDD+ investments for green economy transformations.

2. THE IMPORTANCE OF ESB IN REDD+ PLANNING

Although it has been argued that loading REDD+ with additional goals could make these programmes overly complex and compromise reaching their primary objective (Kinzig *et al.* 2011; Minang and van Noordwijk 2012), considering impacts on ESB in REDD+ is important for various reasons. Firstly, narrowing down the complexity of ecosystems to a single commodity (i.e. reduced carbon emission units) veils important ecosystem interactions, as well as ecological and social functions (Kosoy and Corbera 2010). Secondly, those options can be identified that deliver important additional benefits alongside carbon so as to make economically optimal choices. The financial value of carbon benefits would only form part of the total economic value of forest-based land use options, which include direct use, indirect use, non-use and option values of ESB (Pascual *et al.* 2010).

ESB contribute to intermediate services that underpin ecological processes produce final services and goods, which directly contribute to benefits for humans (Boyd and Banzhaf 2007; Fisher and Turner 2008; Mace *et al.* 2012) . In ecosystem assessments and valuation there is growing focus on benefits from final services and goods so as to prevent double-counting (Bateman *et al.* 2011; Ojea *et al.* 2012; TEEB 2010). Forests provide the following benefits from ESB: forests goods (timber and non-timber products, genetic resources), research and education, recreation, cultural knowledge and traditions (all with direct use values), water flow regulation, purification and provision, soil fertility and sedimentation control, clean air and favourable climatic conditions, prevention of disease or damage from natural hazards (all with indirect use values), intangible benefits that people enjoy from the mere existence of forests (non-use values) and potential benefits under changing economic and ecological conditions (option values) (Bishop 1999; Pascual *et al.* 2010; Pearce 2001). Forest biodiversity represent a direct benefit with economic values if people value the existence of unique species or ecosystems (Naidoo and Adamowicz 2005) or where it provides a pool of biological resources for research and development sectors (Simpson *et al.* 1996; Swanson and Goeschl 2000).

Many of these benefits from ESB other than timber and non-timber forest products do not represent a market benefit which is associated with a financial value through a market price. This is because many benefits from ESB share public good characteristics resulting in a market failure, whereby they are not exchanged at markets (Pearce and Moran 1994). Hence, non-market benefits from ESB are, generally, provided as positive externality the provisioning country or land user is not rewarded for (Bishop 1999).[1]

Figure 1 depicts this problem behind deforestation in a simplified way, assuming that there are two land use options only: forest land can either be maintained or be converted into agricultural land. The marginal values of benefits from agriculture increase with agricultural productivity as depicted on the x-axis, while the marginal values of market benefits from forests are assumed to stay relatively constant. Only considering these financial values, agriculture would outperform forest related land use from a given point of agricultural productivity D_0 , so that forest conversion would be financially desirable on the right of D_0 (cf. Fig 1).[2]

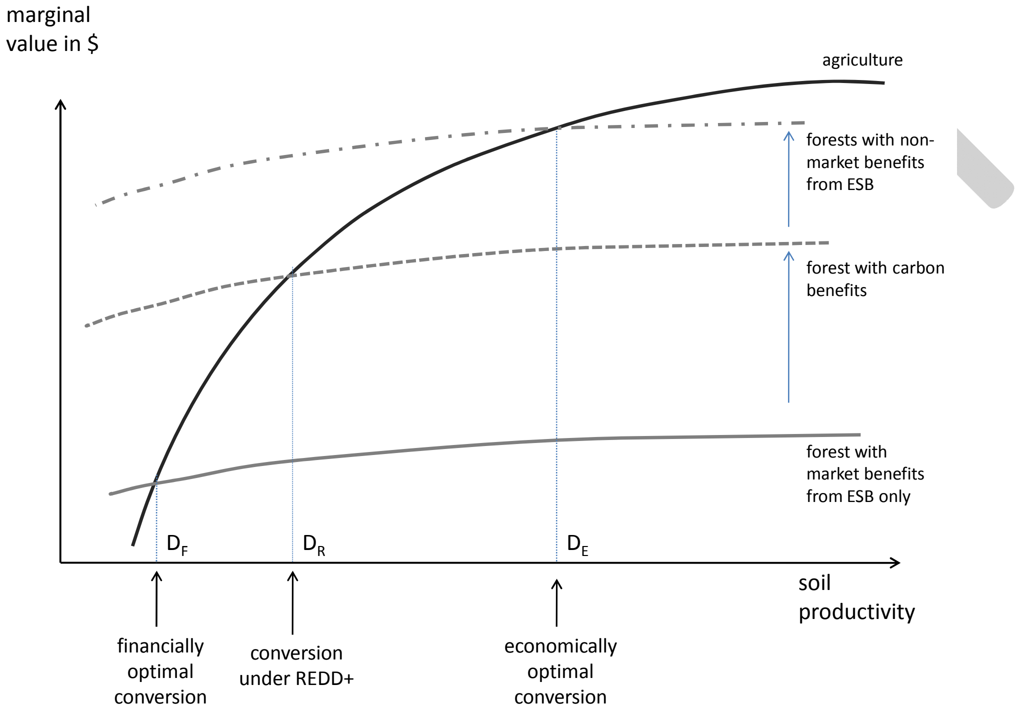

Figure 1 *Marginal value of benefits from agriculture compared to marginal value of benefits from forests*

The economically optimal conversion point, however, would be based on the total economic value of forests. As can be seen from the marginal value curve of multiple benefits from forests including market-benefits, carbon and non-market ESB, this is to the right of the current conversion point at D_S (cf. Fig 1). Although the exact conversion points depend on the elasticities of the marginal value curves, it can be seen that decisions for conversion between D_0 and D_S are sub-optimal, insofar as while it appears financially desirable it is not economically justified.

[1] Additionally, policy interventions may artificially increase the financial values of benefits from non-forest land uses, for instance, through agricultural subsidies.

[2] The size of this financial incentive can be determined by the distance between benefit curve from agriculture and the market benefit curve from forests.

Touching upon the idea of payment for ecosystem services (PES), REDD+ would provide payments for non-market carbon benefits thereby increasing the financial incentives for maintaining forests (Jack *et al.* 2008; Muradian *et al.* 2010; Wunder 2005; Wunder *et al.* 2008). A carbon payment shifts the financial values of forests to the upper right, so that the conversion point moves to D_R.

In areas of high agricultural potential (here to the right of D_R), carbon payments only may not be able to compete with the financial incentives for converting tropical forests (Persson and Azar 2010). But given the presumably high benefits from forests ESB, the marginal financial value curve of REDD+ benefits would be unlikely to be close to the marginal economic value of all multiple benefits. Accordingly, on forest lands between D_R and D_S, a carbon payment only would unlikely reduce deforestation despite of forest conversion being economically unjustified. It is on these lands where the values of ESB would need to be captured, e.g. through wider PES schemes that pay for bundled services (as per Wendland et al. 2010). Yet in many cases just the demonstration of economic values of ESB could change land use decisions in favour of REDD+ related forest options (Naidoo *et al.* 2009). These illustrations show that taking impacts on ESB into account could be very important to make not only financially, but also economically optimal land use choices.

3. COST-BENEFIT ANALYSIS FOR REDD+ PLANNING

It is in this context that land use planning should be based on the total economic values from different land use options so as to choose those options that maximize the net benefits over a certain time span[3] (Yaron 2001). Net benefits from non-REDD+ options can also be understood as the opportunity costs of REDD+. Following a cost-benefit logic, these opportunity costs would need to be compared with the benefits of REDD+ options. Cost-benefit analyses are an important means to guide land use choices (Fisher *et al.* 2008; Pearce *et al.* 2006) and have been applied in REDD+ contexts (Boerner *et al.* 2010; Butler *et al.* 2009; Fisher *et al.* 2011b). Yet as different benefits and costs can be very unevenly distributed across spaces, such analyses would need to be spatially explicit, as nicely illustrated in an study on conservation corridors in Paraguay (Naidoo and Ricketts 2006).

3.1 The merits of cost-benefit analysis

Once all relevant information for calculating costs and economic values is collected and aggregated over the relevant planning horizon, the appeal of cost-benefit analysis in a REDD+ planning context is its relative straightforwardness in guiding REDD+ decisions. Only options should be chosen whose economic values exceed their costs (Pearce *et al.* 2006).

This utilitarian approach rooted in neoclassical economic theory reflects that environmental problems often driven by the lack of financial incentives for more sustainable management strategies (Pearce and Moran 1994). Applying cost-benefit analysis can not only foster understanding of the drivers of deforestation, forest degradation and unsustainable forest management where the lack of financial incentives prevails, but can also provide pragmatic guidance to prioritise land use options for investment and intervention (Daily *et al.* 2009; Pearce *et al.* 2006) .

Different REDD+ options can be associated with different combinations of carbon benefits and impacts on ESB (Millennium Ecosystem Assessment, 2005 2431 /id}. For instance, if implementing REDD+ through excluding it from any human use could maximise carbon, water and biodiversity

[3] Alternative land uses provide a flow of benefits that reaches far into the far future, so that these need to be expressed in net present value terms. Generally, a time frame according to the major alternative land use cycle is used (e.g. for palm oil it is 30 years) (World Bank 2011).

benefits, while a sustainable forest management regime would allow for the use of timber and non-timber forest products, which to some extent may compromise the former. Furthermore, not all ESB and carbon are complementary with one another in all locations, as areas hosting the most threatened species or being most critical for water services may not contain the highest carbon stocks (Barton *et al.* 2009; Wendland *et al.* 2010). Yet these trade-offs cannot be assessed very easily if benefits are measured in very different units. Expressing these in monetary terms allows comparing different land use options in relation to their monetary benefits and costs.

3.2 Limitations of economic valuation

Yet there are ethical objections to valuing and commodifying ecosystems, as creating exchange values could just give a justification to sell nature (Kosoy and Corbera 2010; McAfee 1999; Norgaard 2010; Redford and Adams 2010). Furthermore, cost-benefit analysis takes it for granted that individual preferences weighted by money as common factor serves as an adequate indicator for social welfare (Pearce *et al.* 2006; Vatn 2005). Such utilitarian and welfarist approaches must ignore multiple dimensions of human well-being and the plural ways values are expressed (Wegner and Pascual 2011).

These concerns aside, cost-benefit analyses would need to be based on the total economic value of land use options and there are practical limitations in going beyond the financial values of market benefits. These relate, on the one hand, to economic valuation techniques available to attach monetary estimates to ESB. On the other hand, these result from the need to quantify ESB impacts at their margin given small, incremental changes in land uses or cover in one location. The total value of all standing forest would give little guidance for land use decisions (Stern, 2007), so that spatially explicit marginal values of ESB need to be calculated (Turner *et al.* 2003). This would require ecological and economic data that is time-consuming and expensive to obtain for larger samples covering wider geographical areas. While this in itself is often a major constraint in national REDD+ planning where time and budgets are tight, further technical challenges remain.

Regarding economic valuation methods, these are either based data from real markets (e.g. replacement/mitigation costs, production functions, hedonic pricing and travel costs methods) or from hypothetical markets (e.g. contingent valuation and choice experiments) (Pascual *et al.* 2010). The former must ultimately underestimate the economic value of ESB if these are not properly reflected in market transactions (Bann, 1998; Pascual *et al.* 2010). Methods based on hypothetical markets have often been challenged due their hypothetical nature in a context of complex choices that individuals are often unfamiliar with (Turner *et al.* 2010; Wegner and Pascual 2011). Additionally, they rely on a number of assumptions in the technical design of the experiments and in the application of complex statistical models (Pascual *et al.* 2010).

Regarding ecological assessments, the usefulness of economic valuation in land use planning depends on the extent to which all relevant ESB can be quantified accurately at a spatially explicit level (Turner *et al.* 2010). Sound and consistent scientific methodologies and frameworks for ecosystem assessments still need to be developed (Daily *et al.* 2009; Maler *et al.* 2008; Seppelt *et al.* 2011; Turner and Daily 2008). Ecosystem relationships are highly complex, so that the challenge of modelling ESB quantities is often much bigger than putting monetary estimates on them (Fisher *et al.* 2008; Kosoy and Corbera 2010; Millennium Ecosystem Assessment 2005; Norgaard 2010). Firstly, many ESB components are highly interconnected. Secondly, the relationship between upstream land use and the downstream ESB benefits generated is often not linear. And last but not least, non-linear relationships also result from possible tipping points above which an ecosystem cannot withstand disturbance anymore and changes into another state (Holling 2001). A major technical challenge is that the concept of marginal values is not easily applied if such non-linear relationships exist (Turner *et al.* 2003). But more fundamentally, the existence of tipping points cannot be brought in line with the assumption of perfect substitutability[4] between natural and man-made capital. So, this leaves a question mark behind the suitability of cost-benefit analysis for land use planning (Turner *et al.* 2010).

4. MULTI-CRITERIA ANALYSIS

Given the urgent need to move beyond the REDD+ readiness phase and to generate larger scale investment in results-based actions(UNEP 2011a; WWF 2012) practical approaches are needed to help policymakers at national level to develop REDD+ strategies and action plans without having to rely on spatially explicit monetary estimates of ESB impacts. Consequently, multi-criteria analyses, as applied in other ecosystem service context (Larsen *et al.* 2011; Newton *et al.* 2012) can be a helpful assessment tool of REDD+ options. It is in this context that Figure 2 brings forward a multi-criteria assessment framework for REDD+ planning combining various carbon, costs and ESB related aspects that can be measured by monetary or non-monetary and spatial or non-spatial criteria.

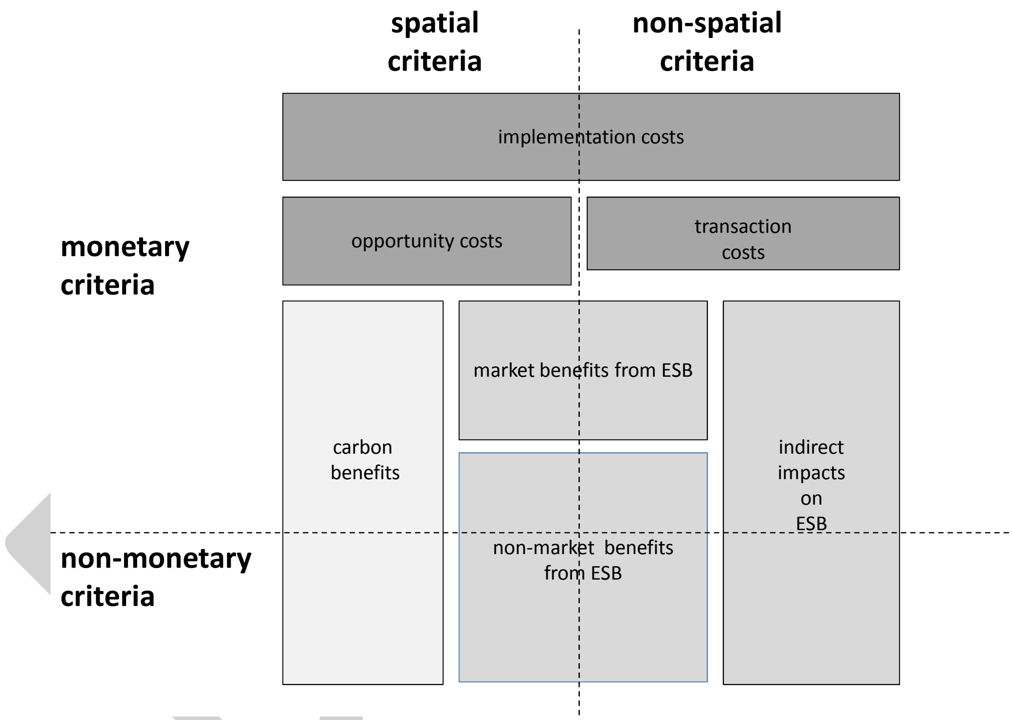

Figure 2: Assessment criteria for REDD+ planning *including carbon (light grey), costs (dark grey) and ESB aspects (grey)*

REDD+ assessments would evaluate suitable options with respect to *carbon benefits* in relation to the cost of a national REDD+ programme. Costs aspects include forgone benefits of non-REDD+ options (i.e. *opportunity costs*), costs for implementing the REDD+ actions required (i.e. *implementation cost*) and the costs for establishing and operating a national REDD+ programme (i.e. *transaction costs*) (Pagiola and Bosquet 2009).

[4] This touches upon the discussion of “weak” versus “strong” sustainability debate as referring to the substitutability of natural capital by other forms of capital (Ekins *et al.* 2003).

Such a conventional REDD+ assessment ought to be complemented by ESB aspects so as to account for the full economic importance of land sue options (cf. Figure 2). It is important to recognise that non-REDD+ options do not necessarily completely eliminate ESB and that some REDD+ options may even reduce ESB benefits.[5] Therefore, impacts need to be assessed in terms of net benefits by comparing the levels of ESB benefits with and without the implementation of REDD+ options. As land use is affected in those locations where REDD+ is implemented, there are direct impacts on *market benefits from ESB* and *non-market benefits from ESB* in these sites. Yet due to indirect land use changes, REDD+ can also have an *indirect impact on ESB* in other sites.

4.1 Carbon benefits

First , the potential of REDD+ options for reducing carbon emission needs to be evaluated. According to the IPCC guidelines, forest carbon comprises above-ground biomass, below ground biomass, dead wood and litter, and soil carbon (IPCC 2007) (IPCC 2007. It is important to note that non-REDD+ options do not completely eliminate carbon stocks, so that one needs to calculate the stock differential of different land use options. Although there are still considerable challenges in measuring the carbon stocks, more and more data and tools to calculate spatially explicit carbon stocks are becoming available (Baccini *et al.* 2008; Baccini *et al.* 2012; Goetz *et al.* 2009; Saatchi *et al.* 2011).

A necessary requirement for REDD+ payments would be the reduction of carbon emissions or the creation of additional carbon stocks as compared to a non-REDD+, business-as-usual (BAU) case. Therefore, actual emissions levels under REDD+ have to be compared against reference emission levels. Although work on this is advancing in many countries, for instance under the UN-REDD Programme, serious challenges are still to be overcome before official reference emission levels can be developed and it is still not clear if these would be spatially explicit.[6] Evaluating forest carbon stocks in areas under threat from deforestation, degradation and unsustainable management is a tractable first step in analysing potential emission reductions under REDD+, as illustrated in national mapping work done by UNEP-WCMC (Bertzky *et al.* 2010; Kapos *et al.* 2010; Musampa Kamungandu *et al.* 2012).

As REDD+ mechanisms would ultimately provide financial incentives to countries, monetary estimates can be calculated for carbon benefits. Carbon credit prices paid at current carbon markets such as the European Union Emission Trading Scheme or California's Cap-and-Trade Program can serve as a benchmark. Yet carbon prices under REDD+ would depend very much on the mechanism set in place[7], so that a range of price scenarios should be taken into account (Khatun 2011).

4.2 Opportunity costs

Opportunity costs of REDD+ are the potential net benefits from non-REDD+ options; that is the revenue flows that can be gained through logging, agriculture or mining less the implementation costs of these options (e.g. converting a forest into agricultural land) and their operation costs (e.g. labour, machinery for planting/harvest etc) . Given their importance in guiding spatial decisions on

[5] Negative impacts may occur when, for example, the reforestation of existing forests with non-native species undermines biodiversity or if a natural ecosystem is converted into a forest plantation.
[6] As per UNFCCC COP 16 countries can use subnational forest reference emission levels and/or forest reference levels as an interim measure depending on national circumstances (Paragraphs 71b, decision 1/CP.16)
[7] For instance, there is not yet any decision if payments would be based on an international market or an international fund.

REDD+ and their relative share in overall REDD+ costs, there are well developed frameworks available for the analysis of opportunity costs (Pagiola and Bosquet 2009; The World Bank 2011; Wertz-Kanounnikoff 2008). Accordingly, there is a growing number of studies on REDD+ opportunity costs comprising local level estimates from household or community surveys (Boerner *et al.* 2010; Butler *et al.* 2009; Fisher *et al.* 2011b; Fisher *et al.* 2011a; Merger *et al.* 2012), generic estimates using global data (Khatun 2011; Olsen and Bishop 2009) or global estimates from partial equilibrium models simulating dynamics in relevant sectors of the entire world economy (Kindermann *et al.* 2008; McKinsey & Co 2009). Net benefits from non-REDD+ options are very location dependent and can vary enormously across space. Determining factors such as land suitability for other non-REDD+ activities, commodity prices, available technologies, land tenure and access to markets need to be studied so as to calculate spatially explicit opportunity costs (Chomitz 2007; Grieg-Gran 2006).[8]

4.3 Implementation and transaction costs

Although other cost elements can make an substantial share of overall REDD+ costs, they have found relatively less attention to-date as compared to opportunity costs. Besides a few published studies (Eliasch 2008; Grieg-Gran 2006; Merger *et al.* 2012; Olsen and Bishop 2009), there are growing efforts to calculate implementation and transaction costs, as for example within national UN-REDD programmes.

Implementation costs of REDD+ encompass expenditure for the actions to be undertaken to achieve emission goals, as for instance, setting up a protected areas, delineating and/or titling of land and other measures to tackle the drivers of deforestation, forest degradation and unsustainable forest management and/or planting trees (World Bank 2011). Implementation costs are not only very sensitive to the actions undertaken, but also to the chosen location (e.g. in a very remote area the measures needed to protect an area from illegal loggers are less extensive than in a forest frontier region).

Transaction costs include investment in formulating REDD+ strategies, setting up REDD+ programmes and the institutions needed, identification and negotiation of compensation levels and contracting of land users, as well as running monitoring, verification and reporting systems (Cacho *et al.* 2008; The World Bank 2011). These costs generally do not vary from place to place within a country. However, transaction costs are correlated with the number of actors and the level of complexity in a REDD+ programme. Therefore, as a rule of thumb, those REDD+ options that involve fewer actors and are easier to implement have the lowest transaction costs associated with them.

4.4 Market benefits from ESB

Forest-based land uses to some extent can be associated with market benefits (cf. Fig. 1) that can be quantified in monetary terms. Forests bring *consumptive use benefits* from ESB through forest goods such as timber and non-timber forest products. While some REDD+ actions would not allow the collection of forest goods at all (e.g. in a strictly protected area), other activities would only restrain their use to sustainable levels (e.g. under sustainable management of forests). For forest goods that are only exchanged informally or that are used for home consumption (such as charcoal, game, medicinal plants), monetary estimates can be calculated through the market prices of substitute products or the labour costs of collection (Labarta *et al.* 2008; Schaafsma *et al.* 2012; Sheil and Wunder 2002). In some contexts, consumers are paying a price premium through eco-labelling

[8] While the interplay of these factors determine a likely land use trajectory (Boerner and Wunder 2008; Boerner *et al.* 2010), opportunity costs could also be expressed on the highest value alternative that is feasible (McKinsey & Co 2009).

schemes for products from forest-based land uses (e.g. silvopastoral livestock keeping or shade-grown coffee production).

Forests are also associated with *non-consumptive use benefits* from ESB that can be assessed in monetary terms. Forests are used for recreation through natural parks and ecotourism projects. These generate income streams through park entry and guiding fees and permits for viewing gorilla or other wildlife species, and contribute to revenues for tour companies and the hospitality industry. Bioprospecting schemes that grant research institutions or private companies the right to use unexplored genetic resources within a specific forest area represent other market benefits from the non-consumptive use of forest resources.

Sometimes market benefits cannot be easily traced back to its location of origin, for example where NTFP are sold at markets far away from the village where they had been collected. There are techniques to capture the flow of such benefits through space, but often essential information is needed (Schaafsma *et al.* 2012). Where this information is to costly to obtain, market benefits cannot be spatially explicit.

4.5 Non-market benefits from ESB

It is often more difficult to attach monetary estimates to non-market benefits from forest ESB. Nevertheless, economic valuation techniques can often be applied for the ecosystem services, such as pollination and nutrient cycling, soil formation and stabilisation, water flow and quality regulation, and prevention of diseases and natural hazards (Kumar et al. 2010). With the Economics of Ecosystems and Biodiversity (TEEB) initiative the number of studies seeking to value non-market benefits from ESB is growing (Pascual *et al.* 2010). The TEEB database compiling monetary estimates for ESB values can serve as an important starting point for ESB assessments by transferring benefit estimates from existing forest-related studies (van de Ploeg et al. 2011). That said, the quality and comparability of the these studies needs to be carefully assessed before transferring values (Turner *et al.* 2010). Most of these studies to-date are not spatially explicit despite the existence of spatial planning tools including economic valuation modules, such as the Integrated Valuation of Environmental Services and Tradeoffs (InVest) and Artificial Intelligence for Ecosystem Services (ArIES). These tools require a lot of high quality data, so that they are often not applicable for national REDD+ planning where budgets and timing are tight.

Yet not all ESB impacts can be assessed in monetary terms given above outlined challenges. Often just identifying and assessing the ESB affected by land use change and linking these to economic activities or cultural traditions provides a way of recognising the value of ESB (TEEB 2010). So, it can be more straightforward to evaluate these impacts in bio-physical units. This may be done through the modelling of land use impacts on ESB indicators. More and more land use models are being developed to depict complex ecosystem processes. Yet these are mainly in the academic sphere and also require a lot of data inputs (REFEERENCES). For national REDD+ planning it may be more practical to identify priority locations through easily measureable proxy variables that are correlated with ESB (e.g. biodiversity is often highest in natural forests and soil erosion control benefits are greatest on steep slopes with exposure to extreme rainfall and urban settlements or hydrological projects downstream).

However, as explained above some non-market benefits, such as quantity of water provided or amount of sedimentation avoided, cannot be clearly linked to land use in a specific location without complex modelling exercises. Accordingly, not for all ESB impacts spatially information will be available. Yet priority areas for ESB that generate benefits in different locations at different scales could be identified though expert consultation workshops assigning importance score to different locations (see (Newton *et al.* 2012)). Although participants may lack full understanding of ecological processes, this can be an important means to demonstrate non-monetary ESB values, as contextual factors can play an important role in the way people express values for public goods (Turner *et al.* 2010; Wilson and Howarth 2002). These group exercises can also facilitate the taking into account of social values, rights and equity in REDD+ land use planning.

4.6 Indirect impacts on ESB

REDD+ can have also impact on ESB through indirect land use changes triggered by feed-back relationships. With growing needs for food and energy, REDD+ options that limit the availability of agricultural land in one place, must arguably lead to agricultural expansion into other areas, intensified agricultural production in existing areas or increasing energy and food prices, thereby counteracting some of its positive REDD+ impacts. Potential negative impacts on ESB can be caused by REDD+ through (i) the displacement of deforestation or forest degradation to non-targeted locations, (ii) conversion of natural non-forest ecosystems and (iii) intensified use of agricultural systems (Miles and Kapos 2008; Nepstad *et al.* 2008; Stickler *et al.* 2009).

REDD+ actions in a specific location cannot clearly be linked to a such indirect impacts that often happen across larger scales. Some of these impacts may be measureable in monetary terms through the expenses for preventing certain risks (World Bank 2011). For instance, a local-level study in Tanzania estimates the shortfall in food and charcoal production due to forest conservation in terms of the costs of increasing agricultural yields and efficiency of charcoal cooking stoves (Fisher *et al.* 2011b). Many other negative impacts of indirect land use change cannot be expressed in monetary terms. And even their quantification in biophysical units may be challenging especially where tipping points are difficult to predict. In such cases the risk associated with REDD+ options of causing environmental harms needs to be evaluated based on qualitative information.

5. INFORMING REDD+ CHOICES

As cost-benefit analysis including those ESB impacts measurable in monetary units can play an important role in multi-criteria analyses (Turner et al. 2010), there is a need to combine different criteria measured in different units in order to allow an overall assessment of REDD+ options. Mapping and scoring exercises can help identify the most preferable REDD+ actions and locations. Yet there can be additional considerations that matter in REDD+ planning, such as environmental and social safeguards and other national priorities. Those options that are associated with the highest carbon benefits in relation to costs while providing additional ESB benefits in line with environmental REDD+ safeguards and national priorities may be of particular interest to countries planning for REDD+.

5.1 Mapping and scoring exercises

One main question in the context of multi-criteria analyses is how to aggregate monetary and bio-physical criteria so as to have a simple decision-making measures. Cost-effectiveness assessments that evaluate the non-monetary benefits of forest-based land use options in relation to their costs have often been applied in contexts such as reducing carbon emissions (Fisher *et al.* 2011b; Olsen and Bishop 2009), conserving biodiversity (Barton *et al.* 2009; Fisher *et al.* 2011a) and controlling soil erosion control (Chen *et al.* 2010; Jack *et al.* 2009). Yet if there are a number of benefits that could be realised at the same time, such assessments are more complicated.

Calculating standardized scores for different criteria and combining these to an overall score can be a straightforward way of identifying priority options. Wuenscher *et al.* illustrate the site selection for a forest-focused PES program in Costa Rica based on the ratio of an additionality score to REDD+ costs including the benefits from pasture, forest protection and other transaction costs (Wuenscher *et al.* 2008). The additionality score combines deforestation risk and the potential for biodiversity conservation, carbon storage, hydrological service and scenic beauty. Wuenscher *et al.* (2006) also add a social development index based on social differences between geographical areas including variables on education, health and electricity consumption (Wuenscher *et al.* 2006). The main caveat of scoring exercises is that they obscure the trade-offs between the different criteria taken into account while being based on arbitrary standardization and weighting methods.

If available criteria are spatially explicit, the production of overlay maps is another practical assessment tool that can combine monetary and non-monetary criteria. Besides the illustrative power of maps, the advantage of this approach is that different layers could be combined without any judgement on which benefit type is more important. Priority locations would be where the greatest overlap of different benefit criteria can be found, while areas with extremely high costs or where negative impacts would be expected could be excluded. Wendland *et al.* (2010) combine spatial information on carbon stocks, species ranges and water quality and deforestation risks as well as opportunity costs in order to identify priority locations. Boerner *et al.* (2010) map the costs per ton of avoided carbon emissions combining spatial data on opportunity costs, deforestation risks and carbon stocks. UNEP-WCMC has produced maps of carbon stocks, deforestation risks and priority areas for biodiversity for a number of countries, such as Ecuador, Cambodia, Tanzania and the Democratic Republic of the Congo (Bertzky *et al.* 2010; Kapos *et al.* 2010; Miles *et al.* 2009; Musampa Kamungandu *et al.* 2012) and is moving towards the integration of additional ecosystem services and cost information.

5.2 Safeguards

REDD+ decisions may also be influenced by environmental and social safeguards that aim to prevent negative and secure positive REDD+ impacts. The Cancun Agreement requests that countries promote and support environmental and social safeguards and develop a system for providing information on how they are being addressed and respected throughout REDD+ implementation (Paragraphs 69 and 71d, decision 1/CP.16). The environmental safeguards included in the Cancun Agreement refer to the protection of natural forests, their ecosystem services and biological diversity and to enhancing other social and environmental benefits through REDD+ (UNFCCC/CP.16/2010/7/Add.1). In addition to the safeguards referred to in the Cancun Agreement, REDD+ funding initiatives, such as the Forest Carbon Partnership Facility (FCPF) and the UN-REDD Programme, have developed environmental and social safeguards.

Safeguards are thus likely to influence REDD+ choices whereby options that bring the risk of negative environmental or social impacts are to be avoided. In the context of environmental harms, this reflects a safety-first principle recognising that there are critical ESB that secure ecosystem functioning and human-well being (Farley 2008; Pearce *et al.* 1989), which cannot be traded-off with carbon benefits or financial revenues.

Safeguards need to be country specific taking into account national contexts and circumstances. Countries may already have policies, laws and regulations in place which require compliance with certain environmental and social standards of relevance for land use decisions. Some of these may be suitable for application in the REDD+ context. However, there might be a need for creation of additional policies, laws and regulations to achieve comprehensive coverage of REDD+ safeguards. The UN-REDD Programme, for instance, supports countries in developing national approaches to safeguards in line with the UNFCCC and to identify risks and opportunities of national REDD+ options.

5.3 Other national priorities

Countries may have a number of land use planning priorities that they would not trade-off with other considerations. Some of these could involve related goals ESB. For instance, most countries have global commitments to protect their biodiversity through the Convention of Biological Diversity (CBD). Ensuring that REDD+ options contribute to the protection of forest ESB, as required, for example, through the Aichi targets, can reduce the costs of implementing National Biodiversity Strategies and Action Plans. REDD+ planning that accounts for ESB can thus contribute towards more integrated land use planning.

Other priorities may not directly be linked to ESB impacts, but may have a close connection to forests uses. Development needs are often of very high priority and policymakers may thus seek to realize certain social benefits through REDD+. The potential of REDD+ to contribute to incomes, employment, land tenure security and improved governance structures in rather poor areas has been highlighted (Peskett *et al.* 2008; UN-REDD 2009). Although not discussed in this paper, social aspects of distributional equity and poverty impacts also matter in the choice of REDD+ options. Where livelihoods are built on food and income, as well as the socio-cultural values from forests, REDD+ can contribute to preserving local benefits for forest-dependent people. If benefit-sharing mechanisms are designed in a way that payments would be directed towards these land users, they could contribute to lower income poverty. That said, REDD+ would need to be implemented in a way that does not exclude people from making use of forest resources they depend upon. For these reasons, population density and poverty rates need to be accounted for when assessing REDD+ options (Bertzky *et al.* 2010).

Alternatively, there may be other country priorities that rule out certain REDD+ options or at least would undermine their effectiveness. For example, countries may be planning to connect remote places through extending road networks so as to enable better access to markets and health care. This could impact on the availability of certain areas for REDD+ implementation and on the cost of implementing REDD+. Similarly, there may be plans for designing new hydrological projects or for extending mining or agricultural decisions that may not align with REDD+ actions in the same areas. Especially in the poorest countries, the political reality may be that short-term development needs prevail even if the long-term costs of loosing forests and their ESB may be higher than the benefits from some such developments.

6. CONCLUSIONS

Countries are faced with complex choices between a number of options of where and how to implement REDD+. Different options will deliver different combinations and levels of carbon and ESB benefits, while also being associated with risk of environmental harms. If assessments of national REDD+ options only consider financial values of carbon benefits and the cost of its provision, REDD+ choices could be sup-optimal in so far that they do not necessarily direct investments towards those options that realize multiple benefits.

Hence REDD+ choices ought to be based on spatially explicit cost-benefit analyses that account for impacts on ESB. Economic valuation, which assesses these impacts in monetary terms, can be an important means to incorporate non-carbon benefits into cost-benefit analyses. Yet where total economic values of land use options cannot not be established accurately and spatially explicitly, cost-benefit analyses should not be the only decision-support tool to guide REDD+ planning. It is in this context that this paper suggests multi-criteria analyses that combine monetary and non-monetary criteria. Mapping or scoring exercises can play a key role in informing REDD+ choices. Yet REDD+ decisions would also be subject to environmental and social safeguards and to national priorities which can reflect ESB concerns to some extent.

Although this paper has pointed at certain limitations of economic valuation, we would like to emphasize that, generally, it can be a powerful tool for raising the awareness of the economic importance of REDD+ beyond carbon. While without precise ecological modelling and detailed field data, it may be extremely challenging to value ESB impacts at spatially explicit levels, valuation exercises based on the growing core of case studies can illustrate potential economic values of forest-based land use options and demonstrate that ESB are not worthless.

With respect to national REDD+ planning, an important question is how to value the many transboundary and global benefits from forest-based land uses. Whereas carbon benefits are generally valued through potential payments that can be earned by the country, current and future prices for carbon credits hardly reflect the full global costs of climate change from deforestation and forest degradation. Similarly, the global benefits from biodiversity conservation would only to some extent be reflected through benefit flows at national level.

While the demonstration of economic values of ESB can provide decision-support for REDD+ planning, greater REDD+ investments would only be generated if mechanisms are put in place that capture these values. While REDD+ payments can be bound to environmental and social safeguards, at the present stage they are unlikely to include financial incentives for realizing ESB benefits. To-date, funding for result-based actions is rather limited, so that complementary mechanism capturing the global values of ESB can play an important role in generating additional finance, including investments from the private sector.

Although beyond the scope of this paper, REDD+ strategies and action plans would also need to secure a fair distribution of benefits, costs and risks so as to enhance the legitimacy of REDD+ on the ground. This would add another layer of complexity to REDD+ planning. Without doubt there are major challenges to be overcome to design REDD+ in a way that it does not only contribute reducing carbon emission, but also enhances ESB and addresses social aspects. This is due to likely trade-offs between different environmental and social benefits and the challenges to optimize a number of very different targets. At the same time, environmental and social impacts would need to be monitored in a simple, cost-effective way not to overburden REDD+ implementation. Despite these challenges, REDD+ options that realize multiple benefits can play a key role in catalyzing green economy transformations by facilitating investment, innovation and long-term stewardship for forests-based land uses that contribute to low-carbon development, reduce environmental scarcities and enhance social equity.

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