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Managing forests for global and local ecosystem services: A case study of carbon, water and livelihoods from eastern Indonesia

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ABSTRACT

Despite a recent increase of interest in global payment for ecosystem services (PES) mechanisms, there has been little comprehensive assessment of PES impacts on ecosystem services (ESs) at smaller scales. Better understanding of localized impacts of global PES can help balance ES deliveries for global benefits with those for meeting landscape and local level needs. Using a case study from eastern Indonesia, we assessed trade-offs and potential synergies between global PES (e.g. REDD+ for forest carbon) and landscape level ESs (e.g., water quantity, quality, regulation) and local ESs (e.g. forest products for food, energy, livelihoods). Realistic land use change scenarios and potential carbon credits were estimated based on historical land use changes and in-depth interviews with stakeholders. We applied a process-based hydrologic model to estimate changes in watershed services due to land use changes. Finally, local community's forest uses were surveyed to understand locally realized ESs. The results show empirical evidence that, without careful consideration of local impacts, a PES mechanism to protect global ESs can have negative consequences for local ecosystem services. We present management alternatives designed to maximize positive synergies between different ESs at varying scales.

1. Introduction

Globally, tropical forests account for approximately 25% of all terrestrial carbon (Bonan, 2008). Deforestation is the largest source of carbon emissions from tropical developing countries (Pan et al. 2011). The 2015 UN climate change conference in Paris reconfirmed the importance of forests in global climate regulation. The agreement explicitly included the REDD+ mechanism[1] as part of the global climate regime, where tropical and sub-tropical countries could receive both public and private funding for reducing carbon emissions and conserving standing forests. Indonesia has the third largest tropical forest in the world, with one of the world's fastest rates of deforestation at more than 1000 km^2 of forests (476 km^2 of primary forest) lost per year between 2000 and 2012 (Hansen et al., 2013; Margono et al., 2014). Indonesia has emerged as the major beneficiary of global negotiations to mitigate climate change through improved forest management (Simula, 2010). It has received the largest portion of REDD+ readiness commitments from the public sector ($757 million out of $2.8 billion total committed and dispersed from 2009 to 2014; Goldstein et al., 2015). In the private sector, carbon credits from protecting Indonesia's forests was 5.5% of all voluntary carbon transactions in 2015 (Hamrick and Goldstein, 2016).

Offering financial incentives for tropical developing countries to reduce deforestation and forest degradation can be a win-win-win solution for climate mitigation, ecosystem conservation and pov-

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[1] Reducing Emissions from Deforestation and Forest Degradation (REDD+) is an effort to offer financial incentives for developing countries to reduce emissions from forested lands. REDD+ projects include activities for (a) reducing emissions from deforestation, (b) reducing emissions from forest degradation, (c) while recognizing the role of conservation of forest carbon stocks, (d), sustainable management of forests, and (e) enhancement of forest carbon stocks (UN-REDD programme, 2017).

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erty alleviation (Pistorius, 2012). However, many previous studies have warned that international intervention in the form of Payments for Ecosystem Services (PES) can exacerbate internal social problems (Blom et al., 2010; Wunder, 2008). Failure to include consideration for local uses of resources in global PES design can undermine rights of indigenous and local communities, exacerbate food and water insecurity (UN-REDD programme, 2017; Fazey et al., 2010), diminish ecological integrity and equity (Motel et al., 2009), and result in less than optimal outcomes for the ecosystem service targeted (Enrici and Hubacek, 2016; Skutsch et al., 2011). Despite a recent increase of interest in global PES mechanisms, there has been little comprehensive assessment of their impacts on localized ecosystem services (ESs) and livelihoods. Better understanding of the localized impacts is needed to find ways of balancing ES benefits at the global scale with local needs for water, food, energy and livelihoods. Using a case study from eastern Indonesia, we present a detailed assessment of trade-offs and potential synergies among global ES (forest carbon), landscape-level regulating services (e.g. water) and localized provisioning services (e.g., forest products for food and energy). Specific research questions are: 1) what are realistic land management scenarios to recover forest area lost and improve forest conditions?; 2) how do these scenarios affect global, landscape and local ES provisions?; 3) how do global modelling results compare with local perception in assessments of ecosystem service change; 4) what are the management alternatives to maximize positive synergies among provisions of different ESs at varying scales?

2. Literature review: ecosystem services trade-offs and synergies

The Millennium Ecosystem Assessment (MA, 2005) placed the term "ecosystem services" firmly in the policy agenda (MA, 2005; Gómez-Baggethun et al., 2010). Since then, many have advocated the urgent need to incorporate sustainable provisioning of ESs into policies and planning for managing landscapes (e.g., Daily et al., 2009; de Groot et al., 2010). However, the flows of ESs are determined not only by ecosystem functions and processes (ES supply), but also by demands from various human actors (ES demand) in multiple-scales (Fig. 1). Mouchet et al. (2014) advanced a typology to understand ES trade-offs by merging ecological and socio-economic considerations found in previous studies. Spatial and time lags of ESs (spatial and temporal trade-offs) can occur in both supply and demand sides, in terms of production and delivery (Rodríguez et al., 2006) and benefits and costs (TEEB, 2010). Also targeting one ES can affect other ESs positively or negatively (among ESs synergies or trade-offs), and resilience of the ecosystem as a whole (reversible trade-off), as well as who "losers" and "winners" are among ES beneficiaries (beneficiaries trade-off) (Mouchet et al., 2014).

The forces of globalization are intensifying interactions among ES demand and supply over distances and cross-scales (Cash et al., 2006; Liu et al., 2015). Managing ESs and anticipating changes in their spatial, temporal and societal distributions are increasingly difficult as local events (e.g. land use change in

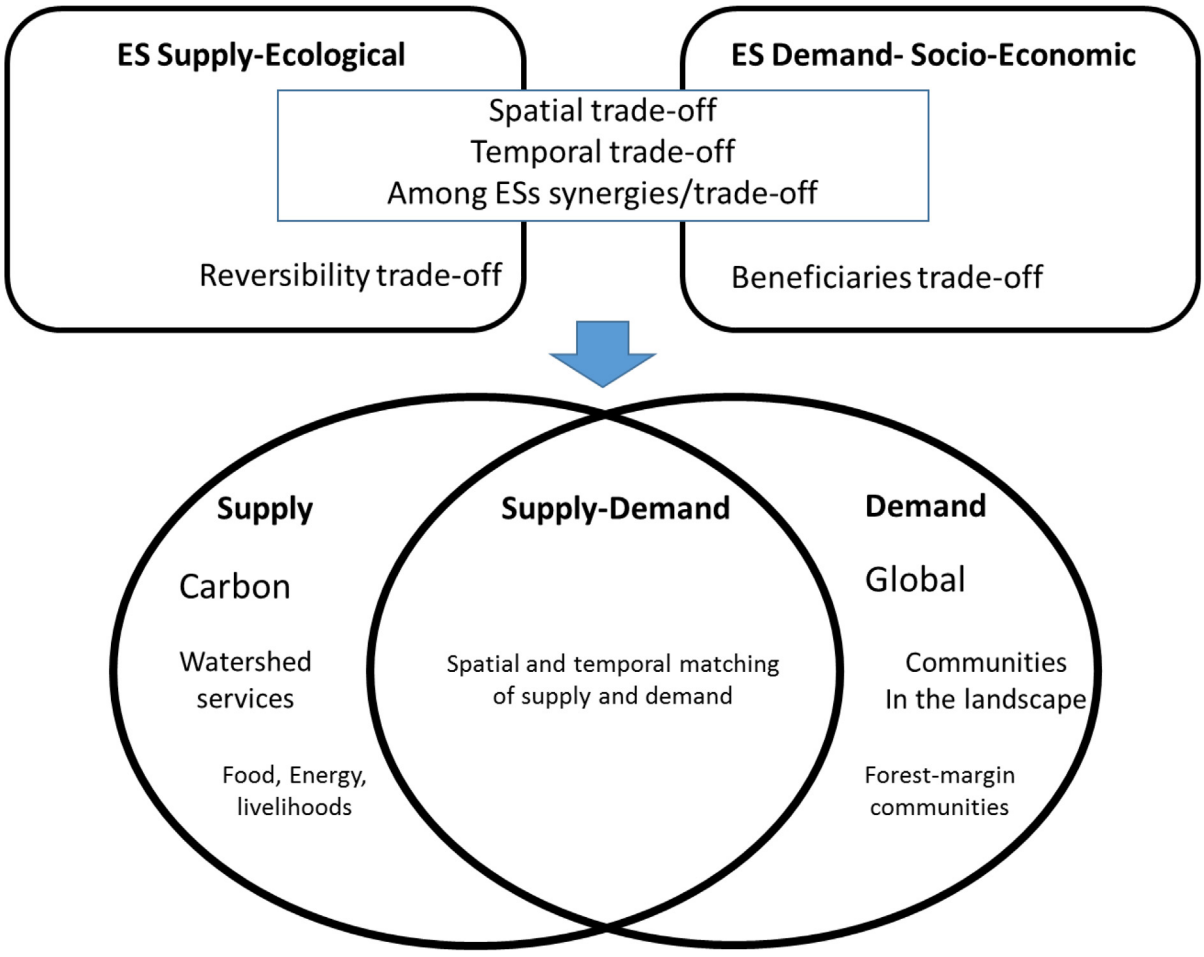

Fig. 1. Conceptual framework to assess ecosystem services trade-offs (modified from Mouchet et al. (2014)).