Linking forest ecosystem services to corporate sustainability disclosure: a conceptual analysis

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Abstract

Despite the increasing awareness of corporate dependencies and impacts on ecosystems, and related business risks and opportunities, scientific and corporate-based information on these issues is lacking. In our paper we 1) summarise results of a literature review of the impacts and dependencies of plantation-based forestry on ecosystem services; 2) identify the existing and missing links between the corporate sustainability indicators and the ecosystem services framework; and 3) propose a set of possible ecosystem services indicators for corporate sustainability reporting. We particularly focus on the catalytic role of the Global Reporting Initiative (GRI) indicators framework for integrating the ecosystem services approach into corporate sustainability reporting. Finally, we discuss how an ecosystem services approach could benefit future sustainability reporting practices in the context of the forest sector, especially in relation to existing gaps and challenges.

1. Introduction

Fast-paced economic development has been achieved at the cost of environmental degradation, loss of biodiversity and ecosystem services, resulting in the exacerbation of poverty and diminished benefits for future generations. According to the Millennium Ecosystem Assessment (MA, 2005) [1], reversing ecosystem degradation while meeting increasing demands for their services can only be met by a change in policies, institutions and practices.

A main strength of the ecosystem services framework proposed by MA is its flexible and holistic approach, which can be implemented into existing public and private governance instruments.

[1] The Millennium Ecosystem Assessment (2005) defined ecosystem services as the benefits that people obtain from ecosystems' functions, e.g. clean water, carbon storage, pollination, pest reduction, food, timber and recreation. Ecosystem services are grouped into four categories: provisioning, regulating, cultural and supporting services.

Research interest has recently grown on the linkages between the ecosystem services framework and business sustainability disclosure (Hanson et al., 2012; Waage, 2012; WBCSD, 2011), especially in regard to business impacts and dependencies on the environment[2]: suggesting that several economic sectors rely directly and indirectly on natural resources, while their operational activities are also a major driver of ecological change (Molnar et al., 2012).

Disclosure of sustainability information by companies is a form of soft regulation consisting of the adoption of external reporting standards on performance indicators, strategies and practices. Corporate reporting of selected sustainability indicators has become mandatory in several European countries and regulatory interest on this matter is foreseen to increase in the future (EC, 2013; Ernst & Young and GreenBiz Group, 2012). In addition, responsibility driven investors, consumers and other stakeholders are increasingly interested in sustainability performance, which provides a rationale for voluntary sustainability disclosure. Corporations are thus progressively taking environmental issues into account due to legislative, economic and social motivations (Cho and Patten, 2006; Waage and Kester, 2014).

Sustainability disclosure is particularly relevant for resource-based industries, such as the forest sector. Forest industry globalization is leading to growing pressure on fragile ecosystems in the Global South (Toppinen et al., 2010). Deforestation still represents a major threat in tropical areas and important land use changes have also taken place in temperate and boreal regions (Hansen et al., 2014). A shift from northern boreal and temperate forests towards the highly productive south is occurring, with forest companies establishing fast-growing plantations and facilities in Asia, Africa, South America and Oceania (Kirilenko and Sedjo, 2007; Vihervaara, 2010). The area of fast-growing plantations worldwide, expected to increase in the future, represents approximately 4% of the total forest coverage, but contributes to one third of the global wood and fibre supply (Bauhus et al., 2010; FAO, 2005, 2006; Indufor, 2012).

The rapid pace of forest industry globalization has triggered a great need for companies to acquire and secure operational legitimacy by regularly disclosing information of their sustainability related activities (Li and Toppinen, 2011). Forest enterprises are concurrently called at responding to several challenges, such as securing resource a base, meeting growing energy demand, globalization of

[2]The concept of 'impact', 'dependency' and 'response' of economic sectors on ecosystem services has been introduced by several initiatives linking business and nature, such as the 'Approach for reporting on ecosystem services' (GRI, 2011), the guidelines released in 'The Corporate Ecosystem Services Review' (Hanson et al., 2012) and TEEB Business (2012), as well as in scientific works (e.g. Houdet et al., 2012).

production and consumption, evolution of international environmental policies, industry competitiveness, communication and public relations and more comprehensive acknowledgement of social and equity issues (Vihervaara and Kamppinen, 2009). In addition to a mere act of 'social responsibility' or compliance with governmental regulations, sustainability reporting can be motivated by financial or strategic opportunities: creating or improving a solid reputation and stakeholder dialogue; improving current practices, e.g. in land management, and securing access to resources for the future (Brody et al., 2006; Dyke et al., 2005; Scherr et al., 2006).

Despite the increasing awareness of corporate dependencies and impacts on ecosystems, and related business risks and opportunities, scientific and corporate-based information on these issues is lacking (Whiteman et al., 2013; Winn and Pogutz, 2013). Measuring and reporting about sustainability performance represents an increasing challenge to businesses of all kind, and previous research has focused on identifying gaps and challenges in current reporting practices (e.g. Lozano and Huisingh, 2011; Li and Toppinen, 2011; Rimmel and Jonäll, 2013), including incorporating meaningful qualitative and quantitative indicators; articulating the discussion on biodiversity, land and resources use; addressing the compartmentalisation and failure to acknowledge the inter-linkages between reporting of economic, social and environmental dimensions. In addition to the existing limitations of sustainability reporting practices, previous research has pointed out the need to promote development of standardized protocols for assessing biodiversity and ecosystem service related impacts and dependencies (Houdet et al., 2012).

Our paper argues how an ecosystem services approach could benefit future sustainability reporting practices in the context of the forest sector. To do so, it identifies potential existing and missing links between forest sector corporate sustainability disclosure and the ecosystem services framework, building on a literature review of plantation-based forestry impacts and dependencies on ecosystem services. We then also propose a set of ecosystem services indicators for corporate sustainability reporting. Our study particularly analyses the catalytic role of the Global Reporting Initiative (GRI, 2011) framework of indicators for integrating the ecosystem services approach into corporate sustainability reporting. The GRI framework was selected for our analysis because it is currently the most comprehensive voluntary standard for corporate sustainability disclosure covering all dimensions of sustainability — environmental, social and ethical aspects — and holding worldwide recognition (Brown et al., 2009a,b; Kolk, 2010; Levy et al., 2010; Toppinen and Korhonen-Kurki, 2013). The GRI also aligns with other international reporting standards, including the OECD and UN guidelines, and represents a platform for developing the holistic corporate responsibility standard ISO26000 (Levy et al., 2010; Hahn, 2012). Large forest companies with high business diversity are found to be active in adopting GRI disclosure (Toppinen et al., 2012). Moreover, GRI has set a transition timeline to its most recent guideline indicators: corporate reports issued after December 2015 must follow G4.

The rest of the paper is divided in three parts. Section two describes the data and methods used, section three covers the results, including a literature review of the impacts and dependencies of plantation-based forestry, and the future development of corporate sustainability indicators based on the identified gaps. Discussion and conclusions are drawn in section four.

2. Methods

This paper is based on a literature review of the environmental and social impacts and dependencies of plantation-based forestry and on a content analysis of the existing GRI indicators. During the literature review (results in 3.1), several studies have been identified that deal with plantations forestry, however these mainly focus on water resources, soil and nutrients, carbon storage and climate change, biodiversity and habitat maintenance at site level. On the other hand, regional or global trends, and links between forestry and some ecosystem services (e.g. genetic resources, pollination, and cultural services) have received little attention by scientific research. For this reason, in addition to a literature search (Web of Science) for peer-reviewed articles in English, an internet search for grey literature was conducted. Various combinations of key words were used in the search, from the general to the more specific. The terms 'plantations, monocultures' were combined with terms 'ecosystem services, impacts, dependencies' and then more specifically with: 'carbon, biodiversity, genetic resources, soil, pollination, recreation, water' and related terms (climate change, floods, fire, pests, rainfall, etc.). When possible, literature was restricted to sources with regional or global scope. The time scope for articles was restricted to year 2001 and beyond. The resulting database for the review includes 23 sources, including empirical studies and literature reviews. The literature used for our review is listed under Table 1. For each source, the spatial scale (global, regional, local) and the main findings regarding impacts and dependencies on different ecosystem services were highlighted, following the stepwise procedure on conducting systematic reviews (e.g. Khan et al., 2003). Most ecosystem services can be broadly classified as operating at local, regional, global or multiple levels (EFTEC 2005; Kremen, 2005; Petrosillo 2010).

The qualitative content analysis (results in section 3.2) focused on the most recent set of corporate responsibility indicators (version G4) released by the Global Reporting Initiative (GRI, 2013). The descriptions of the indicators were examined in the content (Krippendorf 1980) to find potential links and gaps with the ecosystem services MA framework. In analysing the data, sustainability guidelines and other relevant documentation from GRI were carefully reviewed. We identified those indicators that hold potentially relevant information regarding forest ecosystem services. We also considered indicators linking to wider social and environmental benefits, such as employment, equality, community involvement and well-being (the importance of these is discussed in e.g. Kettunen and ten Brink, 2013); indicators linking to supply chain responsibility and to disclosure of financial information. The Global Reporting Initiative (GRI 2011) identifies three categories for the indicators: dependency, impact, response. Indicators of impacts include information regarding the pressures exerted on the environment by the company, such as the amount of pesticides spread around plantations. Indicators of dependencies include information on the importance of ecosystem services to the company's operations and general performance. An example of dependence is the water used for growing trees in plantations. Indicators of responses refer to actions or behaviour by the company that can compensate for its negative impacts in any part of the supply chain. This can refer, for instance, to sustainable management of ecosystem offset.

Building on the gaps between the GRI indicators and the ecosystem services framework, we identify possible future indicators of ecosystem services for corporate sustainability reporting in the context of plantation based forestry (3.3). The analysis proposed in this paper differs from the one initiated by GRI (2011) in several aspects. The GRI identified the available and potential indicators based on the key threats to ecosystems (habitat loss, overexploitation of resources, climate change, pollution, and invasive alien species) rather than based on ecosystem services. In addition, the analysis proposed by GRI is an overview all organizations and sectors, while our analysis - even though applicable to other sectors – specifically focuses on the forest sector, building on the existing scientific knowledge linking forestry and ecosystem services.

3. Results

3.1 Forest industry dependencies and impacts on ecosystem services: a literature review

3.1.1 Dependencies

The global forest industry, especially in emerging markets such as China, Brazil and India, is in continuous deficit of raw materials, e.g. wood and fibre biomass (Hansen et al., 2014). Besides fibre for wood, pulp and paper and bioenergy production, forest industry production depends more or less directly on various other natural resources or processes (Table 1). Water is one of the primary environmental inputs for forest-related enterprises, as it is employed in pulp and paper production manufacturing. Water availability, together with soil quality and fertility and extreme weather events, is additionally a major constraint to pulpwood plantations (Wei and Xu, 2003). Climate change, associated with impoverished soil, vegetative cover and biodiversity loss is widely expected to increase risks for the forest industry. Although some models suggest that global timber productivity will likely increase with climate change, regional production will exhibit large variability (Kirilenko and Sedjo, 2007). Increased frequency and unpredictability of extreme weather events such as storms, flooding and droughts will represent a great threat in terms of productivity. Costs for forestry operations and other services might increase, such as logistics costs and insurance fees. Other vulnerabilities include changes in wood quality, forest fires or pest outbreaks (Pawson et al., 2013). Reduced biological control in modified forests is a critical issue to forestry. Plantations in areas outside their native range might be more sensitive to pest invasions (Nair, 2001; Walther et al., 2009). All these threats, especially relevant in monocultures, can result in substantial economic uncertainty to the forest sector (Kirilenko and Sedjo, 2007). Although some activities (e.g. pulp production) are based on the utilization of single or few species, forest industry is a biodiversity-dependent industry and several local level linkages to species and genetic diversity exist. Genetic diversity maintenance is necessary for bioprospecting and for securing material for genetic improvement (Fenning and Gershenzon, 2002; Fox et al 2014). Harvesting and sourcing a wider portfolio of species can therefore reduce reliance on a narrow set of species as the primary source of income, increasing adaptive capacity and reducing sensitivity (TEEB National and International Policy Making, 2011; WWF, 2013).

3.1.2 Impacts

Plantations provide opportunities for efficient fibre production and carbon sequestration. The international carbon market has promoted reforestation during past years. Reforestation often uses exotic species (frequently *Eucalyptus* and *Pinus* spp., acacias, poplars) with desired traits, i.e. fast growth, high yield, known site preference and high reproductive rate (Cossalter and Pye-Smith, 2003). *Eucalyptus*, endemic to Australia and adjacent islands, is widely appreciated for paper pulp, fibreboard, industrial charcoal and fuelwood production (Turnbull, 1999).

However, enhancing biomass production for commercial purposes and carbon sequestration imposes trade-offs with several other ecosystem services. This is especially true when plantations are established of natural or semi-natural forests. Monoculture plantations in particular have been criticized to place considerable stress on biodiversity, groundwater recharge, soil quality and other ecosystem services (e.g. Barlow et al 2007; Lamb et al. 2005; Erskine et al. 2006). Even though the impacts of plantations on water resources is controversial and context specific, water uptake increases with ecosystem productivity and fast-growing species are more likely to negatively affect water supply and stream volume, particularly in arid and semi-arid regions. Nutrient demand is also very high in plantations, with effects on soil pH and chemical properties (Jackson et al., 2005; Thompson et al., 2014). Several links exist between forestry, biodiversity and services such as maintenance of genetic resources, biological control and pollination. Forestry may represent a risk for natural habitats and existing wildlife species, particularly in some tropical regions, leading to loss of diversity, invasiveness of commercial alien species, risk of hybridization with local species, effects on pollinator abundance (de Wit et al., 2001; Fenning and Gershenzon, 2002; Taki et al., 2011). The ecological and genetic impacts of introduced commercial species on native populations have in any case not yet been thoroughly monitored (Laikre et al., 2010).

As the human population grows, afforestation competes with agriculture or other activities for land use in some part of the world (Pawson et al., 2013). Local communities might experience a reduction in their ability to access land or benefit from consumptive sources such as non-timber forest products and raw materials (e.g. firewood) (e.g. Vihervaara et al., 2012). Cultural ecosystem services, e.g. aesthetic and landscape values, education and scientific research, recreation and nature-based tourism and spiritual values, are also influenced by land use. Forests hold non-tangible values such as ethical, spiritual and existence values at the local and global levels. Plantations may provide recreational opportunities, especially near urban populations, although conflicts may easily arise caused by forest operations (Indufor, 2013). The social engagement of companies, particularly in developing countries plays a role on wider social and economic factors such as employment, promotion of gender equality, community livelihood and cohesion, investment-induced and indirect local and regional development (e.g. roads and logistics), poverty, land tenure and property right issues, as well as exercise of indigenous rights.

Overall, the nature and magnitude of impacts is very context-specific and varies according to plantation type and local factors. When properly managed, plantations can positively support ecosystem services on degraded land, thereby reducing pressure on natural forests (Eckehard, et al. 2008; Evans and Turnbull, 2004; Hartley, 2002) and creating positive societal value.

Table 1 Impacts and dependencies of plantation-based forestry on ecosystem services and their spatial levels (L=local, R=regional, G=global).

Ecosystem services	Level	Impacts	Dependencies
Provisioning			

Crops, livestock, fisheries, wild foods (j, n, q, s, v)	L-G	Competition with crops and other land uses; limited goods compared to those provided by original forests; restricted access to local communities	n.a.
Timber, fibres, resins, biomass fuel (f, n, r, w)	L-G	Influence on timber quality and species portfolio; competition with bioenergy crops;	Growing demand for wood, pulp and paper and bioenergy production
Freshwater supply (c, j, k, s, u)	L-R	Impact on water groundwater resources: quality and quantity	Input and constraint for plantations
Genetic resources (a, g, h, m, n, o)	L-G	Loss of diversity, risk of hybridization between planted and local species	Genetic improvement
Biochemicals and pharmaceuticals (r)	L-G	Loss of potential resources deriving from genetic and species loss	n.a.
Regulating			
Air quality regulation (r)	R-G	Emissions by various operations; Uptake by planted forests	n.a.
Carbon sequestration and climate regulation (c, k, l, p, t)	L-G	Emissions by various operations; uptake by planted forests	Indirect effects of climate change
Regulation of water timing and flows (c, j, k, s)	L-R	Impacts on water flow and storage	Input and constraint for plantations
Water purification and waste treatment¨ (j, s, u)	L-R	Nutrient leaking and salinization	n.a.
Soil maintenance and fertility, erosion control (c, j, k, p, s, u)	L-R	Impact on soil quality	Input and constraint for plantations
Biological control (a, d, g, l, o, s, t)	L-R	Uncontrolled expansion of planted species	Plantation sensitivity to pests and diseases
Pollination (q, s)	L-R	Potential effects on pollinators	n.a.
Mitigation of extreme events (l, p, u)	L-R	n.a.	Risks for plantations and facilities
Cultural			
Recreation and ecotourism (j)	L-G	Recreational opportunities as well as conflicts caused by forest operations	n.a.
Cultural identity and spiritual values (r, v)	L-G	n.a.	n.a.
Education and research (a, g, h)	L-G	n.a.	Importance of R&D e.g. genetic engineering
Supporting			
Habitat and biodiversity maintenance (b, c, e, f, g, i, j, n)	L-G	Reduced biodiversity, ecosystem simplification compared to natural forest	n.a.
Nutrient cycling (h, j, k, s, u)	L-R	Intensively managed plantations have a negative nutrient balance	Input and constraint for plantations

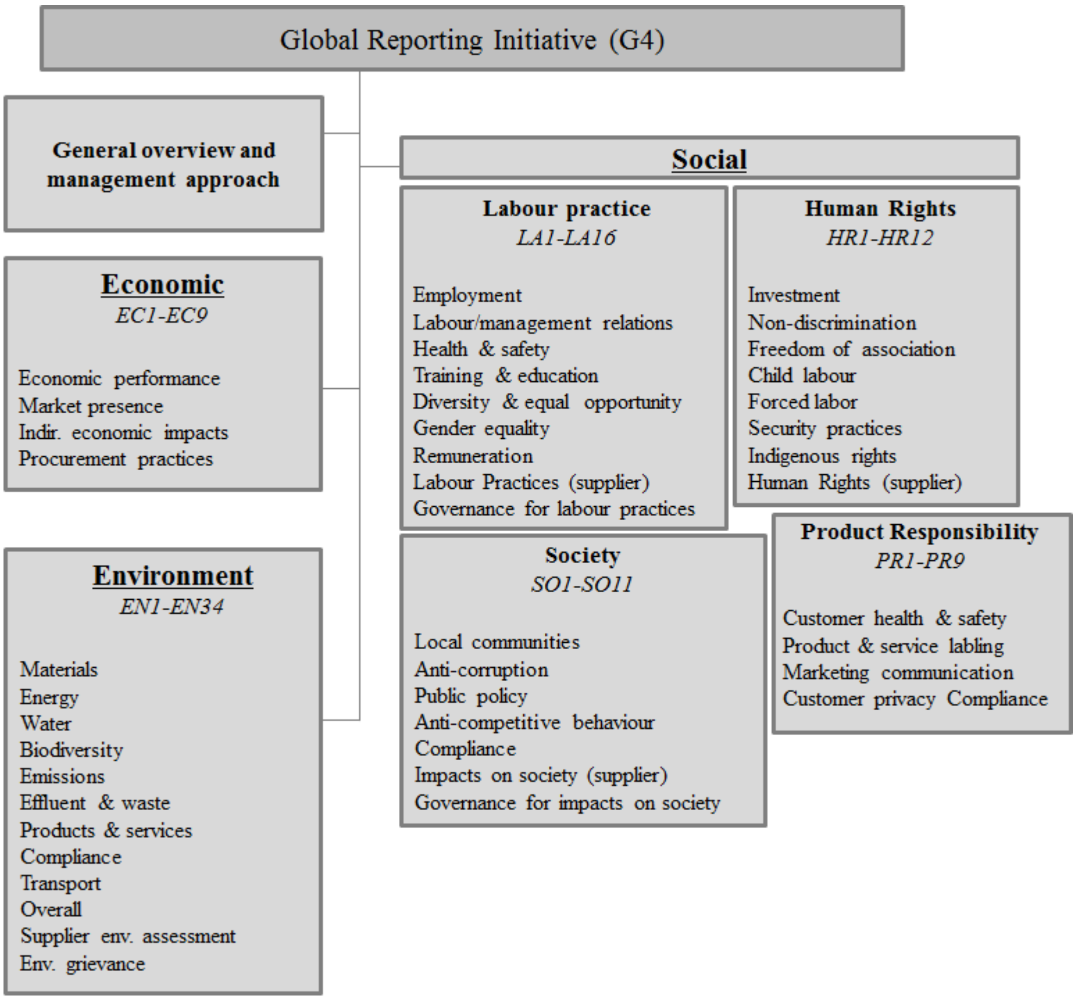
[a] Barber, 2004; [b] Barlow et al., 2007; [c] Cossalter and Pye-Smith, 2003; [d] de Wit et al., 2001; [e] Eckehard et al., 2006; [f] Erskine et al., 2006; [g] Fenning and Gershenzon, 2002; [h] Fox et al., 2002; [i] Hartley, 2002; [j] Indufor, 2013; [k] Jackson et al., 2005; [l] Kirilenko and Sedjo, 2007; [m] Laikre et al., 2010; [n] Lamb et al., 2005; [o] Nair, 2001; [p]

Pawson et al., 2013; [q] Taki et al., 2011; [r] TEEB National and International Policy Making, 2001, Chapter 4, p. 23-34; Chapter 7, p. 7; [s] Thompson et al., 2014; [t] Walther et al., 2009; [u] Wei and Xu., 2003; [v] Vihervaara et al., 2012; [w] WWF, 2013.

3.2 Developing Indicators for Corporate Sustainability Disclosure

3.2.1 Existing GRI indicators

The GRI framework covers three domains: economic, environmental and social responsibility (Figure 1). Social domain is further divided into four categories. Each of these domains lists a number of indicators that quantify corporate performance. The indicators are coded according to the information type they hold: 'EC' stands for Economic; 'EN' for Environment; 'LA' for Labour Practices; 'HR' for Human Rights; 'SO' for Society; 'PR' for Product Responsibility. Each indicator is composed of the category abbreviation followed by a number. Table 2 includes the content of existing GRI indicators that might hold ecosystem services-related information in an impact-dependence-response evaluation. Most of the relevant indicators for this study are obviously classified under the 'Environment' category. However, significant information can also be found under the 'Economic', 'Labour Practices', 'Human Rights' and 'Society' indicators. Next we will discuss the current state and development needs of sustainability indicators in relation to different ecosystem services.



Modified from GRI (2013)

Figure 1 The GRI framework on economic, environmental and social sustainability indicators.

Information related to ecosystem services is relevant particularly when companies report on their environmental and ecological impacts and dependencies and on related business risks, their environmental governance and their contribution to current and future society in terms of social engagement. Some indicators of provisioning services are generally already available as they are incorporated into marketed commodities. GRI indicators EN1 and EN2, for example, refer to weight or volume of input materials (e.g. timber and fibres) which are used in production and percentages of recycled materials.

Given the global importance of water resources, water-related issues have gained increasing attention in corporate sustainability disclosure. Companies report their water withdrawal by volume and source (e.g. water bodies, wetlands, oceans, groundwater, etc.) in the GRI system. Sources heavily affected by abstraction are described in terms of size, protection status, biodiversity value and importance to local communities. The volume of water recycled and reused is also reported (GRI codes EN8–EN10).

These indicators can deliver important information regarding water availability for companies and other stakeholders' use and consumption. The following indicators are relevant regarding water quality (GRI codes EN22–EN26): planned and unplanned water discharges in terms of volume, quality and destination; hazardous and non-hazardous waste, including weight and disposal practices; water bodies and related habitats affected by discharges, including size, eventual protected status, biodiversity value; recorded significant spills; transported, imported, exported or treated hazardous waste.

Business enterprises have a certain awareness of the non-monetary and financial implications of climate change, as these issues have had enough time to penetrate business language and thinking. Carbon-related issues are of particular global relevance to forestry and forest industry (Canadell and Raupach, 2008). Companies report "risks and opportunities posed by climate change that have the potential to generate substantive changes in operations, revenue or expenditure" within the GRI indicators (GRI code EC2). GRI quantitative indicators include emissions and reductions achieved from direct and indirect greenhouse gases, ozone-depleting substances, nitrogen, sulphur oxides and others (GRI code EN15–EN21).

Biodiversity related indicators include information concerning operational sites near or within protected areas or areas of high biodiversity value. Companies may report significant impacts, habitats protected or restored, the number of nationally or internationally (e.g. International Union for Conservation of Nature IUCN) endangered species with habitats in areas affected by operations (EN11–EN14). The presence of protected areas or areas of high biodiversity value near operational sites (EN11) can also indicate potential links with cultural services, such as ecotourism and recreation. An important element for cultural identity, especially in developing countries, concern indigenous rights (HR8). Relations between indigenous and local communities and the forestry industry are often marked by conflict, primarily because of land access and customary rights and companies report about the number and status of rights violations and remediation plans.

Several GRI indicators that are listed under 'Environment' category may be useful for a more comprehensive analysis of the relationships between business and ecosystem services. Companies address social and economic issues when reporting about market presence, economic impacts and procurement practices (EC5–EC9), labour practices (LA1–LA16), human rights (HR1–HR12) and society (SO01–SO11). Companies report also about diversity and equal opportunities in investments in training and education, employment and remuneration, labour practices, and well-being of local communities. All these aspects link to social impact and regional development.

Corporate environmental disclosure rarely focuses on indirect impacts deriving from non-operational activities of the supply chain, such as logistics and other services. *In situ* operations evidently represent the most significant portion of the biodiversity and ecosystems impacts for plantation-based forestry. However, companies also rely on the health and productivity of lands and other resources upstream or downstream in their supply chains. The supply chain network ranges from small, local companies to large global suppliers. A more holistic understanding of the direct and indirect dependencies and impacts of forest industry on ecosystems and related services is needed. The current GRI standard emphasizes the incorporation of impacts deriving from supply chain and other indirect services, including suppliers and logistics (EN29–EN34).

In several countries, industrial plantations have been established with financial incentives from the state including tax exemption and direct or indirect subsidies (Cossalter and Pye-Smith, 2003).For example, reporting on 'financial assistance received from government' (EC4), such as subsidies, may be of relevance for cost-benefit analyses and determine business risks and opportunities in a scenario of subsidized versus free market.

Table 2 Areas of integration between the ecosystem services approach and the existing GRI indicators (G4) in an impact-dependence-response matrix.

Ecosystem services	GRI Indicators (G4)		
	Impact	Dependence	Response
Provisioning			
Timber, fibres *EN1, EN2*	n.a.	Material used by weight or volume	Recycled materials (%)
Water supply *EN8–EN10*	Water sources affected by withdrawal (volume)	Water withdrawal by source (volume)	Water recycled and reused (volume)
Regulating			
Water purification and waste treatment *EN22–EN26*	Water and waste discharges (volume) and relative disposal methods; affected water bodies and related habitats (size, protected status, biodiversity value)	n.a.	n.a.
Carbon sequestration and climate change *EC2; EN15–EN19*	Direct and indirect greenhouse gases (weight)	Risks and opportunities posed by climate change	Reduction achieved (weight)
Air regulation *EN20–EN21*	Ozone-depleting substances, nitrogen and sulphur oxides	n.a.	n.a.

	and other significant emissions (weight)		
Biological control *EN14*	Introduction of invasive species, pests, and pathogens near or within protected or high biodiversity areas	n.a.	n.a.
Cultural			
Recreation and other cultural services *EN11*	Number, type and impacts of operational sites near or within protected or high biodiversity areas	n.a.	n.a.
Supporting services			
Habitat and biodiversity maintenance *EN11–EN14* *HR8*	Number, type and impacts of operational sites near or within protected or high biodiversity areas (e.g. changes in ecological processes, pollution); number of endangered species in areas affected by operations; Number and status of rights violations of indigenous people	n.a.	Size and status abitats protected or restored Remediation plans for violation of indigenous rights
Other social and environmental indicators			
Wider social and economic benefits *LA1–LA16; HR1–HR12; SO1–SO11*	Various indicators related to labour practices, human rights and society	n.a.	n.a.
Responsibility along the supply chain and financial indicators *EC 1, EC4* *EN29–EN34*	Direct economic value generated and distributed; Actual and potential negative environmental impacts in the supply chain	Financial and non-monetary sanctions for non-compliance with regulation; environmental expenditures and investments; Environmental grievances	Percentage of partners screened by environmental criteria; behaviour toward impacting partners (e.g. relations terminated)

GRI Indicators are coded according to the type of information they hold: 'EC'=Economic; 'EN'=Environment; 'LA'=Labour Practices; 'HR'=Human Rights; 'SO'=Society; 'PR'=Product Responsibility (Figure 1).

3.2.2 Identifying future sustainability indicators

In Table 3, we identified a set of possible future indicators of ecosystem services for corporate sustainability reporting in the context of plantation-based forestry. In the background, forest companies rely on independent institutes and on internal assessments for monitoring the impacts on biodiversity, soil erosion, nutrients leaking, water resources, ecologically or culturally sensitive areas. If rigorously conducted, this information could be integrated in voluntary reporting standards. Indicators of impact could include land use changes (ha of land, ecosystem types) and number of people affected by operations (e.g. reduced access to land, resources, recreation opportunities), as well as metrics on changes in water table, soil quality and nutrients. Indicators measuring dependence include, for example, species and genetic resources directly related to production, risks and economic losses from pests and extreme weather events, amount and costs of fertilizers application. Indicators measuring corporate response strategies or actions can build on information concerning company's efforts – eventually in cooperation with a third party - dedicated to ecosystem services and biodiversity conservation, restoration or offset. Examples of these include monitoring of and protection of ecologically or culturally sensitive areas, for example through mapping, or establishment of buffer zones; management with multiple species rather than monocultures; land managed in synergy with activities such as farming, fishery, apiculture.

Table 3 Possible future indicators of ecosystem services for corporate sustainability reporting in the context of plantation-based forestry.

Ecosystem services	Potential indicators		
	Impact	**Dependence**	**Response**
Provisioning			
Crops, livestock, fisheries, wild foods	Ha of land area potentially competing with other land use forms; No. of people with denied or restricted access to resources	n.a.	No. of farming, fishing or other activities occurring on site
Timber, fibres, resins, biomass fuel	Ha of land area potentially competing with other land use forms; No. of people with denied or restricted access to resources	n.a.	Ha of land area managed with multiple species; No. of species used in production
Freshwater supply	Ha of land area and ecosystem types experiencing land use changes or management practices with potential negative impacts	Demand for freshwater per ha	Ha of land area with monitoring in place, under sustainable management or set aside for conservation, restoration or offset
Genetic resources	n.a.	No. and type of species directly or indirectly related to production; genetic diversity necessary for genetic improvements (%)	n.a.
Biochemicals and pharmaceuticals	No. and type of potentially useful species affected or threatened by company operations	n.a.	n.a.
Regulating			
Air quality regulation	No. of people affected in the surroundings of operation sites; Pollutant sequestrated by biomass (volume)	n.a.	Ha of land area with monitoring in place, under sustainable management or set aside for conservation, restoration or offset to reduce emission related to operations, land conversion, forest fires
Carbon sequestration and climate regulation	Carbon sequestrated by biomass (volume)	n.a.	Ha of land area with monitoring in place, under sustainable management or set aside for conservation, restoration or offset to reduce

			emission related to operations, land conversion, forest fires
Regulation of water timing and flows	Ha of land and ecosystem types experiencing land use changes or management practices with potential negative impacts; Metrics on changes in water table	Ha of land important for operations where changes occur	Ha of land area with monitoring in place, under sustainable management or set aside for conservation, restoration or offset
Water purification and waste treatment	Metrics on water quality changes; Ha of land and ecosystem types experiencing land use changes with potential negative impacts	Ha of land important for operations where changes occur	Ha of land area with monitoring in place, under sustainable management or set aside for conservation, restoration or offset (e.g. mapping, buffer zones)
Soil maintenance and fertility, erosion control	Ha of land and ecosystem types experiencing land use changes or management practices with potential negative impact; Metrics on pH changes	Ha of land important for operations where changes occur	Ha of land area with monitoring in place, under sustainable management or set aside for conservation, restoration or offset
Biological control	n.a.	Ha of land area at risk of / affected by pests; Economic loss	Ha of land area with strategies in place; type of strategies in use
Pollination	No. of pollinator species occurring on site	n.a.	Ha of land area managed in synergy with activities such as farming, apiculture
Mitigation of extreme events	n.a.	Ha of land area at risk of / impacted by extreme weather events; Actual or potential economic loss	Ha of land area with monitoring in place, under sustainable management or set aside for conservation restoration or offset
Cultural			
Recreation and ecotourism	Ha of land area of relevance to local and international recreation and tourism; No. and type of operational activities affecting recreational opportunities	n.a.	Ha of land area with monitoring in place or set aside; type of actions to minimise adverse impacts local communities.(e.g. mapping, buffer zones)
Cultural identity and spiritual values	Ha of land area of relevance to cultural or spiritual values; No. of items of cultural or spiritual relevance on site (e.g. graves, sanctuaries); No. and type of operational activities affecting spiritual values; Number and type of disputes related to land use and customary rights with local and indigenous people	n.a.	Ha of land area with monitoring in place or set aside; type of actions to minimise adverse impacts local communities. Remediation plans or actions for violation of land use and customary rights
Education and research	Ha of land area or No. of projects involved in collaborations with universities or research institutes	n.a.	n.a.
Supporting			
Habitat and biodiversity	Ha of land and ecosystem types experiencing land use or management practices with potential negative impact.	n.a	Ha of land area with monitoring in place, under sustainable management or set aside for conservation, restoration or offset
Nutrient cycling	Ha of land and ecosystem types experiencing land use or management practices with potential negative impact; Metrics on changes in nutrient content	Ha of land important for operations where changes occur: Demand of fertilizers (kg) per ha and economic costs	Ha of land area with monitoring in place, under sustainable management or set aside for conservation, restoration or offset

4. Discussion and conclusions

Forest industry and forestry rely on a variety of ecosystem services and underpinning biodiversity for operating successfully. These ecosystems are, nonetheless, affected by company operations and by other indirect activities. Focusing on a narrow set of forest ecosystem services might thus compromise the capacity of ecosystems to deliver services and benefits to business and society in the long run. Based on our content analysis, existing quantitative GRI indicators for business activities either focus on social or environmental sustainability, with information available on several globally critical issues, such as timber and fibre resourcing, water uptake, waste, carbon and pollutant emission. Some relevant ecological or social indicators are however to a large extent still lacking. In addition, existing indicators particularly focus on corporate social or environmental impacts, while the strategic perspective, i.e. understanding of dependency and response strategies is insufficiently reported.

Regarding developing future indicators from the perspective of forest ecosystem services, carbon and water disclosure will continue to be of uttermost relevance in the future. While carbon emissions are currently monitored for industrial activities, forestry operation impacts are difficult to assess due to their diverse sources. Carbon uptake monitoring carried out by forestry has been the attention object of companies, in relation to the development of carbon trading schemes. Despite the current loss of momentum on carbon trading (Ecofys, 2013), the introduction of initiatives such as the Forest Footprint Disclosure Project (FFD) and its recent merger with Carbon Footprint Disclosure are likely to promote better carbon management integration into corporate business strategies. Regarding water resources, the applicability of the water footprint tool for forestry and forest-based products has been developed and tested with pioneering water footprint accounting (Launiainen, 2014; Stora Enso, 2011; UPM, 2011; van Oel and Hoekstra, 2010, 2012).

Future development of sustainability indicators could furthermore integrate information on land use changes and land use competition, genetic resources, soil maintenance and fertility, erosion control, biological control, and cultural values. These aspects are not only of critical relevance to forestry and forest industry, but to many other natural resource-intensive sectors as well. Emphasis should be placed on better understanding dependencies and response strategies, as existing indicators on these issues are clearly insufficient. We especially tried to develop indicators to this aim, based on the recommended sustainable forestry management practices, arising also from existing forest certification standards.

In developing relevant new indicators, it must be acknowledged that companies face practical difficulties in reporting qualitative sustainability issues which may appear as over or under emphasizing the company sustainability performance (Toppinen and Korhonen-Kurki, 2013; Toppinen et al 2012). On the other side, manifold challenges exist in developing meaningful quantitative environmental indicators (Feld et al., 2009; Müller and Burkhard, 2012): companies may incur into technical difficulties and lack sufficient resources to undertake wide-scale assessments; in addition, scaling up of quantitative information from site level to multi-site or even global trends may be challenging.

Nonetheless, the concept of ecosystem services has recently appeared in several companies' sustainability disclosure documents. Pioneering qualitative and quantitative assessments led by multinational companies have identified several ecosystem services relevant to corporate impacts and dependencies (Hanson et al., 2012; WBCSD, 2011; Waage and Kester, 2014) and some front-runner examples also exist among forest companies, such as Mondi, Fibria and MeadWestvaco (Waage, 2012). An ecosystem services approach could benefit future sustainability reporting practices by encouraging the currently disarticulated discussion on biodiversity, land use and resource stewardship; by providing a more holistic view on the economic, social and environmental dimensions of corporate reporting; and by feeding into currently missing sector-specific guidelines.

Previous research on corporate reporting has shown that biodiversity issues are a very recent phenomenon for forest companies and no clear disclosure strategies have been developed yet (Houdet et al., 2012; Rimmel and Jonäll, 2013). Integrating measurable ecosystem services indicators could help filling the gap between rhetoric and action. A more comprehensive approach to corporate sustainability performance does not necessarily mean the achievement of solid environmental and social standards, but it represents a needed (Gray 2010) willingness to participate in dialogue with influential or influenced stakeholder groups in the contexts of operations. Different stakeholder groups usually prefer indicators that respond to and reflect the scale of their particular concerns (O´Connor and Spangenberg, 2007). Many influential stakeholder groups, such as the environmental NGOs, consider GRI reported information not sufficiently detailed (Levy et al. (2010). Furthermore, they tend not to trust the external assurances provided by the (optional) audit process, done for GRI reports by commercial companies. From the perspective of transparency and legitimacy of corporate actions, improved reporting is necessary, but it may not still be sufficient if company actions are found to deviate from words.

Existing sustainability indicators - based on the triple-bottom line of economic, environmental, and social dimensions - have also been criticized to create compartmentalisation in reporting (Lozano and

Huisingh, 2011). This means that despite economic, environmental and social issues are often related to each other, indicators are not discussed holistically. The ecosystem service approach instead highlights the synergies - positive and negative - among these three dimensions (TEEB National and International Policy Making, 2011), as many ecological processes are intertwined with each other (e.g. water, soil, nutrients), and with economic, cultural and social aspects (e.g. property rights, management practices). This means that the same indicator can supply layered information, and strategies or practices in use can deliver multiple benefits. Finally, ecosystem services indicators could feed into sector specific reporting guidelines. Despite global diffusion of corporate disclosure based on GRI (e.g. del Mar Alonso Almeida et al., 2013), the variety of sustainability reporting guidelines indicates existence of heterogeneous sustainability strategies, in e.g. different geographical regions and sectors of industries. GRI industry and sector specific supplements exist for some sectors, such as mining, but they are still lacking for the forest industry, despite many sector specific characteristics and expressed need in the previous literature (Li and Toppinen, 2011; Panwar and Hansen, 2007; Sinclair and Walton 2003;). We believe that the systematic development of corporate disclosure by applying an ecosystem services approach could contribute to the progress of forest sector reporting practices and most importantly, to the achievement of enhanced sustainable use of forest resources.

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