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Climate-Smart Forestry: the missing link

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ABSTRACT

To achieve the objectives of the Paris Climate Agreement, a significant reduction in carbon dioxide emissions is needed, as well as increased removals by carbon sinks. In this context, we argue that Climate-Smart Forestry is a necessary, but still missing component in national strategies for implementing actions under the Paris Agreement. Climate-Smart Forestry is needed to (a) increase the total forest area and avoid deforestation, (b) connect mitigation with adaption measures to enhance the resilience of global forest resources, and (c) use wood for products that store carbon and substitute emission-intensive fossil and non-renewable products and materials. Successful Climate-Smart Forestry has important policy implications on finding the right balance between short and long-term goals, as well as between the need for wood production, the protection of biodiversity and the provision of other important ecosystem services. CSF thus can provide important co-benefits that are increasingly being recognized as essential for sustainable well-being.

1. Introduction

The Paris Agreement requires major societal and economic reforms to ensure that the global average temperature remains below 2 °C pre-industrial levels. Achieving this target requires a significant reduction in gross anthropogenic carbon dioxide (CO_2) emissions and an increase in human and biosphere carbon sinks (Rockström et al., 2017). Forests and forestry can play an important role in this context; reducing deforestation and forest degradation lowers greenhouse emissions, forest management can maintain or enhance forest carbon stocks and sinks and wood products can store carbon over the long-term and can substitute for emissions-intensive materials reducing emissions (IPCC 2019).

'Natural climate solutions' (Griscom et al., 2017) have been suggested as important means to mitigate climate change that can contribute up to 37% (23.8 Pg CO_2 eq. yr^{-1}) of the required global emissions reduction by 2030. Approximately two-thirds of the total mitigation potential from these natural climate solutions could be achieved through storing carbon in forest ecosystems (Griscom et al., 2017). However, only storing carbon in forest ecosystems ignores three important issues. Firstly, such a strategy mainly provides benefits until the sink saturates and ignores the many other functions that forests fulfil (Nabuurs et al., 2013). Secondly, storing carbon in forest ecosystems is not free of risks; many existing climate impact studies suggest an increasing risk from natural disturbances (Seidl et al., 2017) and render such strategies less successful (Seidl et al., 2014). A successful mitigation strategy must consider adaptation measures to ensure the resilience of forest ecosystems (Schoene and Bernier, 2012). Thirdly, a mitigation strategy that only emphasizes storing carbon in forests also disregards the urgent need to decarbonize the global economy. Under existing trends, global resource extraction for biomass, fossil fuels, metal ores, and minerals is estimated to increase from 84 to 184 billion tons per year between 2015 and 2050, which is associated with a 41% increase in greenhouse gas emissions (Hatfield-Dodds et al., 2017). In this context, forests, which are the primary source for non-food and non-feed renewable biological resources globally, play an important role and should therefore not be set-aside for storing carbon only. Emerging technologies provide unprecedented possibilities for using wood to produce a new range of bio-based and renewable solutions that can replace fossil-intensive and non-renewable products, such as construction, chemicals, textiles or plastics. Therefore, a forest management that ensures a continued, sustainable flow of woody raw material is also crucial to mitigate climate change.

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2. The need for Climate-Smart Forestry

Climate change will strongly affect humans and ecosystems, especially if the global average temperature rise will exceed 1.5 °C (IPCC, 2018). There is thus a need to adapt to the impacts of climate change in addition to the need to mitigate climate change. Unfortunately, mitigation and adaptation are often not considered together in national strategies for implementing actions under the Paris Agreement (i.e. Nationally Determined Contributions) (Nordic Council of Ministers, 2017; Seddon et al., 2019). Here, we argue that a Climate-Smart Forestry (CSF) is a necessary, but still missing component in these strategies. CSF aims to connect mitigation with adaption measures, enhance the resilience of forest resources and ecosystem services, and meet the needs of a growing population and expanding middle class. CSF has been introduced as a holistic approach to guide forest management in Europe (Nabuurs et al., 2017; Jandl et al., 2018; Yousefpour et al., 2018), but the approach is of global relevance (e.g., Bele et al., 2015). CSF builds on the concepts of sustainable forest management, with a strong focus on climate and ecosystem services. It builds on three mutually reinforcing components:

- Increasing carbon storage in forests and wood products, in conjunction with the provisioning of other ecosystem services;
- Enhancing the health and resilience through adaptive forest management; and
- Using wood resources sustainably to substitute non-renewable, carbon-intensive materials.

CSF aims to have a mix of these measures by developing spatially-diverse forest management strategies that acknowledge all carbon pools simultaneously to provide longer-term and larger mitigation benefits, while supporting other ecosystem services. Such strategies should combine measures to maintain or increase carbon stocks in forest ecosystems and wood products, and maximize substitution benefits, while taking regional conditions into account. Here we formulate three key messages to realize the full potential of CSF.

3. Key messages

3.1. Enhance global afforestation and avoid deforestation and degradation

Global afforestation and avoiding deforestation and degradation have received - together with bioenergy - significant attention in global forestry-related climate change mitigation efforts. Their contribution to climate change is significant and ranges from 0.5–10.1 Pg CO_2 eq. yr^{-1} for afforestation, 0.4–5.8 Pg CO_2 eq. yr^{-1} for reduced deforestation and 1–2.2 Pg CO_2 eq. yr^{-1} for reduced degradation and all relate predominantly in the tropics (Roe et al., 2019). The Bonn Challenge and the New York Declaration on Forests are prime examples of initiatives aiming to restore and establish large tracts of forest land. However, successful global afforestation efforts go well beyond planting trees; socio-economic conditions and forest-management related choices (e.g., tree species, management regimes) greatly affect the outcome of such efforts (Lewis et al., 2019). Policymakers must confront weak governance and develop incentives, clear regulations (land tenure), and standards that offer certainty and confidence in carbon markets. This is required to attract investments and assure the longevity of established forests, their sustainable management, and locally recognized role in rural economies (FAO, 2016). Avoiding deforestation is especially important in tropical regions, such as Latin America and Southeast Asia, where the production of commodities such as soy, beef, palm oil, coffee, cocoa is responsible for over 60% of the conversion of forests into agricultural land (Curtis et al., 2018). To avoid further deforestation, as well as degradation from unsustainable wood production, policymakers must address commodity prices and demand, inadequate conservation policies, and weak law enforcement. Taken together, these can currently make forest conversion to other land uses appear more profitable (FAO, 2016). Increased transparency of investment flows associated with deforestation should also be a priority.

3.2. Combine mitigation and adaptation measures in the management of forests

Improved forest management measures can contribute to climate change mitigation by 0.4–2.1 Pg CO_2 eq. yr^{-1} (Roe et al., 2019) and are additional to the contribution of forest management to afforestation efforts. That is, forest management can affect or determine the composition of new forests in terms of tree species and provenances, and their rate of removing carbon from the atmosphere. The choice of tree species and provenances is also a key management option in forests already managed for wood production, which are mainly located in North America, Europe, Russia, China, Southern Brazil, Chile, South Africa, and Australia (Curtis et al., 2018). Forest managers have typically simplified forest structures, favoring a few tree species. However, it is becoming increasingly clear that tree species richness is positively related with forest productivity and biodiversity (Liang et al., 2016), which is interesting from both a mitigation and adaptation perspective. For example, increasing species diversity - especially by increasing the share of broadleaved species - in temperate and boreal forest stands improves the resilience of forests to disturbance risks from wildfires, wind, and pests (Jactel et al., 2009; Jactel et al., 2017; Astrup et al., 2018) and avoid significant emissions associated with these disturbances. Forest managers should consider a broader set of tree species and policymakers must incentivize the development of new value chains and technologies to stimulate the use of a larger set of tree species (Astrup et al., 2018; Verkerk et al., 2018). Other examples of combining mitigation and adaptation measures include practices focusing on biomass production in areas subject to a high risk of disturbances and focusing on high quality wood production in areas with low disturbance risks (cf. Nabuurs et al., 2013). The portfolio of potential forest management measures that affect carbon balances in forest ecosystems includes many more measures than species or provenance selection and harvest regimes, but these options may be of more importance regionally. Successful forest management strategies must consider carbon balances of forests and products, as well as biophysical climate impacts (Astrup et al., 2018; Luyssaert et al., 2018), although these latter impacts are still not well understood. More research is needed into how forest management may affect climate beyond carbon and into how mitigation and adaptation measures can strengthen each other (Locatelli et al., 2015).

3.3. Use wood sustainably and substitute non-renewable carbon-intensive materials

Decarbonizing the economy and decoupling economic growth from resource use and environmental impacts requires moving from fossil and non-renewable resources to intelligent, circular, and sustainable use of renewable resources as the basis for products and materials. Industries that rely on fossil-intensive materials (e.g. the construction sector) or fossil-based resources (e.g. textiles, chemicals, or plastics) need to transform towards fossil-free, renewable solutions and wood can be an important alternative raw material. A recent literature review of substitution impacts (Leskinen et al., 2018) showed that wood-based products generally provide important mitigation benefits compared to functionally equivalent non wood-based products. For example, wood used in construction can substitute 2.4–2.9 kg CO_2 per kg and textiles even 5.1 kg CO_2 per kg of wood product. In addition to using wood for substitution, it is also important to utilize biomass as efficiently as possible. The mitigation impact of using wood sustainably can be further developed by adopting the principles of resource-efficiency and the circular economy as the basis for a sustainable forest-based bioeconomy. Policymakers should create flexible incentives to support that,

Box 1
The Four I's (Rockström et al., 2017) for Climate Smart Forestry.

Innovations to bring to the market a new generation of resource-efficient bio-based products and business models to replace fossil-intensive and non-renewable materials that reduce emissions. Innovations are also needed to better measure, monitor, and manage forest ecosystem services and biodiversity.
Institutions to develop policy measures, including public procurement, carbon pricing, standardization and certification of bio-products to create new markets for bio-based solutions, public-private partnerships to invest in forest ecosystem services.
Infrastructures to mobilize and process sustainably harvested forest biomass into new wood-based products. New and better-adapted forests are also key as biological infrastructures.
Investments in new business models, products and technologies to create new value chains and markets. These new value chains will increase, activate, and improve forest management to mitigate and adapt to climate change while providing valuable ecosystem services and conserving biodiversity.

firstly wood is procured and processed as resource-efficiently as possible and used for products that store carbon as long as possible. Secondly, woody biomass should be used to replace products that are the most carbon-intensive and non-renewable and which do not have promising technological solutions to decrease their emissions. Thirdly, attention should be paid to cascading of wood and the end-of-life; material or energy recovery from wood products should be preferred over landfilling.

4. Policy implications

The three messages above call for improved forest policies related to land use, forest management and the enhanced use of wood and wood-based products. However, wood production and climate change mitigation are just two of the many ecosystem services that forest ecosystems provide. The value of global forest ecosystem services has been estimated at \$16 trillion yr^{-1} in 2011 (Costanza et al., 2014), of which 19% comes from climate regulation and 4% from raw material production. Recreation, storm protection, water supply, erosion control, soil formation, nutrient cycling, habitat, genetic resources and non-timber forest products provide most of the rest. Forests are also important to achieving the United Nations Sustainable Development Goals. CSF thus can provide huge co-benefits that are increasingly being recognized as essential for sustainable wellbeing.

The successful development of CSF calls for policymakers to create incentives for investments needed to activate forest management and finance mitigation and adaption measures (cf. Verkerk et al., 2018), which include protecting biodiversity and other ecosystem services. Such a development requires holistic policy frameworks and action plans that address the Fours I's: Innovations, Institutions, Infrastructures, and Investments (Rockström et al., 2017), to strategically connect sustainable land-based mitigation and adaptation strategies with bio-based value chains (Box 1). To implement these Four I's, policymakers should seek to align the economic incentives with regulation to avoid environmentally irresponsible behavior by economic players. Focusing on economic instruments such as taxes, subsidies and public procurement, as well as introducing extended producer responsibility, incentives for retaining value in the circular economy processes, and supporting all the initiatives in the context of greening of the finance, is essential.

Rockström et al. (2017) presented a roadmap for decarbonization by halving global emissions every decade, reducing land-use emissions, and ramping up CO_2 removal technologies. Successful CSF requires a balancing act between wood production, biodiversity, and other important ecosystem services. The optimal balance will vary from country to country and region to region depending on the socio-ecological and technological framework, climate change impacts, and cultural aspects. For example, intact forest landscapes might be better preserved for their unique biological diversity, carbon storage, and other ecosystem services (Watson et al., 2018), while regions with planted forests (and with a long-term forestry tradition) can place more emphasis on wood production. We urge countries to consider CSF and assess its potential contribution in their national mitigation and adaptation strategies, as part of their Nationally Determined Contributions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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