Comparison of greenhouse gas emissions of different biomass management scenarios in Indonesian peatlands

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Abstract:
Peatlands play an important role as carbon pools with one third of the world's soil carbon stored (Joosten & Clarke, 2002). However, peatlands of Southeast Asia have suffered shrinkage due to economic and natural resource pressure, often caused by land use change and fires. In this work, a comparison of three scenarios related to current land uses and aboveground biomass valorization of peatlands was performed. The objective of this study is to compare the global contribution to climate change that could be avoided by means of the biomass valorization and stopping the fires in peatlands. Three scenarios were defined to compare the impact to climate change through greenhouse gas emissions of different land management for biomass from peatland. The scenario assessment is based on meta-analysis reviews. The total greenhouse gas emissions estimated for the scenarios "conservation", "business as usual" and "biomass valorization" were 141, 1114 and 205 t ha^{-1} CO_2 equivalent respectively. The "biomass valorization" scenario avoid 909 t ha^{-1} CO_2 equivalent in comparison with "business as usual" scenario and, contributes 64 t ha^{-1} CO_2 equivalent more than "conservation" scenario. Scenario "biomass valorization" is an alternative to stop the fires in peatlands maintaining a balance between economic activities and contributing in peat formation.

Keywords: *Carbon stock; Peat soil; Peatland; Greenhouse gas; Wildfires; Indonesia*

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1. Introduction

Peatlands cover around 3% of land mass and play an important role as carbon pools with one third of the world's soil carbon stored (Joosten and Clarke, 2002).

However, since 1982, peatlands of Southeast Asia have suffered shrinkage due to economic and natural resource pressure, often caused by fires on forest and agricultural lands. The most important fire episodes occurred in 1997-98 and 2015 in Indonesian peatlands, both during the El Niño event (Huijnen et al., 2016). During the episode of 1997-98, an area of about 10 million ha, including large areas of peat bogs in Sumatra, Indonesia was affected by fires (Tacconi, 2003), having the record of carbon emission for fires (Huijnen et al., 2016). This episode caused emissions to the atmosphere that were estimated between 0.81-2.57 Gt of carbon (Page et al., 2002), contributing in 40% of global anthropogenic carbon emissions estimated in 1998 (Van der Werf et al., 2010).

The biomass valorization from peatlands can be an option to reduce the carbon emissions into the atmosphere by fires on peatlands, converting aboveground biomass into bioenergy or other bio-products and, at the same time, creating incentive for the population (Goralski et al., 2015).

In this work, a comparison of three scenarios related to current land uses and aboveground biomass valorization of peatlands was performed, taking into account the ecological balance of the peatlands. The scenarios defined are: 1) peatland conservation, 2) business as usual including current fires and 3) prospective biomass valorization. The objective is to compare the global contribution to climate change that could be avoided by means of the biomass valorization and stopping the fires in peatlands. For each scenario, the quantification of this global contribution includes both greenhouse gas emissions and carbon storage due to peat bog formation.

2. Material and methods

Three scenarios were defined to compare the impact to climate change through greenhouse gas emissions of different land management for biomass from peatland. The scenario assessment is based on meta-analysis reviews. The scope of these reviews is tropical peatland, specifically in Southeast Asia. To compare the global contribution to climate change of each scenario, the greenhouse gas and carbon storage are considered. For each scenario, a database with the main parameters was created from existing literature. Finally, a statistical analysis, including the variability is carried out.

3. Scenario description

a) Scenario "conservation": The review work was carried out to collect a dataset of flux gases and carbon accumulation of peat swamp forest in drained conditions. In addition, the carbon sequestration in aboveground biomass and peat accumulation were taken into account.
b) Scenario "business as usual": This scenario is based on the current fires of Indonesian peatlands, as consequence of the traditional land preparation. Cropland or wood plantations require drainage and fires to set the proper conditions for more intensive agricultural uses. This land preparation increases the risk of fire expansion (Farmer et al., 2011). To estimate the greenhouse gas emissions that could occur in future fires due to peat combustion, the default values of the parameters involved provided by Rodríguez et al. (to be published) were used. These parameters are bulk density of peat soil measured over the first 85 cm, burned area depth measured in wildfires and emission factors of CO_2, CO, CH_4 and NO. These default values were obtained from a meta-analysis based in mixed-effects models. To estimate the emissions of aboveground biomass combusted in fires, the value provided by Page et al. (2002) was used.
c) Scenario "biomass valorization": This scenario assumed the conversion of the current practices of field managed with fire, to a system of biomass valorization for biofuel production based in the concept of the paludiculture provided by Wichtmann and Joosten (2007). That assumed to use the part of biomass that is not necessary for peat formation. In this way, the emissions considered were flux gases according to the water table, carbon sequestration by aboveground biomass, the combustion of the harvested biomass as biofuel, carbon sequestration from peat accumulation and the impact from bioenergy production.
The assessment considered a 5-year timeframe, with the same initial conditions for each scenario at the beginning of this timeframe.

4. Results

The total greenhouse gas emissions for the scenarios "conservation", "business as usual" and "biomass valorization" were 141, 1114 and 205 t ha^{-1} CO_2 equivalent respectively. The contribution of each emission source is given in Table 1 and Fig. 1.

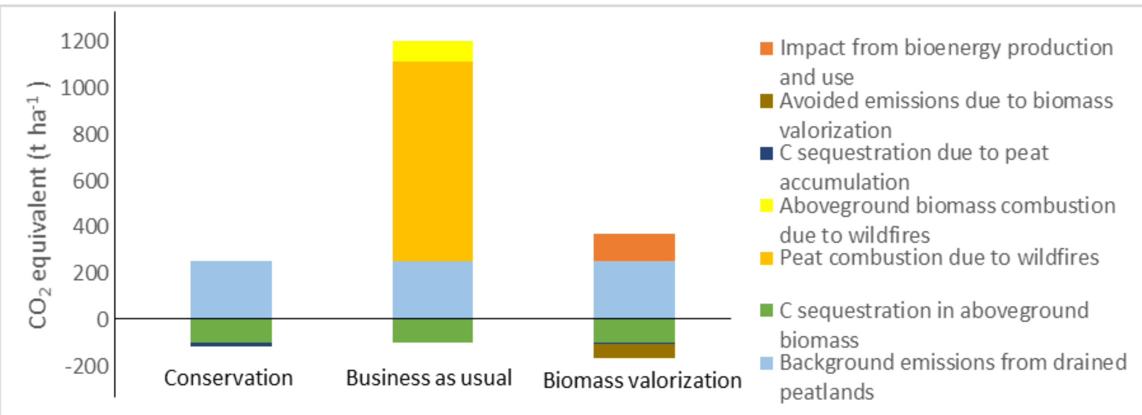

Fig. 1 Greenhouse gas emissions of three scenarios

Table 1 Data set collected to estimate the impact on the atmosphere of each scenario in CO_2 equivalent t ha^{-1} y^{-1}

	Scenario "conservation"	Scenario "business as usual"	Scenario "biomass valorization"
Background emissions from drained peatlands(i)	255	255	255
C sequestration in aboveground biomass(ii)	-96	-96	-96
Peat combustion due to wildfires	0	859(iii)	0
Aboveground biomass combustion due to wildfires	0	96(ii)	0
C sequestration due to peat accumulation	-18.35(iv)	0	-7(v)
Avoided emissions due to biomass valorization	0	0	-62(vi)
Impact from bioenergy production and use	0	0	114.5(vii)

(i) According to (Hooijer, Silvius, Wosten, & Page, 2006)
(ii) According to Page et al. (2002);
(iii) According to Rodríguez et al. (to be published);
(iv) Average value from (Page et al., 2004; Parish et al., 2008; Ritzema & Wösten, 2006; Yule & Gomez, 2009);
(v) According Wichtmann & Joosten (2007);
(vi) According to (Edwards et al., 2014);
(vii) Corrrespond to 18.5 CO_2 equivalent t ha^{-1} y^{-1} for bioenergy production according (Edwards et al., 2014) and 96 CO_2 equivalent t ha^{-1} y^{-1} for biomass combusted.

5. Discussion

The scenario "conservation" is used as a basis to compare the other two scenarios. Usually, the field is burnt as a practice of agricultural management, but is also used in others land use to clean land and open pathways. Conversely, the scenario "biomass valorization" was proposed to avoid fires for land cleaning. The "biomass valorization" scenario avoid 909 t ha^{-1} CO_2 equivalent in comparison with "business as usual" scenario and, contributes 64 t ha^{-1} CO_2 equivalent more than "conservation" scenario. Peatlands conservation is an important ecological objective that also, plays an important role to climate change. However, there are a significant area of peatlands which is currently used as cropland or wood plantation. This represents an important part of the local economy and finding good practices for field management is necessary. In addition, biomass valorization can provide an income to the population.

6. Conclusion

Greenhouse gas emissions of three different scenarios of land management were estimated. Moving from current practices for land cleaning with fires to biomass valorization avoids 909 t ha^{-1} CO_2 equivalent. Scenario "biomass valorization" is an alternative to stop the fires in peatlands maintaining a balance between economic activities and peat formation.

Acknowledgements

The authors wish to thank the World Bank, the University of Costa Rica and CIRAD for their financial support.

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