A spatially-explicit scenario analysis for reconciling agricultural expansion, forest protection, and carbon conservation in Indonesia

Summary

Palm oil is the world's most important vegetable oil in terms of production quantity. Indonesia, the world's largest palm-oil producer, plans to double its production by 2020, with unclear implications for the other national priorities of food (rice) production, forest and biodiversity protection, and carbon conservation. Using a spatially-explicit scenario analysis I demonstrated that every single-priority development pathway had substantial tradeoffs associated with other priorities. The exception was a hybrid approach wherein expansion targeted degraded and agricultural lands that are most productive for oil palm, least suitable for food cultivation and contain the lowest carbon stocks. This approach avoided any loss in forest or biodiversity, and substantially ameliorated the impacts of oil-palm expansion on carbon stocks (limiting net loss to 191.6 million tons) and annual food production capacity (loss of 1.9 million tons). These results suggest that the environmental and land-use tradeoffs associated with oil-palm expansion can be largely avoided through the implementation of a properly-planned and spatially-explicit development strategy.

Description of research

In this research I developed a multiple-scenario computer model that simulated the spatial pattern of oil-palm expansion in Indonesia as oil-palm demand and production continue to grow. These scenarios include: i) a business-as-usual scenario whereby oil palm expansion proceeded from the most productive to least productive areas for oil palm; ii) a food production scenario whereby oil-palm expansion proceeded from the least productive to most productive areas for rice; iii) a forest preservation scenario whereby expansion proceeded in sequence from degraded lands, through agricultural lands and secondary forests to primary forests; iv) a carbon conservation scenario whereby expansion proceeded in areas from lowest to highest carbon stock; and v) a hybrid approach whereby expansion proceeded by simultaneously accounting for the priorities of maximizing oil-palm production, while minimizing impacts on food production capacity, forest cover and carbon stocks. For each oil palm-expansion scenario, I evaluated the consequences for the following outcome variables: i) area of primary and secondary forests, ii) forest biodiversity (modeled using a matrix-calibrated species-area model), iii) biomass and peat soil carbon stocks, and iv) annual rice production capacity.

Indonesia plans to increase its annual production of oil-palm fruit from the current 80 million tons to 160 million tons over the next 10 years. From a conservation perspective, my analyses suggest that Indonesian oil-palm production can indeed double without necessarily impacting forest cover or biodiversity. Under the forest preservation scenario, forests were not converted (and biodiversity not impacted) until all suitable degraded and agricultural lands had been used for oil palm—when annual oil-palm production exceeded ~450 million tons. However, strict enforcement of forest protection as implied by the forest preservation scenario incurred substantial tradeoffs in terms of carbon stocks (net carbon loss of 479 million tons), and rice production (reduction of 10 million tons in annual production capacity, or 66% of Indonesia's future potential for rice production). This is due primarily to the significantly larger land area (5.4 million ha) needed to be turned over to oil palm under this scenario compared to the business-as-usual approach (3.1 million ha).

The business-as-usual scenario reflects the land-sparing approach that has been advocated by many as a way to minimize land requirements by intensifying production. Consequently, business-as-usual performed better than the forest preservation approach in terms of both conserving carbon stocks (limiting net loss to 278.2 million tons) and maintaining annual food production capacity (loss of 5.1 million tons). Nevertheless, business-as-usual still resulted in biodiversity losses of 0.43% (equivalent, for birds alone, to the local extirpation of 7 species, or global extinction of 2 species).

Reducing emissions from deforestation and forest degradation (REDD) is a carbon conservation and payment scheme designed to compensate landowners for the value of carbon stored in forests that would otherwise be released into the atmosphere. A REDD or REDD+ approach, which additionally recognizes efforts at reforestation and sustainable forestry, is best represented by my carbon conservation scenario. This scenario performed the best in ameliorating the impacts of oil-palm expansion on carbon stocks. In fact, net carbon stocks increased by 158.8 million tons. However, this scenario too impacted annual rice production substantially (loss of 9.8 million tons) in the context of a doubling of oil-palm production. The impacts of development on food production could be reduced by avoiding the most productive areas for rice (food production scenario): food production did not begin to be affected by oil-palm expansion until annual oil-palm production exceeded ~400 million tons. However, the prioritization of food production has the most serious implications for biodiversity among all scenarios considered: a doubling of oil-palm production caused a 0.7% biodiversity decline (extirpation of 11 species, or global extinction of 3 species).

Every single-priority scenario I explored produced both benefits and tradeoffs. This is not surprising given the multiple competing priorities of maximizing oil-palm production, while avoiding losses in forest cover, biodiversity, carbon stocks and food production capacity. The best prospect for an optimal solution proved to be the hybrid approach that would enable Indonesia to double its oil-palm production by bringing an additional 3.4 million ha of land into cultivation, most of which would be located in provinces on the islands of Borneo (62%) and Sumatra (32%). Under this scenario, oil-palm expansion would be targeted at degraded (53%) and agricultural (47%) lands that are most productive for oil palm, least suitable for food cultivation and contain the lowest carbon stocks. Indeed, by taking account of all these factors, the hybrid approach produced the second best results for maintaining annual food production capacity (limiting loss to 1.9 million tons) and carbon stock (net loss of 191.6 million tons), while avoiding any impact on forest or biodiversity. An oil-palm expansion strategy based on this hybrid approach can therefore avoid many of the tradeoffs inherent in other scenarios that prioritize one aspect or another. Furthermore, by virtue of its implicit recognition of a wider set of priorities, the hybrid approach represents a more nuanced strategy than forest preservation, land sparing, REDD or food-production driven approaches, and is therefore more likely to be politically and socially acceptable.

Implementing the hybrid approach does necessitate the loss of at least some degraded and agricultural land, particularly in the Indonesian provinces of East, Central and West Kalimantan, which may result in the displacement of people, and conflicts over issues of land rights and tenure. Nevertheless, the alternatives—where food production has priority over oil-palm expansion (food production scenario) or oil-palm development trumps everything else (business-as-usual scenario)—imply substantial biodiversity losses. The question that remains is whether Indonesian and/or global society is prepared to either pay the financial and societal costs of withholding oil-palm development or accept a comparatively small tradeoff with agricultural land (hybrid approach), in return for the conservation of its forests and biodiversity. I have shown through my analyses that it is at least possible to pursue a course of development that substantially minimizes the tradeoffs of oil-palm expansion—so that we may have our cake, and eat most of it too.

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