World CO2 emission reduction by forest plantations on agricultural land up to 2050

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Abstract

The main objective of this study was to determine the possible contribution on CO_2 emission reductions of new forest plantations on agricultural land which may become available in the world from now to 2050. Emission reductions have been calculated by taking into account potential changes in carbon stocks on afforested land (in biomass and soil) and replacement with biomass of fossil fuel and material such as steal, aluminium or concrete. Increase of carbon stocks in wood in buildings and final conversion of waste wood from buildings into energy to replace fossil fuel have also been taken into account.

Four types of plantations have been considered:

1. short rotation plantations (from 8 years rotations under moist tropical conditions up to 30 years rotations under boreal climate), with high densities, to meet local energy needs (thermal and electrical needs, but excluding liquid biofuel consumption for transportation) and to replace fossil fuel;
2. short rotation plantations, with high densities, similar to the previous option, but producing only wood for material;
3. more conventional plantations, with long rotations (80 years), thinned every ten years, producing also mainly wood for building;
4. plantations which are never harvested, but are planted only to sequester more carbon in biomass and soil organic matter of the afforested land.

The last kind of plantation is taking place whenever agricultural land becomes available whereas other plantations are made according to the increase in local demand of wood for energy or for material. It has been considered that penetration of wood for energy ranged from 15 % to 25% of the final energy consumption, depending on the sector considered. It was also considered that the supplementary consumption of wood material in new buildings was limited at 20% of the new area built.

Agricultural land becoming theoretically available for such plantations depends mainly on the developmental pathways which are considered. Two opposite and extreme scenarios (A2 and B1) out of the four scenarios developed by IPCC for the 21st century have therefore been considered. The Dutch RIVM modelling indicating where future agricultural land is becoming available under those scenarios has been used. Under Scenario A2, with a high population growth (11.3 billion inhabitants in 2050), not largely open to the world, technological improvements are slow. On the opposite, under scenario B1 with a lower population growth (only 8.7 billion inhabitants in 2050), more open to the world, more ecologically and socially driven, technological improvements take place faster; energy efficiency and land use efficiency (increase in annual production per hectare both through higher crop yields and more crops per year on the same land) are therefore higher and livestock requirement to satisfy human nutrition are lower than under A2.

Greenhouse gas emission reductions depend on the agricultural land which becomes available until 2050 as well as on demand of wood. Until 2050 only 140 million hectares become available under Scenario A2, whereas under B1 950 million hectares, mainly in South America, in Africa and in China, become available.

With short rotation energy plantations to meet local energy demand respectively 118 million hectares (84% of the land becoming available under Scenario A2) and 420 million hectares (but only 45% of the land becoming available under Scenario B1) may be afforested. Cumulated emission reductions until 2050 could reach respectively 7.3 GtC (1% of total cumulated emissions until 2050 under Scenario A2) and 27.8 GtC (5% of total cumulated emissions under Scenario B1). In the latter case

only 15% of the land becoming available in Latin America would for instance be sufficient in 2050 to saturate the local energy demand (not including liquid biofuel). This situation would improve with the possibility to convert wood into liquid biofuel which would offer new markets and increase climate change mitigation; in particular under Scenario B1 with high land availability. Under the latter Scenario, with all possible uses of wood from the new plantations, about 10% of the CO_2 cumulated emissions until 2050 could be avoided. This option has however not been studied specifically.
With the assumptions made the demand of wood products remains limited. The world demand of that category of products may increase only about 25% between 2000 and 2050. Thus, in spite of the fact that the substitution with wood products of fossil fuel intensive products (such as steal or concrete), is efficiently reducing CO_2 emissions total emission reductions with material dedicated plantations remain however low because of the low demand of such products. With long rotations cumulated emission reductions until 2050 reach 2.1 GtC under A2 and 5.4 GtC under B1. With short rotations emission reductions are respectively 5% and 18 %.lower than with long rotations. Only a small fraction of the land becoming available is then utilized; 6% of the 140 million hectares under A2 and only 2% of the 940 million hectares under B1. With long rotations more land is needed; respectively 37% and 9% of the land becoming available.

When we compare the different strategies of land use studied into detail and when taking into account potential demands of products derived from wood, short rotation plantations to meet local energy demand appear to be the best option to reduce emissions until 2050. Under B1 with much land becoming available, plantations which are never exploited could offer the same potential of emission reductions but would need twice as much land. When not much land is becoming available short rotation plantations is by far the best option to reduce emissions.

When combining options to maximize CO_2 emission reductions until 2050 it can therefore be recommended to first use short rotations to produce wood for material, according to the demand, as this is the most efficient option on an area basis. Short rotation for energy is the next best option. Plantations of forests not to be harvested, made only to increase carbon stocks in living trees and soil organic matter, is the last option to be considered.
The latter option raises also two questions; the permanency of emission reductions and the burden for future generations. Up to 75 and 85% of emissions reductions through substitution of fossil fuel with wood for energy from short rotation plantations are permanent in 2050, whereas gains of carbon storage in plantations just made to sequester carbon may be reversible and be destroyed later on by storms, fires, pests or future climate change. Although plantations made just to sequester carbon may sometimes offer other benefits, such as soil and water conservation, they freeze the land use indefinitely and leave the responsibility to protect such stands to future generations. Whereas options with harvesting of wood present economical benefits which will probably help to maintain such plantation in the future.

Finally we must emphasize that CO_2 emission reductions (or carbon benefits) from afforested agricultural land become significant only after 2030 or 2050, and even at a latter stage with long rotations. For the latter about 100 years are needed to get the full benefits. Forest plantations can therefore only be considered as long term options. And except when such plantations on agricultural land allow to avoid deforestation, can therefore not be considered as options to “buy time” while waiting for the results of other policies aiming also to reduce greenhouse gas emissions.