FRIENDSHIP

FRIENDSHIP carbon offset initiative
Estimated CO_2 absorption capacity of a mangrove plantation

Blue carbon coastal ecosystems — such as mangroves, seagrass meadows and tidal wetlands — are named for their place at the boundary between land and sea, and their unmatched ability to suck CO_2 out of the atmosphere and store it in the ground below[1]. Mangroves are among the most carbon-rich forests in the tropics, containing on average 1,023 t carbon per hectare[2] in existing forests, most of which is stored in soils >30 cm deep. The average carbon storage value per hectare is much higher in mangroves than in other forests. According to Donato, Kauffman et al.[3], this is due in particular to a large peat layer, several tens of centimetres thick, very rich in organic elements, which constitutes the soil surface in these ecosystems. Organic matter in suspension in the water accumulates, accelerating sedimentation and therefore CO_2 storage. This is a particularity of mangroves because for most plants, it is through the process of photosynthesis, via the leaves, that carbon is captured. Although carbon storage is different for old forests than for newly planted stands, according to Alongi's research of 2014[4], thanks to their high capacity to stock carbon, "mangroves are prime ecosystems for reforestation and restoration".

Calculation Method

In order to calculate the CO_2 absorption capacity of a mangrove plantation, we must first know its carbon sequestration capacity. The usual way to measure the fixing of carbon for a plantation is to consider the net primary production (NPP) of aboveground and belowground biomass.

We have found various researches providing NPP of dry weight biomass for mangrove forests. According to Alongi[5], the average net primary production of biomass is 11,1 t of dry weight (DW) per ha per year and the median value is 8.1 t. To have the total value of NPP, i.e. including the roots of the trees, we have to multiply by 2 because "belowground carbon biomass is, on average, equivalent to carbon allocated aboveground"[6].

The content of C in dry wooden biomass can be considered on average very close to 50% of the weight for whatever species of tree[7].

As dead biomass (litter of the year) is not completely sequestered in the soil, we considered the net ecosystem productivity (NEP), which takes into account the heterotrophic respiration (HR), which is mainly the loss of C generated by the decomposition process of dead biomass.

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[1] https://www.abc.net.au/news/science/2018-03-26/blue-carbon-mangroves-seagrass-fight-climate-change/9564096

[2] https://www.nature.com/articles/ngeo1123

[3] http://www.savoirs.essonne.fr/sections/actualites/conserver-les-mangroves-puits-de-carbone/

[4] Alongi D., Carbon sequestration in mangrove forests, Carbon Management, 2014.

[5] Ibid. p314 and p320

[6] Ibid. Other studies have indicated that more carbon biomass is allocated belowground supporting the notion that mangroves store a disproportionate fraction of fixed carbon underground but we chose here a rather conservative approach.

[7] How is carbon stored in trees and wood products, Forest and Wood Products Australia.

According to Poungparn & Komiyama[8], the HR in mangroves measured in Thailand was roughly around 20% of the NPP (net primary productivity). A plantation would definitively have a lower value of HR but we chose a rather conservative approach.

Kamruzzaman et al.[9] studied the net primary productivity of mangroves in a sample plot in Bangladesh and came up with an estimation of a total NPP of 21 t of dry biomass per ha per year.

For the conversion of carbon into the respective value for CO_2, the factor of 3.667 [t CO_2/t C] shall be used. Indeed, the atomic weight of carbon is 12 atomic mass units, while the weight of carbon dioxide is 44, because it includes two oxygen atoms that each weigh 16. So, to switch from one to the other, the formula is: 1 ton of carbon equals 44/12 = 11/3 = 3.667 tons of carbon dioxide or 3 tons of carbon fixes 11 tons of carbon dioxide.

The various studies and figures found are summarized in the table below. It shows that the CO_2 absorption capacity of a mangrove planted forest varies between 23.76 tCO_2 per ha per year to 38.50 tCO_2 per ha per year. Using the lowest value of **23.76 tons of CO_2** gives a safety margin of 23% compared to the Bangladesh study plot (30.80 tCO_2 per ha per year).

Absorption capacity used for offsetting

Friendship has gained experience in mangrove plantation in Southern area of Bangladesh (Satkhira District, at the border of the Sundarbans). We estimate that each hectare of such plantation will absorb every year an average of **23.76 tons of CO_2**, considering a growing phase of around 10 years. People or organisations wanting to neutralize their CO_2 emissions related to their travels or activities can fund, at a price to be determined, a surface of mangrove plantation enhancing thereby the earth's absorption capacity. For information, CO_2 offset calculators usually use the European Emission Allowances Price per ton, which is around 25€[10] but well below Friendship's plantation costs.

As a reminder, CO_2 emissions per person per km for a flight travel is around 100g for a Boeing 737 and a short distance (926 km)[11]. For a Boeing 777 and long distances (>7,500 km) the value is above 230g CO_2 per person per km[12]. According to various CO_2 calculators[13], the emissions vary from 360g to 495g per person per km in business class (depending if the radiative forcing of kerosene is taken into account). A long distance return flight in a Boeing 777 corresponds to an amount of emitted CO_2 of about 4 tons to more than 6 tons. The IPCC's recommendation is not to exceed 2tCO_2 emissions per person per year if we want to remain below 1.5°C of global warming.

[8] Poungparn S; & Komiyama A., Net Ecosystem productivity Sutdies in Mangrove Forests, in Agricultural Science, 1: 61-64, 2013

[9] Kamruzzaman et al., Biomass and net primary productivity of mangrove communities along the Oligohaline zone of Sundarbans, Bangladesh, in Forest Ecosystems 4:16, 2017

[10] https://markets.businessinsider.com/commodities/co2-emissionsrechte

[11] https://www.carbonindependent.org/sources_aviation.html

[12] https://paullaherty.com/2015/01/10/calculating-aircraft-co2-emissions/

[13] https://co2.myclimate.org/en/portfolios?calculation_id=1506923&localized_currency=EUR (MyClimate is the CO_2 emissions calculator proposed the Lufthansa passengers who want to offset their emissions) and https://www.greentripper.org/calculator.aspx?cl=fr&ol=0

Research*		NPP* aboveground dry weight biomass	NPP belowground dry weight biomass	NPP total dry weight biomass	NPP total C**	HR*** loss of C through decomposition	NEP**** total C	CO_2 sequestration in t per year per ha
		All values are tons per year per hectare						
Alongi[14]	Average	11.1	11.1	22.2	11.1	-2.22	8.88	32.56
	Median	8,1	8,1	16,20	8,10	-1,62	6,48	**23,76**
Poungparn, Komiyama[15]	East Thailand 1				11,99	-2,45	9,54	34,98
	East Thailand 2				12,44	-1,94	10,50	38,50
	east Thailand 3				9,88	-2,13	7,75	28,42
Kamruzzaman[16]	Bangladesh			21,00	10,50	-2,10	8,40	30,80

* NPP = Net Primary Production

** 50% of dry weight of biomass created is C (Carbon)

*** HR = Heterotrophic Respiration. Around 20% of C is loss through dead biomass decomposition. The HR of Alongi and Kamruzzaman are calculated with a factor of 20% based on Poungparn & Komiyama's findings. The HR of Poungparn & Komiyama are measured values.

**** NEP = Net Ecosystem Production

1 ton of C corresponds to 3.667 tons of CO_2

[14] Alongi D., Carbon sequestration in mangrove forests, Carbon Management, 2014

[15] Poungparn S; & Komiyama A., Net Ecosystem productivity Sutdies in Mangrove Forests, in Agricultural Science, 1: 61-64, 2013

[16] Kamruzzaman et al., Biomass and net primary productivity of mangrove communities along the Oligohaline zone of Sundarbans, Bangladesh, in Forest Ecosystems 4:16, 2017