Considerations in Blue Carbon Accounting With Mangrove Restoration – Case Studies from South Fujian, China

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Mangrove restorations in China

- Mangrove restorations have been spontaneously conducted since 1950s by few local communities in South China, and now are organized by NGO, research institute and local/central governments.

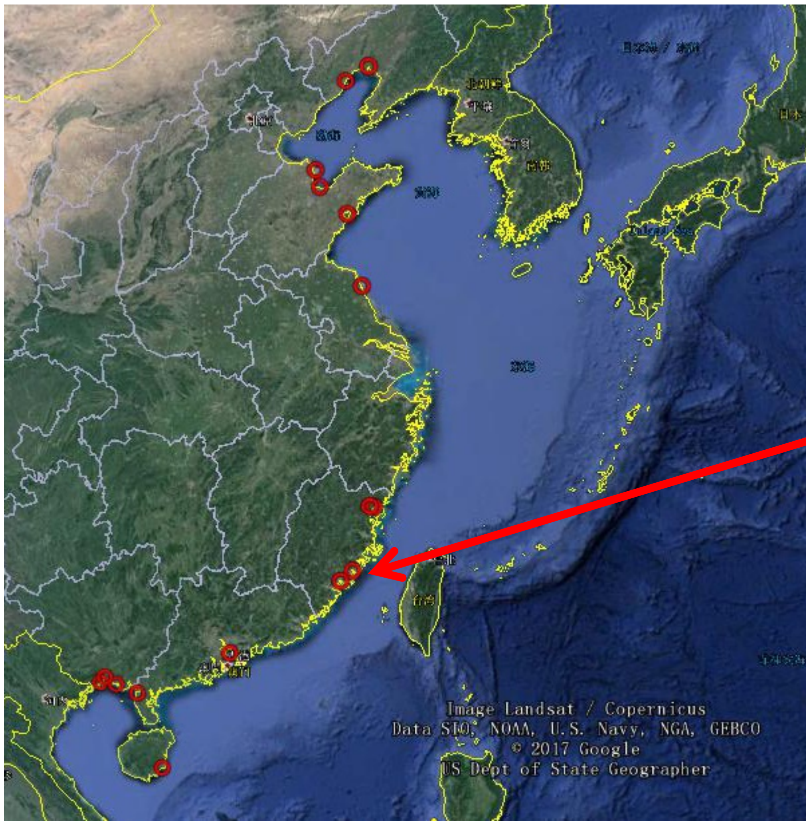
Planted *Sonneratia apetala* in Zhanjiang, Guangdong

Rehabiliated mangrove in Futian national reserve, Guangdong

Luoyang Estuarine mangrove (Fujian) majorly consisted of rehabilitated mangroves

- 8 out of the 24 true mangrove species in China are commonly used for restoration, most of which are viviparous species (Ye et al., 2003).

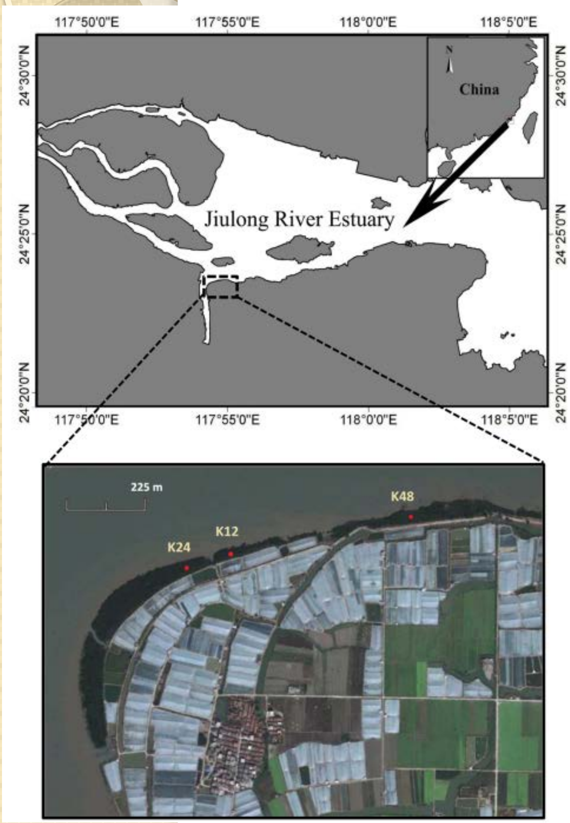
- The State Oceanic Administration (SOA), China has launched a national-scaled coastal wetland restoration program since 2010, aiming to increase the saltmarsh (in North China) and mangrove (in South China), including seagrass areas by >8000 ha costal wetlands till 2020, including 2500 ha mangrove, 5500 salt marsh.

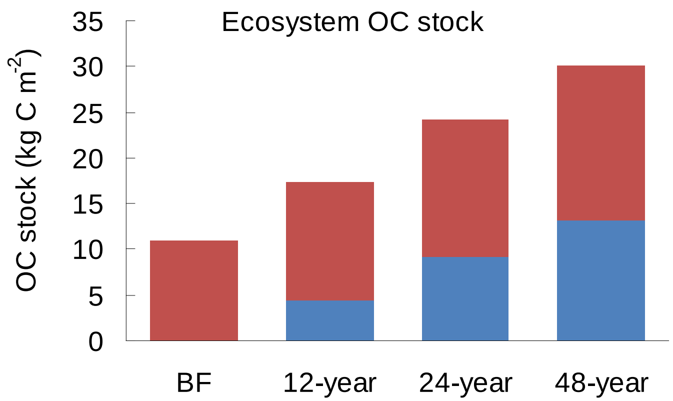


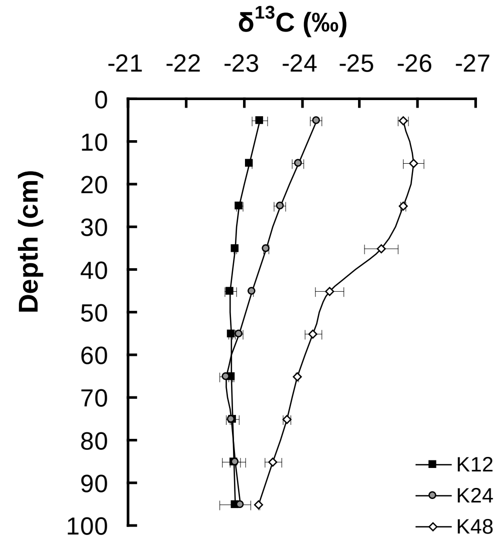
Ecological restoration projects of coastal wetlands supported by SOA since 2010

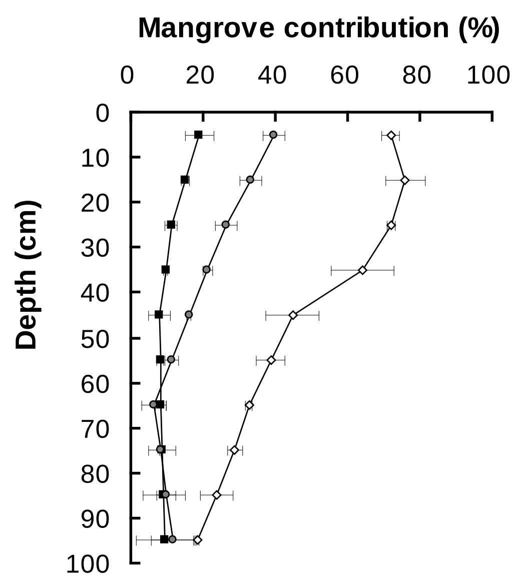
Restored mangrove in Xiamen, Fujian, planted in 2002;
Photo taken in 2018 by G. Chen

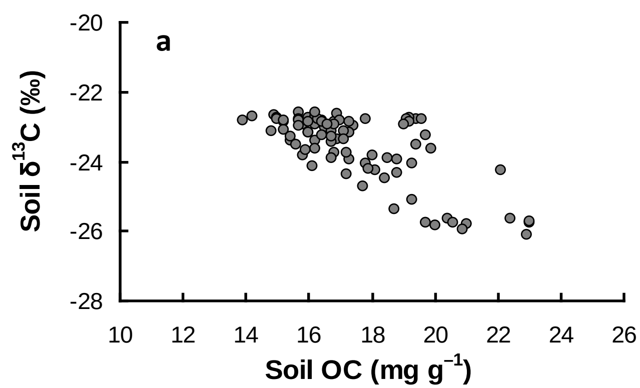
- *Kandelia obovata* is the most widely used species in mangrove restorations











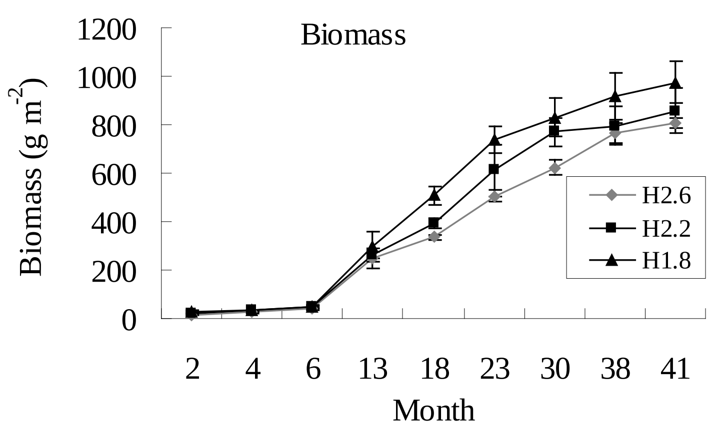
Chen et al., 2018, and unpublished data

Considerations in Blue Carbon Accounting

- Site selection to promote the carbon sequestration
- Species composition considered for Blue Carbon benefits
- Pollution control to reduce soil greenhouse gas emissions

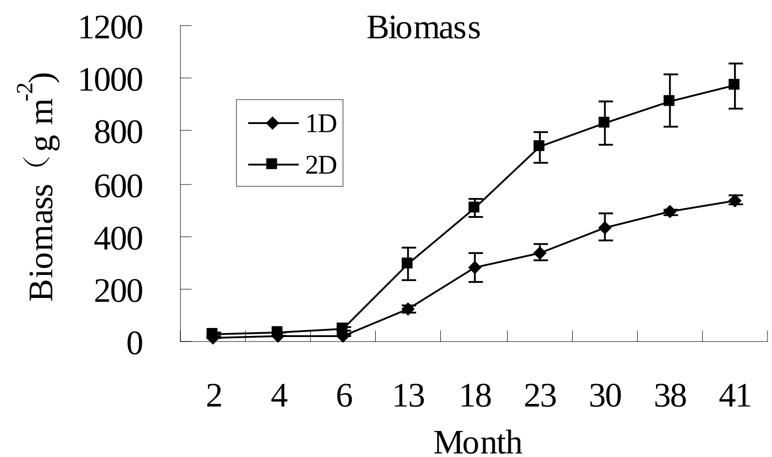
Site selection to promote the carbon sequestration

- Suitable habitat conditions, e.g. soil surface elevation, substrates and salinity, and dense plantation as well, would potentially improve the biomass carbon sequestration.



Higher biomass accumulation of *K. obovata* at a tidal elevation of 1.8 m (soil surface elevation relative to Yellow Sea level) than those at elevation of 2.2 and 2.6 m in Xiamen

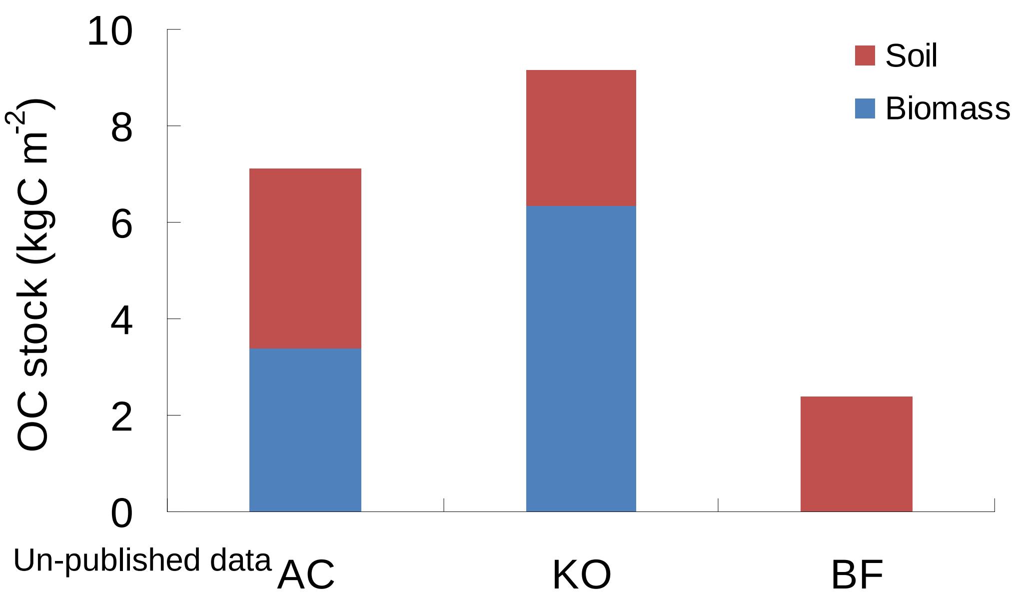
Soil accretion rates would decreased with the increase in tidal elevation of soil surface (Alongi et al., 2005; Cahoon et al. 2006; Adame et al. 2010).

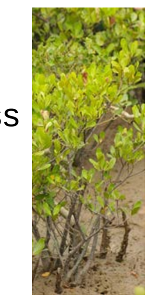


Dense plantation (0.5m*0.4m, 2D) of *K.obovata* results in higher biomass accumulation than that with a density of (0.5m*0.8m, 1D) in the early stage of mangrove restoration

Species composition considered for Blue Carbon benefits

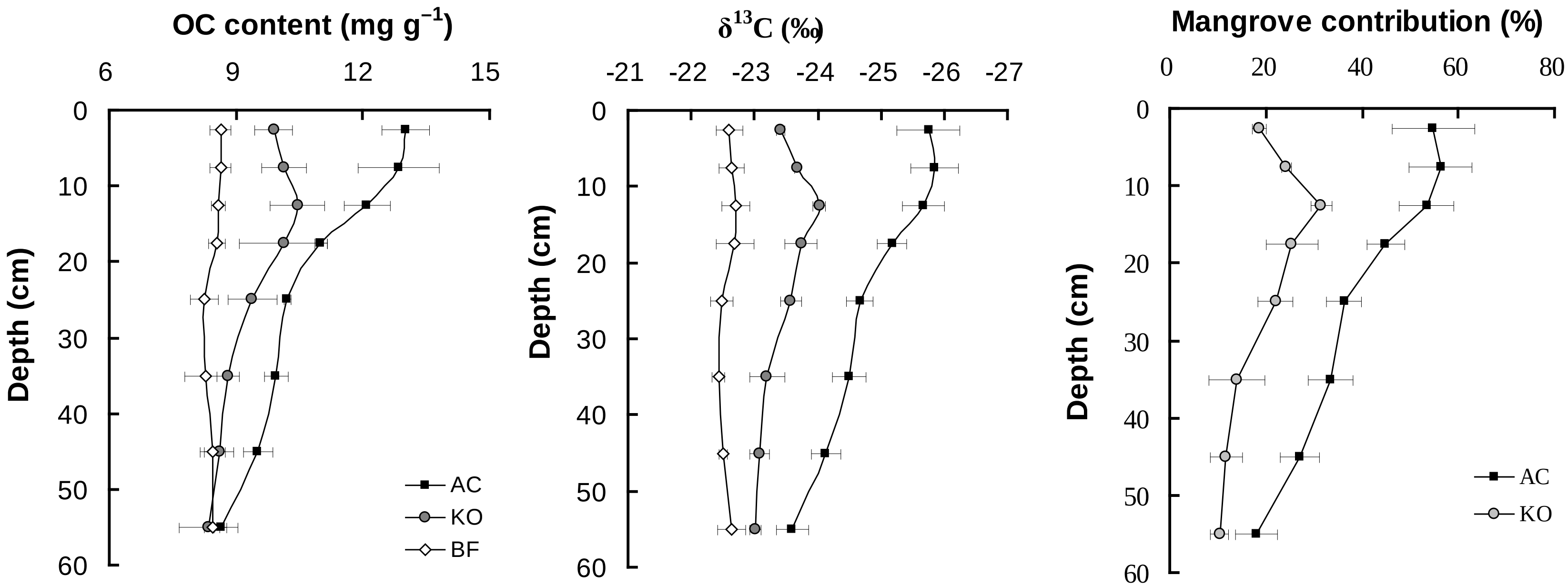
- Mono-species plantation of *Kandelia obovata*, a tree species, is popular in Fujian, for easy plantation and cost efficiencies purposes.
- <u>Ecosystem carbon sequestration capacity is species-specific</u>.





AC: *Aegic*
KO: *Kand*
BF: non-vegetated flat

Mangroves planted around 2002



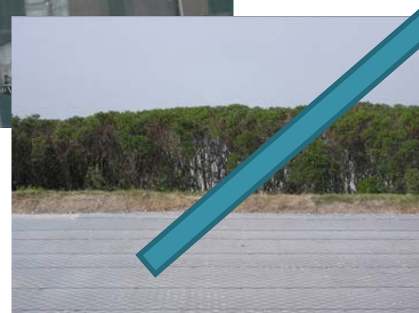
The vertical profiles of soil OC contents indicated a more substantial mangrove-effect on soil OC pool in the surface layer which decreased with soil depth, and that *A. corniculatum* had a more apparent effect relative to *K. obovata*.

Standing stock of leaf litter on mangrove floor

Site	Density pc m^{-2}	Biomass gDW m^{-2}
AC	50±18	19±7
KO	7±6	3±2

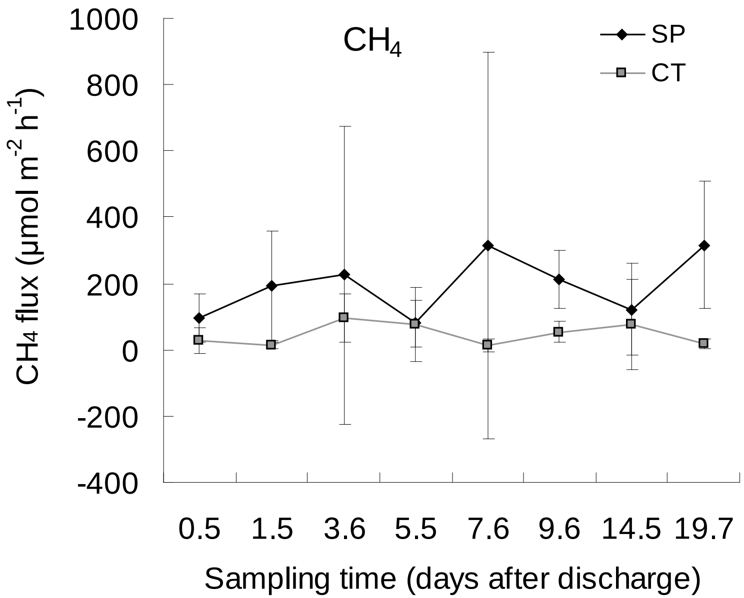
Pollution control to reduce soil greenhouse gas emissions

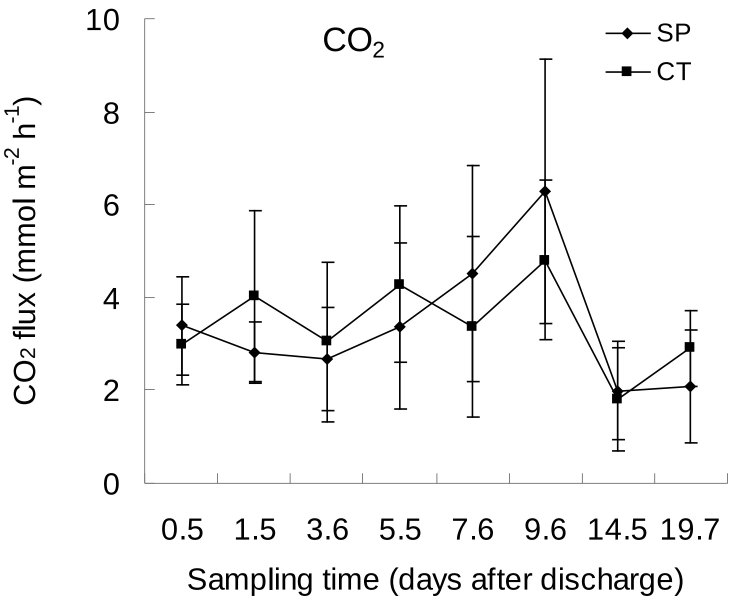
In south China, mariculture ponds are often located next to mangrove wetlands, at the landward zone.

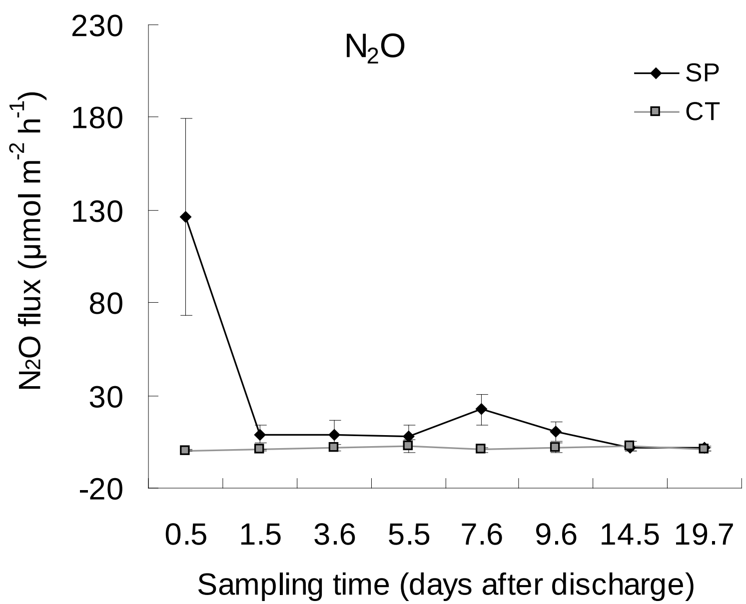


Picture taken in Jiulong River Esuary, Fujian

The bottom sediments of ponds with high organic matter and nutrient levels are washed out and discharged into the adjacent mangrove during cleaning the pond at the end of each culture rotation.







N_2O μ mol m^{-2} h^{-1}	CH_4 μ mol m^{-2} h^{-1}	CO_2 mmol m^{-2} h^{-1}
23.5	194.6	3.4
1.31	47.1	3.4

Muara Angke, Indonesia

Pandamaran River, Malaysia

Kema, Indonesia

Futian, China

Klang Island, Malaysia

Mangrove	N_2O µmol m^{-2} h^{-1}	CH_4 µmol m^{-2} h^{-1}	CO_2 mmol m^{-2} h^{-1}
Kema	0.10 (-0.56~ 1.16)	1.82 (-8.26~13.01)	3.15 (-5.83~9.47)
Klang Island	-0.17 (-3.06~1.26)	12.81 (-9.86~75.96)	7.91 (-0.12~28.72)
Muara Angke	3.53 (-0.99~ 46.99)	1352.56 (-1730.23~17928.51)	14.023 (1.72~48.05)
Futian, China	0.94 (-0.60~6.28)	262.13 (-458.51~2930.04)	8.68 (-0.42~34.23)
Pandamaran River	1.60 (-0.08~11.4)	342.53 (-4.36~6353.80)	11.91 (1.35~ 27.56)

The gas fluxes were converted to CO_2-equivalent fluxes to indicate their respective warming effect using the global warming potential (GWP) of each gas. The GWPs were 1, 34 and 298 for CO_2, CH_4 and N_2O, respectively, over a 100-year timeframe according to Myhre et al. (2013).

Comparison of the warming effect of soil greenhouse gas emissions with the plant CO_2 sequestration rate to indicate the ecosystem atmospheric cooling effect.

Mangrove	Warming Effect of GHGs $gCO_2\ m^{-2}\ yr^{-1}$				NPP $gC\ m^{-2}\ yr^{-1}$	Plant CO_2 sequestration $gCO_2\ m^{-2}\ yr^{-1}$
	N_2O	CH_4	CO_2	Total		
Kema, Indonesia	11	9	1214	1234	990	3630
Klang Island, Malaysia	-20	61	3048	3048	NA	NA
Jiulong Estuary, China[a]	53	238	931	1222	1358	5930
Muara Angke, Indonesia	406	6447	5407	12259	1724[b]	6321
Futian, China	111	2772	3306	6189	2006[c]	7357
Pandamaran River, Malaysia	1434	1239	4393	7066	NA	NA

a: Chen et al., 2016; b: Sukardjo, 1989; c: Liu et al., 2014

Conclusions

- Mangrove restoration benefits the increase in “blue carbon stock”, and the OC accumulation in soils is mainly attributed to mangrove-derived OC;
- Suitable habitat conditions would potentially improve the biomass carbon sequestration, at least at the early stage of vegetation development;
- Variability of mangrove species in supporting ecosystem function should be considered in the mangrove restorations;
- The benefit of mangrove restoration for carbon sequestration could be reduced by soil greenhouse gas emission elevated by exogenous nutrient input.