Climate regulation

Summary of natural capital assets and drivers of change

A three-tier (red/amber/green) assessment of: (1) the importance of natural capital assets to ecosystem service provision; and (2) the influence of drivers of change on these natural capital assets.

			Natural capital assets					
	Importance of natural capital asset to ecosystem service		Atmosphere	Habitats	Soils and sediments	Species	Water	
Drivers of change	Anthropogenic	Industrial or domestic construction						Influence of drivers on natural capital assets
		Industrial or domestic activities						
		Habitat modification						
	Biological resource use	Overharvesting						
	Climate change impacts	Ocean current and circulation						
		Sea level rise						
		Sea surface temperature						
		Weather conditions						

Description of ecosystem service

Global climate regulation is provided by nature through the long-term storage of carbon dioxide in soils, vegetable biomass, and the oceans. At a regional level, the climate is regulated by ocean currents and winds while, at local and micro-levels, vegetation can modify temperatures, humidity, and wind speeds.

Ecosystem service: classification according to CICES

Section	Division	Group	Class
Regulation and maintenance	Maintenance of physical, chemical and biological conditions	Atmospheric condition and climate regulation	Climate regulation

Natural capital assets providing the service: identification and hierarchical classification of the key natural capital assets that provide or enable the ecosystem service (Leach *et al*. in review)

Level 1	Level 2	Level 3	Level 4
Abiotic	Functional	Atmosphere	Atmospheric processes
		Water	Surface Ocean
		Soils and sediments	Top-soil Sub-soil Ocean sediments
Biotic	Biodiversity	Habitats	Littoral Sub-littoral Deep-sea Coastal Inland surface waters Grasslands Heathland and scrub Woodland and forests Unvegetated or sparsely vegetated Agriculture and croplands Habitat complexes
		Genetic resources and plant, animal, fungal and algal species	Wild Domestic, commercial

Narrative description of the natural capital asset- ecosystem service system: generic description of the way in which natural capital assets provide the ecosystem service.

Climate regulation is delivered through the atmosphere, habitats, soil and sediments, species and water.

- **Atmosphere -** Climate regulation at a large scale is fully dependent on the atmosphere. The scale and complexity of the atmosphere means that human-induced changes often cannot be reversed over a human lifetime.
- **Habitats -** Habitats play an important role in global climate regulation through carbon sequestration and carbon storage. They also play important roles in local climate regulation, for example through their capacity for water retention or shade provision. Some changes to habitats may be reversible but generally over a long time-frame. Other changes may not be reversible, for example deforestation in tropical regions could result in a drier climate which may prevent areas from being reforested.

- **Soils and sediments -** Global climate regulation by terrestrial ecosystems is sensitive to changes in soils and sediments which happens as a result of deforestation, land use change and wetland drainage.
- **Species** - Global, regional and micro climate regulation by terrestrial ecosystems is sensitive to changes in species as they play an important role in carbon sequestration and carbon storage.
- **Water** - Micro and regional climate regulation are sensitive to changes in water as it plays a role in local climate regulation through ocean circulation and changes in surface water. Major changes in ocean circulation would be irreversible.

Drivers of change in the asset-service system

Driver of change	Asset affected	Likely response of asset	Effect on variability of service provision	Human action or natural variation	Timescale	Spatial characteristics	Reference
Industrial or domestic construction, Industrial or domestic activities, Habitat modification	Habitats, Soils and sediments	Land use change can alter sediment supply and expose upper soil layers resulting in loss of soil organic carbon.	Soil drainage increases aeration. Soil microorganism respiration rates therefore increase. Soil no longer accumulates soil organic carbon but becomes a CO_2 source. Carbon burial in marine sediments is reduced, increasing carbon emissions.	Human action	Short term	Global – wetlands and coastal ecosystems	Raich & Schlesinger, 1992; Barbier et al., 2011.
	Water	Altered freshwater supply and resources.	Changed habitat dynamics, reduction in stability of blue carbon habitats.	Human action	Short term	Coastal ecosystems	Matson et al., 1997.
Industrial or domestic construction	Atmosphere, Habitats, Water	The sealing of soils by urban construction in urban areas modifies the local climate.	Vegetation no longer regulates climate, leading to even higher temperatures.	Human action	Short term	Urban areas	Scalenghe & Marsan, 2009.
Habitat modification	Habitats, Species	Conversion of forests to cultivated land causes removal of above ground biomass.	Increase in carbon emissions.	Human action	Short term	Mainly tropical but also boreal forests	Kindermann et al. 2008.
	Habitats, Water, Atmosphere	Conversion of wetlands for commercial purposes and resource extraction leads to loss of regional climate regulation function.	Conversion of wetlands caused the average temperature to increase by 0.77°C in all four seasons.	Human action	Mid term	Global - wetlands	Zhang et al., 2016.
	Habitats	Deforestation reduces tree density and diversity.	Evapotranspiration decreases, and more ground surface is exposed increasing albedo and climate warming.	Human action	Mid term	Especially pronounced in tropics	Met Office, 2012.

	Soils and sediments	Wetland drainage and peat harvesting causes land use change and exposes the upper soil layer resulting in loss of soil organic carbon.	Wetland drainage increases soil aeration. Soil microorganism respiration rates therefore increase. Wetlands no longer accumulate soil organic carbon but become CO_2 sources.	Human action	Short term	Global - wetlands	Raich & Schlesinger, 1992.
Overharvesting	Soils and sediments, Species	Timber and wood harvesting leads to a reduction in standing timber biomass and exposes the upper soil layer.	Soil organic carbon declines rapidly under cultivation, e.g. woodland conversion results in soil degradation, erosion and loss of organic matter, diminishing the soil's potential to sequester carbon.	Human action	Long term	Global – forested areas	Syampungani et al. 2014.
	Soils and sediments, Species	Stump and root harvesting as a source of woody biomass for bioenergy generation leads to soil disturbance.	Stump harvesting causes existing soil organic carbon to become mineralised, leading to carbon loss as carbon dioxide, e.g. 1 tonne of carbon per hectare per year might be lost compared with sites undisturbed by stump harvesting operations.	Human action	Short term	Forests globally (but examples cited in temperate forests in the UK and British Columbia, Canada).	Hope, 2007; Reynolds, 2007; Moffat et al., 2011.
Ocean current and circulation	Habitats, Water	An increase in freshwater due to melting of ice caps and rapid glacial melting linked to climate change leads to weakening or collapse of the ocean thermohaline circulation.	Air-sea carbon uptake is substantially reduced. Rapid climate cooling and loss of regional climate regulating function.	Human action	Long term	Global (ice caps) – oceans Regional (glaciers) – seas all small regions of oceans	McKinley et al., 2016; Sarmiento & Le Quéré, 1996; Broecker, 1987.
Sea level rise	Habitats, Water	The surface area of coastal habitats is	Removal of organic component of coastal sediments	Human action	Long term	Coastal ecosystems	Hoegh-Guldberg & Bruno, 2010.

		reduced by rising sea levels.	and their burial. Loss of carbon sink.				
Sea surface temperature	Water, Species, Habitats, Soils and sediments	Caused an annual 1% decline in phytoplankton in worlds' oceans.	Less carbon absorbed by phytoplankton for photosynthesis.	Human action	Short term	Global - oceans	Boyce at al., 2010.
Weather conditions	Soils and sediments	Precipitation increase associated with higher soil organic carbon content. Temperature is negatively associated.	Variation in weather conditions impacts the amount of soil organic carbon stored in upper soil layers.	Natural variation	Short term	Global	Hobley et al., 2015.
	Habitats, Species	Permafrost (frozen soil layer) melting due to higher average annual temperatures.	Methane gas bubbles trapped in soil are released as it melts, increasing emissions to the atmosphere, exacerbating the warming effect in the short term and causing a positive feedback in the long term as warming continues to melt permafrost releasing more methane.	Human action	Long term	High latitudes	Walter et al., 2006.
	Habitats, Water, Atmosphere	Climatic anomalies (e.g. ENSO) create deficits and excesses in temperature and precipitation.	Regulation of regional climate is heavily impacted, e.g. an El Niño is associated with warm and very wet weather months in April–October causing major flooding in southern hemisphere countries such as Peru and Ecuador.	Natural variation	Long term	Regional – tropics and sub-tropics	University of Illinois, n.d.

Information and data

Data needs: Identification of data needed to assess the current of historical state of the asset-service system.

Description of data need	Classification	Aspect of the system
Change in atmospheric conditions	Atmosphere	Natural capital asset
Change in habitat quality	Habitats	Natural capital asset
Degree of soil degradation	Soils and sediments	Natural capital asset
Change in species abundance and occurrence	Species	Natural capital asset
Change in availability of surface and ground water	Water	Natural capital asset
Change in construction activity	Industrial or domestic construction	Drivers of change
Change in population density and shipping activity	Industrial or domestic activities	Drivers of change
Change in land use and land cover	Habitat modification	Drivers of change
Change in number of species traded	Overharvesting	Drivers of change
Change in ocean currents	Ocean current and circulation	Drivers of change
Change in sea level rise	Sea level rise	Drivers of change
Change in sea surface temperature	Sea surface temperature	Drivers of change
Change in the seasonality of temperature, precipitation and wind	Weather conditions	Drivers of change

References

Barbier, E.E.B. et al. (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs, 81*(2), pp.169–193.

Boyce, D.G., Lewis, M.R. & Worm, B. (2010). Global phytoplankton decline over the past century. Nature, 466(7306), 591–596.

Broecker, W.S. (1987). Unpleasant surprises in the greenhouse? *Nature, 328*(6126), 123–126.

Hobley, E. et al. (2015). Drivers of soil organic carbon storage and vertical distribution in Eastern Australia. *Plant and Soil, 390*(1), 111–127.

Hoegh-Guldberg, O. & Bruno, J.F. (2010). The Impact of Climate Change on the World's Marine Ecosystems. *Science, 328*(5985).

Hope, G.D. (2007). Changes in soil properties, tree growth, and nutrition over a period of 10 years after stump removal and scarification on moderately coarse soils in interior British Columbia. *Forest Ecology and Management, 242*(2), 625–635.

Kindermann, G. et al. (2008). Global cost estimates of reducing carbon emissions through avoided deforestation. *Proceedings of the National Academy of Sciences, 105*(30), 10302–10307.

Leach, K. (in review). A common framework of natural capital assets for use in public and private sector decision making.

Matson, P.A. et al. (1997). Agricultural Intensification and Ecosystem Properties. *Science, 277*(5325), 504–509.

McKinley, G.A. et al. (2016). Timescales for detection of trends in the ocean carbon sink. *Nature, 530*(7591), 469–472.

Met Office, 2012. *Relationships between forests and weather*, Exeter United Kingdom.

Moffat, A., Nisbet, T. & Nicoll, B. (2011). The potential of primary forest residues as a bio-energy source: the technical and environmental constraints. *Forestry Commission Research Note, (September),* 1–12.

Raich, J.W. & Schlesinger, W.H. (1992). The global carbon dioxide flux in soil respiration and its relationship to vegetation and climate. *Tellus B, 44*(2), 81–99.

Reynolds, B. (2007). Implications of changing from grazed or semi-natural vegetation to forestry for carbon stores and fluxes in upland organo-mineral soils in the UK. *Hydrology and Earth System Sciences, 11*(1), 61–76.

Sarmiento, J.L. & Le Quéré, C. (1996). Oceanic Carbon Dioxide Uptake in a Model of Century-Scale Global Warming. *Science, 274*(5291), 1346–1350.

Scalenghe, R. & Marsan, F.A. (2009). The anthropogenic sealing of soils in urban areas. *Landscape and Urban Planning, 90*(1–2), 1–10.

Syampungani, S. et al. (2014). The impact of land use and cover change on above and below-ground carbon stocks of the miombo woodlands since the 1950s: a systematic review protocol. *Environmental Evidence, 3*(1), 25.

University of Illinois, Atmospheric Consequences of El Niño. *Department of Atmospheric Sciences.*

Walter, K.M. et al. (2006). Methane bubbling from Siberian thaw lakes as a positive feedback to climate warming. *Nature, 443*(7107), 71–75.

Zhang, W., Zhu, Y. & Jiang, J. (2016). Effect of the urbanization of wetlands on microclimate: A case study of XixiWetland, Hangzhou, China. *Sustainability (Switzerland), 8*(9).