POLICY PAPER

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Theme:

Mitigation

Boosting Carbon Sequestration in Agri-Food Systems through Nature-Based Solution(NBS) for People, Planet and Prosperity.

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Abstract

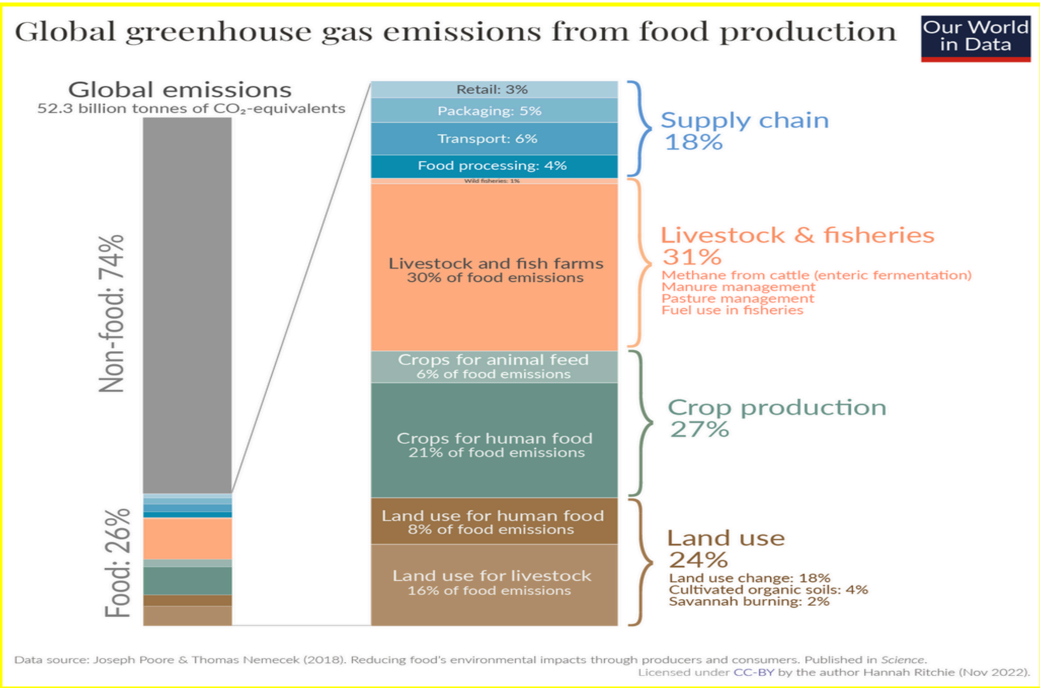
In 2015, 196 United Nations' Parties adopted the **Paris Agreement** at **COP21**, marking a historical milestone in the Climate Negotiations and international cooperation to limit global warming to well below 2°C above the pre-industrial levels by 2030. Since then, countries have committed to present their Nationally **Determined Contributions (NDCs)** to tackle this life and death issue. However, despite all the efforts made, today the climate crisis accelerates beyond previous projections, and solutions seem to be still in the waiting room.

Achieving the 1.5°C climate target demands transformative climate action, especially in the Agri-Food System, as it is both one of the major contributors and victims of Climate Change, accounting for 8-10% of total global **Greenhouse Gases (GHG)** emission annually. In this context, **Nature-Based Solutions (NBS)** appear as a promising pathway to mitigate the effects of climate change in this sector, while enhancing the resilience of natural ecosystems. Thus, given the land functions as a critical carbon sink, this policy paper will focus on how NBS can be applied in the Agri-Food System in order to boost Carbon Sequestration through **Sustainable Soil Management (SSM)** such as increasing **Soil Organic Carbon (SOC)** through Biochar, which is proven to be a climate-smart solution to support a just and sustainable transition to more resilient form of agriculture.

The Scope of the Problem:

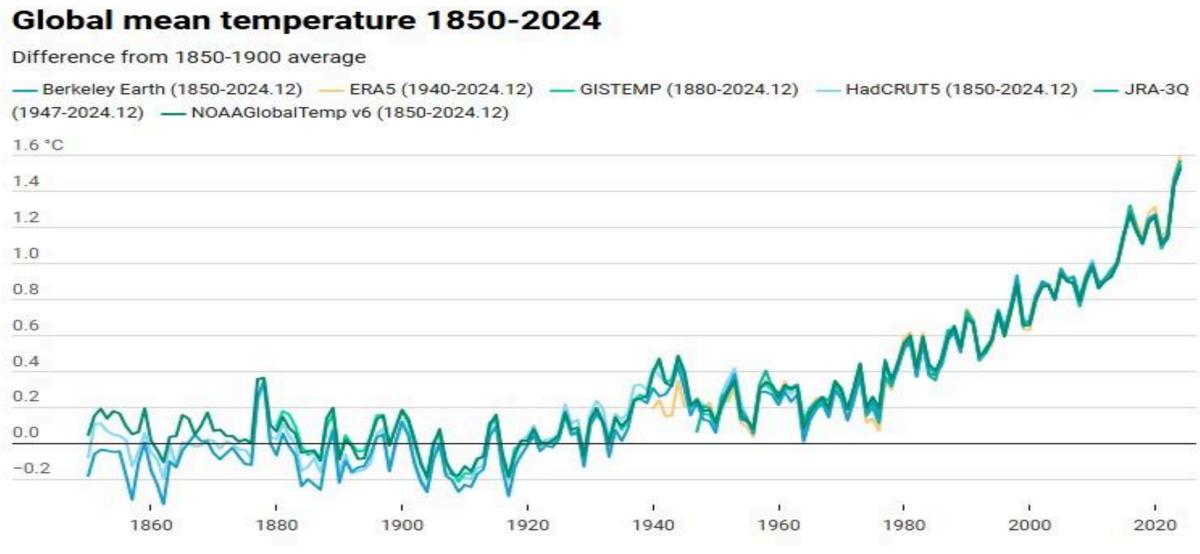
GHG emission in the agriculture sector.

Agriculture represents a key element to rural development since it is a source of food security, employment and a range of other social and environmental services that are critical to achieve many **Sustainable Development Goals (SDGs)** *(Roberto Ridolf-FAO,2019*). However, currently it is estimated that between 638 to 720 million people face hunger in 2024 (FAO), being the majority of this population residing in developing countries. Additionally, agriculture is also a source of GHG that drives climate change, contributing to up to 13-21% of total global Greenhouse Gas emission annually (IPCC,2024), being also a potential driver of deforestation and other land use changes that contribute to the current climate crisis.



One quarter of the world's greenhouse gas emissions result from food and agriculture

Under this context, the **State of the Global Climate** reported 2024 to be the hottest year ever recorded, with a global mean temperature of 1.55°C, surpassing the climate warming threshold of 1.5°C for the first time. In that context, scientists estimate that if humanity continues this path, we would be reaching a point of no return, where no climate solution would be technically viable. (World Meteorological Organization, 2024)

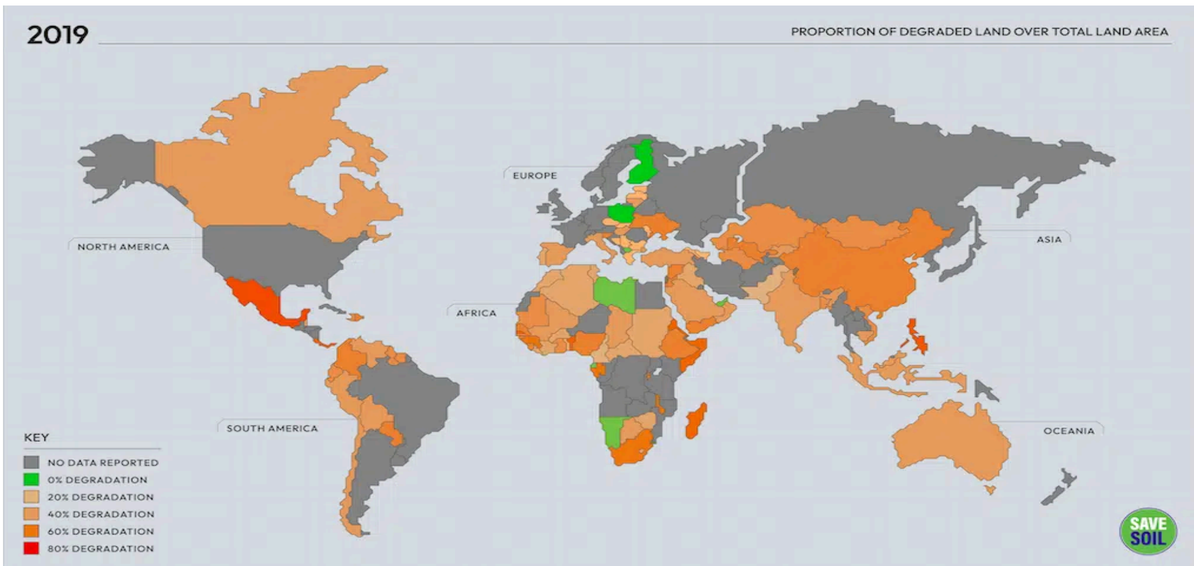


Annual global mean temperature anomalies relative to a pre-industrial (1850–1900) baseline shown from 1850 to 2024

Soil degradation

On the other hand, soil degradation, resulting from intensive and unsustainable farming practices exacerbate the climate crisis as it reduces possibility for food production due to contamination with agrochemicals and poor soil fertility. Experts estimate that one-third of the world's agricultural soil has already degraded so far. This degradation is a serious issue, with potential to worsen as it is also estimated that if keeping the rate of soil degradation, 90% of it can be totally devastated by 2050. (FAO,2025)

Science warns that every year, 24 billion tons of fertile soils are being lost, largely due to unsustainable agriculture practices. (SaveSoil.org)



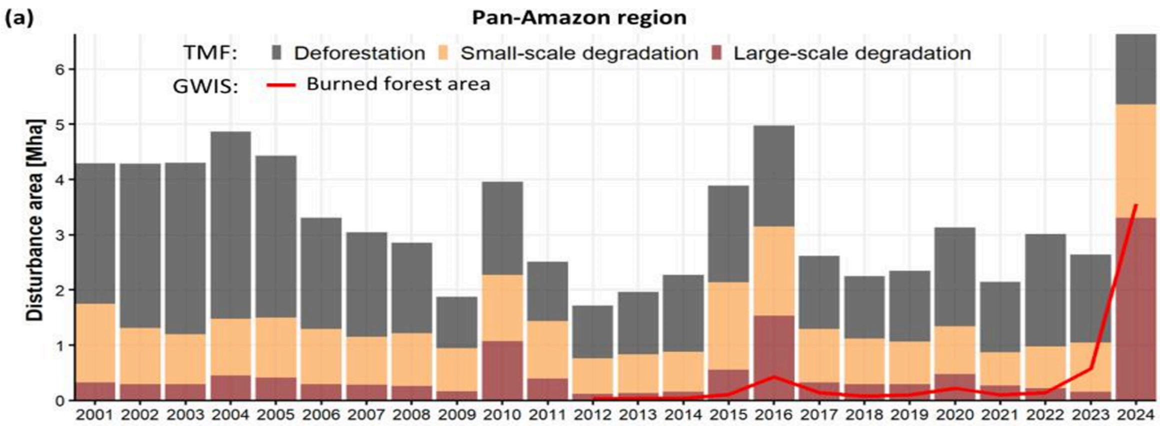
Map of degraded land over total land area in 2019. Data: UNCCD. Image: Save Soil.

A new map from the Save Soil movement illustrates the shocking percentage of global soil degradation predicted by 2050. Image: Save Soil

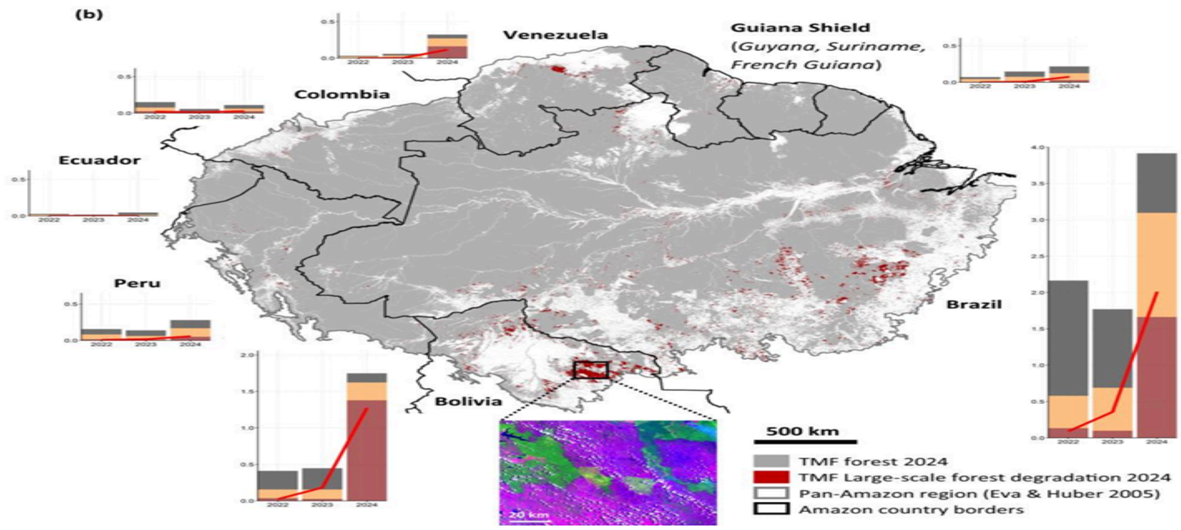
Tropical Forest Deforestation.

The large-scale clearing of the Tropical Forests have been taking place for centuries, through human activities such as logging, grazing cattle and extensive agriculture monocrops, resulting in degradation of forested areas. This heavy pressure on this invaluable ecosystem is taking it to the edge of extinction within a 100 years (Gerald Urquhart et al,2019). By far, more than 42 million hectares of Tropical Forest areas are threatened by deforestation by 2050, along with the rapid wildlife extinction. Over 10,000 species of plants and animals are at high risk facing habitat loss, hunting, and the impacts of climate change. (Luciana Gatti, 2021)

Additionally, recent studies have shown that global warming is impacting the Amazon forest with dramatic precipitation deficit and prolonged, intense heat waves (Kornhuber et al. 2023, Marengo et al. 2024) which has severely stressed vegetation,creating conditions that significantly elevate the likelihood and severity of forest fires.



(a) Pan-Amazon Tropical Moist Forest (TMF) Disturbances (2001-2024), including deforestation (dark grey), small-scale degradation (orange), and large-scale degradation (dark red) from TMF. GWIS burned forest area (red line) represents GWIS thermal anomalies overlapping with TMF historical degradation and 2023-2024 TMF disturbances, where GWIS detected the fire in the same or previous year.



(b) Tropical Moist Forest Map: Large-scale TMF 2024 forest degradation and recent country forest disturbances (legend as panel a). The inset shows Landsat-8 imagery (courtesy of the U.S. Geological Survey USGS/NASA), with burn scars in purple and undisturbed forest in green (Oct. 21, 2024; RGB: bands 6, 5, 4). The Pan-Amazon region from Eva & Huber 2005 comprises the regions 'Amazonia stricto sensu' and 'Guiana'. Figures A1-A3 provide further details on TMF-GWIS data integration and on absolute/relative forest disturbances at the country-level.

As Amazon fire threats grow, rapid and accurate detection is paramount as this situation also represents a threat to wildlife as In the last two decades, deforestation and forest fires have encroached on the ranges of thousands of plant and animal species in the Amazon rainforest, leading the fires destroy habitats, displace animals, and can lead to local extinctions.(Buehler,201). Therefore, distinguishing forest degradation fires from agricultural fires is key to assessing impacts on people, ecosystems, and climate, and to developing effective mitigation measures.

Proposed Solutions

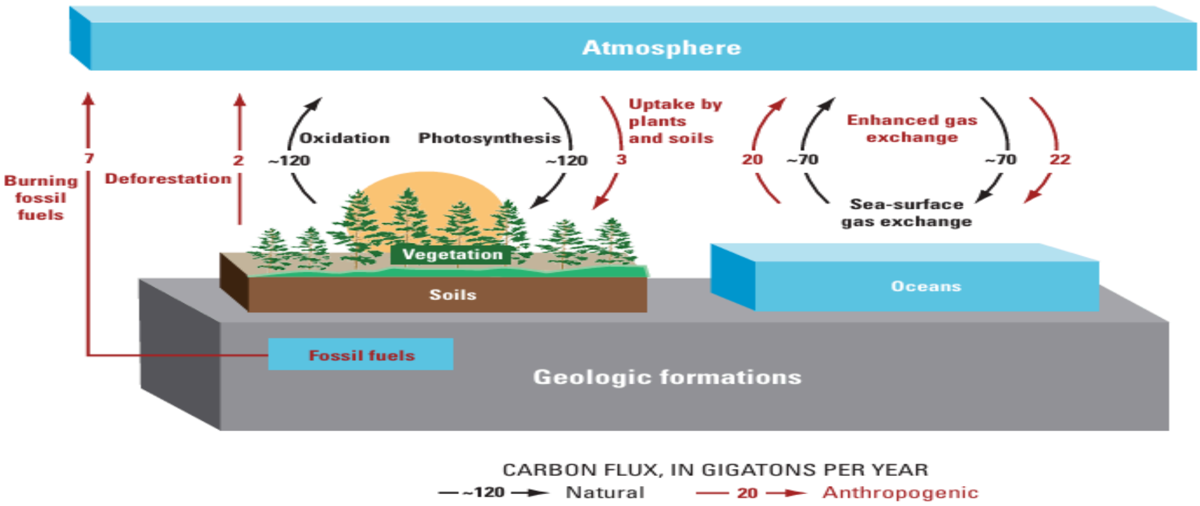
Pathways to include Nature-Based Solution (NBS) in the Agri-Food System.

Nature-based solutions are defined as actions to protect, sustainably manage and restore natural or modified ecosystems with a view to addressing societal challenges (Manuel Pulgar-Vidal et at,2020), thus they are a critical part of transforming the agri-food system to deliver better prosperity for people and the planet. There has also been increasing attention to the role that land-based NbS play in climate change mitigation. Recent evidence suggests that the implementation of 20 different landbased solutions can provide around 30% of global mitigation needed to deliver the 1.5°C temperature target, whilst also securing the climate regulation function of the existing land sink.

Some NBS strategies applied in Agri-Food system include:

Soil Carbon Sequestration (SCS).

The major natural sinks of Carbon Dioxide (Co_2) are oceans, soils and biomass, mainly forest. Carbon sequestration is the process by Co_2 is removed from the atmosphere or diverted from emission sources and stored in soil or the ocean. (USGS,)



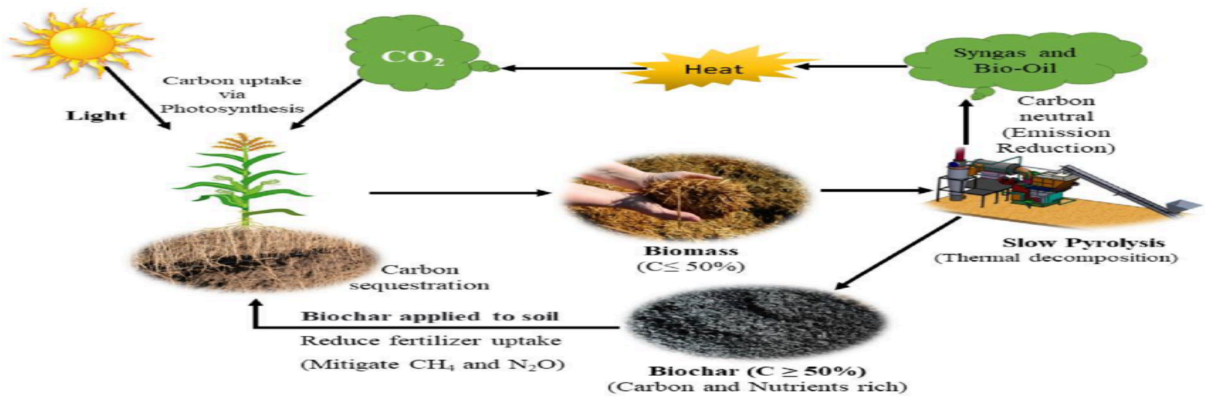
The global carbon cycle. (USGS,2008)

Currently the **Clean Development Mechanism**, established under the **Kyoto protocol**, considers only afforestation and restoration as acceptable sequestration activities and incentives such as **Reduced Emissions from Deforestation and**

Degradation (REDD) are focusing on developing countries and forest lands, since those nations often experience more severe impacts from extreme weather events, rising sea levels, and changing weather patterns, leading to increased poverty, food insecurity, and displacement. However, there are opportunities for soil carbon sequestration across all climatic zones and a wide range of cropping, grazing and forestry land use systems.Moreover, there are multiple benefits of management practices that restore soil carbon including reversing degradation and desertification, enhancing productivity and the provision of a range of ecosystem services and increasing resilience to climate change.

Soil carbon sequestration is thus very cost effective and could take effect very quickly (FAO, 2008).It also constitutes a valuable win-win approach combining mitigation (CO2 is removed from the atmosphere) and adaptation, through both increased agroecosystem resilience to climate variability and more reliable and better yields. The following agricultural practices reduce greenhouse gas emissions by enhancing carbon storage in soil.

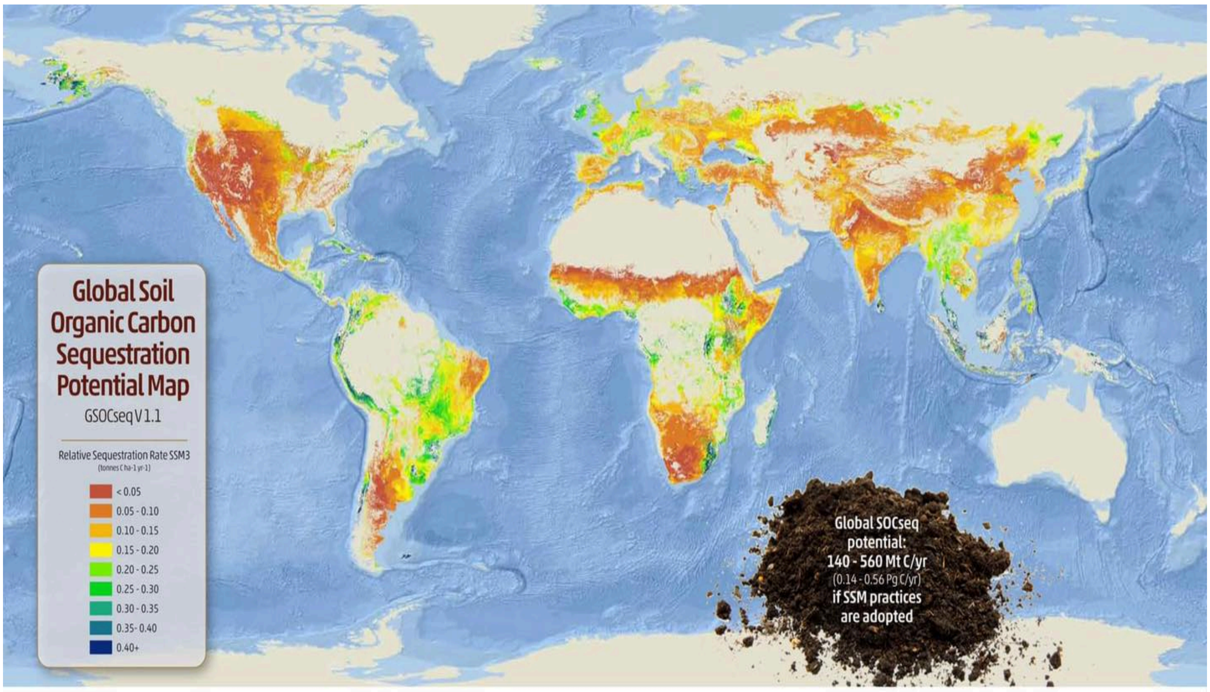
Sustainable Soil Management (SSM)
Currently, FAO has been advocating sustainable soil management practices through promoting agricultural technologies that restore carbon pools and soil quality. One of these **Negative Emission Technologies (NETs)** involves the use of Biochar, which is created through the pyrolysis of biomass and can be used as an efficient Climate-Smart Carbon Sequestration Strategy in agriculture while enhancing resilience to climate change and promoting sustainable development. Biochar increases the inorganic carbon content in the soil which persists over longer timescales.



C sequestration cycle of biochar in soil and crop plant system.

Smith (2016) estimated that increasing **soil organic carbon (SOC)** could remove up to 0.7 GtC/year from the atmosphere. Recent studies (Minasny et al., 2017; EASAC, 2017a) suggest that SOC increases would peak after 10–20 years as the SOC levels approached saturation, but if SOC could be increased across the top 1 metre of soil, increasing SOC could have the potential to absorb 2-3 GtC/year.

Minimizing **Soil Organic Content (SOC)** loss through **Sustainable Soil Management (SSM)** is therefore crucial, and is often the easiest and most cost-effective option. Thus,It is critical to identify regions, environments and agricultural systems that hold the greater potential to maintain and increase SOC stocks, and to establish priorities for the implementation of public and private policies on climate change mitigation and adaptation guidance to meet the Global Climate Action Agenda and the **Sustainable Development Goals (SDGs)**



Global Soil Organic Carbon Sequestration Potential Map

Cases Study:

Case of study 1: Terra Petra (Pre-Columbian Amazonian Dark Soils)

In 1542 Francisco de Orellana, the first European to navigate the Amazon river, reported the presence of remarkably fertile soils in the region. Later on, in 1874 geologist Chalers Hartt researched this case, and described Terra Petra as the result of millennial sophisticated agricultural practices developed by ancestral indigenous soil management and agricultural practices that enable them to thrive despite the poor soil characteristics of Brazil's Amazon basin. (Lehmann, 2013)

By enriching soils through the application of stable organic matter in the form of biochar in conjunction with nutrient additions and organic matter such as animal manure and bones, indigenous communities achieve to make Terra Petra a highly fertile soil with important concentration of Nitrogen (N) Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Zinc (Zn) and Manganese (Mn). (Sombroek Wim et al,2002) . Additionally, it was discovered that due to Terra Petra's soil composition, it has a large potential not only for preserving fertile soils but also for carbon sequestration from the atmosphere as it acts as a long-term carbon sink.

Terra Preta soil (left) compared to a typical Amazon soil profile (right).

Terra Preta soils have inspired a modern debate over the use of charcoal, also known as "biochar" as a large-scale solution to soil quality issues, peak oil, deforestation, global warming and respiratory disease. This Negative Emission Technology (NET) and Nature Based Solution would sequester carbon in the soil as an efficient strategy to reduce the amount of $CO2$ in the atmosphere and thus mitigate the effects of climate change in the Agri-Food System.

Conclusion

The climate crisis is no longer a distant threat but a present reality affecting life on earth in all ways possible, therefore, in order to tackle this escalating reality bold and efficient responses must be addressed by states to combat and mitigate global warming and climate change through extraordinary and transformative solutions rooted in nature, equity and sustainability.

Nature-Based Solutions (NBS) applied in the Agri-Food System, offer a powerful pathway to keep the 1.5°C within reach by mitigation of CO2 emissions, restoring soil's capacity to sequester carbon and enhance food security in the most vulnerable regions of the Global South. Hence, ancient Sustainable Soil Management such as Terra Petra can provide a scalable, resilient and locally adapted climate strategy to achieve the Paris Agreement mitigation targets. Additionally, Governments, institutions and communities must work together to mainstream NBS in national policies that guarantee the implementation of more realistic and achievable NDCs.

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