Understanding the terminology around Carbon, Land Use, and Net Zero Goals



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Why Carbon and Land Use Matter for Net Zero:

Carbon and land use are fundamental to achieving net zero because land acts as both a source and a sink for carbon. Human activities like deforestation, agriculture, and land conversion can release significant amounts of carbon to the atmosphere, accelerating climate change. On the other hand, sustainable land management practices, such as reforestation, conservation agriculture, and regenerative farming, can enhance carbon sequestration, where CO_2 is absorbed by soils and vegetation, reducing the overall carbon footprint.

In the quest for net zero, optimizing land use to maximize carbon capture and minimize emissions is crucial, as it helps balance the carbon released from other sectors like industry and transportation. Achieving net zero requires integrating land use strategies that prioritize carbon storage while maintaining productivity and biodiversity.

Key Terms and Metrics:

Understanding the following terms will help clarify the role carbon and land use play in climate action:

- **Carbon Sequestration:**
  The process by which CO_2 is captured from the atmosphere and stored in plants, soils, oceans, or other carbon sinks. Forests and agricultural land can play a key role in this process.
- **Carbon Footprint:**
  The total amount of greenhouse gases (GHGs), including CO_2, methane (CH_4), and nitrous oxide (N_2O), emitted by human activities. It is typically measured in metric tons of CO_2 equivalent (CO_2e), a unit based on carbon dioxide's global warming potential (GWP).
- **Net Zero:**
  Achieving a balance between the amount of GHGs emitted into the atmosphere and the amount removed or offset. Achieving net zero is essential to limit global warming.

- **Carbon Intensity:**
  The amount of carbon emissions produced per unit of energy, product, or economic activity. Reducing carbon intensity is a key strategy for decreasing overall emissions.
- **Carbon Offsetting:**
  Mechanisms that allow companies or individuals to compensate for their emissions by investing in projects that reduce or capture CO^2 elsewhere, such as reforestation or renewable energy projects.
- **Carbon insetting:**
  A strategy where businesses invest in carbon reduction or sequestration projects within their own practices rather than relying on external offsets.
- **Carbon Budget:**
  A way of tracking the balance between carbon emissions from operations, such as farming or forestry activities, and carbon sequestered through practices like soil management, reforestation, or crop growth. By managing this balance minimizes net carbon output and contributes to sustainability goals.

- **Greenhouse Gas (GHG) Emissions:**
These include CO_2, methane (CH4), nitrous oxide (N2O), and other gases that contribute to global warming. Different gases have varying impacts on the climate and remain in the atmosphere for different durations.

The GWP is used to compare their effects over time. Below is a table from NASA (which describes the major greenhouse gas sources, their lifespans and possible added heat.

Major Greenhouse Gas Sources, Lifespans, and Possible Added Heat

Greenhouse Gas	Sources (Contributions to Global Warming)	Average Lifetime in the Atmosphere	Possible Added Heat ("Global Warming Potential") Over a 20-Year Period	Possible Added Heat Over a 100-Year Period
Carbon Dioxide	**Human sources (100%):** mostly the burning of fossil fuels (such as coal, oil, and natural gas), deforestation/land-use change, and wildfires/biomass (plant material) burning **Natural sources (0%):** volcanic eruptions, respiration, weathering of certain rocks, and wildfires/biomass burning; permafrost	Hundreds to thousands of years; about 25% of it lasts effectively forever	Carbon dioxide is used as a reference point for other greenhouse gases, so its possible added warming (or global warming potential, GWP) is 1.	Carbon dioxide is used as a reference point for other greenhouse gases, so its possible added warming (or global warming potential, GWP) is 1.
Methane	**Human sources (60%):** leaks from fossil fuel production and transportation; landfills; livestock digestion and maure; rice farming; natural gas; wildfires/biomass burning **Natural sources (40%):** plant-matter breakdown in wetlands, lakes, ponds; wildfires/biomass burning; termites; ocean; sediment; volcanoes; permafrost	About a decade	One metric ton can trap **about 80 times** the heat of 1 metric ton of carbon dioxide.	One metric ton of methane can trap **about 30 times** the heat of 1 metric ton of carbon dioxide.
Nitrous Oxide	**Human sources (40%):** production and use of organic and commercial fertilizer; burning fossil fuels; burning vegetation **Natural sources (60%):** bacteria breaking down nitrogen in soils and the ocean	About 110 years	One metric ton can trap **273 times** the heat of 1 metric ton of carbon dioxide.	One metric ton can trap **273 times** the heat of 1 metric ton of carbon dioxide.
Chlorofluorocarbons (CFCs, namely CFC-11, CFC-12, CFC-113)	**Human sources (100%):** refrigerants; solvents (a substance that dissolves others); spray-can propellants **Natural sources:** effectively none	About 52 to 93 years	One metric ton can trap **thousands to tens of thousands of times** the heat of 1 metric ton of carbon dioxide.	One metric ton can trap **thousands to tens of thousands of times** the heat of 1 metric ton of carbon dioxide.

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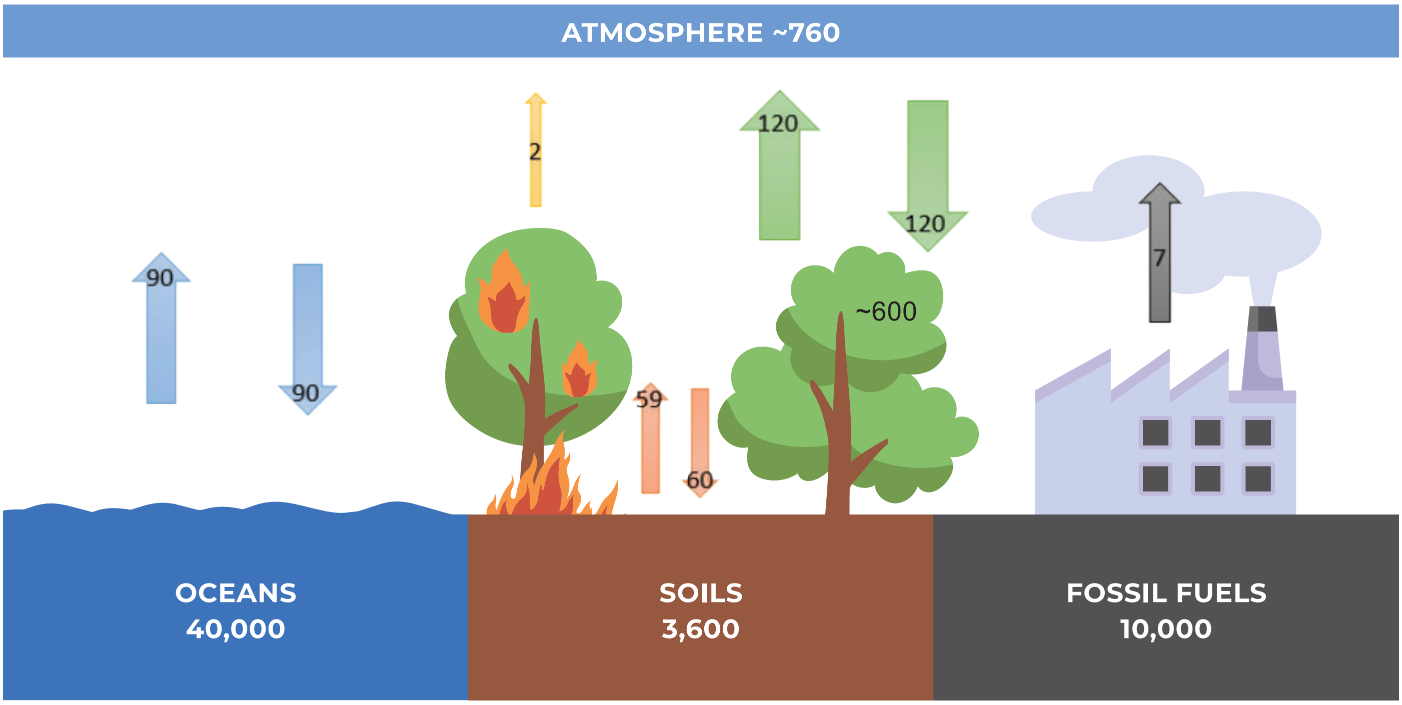
- **Soil Carbon Stocks and flows:**
  This distinction is crucial when discussing carbon in soils. Soil carbon stocks refer to the amount of carbon stored in the soil, while carbon flows describe the rate of carbon entering or leaving the soil. Although soils can store large quantity of carbon, the rate at which they accumulate more is often slow and depends on many factors, including the soils' existing levels and overall soil health. Generally, if the level of soil carbon is high, the rate at which new carbon can be incorporated is very low or static – the soil is in a steady state.. It's important to know that soil carbon is usually measured in terms of mass. For example, 1 gigaton of carbon (GtC) refers to the weight of carbon molecules stored in the soil. When this carbon is released into the atmosphere, it combines with oxygen to form carbon dioxide (CO_2), a greenhouse gas. The weight of carbon dioxide is about 3.67 times heavier than the carbon alone. This is because the molecular weight of CO_2 includes both carbon and oxygen atoms (44 for CO_2 compared to 12 for carbon). So, when carbon leaves the soil and becomes CO_2, the overall impact on the atmosphere is greater in terms of weight.

Global Carbon Flux (Gigatonnes (Gt)/ year) and Storage (Gt)



GLOBAL CARBON FLUX (Gt/yr) & STORAGE (Gt)

- **Carbon Sink:**
  A natural or artificial reservoir that absorbs and stores more carbon than it releases. Forests, oceans, and soils are the most significant carbon sinks.
- **Impact of Crops and Land Use on Carbon:**
  Different crops absorb and release carbon at varying rates, with perennial and deep-rooted crops typically sequestering more carbon in the soil over their lifespan than shallow-rooted or annual crops.
- **Temporal Considerations in Carbon Accounting:**
  Carbon levels in the soil fluctuate within and between years due to seasonal changes, weather patterns, and crop cycles, with higher rates of carbon uptake typically occurring during the growing season. For long-term net zero strategies, understanding these fluctuations is critical to accurately assessing carbon budgets and implementing practices that stabilize or increase sequestration over time. It's important to understand that soil carbon is always in flux, i.e. it's constantly being added to and released from the soil. How long carbon stays in the soil depends on how well it's protected within undisturbed soil aggregates. These aggregates shield carbon from microbial decomposition and release it into the atmosphere as CO_2. This means that the structure of the soil plays a big role in how stable soil carbon is. Well-structured soils, with strong aggregates, help keep carbon stored for longer periods, contributing to carbon sequestration.

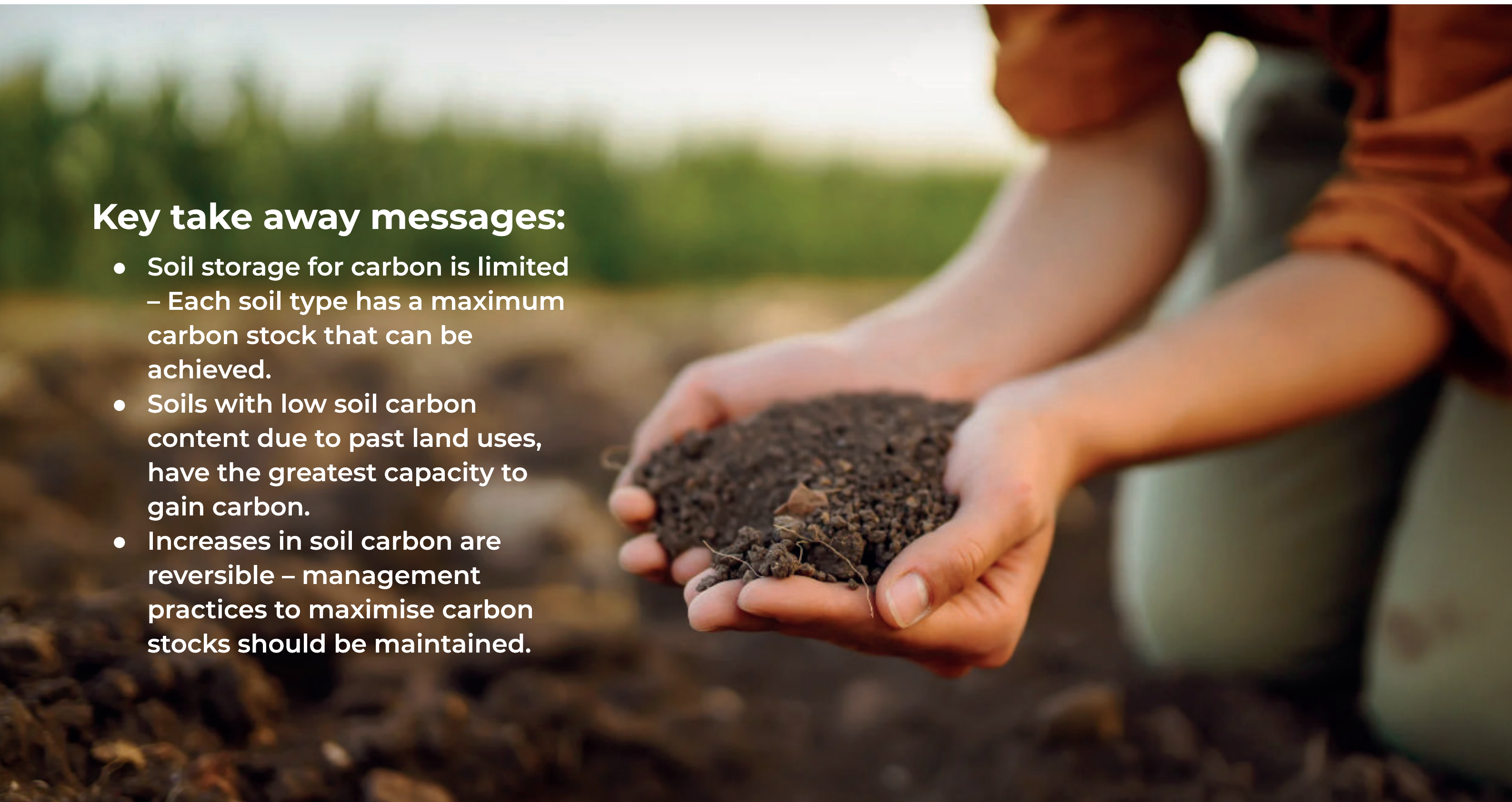
- **Soil Carbon sequestration potential**
  Every soil has a maximum capacity to store carbon. This means that there is a limit to how much carbon can be added to the soil, depending on many factors including climate and the time period. This limit is known as the soil carbon sequestration potential, i.e. the maximum amount of carbon that the soil can hold under certain conditions. Once this limit is reached, soils won't be able to store much more carbon, so managing soils to maintain their carbon levels is crucial for long-term carbon storage. The IPCC (Intergovernmental Panel on Climate Change) suggests that it can take about 20 years for soils to reach a new level of carbon storage, called equilibrium or saturation. However, this process doesn't happen at a steady rate, it slows down over time. In fact, it can take 10 to 50 years or even longer for soils to reach their maximum carbon storage capacity. This means that while soil can absorb carbon, the rate of absorption decreases as it gets closer to its limit.

- **What are Carbon Credits and Verified Carbon Units?**
  Carbon Credits and/or Verified Carbon are common units based on one tonne of carbon dioxide (CO_2). Agricultural practices that avoid, reduce, and/or remove one tonne of Greenhouse Gases (GHGs), including CO_2, out of the atmosphere can generate one Carbon Credit or one Verified Carbon Unit in the carbon market. One tonne of carbon is equal to 3.67 tonnes of CO_2.

- **What is the Carbon Market?**
  The carbon market is a system where companies, governments, or organizations can buy and sell carbon credits to help reduce global carbon emissions. Companies that reduce their emissions can sell their unused carbon credits to others who need them. This creates an incentive to cut emissions because companies can make money by selling excess credits. Important to mention that there are two main types of carbon markets:

1) Compliance markets, where companies are legally required to limit their emissions.
2) Voluntary markets, where companies or individuals choose to buy credits to offset their carbon footprint.

Carbon markets aim to lower overall emissions by putting a price on carbon, encouraging more sustainable practices.



Key take away messages:

- **Soil storage for carbon is limited – Each soil type has a maximum carbon stock that can be achieved.**
- **Soils with low soil carbon content due to past land uses, have the greatest capacity to gain carbon.**
- **Increases in soil carbon are reversible – management practices to maximise carbon stocks should be maintained.**