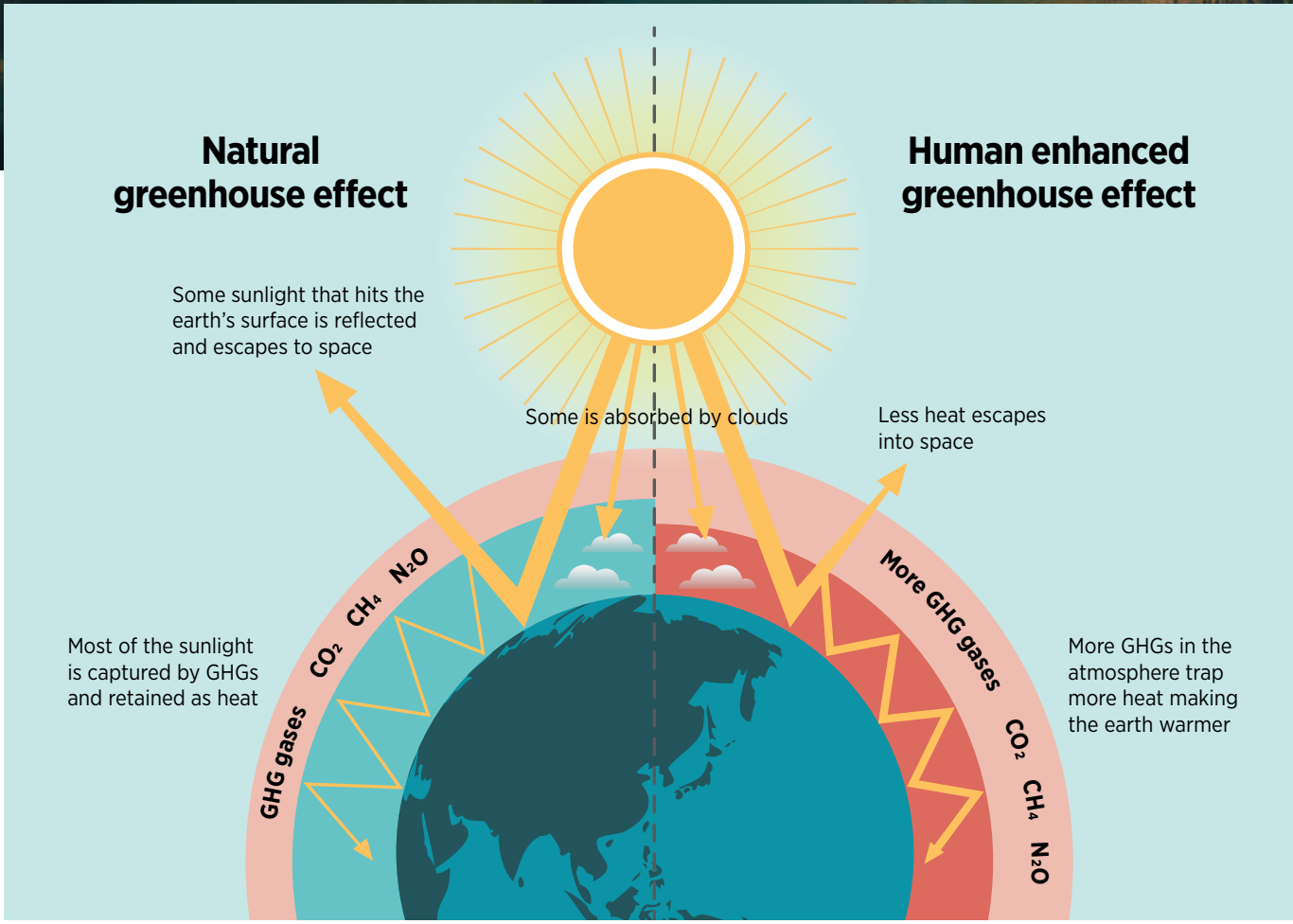
FACTSHEET

The Greenhouse effect, including long and short-lived gases



The Earth's atmosphere is made up of naturally occurring greenhouse gases (GHGs), the largest of which is water vapor (H_2O), but also includes carbon dioxide (CO_2) mainly from the decay of plant matter, methane (CH_4) mainly from wetlands, nitrous oxide (N_2O) mainly from soils and oceans, and ozone (O_3), which is produced and destroyed by chemical reactions in the atmosphere.

Solar radiation from the sun enters the Earth's atmosphere. Some is absorbed by the Earth's surface and then a proportion of this is re-radiated as heat back out into the atmosphere. Some escapes through the layer of GHGs and is lost to outer space, while the rest is trapped by the layer of GHGs that creates a warming effect. This process ensures that Earth is kept at an average temperature of 15˚C and without those naturally occurring GHGs trapping heat the average temperature at Earth's surface would be -18˚C.

Human activities can increase the total amount of GHGs in the atmosphere which means more heat is trapped in the atmosphere, warming the earth's surface. Since humans started using fossil fuels the average temperature at Earth's surface has increased by 1˚C.

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Emissions vs. Warming Impact

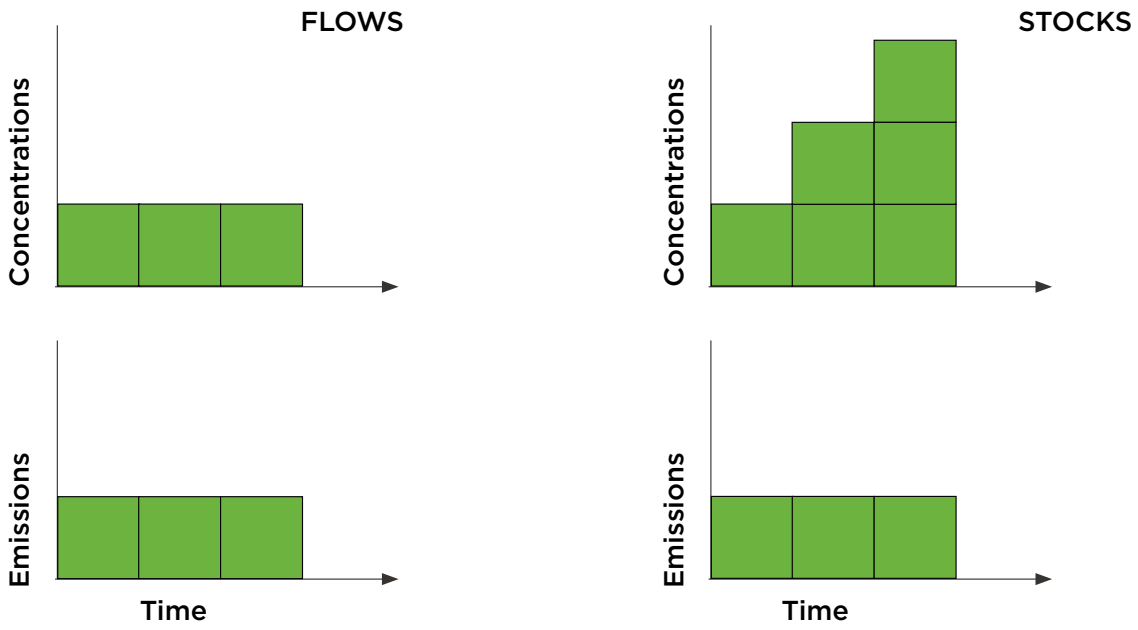
The atmosphere is warmed by a number of different gases including carbon dioxide, methane, and nitrous oxide. Any increase in these emissions will increase global temperatures so it is important to manage them. However, not all greenhouse gases have the same warming impact, something there is strong scientific agreement on. The disagreement comes when comparing the warming impact of one greenhouse gas (GHG) against another which is really important to get right since not all GHG emissions have the same warming effects on the atmosphere.

Short-lived and long-lived gases

Methane (CH_4) is a short-lived 'flow' gas meaning that it breaks down a lot faster than other gases, but while it's in the atmosphere it is more potent than Carbon Dioxide (CO_2) and has a greater immediate impact on warming. A molecule of methane will be basically gone from the atmosphere within about 12 years so if the amount of CH_4 being emitted to the atmosphere remains constant, then over an extended period of time the amount entering and leaving the atmosphere will balance out.

Long-lived gases such as CO_2 and Nitrous oxide (N_2O) are 'Stocks' they can take 100s to 1000s of years to break down and therefore accumulate over time. Each additional unit of CO_2 or N_2O emitted adds to the total in the atmosphere and therefore additional warming.

Short-lived gases are 'Flows' while long-lived gases are 'Stocks'.



What are 'Global Warming Potentials' and 'CO_2 equivalent emissions'?

Global Warming Potentials (GWP) are used to compare the different warming impacts of different greenhouse gas emissions in the atmosphere. Most of these tend to use CO_2 equivalent emissions as a way to compare the warming impact of different greenhouse gas emissions against the warming impact of CO_2.

The current metric (standard of measurement) used globally to compare the warming impact of the various gases is GWP100, which compares the warming impact of the gases over a 100-year period. This metric is accurate for measuring the impact of long-lived gases on warming but can have limitations when methane is stable or decreasing within the 100-year timeframe.

What are some human-induced GHGs and their sources?

Greenhouse gas emissions can come from 'natural' sources or as the result of people's actions. Natural sources include the decomposition of plant materials, release of gases from the ocean, and the release of gases from volcanic eruptions. Anthropogenic or human-induced GHGs include:

1. Carbon dioxide (CO_2) from the burning of fossil fuels like oil or coal, deforestation and land use change (e.g. from a natural state to pasture);
2. Methane (CH_4) from the burning of natural gas, fossil fuel extraction/transport, farmed ruminants (such as cattle, sheep and deer), landfills, animal effluent storage and wastewater management;
3. Nitrous oxide (N_2O) from urine patches, nitrogen fertilisers, animal effluent storage and wastewater management; and
4. Other synthetic gases like CFCs (chlorofluorocarbons) from industrial processes and refrigeration.

Does the source of emissions matter?

Emissions of greenhouse gases form part of the 'carbon cycle.' However, different sources of emissions move through this cycle at different speeds.

Fossil fuel emissions go through the carbon cycle more slowly than those from ruminant animals. This is because the extraction and burning of oil, gas, and coal releases carbon that has been stored beneath the earth's crust for millions of years in the form of CO_2 emissions that then stay in the atmosphere for hundreds of years.

While emissions from ruminant animals, primarily come from the animals converting the carbon (that was created by sequestered carbon dioxide already in the atmosphere) from grass (or other feed sources) into CH_4 as part of their digestion process. CH_4 breaks down in the atmosphere more quickly than CO_2.

What does 'net' mean?

'Net' is the difference between what is being emitted into the atmosphere (gross emissions) and what is being removed from the atmosphere (known as carbon sinks, sequestration or carbon removals).

How can CO_2 be removed from the atmosphere?

Carbon sequestration is when carbon dioxide is removed from the atmosphere and stored for the short or long term. This can be done as part of the biological carbon cycle or via other means such as carbon capture technology.

You can find out more in the fact sheet 'Carbon sequestration in woody vegetation' link at the end.

What about soil carbon?

Soil can store quite a lot of carbon, but

- It is expensive and difficult to measure at farm scale:
  - Soil samples only measure a small part of the soil and it is too expensive to take enough samples over a whole farm. Scientists are working on new tools.
  - There are still big gaps in knowledge about how soil carbon behaves.
- It can be lost very quickly for reasons beyond a farmer's control such as during a drought.
- There are lots of things that affect soil carbon such as underlying soil types.
- New Zealand soils are very young and most still have very high soil carbon levels, with the exception of repeatedly cultivated soils. Other countries that have been cultivating their soils for hundreds of years may have very low soil carbon levels, and therefore have greater capacity to add additional carbon to the soil.

Average soil carbon stocks to 30cm

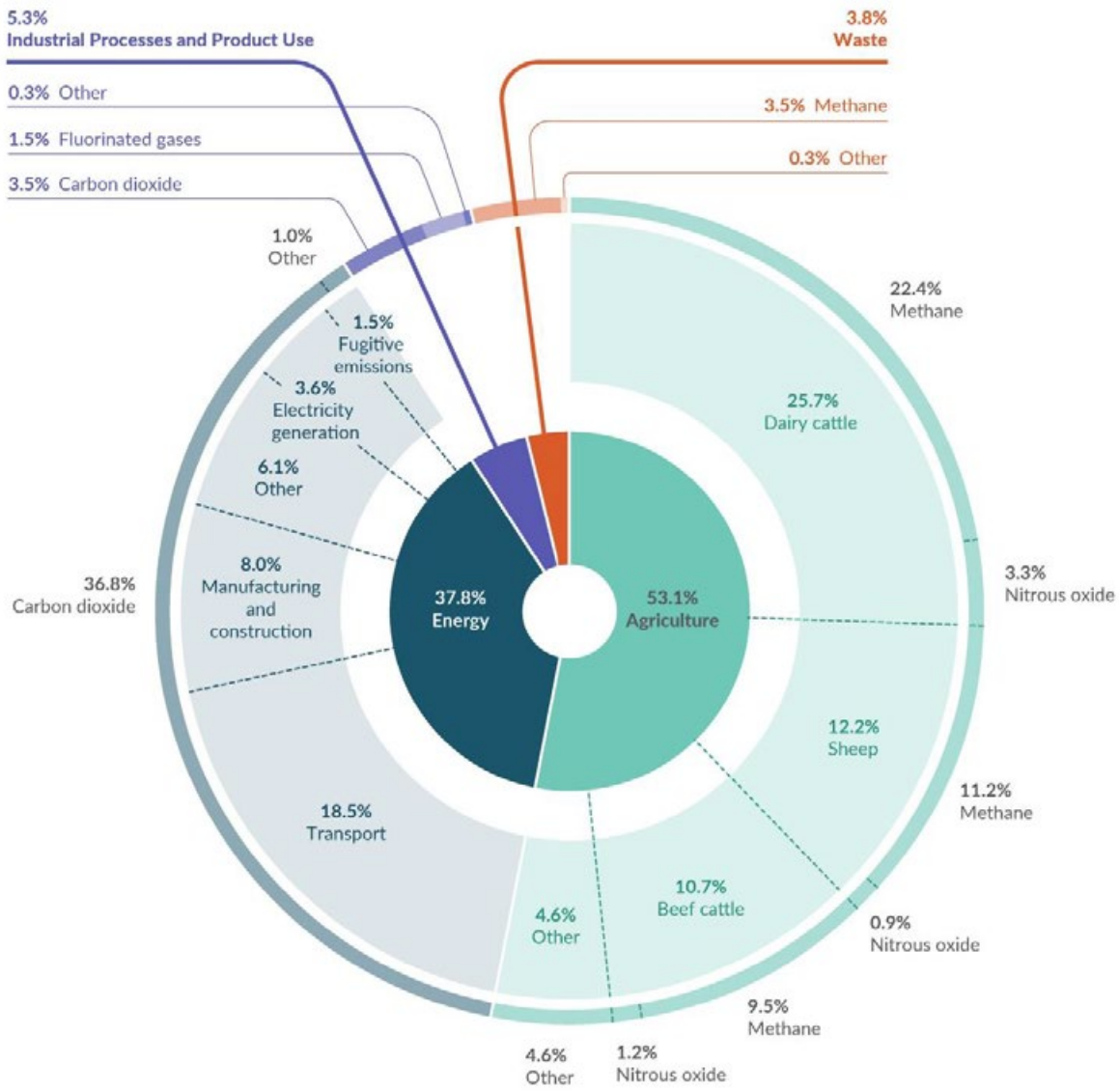
Location	Quantity
New Zealand	89 t C ha
Australia	30 t C ha
United States	45 t C ha
Global	62 t C ha

Source: https://www.nzagrc.org.nz/assets/1535-Wed_Peter-Millard_Soil-Carbon-for-NZ-1.pdf

There are things that can be done to protect soils and soil carbon as much as possible as well as helping to build soil carbon. Carbon is added through photosynthesis so avoiding bare soil and having growing plants on soil as much as possible is the way to avoid soil carbon loss.

- No-till cultivation and other carbon building actions.
- Avoiding compaction and soil damage through pugging wet soils or heavy machinery.
- Avoiding soil losses through erosion, keeping soils in place.

Below is a diagram of New Zealand's 2023 greenhouse gas emissions percentages by sector and by gas



Further information can be found here:

B+LNZ Factsheets: Find these Factsheets on the B+LNZ Knowledge Hub www.knowledgehub.co.nz

- Biogenic methane from ruminant animals and nitrous oxide from agricultural soils
- Carbon sequestration in woody vegetation
- Greenhouse gas management and mitigation for sheep and beef farmers

B+LNZ Farm Plan: Environment Module

- You can download the Farm Plan 'Responding to a changing climate' chapter at www.beeflambnz.com/farmplan

Websites

- www.agmatters.nz
- https://niwa.co.nz/agriculture/climate-change-information-climate-solvers/climate-change-and-agriculture
- https://niwa.co.nz/climate-change-information-climate-solvers/climate-change-science
- https://www.sciencelearn.org.nz/resources/2959-greenhouse-gases-and-the-atmosphere

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