



MIE Lab: Maths Modelling Challenge

Student Handout

Scenario: Environmental Impact of Meat Consumption



Australia is one of the largest consumers of meat in the world. The average person in Australia now consumes ~100kg of meat a year. Animal agriculture is the second largest contributor to human-made greenhouse gas emissions after fossil fuels and is a leading cause of deforestation, water and air pollution and biodiversity loss. Raising and feeding livestock requires a lot of land. Land that could be used to feed a lot more people more efficiently.

Planetary health is a relatively new branch of science focusing on safeguarding the health of human civilisation and the state of the natural systems on which we depend. This branch of science has put lower meat consumption at the heart of reducing humanity's negative impact on the environment. Deforestation of land for livestock adds to the carbon footprint of a heavy meat diet and reduces available land that could produce far more plant-based food for the world's increasing population. In fact, in order to be able to sustain increasing population, we need to reduce our global meat consumption by half.

The Australian government is launching a public awareness campaign on the environmental impact of a high meat diet. The campaign will inform and encourage the public to move towards a more plant-based diet. The government has asked your group to provide valuable data on the environmental impact of Australia's meat consumption to help with the campaign.

There are many ways to approach this problem but a good place to start is to consider the amount of meat Australians eat on average per year and the land required to raise that livestock.

Key points the Australian Government have asked you to address are:

- How much land is used for animal agriculture globally and how much of that is used to sustain Australia's annual meat consumption?
- If Australia led the way on this global mission to dramatically lower meat consumption, with every Australian reducing their weekly meat intake by 50%, how much land would be required to grow crops to provide the same amount of protein to replace meat in this more plant-based diet?
- If this land was reforested how much carbon would be absorbed from the atmosphere?

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USEFUL RESOURCES

There are many ways to approach this problem and many sources for reference. Below is a list of useful links and hints that provide some background reading and may aid in your approach to the problem. These can all be accessed without special licenses to journals.

Environmental impact of eating meat 

https://www.peta.org.au/issues/food/meat-environment/?gclid=CjwKCAjwwYP2BRBGEiwAkoBpAh-v16Lkuo1cr5YijjNYw8lgGyhQsxsdcVOZ7uV5Y-0lWQFHgEMgzjoRoCbfcQAvD_BwE

Land used for livestock globally

https://www.veganaustralia.org.au/impact_of_a_vegan_agricultural_system_on_land_use
<https://www.globalagriculture.org/report-topics/meat-and-animal-feed.html> 

Meat consumed globally per year

<https://ourworldindata.org/meat-production>

Australia's meat consumption

<https://www.agriculture.gov.au/abares/research-topics/agricultural-commodities/mar-2019/meat-consumption>

<https://theconversation.com/three-charts-on-australias-declining-taste-for-beef-and-growing-appetite-for-chicken-78100> 

Land use per 100g of protein (this also quotes land used for agriculture globally as 40million km²)

<https://ourworldindata.org/agricultural-land-by-global-diets>

Carbon absorption rate of trees (Some useful links as calculations vary greatly.) 

<https://www.thequint.com/tech-and-auto/how-many-trees-needed-to-absorb-co2-sadhguru-and-quint-calculations>

<http://medcraveonline.com/FREIJ/FREIJ-02-00040.pdf>

<https://www.eea.europa.eu/articles/forests-health-and-climate-change/key-facts/trees-help-tackle-climate-change> 

Carbon offset calculator

https://savingnature.com/offset-your-carbon-footprint-carbon-calculator/?gclid=CjoKCQjwnv71BRCOARISAlkxW9HS2X-Q2dgRAPFkDATNsJAWiMehEcz8iwdHg-1du-R-b_3G-pWpe5ywaAsLtEALw_wcB

INDEX

~: symbol for approximately

Fossil fuels: A natural fuel such as petroleum, coal or gas, formed in the geological past from the remains of living organisms.

Animal agriculture: Breeding animals for the production of meat and animal products such as beef, pork and dairy products.

Planetary health: The health of human civilization and the natural systems, such as the environment, on which it depends.

Deforestation: The practice of clearing large area of trees, often to use for farming or industry.

Annual meat consumption: The total amount of meat produced every year, this is usually quoted in tonnes and is the amount we eat plus the amount that is wasted.

Per capita: for each person.

Greenhouse gas emission: The release of harmful gases into our environment from transport, industry and other human activity.

Carbon absorption rate of trees: A process whereby carbon is removed from the atmosphere and stored long-term in trees, roots and soil.





Maths Modelling Challenge: Years 9 and 10

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Additional Notes for Teachers

All entries must be students' own work and verified on submission. Acceptable teacher support for students please refer to below *Footnotes - points of discussion and exploration*.

- Students will need to research global meat consumption, global landmass used for agriculture and Australian population to evaluate the land required to produce the amount of meat consumed annually in Australia.
- When modelling the potential to reduce landmass used, students will need to research land required to produce protein from different meat and plant-based sources.
- CO₂ absorption rate of many different forests and other carbon sinks can also be found on the internet.

Example Work Through

Land required to produce Australia's annual meat consumption

Land used for animal agriculture globally = ~26% of Earth's ice free land* = 33.8million km².

This is about 4.4 times the size of Australia.

Meat consumed globally per year = 320 million tons.

Australia's meat consumption = 100kg per capita per year**

Population of Australia = 24.6million

Tons of meat consumed in Australia each year = 24.6 x 0.1tons = 2.5 million tons

Percentage of meat consumed by Australia = (2.5/320) x 100 = 0.8% of global consumption.

Land used to provide Australia with meat*** = 33.8million km² x 0.008 = 270,400km². Roughly the land mass of New Zealand.

Land required to grow crops to produce the same amount of protein

Land required to produce 50% of meat = 270,400km²/2 = 135,200km²

100g of protein from meat requires 170m² of land. ****

100g of protein from soya, pulses and nuts requires 5m² (2.2-7.9m²) of land.

percentage of land required to produce protein from plants = (5m²/170m²)100 = 2.9%

land needed to supply 50% of protein from plants = 135,200km² x 0.029 = 3,921km².

Roughly 1/3 the size of Sydney.

Carbon absorbed from reforestation

Land saved to be reforested = 135,200km² - 3,921km² = 131,279km²

1km² of trees can absorb between 100 - 1,000 tons of CO₂ per year. Assume an average of 500 tons†

Annual CO₂ absorbed = 131,279km² x 500 tons CO₂/km² = 65.6 million tons CO₂

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Additional Notes for Teachers

Footnotes - Points of Discussion and Exploration

* This varies slightly depending the source and if land used to grow food for the livestock has been considered. Students may only model the land used to raise livestock, in which case this will be less.

** This can vary from 91-111kg per capita depending on year of survey.

*** There are several ways to estimate this and the answer may well be available online already.

**** Land required to produce protein from different sources can be found online. The example takes an average of land required to produce protein from beef, lamb and poultry as well as an average from land required to produce protein from soya, nuts and pulses. Students may wish to model a more accurate land size by researching % of beef/pork/poultry that is consumed annually.

† This varies depending on age and species of tree as well as climate. A temperate deciduous forest may store less CO₂ annual than a rainforest for example. As only ~30% of Australia's beef is exported, students may wish to model different forest types that are typically found in Australia or another carbon sink entirely. These absorption rates can be found online.

USC STEM programs are designed to inspire the next generation of leaders in Science, Technology, Engineering and Mathematics. Underpinned by the ethos that STEM has applications across the curriculum and beyond the classroom, all activities challenge students to use STEM in solving every day, real-life problems. W: usc.edu.au/STEM E: uscSTEM@usc.edu.au

School of Science and Engineering and School of Education.

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