Agroecology and Sustainable Food Systems: from production to the consumer

Presented by
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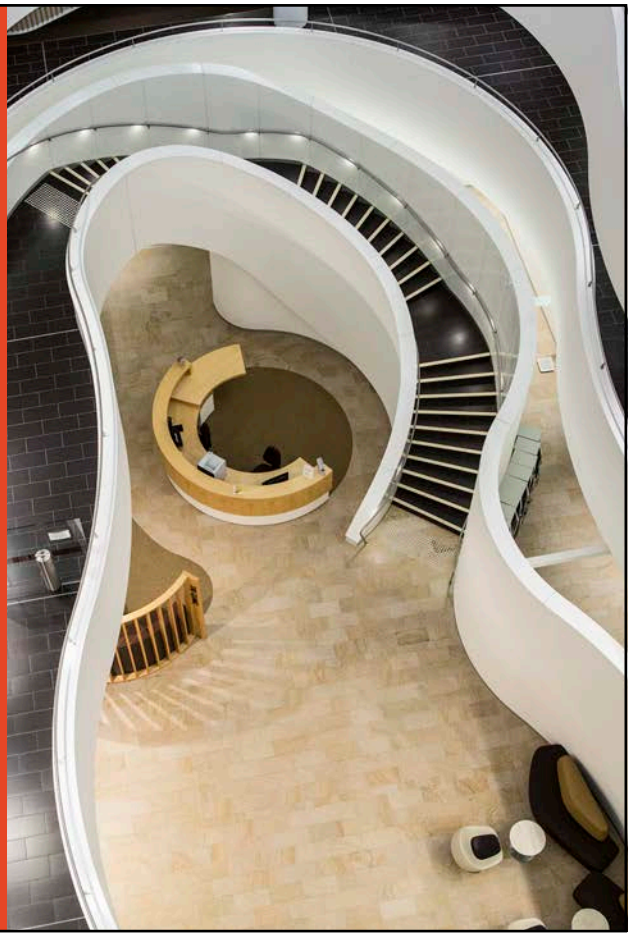
Postgraduate Coordinator, Agriculture and Environment
School of Life and Environmental Sciences

THE UNIVERSITY OF SYDNEY



1

One of the world's top research universities

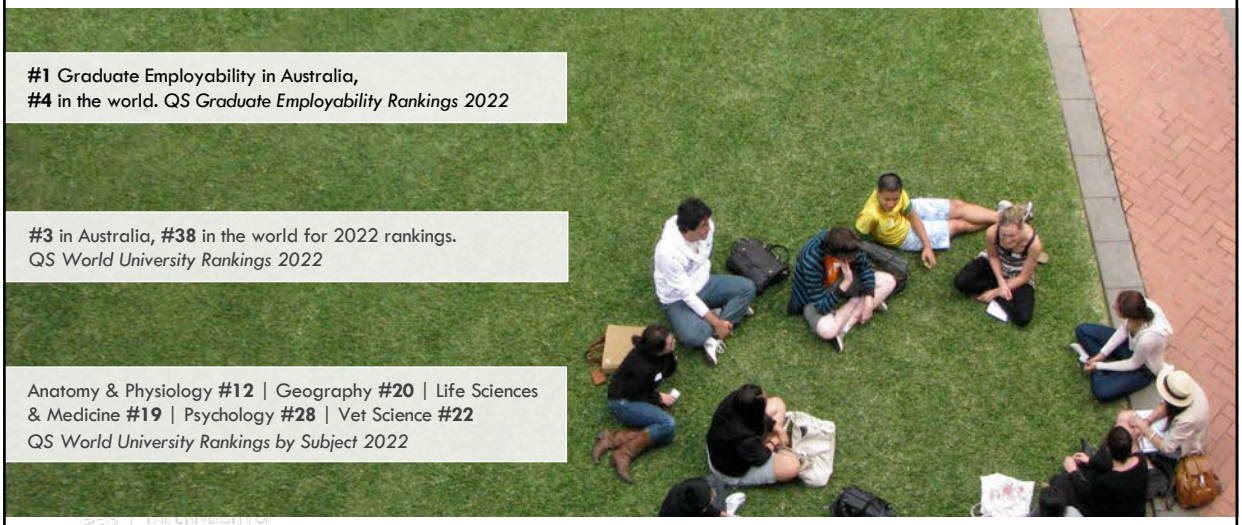
- In the **top 40** of the world's best research universities[1]
- All our research is ranked at **world standard or above**[2]
- Ranked **4th in the world** for graduate employability[3]
- **90+ multidisciplinary** research and teaching centres
- **10 multidisciplinary research initiatives** among the world's leaders

1 QS World University Rankings 2022
2 2022 Excellence in Research for Australia (ERA)
3 QS World University Rankings 2022

2

Science at Sydney

Join an extraordinary science community filled with talented students, academics, researchers and a global network of alumni who work to shape global science and health agendas.



3

Master of Agriculture and Environment

- Professional experience in the lab and out in the field
- Research project addressing modern-day problems
- Solve the big challenges in the world: food security, climate change, and management of carbon, water and the environment
- Streams: Agriculture & Environmental Economics; Agricultural & Environmental Technologies; Horticultural Technologies
- Duration: 1.5 years full time

4

Master of Environmental Science

- A grounding in basic environmental issues
- Great flexibility in what subjects you take and how deep you delve into them
- Link your education in environmental sciences (such as ecology, climate change and chemistry) with studies in politics and law, project evaluation and assessment, decision-making and conflict resolution
- Duration: 1.5 years full time

5

Sample Course Plan

Master of Agriculture and Environment

YEAR 1		YEAR 2
Soil Processes, Assessment and Management	Climate Change: Process, History, Issues	Research Methodology and Project
Advanced Plant Production Systems	New and Emerging Tech in Animal Science	
Foundation in Strategy, Innovation and Management	Global Environmental Politics	
Sustainable Horticultural Cropping	Life Cycle Analysis	

6

Lecture Outline

- Production systems and sustainability
- Global food systems
- Consumption and diets
- Dietary recommendations
- Healthy diet, healthier planet?

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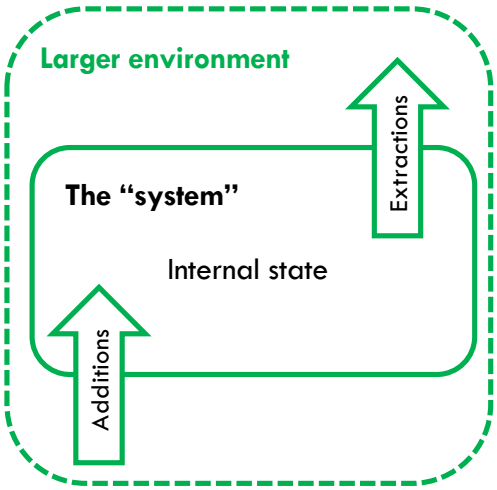
Sustainability

Sustainability matrix: (a) inputs, (b) outputs (losses) and (c) internal state changes



Extractions: *Intentional and unintentional losses*

Is replacement needed?
Do losses affect 'downstream' systems?

State changes: *Internal changes*

Is system functioning affected?
Is 'repair' needed (including additional extractions or additions)?

A sustainable system (or operation of that system) meets the needs of the present without compromising the ability of future generations to meet their needs

Additions: *Intentional, unintentional and 'natural' inputs*

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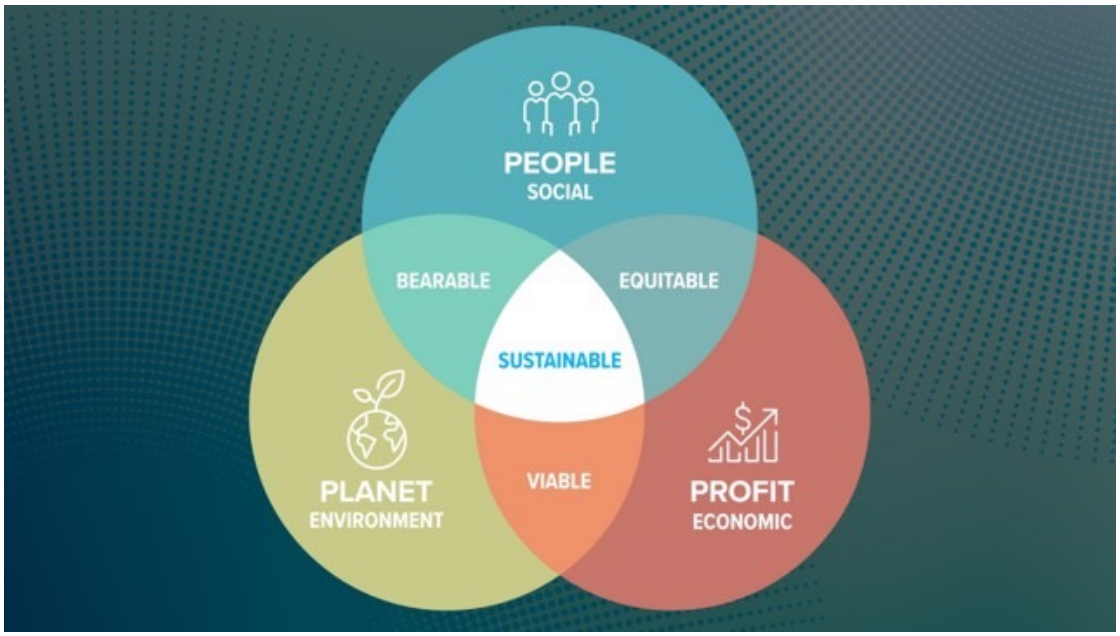
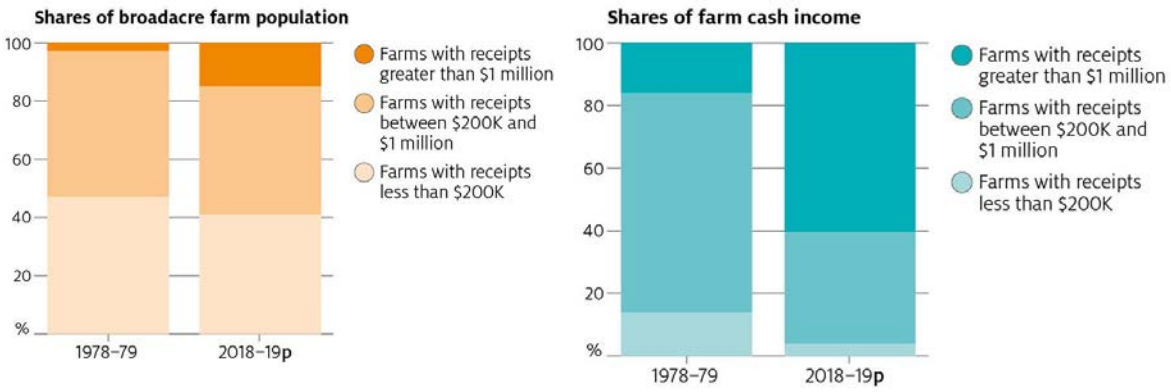
Sustainability – Triple Bottom Line

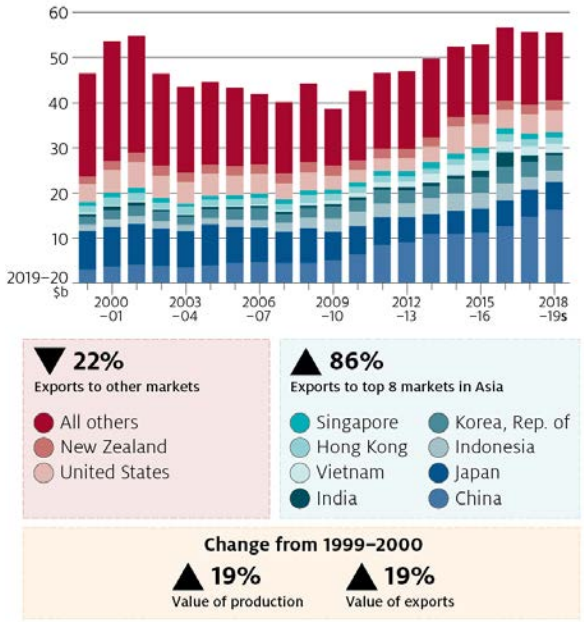


Economic Sustainability - Economic performance is driven by the most productive farms



High-revenue (large) farms now account for one fifth of the broadacre population but two thirds of land, income and output

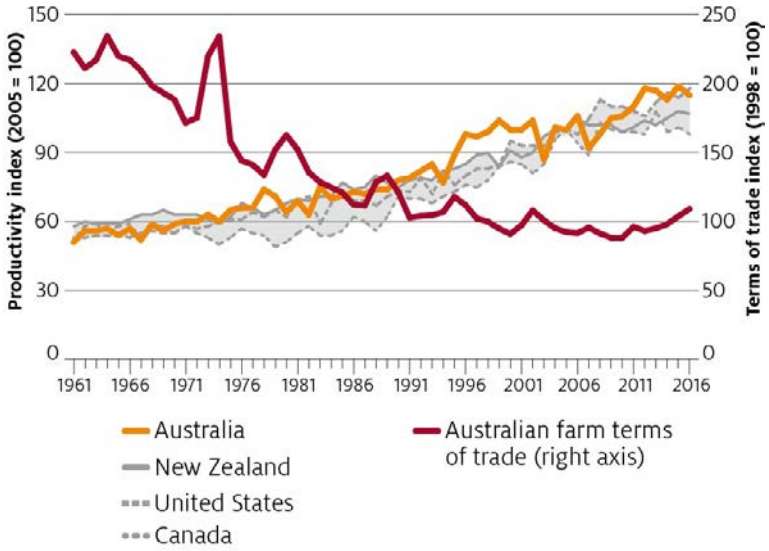
Two thirds of agricultural output is exported



Note: export values are measured at the border and so include processing of some commodities beyond the farm gate (for example wine from grapes and cheese from milk) – for this reason production and export values are not directly comparable. s ABARES estimate. Source: ABARES, ABS International Trade in Goods and Services, Australia (cat. 5368).

Agriculture productivity growth and terms of trade, 1961 to 2016

Ag productivity growth comparable to other countries



Note: 100 = 2005. Shaded area represents agricultural productivity growth for Canada, United States and New Zealand. These data compare productivity growth over time, and do not represent the level of productivity in each country. Source: ABARES, United States Department of Agriculture Economic Research Service (PSD).

Environmental Sustainability - What is life cycle assessment?

- An internationally agreed approach, used to assess environmental impacts from producing a unit of a commodity.
- Informs 'cradle-to-grave'
- Developed in the manufacturing sector
- Based on LCI, published papers and direct measurement; and guided by ISO 14040 and ISO 14044

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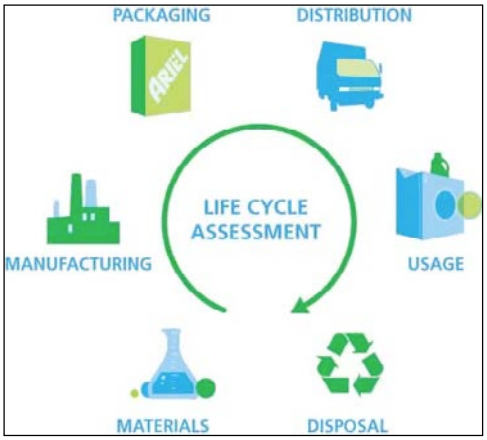
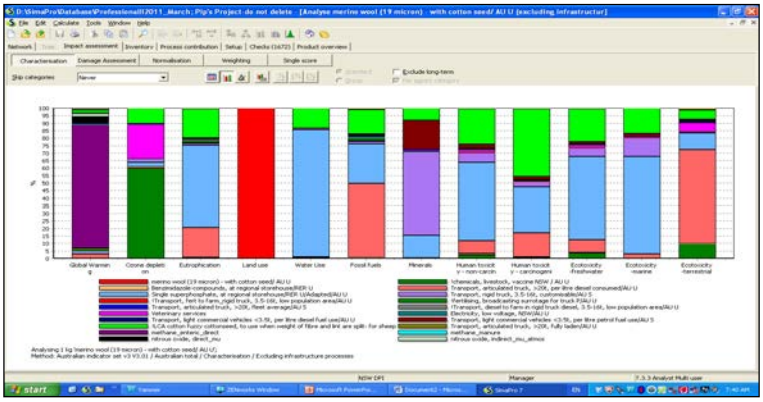


Common impact categories

- Greenhouse gas (GHG) emissions (global warming)
- Energy use
- Water use
- Land use
- Eutrophication
- Ecotoxicity
- (limited work on Biodiversity, Social Health and Economics)



Steps in lifecycle assessment

- Goal and scope definition, inventory analysis, impact assessment and interpretation.

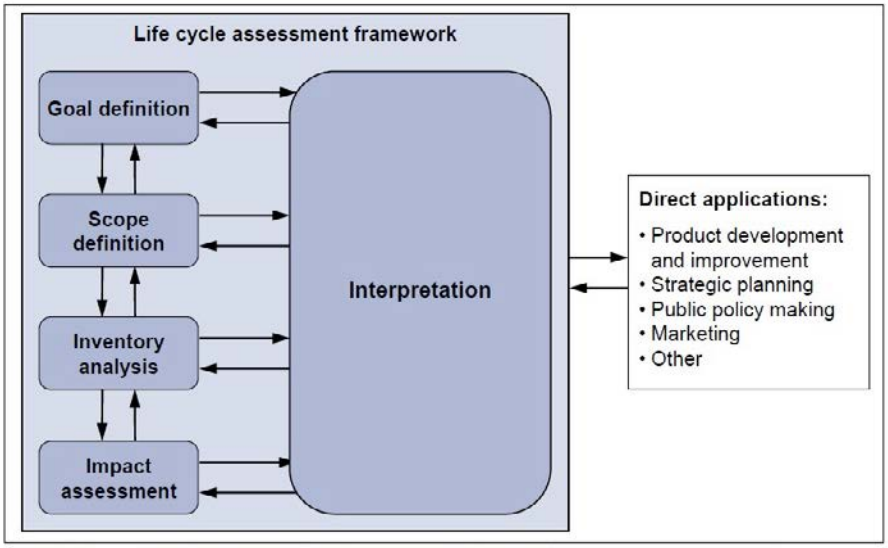


Figure 1 Framework for life cycle assessment (from ISO 14040:2006; modified)

Source: European Commission 2010

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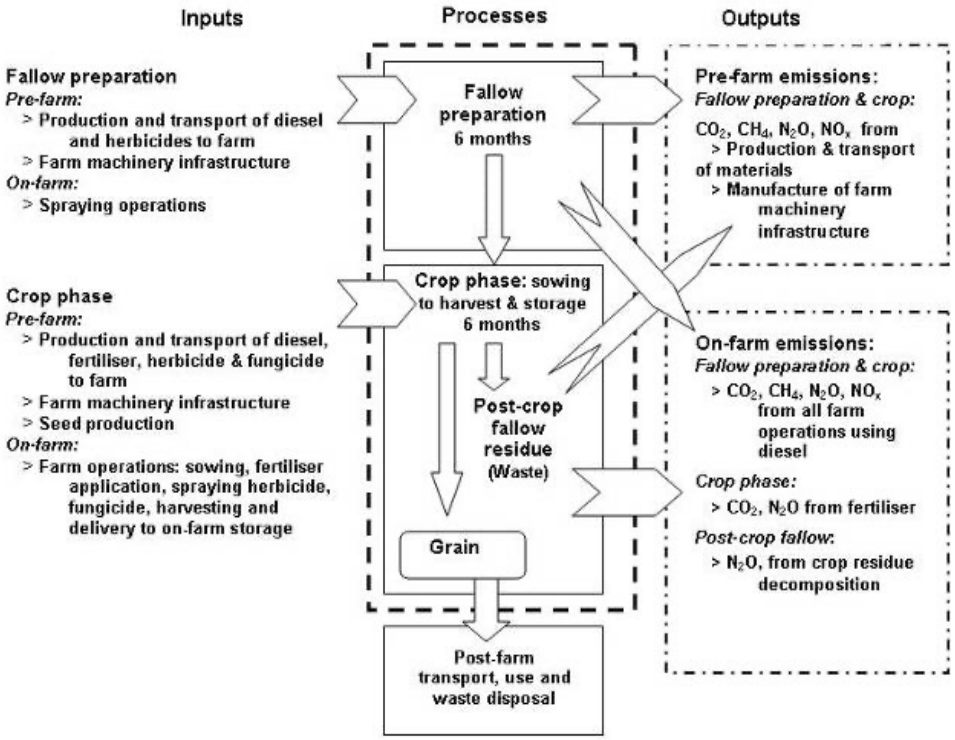
System boundary for wheat production



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Life cycle assessment of cotton-corn farming systems – case study


Cotton-corn rotation at ACRI


Corn at Breeza Station

– Daniel Tan

With co-authors, Dr Pip Brock,& Dr Nilantha Hulugalle, NSW DPI & George Quigley

Aims

- Aim: To determine the lifecycle greenhouse gas emissions associated with growing cotton and corn under irrigated and dryland scenarios in the Namoi Valley.
- Identify any emission source 'hotspots'
- Determine which is the most/least efficient system in both crops

Methods

- 'Cradle-to-gate'
- Data obtained from the growers' actual crop records
- Data analysed using the LCA software SimaPro v.7.3
- Emissions from different practices, crops and production systems were compared
- Emission 'hotspots' identified

SimaPro

Location of farms for the lifecycle assessment case studies

Emission profile of cotton

Tan DKY, Brock PM, Hulugalle, NR and Quigley G (2013)

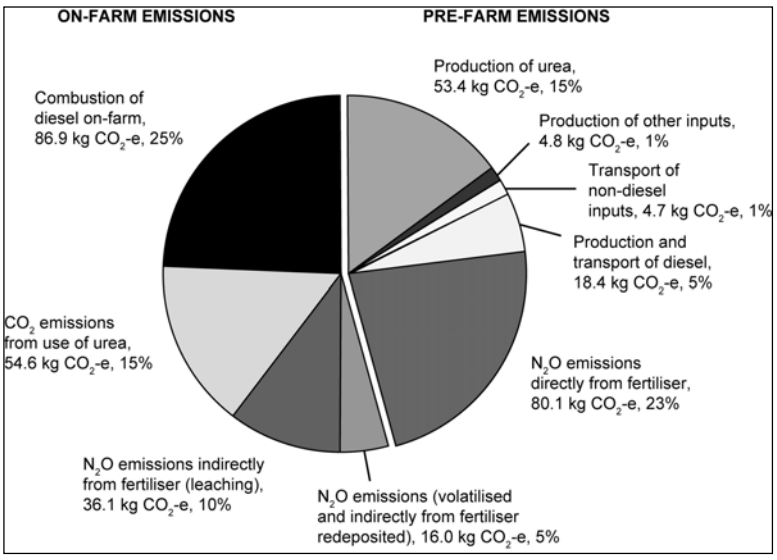


Figure 1. Greenhouse gas emissions (kg CO_2-e) from the production of 1 tonne of cotton lint and seed at ACRI, Narrabri, NSW, Australia (Total: 300 kg CO_2-e).

NSW Department of Primary Industries

Emissions from cotton and corn

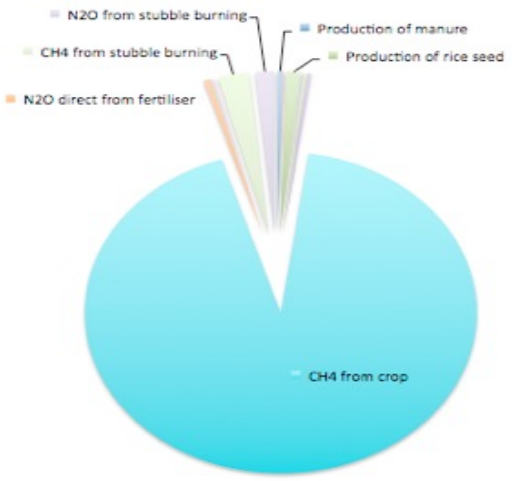
Farm and scenario	Total emissions per tonne of produce (kg CO_2-e)	Yield (t/ha)
NSW DPI gross margin (irrigated cotton)	468	5.3
ACRI Myall Vale (irrigated cotton)	355	5.3
Breeza Station (irrigated cotton)	217	6.8
NSW DPI gross margin (dryland cotton)	300	2.4
Rossmar Park (dryland cotton)	385	3.4
NSW DPI gross margin (irrigated corn)	334	10
ACRI Myall Vale (irrigated corn)	308	10
Auscott Narrabri (irrigated corn)	335	10

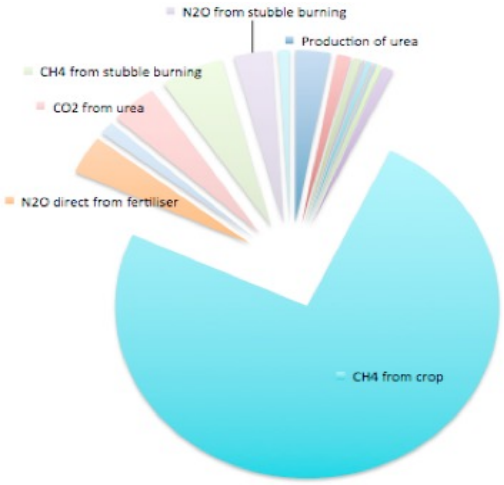
Greenhouse gas emissions averaged 345 kg CO_2-e for the production of 1 tonne of cotton lint and seed for both irrigated and dryland cotton and 325 kg CO_2-e for the production of 1 tonne of corn.

Conclusions

- Nitrogenous fertilisers were the major source of greenhouse gas emissions.
- Direct nitrous oxide (N_2O) emissions from N fertilisers is a major 'hotspot' in all systems
- Replacing nitrogenous fertilisers with biologically fixed N using a legume-based system may reduce these emissions. [However, it is important to acknowledge the carbon cost of nitrogen fixation.]

Rice - Laos versus Australia





Laos (traditional organic)
(Nakau, wet season, yield: 2.3 t/ha)
1.8 kg CO_2-e/kg rice

Australia (conventional fertilisers)
Yield: 10 t/ha
0.7 kg CO_2-e/kg rice

Australia has lower CO_2e emissions per unit of rice yield than Laos due to the high yield

http://www.lcaconference.org.nz/sites/default/files/sites/default/files/Proceedings2014/25%20Suenaga.pdf

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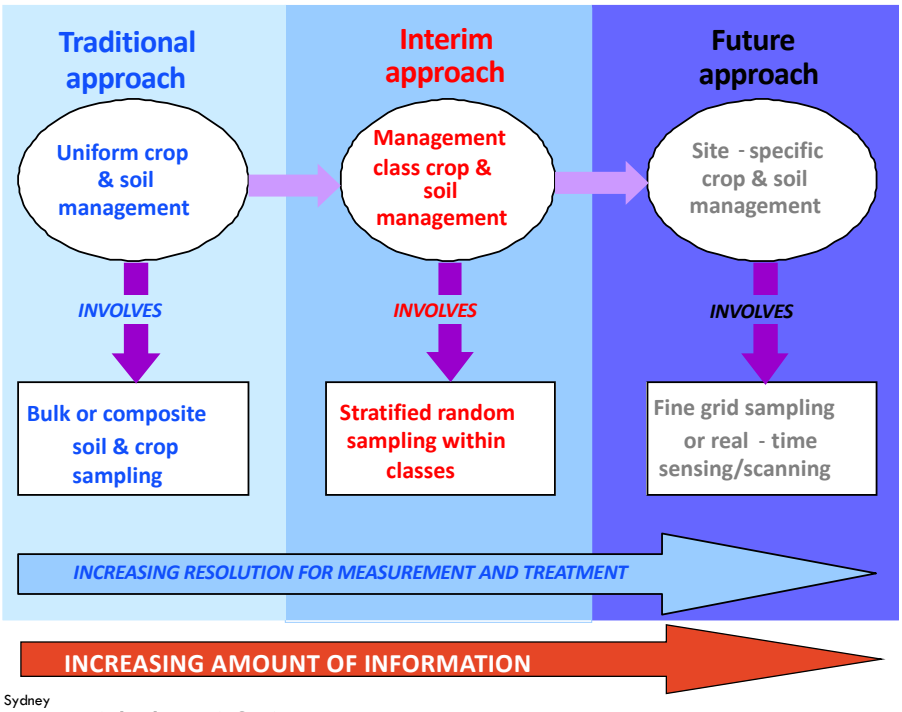
Site Specific Crop Management

Australian Centre for Precision Agriculture

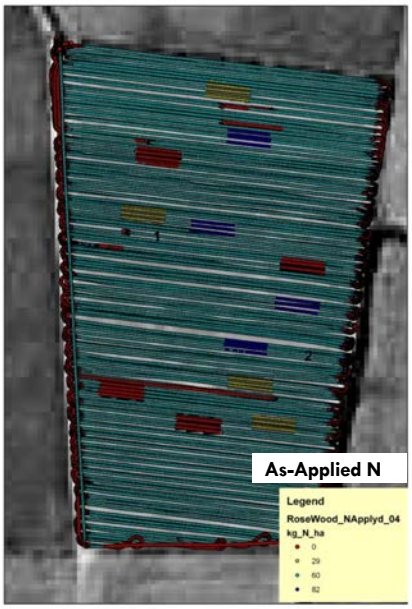


Source: Brett Whelan, ACPA

Management Classes, Moree

Australian Centre for Precision Agriculture

Management classes



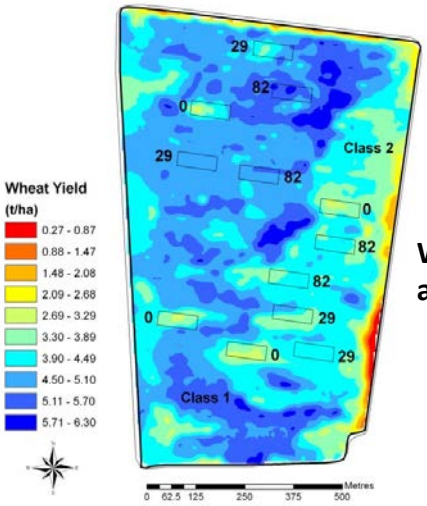
N rate experiment

Source: Brett Whelan, ACPA

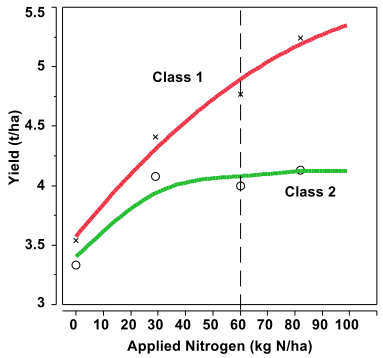
Response Experiments - Classes

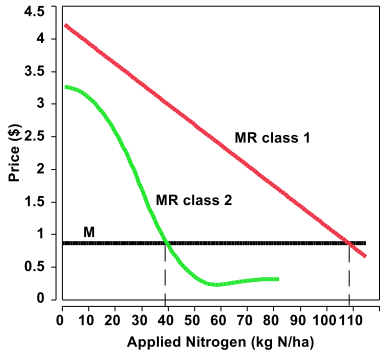
Australian Centre for Precision Agriculture

Non-uniform yield potential



Wheat yield at Moree





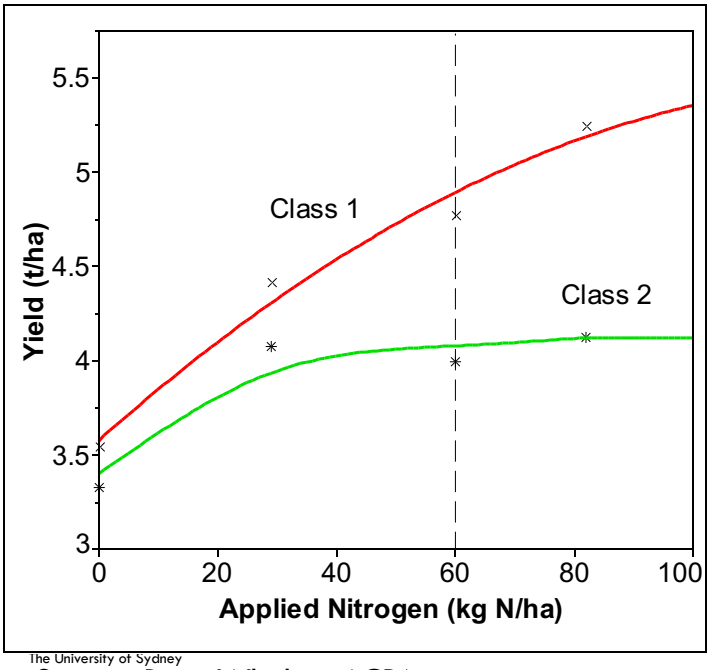
MC=MR analysis shows that:
Class 1 optimum = 109kg N/ha;
Class 2 optimum = 39 kg N/ha.

Source: Brett Whelan, ACPA

Response Experiments - Classes

Australian Centre for Precision Agriculture

Management options



- **Paddock Average Application = 60 kg N applied as BigN**
- **Optimum**
  Class 1 = 109kg N Class 2 = 39 kg N
- **Scenario 1: maintain the total amount of fertiliser applied to the paddock but move the over-application on Class 2 to class 1**
  = Improved gross margin of $11.50/ha or 21% of average fertiliser costs
- **Scenario 2: apply correct amount to each Class**
  = Improved gross margin of $25/ha or 46% of average fertiliser costs.

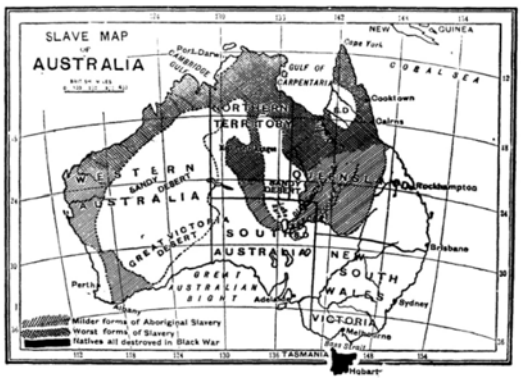
Source: Brett Whelan, ACPA

Social Sustainability

- Gender rights – a person's gender affects their rights to own property, to access education, get fair pay, be exposed to risks.
- Land rights – Who owns land, and has rights to use it, is a serious question to consider in food systems as it can be a cause of injustice if land is taken from customary or legal owners who do not have access to legal protection.

Slavery in agricultural production

- Scott Morrison claimed in 2020 that the colony of NSW was founded on the basis there would be no slavery. Is he correct?
- Tens of thousands of Melanesian people were brought to Australia to work on sugar plantations as bonded labourers.



In 1891 a 'Slave Map of Modern Australia' was printed in the British Anti-Slavery Reporter

Modern Slavery Act 2018 - Australia

- Entities will need to report under the Commonwealth Act if they are an Australian entity or carry on business in Australia with a minimum annual consolidated revenue of $100 million https://www.legislation.gov.au/Details/C2018A00153

Cotton from Xinjiang, China

What is a sustainable diet?

The FAO defines sustainable diets as:

"Those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations"

http://theconversation.com/healthy-diet-healthier-planet-26152

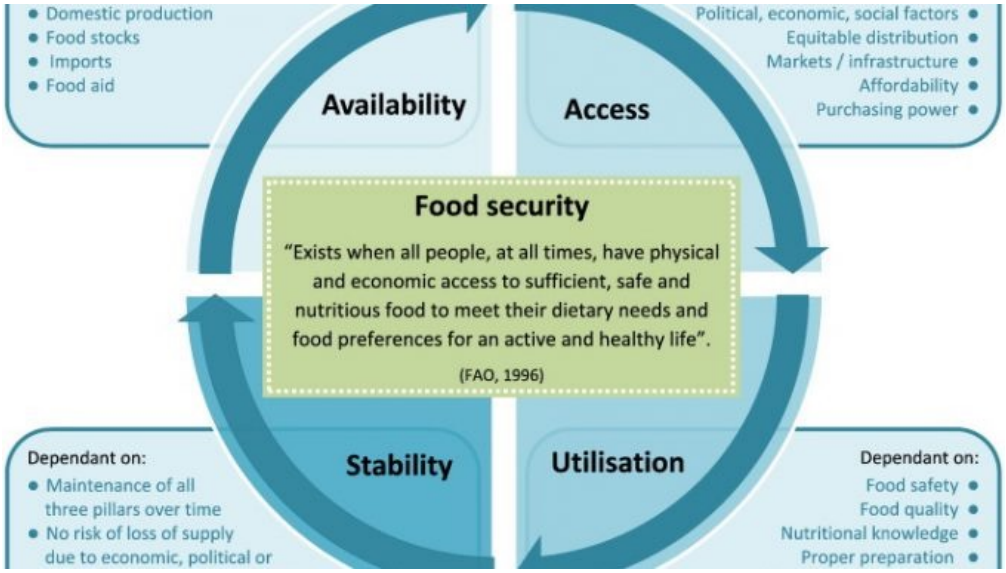
http://www.ncbi.nlm.nih.gov/pubmed/23759140

https://tabledebates.org/node/12346

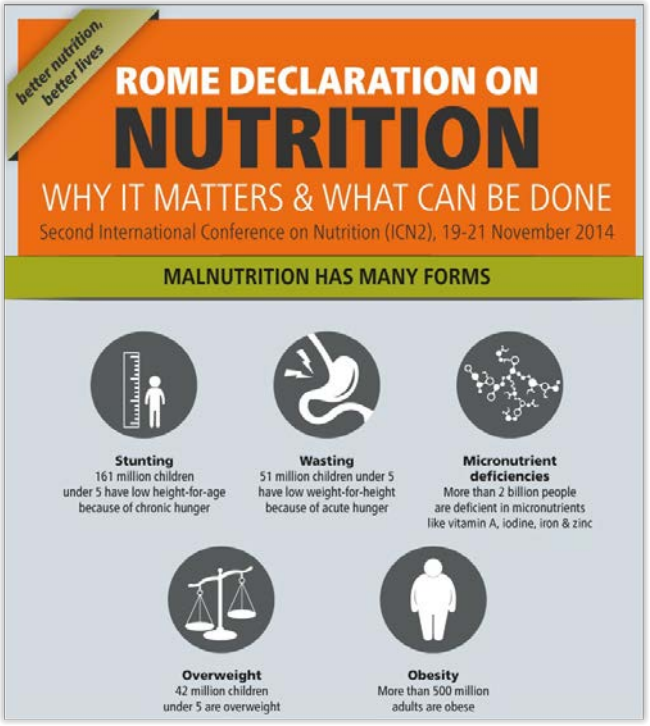
http://www.fao.org/3/ca6640en/CA6640EN.PDF

What is food security?

When all people have reliable access to sufficient, affordable, nutritious food to support a healthy life.



Rome Declaration on Nutrition
Nutritional Paradox – Obesity & Starvation



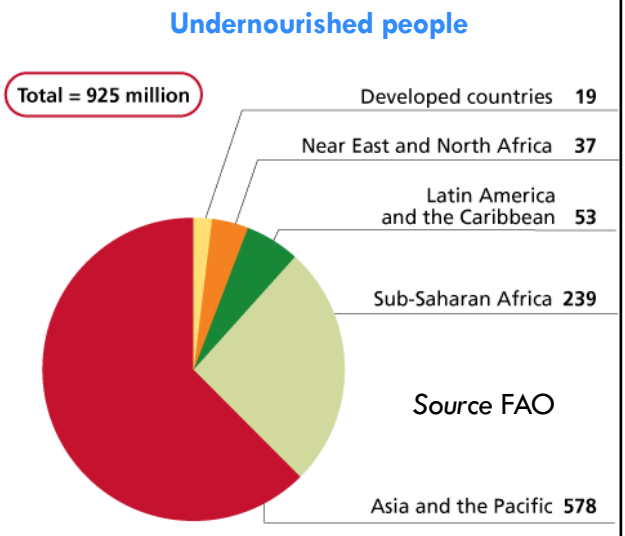
Secure/insecure?

http://deskofbrian.com/

http://www.akha.net/

Paradox

- Australia: ~1.5 million people under the age 18 are considered overweight or obese. This means about 20-25% of Australian children are overweight or obese
- EU: 75 million children are overweight and 5.1 million are suffering from obesity
- Worldwide: 1 in 7 people are hungry



Obesity – caused by lack of protein?
Nutritional geometry

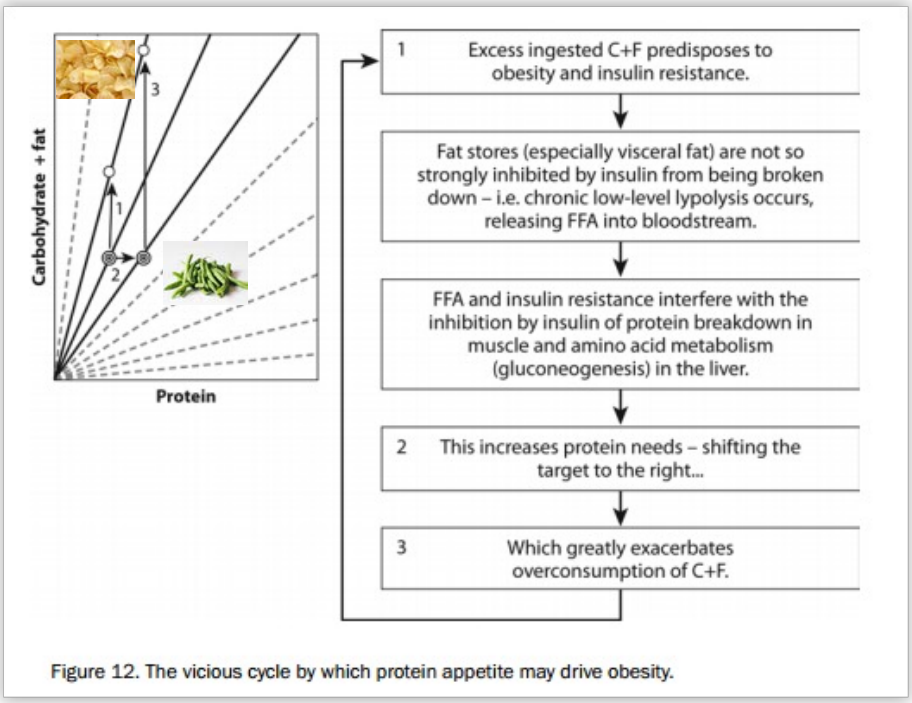


Figure 12. The vicious cycle by which protein appetite may drive obesity.

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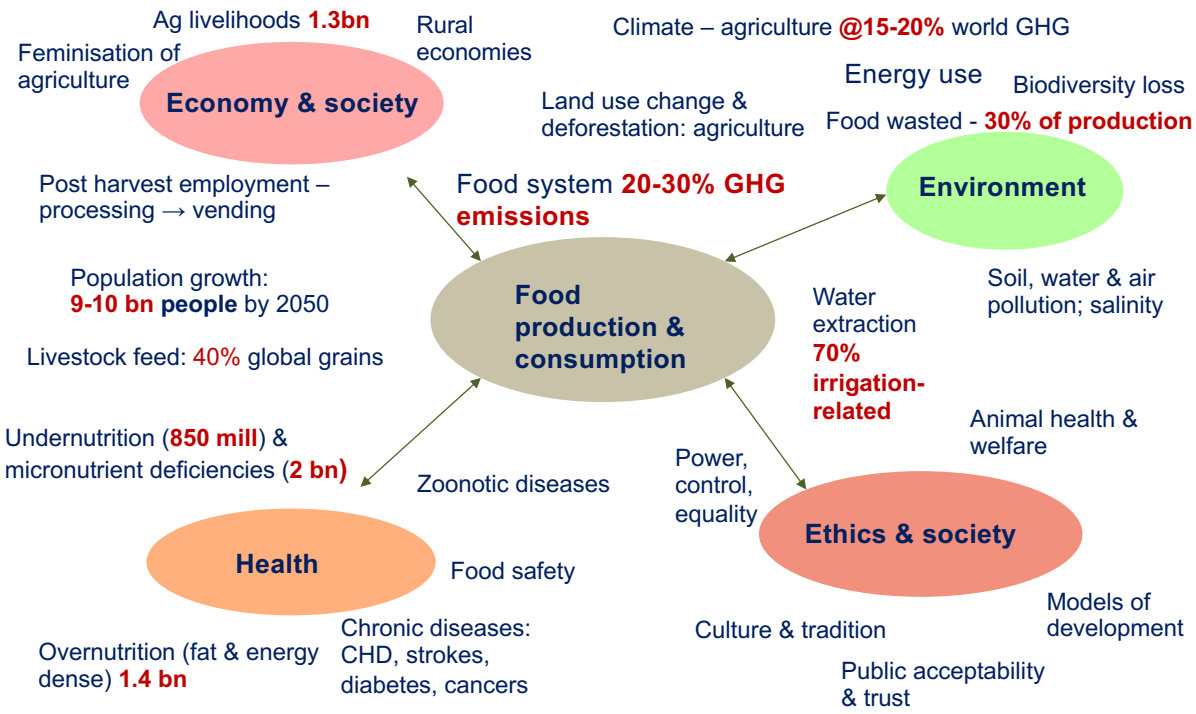
Food & the big picture



Acknowledgement: Tara Garnett

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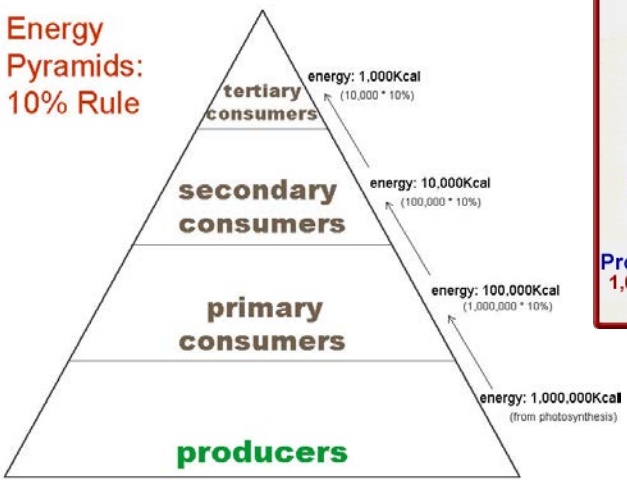
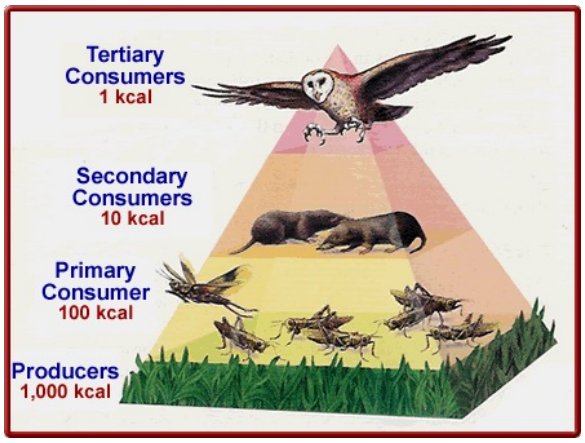
Trophic Levels in a Food Chain





Between each trophic level, there is a loss of energy

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Global meat consumption

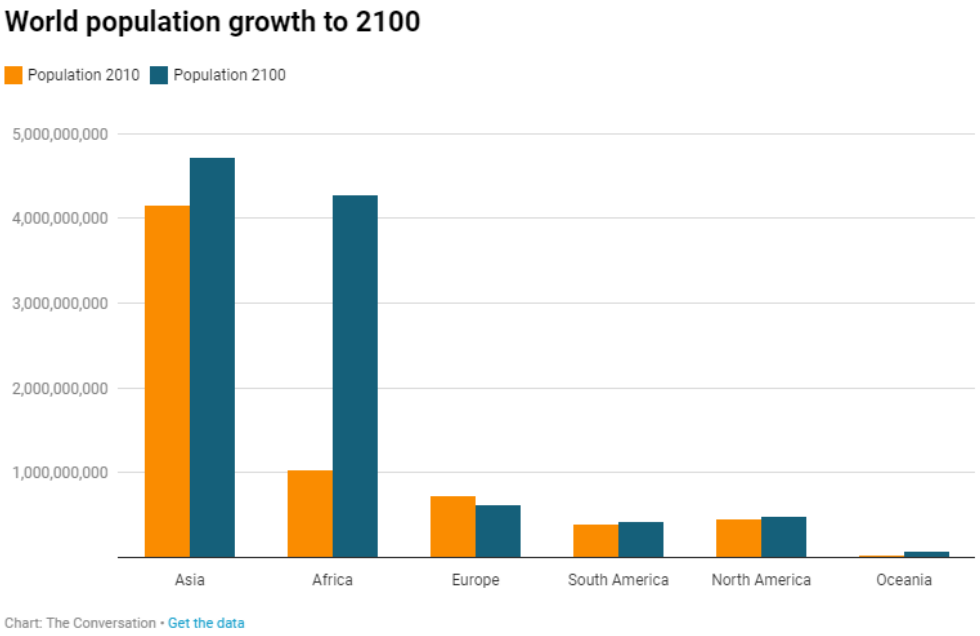

Chart: The Conversation

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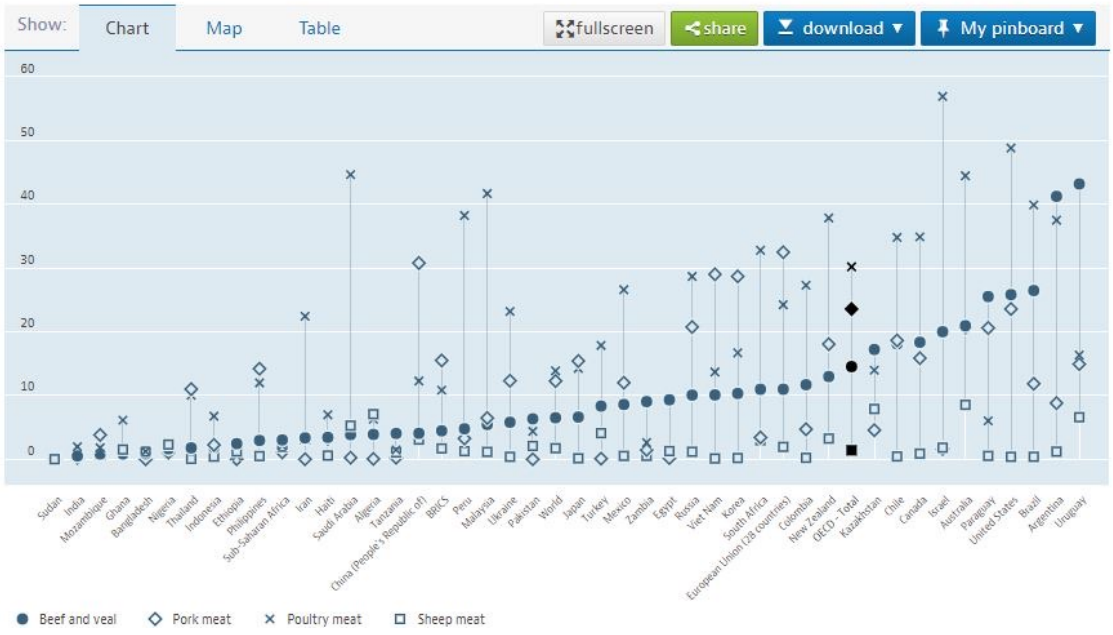
Global meat consumption

Meat consumption Beef and veal / Pork meat / Poultry meat / Sheep meat, Kilograms/capita, 2017 Source: OECD-FAO Agricultural Outlook (Edition 2017)



https://data.oecd.org/agroutput/meat-consumption.htm#indicator-chart

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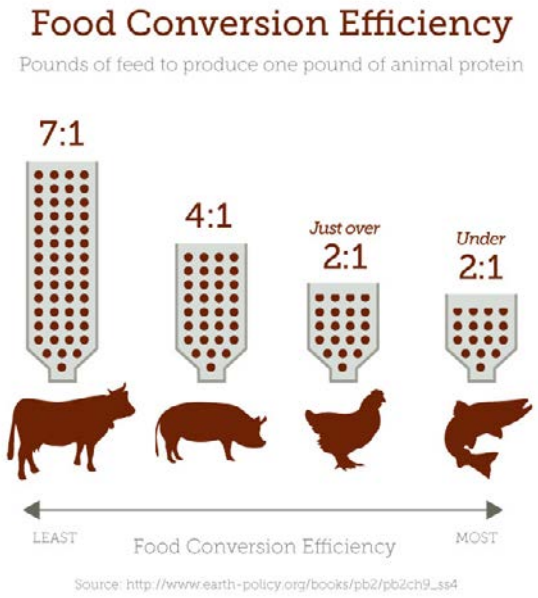
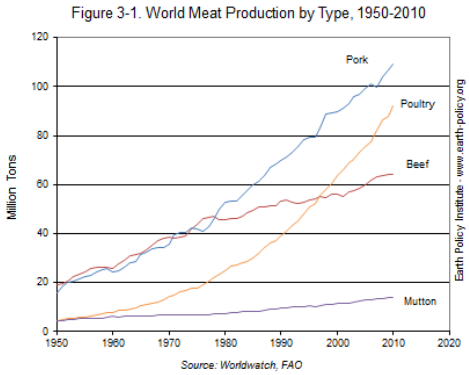
Grain to Meat Conversion Rates





Production of livestock, on average, may require 4 kg of cereal grain for the production of 1 kg of meat

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Livestock & meat

Emit 14.5% global GHG emissions

Consume 40% grains produced

Occupy 70% agricultural land (1/3 arable land)

Main driver of deforestation, biodiversity loss & land degradation

Over 0.75bn poor livestock keepers

Can recycle residues & utilise 'leftover' land

70% diseases zoonotic in origin

Major source water pollution

Meat, dairy & nutrition: protein & micronutrients – but saturated fats and energy

Meat – culture, tradition, enjoyment

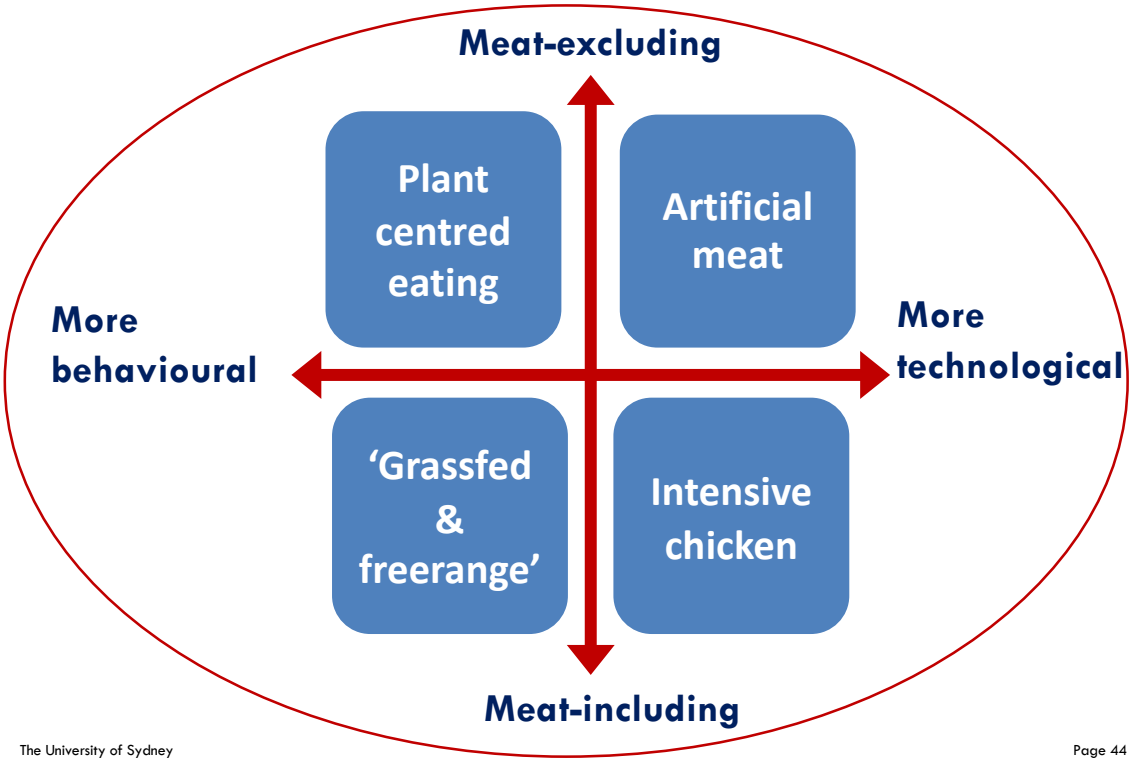
Ethics: Animal rights, animal welfare

Use 15% irrigation water

https://www.youtube.com/watch?v=nub7pToY3jU&feature=youtu.be

Acknowledgement: Tara Garnett

Narratives around meat



Acknowledgement: Tara Garnett

Advice on sustainable diets is not new

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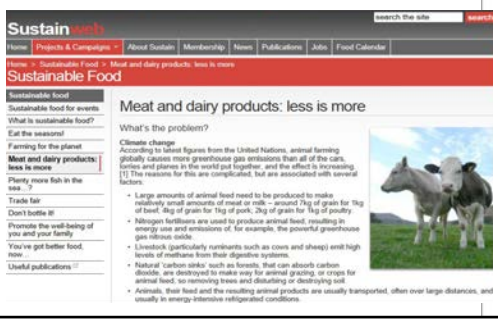

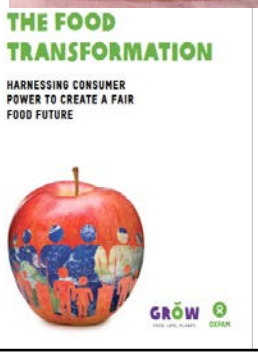

Acknowledgement: Tara Garnett

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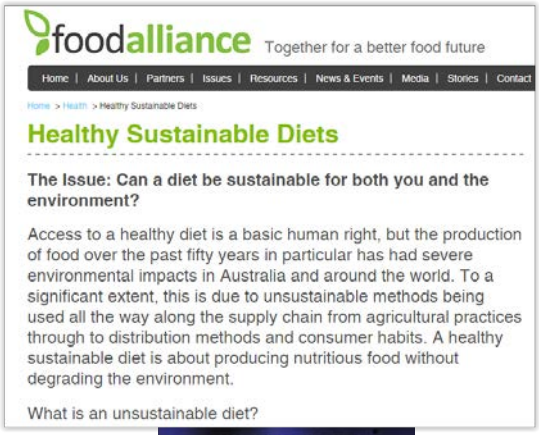
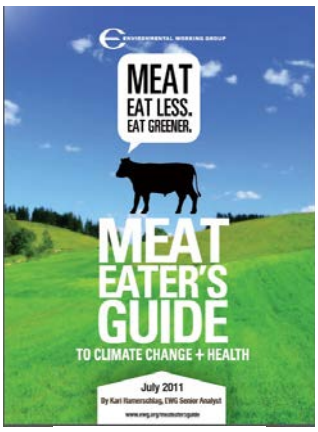
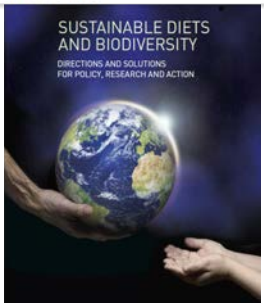
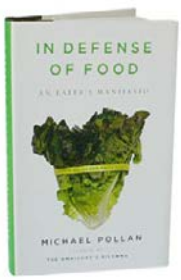
But has proliferated rapidly









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Acknowledgement: Tara Garnett

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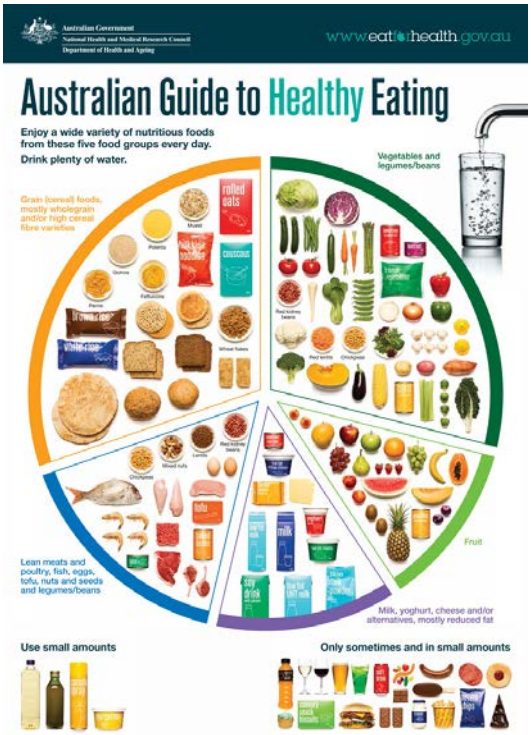
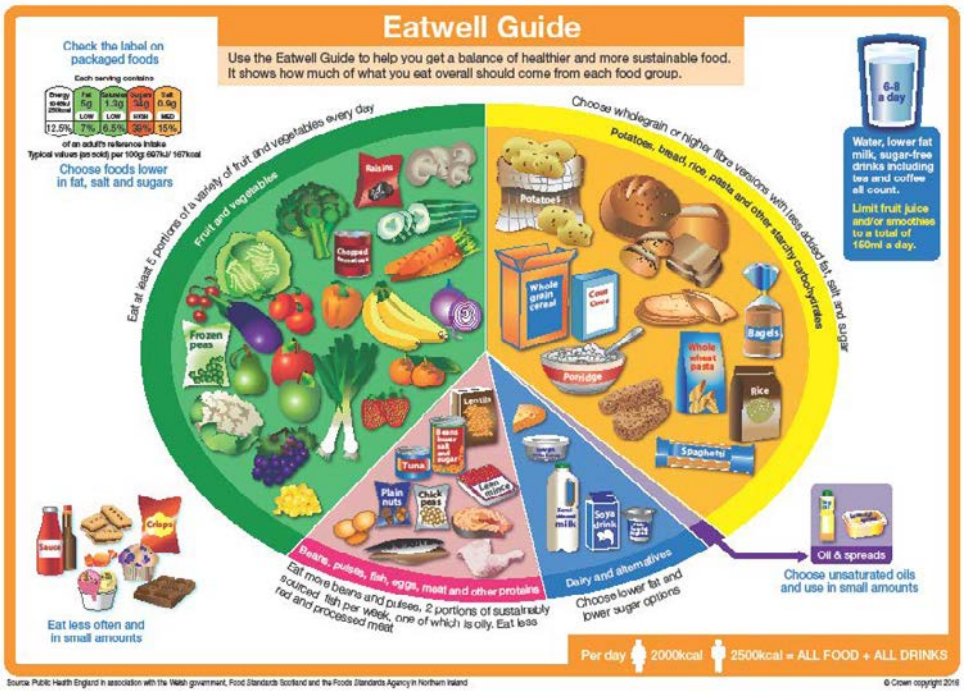
Australian Dietary Guidelines

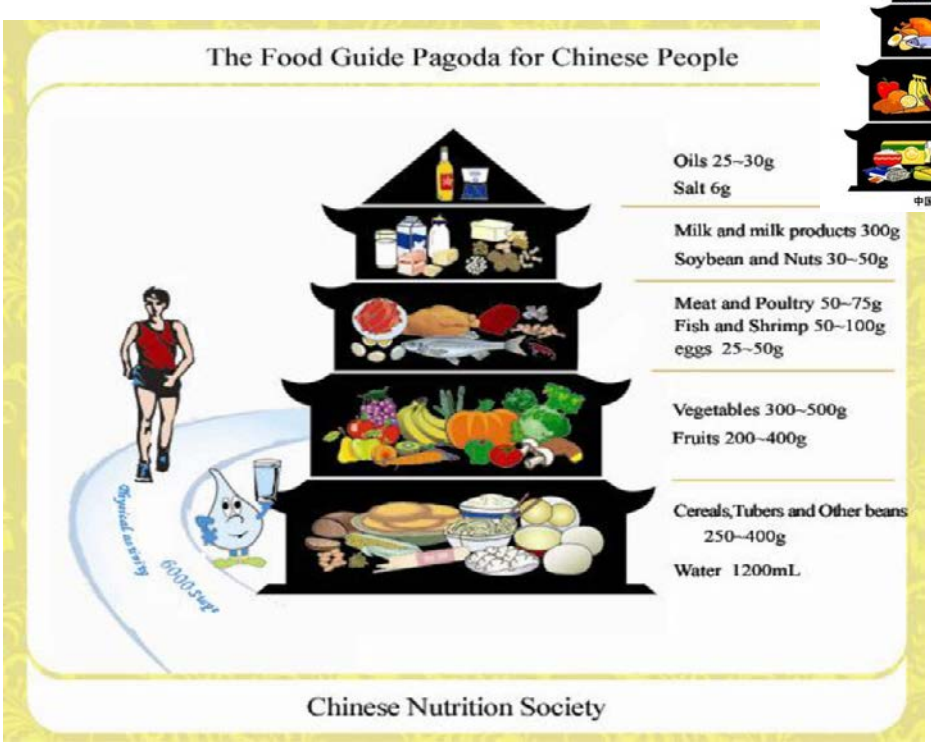


https://www.eatforhealth.gov.au/sites/default/files/content/n55_australian_dietary_guidelines.pdf

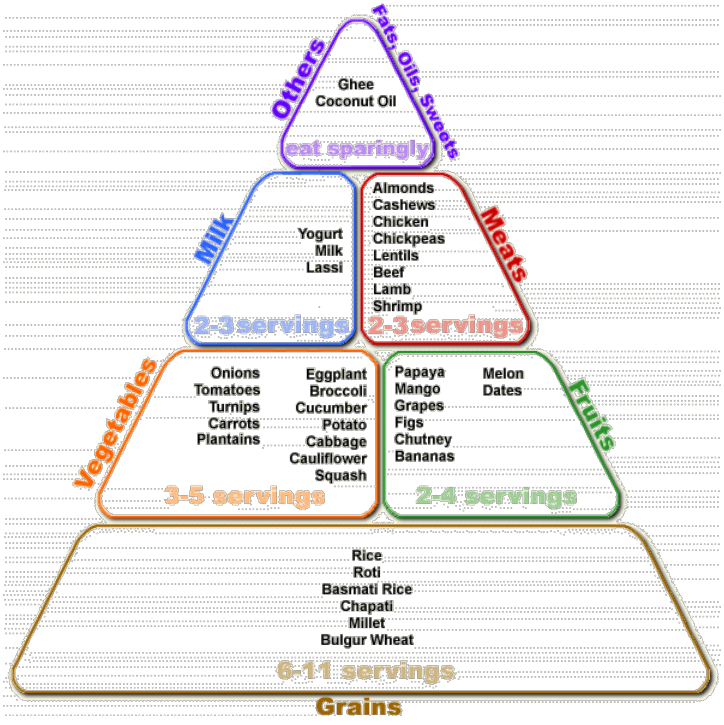
New British Eatwell Guide



Chinese Food Pagoda

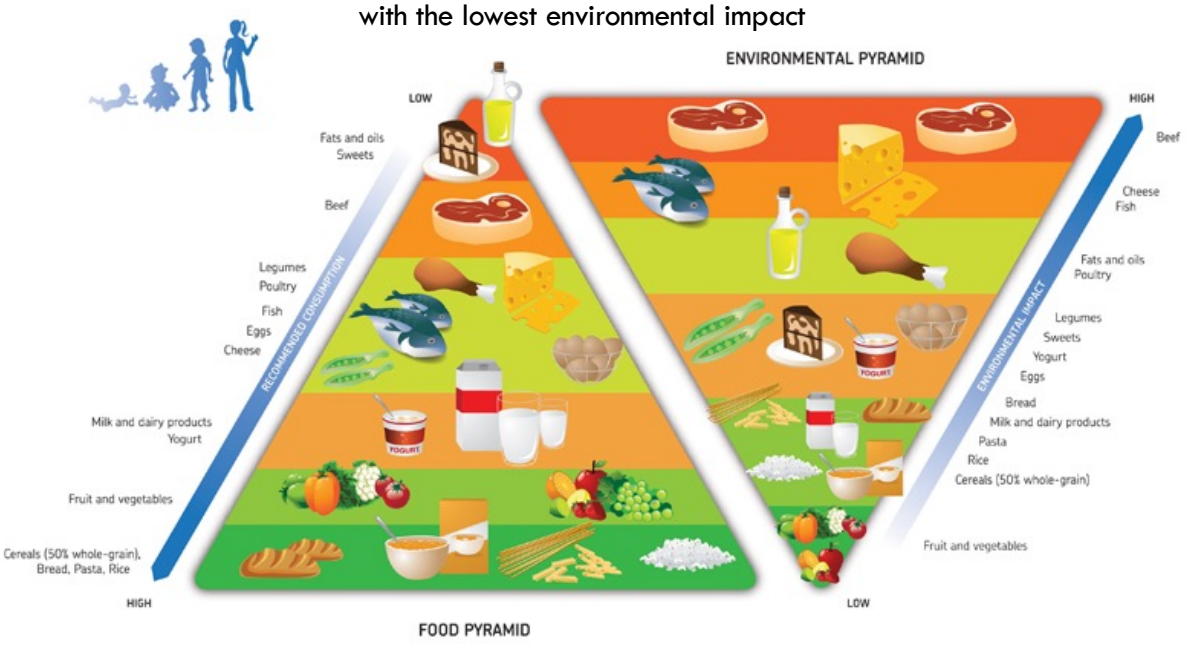


Indian Food Pyramid

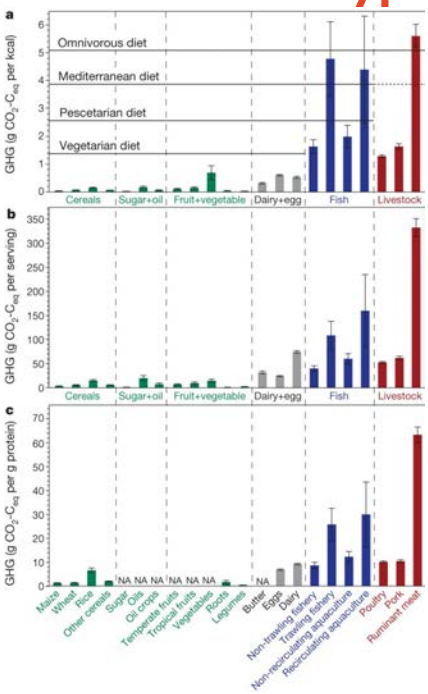


Italian Inverse Pyramid

In general, foods at the base of the food pyramid are also those with the lowest environmental impact



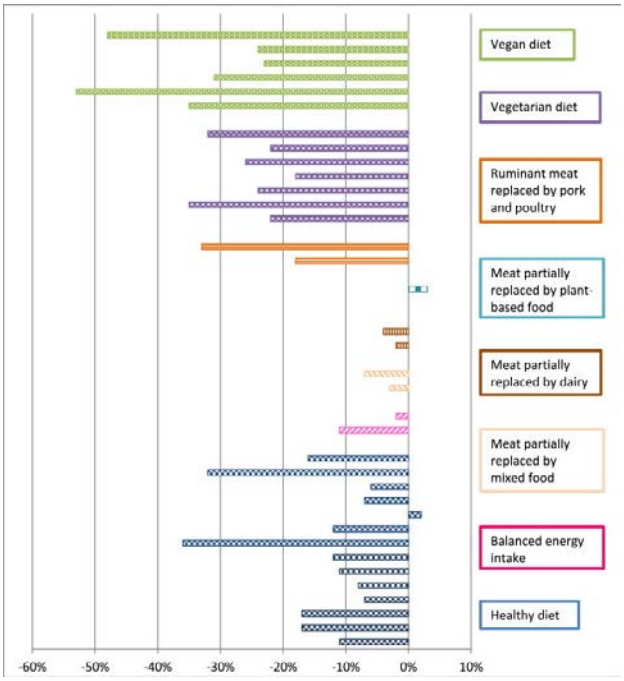
Lifecycle GHG emissions (CO2-Ceq) for 22 different food types.



D Tilman & M Clark *Nature* **000**, 1-5 (2014) doi:10.1038/nature13959

nature

Impact of dietary changes on GHG emissions (CO2-Ceq)

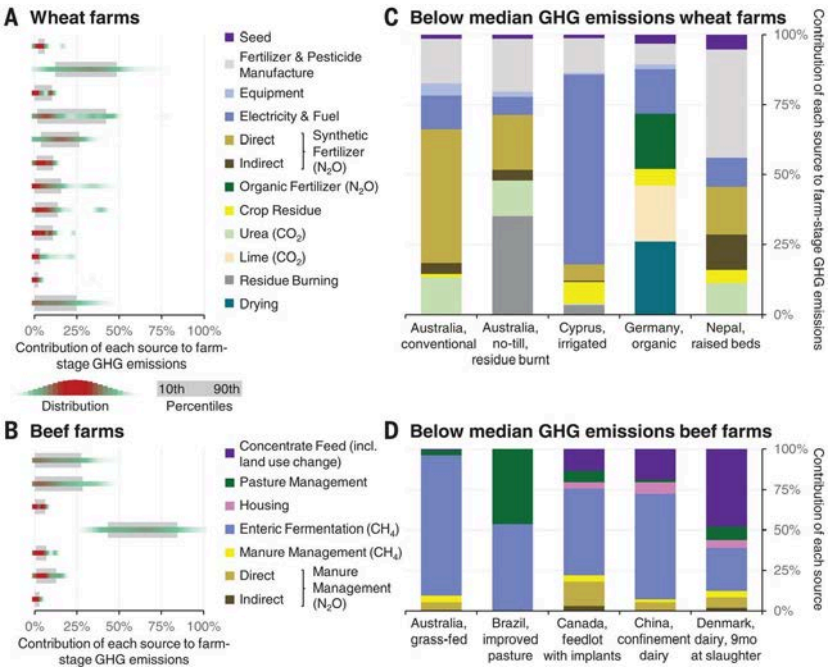


Impact of dietary change on GHG emissions from the diet, in % of relative change in GHG emissions compared to the reference scenarios. Presented data are based on the results from 12 articles,

Environmental Impact of dietary change: a systematic review

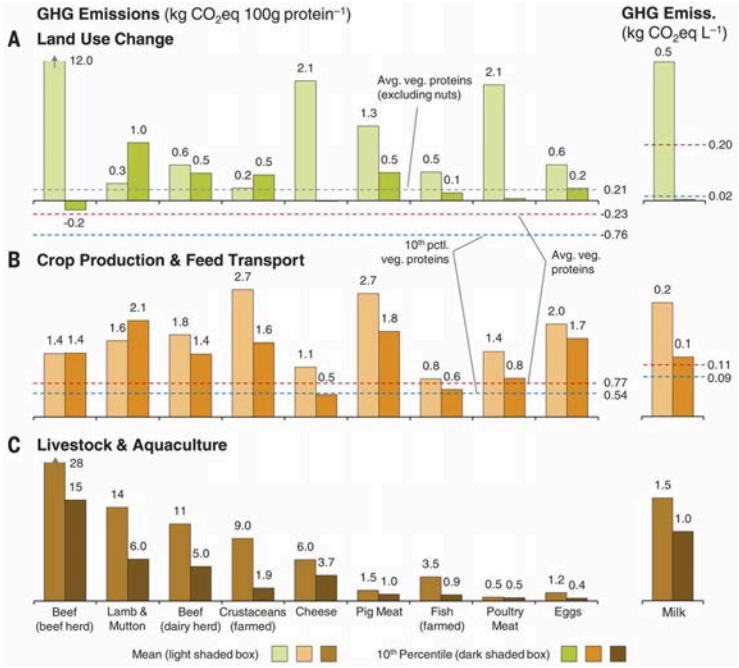
Journal of Cleaner Production (2015): 91, 1-11.
http://www.sciencedirect.com/science/article/pii/S0959652614012931

Contributions of emission sources to total farm-stage GHG emissions.



J. Poore, and T. Nemecek Science 2018;360:987-992

Mean and 10th-percentile GHG emissions of protein-rich products across three major production stages.



J. Poore, and T. Nemecek Science 2018;360:987-992

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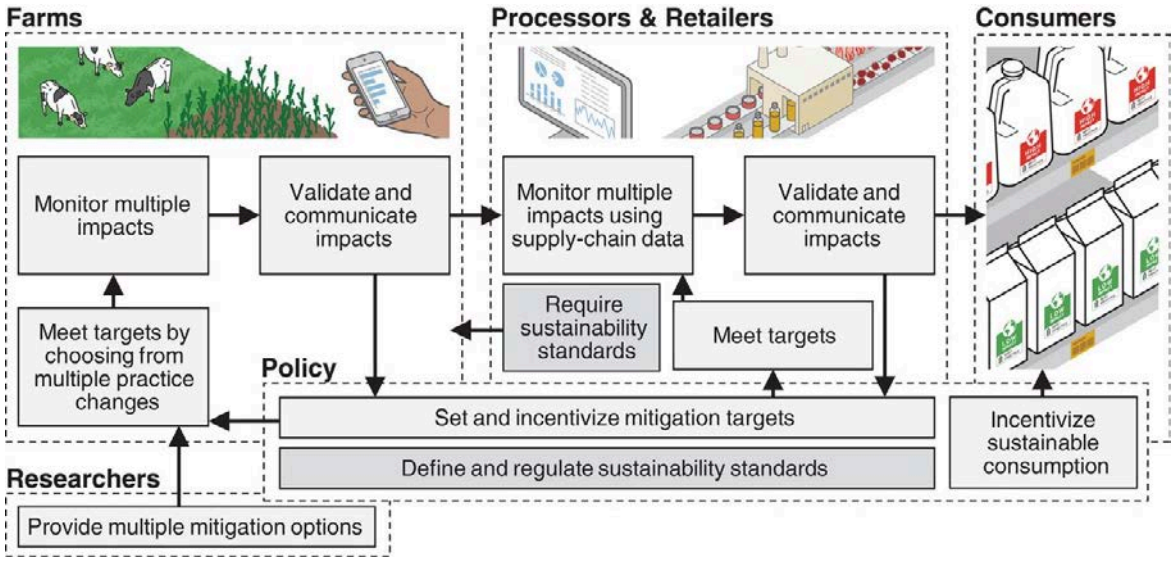
Graphical representation of the mitigation framework.



J. Poore, and T. Nemecek Science 2018;360:987-992

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Situation in Australia

- In 2022, 30% of Australian adults are obese - up from just 10% in 1980
- In Victoria, for example, **fewer than 8% of adults** consume the recommended daily intake of five or more serves of vegetables, and fewer than 46% eat the recommended daily intake of two or more serves of fruit
- The recent **Australian Health Survey found** that one in four adults were eating *no* vegetables on an average day and only 7% were eating the recommended five servings
- An energy-dense diet made up of refined grains, added sugars and added fats may also be **more affordable** than a healthy and sustainable diet based on fruits and vegetables and lean meats

Re-thinking Healthy Diet Advice

- Given that fewer than 11% of people in Australia are vegetarian, it is unrealistic to suggest a meat-free diet for everyone.
- Replace quantities of red meat and processed meat with lean, less environmentally-harmful meat options such as chicken and plant-based proteins such as legumes.

Can eating more plant-based foods be good for our planet?

- Cereal grain crops are primary producers and have lower water and carbon footprint
- Legumes (e.g. chickpea and lentil) have less than half of the greenhouse gas emissions of other cereal crops as they can fix nitrogen naturally from the air and do not need any nitrogen fertilisers
- Vegetables, fruits and nuts have lower emissions than animal products on a per tonne basis.

http://www.ncbi.nlm.nih.gov/pubmed/23759140

Take home messages

- Nutrient-rich plant based diets (mostly unprocessed) can be healthy and sustainable.
- Reduce and recycle food waste
- No GST on fresh food from core food groups so that the poor can afford to eat more fruits and vegetables
- Restrict junk food promotion and reinstate the healthy-food star rating systems

Thank you.

More resources:
Faculty of Science website:
sydney.edu.au/science

Course guide:
sydney.edu.au/my-course-guide

Handbooks:
sydney.edu.au/handbooks/science/

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