The environmental impacts of our food choices – do they even matter?

Introducing Environmental Nutrition: the emerging frontier of public health

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Contents

• Why focus on food?
  - resource use
  - environmental degradation
• Are there any solutions?
• What are we doing about it?
Resource use

- **Water**
  - Agriculture uses 70% of fresh water – 38% in US

- **Energy**
  - Food production uses 16% of all energy in US

- **Land**
  - >45% available land is used for food production
Processes that cause environmental impacts: life cycle
Our food uses up a significant chunk of natural resources...

So what?
Can’t we just change other things and leave our food alone?
Planet under pressure

• Reliance on finite natural resources
• Reduced availability of natural resources due to contamination
• Population rise → more demand for finite resources
• Increased wealth → more demand for finite resources
Increased affluence: shifting consumption patterns...

- 7.9 billion acres of arable land in the world
- Takes 3.25 acres to feed one person the typical western diet
- ~7 billion people would require over 21 billion acres, or the equivalent of almost three planet Earths...

Lapp 1982, FAO.
We are exceeding Earth’s biophysical capacity...
Our food has environmental impacts, so what?

- Planetary boundaries – planet is in serious trouble, we don’t have another one to go to, we need to remediate and preserve this one.

- Compounding factors: Population rise, Finite resources, including land
  - Climate change – already happening (give example)
  - Contamination of resources, e.g., water. Only X amount is available anyway, and the availability of clean water is diminishing.
  - Unequal distribution – if everyone had a western diet, we would need 3 planets…
  - Biodiversity loss – intensive farming results in highly concentrated point-source pollution e.g., run off from 1 farm or slaughter house can kill an entire river flora and fauna, also deforestation huge driver of biodiversity loss and food production is main driver. Stats on rainforest clearing rate, soil degradation, loss of carbon store = carbon emissions. Reduced potential to store carbon again the future due to soil degradation. Palm oil – Asia, orangutans, Amazon – meat production, soy.

Use planetary boundaries framework to talk about degradation.

Several boundaries that retain planetary homeostasis have been crossed.

Steffen et al., 2015
Environmental degradation

- Land use change
- Chemical pollution
- Biodiversity loss
- Greenhouse gas emissions
Greenhouse gas emissions are relevant because...

• They retain heat in the atmosphere causing the ‘greenhouse’ effect
• More gas = more heat
The world’s top climate body, the Intergovernmental Panel on Climate Change has stated that continued emissions of greenhouse gases...

"will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts."

and

“we have a very limited window of opportunity, the global community must look at these numbers and show the resolve by which we can bring about change.”

IPCC, 2014.
Some of those impacts are already occurring and include:

- Flooding
- Drought
- Warmer temperatures
- Storms
- Hurricanes
- Crop disruption/reduced yield
- Ocean acidification
- Sea level rise

“It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century”

IPCC, 2014
Livestock = ~15% of total
Significant reductions in non-\(\text{CO}_2\) emissions are essential to avoiding catastrophic climate change.

Major cuts are required from ALL sectors, including FOOD.
“Although a main focus of climate policy has been to reduce fossil fuel consumption, large cuts in CO₂ emissions alone will not abate climate change.”

Ripple et al., 2014.
Livestock are the biggest source of methane (44%) and nitrous oxide (53%)

FAO, 2013.
Methane emissions

Much shorter atmospheric lifetime (~9 years) than CO$_2$ and holds the potential for more rapid reductions.
Nitrogen and phosphorus

• Food production is the leading cause of nitrogen and phosphorus pollution.
• 70% of phosphorus footprint related to diet is linked to animal products.
• Of all the nitrogen released into the environment, livestock production is linked to ~60%.
• Excessive amounts of these chemicals in the environment disrupts natural biochemical flows.
• Range of adverse environmental impacts.

Metson et al 2012; Pelletier & Tyedmers, 2012
Excess nutrients cause algal blooms which reduce light and oxygen availability for all other fauna and flora.
Excess nutrients also cause oceanic ‘dead zones’
Case study: agriculture = main cause

Figure 3: Sources of nutrients released into the Gulf of Mexico

Deforestation - land use change and biodiversity loss
Food production is a major contributor to deforestation

- Agriculture is estimated to be the direct driver for around 80% of deforestation worldwide
- Livestock production is linked to ~70% of deforestation in the Brazilian Amazon
- Forests are among the most important repositories of terrestrial biological diversity
- Forests are a natural carbon sink, when removed this causes atmospheric imbalance

Wageningen University and Research Centre; Nepstad et al., 2014; FAO, 2015.
Biodiversity loss

- Food production is a leading cause of biodiversity loss
- 30% of global biodiversity loss is linked to livestock production
- Also a huge imbalance in biomass...
Earth's Land Mammals by Weight

- Humans
- Our Pets and Livestock
- Wild Animals

Data from Vaclav Smil's 'The Earth's Biosphere: Evolution, Dynamics, and Change,' plus a few other sources.
Why is biodiversity important?

- Trophic cascades
- Complex dependencies

Ripple et al., 2015
Species loss

44 of the 74 largest terrestrial herbivores (~60%) are listed as threatened with extinction (including 12 critically endangered or extinct in the wild)
The biggest threat is human consumption of animal products...

- Hunting for meat
- Competition with livestock
- Habitat loss
Meat Consumption Patterns By Region

g/person/day

Industrial Countries
Brazil
China
Developing Countries

Source: FAO Food balance sheets, 2009
Our food choices are using finite resources and exceeding Earth’s biophysical capacity.

What’s the solution?
We need to use less resources to produce more food, and avoid dangerous tipping points...

• Sounds impossible – but....
Let’s first look at the variation in resource use...
SHIFTING MAJOR CROPS TO 100% HUMAN FOOD

- ~1/3 of global crops are fed to animals
- On average, 4 calories of crop-based feed roughly equals 1 calorie of animal products

28% increase of food supply and 45% increase of dietary energy by shifting crop use to human consumption

Pradhan et al., 2013; Cassidey et al, 2013; Foley, et al., 2011
Water use

- Water required to produce 1kg:
  - Apples 700 liters
  - Soybean 2,145 liters
  - Beef 15,400 liters
- Per serving ~375 liters for soybeans and 2,700 liters for beef.

- Average American family of 4 uses ~1,500 liters of water/day.
- Standard shower head uses ~9 liters of water/minute.

‘Climate change is projected to reduce renewable surface water and groundwater resources in most dry subtropical regions’. IPCC, 2014
Average freshwater impact for 1g of protein for various types of foods

Meat contributes 37%* to the food-related water footprint of an average American Citizen

(Mekonnen & Hoekstra, 2012)
12,000 gallons of water
is enough water for a family of four for a year

12,000 gallons of water
is the amount required to produce 10 pounds of beef

http://plantricianproject.org
Land use

• In comparison to tofu:
  ➢ Beef requires 32-900 times more land
  ➢ Lamb requires 73 times more land
  ➢ Chicken requires 10-16 times more land

  o In comparison to staples like potatoes, wheat, and rice, beef requires 160 times more land
  o Currently around 75% of agricultural land is used for livestock production
  o Beef production uses ~60% of agricultural land, but produces <2% of the calories that feed the global population

Boucher et al., 2012
STANDARD AMERICAN DIET
2 football fields (1.3 acres each) feed 1 person per year

PLANT-BASED DIET
2 football fields (1.3 acres each) feed 14 people per year

IF EVERYONE IN THE WORLD ATE A PLANT-BASED DIET...

5 billion football fields (1.3 acres each) worth of land could be returned to forests

Cow: 3.1 miles, 4 baths* (From et al., 2011)
Soy: 1.5 miles, 1 bath* (From et al., 2011)
Cheese Burger: 5.9 miles, 9.6 baths* (From et al., 2011)
Veggie Burger: 2.4 miles, 0.6 baths* (From et al., 2011)

Graphics: Food Choice Taskforce
Energy use

• Energy used to produce 1kg:
  - Peaches 344 kJ
  - Beans 2,861 kJ
  - Almonds 4,646 kJ
  - Beef 7,880 kJ

• Average American home uses 104,400 kJ electricity per day

‘Energy use can be substantially lowered through changes in consumption patterns, adoption of energy savings measures, dietary change and reduction in food wastes.’ IPCC, 2014.
The environmental cost of protein food choices

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Inputs To Produce 1 Kg Of Protein From Beans

1 kg bean protein

Cooked Weight (11 kg)

Raw product from farm/retailer (4 kg)

Moisture gain (7 kg) = 166%

Total fuel (0.3 L)

Land (16 m²)

Water (10 m³)

Pesticide (9 g)

Fertilizer (161 g)
Inputs And Animal Waste Generated To Produce 1 Kg Of Protein From Each Commodity

<table>
<thead>
<tr>
<th>Food Yields (kg)</th>
<th>Kidney beans</th>
<th>Almonds</th>
<th>Eggs</th>
<th>Chicken</th>
<th>Beef</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw weight from farms</td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Raw weight from retailers</td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Cooked weight</td>
<td>11</td>
<td>5</td>
<td>8</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Protein</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Factors</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Land (m²)</td>
<td>16</td>
<td>21</td>
<td>38(^a)</td>
<td>32(^a)</td>
<td>283(^a)</td>
</tr>
<tr>
<td>Water (m³)</td>
<td>10</td>
<td>23</td>
<td>11(^b)</td>
<td>14(^b)</td>
<td>109(^b)</td>
</tr>
<tr>
<td>Fuel(^c) (L)</td>
<td>0.3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Fertilizer(^d) (g)</td>
<td>161</td>
<td>426</td>
<td>264</td>
<td>320</td>
<td>1945</td>
</tr>
<tr>
<td>Pesticide (g)</td>
<td>9</td>
<td>104</td>
<td>17</td>
<td>16</td>
<td>93</td>
</tr>
<tr>
<td>Animal waste (kg)</td>
<td>-</td>
<td>-</td>
<td>17</td>
<td>22</td>
<td>105</td>
</tr>
</tbody>
</table>
Relative Environmental Impacts To Produce Protein From Plant And Animal Sources

- Beans as the reference value = 1
Comparing the water, energy, pesticide and fertilizer usage for the production of foods consumed by different dietary types in California

Harold J Marlow\textsuperscript{1,\dagger}, Helen Harwatt\textsuperscript{1,*}, Samuel Soret\textsuperscript{2} and Joan Sabaté\textsuperscript{1}

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\textsuperscript{2}Department of Environmental Health and Geoinformatics Sciences, Loma Linda University, Loma Linda, CA, USA
Resources Used:
Vegetarian Vs Moderate Meat Diets

- Water
- Energy
- Pesticide
- Fertilizer
Environmental degradation aspects of foods and dietary patterns
Greenhouse Gas Emissions From Protein-rich Foods

‘Grass fed/free range’ is not the answer

Ripple et al. 2014.
Average greenhouse gases emitted for 1g of protein for various types of food

Greenhouse Gas Emissions by Diet Pattern

GHG emissions in meat-eaters are twice as high as those in vegans

Scarborough et al., 2014.
Climate change mitigation and health effects of varied dietary patterns in real-life settings throughout North America$^{1-4}$

Samuel Soret, Alfredo Mejia, Michael Batech, Karen Jaceldo-Siegl, Helen Harwatt, and Joan Sabaté

ABSTRACT

Background: Greenhouse gas emissions (GHGEs) are a major consequence of our dietary choices. Assessments of plant-based compared with meat-based diets are emerging at the intersection of public health, environment, and nutrition.

GHGEs based on a range of conservative and more inclusive assessments (11, 12).

To alleviate the environmental pressure imposed by the modern food system, both the average worldwide consumption of animal products and the intensity of emissions from livestock production
% Energy From Each Food Group According To Diet Pattern

- **Plant Foods**
  - Moderate Meat: 70%
  - Low Meat: 90%
  - Vegetarian: 90%

- **Meat**
  - Moderate Meat: 10%
  - Low Meat: 5%
  - Vegetarian: 5%

- **Dairy/Eggs**
  - Moderate Meat: 20%
  - Low Meat: 10%
  - Vegetarian: 5%

- **Beverages**
  - Moderate Meat: 5%
  - Low Meat: 5%
  - Vegetarian: 5%
Greenhouse Gas Emissions By Dietary Pattern And Food Groups (With % Contribution)

- Vegetarian: 68% Plant Foods, 15% Meat, 13% Dairy/Eggs
  - 29% decrease
- Low Meat: 59% Plant Foods, 6% Meat, 17% Dairy/Eggs, 14% Beverages
  - 22% decrease
- Moderate Meat: 40% Plant Foods, 20% Meat, 19% Dairy/Eggs, 17% Beverages
Example of ecosystem restoration when livestock are removed

More birds and other wildlife

Batchelor et al. 2015
Can technology save the day?

• 32% reduction through technology and ambitious farming techniques, BUT

Reducing the consumption of animal products is unavoidable
No longer a ‘fringe’ interest

• Growth in ‘Meat free Monday’ campaigns
• USDA dietary guidelines – considering sustainability
• 1st food campaign from environmental NGO ‘take extinction off your plate’
• Rise in meat analogs
• Impossible Foods vegan burgers that ‘bleed’
• Growing public concern
Why we are working on this topic@Loma Linda University?

• Dominated by industry bias
• Need clear, factual database
• Public respect expert opinion
Figure 9: Actors perceived as helpful sources of information on climate and livestock issues

Why I’ve given up eating beef
Higher level of awareness = higher likelihood of taking action

Figure 8: Comparison of the impact of awareness on willingness to take individual action on transport habits and on meat and dairy consumption

Health & Environment: Relationships

**Sustainable**
- Low in nutrient rich foods
- Focussed on 1 or 2 main plant foods
- Low food waste

**Unsustainable**
- High in animal products and processed foods
- Low in whole plant foods
- High food waste

**Healthy**
- Low or no animal products and processed foods
- High in whole plant foods
- Low food waste

**Unhealthy**
- Focussed on air freighted fruits and vegetables
- High levels of food waste
All Cause Mortality HRs by Dietary Pattern (Death Rate)

- Vegetarian: 5.6 deaths/1000 p y
- Low Meat: 5.5 deaths/1000 p y
- Moderate Meat: 6.7 deaths/1000 p y

Soret et al., 2014
Conclusions

What we eat matters, a lot
Food production has a significant environmental ‘cost’

- Livestock uses the majority of agricultural land and water, and is a leading cause of climate change, chemical pollution, deforestation and biodiversity loss
- In exchange for <2% of global calorie provision!
- Increasing pressure from population and affluence growth...

To stay within Earth’s biophysical capacity