Could consumption of insect or cultured meat global agricultural land use?

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Sorry!

Not this one...
Why novel foods might play a role in environmental sustainability

- Food production overall
  - 26% of anthropogenic GHG emissions
  - 11% of anthropogenic CO$_2$ associated with land use change
  - Two-thirds of freshwater withdrawals for irrigation
  - Biodiversity loss, eutrophication, etc.

- Conventional livestock
  - 70% agricultural land globally is used for livestock production, including cropland for feed (50-65% of land use change)
  - Around half of agricultural greenhouse gas emission
  - But, proportion of food provide by animal products is lower
    - ~15% of energy and ~30% of protein
Global harvested crop losses

- Livestock single biggest loss to food system
  - Except in wet mass, which is highly misleading
- Overall, around half of harvested crops are lost
  - More than the 1/3 more commonly quoted
- Around ~10% of commodities reaching consumers or retailers is discarded
- At least as much lost due to over-consumption

Losses of harvested crops (excluding grassland and forage crop inputs to livestock production) by stage in the food system.
Land use associated alternatives to conventional animal products
Entomophagy is worth considering

• Insects production for food (‘mini livestock’) is claimed to have lower GHG emissions and land use compared to conventional livestock
  • Higher fraction of insect consumed, up to 100%
    • e.g. only ~40% of live animal weight is consumed with cattle
  • Insects are poikilothermic
    • lower energy usage
  • Higher fecundity
    • potentially thousands of off-spring
    • rather than just one
  • Rapid growth rates
  • Reach maturity in days
    • rather than months or years
  • All contain essential amino acids
Current status of insect as food

• Isotope analysis of bones indicates that insectivorous diets are entrenched in human evolution

• > 2000 species currently consumed across 119 countries (Rumpold and Schlüter, 2013)

• Limited consumer acceptability, particularly in western countries
  • But some evidence this might be changing – slowly...

Consumer acceptability of entomophagy

- Currently a major barrier in the western countries
- Historical precedents of slow changes being possible
  - tomatoes in Britain were widely viewed with suspicion and dismissed for over 200 years, until mid-1800s (Bir, 2014; K. A. Smith, 2013)
  - lobster in America was initially a poverty food eaten by slaves and prisoners, and used as fertiliser and fish bait (Dembosky, 2006).
- Arguably a slow change towards is occurring, starting with awareness and interest.
  - Although still some element of ‘bush-tucker trial’.
- Less obvious inclusions of insects likely to be more easily accepted

In-vitro or cultured meat

• Technology has been improving rapidly
  • Rapid drop in production costs, closer to conventional retail prices

• Avoids the issues of low edible percentages

• Still requires a feedstock (“broth”) in which to grow
  • Some research calculated using algae to provide feedstock

• Likely to also have high direct energy input requirements
  • Need a cheap energy source and low carbon
Allocating areas for existing (and then novel) food commodities

- Use global FAO data
  - Production areas
  - Uses of crops (‘commodity balance’)
  - Food supply, calorific and protein contents

- 90 commodities
  - 50 primary, 32 processed, 8 animal products
  - 99.4% of food calories consumed

- Links needed between
  - Production and consumption ‘items’
  - Primary and processed commodities
  - Feed and livestock products
Allocating production areas to commodities

1. Allocate areas for production of each primary crop, e.g. Soyabean

Food (10Mt)  Feed (13Mt)  Processing (224Mt)

Waste (4Mt)  Seed (7Mt)

Non-food use (1Mt)  Stock variation (2Mt)

Areas not allocated to losses, waste or seed

2. Allocate areas for processed commodities by economic value

Soyabean oil 42Mt from 51 Mha
Soyabean meal/cake 175 Mt from 51 Mha

Loss 8Mt

Then allocated by use as for primary commodities

Food (25 Mt)  Non-food (17Mt)

Feed (172Mt)

3. Allocate areas for animal products

- Feed requirements from feed conversion ratios
- Monogastrics just from feed, ruminants each remainder of feed (~20-30%) plus all pasture

90 commodities (50 primary, 32 processed, 8 animal products), 99.4% of food calories consumed, for each year and country in FAO panel data

NOT to scale.
Alternatives to conventional animal products

- Insects
  - Mealworm larvae (Tenebrio molitor) & Crickets (Acheta domesticus)
  - Selected on availability of data
- Cultured (a.k.a. *in vitro*) meat
- Imitation meat (based on tofu)
- Aquaculture of herbivorous species (Carp & Tilapia)

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Percentage edible (% EW of LW)</th>
<th>Feed conversion by mass (kg DM feed/kg EW)</th>
<th>Energy content (MJ/kg EW)</th>
<th>Protein content (g / kg EW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mealworm: larvae (Tenebrio molitor)</td>
<td>100</td>
<td>1.8</td>
<td>8.9</td>
<td>179</td>
</tr>
<tr>
<td>Crickets: adults (Acheta domesticus)</td>
<td>80</td>
<td>2.1</td>
<td>5.9</td>
<td>205</td>
</tr>
<tr>
<td>Cultured meat</td>
<td>100</td>
<td>4</td>
<td>8.3</td>
<td>190</td>
</tr>
<tr>
<td>Imitation meat (based on soy bean curd)</td>
<td>-</td>
<td>0.29</td>
<td>3.2</td>
<td>81</td>
</tr>
<tr>
<td>Tilapia</td>
<td>37</td>
<td>4.6</td>
<td>4.0</td>
<td>201</td>
</tr>
<tr>
<td>Chinese Carp</td>
<td>37</td>
<td>4.9</td>
<td>5.3</td>
<td>178</td>
</tr>
</tbody>
</table>
Land use efficiency of conventional animal products and alternatives

Energy and protein per unit area of agricultural land for conventional and alternatives to animal production. Error bars show the yield range from uncertainty in feed conversion ratios and nutrient contents.
Putting dietary changes in a global context

• Land allocation values to quantify land require for any diet
• Calculated for average diets consumed in each country
  • NOT a land use footprint – which combines aspects of consumption and production
  • Rather, a comparative metric for diet only
• Expressed as percentage of the world land surface required for the global population to consume that diet - or HALF index.

Map of HALF index by country in 2011.
HALF index from 1961 to 2011, globally and for selected counties. Solid lines show variable diets, but constant population and agricultural production systems (at 2011 values).
Food consumption trends

Total energy per capita and percentage from animal products

Main types of animal products consumed over time
Comparison between some current diets

Cropland and pasture required to produce food under alternative dietary scenarios, expressed as required percentage of world land area to produce food required for global population given current global average production.
Land use of alternatives to animal products

Cropland and pasture areas for food production under scenarios assuming 50% of current nutrients from animal productions are substituted with the indicated food, to provide at least equal energy and protein. Results expressed as percentage of global land required, or HALF index, based on 2011 population and food production systems.
Transformation through marginal gains

Conclusions

• Importance of diet for environmental sustainability
• Multiple small changes cumulatively have substantial impact, e.g.
  • Less meat over-all
  • Switch from beef to chicken
  • Less over-consumption and other forms of waste
• Novel foods such as insects and cultured meat part of a solution
• No single “silver bullet” or technology solution and consumer behaviours/diets in developed countries do need to alter.
Thank you.


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