Sustainability of Plant-based Diets

[ Back to the Future ]

Joan Sabaté, MD, DrPH
Department of Nutrition
Loma Linda University
“The most important and urgent issues that confront food and nutrition scientists in the 21st century are beyond the scope of conventionally defined human biology. We must be willing to encompass the social, economic, political and human rights.

Ricardo Uauy
ISSUES

- World population is growing exponentially
- Diets are not adequate/healthy
  - 1 billion hungry people
  - 2 billion people with micronutrient malnutrition
  - 2 billion people overweight and obese
- Environments are not sustainable
  - Natural resources overdrawn
  - Ecosystems degraded, biodiversity lost
- Agriculture is not sustainable
  - Land, water, energy
  - Inefficiencies and waste
OUTLINE

• What is sustainability?
• Comparing environmental indicators of plant-based and meat-based diets
• The case for plant-based diets at the global level
• Issues and challenges
• Conclusions
What is sustainability?

What constitute a sustainable diet?
SUSTAINABLE DIETS?

- Sustainable diets for who?
  - Farmer
  - Cultural heritage
  - Agro-business
  - Food manufacturer
  - Consumers

- Definition of sustainable diets generally address aspects from ecology, economy and society
Sustainable Diets

Those diets with low environmental impacts that contribute to food and nutrition security and to healthy lives for present and future generations.

Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe and healthy, while optimizing natural and human resources.

United Nations Food and Agriculture Organization, 2010
SUSTAINABLE DIET DIMENSIONS

Sustainable Diets

Nutritional adequacy

Environmental sustainability

Cultural acceptability

Low cost – accessibility

Tautology – a concept used to define the concept

Dimensions of Environmental Sustainability

- Environmental Sustainability
- Efficiency
  - Environment
Environmental Sustainability

• Efficiency
  • A measure of how natural resources are used to accomplish a task or purpose
  • Quantified by the ratio of output/input

• Environment
  • The preservation of ecological systems that allow life on earth – biosphere
  • Measured by environmental indicators
    • i.e. global working potential, biodiversity, eutrophication
WHAT IS SUSTAINABILITY?

Agriculture
TRADITIONAL/PASTORAL AGRICULTURE

- Solar energy
- Spatio-temporal complexity: polycultures
- Low inputs
- Crops and animals in the same farm
Industrial Agriculture

- Fossil fuel based
- High inputs: chemicals, water, energy
- Monoculture
- Decoupling between plant and meat production
- De-regionalized
FARM PRODUCTION AS A SYSTEM

Inputs and Outputs

Energy
Emissions to air
Food primary products
Industrial raw material
Energy

Emissions to water

Fertilizer
Feed

Eriksson, et al. Ambio, 2005
Agriculture has the most influence on land use

And therefore on...

- Habitat change
- Biodiversity loss
- Water use
- Pollution with nitrogen and phosphorus
- GHG emissions
Life Cycles

From “Farm to Fork”

Food’s link to global warming

About a third of greenhouse gas emissions linked to global warming comes from the ingredients and energy used in food production. Scientists have tallied a carbon footprint from raw materials to leftovers sent to the landfill.

Life cycle of cheese

1. Manufacturing fertilizer
   Factories emit carbon dioxide (CO₂) in a high-intensive process to make nitrogen fertilizer.

2. On the farm
   Excess fertilizer applied to fields escapes into the atmosphere as nitrous oxide, a greenhouse gas with 296 times the warming potential of CO₂.

3. The harvest
   Corn, used as feed for cows, is harvested, processed, trucked and stored by CO₂-emitting equipment.

4. At the dairy
   A cow annually releases about 146 pounds of methane, which has 23 times the warming potential of CO₂, and 39 pounds of nitrous oxide emissions. Milk from the dairy is processed using heat, then trucked to cheese factory.

5. Transportation
   Cheese is trucked or flown in temperature-controlled containers to warehouses, then distributed to supermarkets.

6. At the market
   Supermarkets display cheese in open cases that require extra power to keep cool.

7. Consumers
   Multiple trips are made to feed stores each week, each car adding to CO₂ emissions. Energy used to cook the cheese adds more carbon emissions.

8. At the landfill
   An estimated 25% of food gets tossed out as leftovers or spoilage. Energy used to produce, transport and cook the food ends up in a landfill, generating methane and CO₂.
Net Energy in the U.S. Food System

Food systems use much more energy than it gives back in food energy – unsustainable enterprise
For every diet calorie 5.75 times more energy is invested. Modern food supply is a way of converting fuel to edible forms.

A CONCEPTUAL FRAMEWORK
Resources
- Sun
- Water
- Land
- Energy
- Chemicals

Pollution
- Solid & fluid waste
- Biological contaminants
- Gas emissions

Natural World

Food System
Life Cycle
- Agriculture
- Livestock
- Fisheries
- Processing
- Packaging
- Transportation
- Storage
- Retail

Demands
- Consumer preferences
- Policy
- Technology
- Marketing
- Social dynamic

Food
Consumption Patterns of Diverse Populations
- Under-nourished
  - Malnutrition
  - Deficiency diseases
- Over-fed
  - Obesity
  - Chronic diseases

Human Societies
Food production takes inputs from the natural world

Desired outcome is food

Undesired outcome is waste

Societal demands also influence the food system
Natural World

Resources
- Sun
- Water
- Land
- Energy
- Chemicals

Human Societies

Demands
- Consumer preferences
- Policy
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- Social dynamic

Food System

Life Cycle
- Agriculture
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- Gas emissions

Food

Consumption Patterns of Diverse Populations
- Under-nourished
  - Malnutrition
  - Deficiency diseases
- Over-fed
  - Obesity
  - Chronic diseases

- Sun
- Water
- Land
- Energy
- Chemicals
COMPARING ENVIRONMENTAL INDICATORS OF PLANT-BASED AND MEAT-BASED DIETS
Efficiency

Environment

Environmental Sustainability
**PROGRESSIVE LOSS OF ENERGY IN FOOD CHAIN**

- 1000 Joules of Light Energy
- 990 Joules energy lost to environment
- 10 Joules Energy
- 1 Joule energy available as food (Herbivore)
- 9 Joules energy lost to environment
- 1 Joules Energy
- 0.1 Joule energy available as food (Carnivore)
- 0.9 Joule energy lost to environment
### GRAIN USED FOR ANIMAL PRODUCTS

**Ratio of Grain Inputs to Animal Product Output (kg)**

<table>
<thead>
<tr>
<th>Animal Product</th>
<th>Ratio (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>13</td>
</tr>
<tr>
<td>Eggs</td>
<td>11</td>
</tr>
<tr>
<td>Pork</td>
<td>5.9</td>
</tr>
<tr>
<td>Turkeys</td>
<td>3.8</td>
</tr>
<tr>
<td>Chicken</td>
<td>2.3</td>
</tr>
<tr>
<td>Milk</td>
<td>0.7</td>
</tr>
</tbody>
</table>

COMPARING ENVIRONMENTAL INDICATORS OF PLANT-BASED AND MEAT-DIETS

Protein
## Efficiency Ratio

<table>
<thead>
<tr>
<th>Source</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>6-17</td>
</tr>
<tr>
<td>Water</td>
<td>4-26</td>
</tr>
<tr>
<td>Fossil fuel</td>
<td>6-20</td>
</tr>
<tr>
<td>Phosphate</td>
<td>7</td>
</tr>
<tr>
<td>Acidifying emissions</td>
<td>&gt;7</td>
</tr>
</tbody>
</table>

Eeijinders, et al. AJCN, 2003
A referent value of 1 assigned to beans
FOSSIL ENERGY USED FOR ANIMAL VS. PLANT FOODS

Ratio of Energy Input to Protein Energy Output

<table>
<thead>
<tr>
<th>Animal</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>40</td>
</tr>
<tr>
<td>Eggs</td>
<td>39</td>
</tr>
<tr>
<td>Pork</td>
<td>14</td>
</tr>
<tr>
<td>Milk</td>
<td>14</td>
</tr>
<tr>
<td>Turkeys</td>
<td>10</td>
</tr>
<tr>
<td>Chicken</td>
<td>4</td>
</tr>
</tbody>
</table>

Average fossil energy input per animal protein produced: 25 / 1 kcal
11 times greater than for grain protein production

Pimentel, et al. AJCN, 2003
Both meat-based and vegetarian diets require significant quantities of non-renewable fossil energy to produce.

Thus, both diets are non-sustainable in the long-term.

However, substantial differences exist between both diets on the use of natural resources: land, water and fertilizer.
Energy “Subsidy” and Food Production

Industrial agriculture uses more energy than it gives back in food energy.
Energy Used vs Food Protein Concentration

Efficiency is much greater for plant foods than animal foods. As protein increases so does efficiency in plant foods.

Gonzalez, et al., *Food Policy*, 2011
PROTEIN DELIVERY EFFICIENCY OF PLANT AND ANIMAL FOODS

GHGe vs Food Protein Concentration

Gonzalez, et al., Food Policy, 2011
COMPARING ENVIRONMENTAL INDICATORS OF PLANT-BASED AND MEAT-DIETS

Foods
GLOBAL WARMING POTENTIAL OF ANIMAL PRODUCTS

FOOD

PROTEIN

ENERGY USE IN PRODUCTION OF LIVESTOCK PRODUCTS

devries, et al. Livestock Science, 2010
COMPARING ENVIRONMENTAL INDICATORS OF PLANT-BASED AND MEAT-BASED DIETS

Diet Patterns
## GHG Emissions of 2 Meals

<table>
<thead>
<tr>
<th>Meal</th>
<th>Edible Weight, kg</th>
<th>GHGe, kg CO₂ eq</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meal A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrots, domestic, fresh, raw</td>
<td>0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Whole wheat, domestic, cooked</td>
<td>0.15</td>
<td>0.09</td>
</tr>
<tr>
<td>Soybeans, overseas by boat, cooked</td>
<td>0.15</td>
<td>0.14</td>
</tr>
<tr>
<td>Apples, domestic, fresh, raw</td>
<td>0.10</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Total for Meal A</strong></td>
<td>0.50</td>
<td><strong>0.36</strong></td>
</tr>
<tr>
<td><strong>Meal B</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables, frozen, cooked</td>
<td>0.10</td>
<td>0.23</td>
</tr>
<tr>
<td>Rice, overseas by boat, cooked</td>
<td>0.15</td>
<td>0.20</td>
</tr>
<tr>
<td>Beef, domestic, fresh, cooked</td>
<td>0.10</td>
<td>3.03</td>
</tr>
<tr>
<td>Tropical fruits, by plane, fresh, raw</td>
<td>0.10</td>
<td>1.13</td>
</tr>
<tr>
<td><strong>Total for Meal B</strong></td>
<td>0.45</td>
<td><strong>4.49</strong></td>
</tr>
</tbody>
</table>

Vegetarian Diets & Organic Foods

Environmental Impact

# Average UK vs. Vegetarian Diets

<table>
<thead>
<tr>
<th>Diet Scenario</th>
<th>GHGe, kg CO2 eq</th>
<th>Cost, £</th>
<th>Protein, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average UK diet of 3458 kcal day&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>7.4</td>
<td>6.59</td>
<td>88</td>
</tr>
<tr>
<td><strong>Vegetarian scenarios</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1: UK average diet with meat energy replaced by dairy energy, normalized</td>
<td>5.79</td>
<td>5.63</td>
<td>76</td>
</tr>
<tr>
<td>to UK food supply per capita energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2: US average vegetarian diet, normalized to UK food supply per capita</td>
<td>6.06</td>
<td>6.01</td>
<td>64</td>
</tr>
<tr>
<td>energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3: UK average diet with meat energy replaced by &quot;healthy&quot; non-dairy</td>
<td>5.54</td>
<td>5.78</td>
<td>66</td>
</tr>
<tr>
<td>alternatives, normalized to UK food supply per capita energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vegan scenarios</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4: UK average diet with meat and dairy energy replaced by all plant-based</td>
<td>5.14</td>
<td>5.64</td>
<td>50</td>
</tr>
<tr>
<td>alternatives, normalised to UK food supply per capita energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5: US vegan diet, normalized to UK food supply per capita energy</td>
<td>5.68</td>
<td>6.26</td>
<td>54</td>
</tr>
<tr>
<td>6: UK average diet with meat and dairy energy replaced by &quot;healthy&quot;</td>
<td>5.55</td>
<td>5.99</td>
<td>62</td>
</tr>
<tr>
<td>plant-based alternatives, normalised to UK food supply per capita energy</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Substantial GHGe savings can be made by eliminating meat and dairy from the average diet.

ASSESSING ENVIRONMENTAL IMPACTS OF MEATLESS DIETS

3 METHODOLOGICAL APPROACHES

• Single food: meat vs. soy
• “Designed” or ideal meatless diets
• Actual diets consumed by vegetarian and non-vegetarian populations
CONTRIBUTION OF MEATLESS DIETARY PATTERNS TO GHGE MITIGATION

The Loma Linda University Study

- To quantify and compare the GHG emissions of current agricultural operations to produce food commodities actually consumed by a health-oriented population of vegetarians and meat eaters in California.

- Adventist Health Study-1 Cohort
  - ≈34,000 Californians, men and women
  - 45% vegetarian (<1 serving of meat per week)
11 Foods Consumed in Different Amounts

- Eggs
- Poultry
- Beef
- Dry fruit
- Canned fruit
- Winter fruit
- Seasonal fruit
- Citrus fruit
- Fruit juice
- Nuts
- Beans
### Weekly Consumption (GR)

<table>
<thead>
<tr>
<th></th>
<th>Vegetarian</th>
<th>Nonvegetarian</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuts</td>
<td>66</td>
<td>28</td>
<td>2.4</td>
</tr>
<tr>
<td>Apples</td>
<td>659</td>
<td>466</td>
<td>1.4</td>
</tr>
<tr>
<td>Beans</td>
<td>257</td>
<td>170</td>
<td>1.5</td>
</tr>
<tr>
<td>Dry fruit</td>
<td>376</td>
<td>386</td>
<td>1.0</td>
</tr>
<tr>
<td>Fruit juice</td>
<td>1814</td>
<td>1705</td>
<td>1.1</td>
</tr>
<tr>
<td>Peaches</td>
<td>383</td>
<td>214</td>
<td>1.8</td>
</tr>
<tr>
<td>Watermelon</td>
<td>468</td>
<td>298</td>
<td>1.6</td>
</tr>
<tr>
<td>Eggs</td>
<td>67</td>
<td>138</td>
<td>0.43 (2.3)</td>
</tr>
<tr>
<td>Poultry</td>
<td>6</td>
<td>136</td>
<td>0.04 (25)</td>
</tr>
<tr>
<td>Beef</td>
<td>23</td>
<td>743</td>
<td>0.03 (32)</td>
</tr>
</tbody>
</table>
### Inputs to Produce Different Diets

#### Nonvegetarian to Vegetarian Ratio

<table>
<thead>
<tr>
<th>Input</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>2.9</td>
</tr>
<tr>
<td>Energy</td>
<td>2.5</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>13</td>
</tr>
<tr>
<td>Pesticides</td>
<td>1.4</td>
</tr>
</tbody>
</table>
## Annual GHG Emissions in CO₂ eq

### By Diet and Food Type

<table>
<thead>
<tr>
<th></th>
<th>Vegetarian</th>
<th>Nonvegetarian</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>All 11 Foods</td>
<td>53</td>
<td>502</td>
<td>+449</td>
</tr>
<tr>
<td>Plant Foods (7)</td>
<td>34</td>
<td>27</td>
<td>-8</td>
</tr>
<tr>
<td>Animal Foods (3)</td>
<td>18</td>
<td>475</td>
<td>+456</td>
</tr>
<tr>
<td>Beef</td>
<td>14</td>
<td>461</td>
<td>+447</td>
</tr>
</tbody>
</table>
THE CASE FOR PLANT-BASED DIETS AT THE GLOBAL LEVEL
DRASTIC REDUCTION OF ANIMAL FOOD CONSUMPTION NEEDED

Efficiency

Environment

Health

Environmental Sustainability
Main Reasons for Reduction

- Conversion of plant food to animal-based food is an intrinsically inefficient process (~10:1)
- Decreasing meat consumption will free up large amounts of food for direct consumption by humans
- Animal factories degrade the environment, exploit natural resources, threaten the normal development of future generations (our children)
- Meat-based diets increase the risk for many diseases, thus reducing the health and survival of those consuming them
Until recently it has been assumed that the world’s living and physical resources were inexhaustible.
However,

- Overall size and economic activity of mankind is exceeding the biocapacity of the natural world

- Humanity has already transgressed several critical planetary homeostatic boundaries

A SAFE OPERATING SPACE FOR HUMANITY

WORLD TRENDS

• The world population is increasing yet it is projected to plateau at some 9B by the middle of the century

• Increased wealth in large segments of population in developing countries – increasing consumption of meat and animal products
Growth deceleration – projected to stabilize at 9 billions in 2050
Meat Consumption is Growing

Kearney, Phil Trans R Soc B, 2010
WORLD CONSUMPTION OF MEATS

Source: FAO Food balance sheets, 2009
MEAT CONSUMPTION PATTERNS BY REGION

Source: FAO Food balance sheets, 2009
THE CASE FOR PLANT-BASED DIETS AT THE GLOBAL LEVEL

Using up world resources
Environmental degradation
WORLD LIVESTOCK INCREASE
INDUSTRIAL MEAT PRODUCTION

(Intrinsically Inefficient)

- Requires very high inputs of natural resources
  - Energy (fossil fuels)
  - Water
  - Cereal grains
  - Growth promoting antibiotics

- For low outputs of dietary energy and nutrients
The case for plant-based diets at the global level

Environmental degradation
Reports from authoritative agencies have accumulated in the last few years documenting the negative environmental impacts of industrial meat production.
livestock’s long shadow
environmental issues and options

Putting Meat on the Table: Industrial Farm Animal Production in America

UN International Panel on Climate Change

UN FAO Livestock Report 2006


Lancet Article
Animal waste has become a public health problem and an environmental hazard.

Meat and dairy production (including feed) accounts for about 80% of GHG emissions from the agricultural sector, contributing to climate change:
- Carbon dioxide from fertilizer and fuel use
- Methane from livestock metabolism
- Nitrous oxide from fertilizer application and manure

Industrial meat production damages the environment by chemical runoff to air, water and soil.
### Global GHGe from Livestock

Million tons annually

<table>
<thead>
<tr>
<th>Animal</th>
<th>Carbon dioxide</th>
<th>Methane, enteric</th>
<th>Methane, manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>1906</td>
<td>75</td>
<td>8</td>
</tr>
<tr>
<td>Sheep and goats</td>
<td>514</td>
<td>9</td>
<td>0.3</td>
</tr>
<tr>
<td>Pigs</td>
<td>590</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Camels</td>
<td>18</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Horses</td>
<td>71</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Poultry</td>
<td>61</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1161</strong></td>
<td><strong>86</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>


Dairy cattle account for a quarter of methane emissions
NITROGEN AND PHOSPHORUS FLOWS

Sutton, et al., Center for Ecology and Hydrology, 2013
Nitrogen Inputs Globally

N Inputs (kgN/km²/yr)

- 0 – 500
- 500 – 1000
- 1000 – 2500
- 2500 – 5000
- 5000 – 7500
- > 7500

FERTILIZER USE BY REGION

TRENDS IN FERTILIZATION

Relates to Global Meat Production

THE CASE FOR PLANT-BASED DIETS AT THE GLOBAL LEVEL

Food security and sustainability on a collision course
Resources
- Sun
- Water
- Land
- Energy
- Chemicals

Demands
- Consumer preferences
- Policy
- Technology
- Marketing
- Social dynamic

Food System
- Agriculture
- Livestock
- Fisheries
- Processing
- Packaging
- Transportation
- Storage
- Retail

Food
- Consumption Patterns of Diverse Populations
- Low Regional Food Yields
- Food Insecurity
- Food
  - Under-nourished
  - Malnutrition
  - Deficiency diseases
- Over-fed
  - Obesity
  - Chronic diseases

Pollution
- Solid & fluid waste
- Biological contaminants
- Gas emissions (GHG)

Climate Change

Natural World

Human Societies
HUMAN’S ECOLOGICAL FOOTPRINT

The graph illustrates the increase in the ecological footprint over time, showing the growing demand on the Earth's biocapacity. The biocapacity is measured in terms of the number of Earths required to sustain the current human activity levels.

Key trends observed in the graph include:
- An upward trend in the ecological footprint, indicating increased demand.
- The importance of considering different types of footprint, such as built-up land, forest land, fishing ground, grazing land, cropland, and carbon footprint.

The graph highlights the need for sustainable practices to ensure that the Earth's resources are not overstressed.
THE CASE FOR PLANT-BASED DIETS AT THE GLOBAL LEVEL

This challenge requires a radical change in the current food system
There is no simple solution to sustainably feed 9 billion people, especially as many become increasingly better off and converge on rich-country consumption patterns.
• A broad range of options needs to be pursued simultaneously
• The goal is no longer simply to maximize productivity
• We must avoid the temptation to further sacrifice Earth’s already hugely depleted biodiversity for easy gains in food production
• We do not have the right to deprive future generations of its economic and cultural benefits
• A complex landscape of production, environment and social justice must be optimized
Book by Harry Aiking, et al., 2006

UK Sustainable Commission Report, 2009

FAO Symposium, 2010

Global Partnership on Nutrient Management, 2013
PROPOSED SOLUTIONS

• More cropland – not a viable option
• Closing the “yield gap”
  • Increase production by making some agriculture operations more efficient
• Sustainable intensification
  • Precision agriculture – applying water, fertilizer and pesticides only to selected places and times
• Reduce food loss and waste
• Changing diets
  • ↓↓meats and ↓dairy products
FOOD LOSS AND WASTE IN FOOD SUPPLY

By Region

Per capita loss and waste

CEREAL LOSS AND WASTE BY REGION

At Different Stages of the Food Supply Chain

Percent of initial production lost or wasted

Fruit & Vegetable Waste by Region

At Different Food Supply Chain Stages

kg/person/year

Percent of initial production lost or wasted

Obesity impacts the environment by extra food (waste) and increase energy needs.
ISSUES AND CHALLENGES

Measureable efficiency and environmental benefits
CLOSING THE DIET GAP

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

ATMOSPHERIC N$_2$O CONCENTRATIONS UNDER DIFFERENT SCENARIOS

ISSUES AND CHALLENGES

Policy challenges
THE CURRENT POLICY FORMULA
Science + capital $\rightarrow$ output $\rightarrow$ cheaper food $\rightarrow$ health

= Progress

ACTUAL FORMULA AND OUTCOMES
Technology + capital + overdrawn natural resources
$\rightarrow$ Food overproduction / insecurity (food disparities)
$\rightarrow$ Over-feed &/or undernourished Populations

= Unsustainable Food Systems
DOUBLE PYRAMID: HEALTH VS. ENVIRONMENT

Ciati, et al., FAO Biodiversity and Sustainable Diets Symposium, 2010
CURRENT TRENDS AND INITIATIVES IN ENVIRONMENTAL NUTRITION

• Production Innovations
  • Meat analogs
  • Alternate grains

• Consumer information
  • Carbon footprint

• Local and political initiatives

• Research
Vegetarian Protein Products

MEAT ANALOGS
CONSUMER INFORMATION

- Labeling at point of purchase
  - Country/region of origin
  - Carbon footprint (GHG emissions)

Sweden

Reference
OPPORTUNITIES FOR FUTURE RESEARCH

• Local vs. “globally-sourced” foods
• Commercial vs. homemade
• LCA studies of convenient or highly-processed foods (e.g. meat analogs)
• Effectiveness of consumer education
• Environmental impacts of different food patterns
• Directly relating dietary patterns to both health and environmental outcomes
CONCLUSIONS
MAIN REASONS FOR A DRASTIC REDUCTION OF CONSUMPTION OF FOODS OF ANIMAL ORIGIN AT THE GLOBAL LEVEL

- Efficiency
- Environment
- Health
- Environmental Sustainability
- Ethics
CONCLUSIONS

• For millennia, meat-less (vegetarian) diets have been advocated on *values* (Religion, Ethics, Philosophy), not science.

• Only in the last 150 years has empirical evidence (scientific data) informed dietary recommendations centered on nutrition and health outcomes.

• Meat and dairy were considered essential in large proportions for adequate nutrition. Consuming plant-based diets was considered inadequate.

• This nutritional paradigm has now changed. Data now supports that most plant-based diets are healthier (Greater longevity, Lower chronic disease) than meat-based diets.
CONCLUSIONS

• Given the demographic explosion and increase in wealth there is a global increase on the demand for foods of animal origins (meats and dairy products)

• This global trend is both environmentally unsustainable and detrimental to human health.

• At the current trends of food consumption and environmental changes, food security and food sustainability are on a collision course by mid-century
CONCLUSIONS

• Changing course to avoid the collision will require dramatic downward shifts in meat and dairy consumption by large segments of the population.

• Food waste reduction, precision agriculture, and other approaches must be simultaneously pursued.

• However, these are insufficient to make the global food systems sustainable.
Is going back the best way forward?

- Will going back to plant-based diets give us a sustainable future?

- Policies in favor of global adoption of plant-based diets will simultaneously optimize
  - The food supply
  - Health
  - The environment
  - Social justice
Implementing drastic nutrition policy is not free of political challenges, but....

It is perhaps the most scientific and moral path to a sustainable future for the human race and other living creatures of the biosphere we share.
Nothing will benefit human health and increase the chances for survival of life on earth as much as the evolution to a vegetarian diet.

- Albert Einstein
Main Reasons for Drastic Reduction

- Conversion of plant food to animal-based food is an intrinsically inefficient process (~10:1)
- Decreasing meat consumption will free up large amounts of food for direct consumption by humans
- Animal factories degrade the environment, exploit natural resources, threaten the normal development of future generations (our children)
- Meat-based diets increase the risk for many diseases, thus reducing the health and survival of those consuming them