Additional Questions

- At what price? Will poor people be able to afford an adequate diet? Will they have the incomes to do so? (access)

- Without destroying the environment?
  Resources, environmental quality, biodiversity

Program in Food Security and the Environment

Can we meet the Millennium Development goals?

Can we meet the Millennium Ecosystem Assessment goals?
Outline for Today

- Agricultural intensification
- Agricultural demand/livestock
- Analogies between agriculture and aquaculture
- Policy approaches

The Pile of Grain

World Production, Area Harvested, and Yield of All Cereals, 1961-2003

Yaqui Valley: Home of the Green Revolution for Wheat
The Green Revolution

What does the price drop mean?
Agriculture,
Productivity,
and the
Environment
Are we saving land for nature?

Industrial livestock revolution
Structural change in the livestock sector

<table>
<thead>
<tr>
<th>Demand shifters</th>
<th>Supply shifters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population growth and other demographic factors</td>
<td>Cheap grains</td>
</tr>
<tr>
<td>Income growth</td>
<td>Cheap energy (fossil fuel)</td>
</tr>
<tr>
<td>Urbanization</td>
<td>Improved technologies (genetics, feeding)</td>
</tr>
</tbody>
</table>

Facilitators
- Market liberalization
- Neglect of externalities

Growing intensities

- Feed: from locally available resources to world sourcing of feed
- Feeding: from supplementary feeding to precision feeding (enzymes, amino-acids)
- Genetics: from breed selection to genomics
- Animal Health: from area-wide disease control to “pathogen-free” and food chain approaches
Livestock sector: Growing scales

- Almost a global feature: very strong in poultry and pigs, less so in dairy
- Number of livestock producers rapidly decreasing in most countries
- Growing scales in post-harvest (slaughterhouses, dairy plants, processing) even more pronounced

Geographical concentration

- Siting of production units is driven by input costs and vicinity to markets; infrastructure a main determinant
- Environmental regulations are becoming a factor in developing countries

Efficiencies of Animal Food Production

<table>
<thead>
<tr>
<th></th>
<th>Milk</th>
<th>Chicken</th>
<th>Pork</th>
<th>Beef</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Kg/kg LW</td>
<td>1.0</td>
<td>2.5</td>
<td>4.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Edible weight (% of LW)</td>
<td>95</td>
<td>55</td>
<td>55</td>
<td>40</td>
</tr>
<tr>
<td>Feed Kg/kg EW</td>
<td>1.1</td>
<td>4.5</td>
<td>7.3</td>
<td>20.0</td>
</tr>
<tr>
<td>Food energy (kcal/kg)</td>
<td>650</td>
<td>1800</td>
<td>3100</td>
<td>3000</td>
</tr>
</tbody>
</table>

How much will food needs expand?

Current per capita grain equiv. consumption
- South: 260 kg
- North: 780 kg

By 2050, total world needs relative to 1990
- w/ current: 1.8x
- w/ converging: 2.2x
- w/ northern: 3.3x
Demand for feed grains (million tons)

Land Use Change

- Extensive production of livestock limited by land availability
- Most growth in livestock production will come from intensive systems, esp. pork and poultry
- Per unit of protein, chickens require 1/10 the amount of land as beef cattle

Deforestation
Pasture expansion into Neotropical forests:
an assessment of the future through system based land use change modeling

Mato Grosso, Brazil – Landsat ETM+
08-Oct-1999 06-Jul-2000
Areas of nutrient overload

N Waste from Livestock

- For monogastrics, only 20-35\% of the nutrients consumed are captured in the final products.
- Industrial systems separated from field agriculture where wastes could be used to fertilize crops (forage)
- Wastes are mostly water, which limits extent of productive distribution

Are we saving land for nature?

Aquaculture: Intensification of fish production
Blue Revolution

- Past 20 yr: aquaculture has grown 4-fold
- Now: 1/3 of global seafood supply
- Drivers:
  - depleted fisheries
  - population growth
  - increasing per capita seafood consumption
    (Global consumption doubled since early ‘70’s)
  - lucrative business prospects

Environmental Challenges for Raising Carnivorous Fishes

Feeds
Escapes
Waste
Diseases
Pollution
Scaling Up

Amount and proportion of global fish meal supplies used for fish farming

<table>
<thead>
<tr>
<th>year</th>
<th>amount ('000 tons)</th>
<th>share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>640</td>
<td>10%</td>
</tr>
<tr>
<td>1994</td>
<td>1,264</td>
<td>17%</td>
</tr>
<tr>
<td>1999</td>
<td>2,060</td>
<td>34%</td>
</tr>
<tr>
<td>2002</td>
<td>2,550</td>
<td>40%</td>
</tr>
<tr>
<td>2010</td>
<td>3,450</td>
<td>60%</td>
</tr>
</tbody>
</table>

Source: International Fishmeal and Fish Oil Organization (http://www.iffo.co.uk)
Nutrient and Chemical Pollution:
Fish farming discharges large amounts of fish feces and other wastes into the ocean.

Are we saving the seas for nature?

Risks of Farmed Fish Escapes

• Establish feral populations
• Compete with wild fish for prey, space, and mates
• Interbreed with and alter genetics of wild fish
• Transmit pathogens to wild fish

Path Forward:
Technology
Management
Diets
Policy
Biotechnology is more than GMOs

The relevant technology also includes:

- Genomics
- Advanced genetics
  - molecular markers
- Bioinformatics
- Tissue culture

Integration of the food chain

Policy Issues

- US Farm Bill, 2007
Policy Issues

- US Farm Bill (2007)
- WTO, Doha Round (2001, ongoing)

Policy Issues

- US Farm Bill (2007)
- California SB 210 on marine aquaculture (2006)
- WTO, Doha Round (2001, ongoing)