Animal protein production in a resource depleted world subject to environmental decline and global warming

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Objectives of this presentation

- Outline important issues in the coming world food crisis- competition for human food, animal feed and biofuel feedstock.
- Provide a basis for agricultural scientists to become aware of the implications for food security and adjust and meet the challenges ahead
- Influence governments/aide agencies to rational actions to meet the challenges

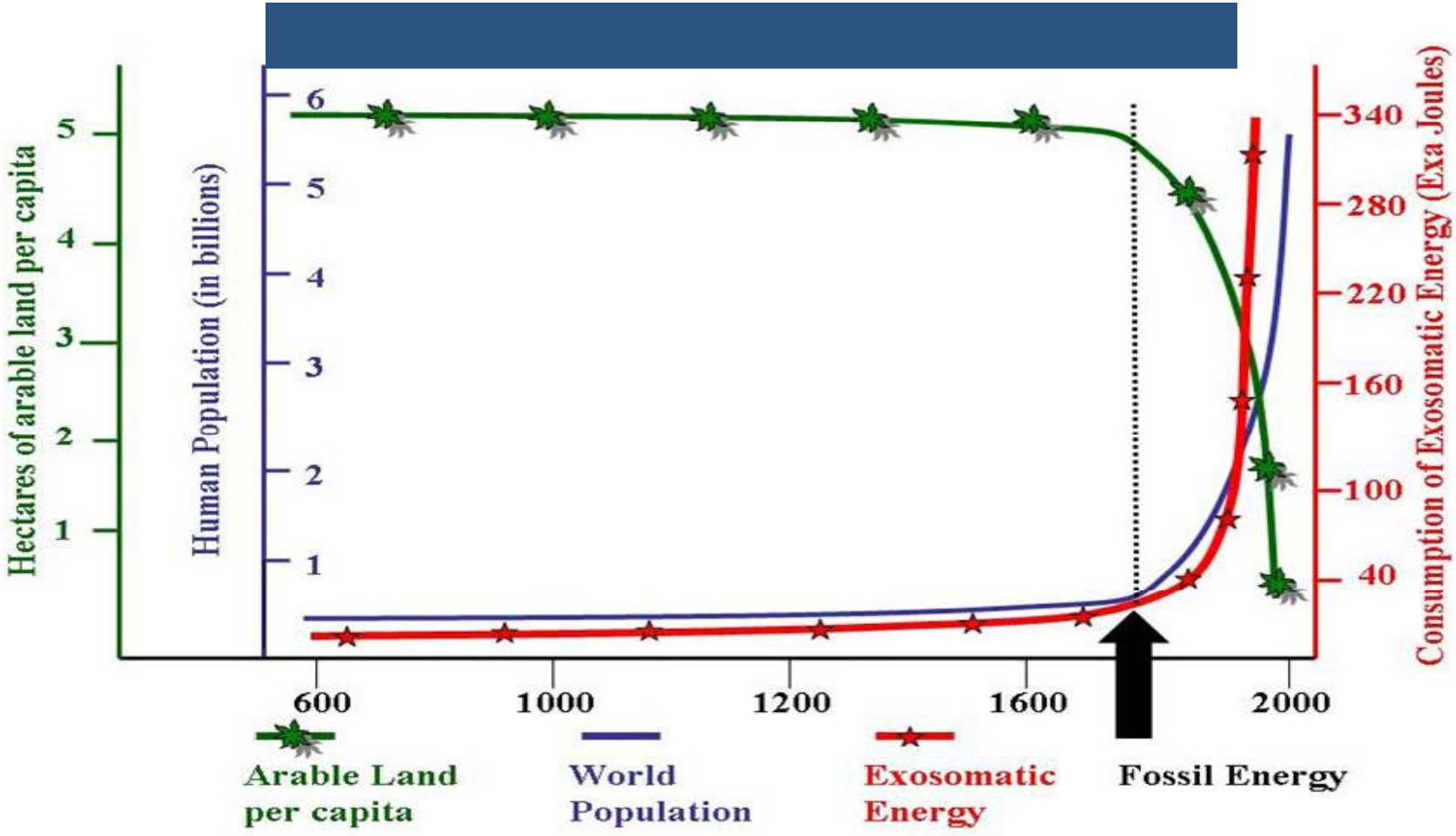
The triple crisis effecting world food production-energy, economics, and the environment.

- Peak oil-the end of inexpensive energy and beginning of expensive inputs into food/feed production
- Global resource depletion including
  - Financial credit
  - mineral fertilizers (N P K and S)
  - irrigation water
  - Soil
- Global climate change

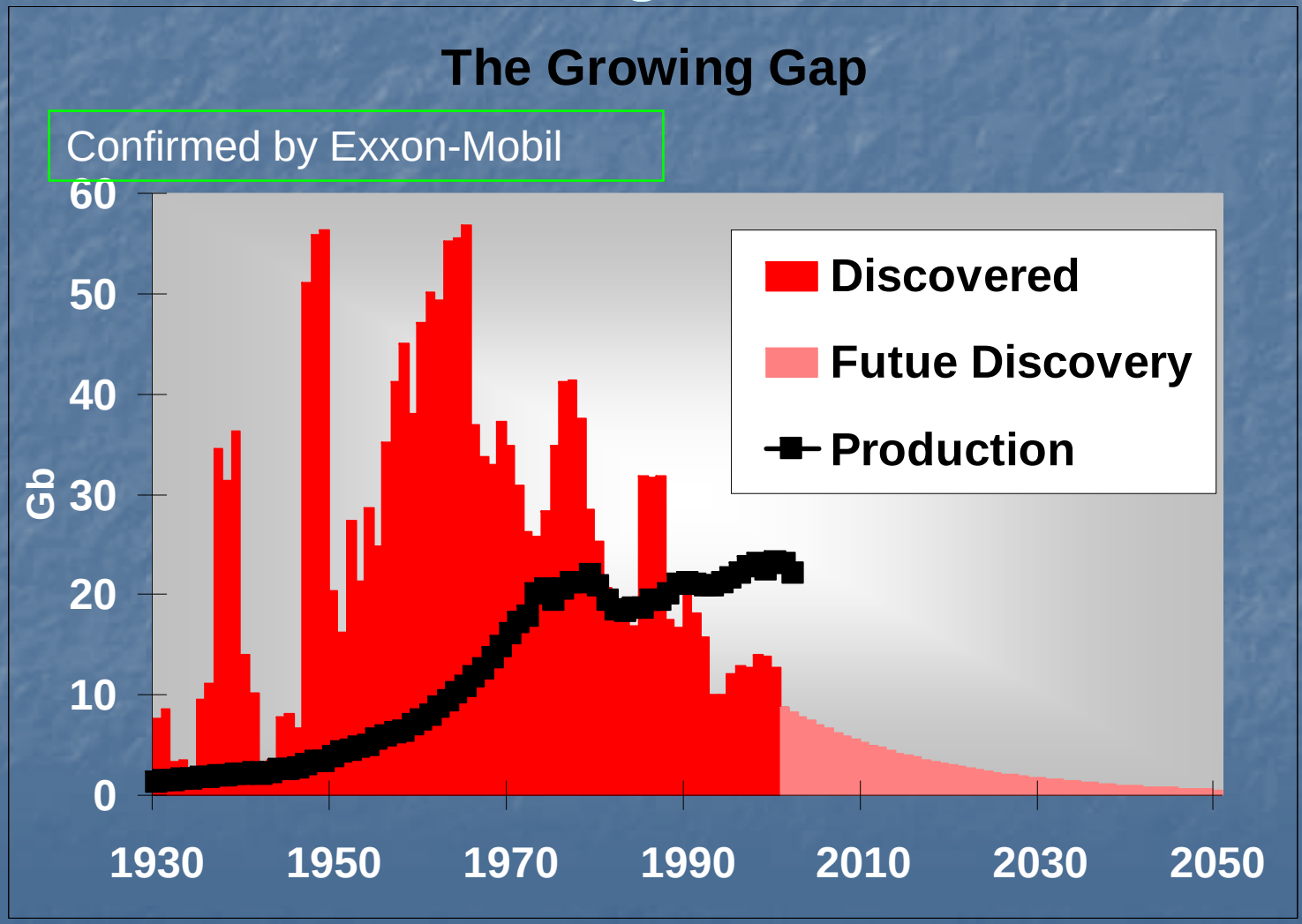
Growth of crop production since 1950 has been a growth in land productivity- ***dependent on inexpensive energy***

- 10 fold increase in fertilizer application
- 3 fold increase in irrigation
- Increased multiple cropping of land on an annual basis
- Availability of high yielding corn (USA) and dwarf wheat and rice (Asia)
- Huge increase in soybean production

Inexpensive Fossil Fuel Energy Fueled World Population Growth

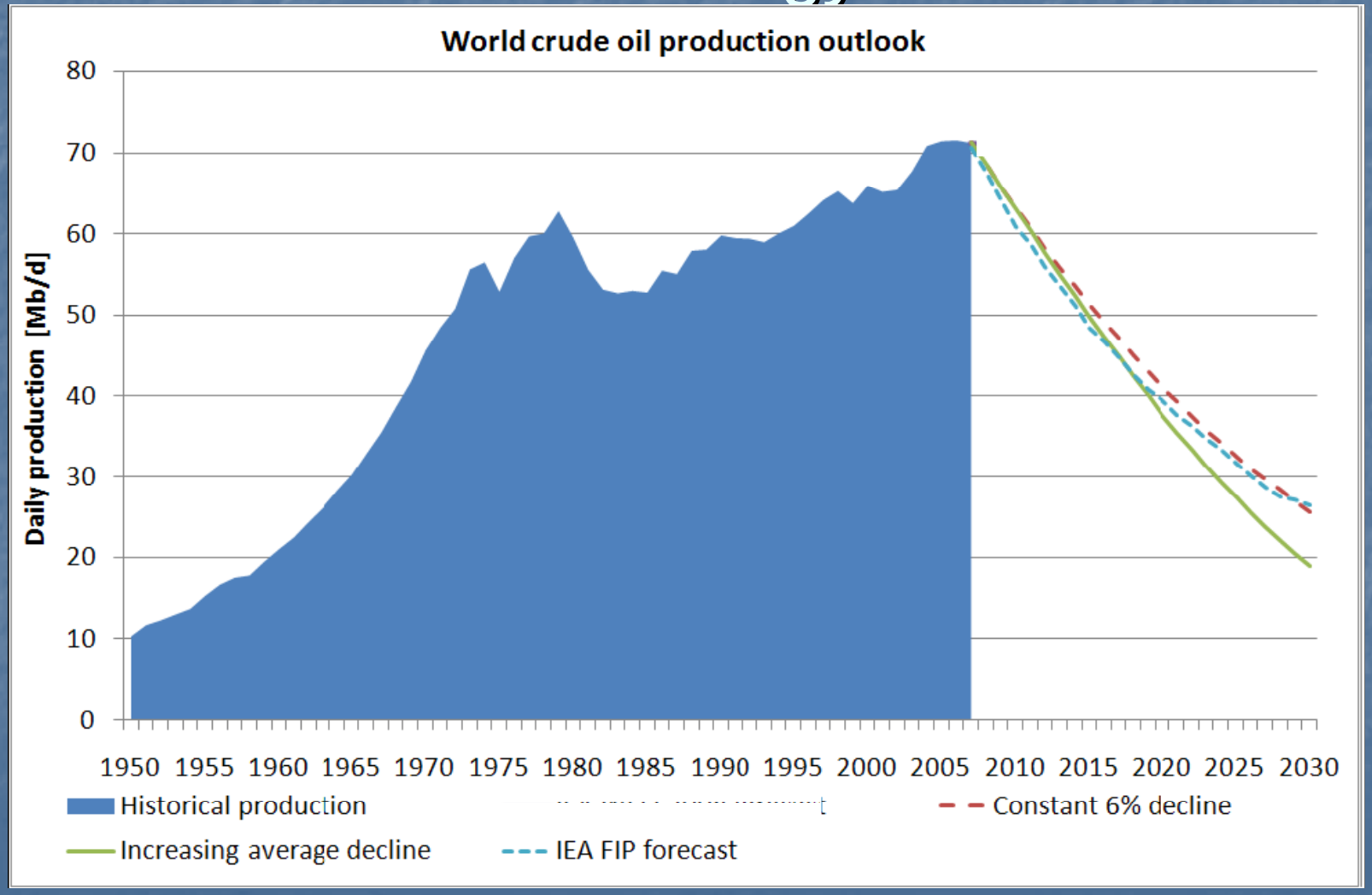


The world is using more fossil energy then is being discovered



(Campbell 2005)

Historical world oil production along with crude oil forecast the reference scenario from IEA World Energy Outlook 2008.



Mikael Höök(2009) Note IEA reference scenario is for a continuing increase in oil production up to 2030

Worldwide, Peak oil possibly took place in early 2008

- **Reaching peak oil represents a transformative moment in the history of the oil and financial markets**

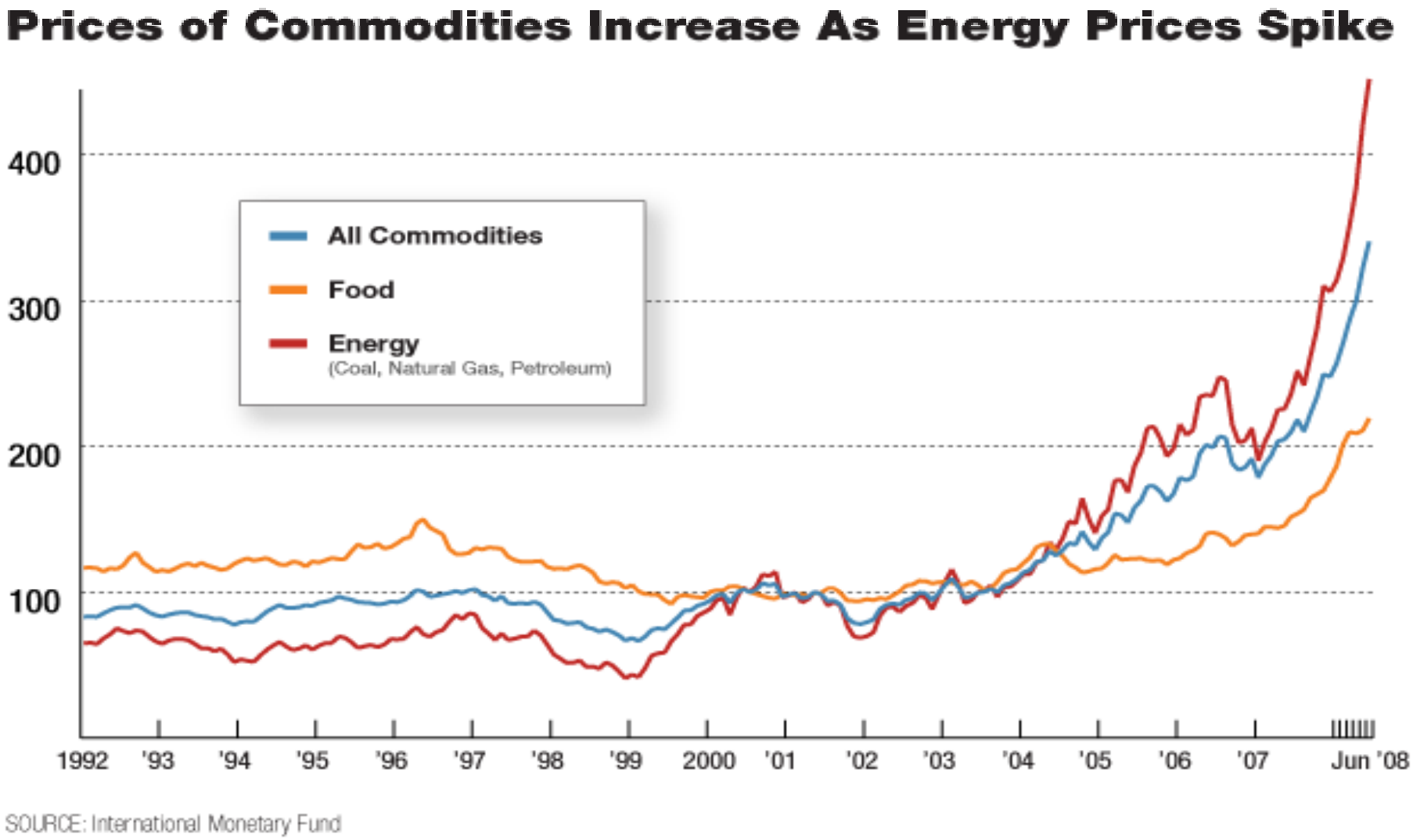
- **It is only a matter of time before prices, particularly of food, feed and feedstock, begin to reflect the reality that oil demand will exceed production and commodity prices will reflect the value of their embedded oil.**

"if there is anything that must be understood with regard to energy it is its relationship to food."

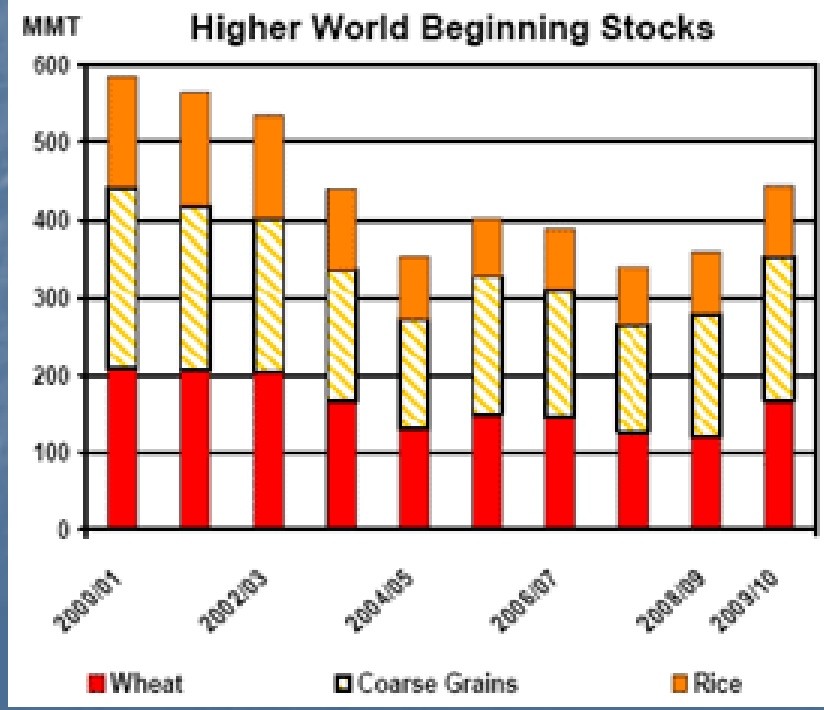
- Agriculture is an energy intensive sector with row crop production particularly affected by energy price increases.

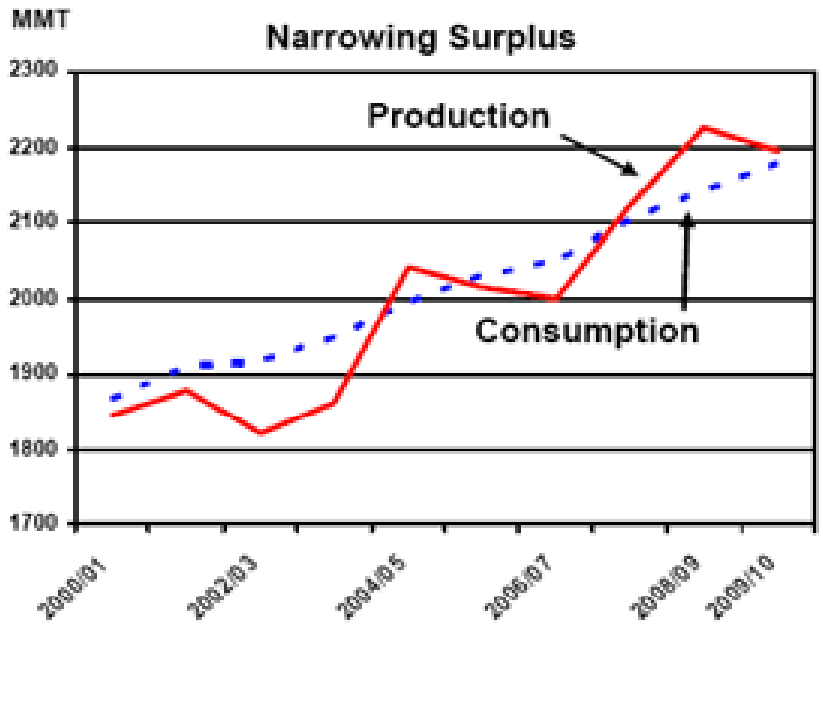
- Fertilizers embody the most energy among production inputs as natural gas is a primary input (70-90 percent of cost of producing nitrogen fertilizer).

Oil price is linked to every aspect of life and standards of living will be effected as price rises



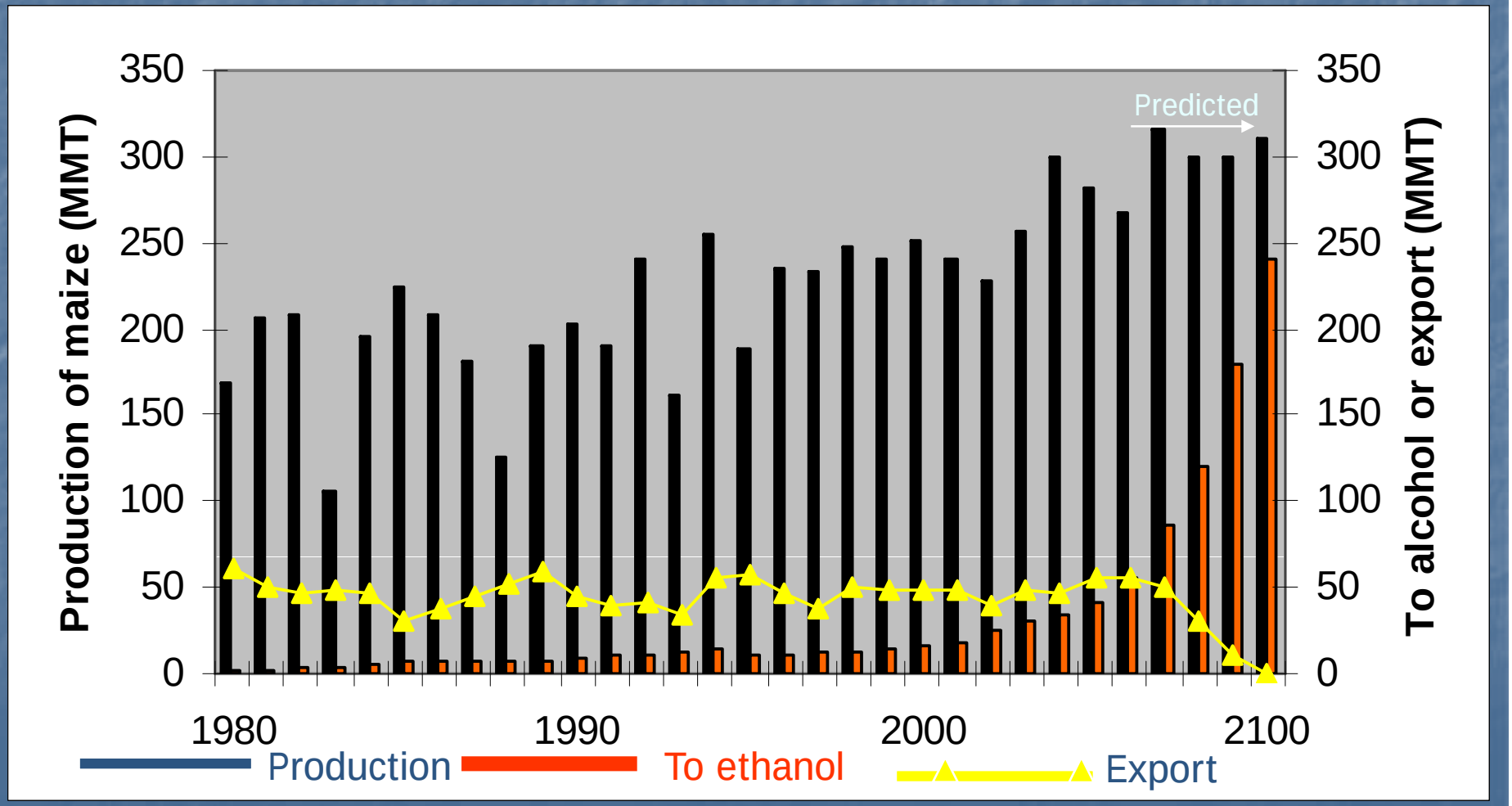
World grain carry over stocks have been dropping since 2000 but may recover with good crop yields in 2008





USDA Foreign Agricultural Service 2009.

Patterns of maize production and use in the USA 2008-2012 (adapted from Earth Policy Institute 2007)

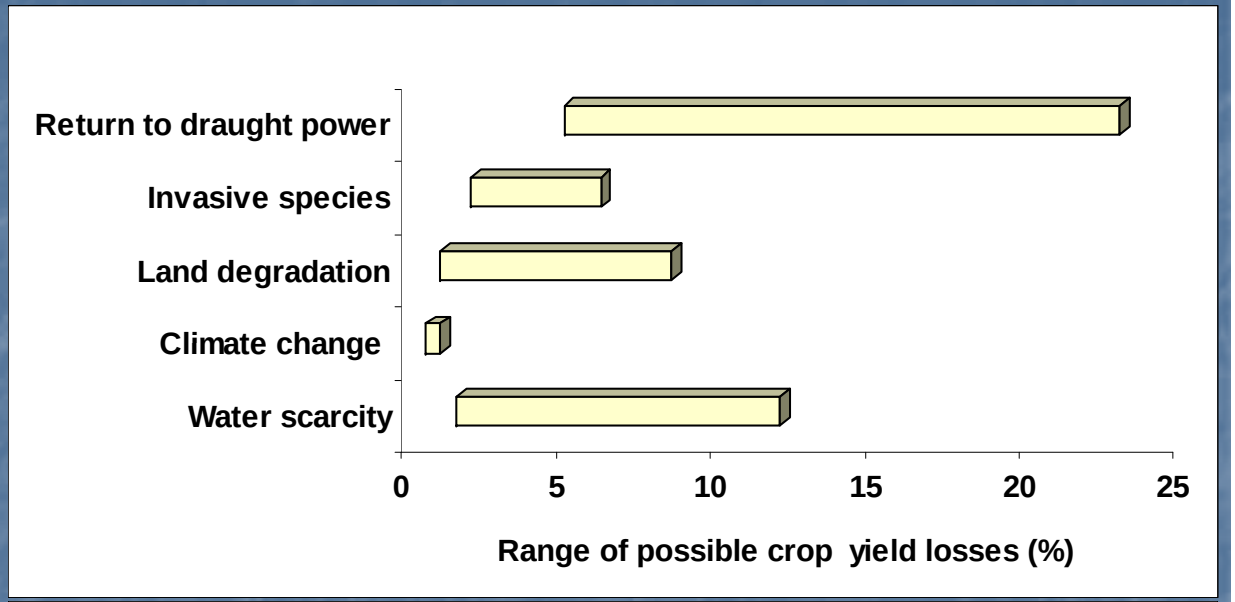


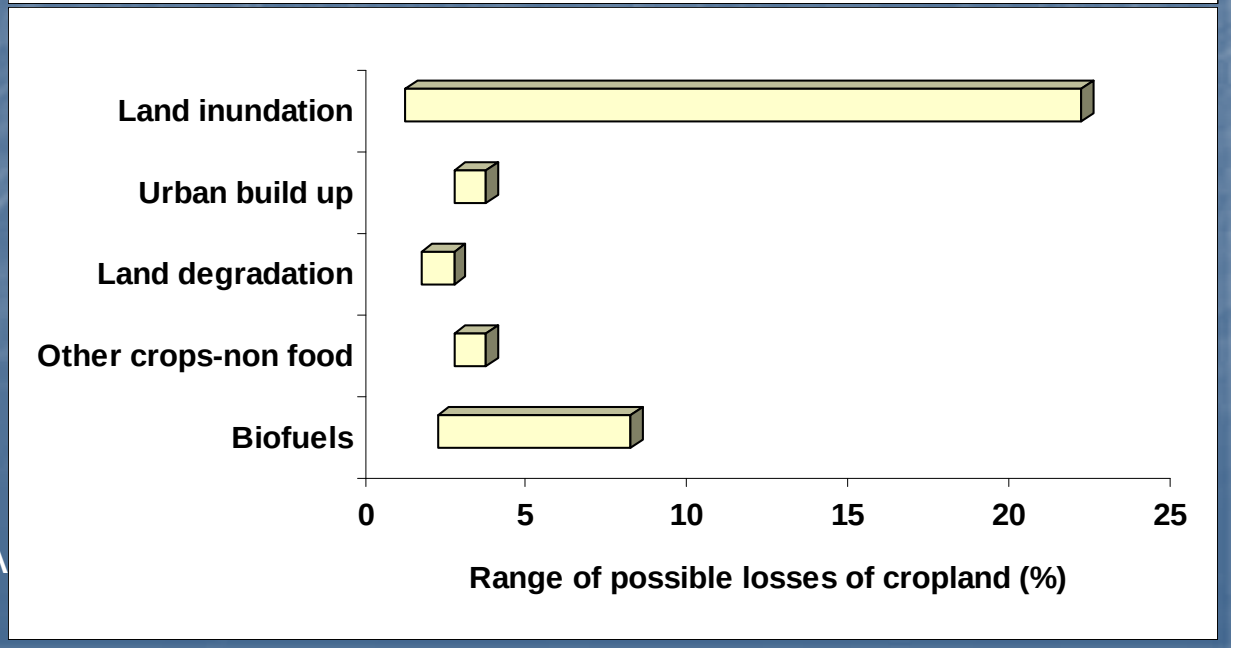
Many other factors impact negatively on future world food production

- ***Decreasing water availability***
  - Increased glacial melt adding to water stress in dry season
  - Draw down of aquifers (loss of irrigated crops)
  - Water priority uses in urban areas and for industry
- ***Decreasing land availability/fertility***
  - Erosion/salination/pollution
  - Construction e.g. roads/mining/cities
  - Decreasing fertilizer response and application
  - Invasive weeds and increasing pests and diseases
- ***Climate change***
  - More frequent crop loses from drought and storms
  - Fertile land inundation from rising seas
  - Lowered crop yields as temperatures rise -for each ^{o}C rise in temperature rice yields decrease by 10%(CGIAR 2008)

Potential loss of world crop land and decreased cereal crop yield

Adapted from-A UNEP RAPID RESPONSE ASSESSMENT)

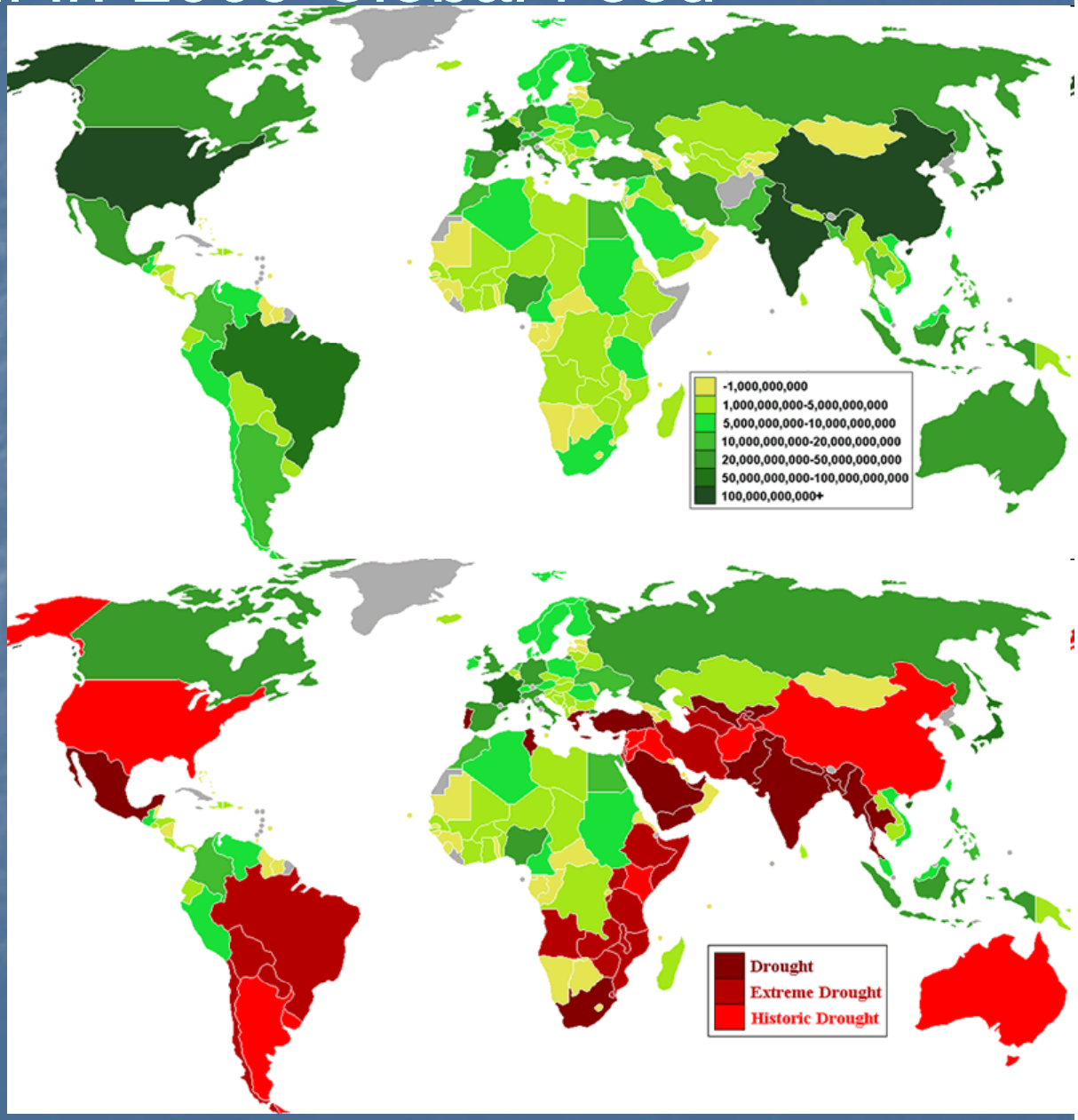




(Nellemann et al 2009 ;Leng RA 2009)

Catastrophic Fall in 2009 Global Food Production?

- **$ value of agricultural output**
- **droughts highlighted.**



de Carbonal (2009)

The world grain production appears to be set to decline in the next 20-30 years by combination

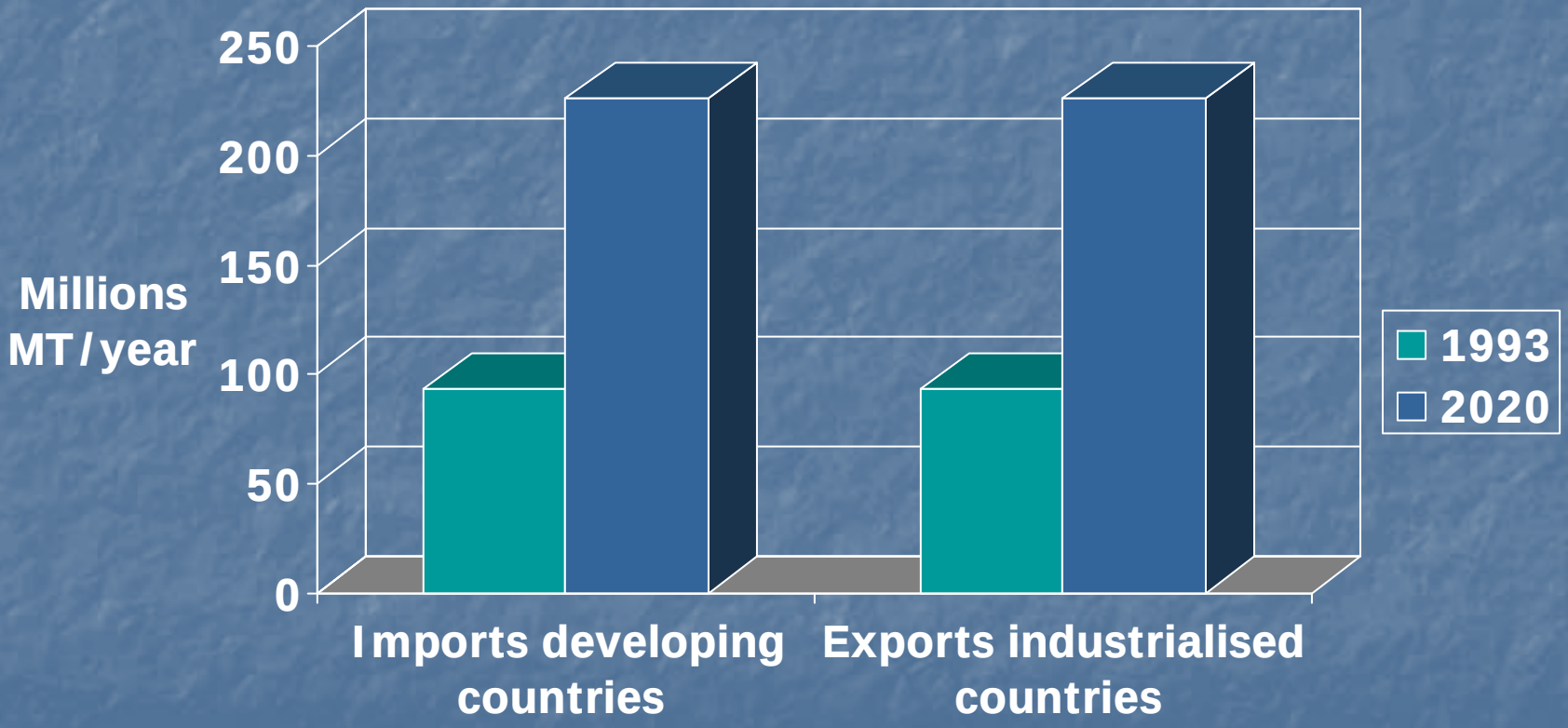
- *Peak oil*
  - High cost of fertilizers, herbicides, irrigation water and traction power (with some return to draught power)
- *Global climate change*
  - More weather related crop failures
  - Fertile land losses-inundation-erosion-construction
  - Temperature related crop losses
  - Disruption in pattern of Glacial melt
- *Land degradation*
  - Invasive weeds

The worst impacts of peak oil will hit much sooner than the worst impacts of climate change

- Arguably this has already started:
  - Oil price spike causes recession followed by oil price collapse-recovery-recession and so on
  - Increase in costs of all inputs into food production
- But climate change could be close to a tipping point?

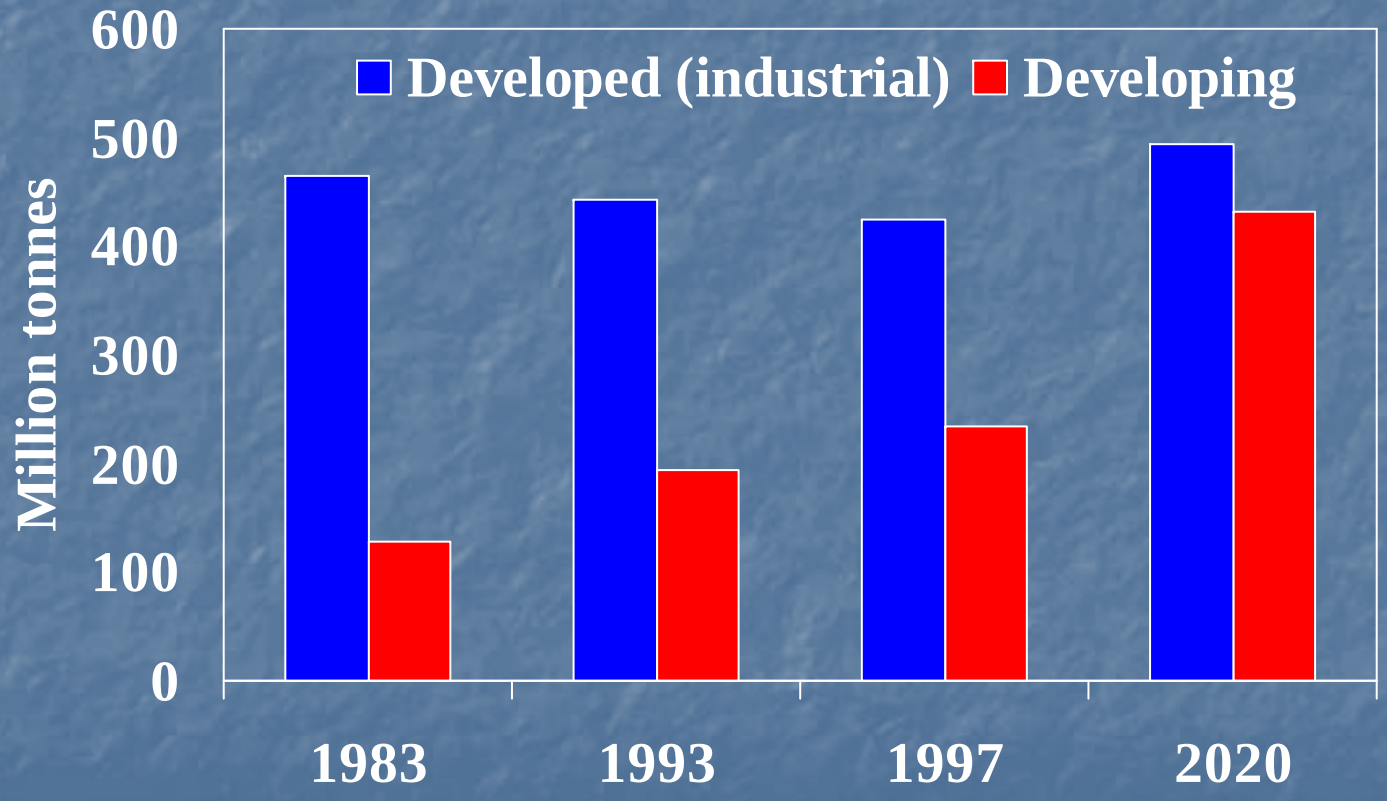
Methane gas bubbles from methane hydrates(?) from a lake in Canada.

The livestock revolution: predicted trade in cereal grain



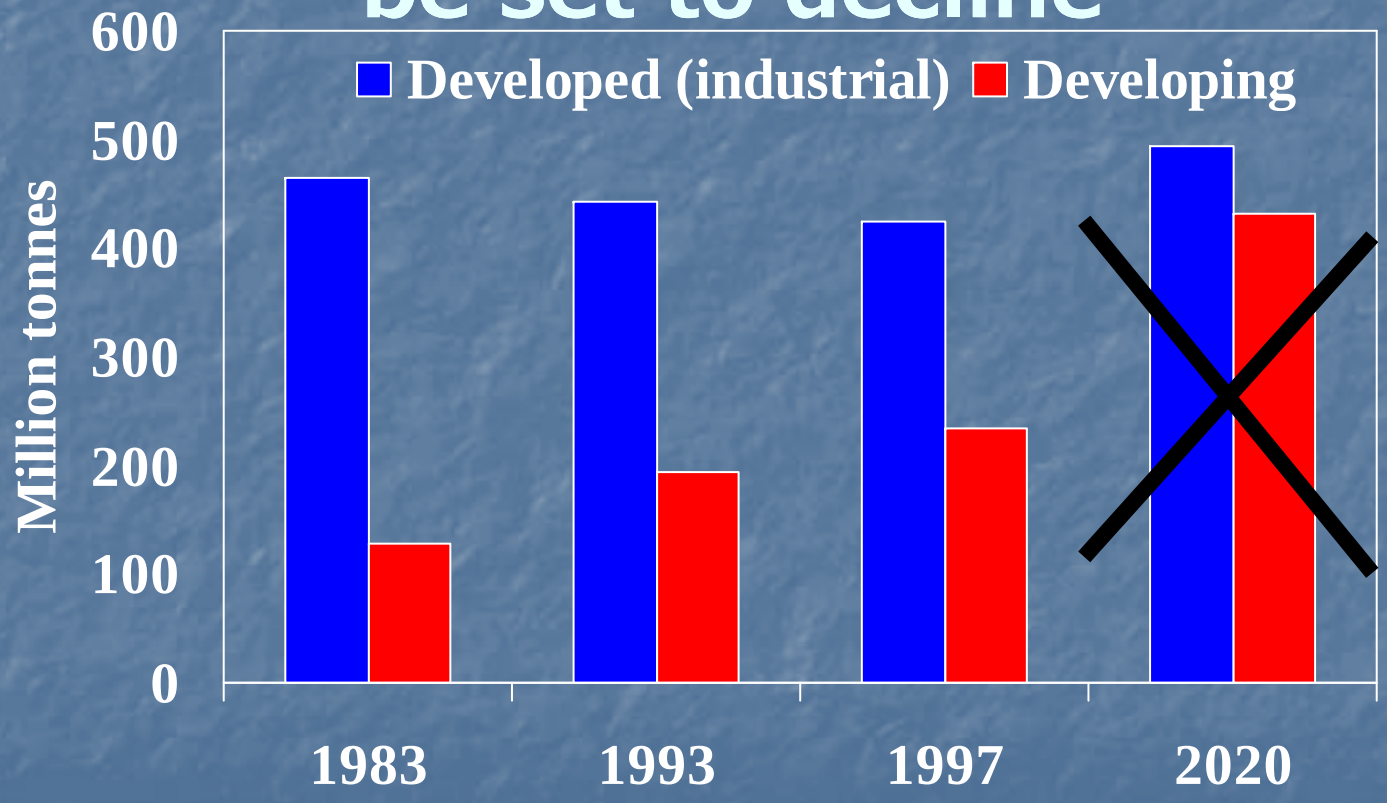
Delgado et al 2002

Trends and predicted use of cereal grain as animal feed in developed and developing countries



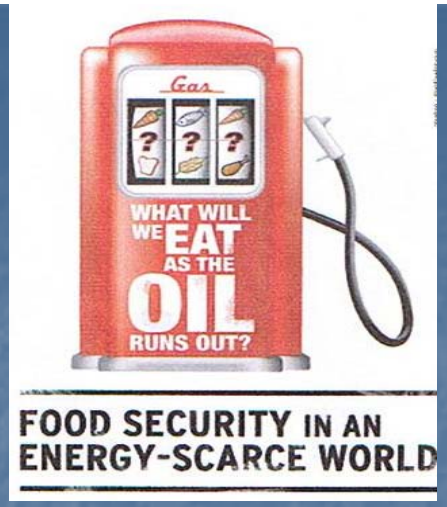
Delgado et al 2002

Trends and predicted use of cereal grain as animal feed (900 MMt) appear to be impossible where world production of 2200 MMt appears to be set to decline



Delgado et al 2002

Implications for animal production enterprises.



- Future massive shortage of cereal grains for humans and animals
- Industrial production ↓ Family farms ↑
- Ruminants and rabbits may be the most likely future candidates integrated with crop production and recycling of wastes
- Herbivorous fish are likely to expand in the region
- Omnivores such as pigs will have special roles in meat production based on local resources

Animal protein is a critical component in the diet of humans

- Poor people in developing countries are often financially constrained to cereal based diets and suffer mental and physical debilitating deficiency of micro nutrients and essential amino acids
- Modern dwarf wheat grain carries on average 20-34% less Zn, Fe, Cu, Se, Mg, then pre-Green Revolution grain varieties.
- For people on mainly cereal based diets (particularly rice), a small daily ration of animal protein corrects these deficiencies.

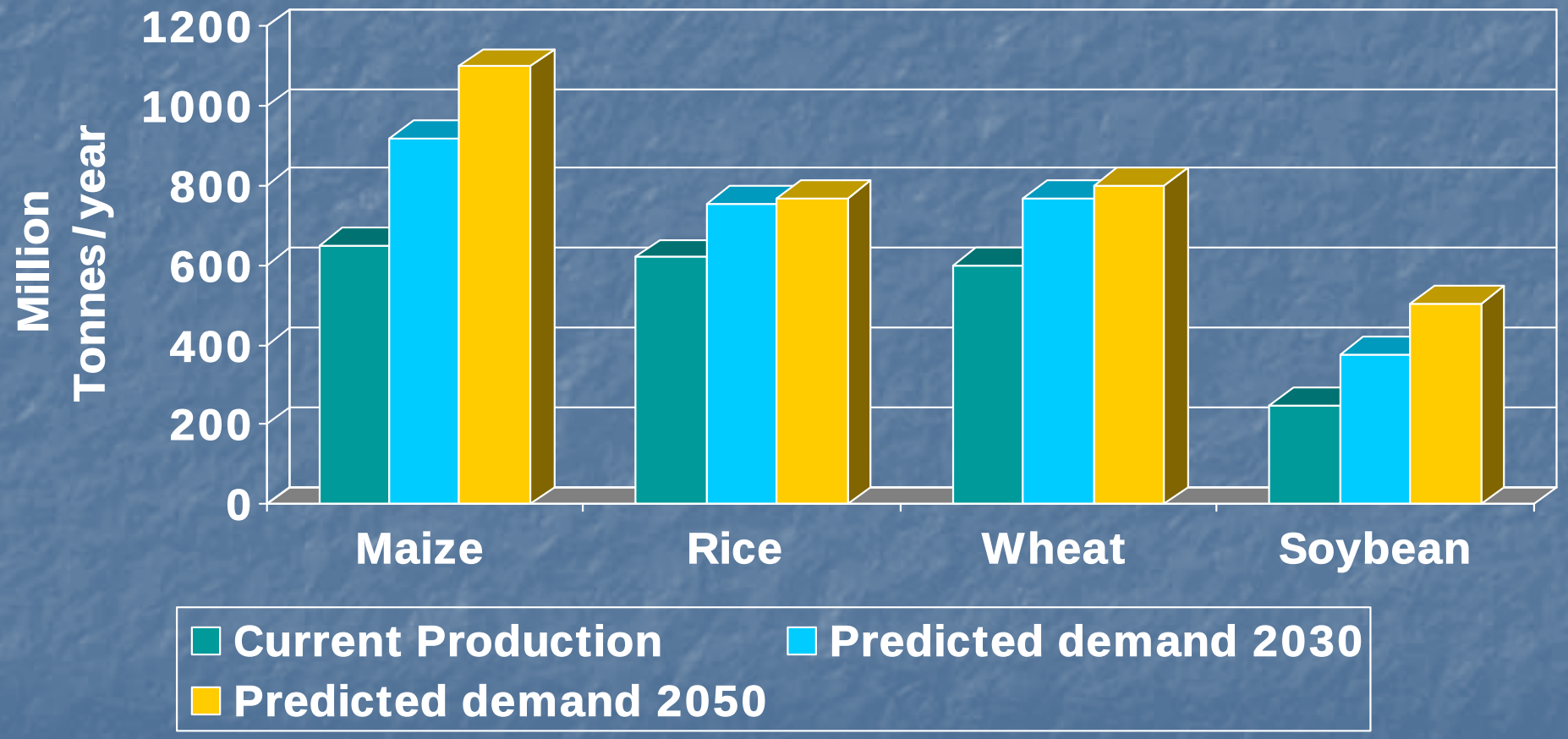
Future animal protein production will depend on herbivores such as ruminants ?

- Ruminants have the capacity to use biomass not used by monogastric animals
- The animal resources are here--Ruminant production is at a low efficiency

  [*1.2 billion large and 2.1 billion small ruminants*]
- The feed resources are here-Crop by-product

  (*world straw production approx 2 billion tonnes +other major under-utilised by products)*

Supply and Demand of Major Cereal Crops*



(*Includes first generation biofuel) from SAGE, FAO stat. World Agriculture to 2050

Priorities in ruminant nutrition are to optimise production from the available feed resources

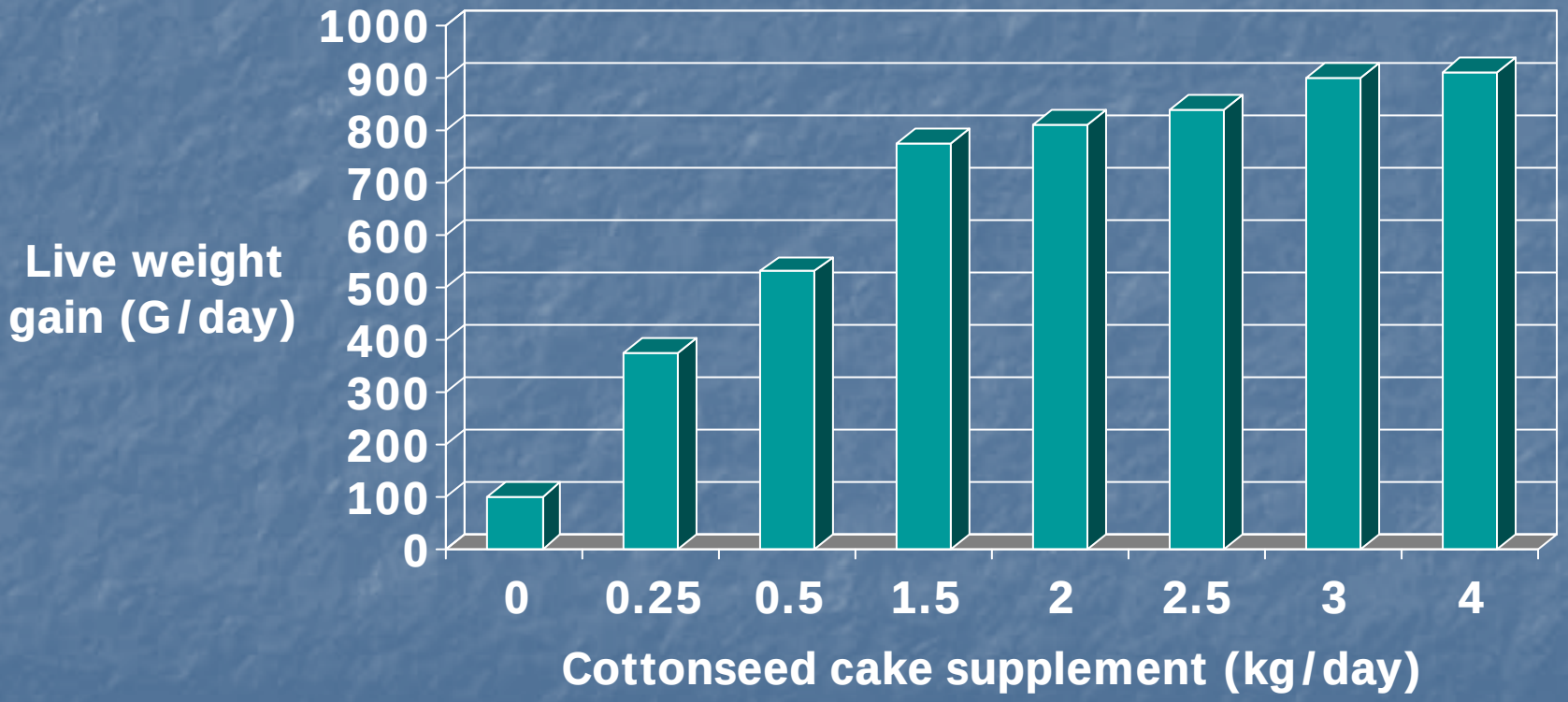
- Optimise forage digestibility
- Balance the nutrition of the rumen microbes to ensure maximum growth
  - Macro and micro minerals
  - Ammonia
  - Sulphur/Phosphorus
- Ensure adequate mineral nutrition
- Feed additional “escape protein” in catalytic amounts

Overcoming the constraints to utilization of biomass by ruminants

Highly fibrous tough composition	Chop or macerate or fractionate
Deficiency of minerals and crude protein to supply	Supplementation with rumen nutrients
No escape or bypass protein	Supplementation with bypass protein
Low and variable digestibility depending on soil and harvest conditions	Treatment with acids or alkalis to improve digestibility
Low bulk density that limits feed intake	Compress or pellet feed

Increasing productivity

Cattle fed ammoniated straw with supplements of cottonseed cake



Dolberg and Finlayson (1995)

Number of young cattle that can be grown-out on 6T of chopped, treated straw and strategic supplementation.

CSC [Kg/day]	Lwt gain [kg/d]	Straw /100kg LWt gain[T]	No. fed on 6 tonne straw
0	.063	6.0	1
0.25	.370	1.1	5+
0.5	.529	0.92	6+
1.5	.781	0.56	10+

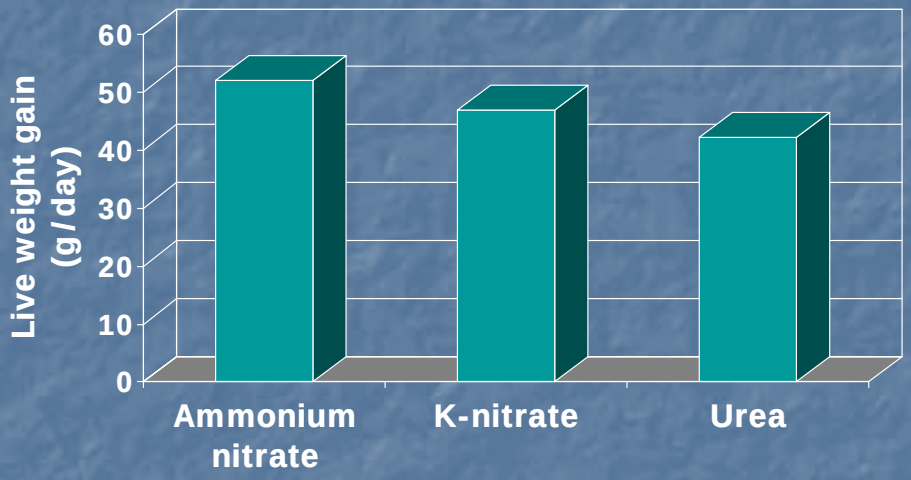
(Leng 2003).

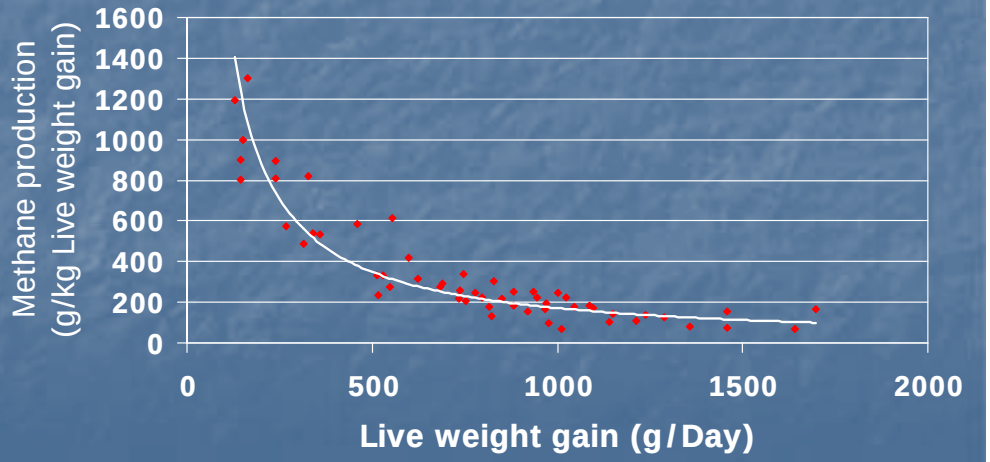
The down side of ruminants as future meat/milk producers-Enteric methane production)

- Methane contributes approx 20 % of global warming
- Ruminant animals produce some 20-30% of global methane (80 million MT)
- Methane is a potent greenhouse gas (21 times more potent then carbon dioxide)

Nitrate supplementation in byproduct diets fed to ruminants could reduce methane production to insignificant amounts.

- Goats adjusted to nitrate as a dietary crude protein grew better then on a urea based diet (Trinh et al 2008)
- Nitrate in the diet at the levels used inhibit enteric (rumen) methane production (Allison MJ, Reddy CA 1984)
- Conclusion, that with development, ruminants fed low protein agro-industrial by products with nitrate will have minimal enteric methane production (Leng 2008)
- So long as growth rate is above 0.75Kg/Kg Lwt gain enteric methane production is minimal (Klieve AV, Ouwerkerk D (2007)





Localized, diversified agriculture appears to be the best option for future food production

- Farms –diversified to produce a variety of products close to centers of population
  - Integrated animal/fish production with cropping
    - Need for local processing
      - Low energy Mini –mills for treatment of lignified by-products
      - Local production of protected proteins from local high protein byproducts
      - Growth of high protein plants for treatment to protect protein (e g duckweed)
    - Recycling of nutrients and water

Decentralized fish farming is part of the animal protein mix needed.

- Aquaculture has been the fastest-growing source of animal protein since 1990, largely because herbivorous fish convert feed into protein efficiently.

- Aquaculture output expanded from 13 million tons in 1990 to 48 million tons in 2005, growing by more than 9 percent a year.

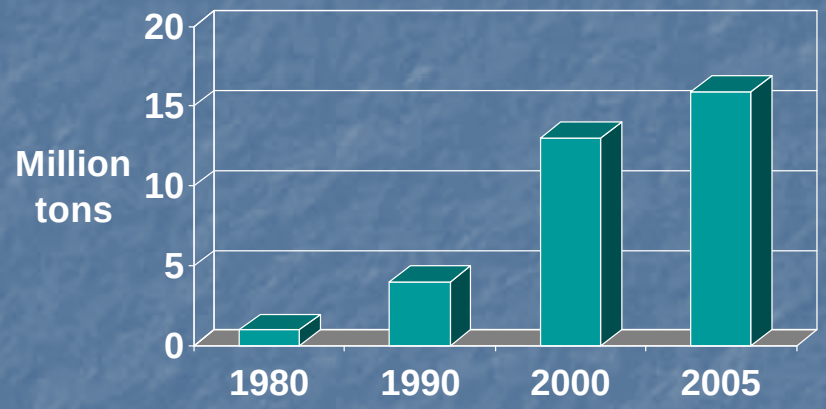
Fish integrate better with herbivorous animal production on byproducts

- **Worldwide, aquaculture is dominated by herbivorous species— Carp in (China and India), Catfish (US) and Tilapia (Asia).**
- **This is where the great growth potential for efficient animal/fish protein production lies-32 million tons of farmed fish produced in China is about 0.3 of the oceanic fish catch**
- **An integrated system of crop residues fed ruminants/rabbits and herbivorous fish seems to be the most likely efficient animal protein production systems for the future.**

China already has working systems for farming herbivorous fish

- China has developed a fish poly-culture using 4 carp species that feed at different levels of the food chain.
- China to produce some 15 million tons of carp in 2005.
- Aquaculture in China-32 million tons, is now twice that of poultry production and 66% of world farmed fish

Increase in carp production in China 1980-2005



Future animal protein production will be from integrated systems –from small to medium sized units close to markets

The example is for a small farm but could be scaled up for larger enterprises such as dairy production

Challenge for the future-integrated production systems with multiple animal/fish species.

- Develop research in natural resource management and sustainability of integrated farming systems
- Provide supportive policies and local infra- structure (local mini-mills for feed preparation and product processing)
- Encourage
  - more aggressive technology application on-farm
  - large scale development of integrated systems for crop animal/fish and energy production


The End –Thank you for your attention
“The presentation is dedicated to those who will not have the benefit of two billion years’ accumulated energy reserves from photosynthesis”
rleng@ozemail.com.au