Food and Agriculture Organization of the United Nations

Food-Feed Competition and The Efficiency Dilemma

Harinder Makkar
Livestock Production Systems Branch
Animal Production and Health Division, FAO, Rome

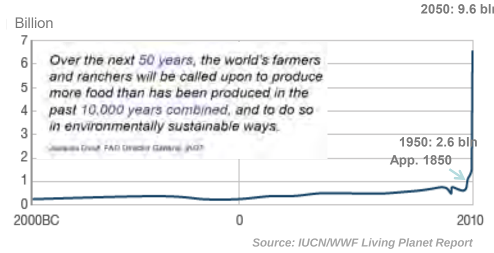
Outline

- Changing Livestock Landscape
- Global Feed Scenarios
- Future Feeds
- The Efficiency Dilemma
- Impact of Food-not Feed Strategy on the Environment, Food Security and Human Diet
- Concluding remarks

Changing Livestock Landscape

The Challenge

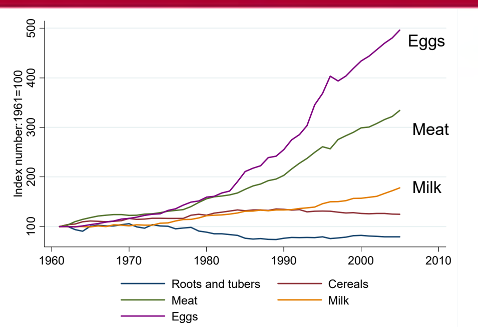
Global Human Population: 2000 BC – 2010 AD



Source: IUCN/WWF Living Planet Report

4

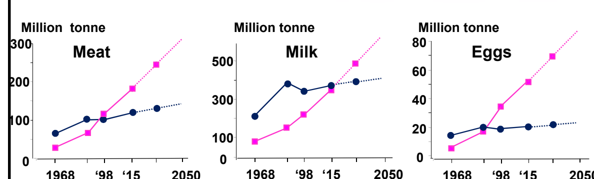
Consumption growing rapidly in developing countries



Per caput consumption of major food items in developing countries – kg per caput per year (index numbers 1961=100)

Expected increase in animal production

World production

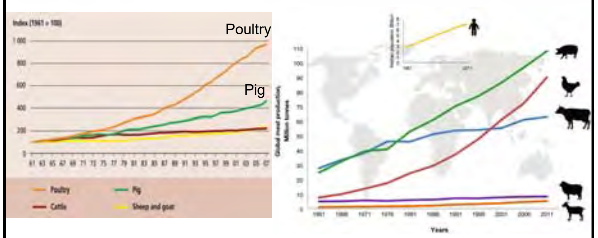


• Industrialized and transition countries ▪ Emerging and developing countries

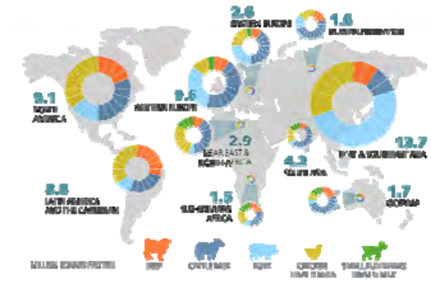
FAO, 2011

Monogastrics progress faster than ruminants

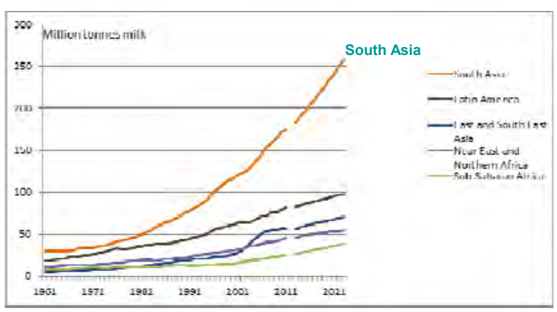
World production of main categories of meat



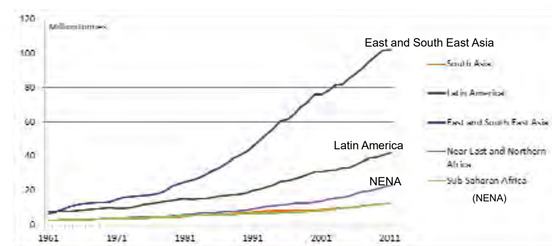
Global livestock production



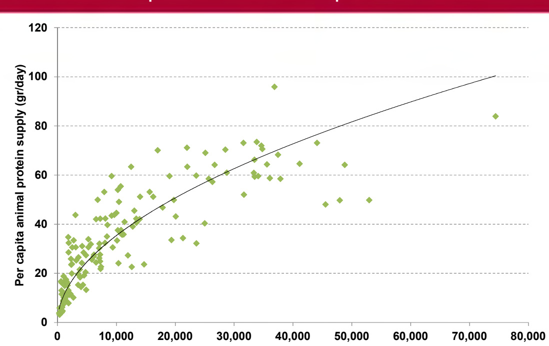
South Asia dominates growth in milk production



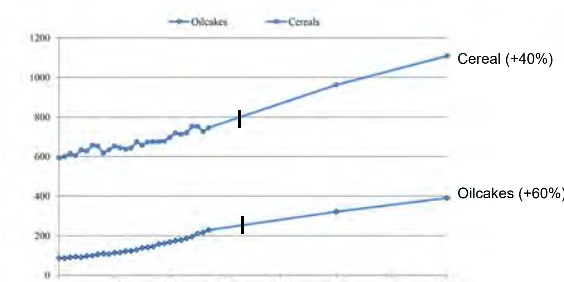
Meat production is growing, with striking regional differences



Relationship between animal protein and income



Oilcakes and cereal use as feed



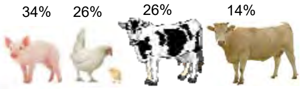
Historical data 1980-2007 from FAOSTAT; Projections: World feed use of Cereals: sum of the country feed projections; World projections of oilcakes feed use: world oilcakes production derived as joint products from the summation of the country production projection of oilcrops.

Food-feed competition

2012–2013: 795 million tonnes cereals (1/3 total cereal) - animal feed

Of the total cereal use in livestock sector

34% 26% 26% 14%

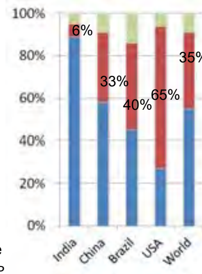


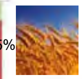
Cereal energy used for meat production, if fed directly

meet

Annual calorie need of 3.5 billion people

Nellemann et al. (2009), UNEP





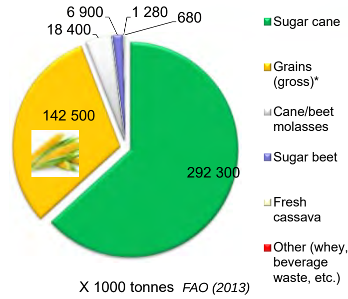
EU: 53%

Fuel-feed competition

A continued rapid expansion of biofuel up to 2050

Undernourished pre-school children

Africa and South Asia being 3 and 1.7 million higher than otherwise *FAO (2009)*

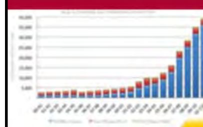


X 1000 tonnes *FAO (2013)*

Future Feed Resources

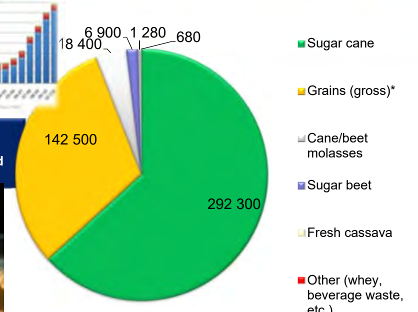
Food-not Feed Resources

2010 world feedstock usage for fuel ethanol (thousand tonne)



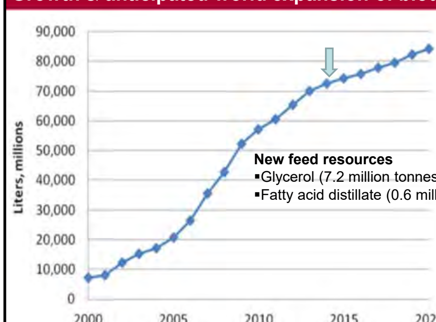
Approximately 1/3 of grain for fuel ethanol produces animal feed co-products

47.5 million tonnes



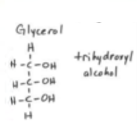
Source: F.O. Licht, 2011

Growth & anticipated world expansion of biodiesel production



New feed resources

- Glycerol (7.2 million tonnes)
- Fatty acid distillate (0.6 million tonnes)

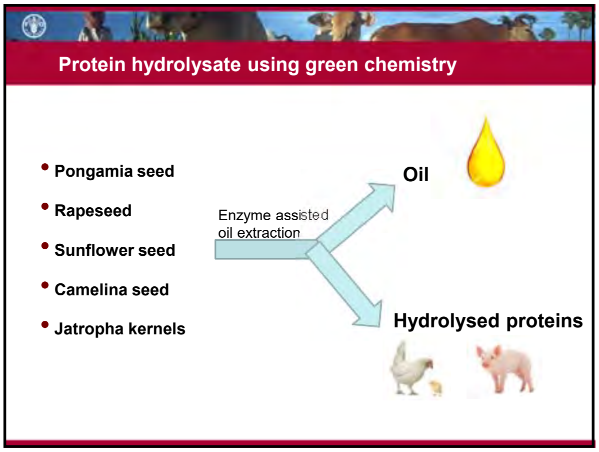


Source: National Biodiesel Board, 2008

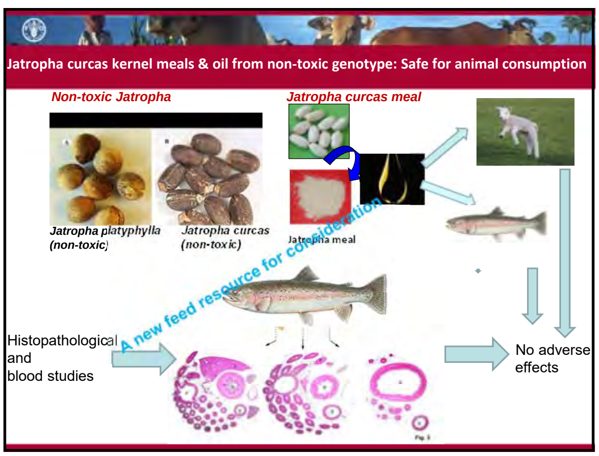
Protein isolate for monogastrcs from unconventional feeds

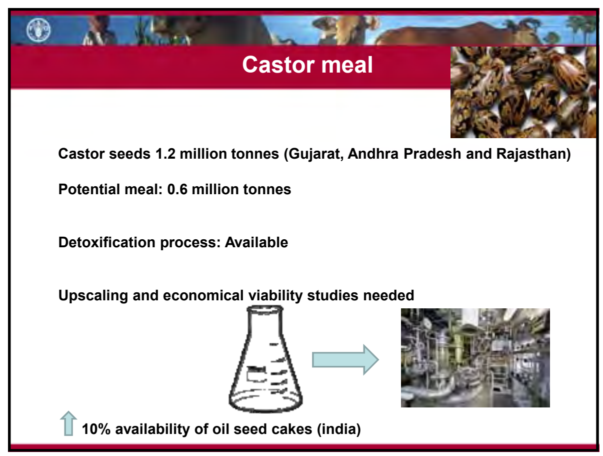
- **Palm kernel cake**
- **Pongamia seed cake**
- **Rapeseed cake**
- **Sunflower cake**
- **Camelina seed cake**
- **Green leuminous forages**

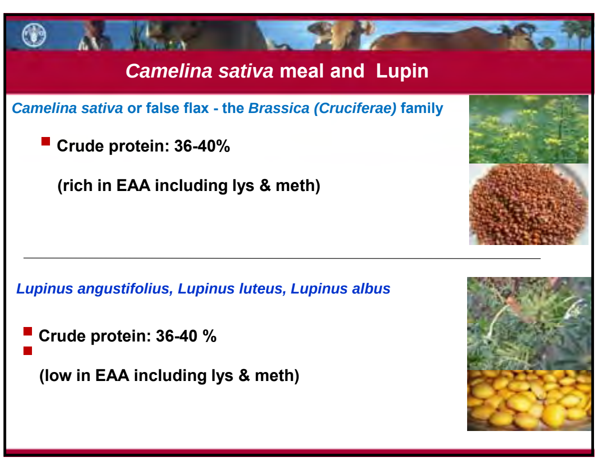
Iso-electric pH → **Protein isolate (80-90% CP)**

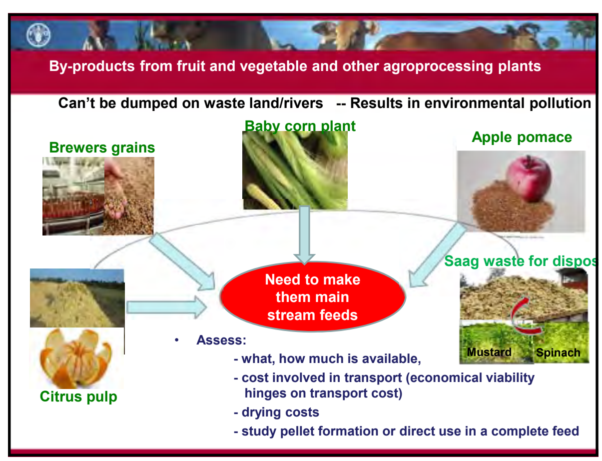

Protein hydrolysate using green chemistry
Pongamia seed
Rapeseed
Sunflower seed
Camelina seed
Jatropha kernels
Enzyme assisted oil extraction
Oil
Hydrolysed proteins

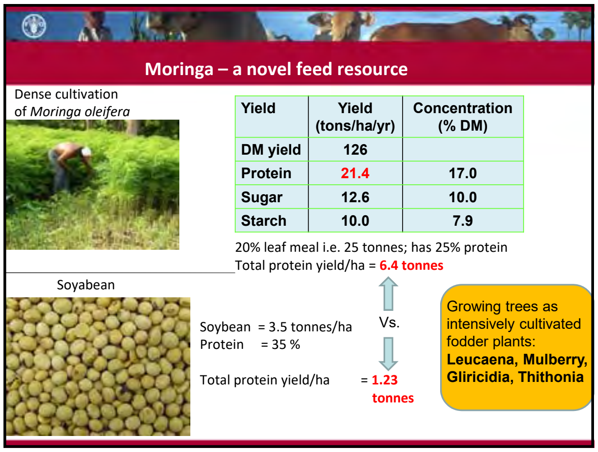

Seaweeds (macro-algae)
Brown algae up to 14% CP
Red Algae up to 50% CP
Green algae up to 30% CP
Rich in bioactive compounds (reduction in enteric methane)
Pre-biotics: alginates, mannitol, laminarin, fucoidan
Source of organic minerals
Seaweed polysaccharides have positive effect on reducing digestive infections in calves, prevent ketosis, boost immunity and reduce metabolic dis
Future areas of work: Develop large scale production, harvesting and drying methods
Animal Feed Science and Technology
Seaweeds for livestock diets: A review
Red seaweed:Asparagopsis -a star performer


Jatropha curcas kernel meals & oil from non-toxic genotype: Safe for animal consumption
Non-toxic Jatropha
Jatropha curcas meal
Jatropha platyphylla (non-toxic)
Jatropha curcas (non-toxic)
Jatropha meal
A new feed resource for consideration
Histopathological and blood studies
No adverse effects


Castor meal
Castor seeds 1.2 million tonnes (Gujarat, Andhra Pradesh and Rajasthan)
Potential meal: 0.6 million tonnes
Detoxification process: Available
Upscaling and economical viability studies needed
10% availability of oil seed cakes (india)


Camelina sativa meal and Lupin
Camelina sativa or false flax - the Brassica (Cruciferae) family
Crude protein: 36-40%
(rich in EAA including lys & meth)
Lupinus angustifolius, Lupinus luteus, Lupinus albus
Crude protein: 36-40 %
(low in EAA including lys & meth)

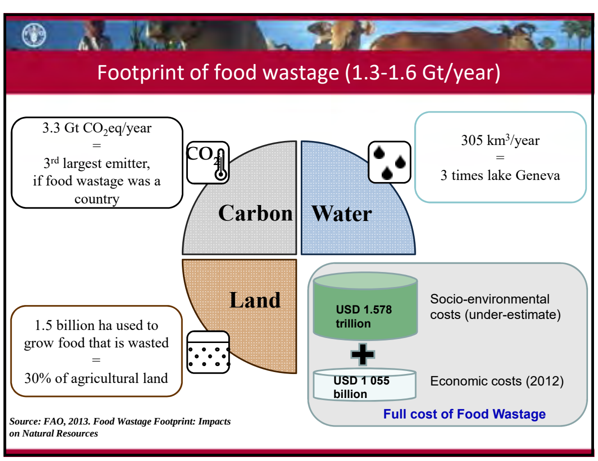

By-products from fruit and vegetable and other agroprocessing plants
Can't be dumped on waste land/rivers -- Results in environmental pollution
Brewers grains
Baby corn plant
Apple pomace
Saag waste for dispos
Need to make them main stream feeds
Mustard
Spinach
Citrus pulp
Assess:
- what, how much is available,
- cost involved in transport (economical viability hinges on transport cost)
- drying costs
- study pellet formation or direct use in a complete feed

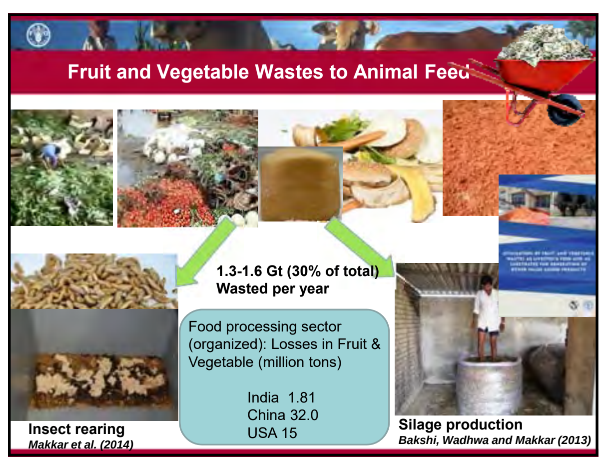

Moringa – a novel feed resource
Dense cultivation
of Moringa oleifera
Yield | Yield (tons/ha/yr) | Concentration (% DM)
DM yield | 126 |
Protein | 21.4 | 17.0
Sugar | 12.6 | 10.0
Starch | 10.0 | 7.9
20% leaf meal i.e. 25 tonnes; has 25% protein
Total protein yield/ha = 6.4 tonnes
Soyabean
Soybean = 3.5 tonnes/ha
Protein = 35 %
Vs.
Total protein yield/ha = 1.23 tonnes
Growing trees as intensively cultivated fodder plants:
Leucaena, Mulberry, Gliricidia, Thithonia


Insect as feed for poultry, pigs and fish
Black Soldier Fly or Hermetia illucens
Maggots: larvae of the housefly Musca domestica
▪ Protein quality is generally high, similar to other animal meat sources
▪ Protein content: ca 50%
▪ Fat content is variable, but in general a good source of essential polyunsaturated fatty acids
▪ A significant source of iron, zinc and vitamin A.
Challenges: Mass production at an industrial scale, safety issue and regulatory aspects
Source: Makkar et al (2014): AFST


Thorn-less cactus (Opuntia ficusindica) as animal feed
Brazil
200 – 260 tonnes/ha
Intensive system
Smallholder system
Only 250 litres/kg
Tunisia (alley farmin
30 – 100 tonnes/ha


A multipurpose plant
Cactus:
a cash-crop
TUNA 200 KILO
Prickly Pear
Cactus Medicine


Footprint of food wastage (1.3-1.6 Gt/year)
3.3 Gt CO2eq/year
=
3rd largest emitter, if food wastage was a country
Carbon
Water
305 km3/year
=
3 times lake Geneva
Land
1.5 billion ha used to grow food that is wasted
=
30% of agricultural land
USD 1.578 trillion
Socio-environmental costs (under-estimate)
USD 1 055 billion
Economic costs (2012)
Full cost of Food Wastage
Source: FAO, 2013. Food Wastage Footprint: Impacts on Natural Resources


Fruit and Vegetable Wastes to Animal Feed
1.3-1.6 Gt (30% of total)
Wasted per year
Food processing sector (organized): Losses in Fruit & Vegetable (million tons)
India 1.81
China 32.0
USA 15
Insect rearing
Makkar et al. (2014)
Silage production
Bakshi, Wadhwa and Makkar (2013)

Reduce losses of feed resources

Making of densified total mixed ration blocks

Forage
Wheat straw, paddy straw, sorghum stalks, Sugarcane tops, bagasse etc.

Concentrate
Oilseed cakes, urea, molasses or other energy sources,

Mixes
Vitamin mix, mineral mix, probiotics, additives, anti-oxidants, antitoxins, etc.

Machine for mixing of chopped straw and concentrate

Hydraulic press for making densified blocks

South-South partnerships

Advantages of Densified straw-based blocks

- Less wastage
- Higher productivity
- Good feed for emergency situations

Easier to feed by farmers

Setting up of National Feed Grid & Fodder Banks possible.

Can discourage straw burning

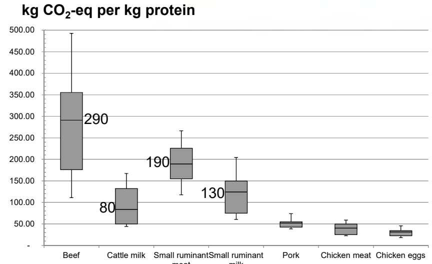
Enhanced public-private partnership will increase adoption of the straw-based total mixed ration technology

Thinking efficiency in multi-dimensions

Estimated global emission intensities (Ei)

Livestock commodities

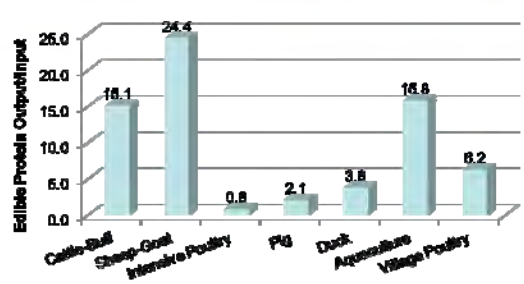
kg CO_2-eq per kg protein



FAO 2013

35

Human edible protein output-input ratio



Mean based on data from India, Pakistan, Bangladesh, Thailand, Bhutan, Mongolia.

Livestock Protein Balances

	EDIBLE PROTEIN OUTPUT/INPUT	EDIBLE PROTEIN OUTPUT-INPUT TONNES
	AV.2005 2007	AV.2005 2007
Saudi Arabia	0.10	650 588
USA	0.53	-7 850 830
Germany	0.62	-1 183 200
China	0.95	[illegible]76
Netherlands	1.0[illegible]	[illegible]
Brazil	1.1[illegible]	[illegible]
Nepal	1.88	[illegible]803
India	4.30	3 379 440
Sudan	8.75	340 895
New Zealand	10.06	638 015
Mongolia	14.00	35 858
Ethiopia	10.95	141 395
Kenya	21.10	202 803

India: Net contribution equivalent to protein needs for 150 million people

Addressing efficiency dilemma

One lactation — Emission intensity (kg CO_2 eq./kg milk), at farm gate

India smallholder dairy farms: up to 2.07 (C), 3.73 (B)(lactation, feed prod.) .. Garg et al. 2016
Kenya smallholder farms = 2.8 (up to 9) — FAO (2015)

Swedish dairy farm	0.90–1.04	van der Werf et al., 2009
French dairy farm	1.04	van der Werf et al., 2009
W. Europe	1.47 (herd basis & feed prod.)	FAO (2013)
North America	1.33 (herd basis & feed prod.)	FAO (2013)

Human edible protein output/human edible protein input

India, milk	10.9	FAO/NIANP (2016)
Jordan, milk	0.60	Hawileh, 2015
USA, milk	1.81	Baldwin, 1984; CAST, 1999)
UK, milk	1.41	Wilkinson, 2011

Vs.

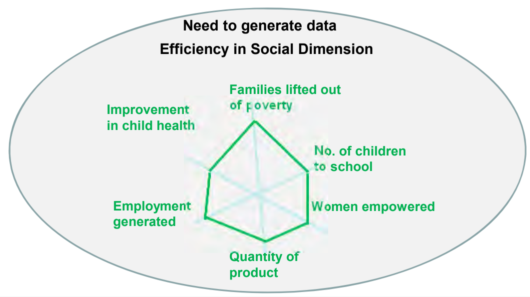
Should we consider only emission intensity?

Anticipated: Emission intensity (kg CO_2 eq./kg milk) on the label !!!!

8 Nov 2016, Nature Climate Change

Addressing an efficiency dilemma

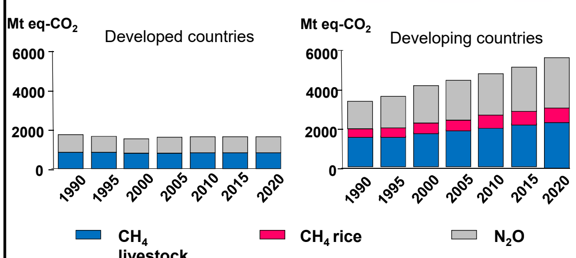
We need to think of efficiency in multiple dimensions



Setting the scene

Expected increase in environmental impacts

Example of non-CO_2 GHG

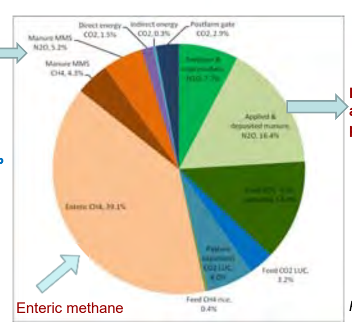


IPCC, 2007

Feed and Environment

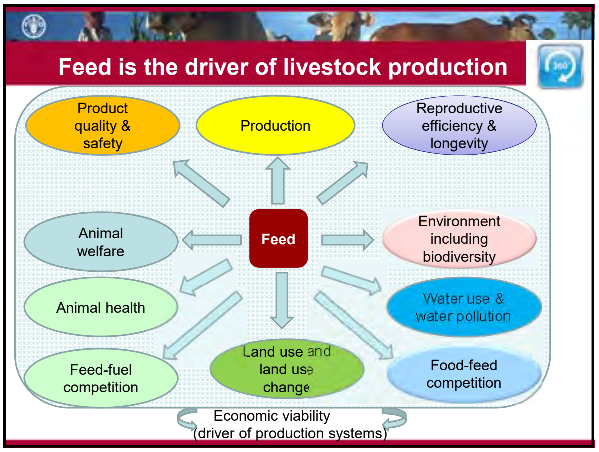
Feeding practices

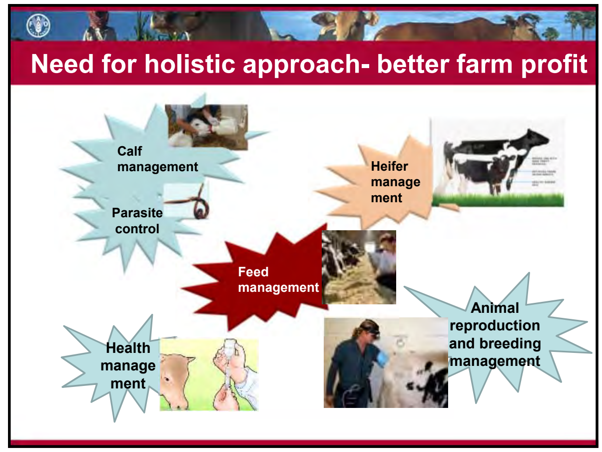
70–90% of Feed P to Manure



Feed production and processing: 45 %

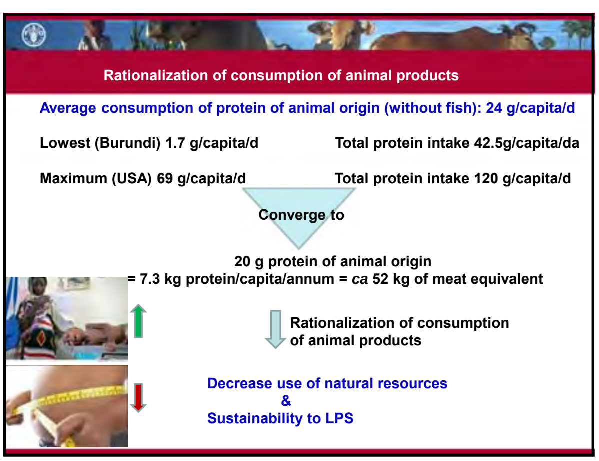
FAO (2013)

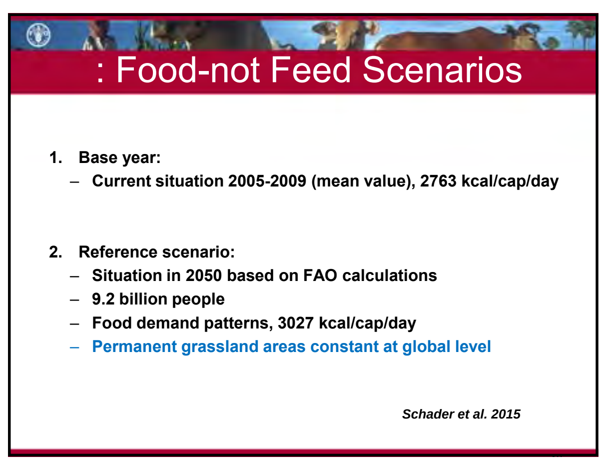

Feed is the driver of livestock production
Product quality & safety
Production
Reproductive efficiency & longevity
Animal welfare
Feed
Environment including biodiversity
Animal health
Water use & water pollution
Feed-fuel competition
Land use and land use change
Food-feed competition
Economic viability (driver of production systems)


Need for holistic approach- better farm profit
Calf management
Heifer manage ment
Parasite control
Feed management
Animal reproduction and breeding management
Health manage ment

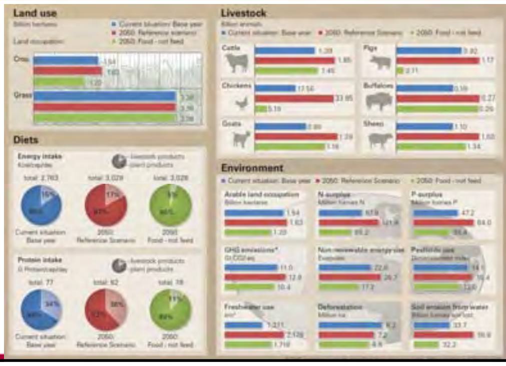

Family in USA, Weekly food budget of US$ 300


(C) Peter Menzel www.menzelphoto.com


Rationalization of consumption of animal products
Average consumption of protein of animal origin (without fish): 24 g/capita/d
Lowest (Burundi) 1.7 g/capita/d
Total protein intake 42.5g/capita/da
Maximum (USA) 69 g/capita/d
Total protein intake 120 g/capita/d
Converge to
20 g protein of animal origin
= 7.3 kg protein/capita/annum = ca 52 kg of meat equivalent
Rationalization of consumption of animal products
Decrease use of natural resources
&
Sustainability to LPS


: Food-not Feed Scenarios
1. Base year:
– Current situation 2005-2009 (mean value), 2763 kcal/cap/day
2. Reference scenario:
– Situation in 2050 based on FAO calculations
– 9.2 billion people
– Food demand patterns, 3027 kcal/cap/day
– Permanent grassland areas constant at global level
Schader et al. 2015

Overview of results



Schader et al. 2015

Take Home Messages

Several human-inedible resources are available and a number of such novel feed resource will be available in the future. Research is required to increase availability of such feed resources

Opportunities exist to convert food waste and loss to animal feed and to learn from East Asian countries

We need to think efficiency in multi-dimension (taking efficiency units in all three-P dimensions), so that LPS can be presented in the right perspective.

Take Home Messages

Improving efficiency of animal food production, distribution and use as well as decreasing their consumption would be some important steps towards sustainable food production systems of the future

Research and innovations towards use of human-inedible feeds without compromising animal production would lead to more sustainable food systems

Only Sound Science can Lead to Sound Policies