Food and Agriculture Organization of the United Nations

Animal Nutrition in a 360 degree view and sustainability of Asian dairying

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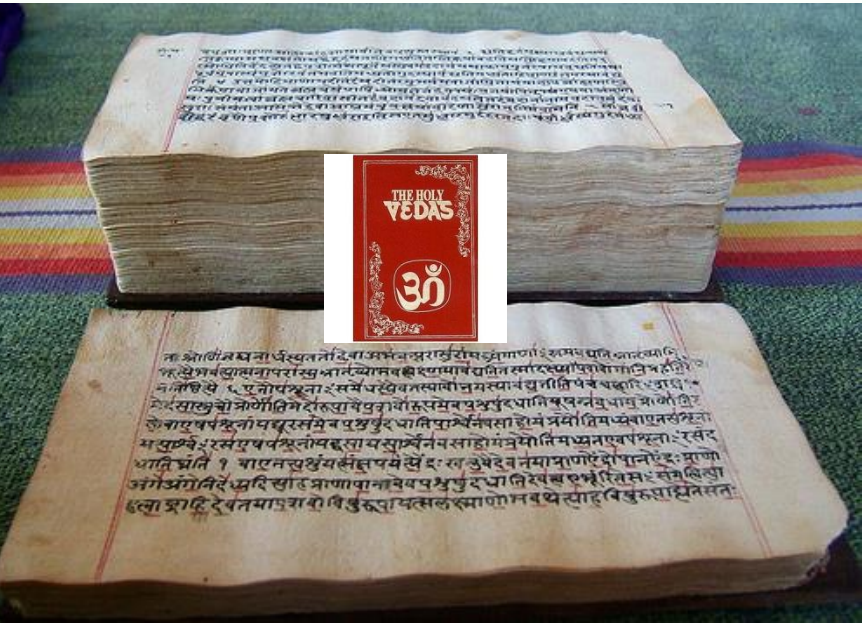
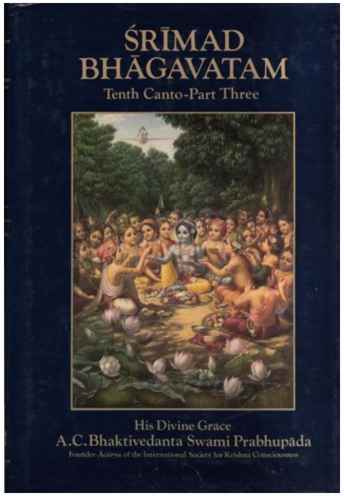
Outline

- Animal nutrition – a historical perspective
- Animal nutrition – from linear to 360 degree view
- Possible direction – a framework for future strategic R & D work for sustainable Asian dairying
- Addressing an efficiency dilemma – an urgent call
- Take home messages

Animal Nutrition: a historical perspective



Secret ancient Hindu scriptures, the Vedas:
Protecting the cow (go-rakshya)
Worshiping the cow (go-puja)
Serving the cow (go-seva)



The Srimad- Bhagavatam:
how Lord Krishna takes the cows and calves every morning to graze on the pastures of Govardhana Hill and how He protected them from toxic plants

Feeding based on local knowledge and without chemical analysis -- before 1800

Some post-1800 period milestones

19th Century: Magendie developed methods for animal feeding experiments:

Utilizing diets of pure carbohydrates and fats, showed that food-N was essential (*Ann Chim Phys (ser 1). 1816; 3:66–77*).

Mid-19th Century: Boussingault developed the concept of basic elements (C, N, P, O) in balance studies with dairy cows (*Ann Chim Phys (ser 2).1839;71:113–127*). To study nutrition and physiology of lactation,

Late 19th & early 20th Centuries: Roles of proteins, carbohydrates, fats, vitamins and micronutrients in animal and human nutrition were broadly described

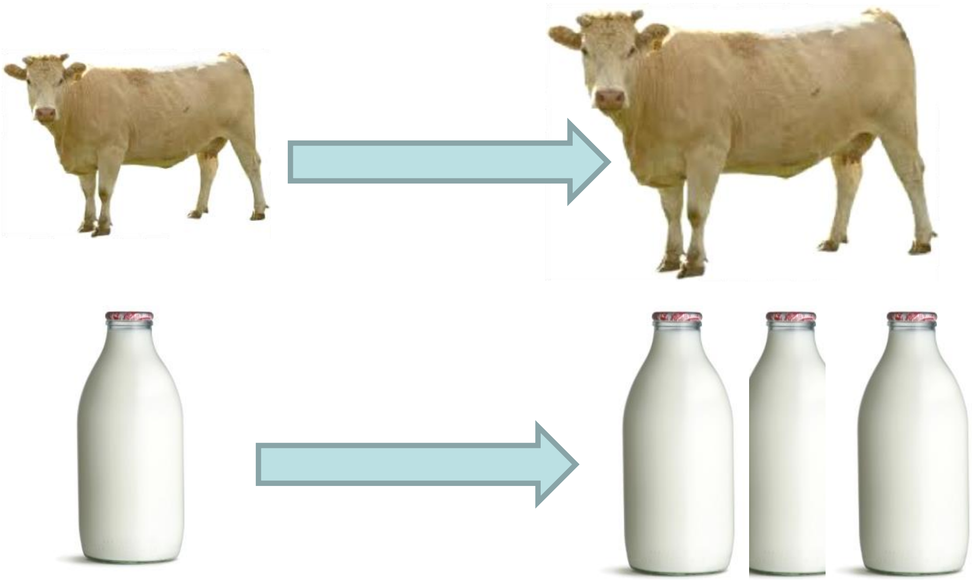
Early to mid 20th Century: DE, ME and NE concepts developed

Mid 20th Century onwards: Estimation of nutrient requirements for most species of domestic animals

From late 20th Century onwards: Nutrigenomics, nutriproteomics, and metabolomics, synthetic biology, *in utero* nutrition, nanotechnology, etc.

Animal Nutrition: till the 20th Century

Objective: maximize animal production



Animal nutrition: science of preparation of feed and its feeding to animals

Animal Nutrition: 360 degree view (future)

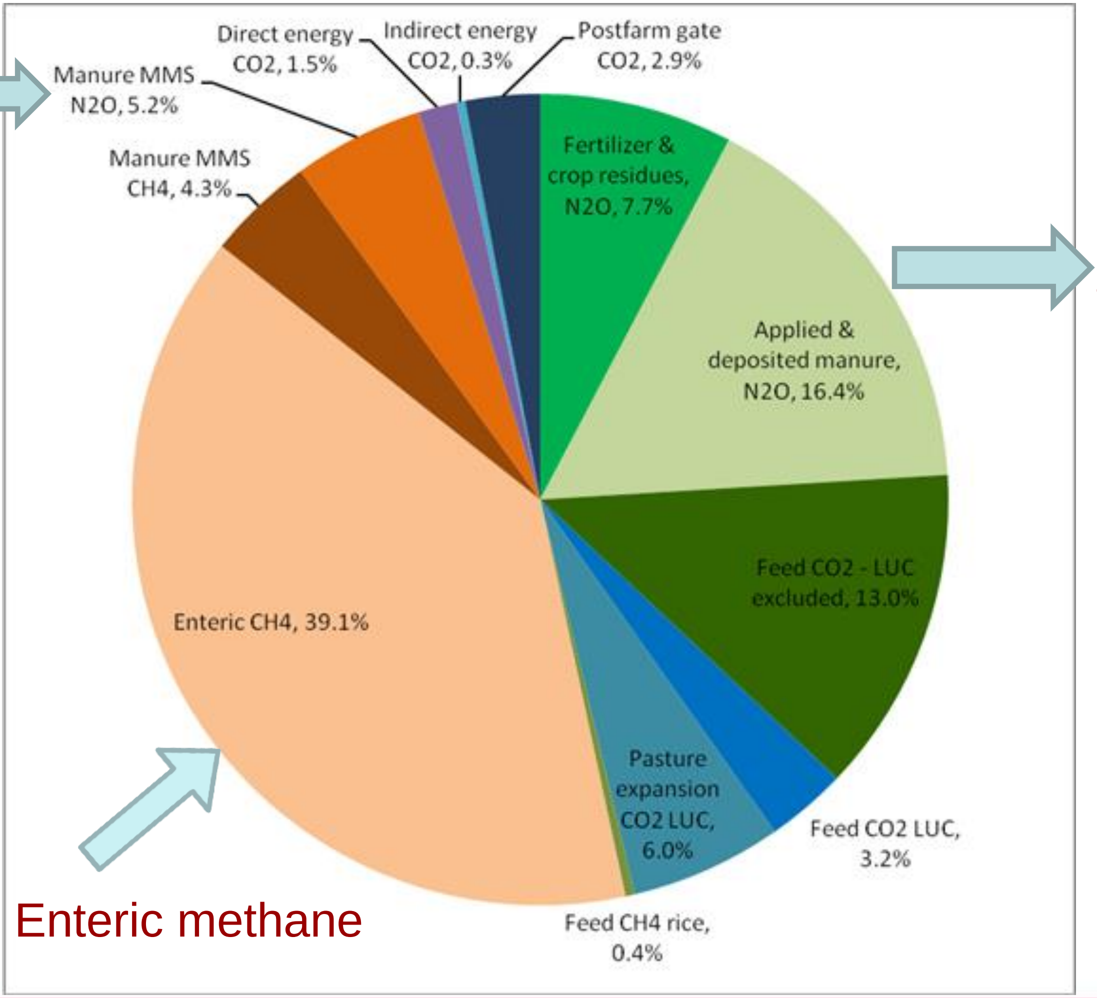
- *Planet*
- *People*
- *Profit*
- *Ethical*

Interactions with different components of bio-physical and socio-economic systems

Feed and the environment (GHG)

Global GHG emissions from livestock supply chains (14.5%), by category of emissions

Feeding practices



Feed production and processing: 45 %

70–90% of Feed P to Manure

Enteric methane

FAO (2013)

Feed and the water use

- Livestock use 15% of global agriculture water
- >90% of water use by livestock is used to produce feed
- Water/kg grain:
  - -- Temperate countries: 1000-2000 kg
  - -- Middle East: 3000-5000 kg

Feed and the land use, land use change and biodiversity

Land

- Area dedicated to feed-crops

  -- 33% of total arable land

- 3.36 billion ha in permanent meadows and pastures
- 1.53 billion ha in arable & permanent crops

- Feed induced land use change: 9% GHG

(Gerber et al., 2013)

Biodiversity

-- Disruption of N-cycle because of huge soybean movement from S to N

-- Water pollution

-- Move towards intensification with limited number of animal breeds and feed resource

Nutrition and animal product safety

Toxic agents:

- Microbiological agents: *Salmonella*, *E. coli* O157, *Listeria*, endoparasites, *Aspergillus*, *Fusarium*
- Industrial & environmental toxins: dioxin, dibenzofurans, dioxin-like polychlorinated biphenyls, melamine, heavy metals, pesticides, radionuclides
- Plant toxins: alkaloids, glucosinolates, di- & tri-terpenes

Feed Safety: *Animal product hotspots*

- Bovine Spongiform Encephalopathy in UK and in most of EU, Japan, Israel, USA, etc.
- Dairy, eggs and poultry contaminated with dioxins and PCBs in Belgium and other European countries
- Chicken with nitrofurans in UK, Thailand and Brazil
- Pork with clembuterol in China
- Pork and its products with dioxins in Ireland
- Milk and dairy with aflatoxins in Europe
- Salmonella infection in many European countries
- *E.coli* O157:H7 infection in USA and Japan
- Listeriosis in USA and France

Antmicrobial Resistance: A Global and Multi-sectorial Concern

Antibiotic resistance sweeping developing world

Bacteria are increasingly dodging extermination as drug availability outpaces regulation.

Call for global action on antimicrobial resistance

Antimicrobial Resistance,

Deaths/year

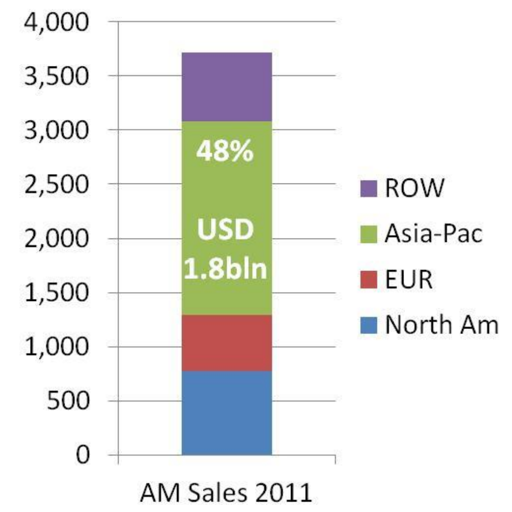
- **25,000 – EU**
- **500,000 – Global (est.)**

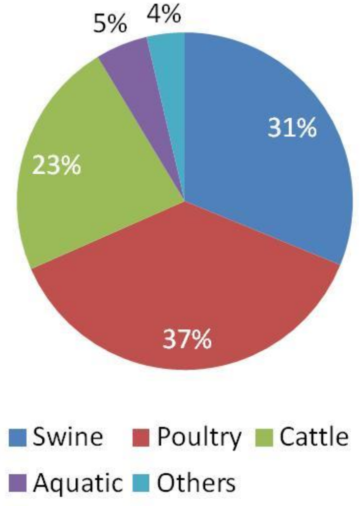
USA health care costs

- **$ 20 bn/yr**

Lost productivity

- USA **$ 35 billion/yr**
- EU **€ 1.5 billion/yr**





Feed safety and feed/food losses

Annual loss due to aflatoxin

US$ 900 million in PHIL, INDO & THAI

US$ 225 million in the US

Fungus

Safe feed helps to:

reduce feed and food losses and wastes

Contaminated feed has often resulted in food of animal origin being recalled and/or destroyed

Economic loss

-ve impact on food security

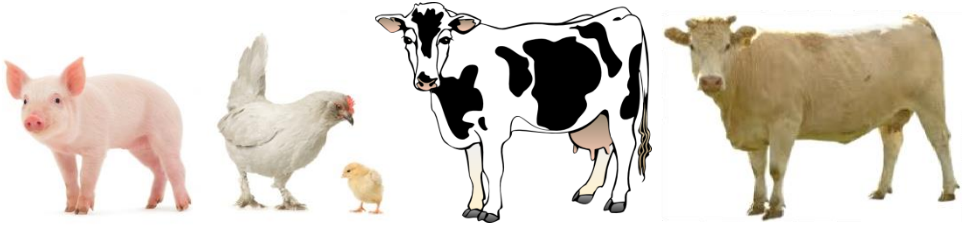
Max. limit (CODEX) for Aflatoxin B1 in feed/feed ingredients = 20 ppb

Animal nutrition and 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%

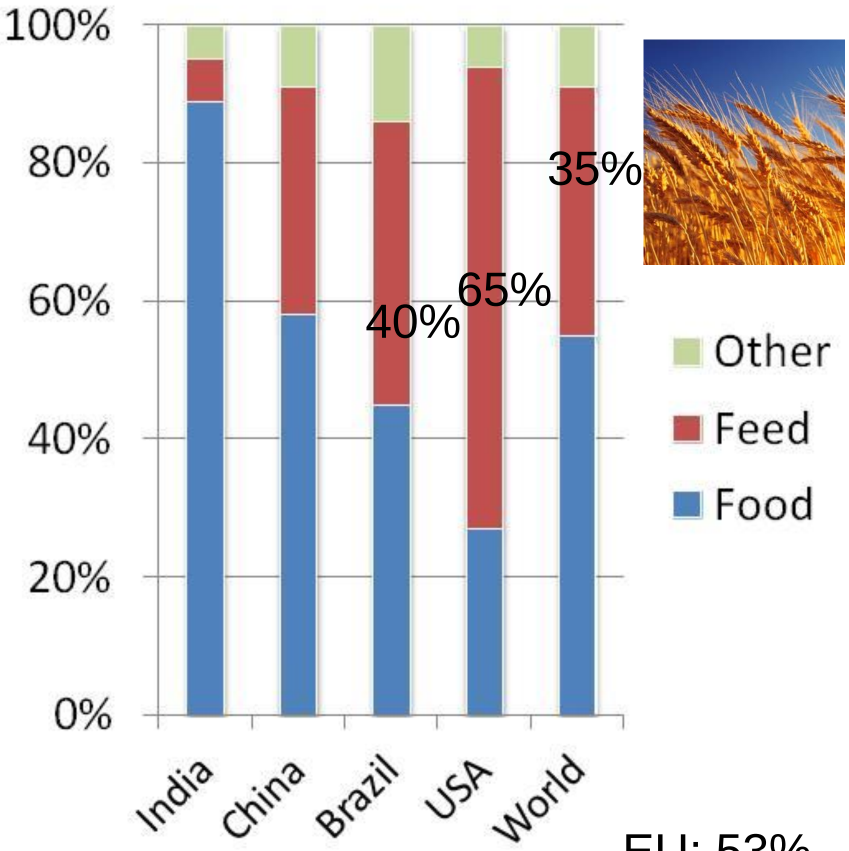


Cereal energy used for meat production, if fed directly

meet

Annual calorie need of 3.5 billion people

Nellemann et al. (2009), UNEP



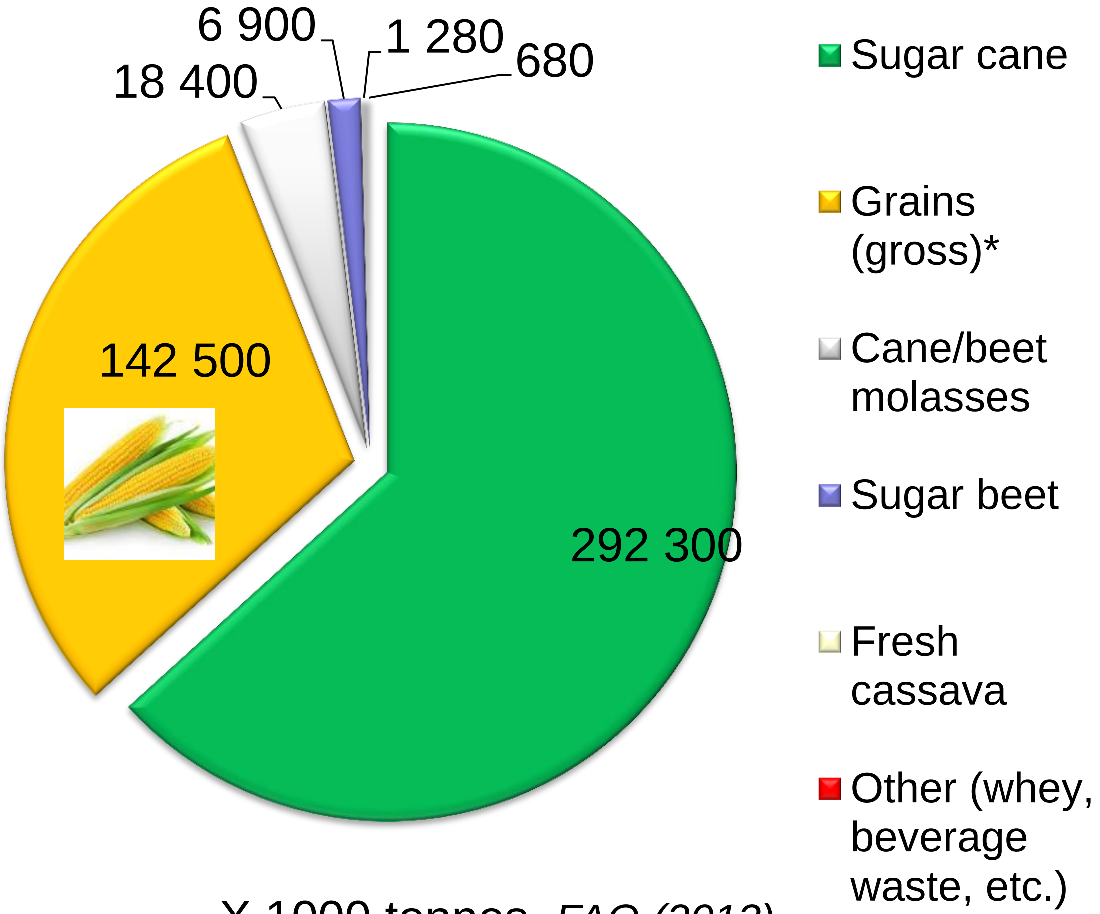
EU: 53%

Animal nutrition and 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)*

Nutrition: foundation for animal wellness

- **Low plan of nutrition of calves**
  - impairs immune function
  - leads to short- and long-term health & welfare consequences
- **Inadequate energy to cow just after calving**
  - subclinical and clinical ketosis
- **High grain**
  - acidosis and lameness
- **Low Ca diet just after parturition**
  - cows with milk fever; increased risk of developing dystocia, displaced abomasum, uterine prolapse

FAO (2012)

Impact of nutrition on animal health

- **Improper nutrition:**

  -- impacts health adversely directly
  -- decreases immunity
  -- in case of disease, corrective measures in the form of medicines are less or not effective. Vaccination might also not properly protect the animals.

- **Good nutrition is also a biosecurity measure**

FAO (2015)

Nutrition and animal product quality

Saponins: meat shelf life

Phenols: antioxidation potential of milk

Tannins: meat colour

Grass-based diets enhance:

a) conjugated linoleic acid (CLA) isomers, trans vaccenic acid (TVA) , a precursor to CLA, and omega-3 (n-3) FAs on a g/g fat basis

b) precursors for Vitamin A and E, as well as cancer fighting antioxidants

Butler (2014); Vazirigohar et al., 2014

Animal nutrition and its impact on animal production

Good feeding increases

- milk production of lactating animals
- growth rate of meat producing animals
- reproductive efficiency: lower age at first calving, lower inter-calving period, higher cyclicity, higher productive life (higher profitability to farmers)

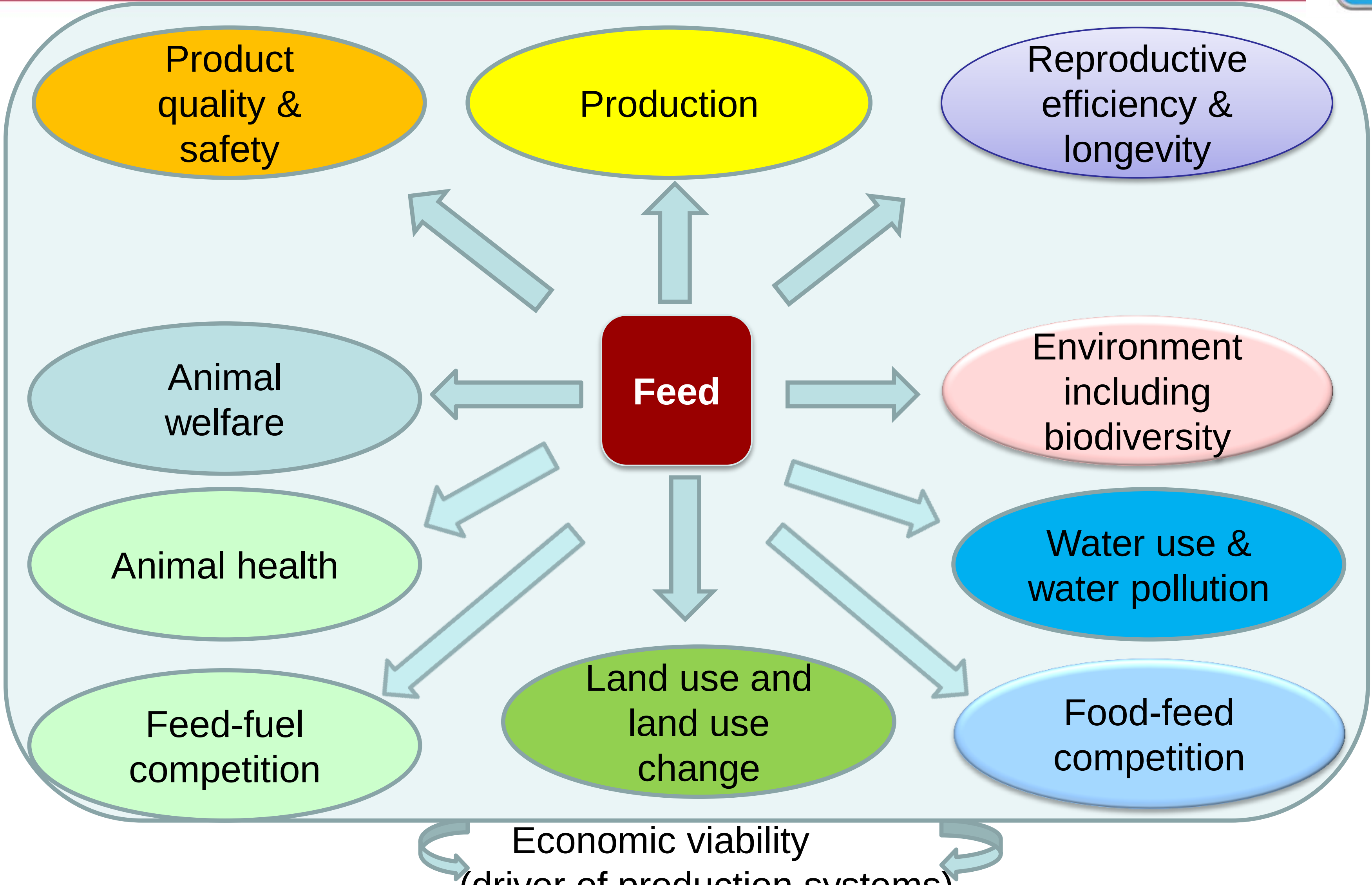
In utero nutrition impacts productivity & health of offsprings later in life

FAO/IAEA (2002) and Bell and Greenwood (2013)

Nutrition and farm economics

- Feed cost can account for up to 70% of the total cost of production
- Feed is financially the single most important element of animal production
- High feed costs can wipe out a livestock rearing operation

Animal Nutrition (Feed & Feeding): A 360º View



A framework for future strategic R & D in animal nutrition for sustainable dairying

Pillar-1

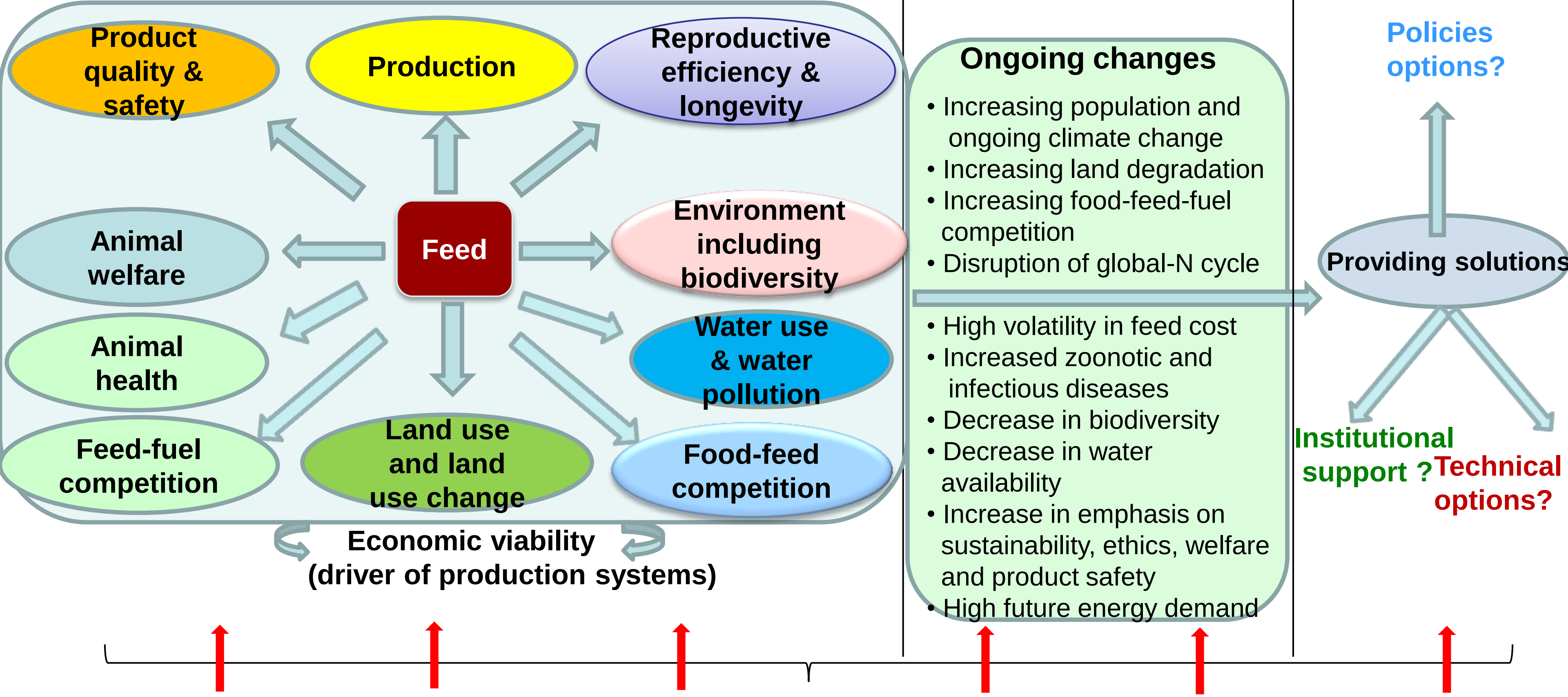
Better understanding of trade offs & synergies between various components of the 360 degree view and generation of quantitative relationships

Pilar-2

Better insight into impact of ongoing changes on interactions

Pillar-3

Providing solution



Feed

Product quality & safety

Production

Reproductive efficiency & longevity

Animal welfare

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)

Ongoing changes

- Increasing population and ongoing climate change
- Increasing land degradation
- Increasing food-feed-fuel competition
- Disruption of global-N cycle
- High volatility in feed cost
- Increased zoonotic and infectious diseases
- Decrease in biodiversity
- Decrease in water availability
- Increase in emphasis on sustainability, ethics, welfare and product safety
- High future energy demand

Policies options?

Providing solutions

Institutional support ?

Technical options?

Nutrigenomics, nutriproteomics, metabolomics, synthetic biology, *in utero* nutrition, nanotechnology, etc.

Addressing an efficiency dilemma – an urgent call

We need to think of efficiency in multiple dimensions

Units of efficiency

Need to reconsider the units used to measure efficiency – Ei an important parameter and must be monitored **BUT it can't just be Ei**

Need to include, for example

-- Land use change impacting soil C

-- Competition for arable land with grain crops

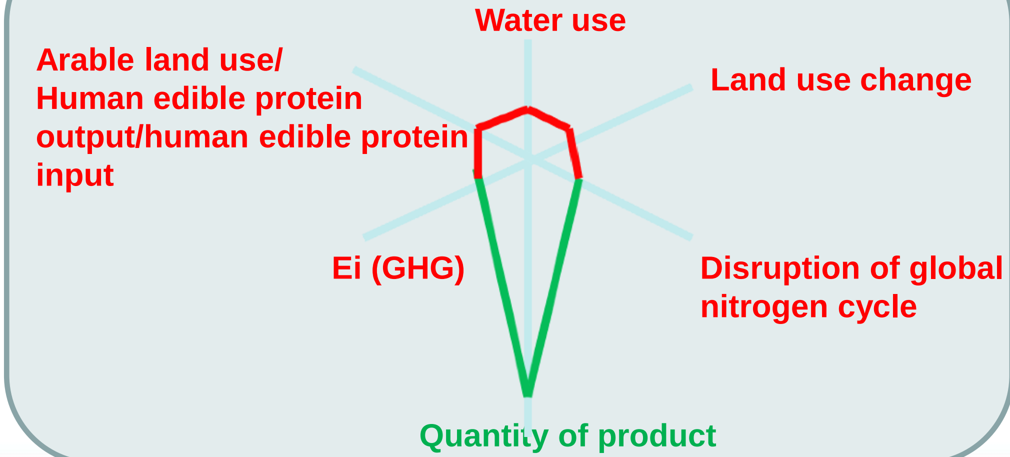
-- Water use associated with feeds

-- Disruption in nitrogen cycles

-- Use of P

Quantity of animal product

An ideal situation



Addressing an efficiency dilemma – examples

How different units of efficiency can affect the conclusions

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

Kenya, smallholder dairy farm	1.3 –1.9 (only lactation)[ca 2-3]	Opio/FAO, unpublished
Swedish dairy farm	0.90 –1.04 (herd basis & feed prod.)	van der Werf et al., 2009
French dairy farm	1.04 (herd basis & feed prod.)	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/BGD/PAK, milk	15.1	Makkar et al., 2015
Jordan	0.60	Hawileh and Makkar, 2015
USA, milk	1.81	Baldwin, 1984; CAST, 1999
UK, milk	1.41	Wilkinson, 2011
Netherlands	4.38	Dijkstra, unpublished

Addressing an efficiency dilemma -- Productive life?

Consider measuring efficiency based on productive life of livestock

	GHG emissions [kg CO2-eq/kg FPCM] (Based on lifetime milk yield)	
Fleckvieh cows, dual purpose (27 farms)	0.90 – 1.26	Zehetmeier et al. (2014)
Holstein–Friesian cows Dairy cows (26 farms)	0.79 – 1.20	
India, Cows*	1.02 – 2.06 (Before ration balancing) 0.55 – 1.0 (after ration balancing)	
India, Buffaloes*	1.40 – 3.73 (Before ration balancing) 0.84 – 1.48 (after ration balancing)	

* Preliminary data. NDDB: Garg et al. (2015)

Take-away messages

- **Animal nutrition impacts almost all sectors & services of the livestock operation**
- **A 360 degree view of animal nutrition could be one of the guiding principles of sustainability**
- **We need to think of efficiency in multiple dimensions, to embrace 360 degree view of animal nutrition – optimise production and not maximise**
- **A framework for future strategic R & D work in animal nutrition for sustainable development of dairy sector could have 3 pillars**

1. *Better understanding of trade offs and synergies between components of the 360 degree view and generation of quantitative relationships*
2. *Better understanding of impact of ongoing changes on interactions of animal nutrition & other components of biophysical and socio-economic systems*
3. *Providing solutions through identifying and implementing proper technological solutions, policy options and institutional support mechanisms*

Thanks for your attention

Challenges are multi-faceted & in 360 degrees but their solutions rest in how feed is produced and fed

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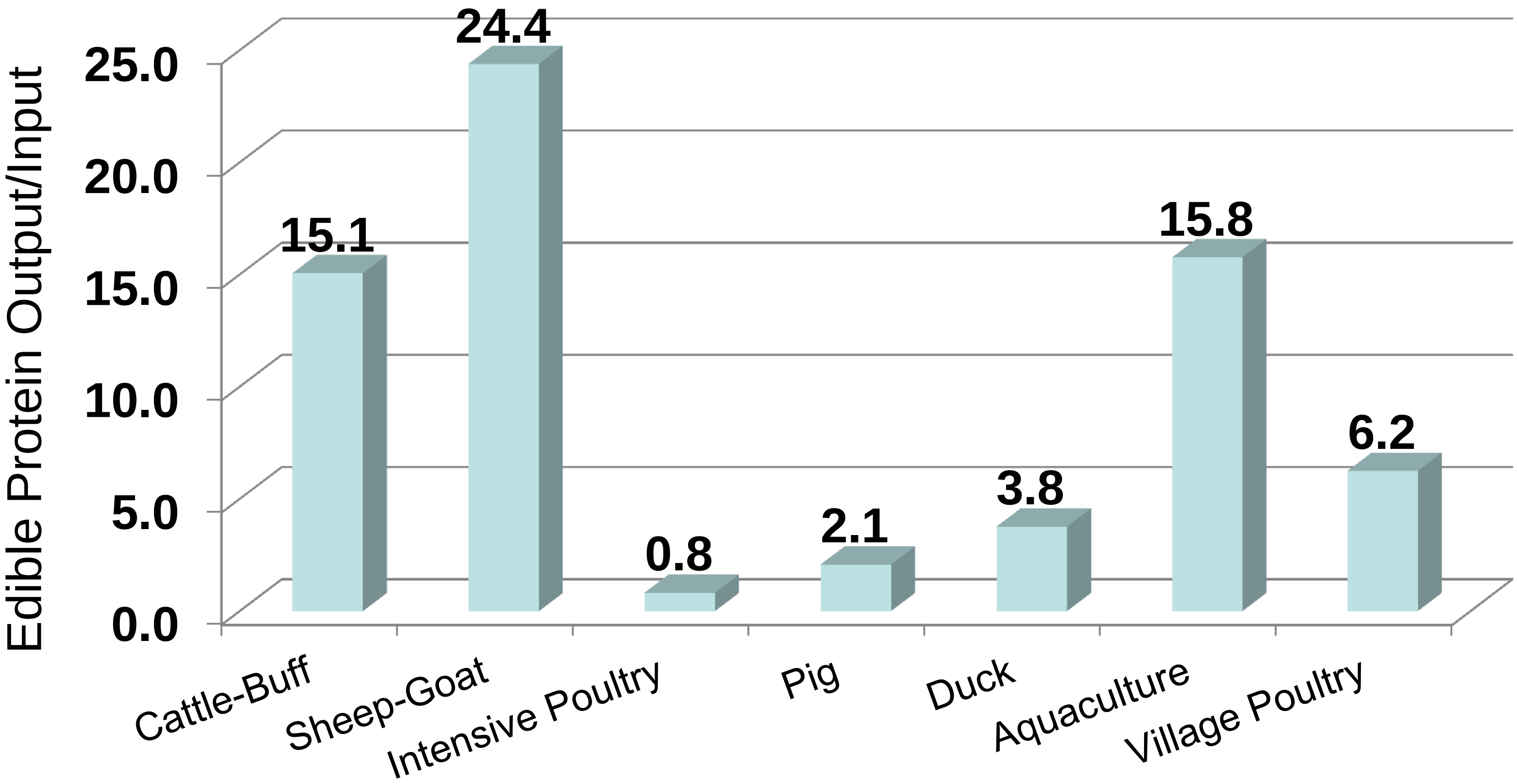
Efficiency of conversion of human edible feed protein to animal product (Blradford et al., 1999)

Country	System	g product protein/g feed protein
South Korea	Dairy	14.30
South Korea	Beef	6.57
Argentina	Beef	6.12
USA	Dairy	2.08
Argentina	Dairy	1.64
USA	Beef	1.19
South Korea	Poultry meat	1.04
USA & Argentina	Poultry meat	<0.7
All 3 countries	Pigs	<0.51

Human edible protein input-output ratio



Source: FAO (2015). Feed Assessments for Asian Countries