

Animal production and Nitrogen: Global trends in growth and efficiency

Liu Q, Wang J, Bai Z, Ma L & Oene Oenema
Wageningen University
China Academy of Sciences



Animals have key functions in societies

Animals provide

- Nutritious food (milk, meat, egg)
- Draught, wool and hides
- Manure

Animals serve/contribute

- Employment & income to farmers, industry
- Savings banks, social status
- Leisure animals
- "Livestock ladder" - smallholders



Animal production is debated

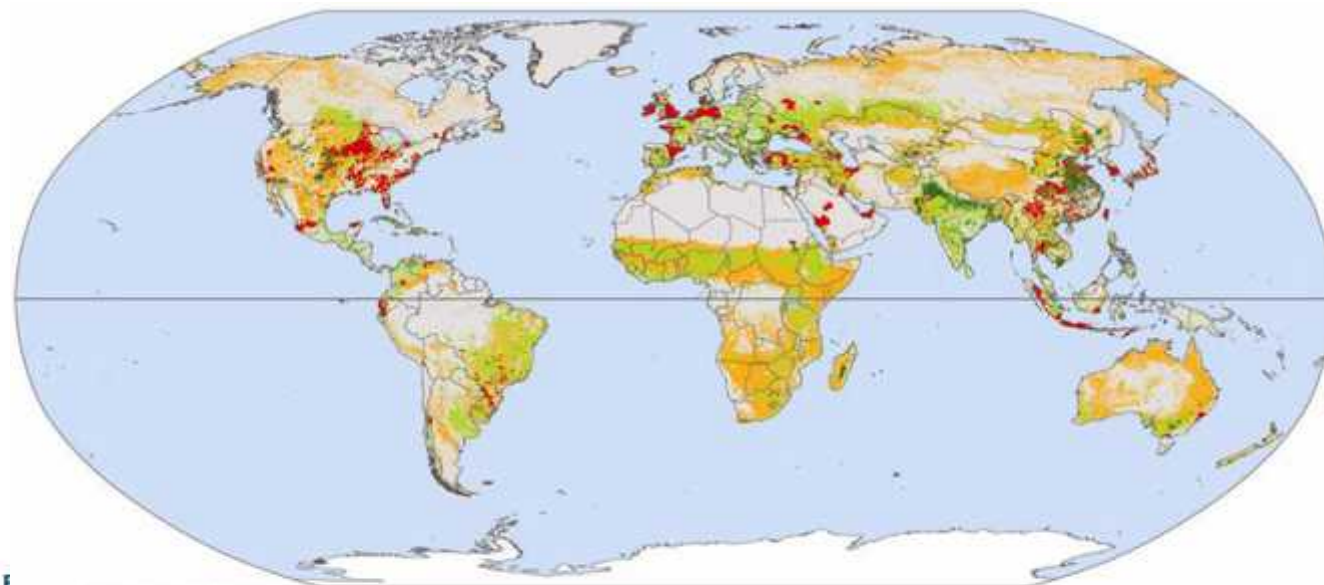
- Animal production contributes to environmental burden:
 - Resources use (land, water, biodiversity)
 - Greenhouse gas emissions (CH₄, N₂O)
 - Ammonia emissions
 - Eutrophication of water bodies
- Animal production contributes to health risks
 - Zoonosis
 - Antibiotics, hormones
 - Diet-related diseases
- Animal welfare is sometimes at stake



Large diversity in animal production systems

A simple & functional categorization:

- Grazing systems
- Mixed crop-animal systems
- Specialized (animal feeding) systems ('foot-loose')



Only 14 domesticated animal species

Animal species	Domestication date
Sheep	10000 BC
Pig	9000 BC
Cattle	8000 BC
Goat	8000 BC
Chicken	6000 BC
Donkey	5000 BC
Water buffalo	4000 BC
Horse	4000 BC
Reindeer	3000 BC
Fox	1800 AD
European Mink	1800 AD
Hamster	1930 AD

Growing demands for animal products

- Driving factors:

 - Population growth

 - Urbanization and changing food patterns

 - Growing middle classes in emerging economies

- At the same time:

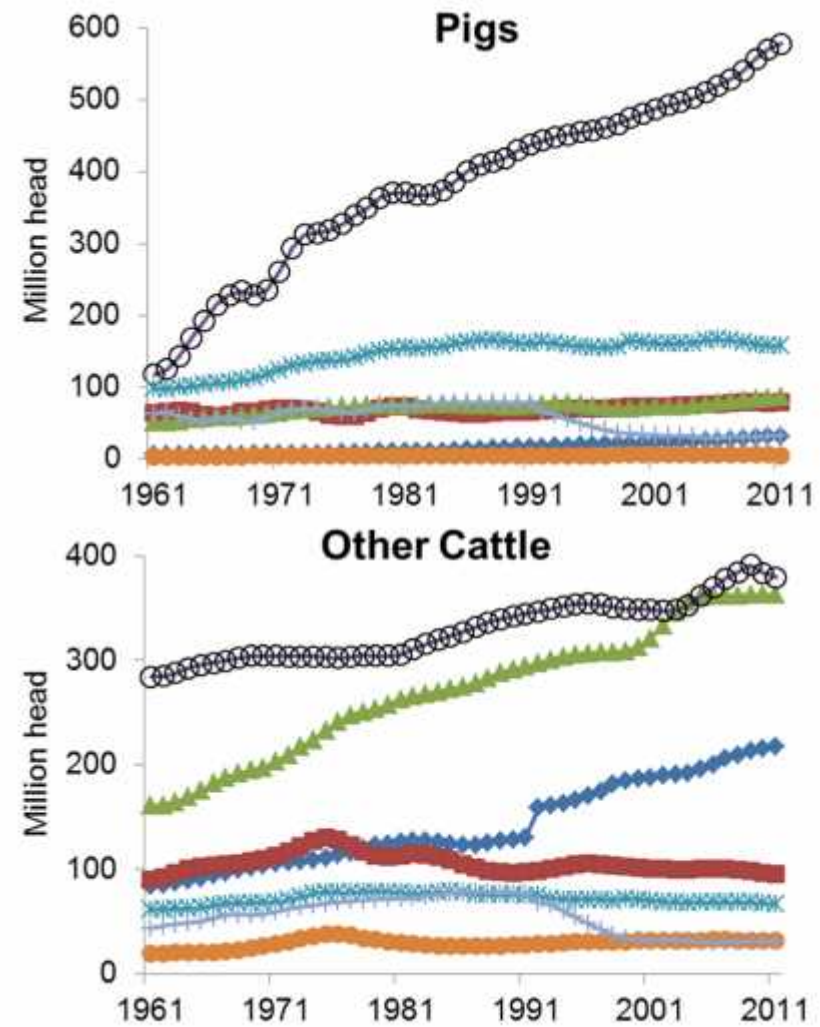
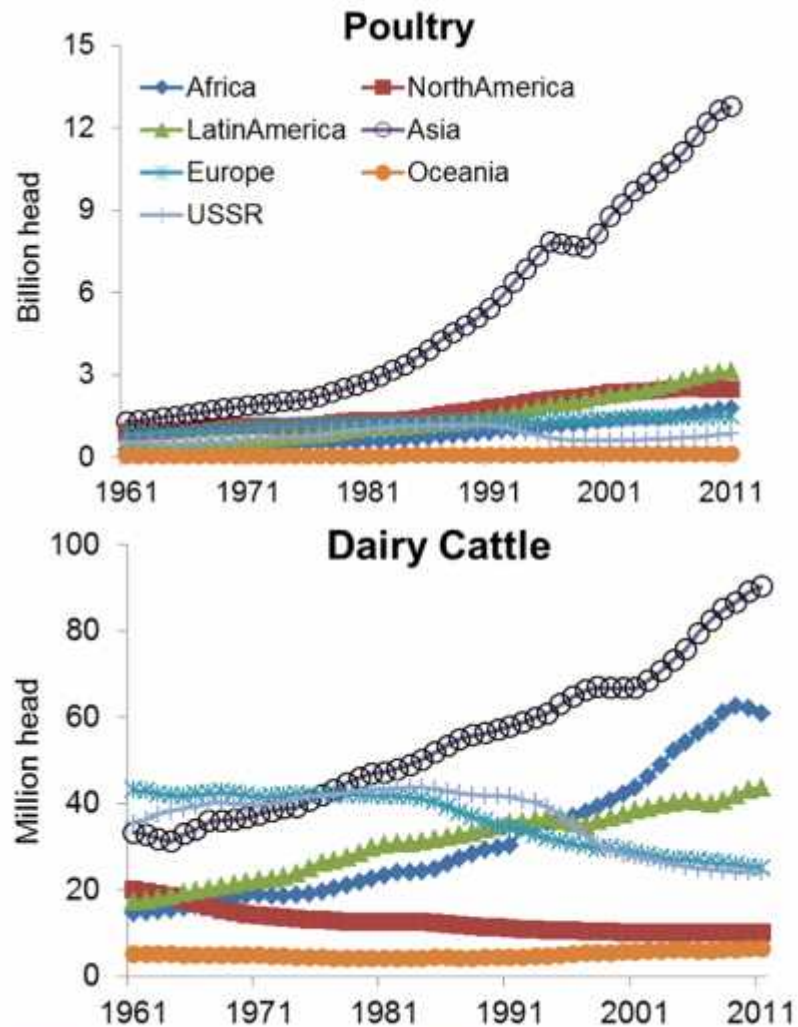
 - Increasing support of suppliers & processing industry

 - An increase in animal and labour productivity

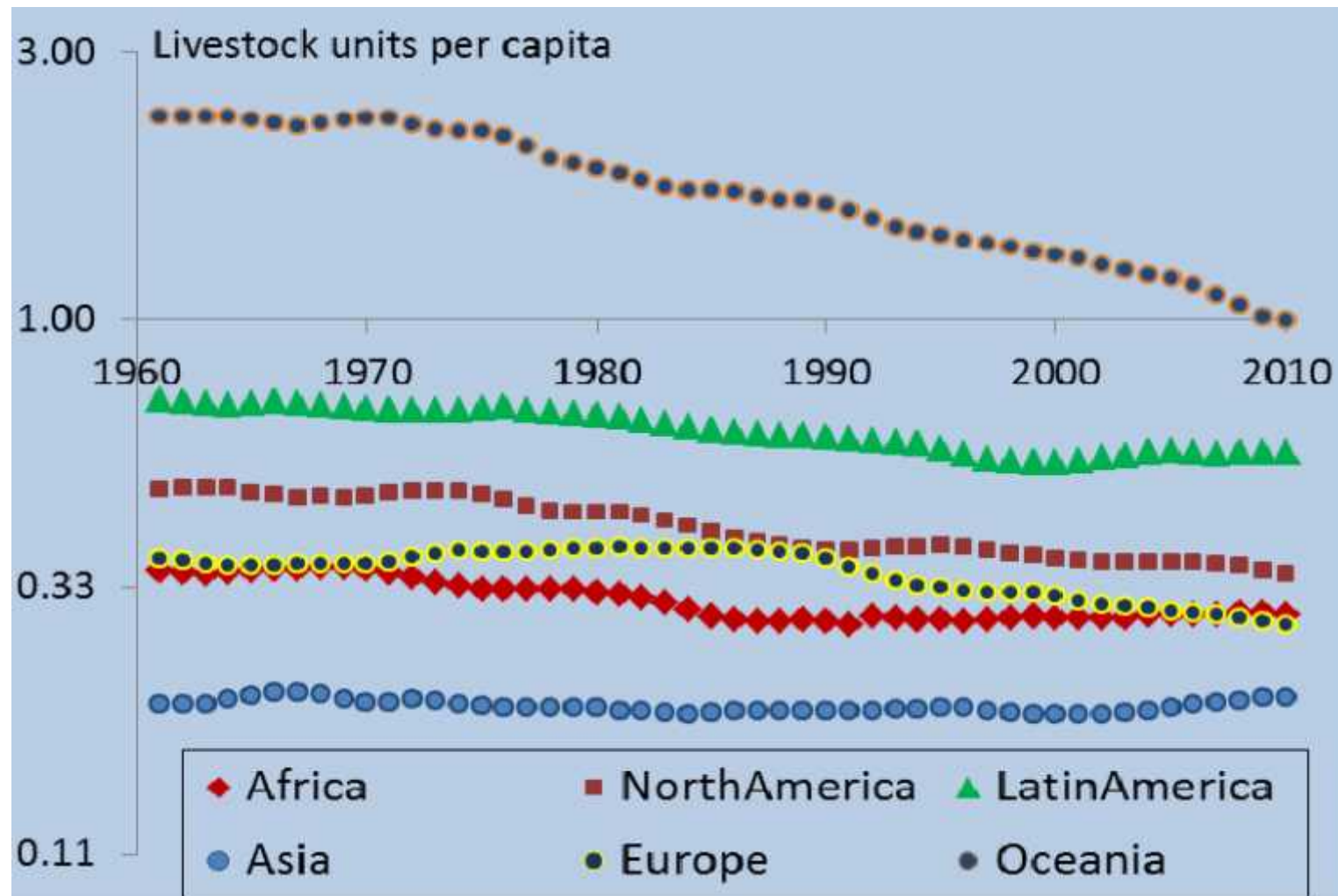
 - A decrease in real prices



Changes in number of animals 1961-2011

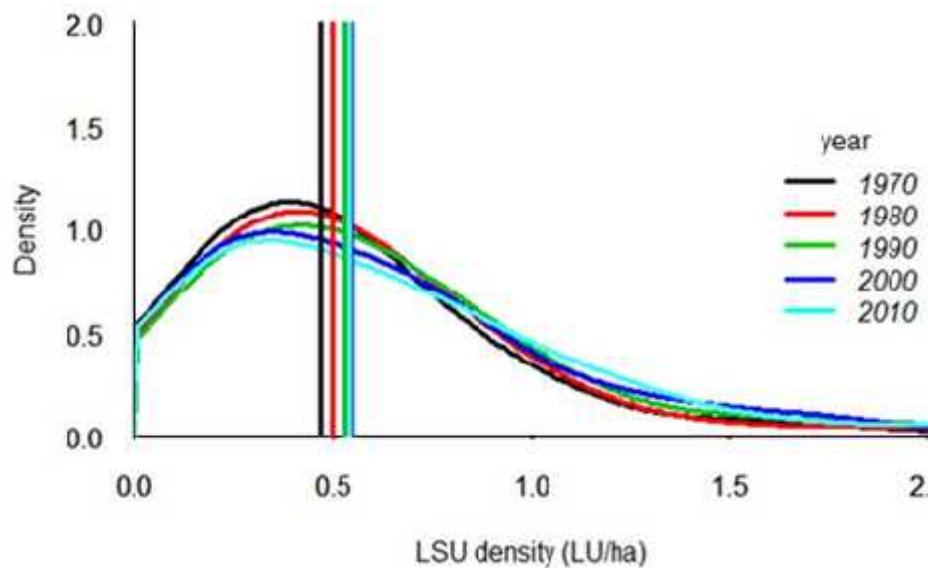


Mean livestock units per capita did not increase

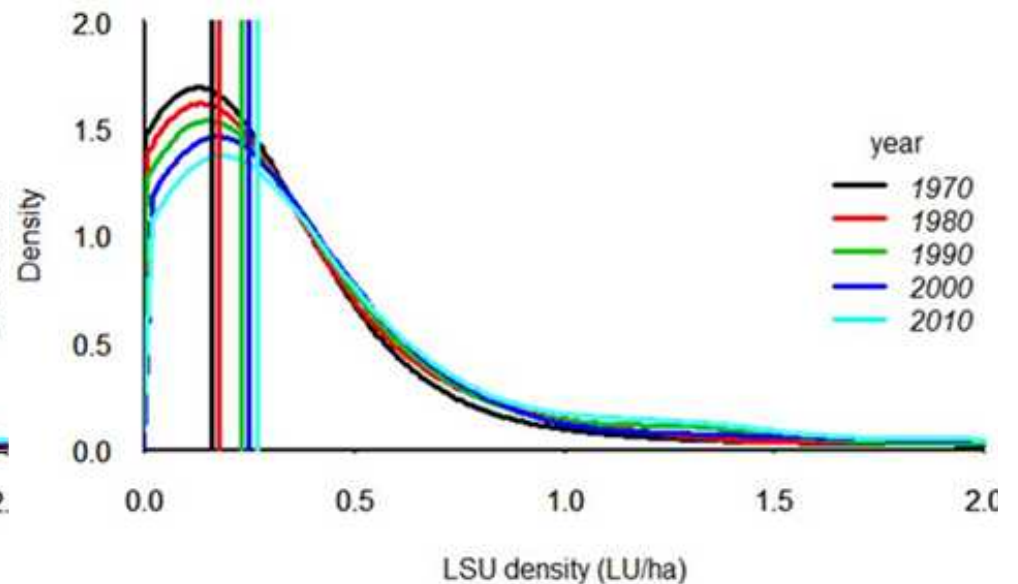


Kernel density distributions of LSU density of 151 countries

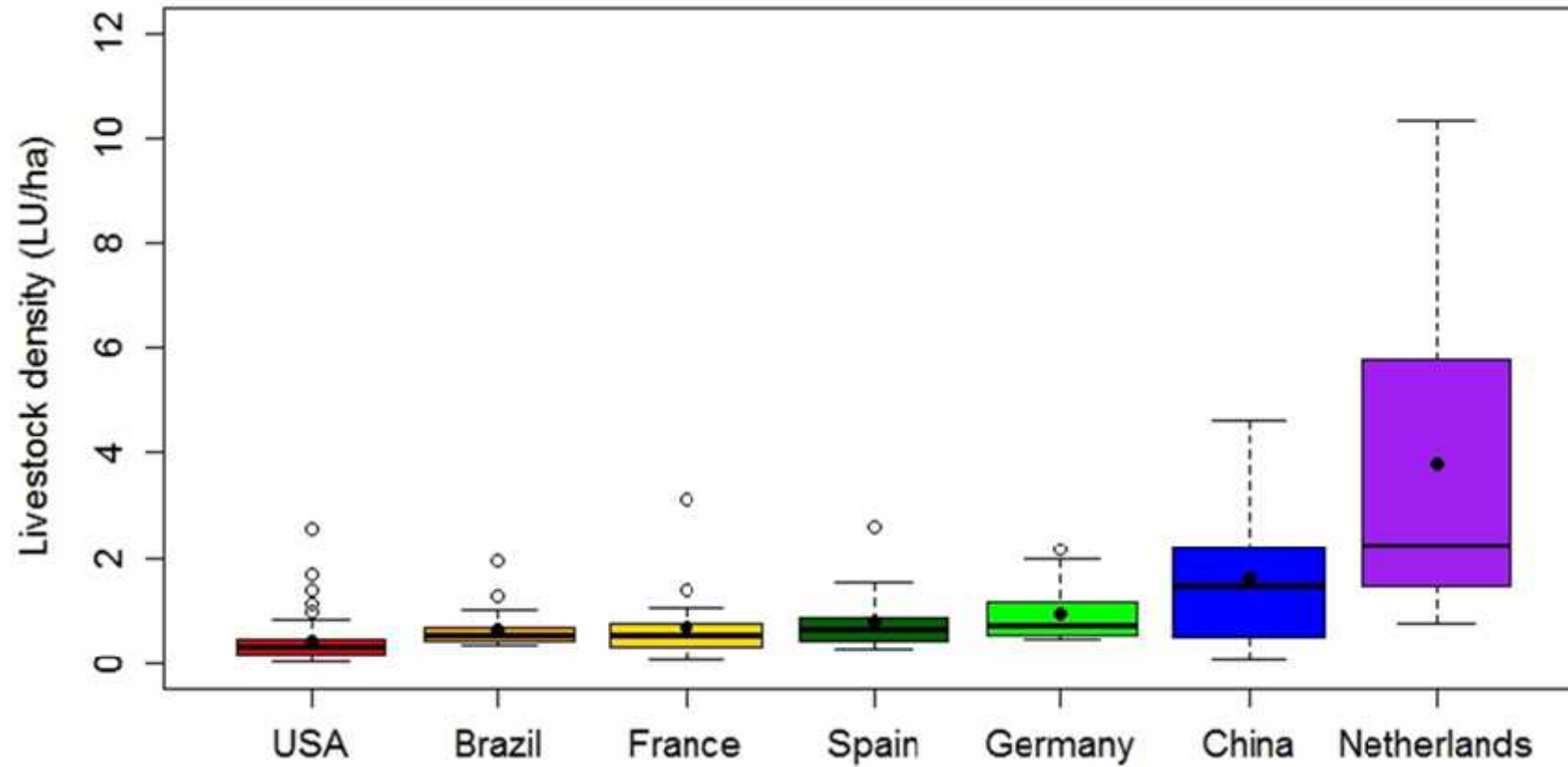
Ruminants



Monogastric animals



Spatial variations within countries



Trends in animal production systems

- Increases poultry > pork > dairy > beef sheep & goat
- Further intensification and concentration of production, i.e. more products per unit of animal, labour, land and feed
- Centralisation of market chains
- New farms in emerging economies are often footloose and industrial, near cities
- Governmental regulations popp-up, in more countries
- Smallholder farms (2 ha) are under pressure;
 “if smallholder farms loose, all may loose”



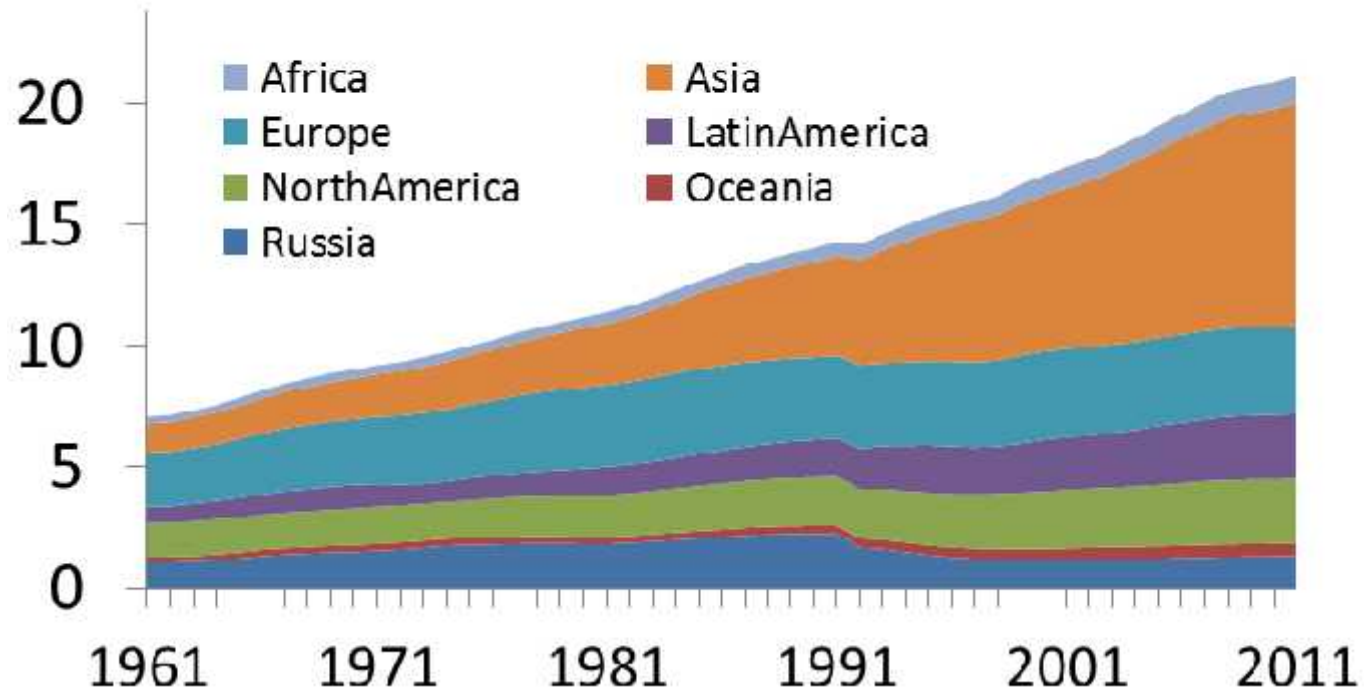
Animal production and nitrogen

- Meat (muscles) is protein and water
- Animal protein contains ~16% N
- Conversion of plant protein in animal protein depends on
 - Animal species & breed
 - Animal age
 - Quality of the feed
 - Management & environmental conditions

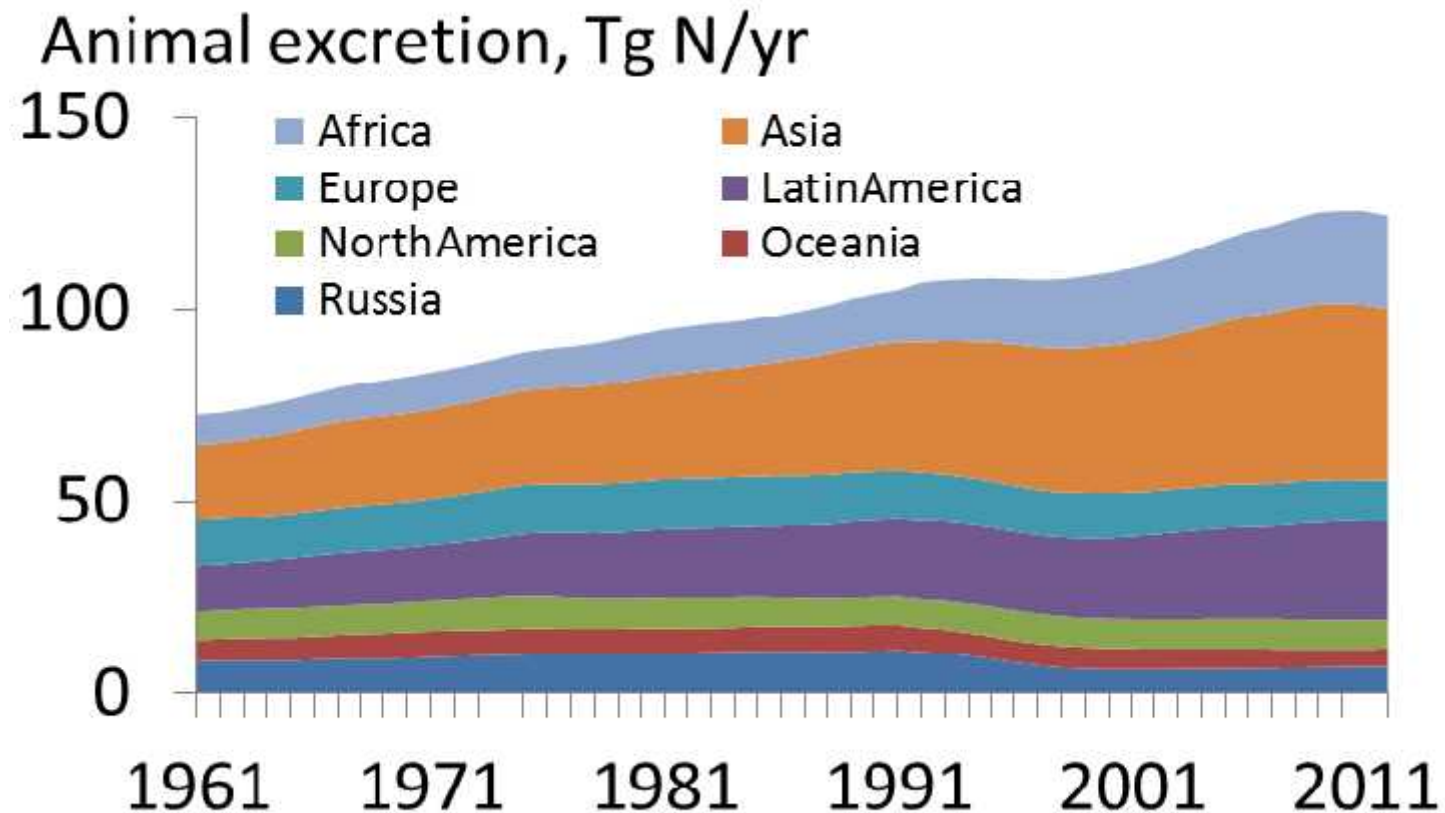


Global animal production is increasing exponentially; ~ 0.3 Tg N/yr in last 10 yrs

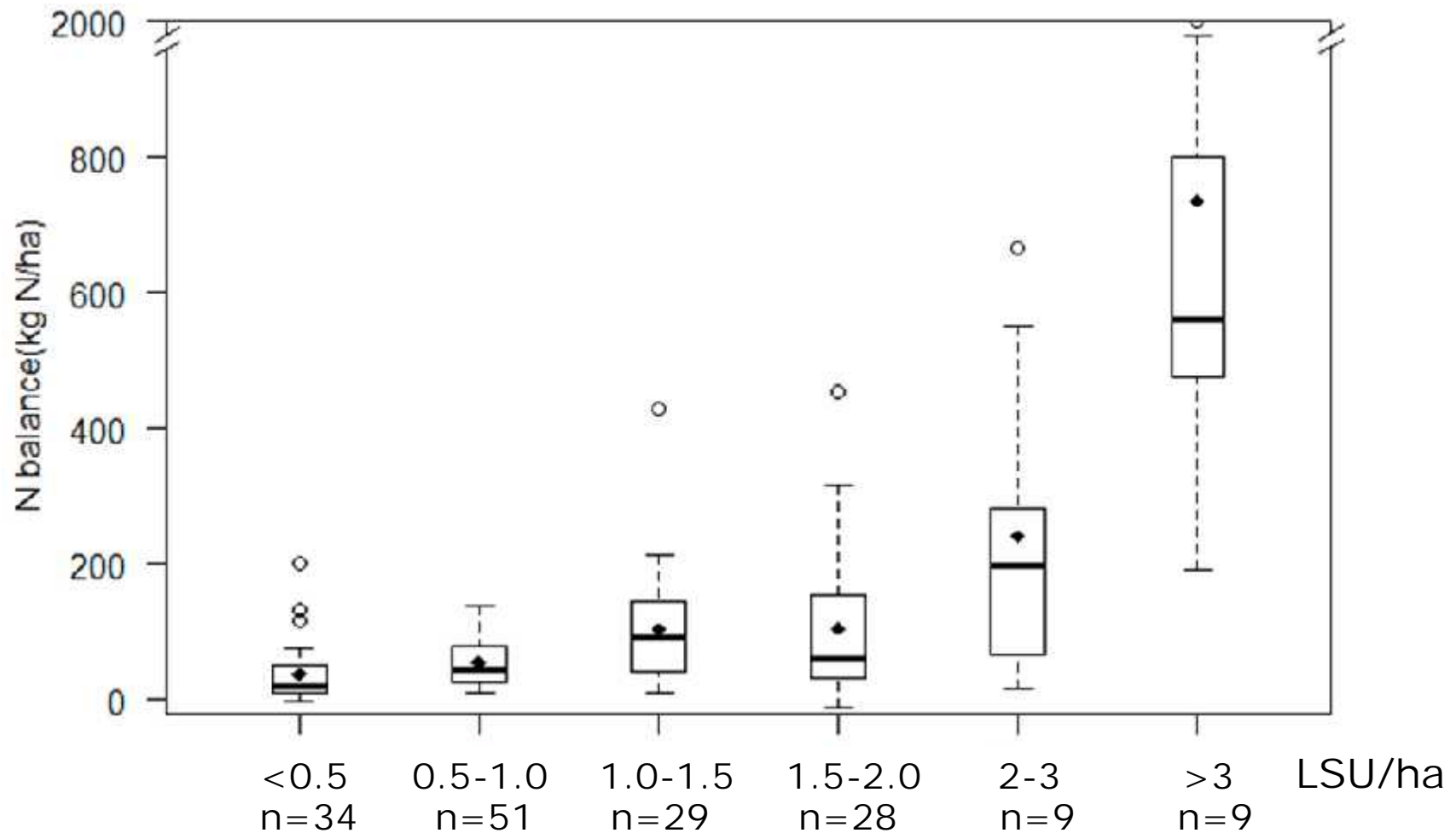
Animal production, Tg N/yr



Global animal excretion is increasing linearly: ~ 1.0 Tg N/yr



Relationship between LSU density and N surplus of 151 countries in 2000-2010

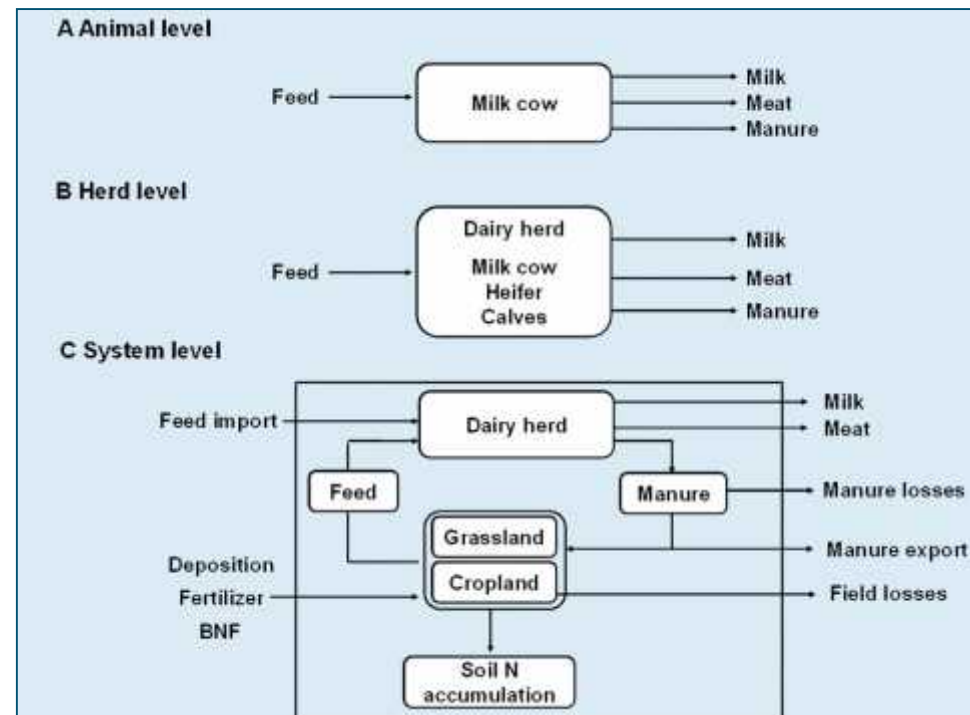


Nutrient Use Efficiency in animal production

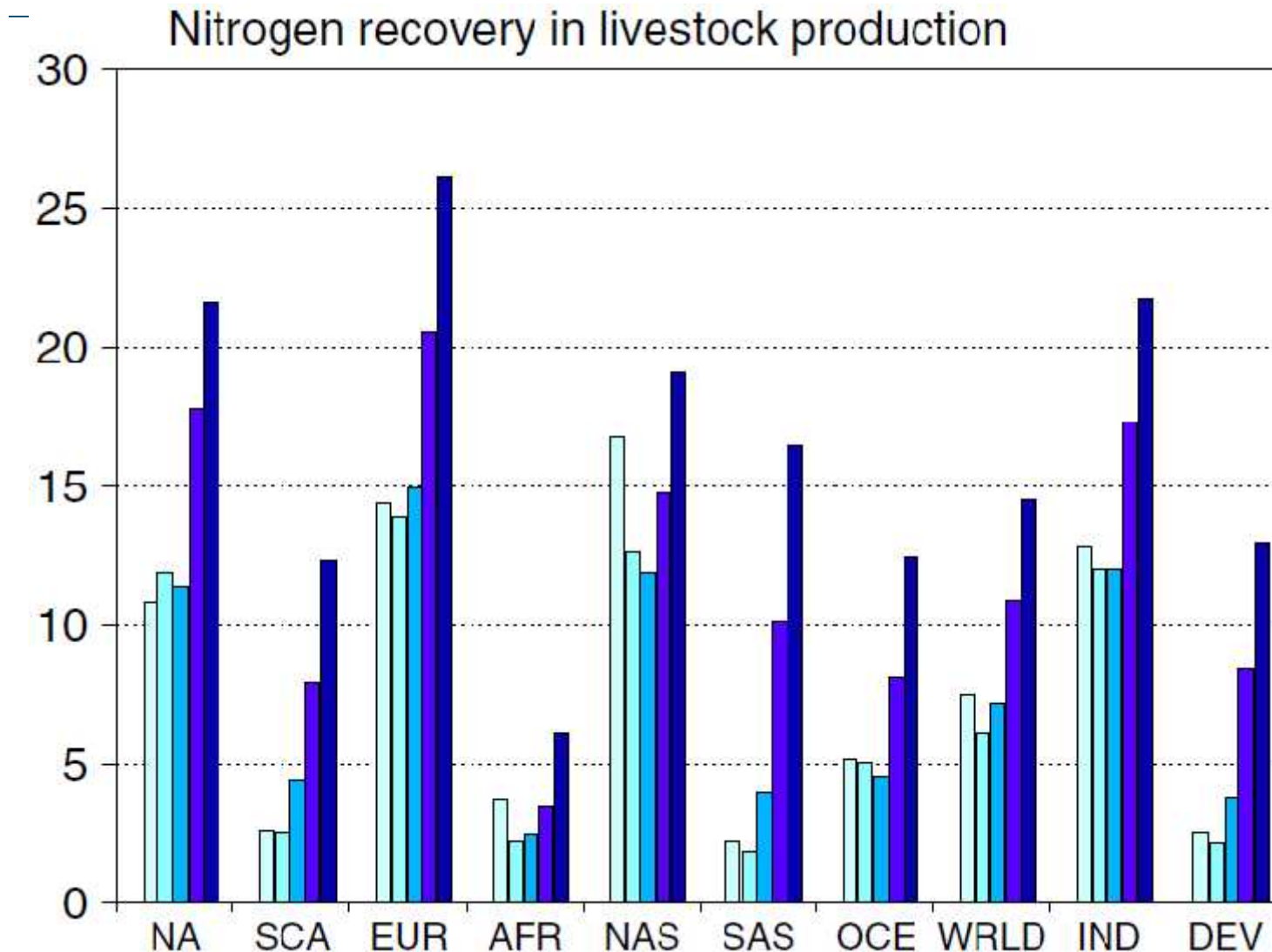
- FCR = Feed conversion ratio, kg feed per kg product
- NUE = N use efficiency, kg N in product per kg feed N

➤ FCR and NUE are defined at:

- Animal level
- Herd level
- System level

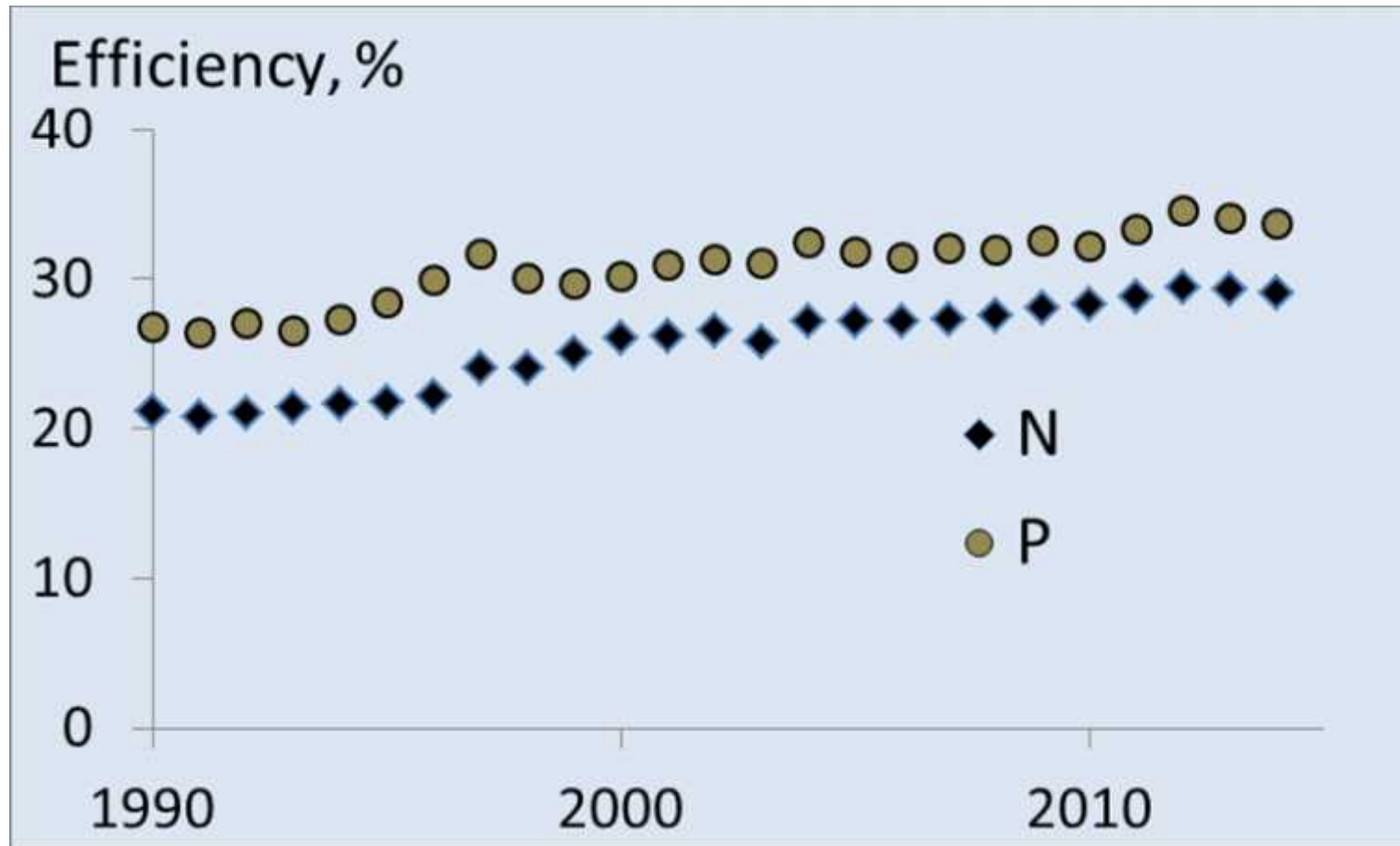


Global changes of NUE-herd, 1900-2050



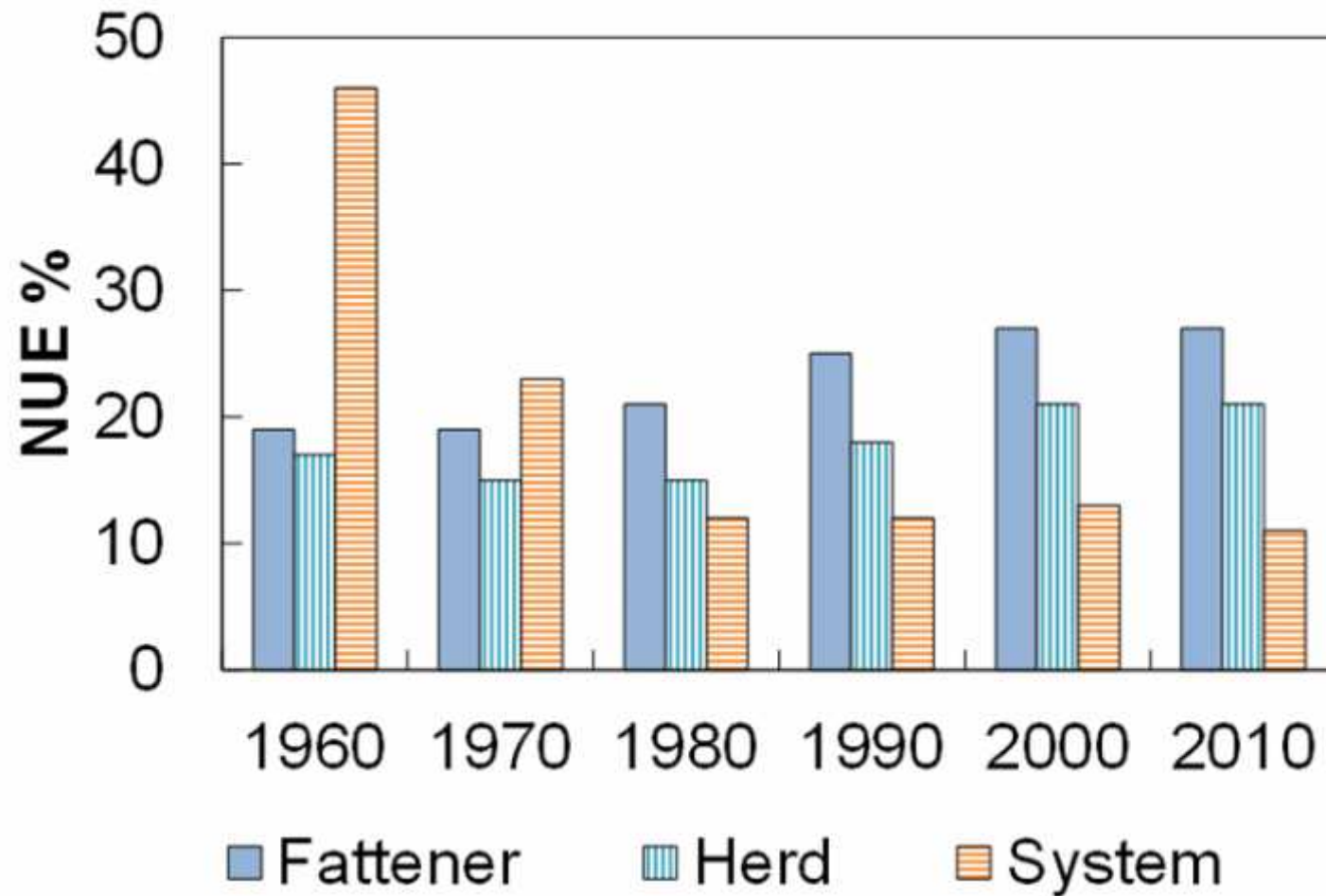
Bouwman
et al., 2013

Increases of NUE- & PUE-herd in NL

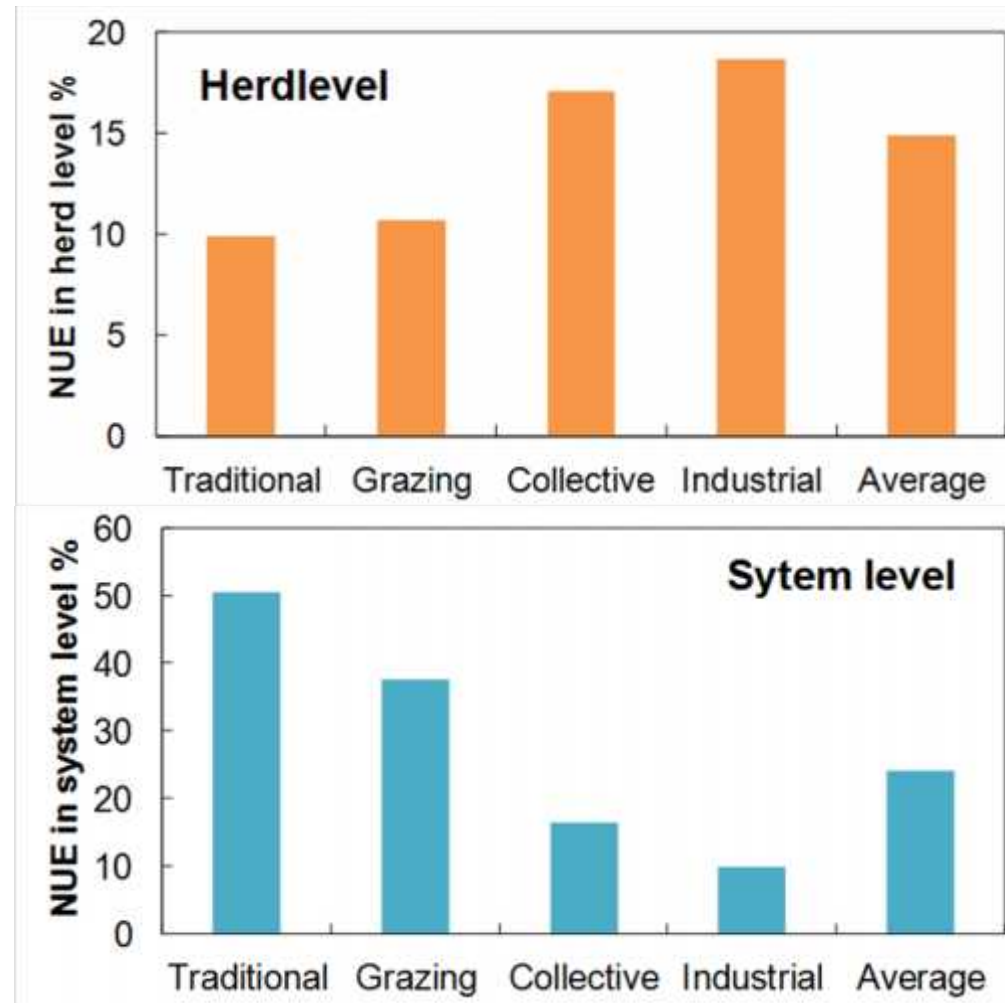


CBS, 2016

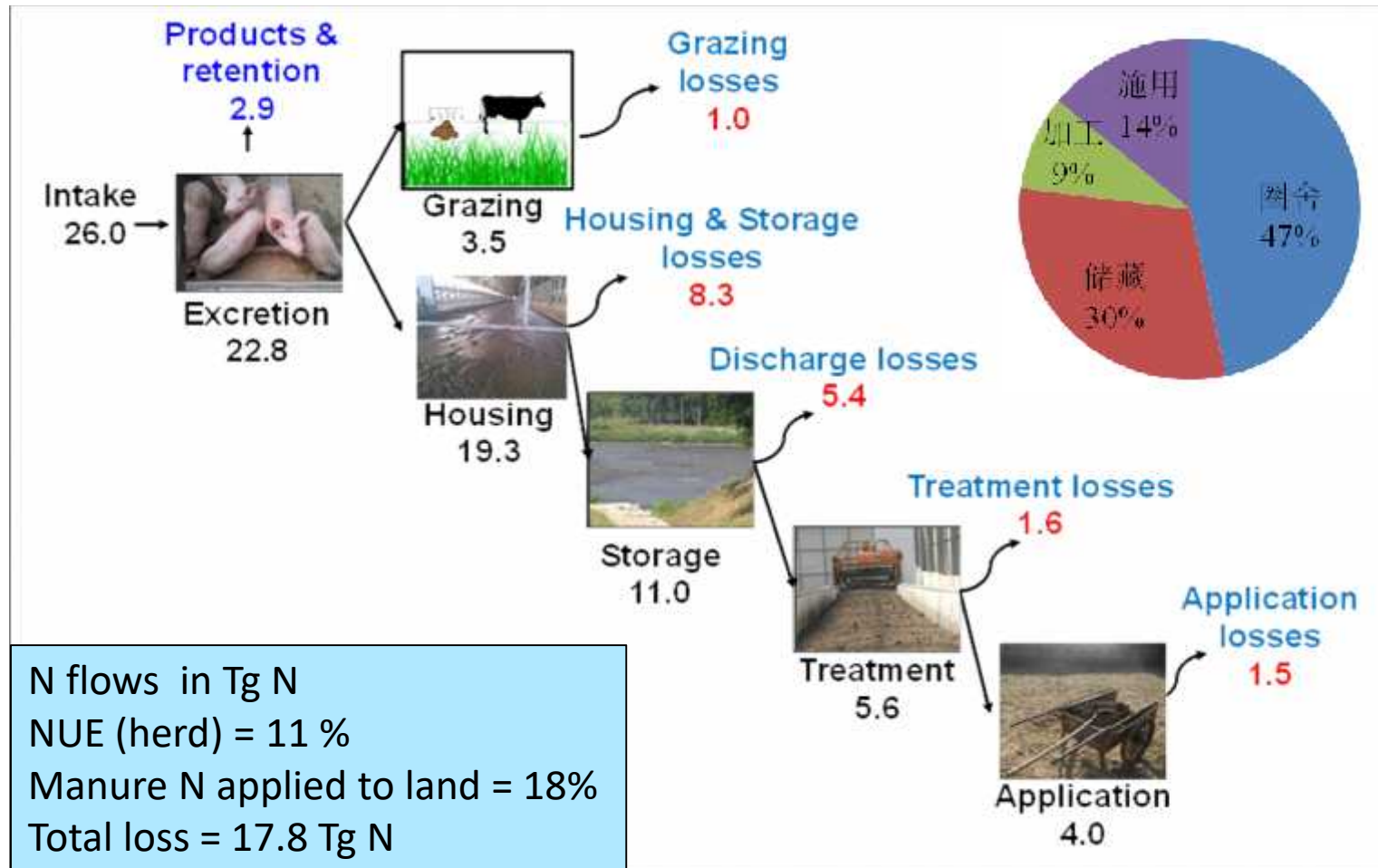
Changes of NUE in pig production in China at animal, herd and system levels



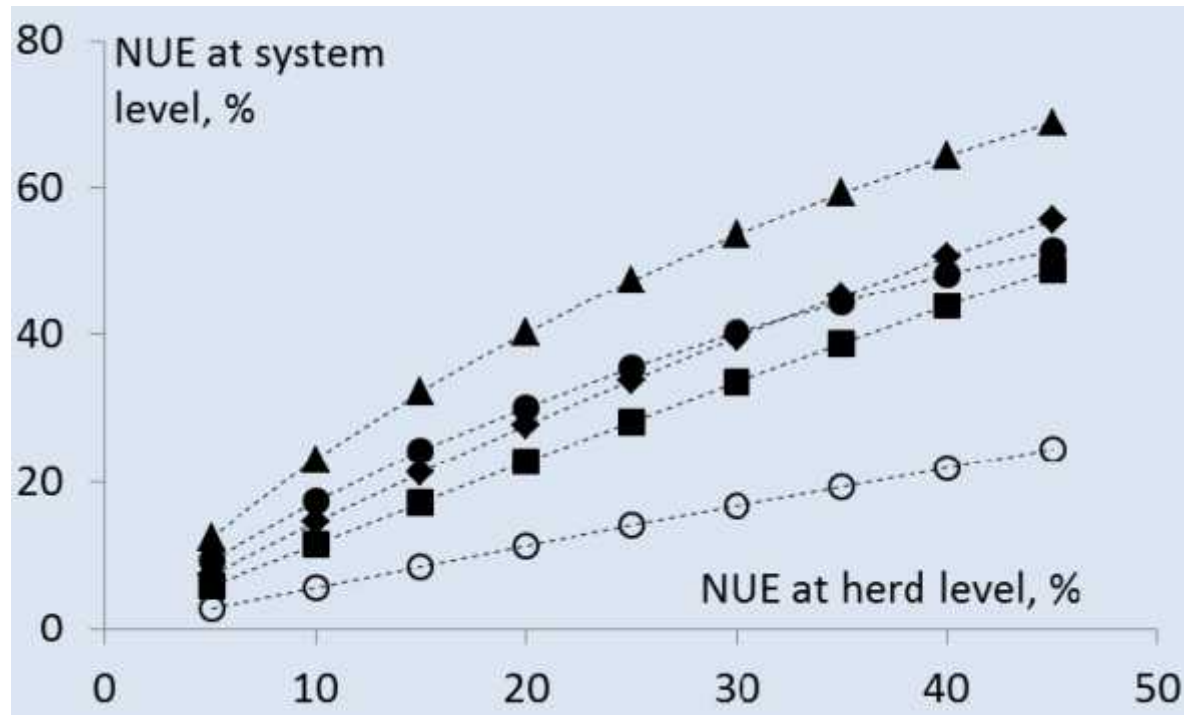
NUE of dairy production in China in 2010 at herd and system levels



N flows in the manure chain of China in 2010

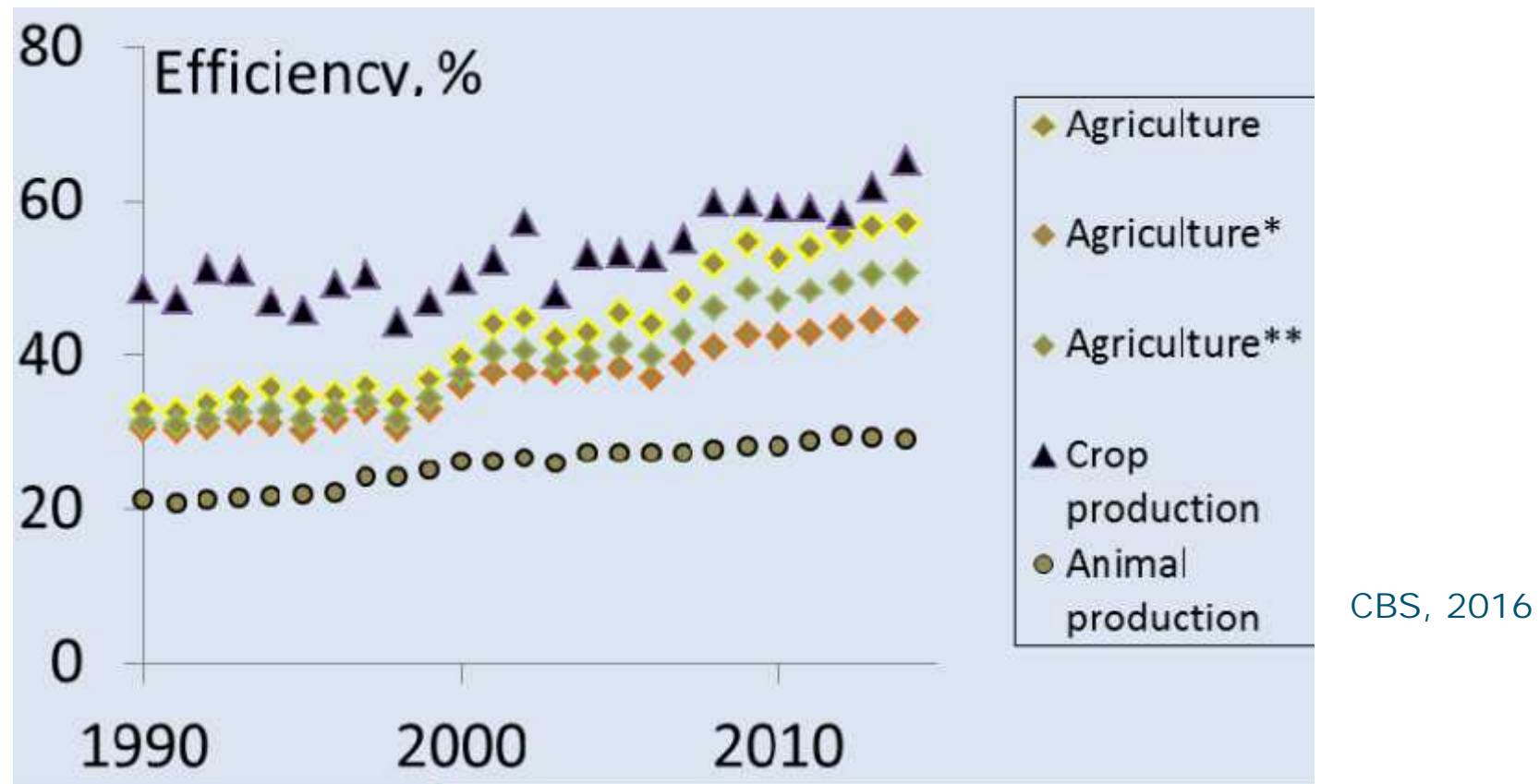


Exploring the boundaries of NUE



Open circles:	manure N loss 50%;	manure N recovery 30%;	'new' N input recovery 50%
Filled circles:	manure N loss 10%;	manure N recovery 70%;	'new' N input recovery 50%
Squares:	manure N loss 50%;	manure N recovery 30%;	'new' N input recovery 100%
Diamonds:	manure N loss 50%;	manure N recovery 70%;	'new' N input recovery 100%
Triangles:	manure N loss 10%;	manure N recovery 70%;	'new' N input recovery 100%

Apparent NUE of agricultural sectors in NL



Note: externalization of feed import not considered
Agriculture: manure export is output
Agriculture*: manure export is neglected
Agriculture**: manure export is negative import

Solutions to improve NUE in animal production

- Continue to improve NUE at herd level through
 - Improved animal feeding
 - Improved breeds
 - Improved health and herd management
- Improve manure management of housed animals:
 - Collect 100% of excrements in leak-tight storages
 - Reduce gaseous N losses to <15% during storage
 - Increase fertilizer N effectiveness to >70%
 - Replace fertilizer by manure nutrients
- Re-connect animal production to crop production
 - Mixed systems or virtual (via feed & manure transport)

Integrating crop and livestock systems in NL: cost of manure distribution is critical

(a)

Mixed crop –
animal farms

Cost of low-emissions manure application ~3 € per m³

(b)

Specialized
crop farms



5-10 € per m³

Specialized
animal farms

~20 km

(c)

Specialized
crop farms



10-20 € per m³

Specialized
animal farms

~100 km

(d)

Specialized
crop farms
abroad



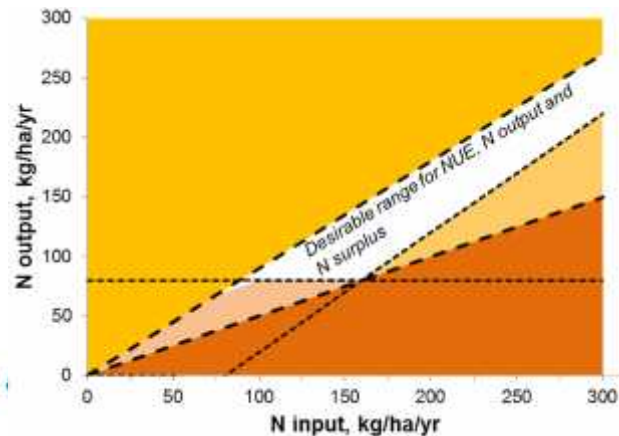
20-25 € per m³

Specialized
animal farms

~500 km

Cooperation and incentives needed

- Cooperation between:
 - Farmers
 - Private sectors: suppliers & processing industries
 - Governments: regulating and facilitating policies
 - Knowledge institutes
- Incentives/regulations related to
 - Implementation of BMPs, BATs
 - Targets/limits of N & P inputs and outputs



Interpretation	Nitrogen surplus (kg/ha/yr)		
	Cropping systems	Mixed crop-livestock systems, 1 LSU/ha	Mixed crop-livestock systems, 2 LSU/ha
Very high	>120	>160	>200
High	80-120	120-160	160-200
Modest	50-80	90-120	130-160
Low	20-50	60-90	100-130
Very low	<20	<60	<100

Summary & conclusions

- Animal production is diverse and rapidly developing
- NUE at herd level is increasing, but not at system level.
- Manure management is critical to improving NUE at system level
- The amount of N in animal excrements is large, but a significant fraction is lost.
- Solutions to improve NUE involve

Cooperation

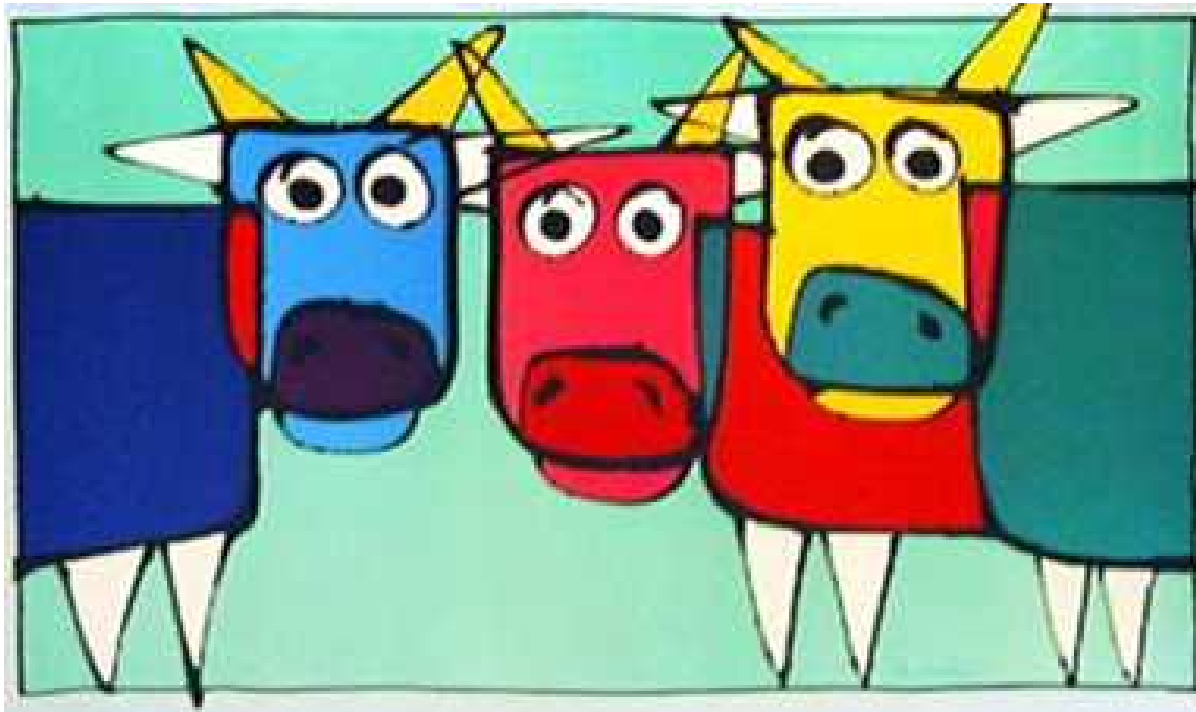
Implementation of BMPs, BATs.

NUE/Noutput/Nsurplus

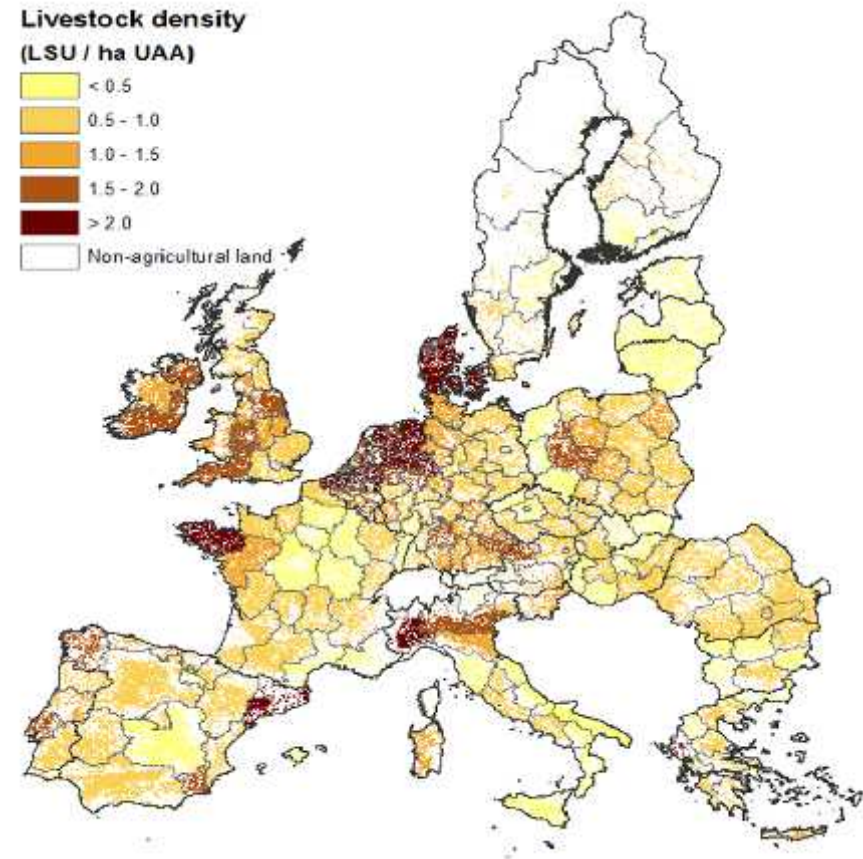
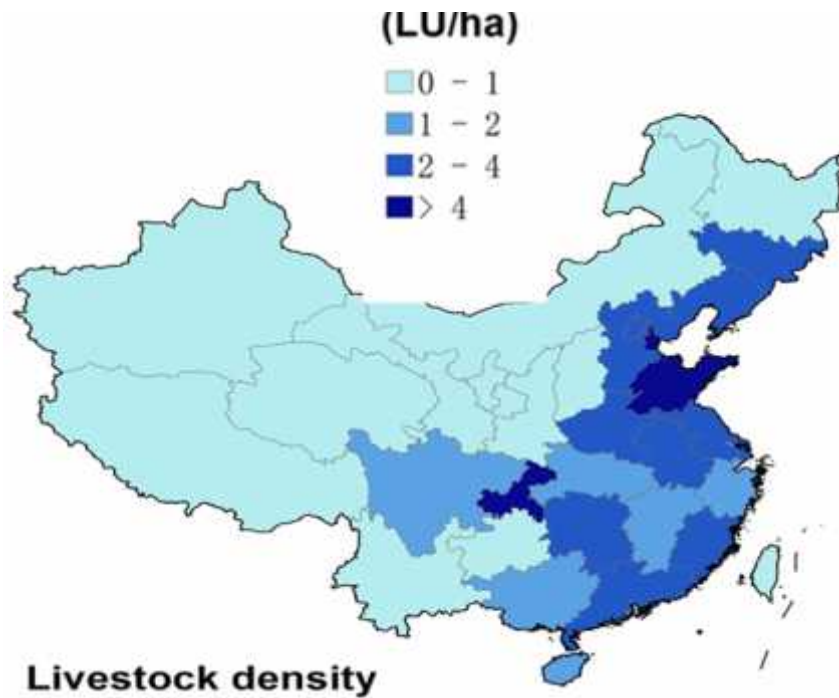


Thank you!

Questions?

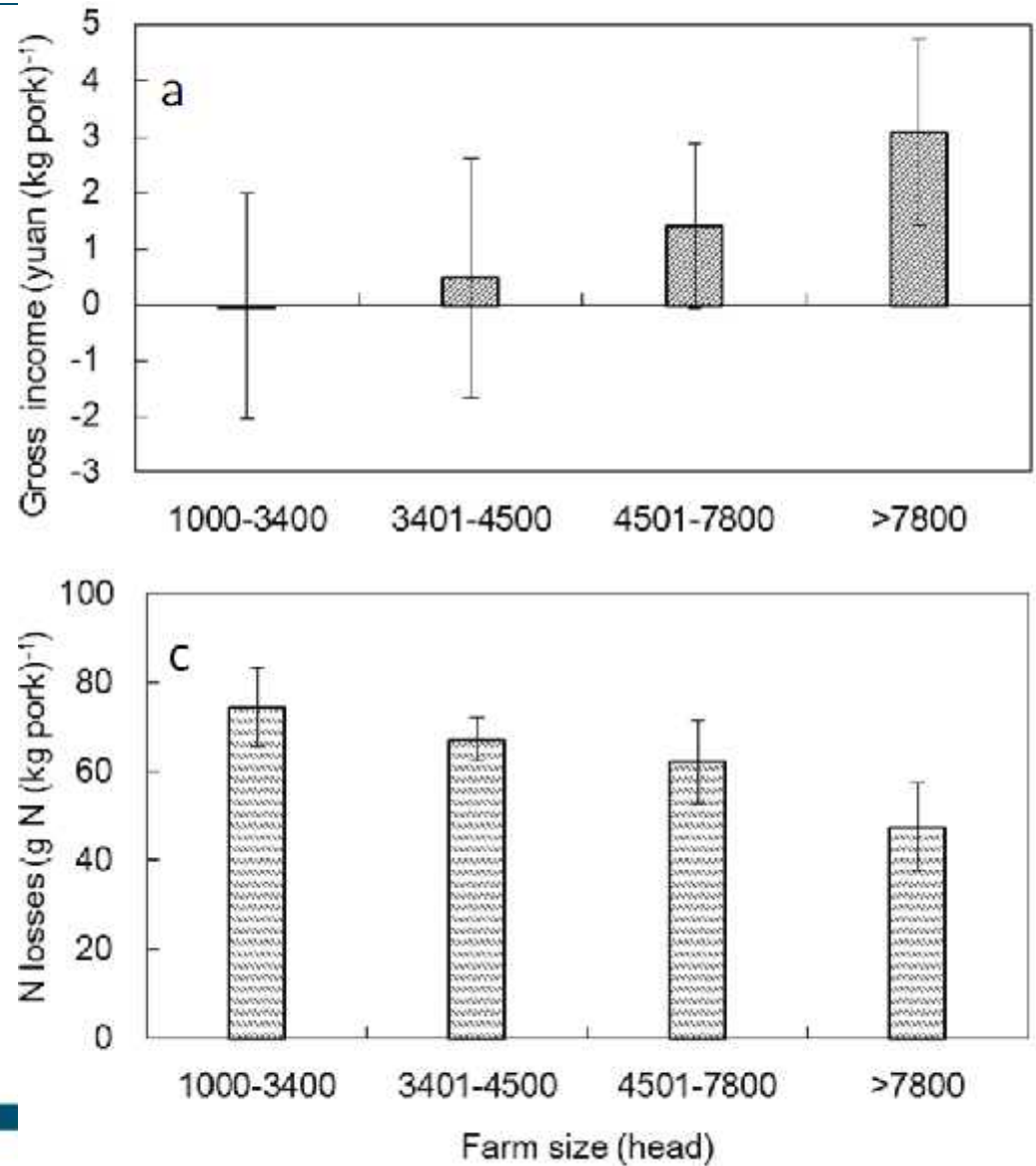


Concentrations of animals

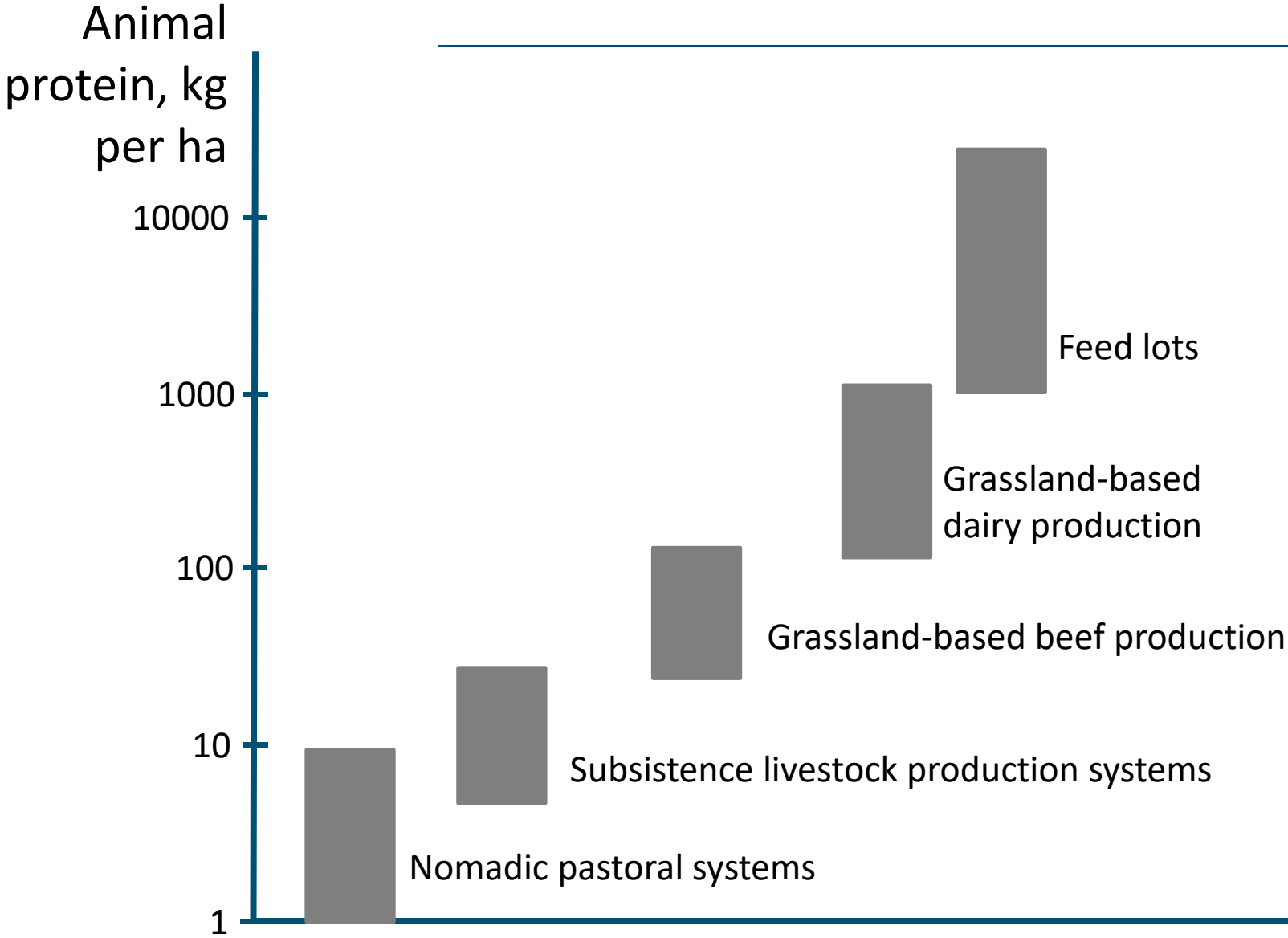


Pig farm size vs farm income & N losses

Survey of 92 pig farms in Beijing



Increasing intensity

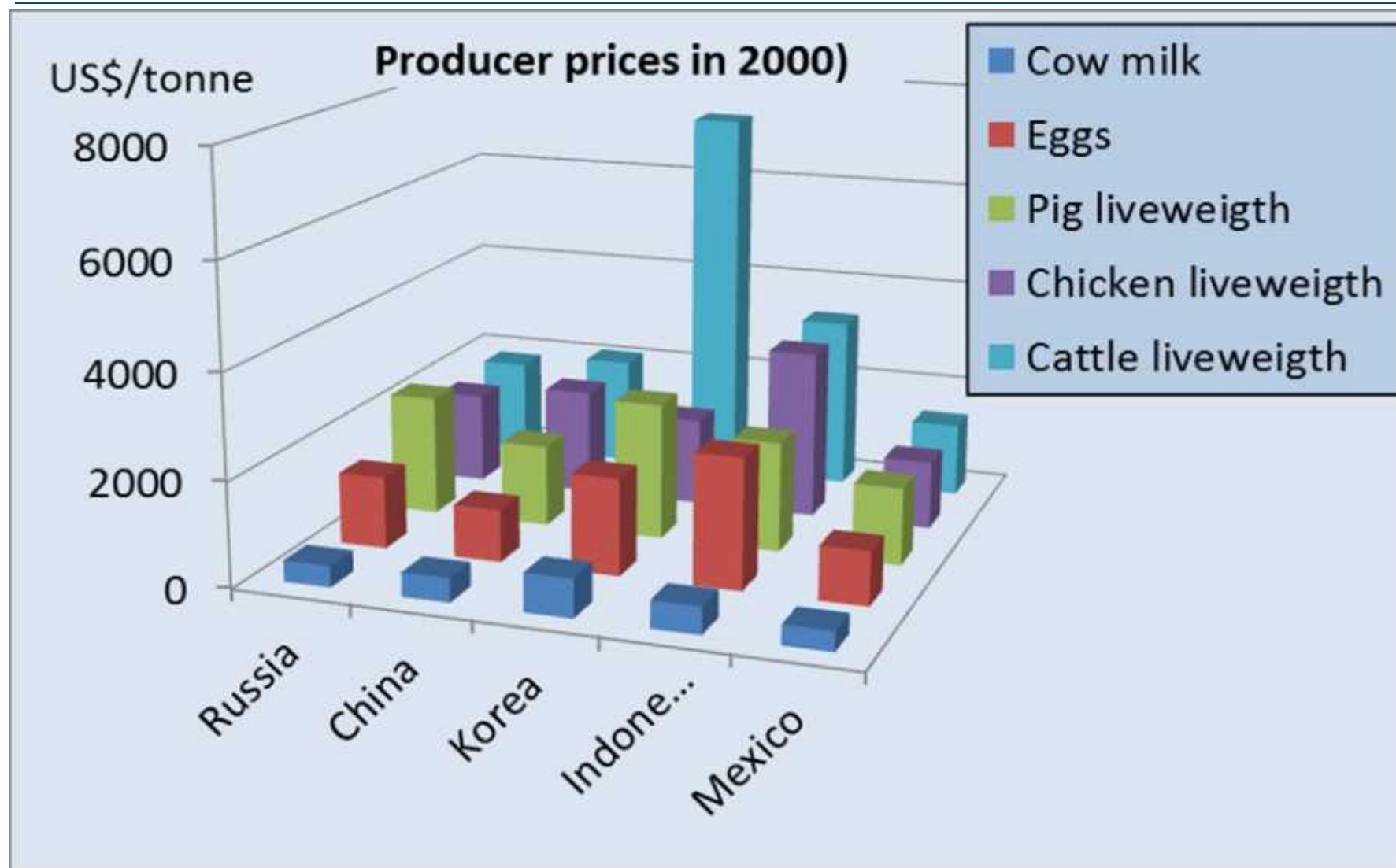


Framework for cooperation in animal production

- Food quality and safety first
- Technology tailored to regional market demands
- Getting the basics right
- Include smallholders
- Act together
- Learn from the past
- Develop capacity

Van der Lee et al., 2013

Global market, but producer prices differ



Mean feed and protein conversion rates

Product	Protein conversion, kg protein/kg human edible protein
Milk	2.5
Egg	3.3
Chicken	5
Pork	10
Beef	25

Changes in mean N content of feed in NL

