BUILDING SUSTAINABLE CROP-LIVESTOCK SYSTEMS

Pierre Gerber
January 9, 2016
Kansas State University

THE CHALLENGE

Demand growth and
Global sustainability issues.

LIVESTOCK SECTOR'S GROWTH

	Per caput consumption of meat	
	2000	**2050**
	Kg/person per year	
Latin America and the Caribbean	58	77
North America and Europe	83	89
East-South Asia and the Pacific	28	51
Sub-Saharan Africa	11	22
Central-West Asia and North Africa	20	33

FAO, 2009

Most of the growth expected to take place in rapidly growing economies

GLOBAL TRENDS

Population growth:

- + 30% since 1990
- + 31% or 9.6 billion people by 2050

Income growth:

- + 1.5%/year since 1980,+ 5-7%/year in Asia
- + 2%/year to 2050

Urbanization:

- 20% in 1900, 40% in 1990, >50% in 2010
- 70% of people in cities by 2050

World demand for livestock food products since 1990:

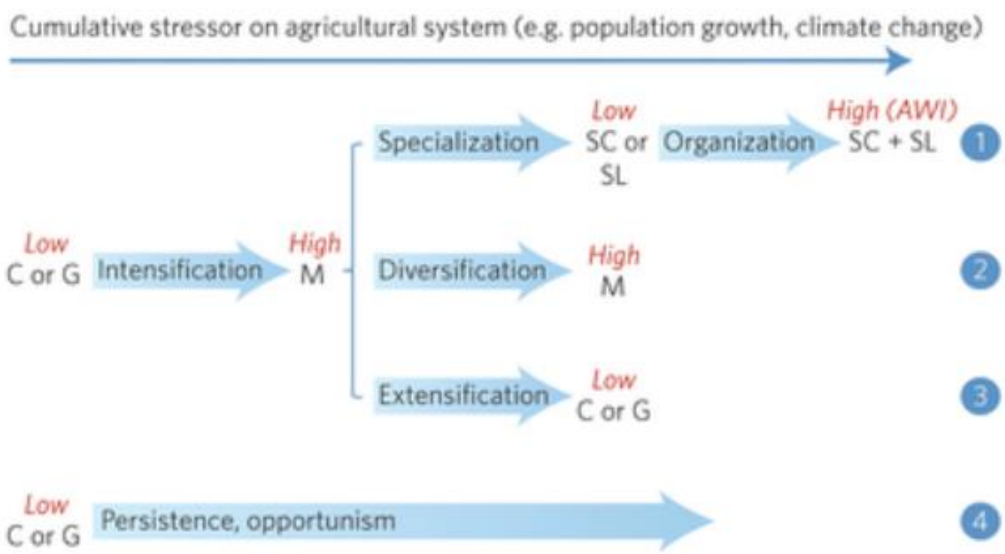
- Milk + 30%   Meat + 60%   Eggs + 80%
  - + 70% by 2050

MIXED CROP-LIVESTOCK SYSTEMS

"Farming systems that to some degree integrate crop and livestock production activities so as to gain benefits from the resulting crop-livestock interactions"

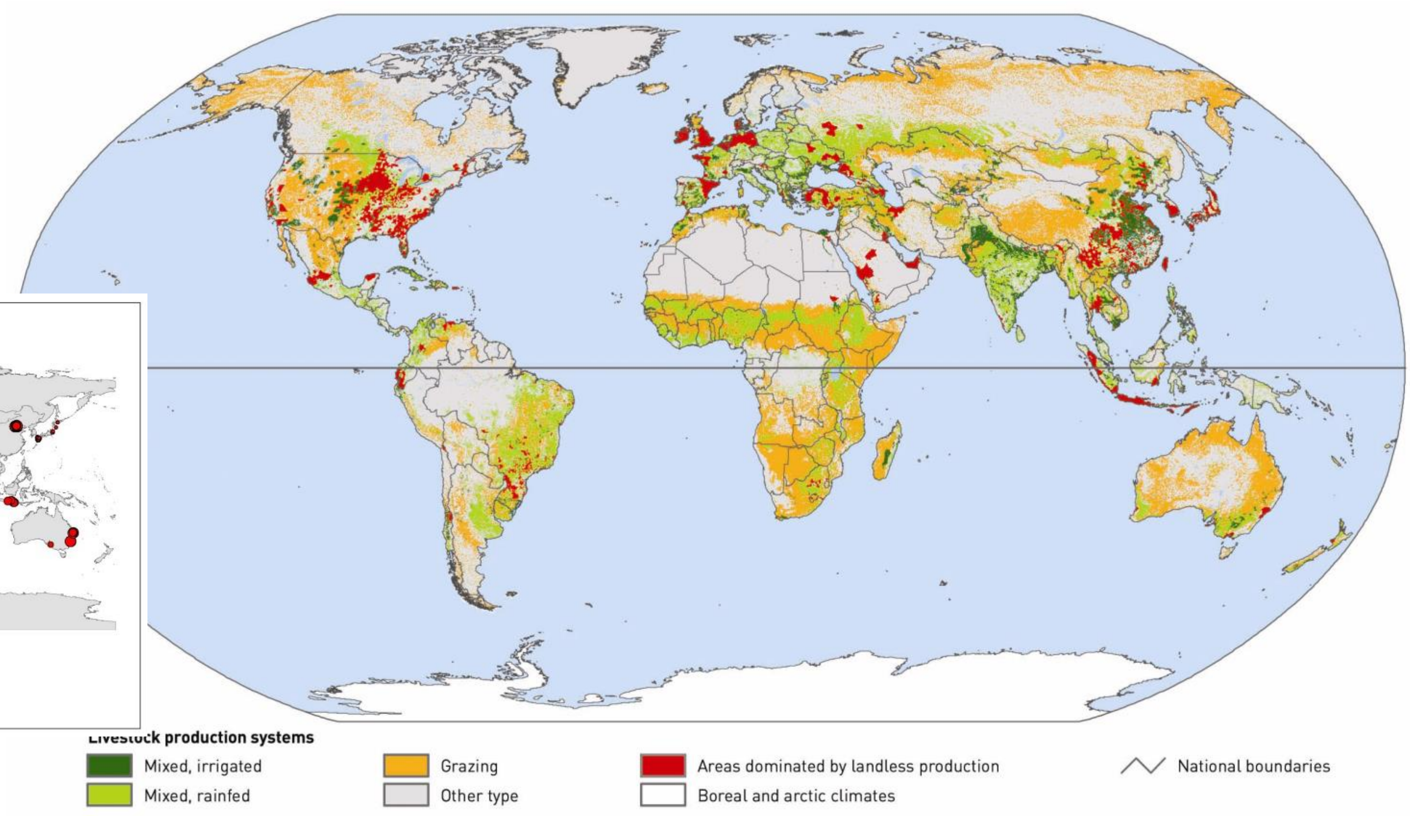
Sumberg, 2003

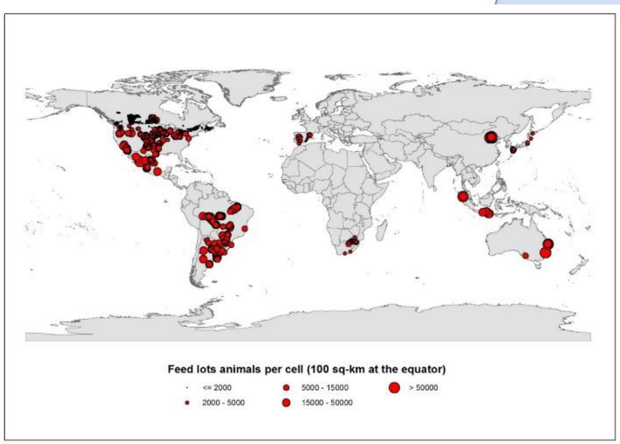
Four possible trajectories of crop and livestock systems.



Thornton and Herrero, 2015

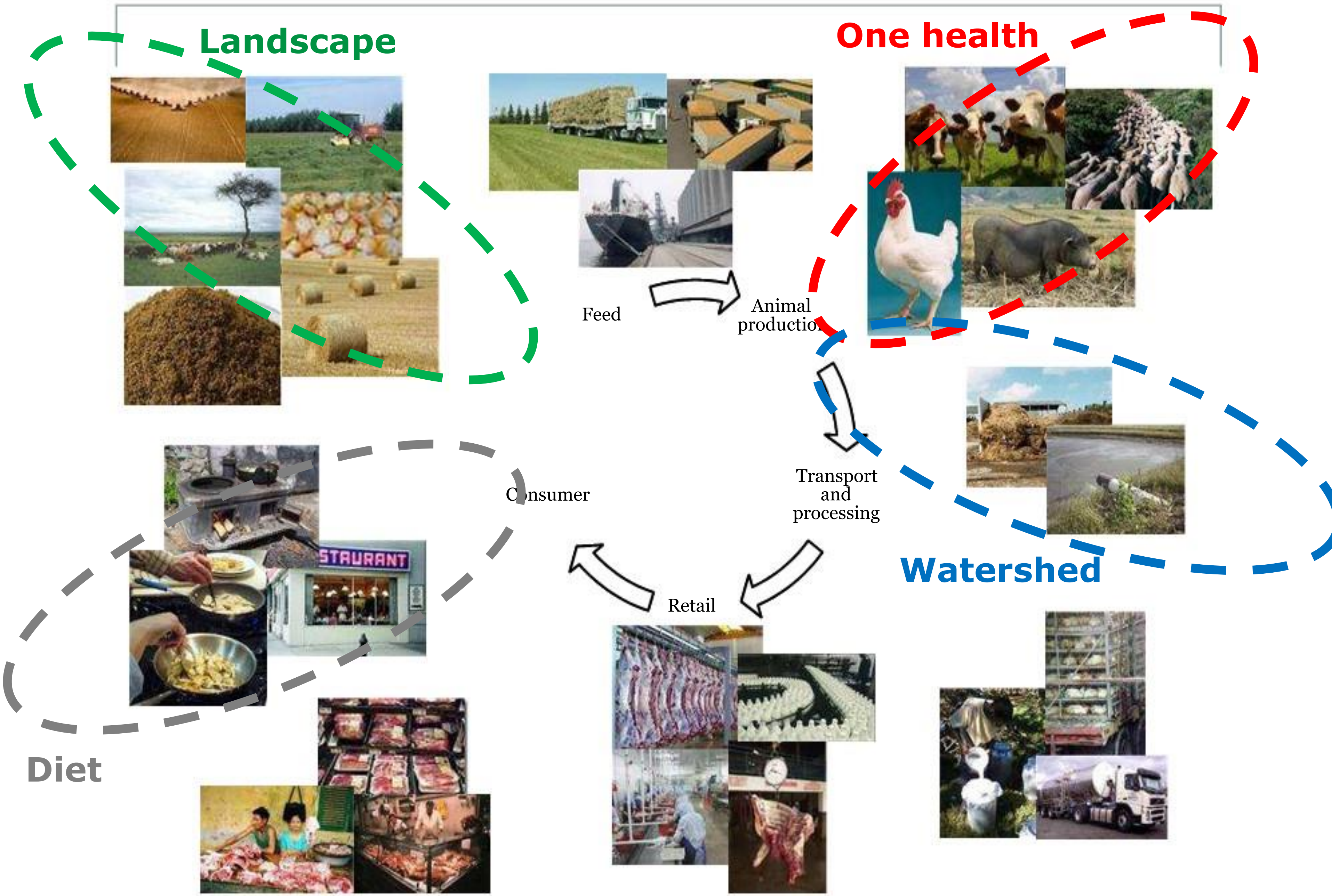
ESTIMATED DISTRIBUTION OF LIVESTOCK PRODUCTION SYSTEMS





FAO, 2006

An overview of livestock supply chains



TRENDS IN LIVESTOCK SYSTEMS

Increase in livestock numbers:

Change in feeding system:
intensive use of limited land resources

Change in scale:
smallholders increasing in size and development of large scale operations, driven by economies of scale and access to market

Geographical concentration:
at small/medium and large scale farms, driven by economies of scope and transport costs

SUSTAINABLE DEVELOPMENT GOALS

Livestock and inclusive, sustainable economic growth

Livestock and equitable livelihoods

Animal source foods for nutrition and health

Livestock and sustainable ecosystems

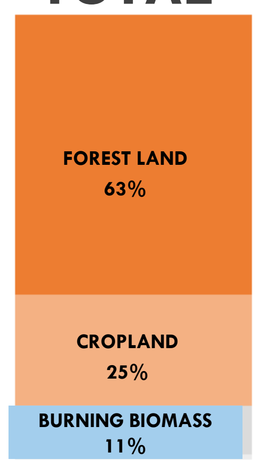
After Tarawali, 2015

From Tarawali, 2015

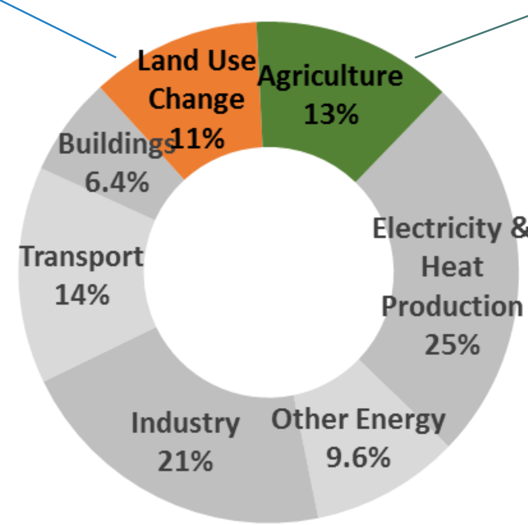
CLIMATE CHANGE

TODAY - THE FOOD SYSTEM **IS PART** OF THE CLIMATE CHANGE PROBLEM

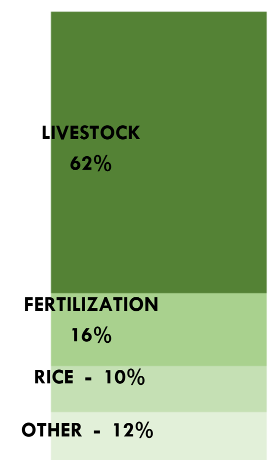
LAND USE CHANGE ~11% OF TOTAL



TOTAL EMISSIONS

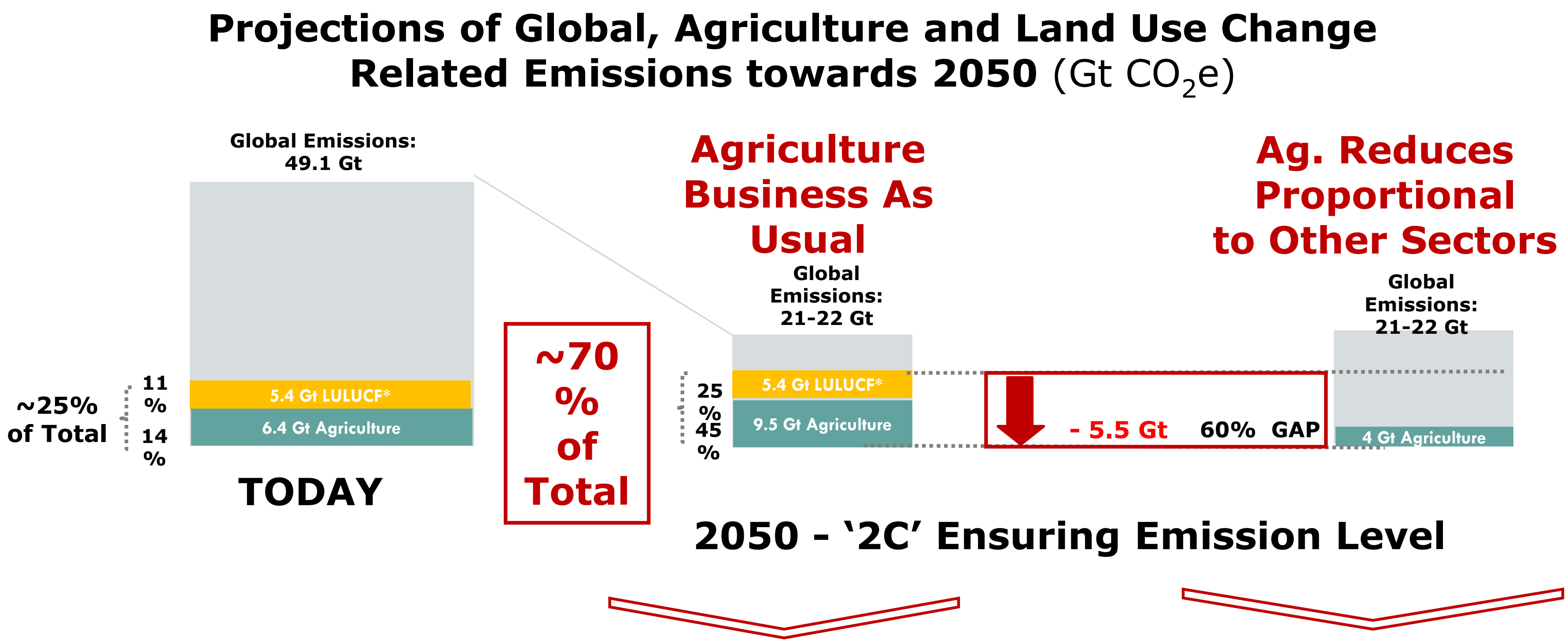


AGRICULTURE ~13% OF TOTAL



IPCC 2014

TOMORROW – THE FOOD SYSTEM COULD BE **THE** CLIMATE CHANGE PROBLEM



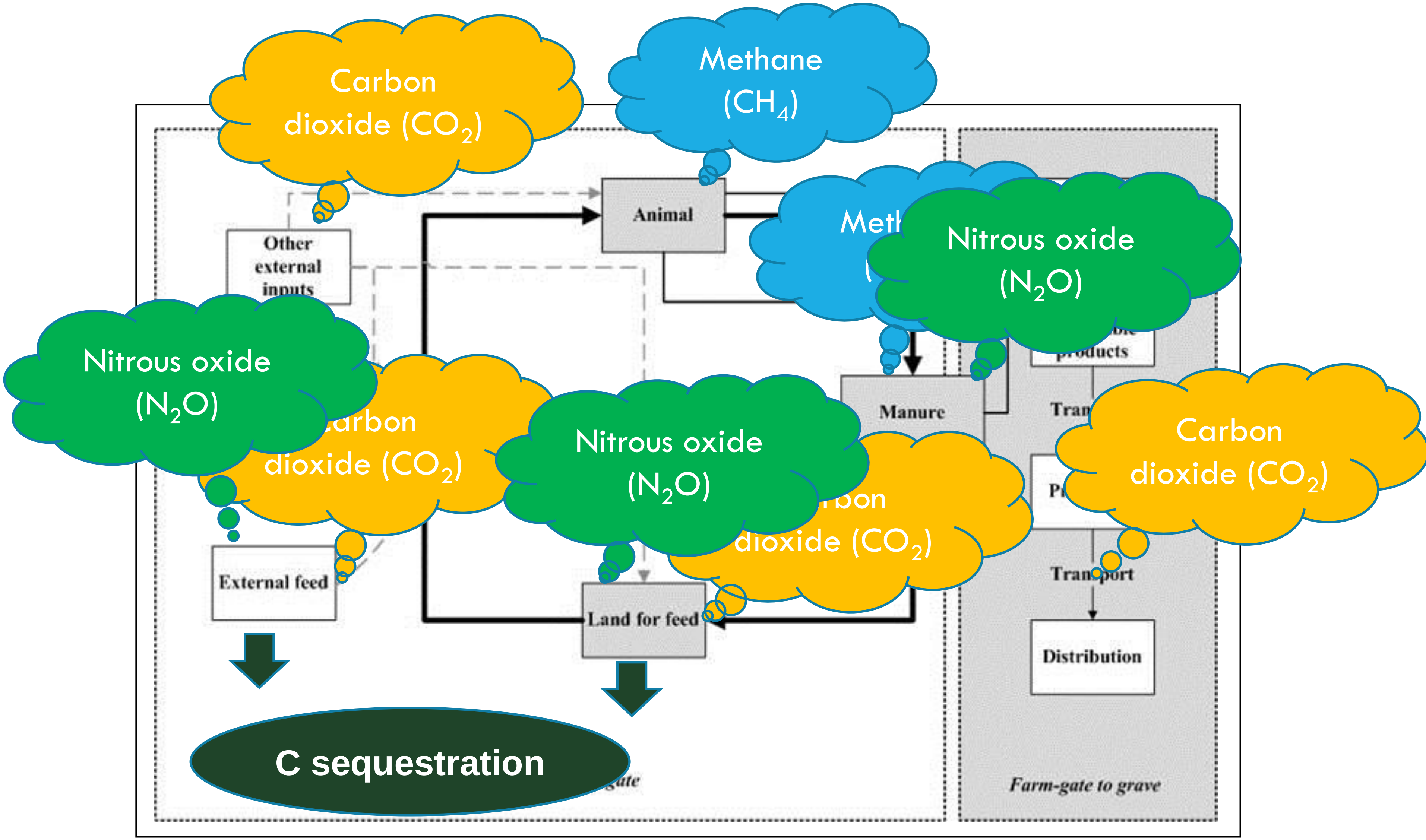
By 2050, Agriculture and Land Use Change could represent 70% of Global Emissions - if global emissions are reduced in accordance with a 2C goal, while Agriculture were to remain in business as usual.

By 2050, Agriculture will have to reduce its emission intensity by 60%, if it is to maintain its footprint in parallel with overall emissions reductions. **This assumes emissions from Land Use Change will have fallen to zero.**

*Land Use, Land Use Change and Forestry

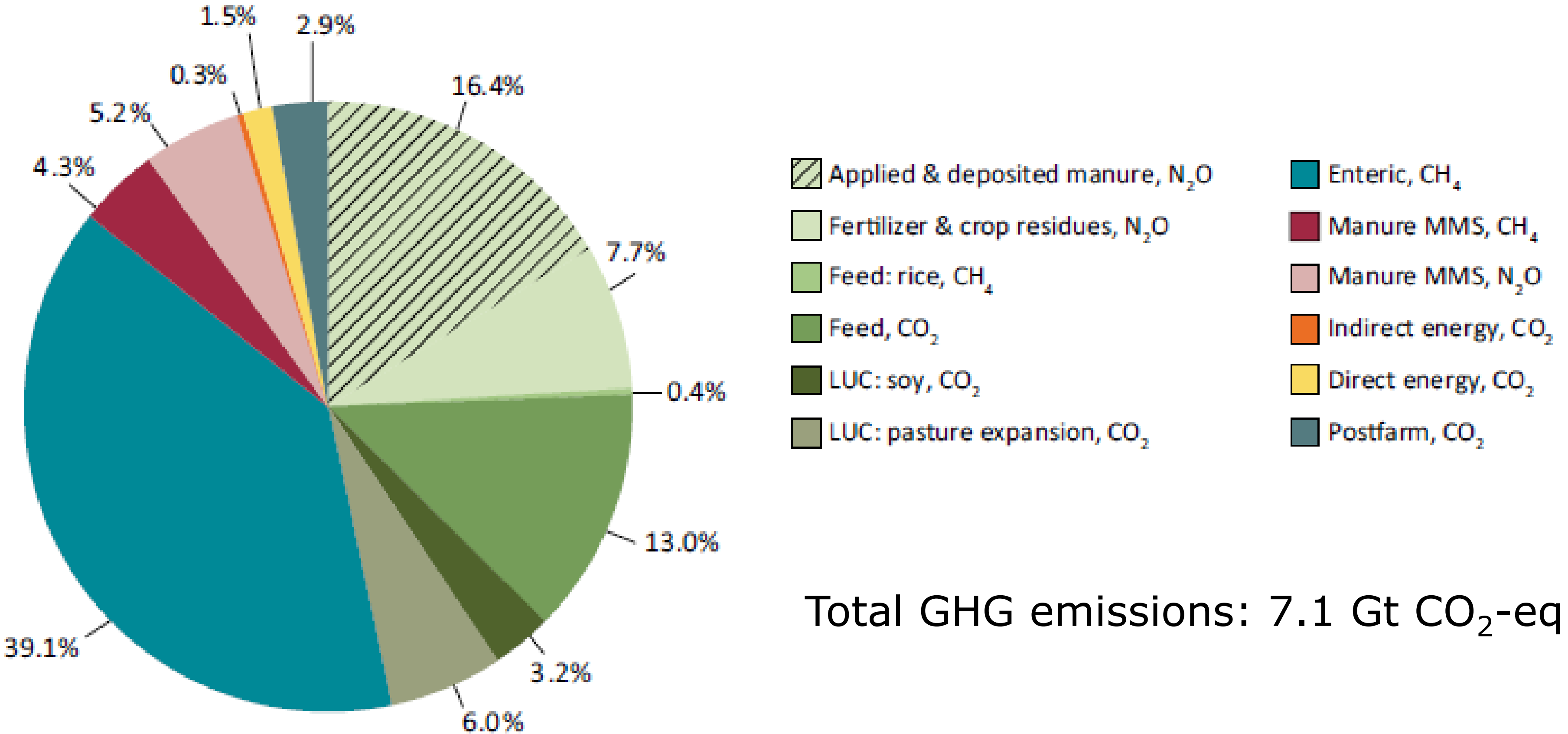
WRI 2013

GHG EMISSIONS IN LIVESTOCK SUPPLY CHAINS



System boundary

RELATIVE CONTRIBUTION OF LIFE-CYCLE PHASES – GLOBAL LIVESTOCK SECTOR



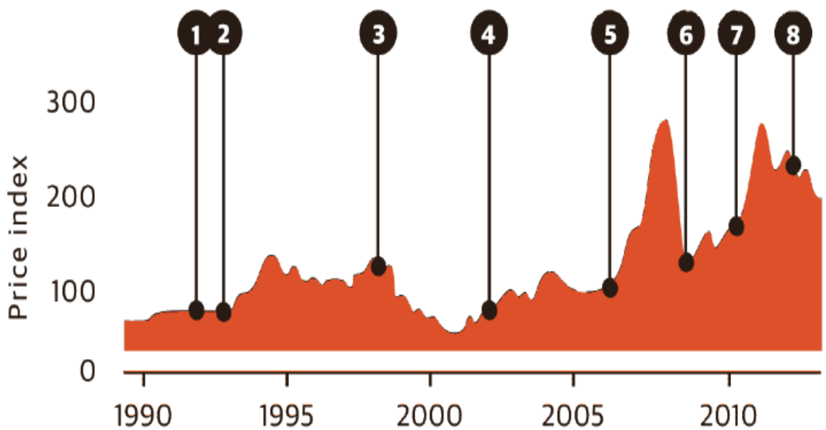
Total GHG emissions: 7.1 Gt CO_2-eq

FAO, 2013

CLIMATE CHANGE IMPACTS ON FOOD SYSTEMS – HERE TODAY

PRODUCTION Volatility Impacts FOOD Prices

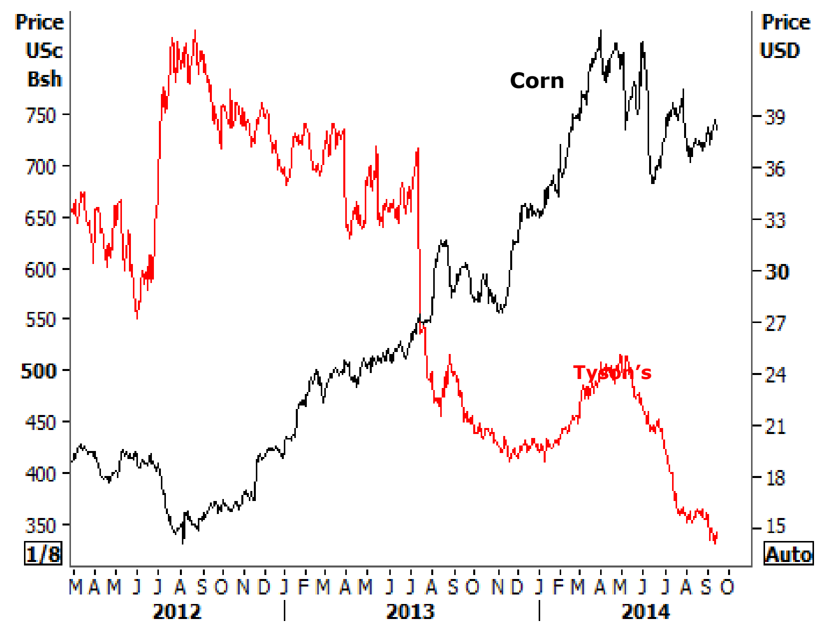
have been linked to extreme weather events



1. Australia wheat. **2.** US maize. **3.** Russia wheat. **4.** US wheat, India soy, Australia wheat. **5.** Australia wheat. **6.** Argentina maize, soy. **7.** Russia wheat. **8.** US maize.

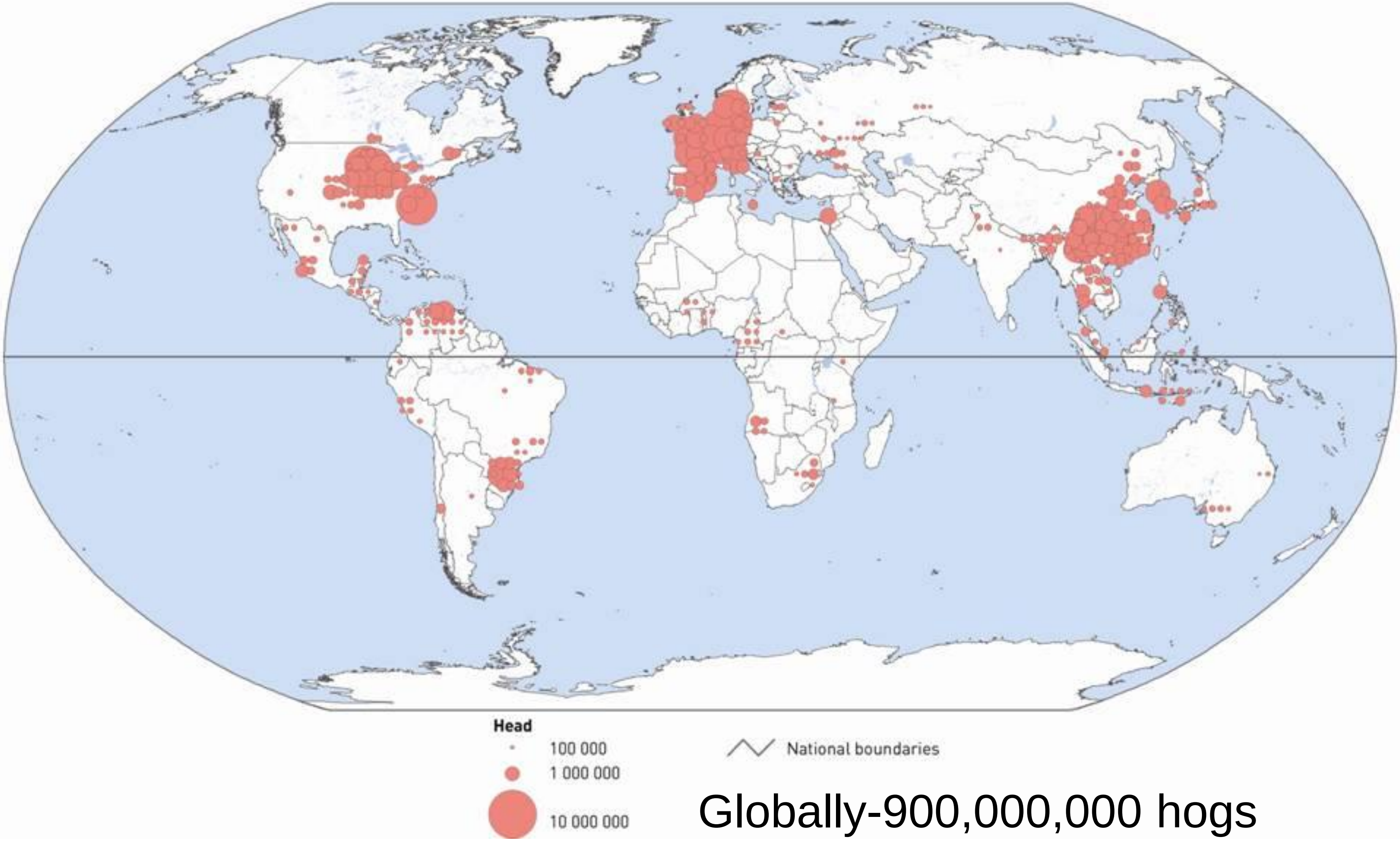
PRICE Volatility Impacts SHARE prices

A price hike in corn (black) drives down the share price of Tyson Foods (red)



World Bank 2008, Reuters Eikon

GEOGRAPHICAL CONCENTRATION AND THE NUTRIENT ISSUE



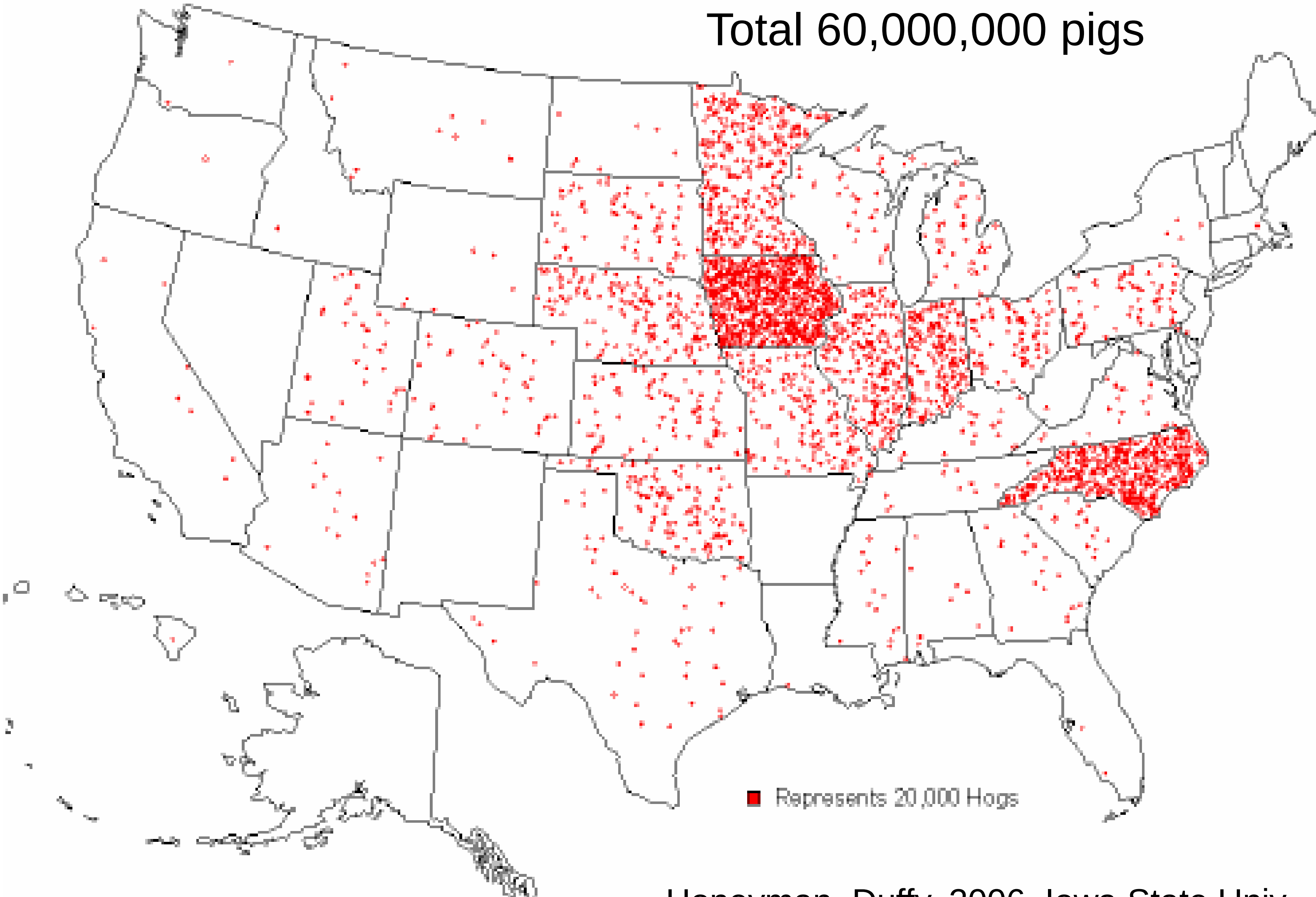
Globally-900,000,000 hogs

Estimated distribution of industrialized produced pig populations

FAO, 2006

US Hog Numbers 2002

Total 60,000,000 pigs

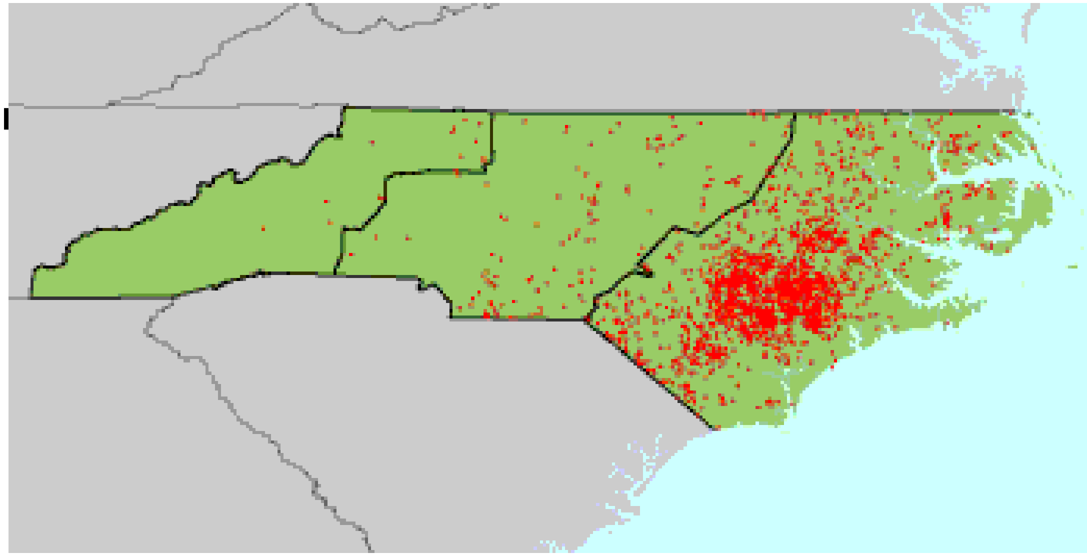


Honeyman, Duffy, 2006. Iowa State Univ

PIGS IN NORTH CAROLINA

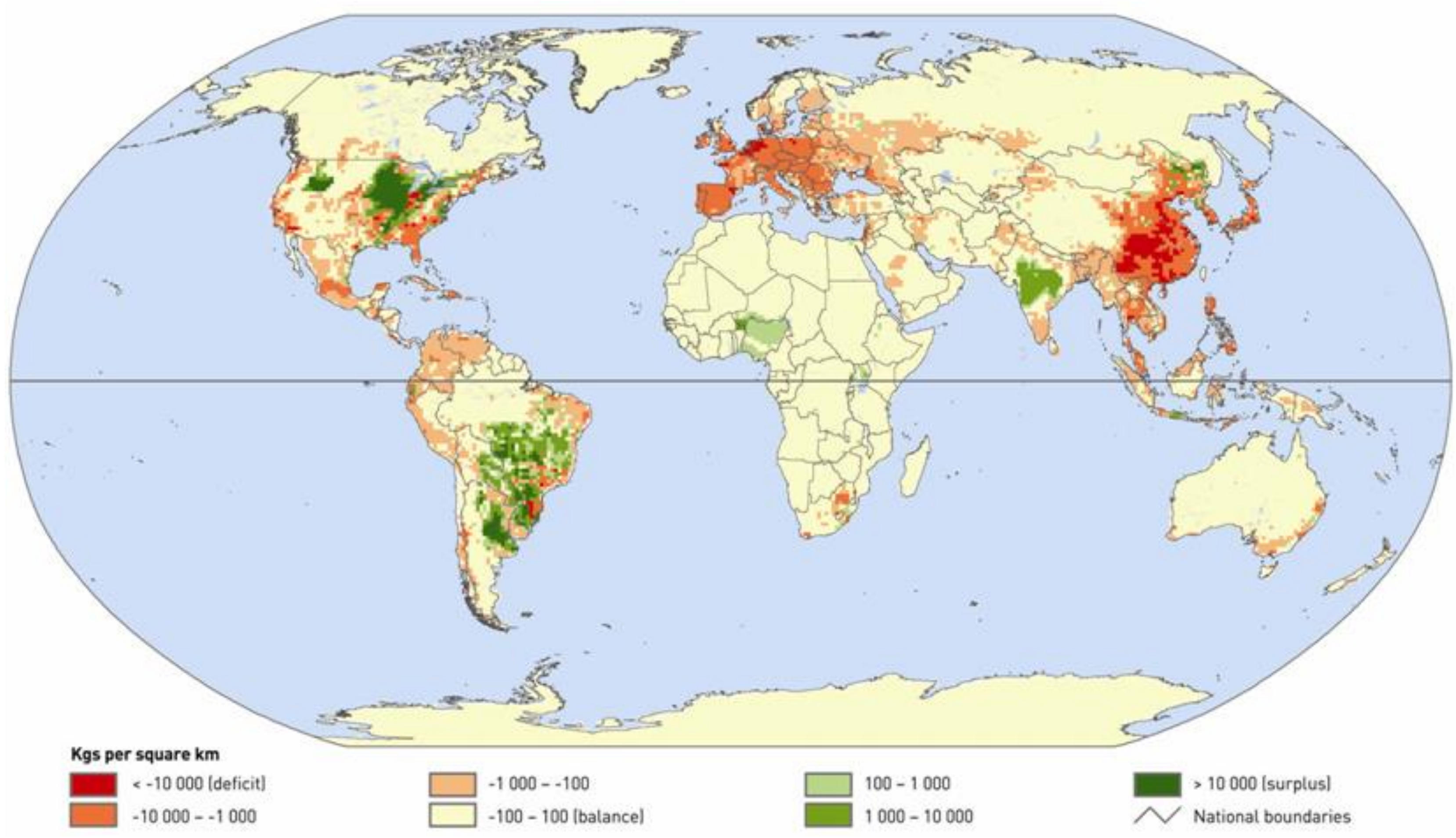
9,800,000 hogs and pigs

45% are in 2 of the 100 counties of the state and are on the coastal plai



US National Agricultural Statistics Service 2005

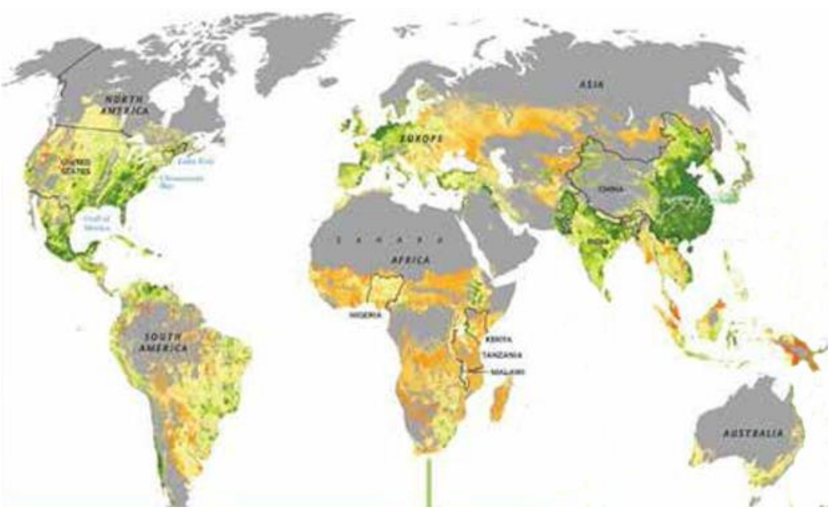
ESTIMATED SOYMEAL SURPLUS/DEFICIT



FAO, 2006

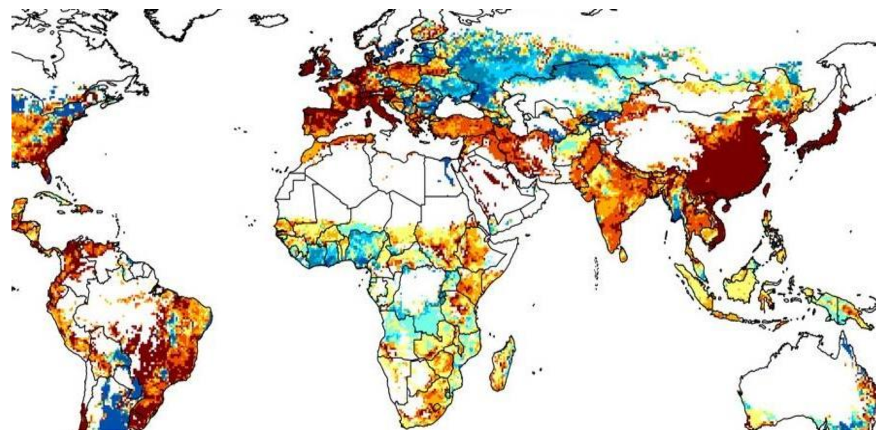
DISLOCATED RESOURCES.

NITROGEN BALANCE



depletion excess

PHOSPHORUS BALANCE



P deficits (kg P ha^{-1} yr^{-1})

- Lowest quartile (0 to -0.8)
- Lower-middle quartile (-0.8 to -1.9)
- Upper-middle quartile (-1.9 to -3.2)
- Top quartile (-3.2 to -39.0)

P surpluses (kg P ha^{-1} yr^{-1})

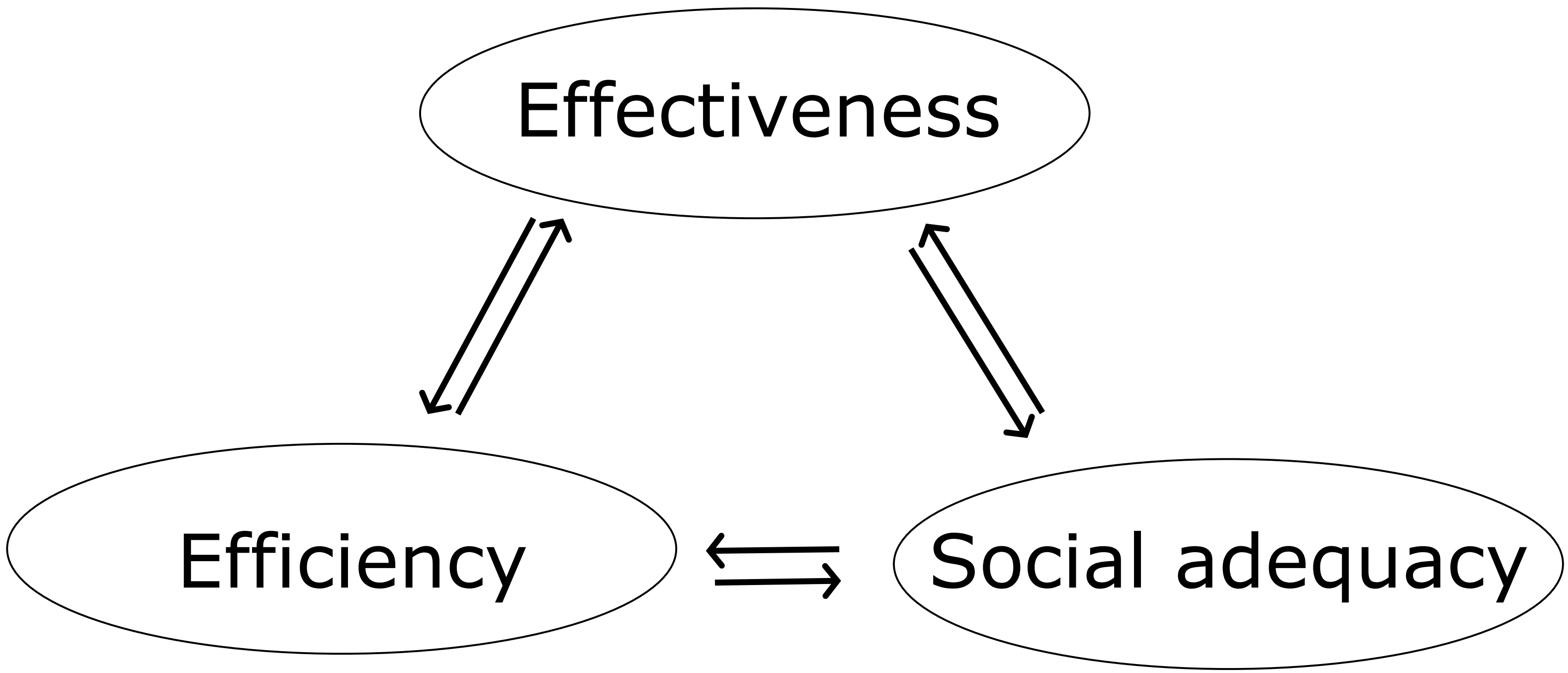
- Lowest quartile (0 to 2.5)
- Lower-middle quartile (2.5 to 6.2)
- Upper-middle quartile (6.2 to 13.0)
- Top quartile (13.0 to 840.0)

MacDonald G K et al. PNAS 2011;108:3086-3091

THE RELEVANCE OF MIXED CROP-LIVESTOCK SYSTEMS

Comparative advantage of integrated systems.

WHERE DOES THE SECTOR NEED TO DELIVER?



EFFECTIVENESS

The sector shall supply the required mix of goods and services, in a safe and robust manner.

Respond to growth – mixed crop-livestock system is the dominant form of production

- output per animal;
- number of animals.

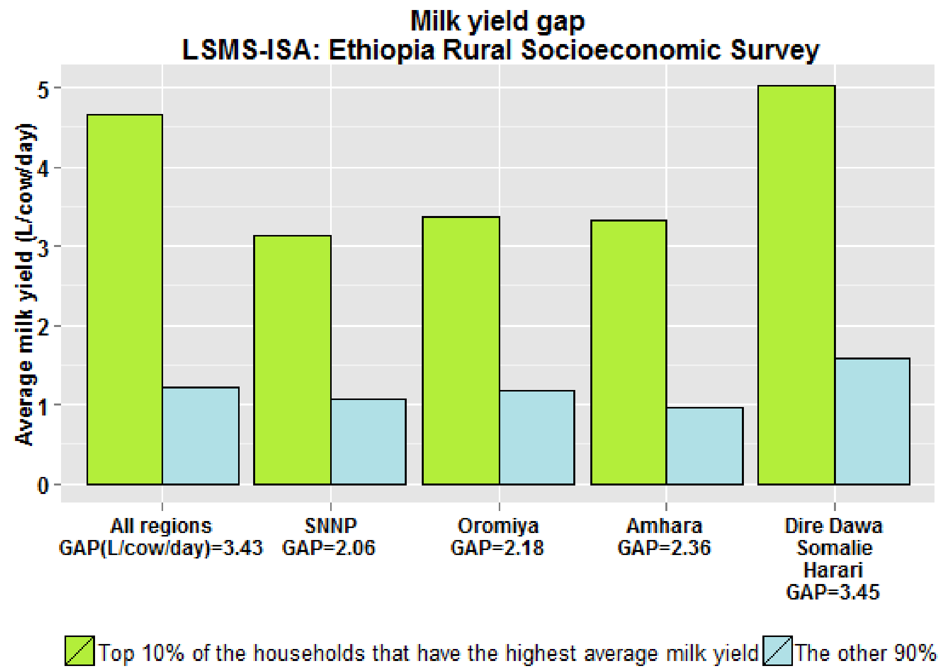
Be resilient to shocks – diversification and integration

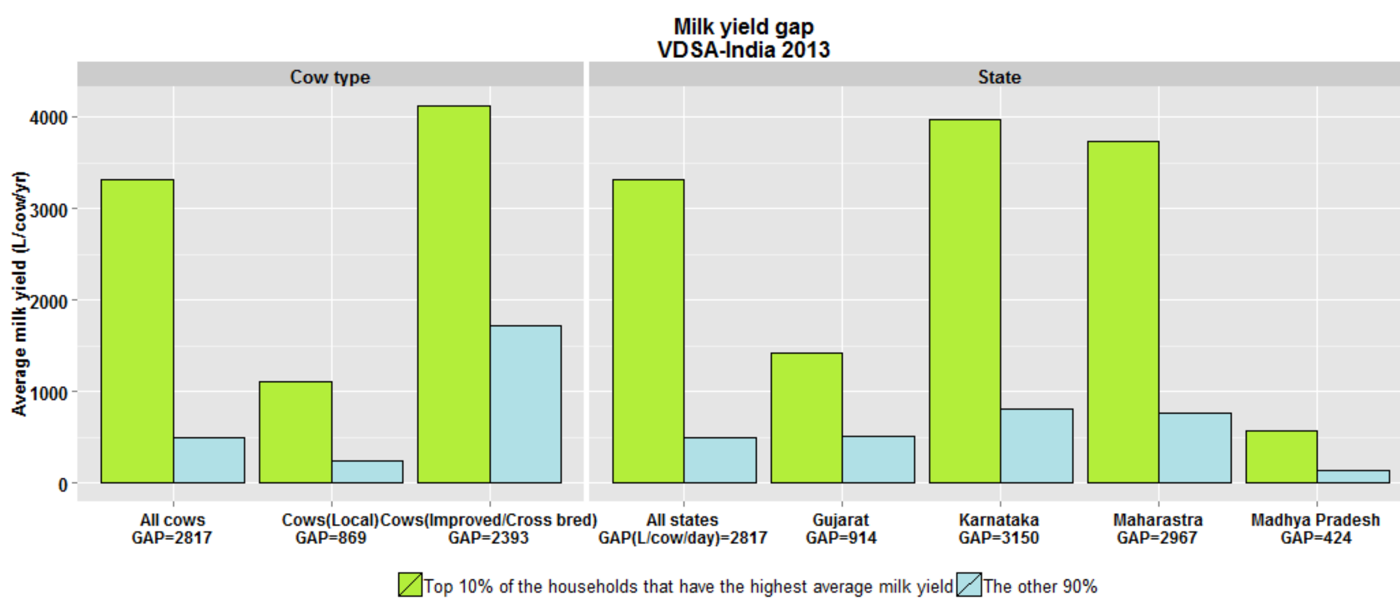
- climate change;
- input and output prices;
- animal health.

Ensure food safety – issue of farm size.

Livestock yield gaps Can be large

2.5 – 4 times
Herrero et al (2015)





REDUCING DEMAND - EVIDENCE

Strong rationale

- Livestock products are generally more resource intensive than others food items
- Health co-benefits
- Reduced demand: dietary change and reduction in food losses and wastes
- Direct and indirect mitigation effects of reduced demand

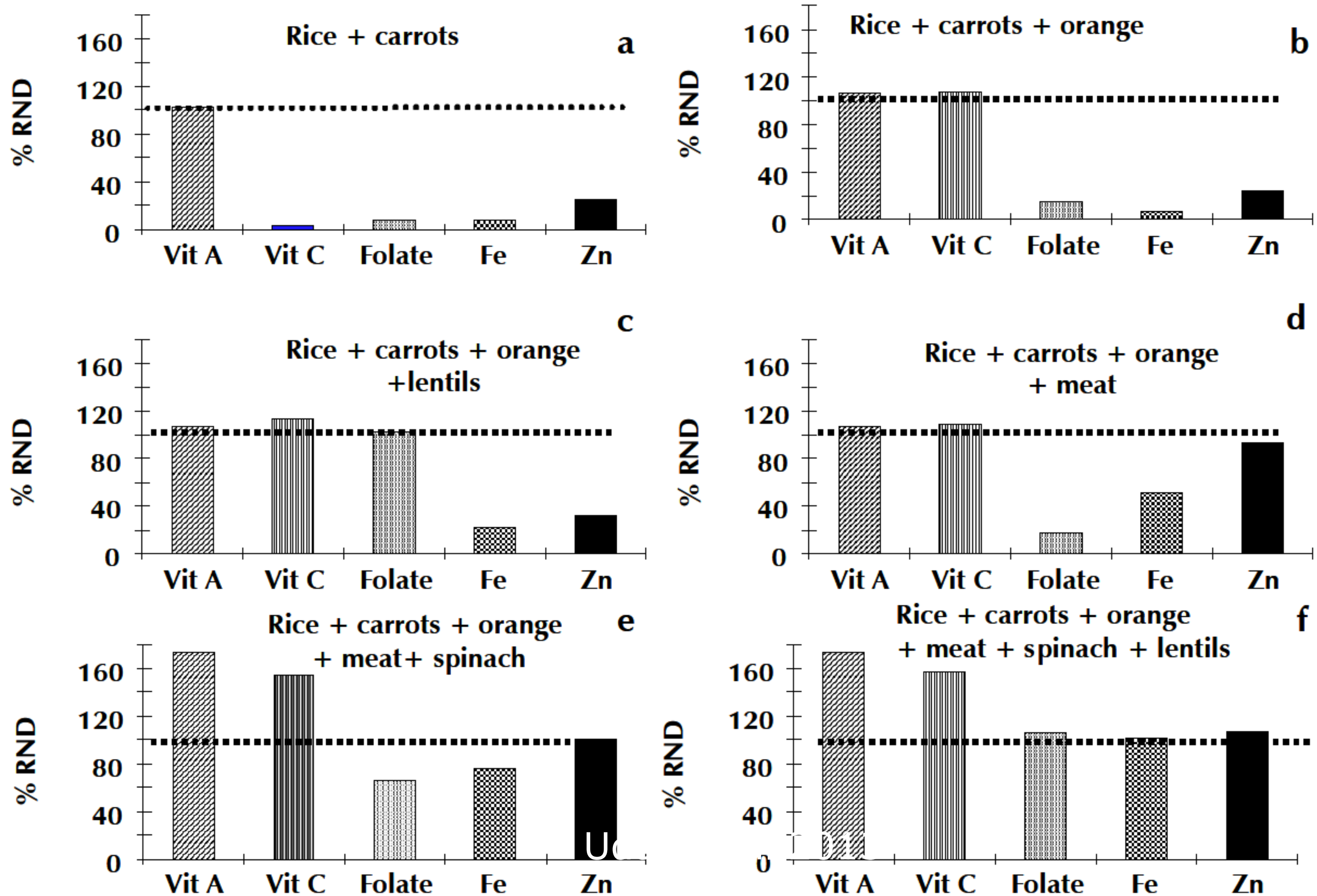
Uncertainties in the analyses

- Effect on farming systems: use of crop residues and food byproducts, fertilization, traction
- Results highly dependent on hypothesis made about alternative land use
- Rebound effect (50 % in Sweden, Grabs 2015)

Constraints to implementation

- Instruments and willingness to influence consumers' choice
- Alternative sources of nutrients aren't always accessible / more environmentally friendly.

NUTRITIONAL DIVERSITY MATTERS



EFFICIENCY

The sector shall minimize the resources mobilized and noxious emissions generated per unit of output.

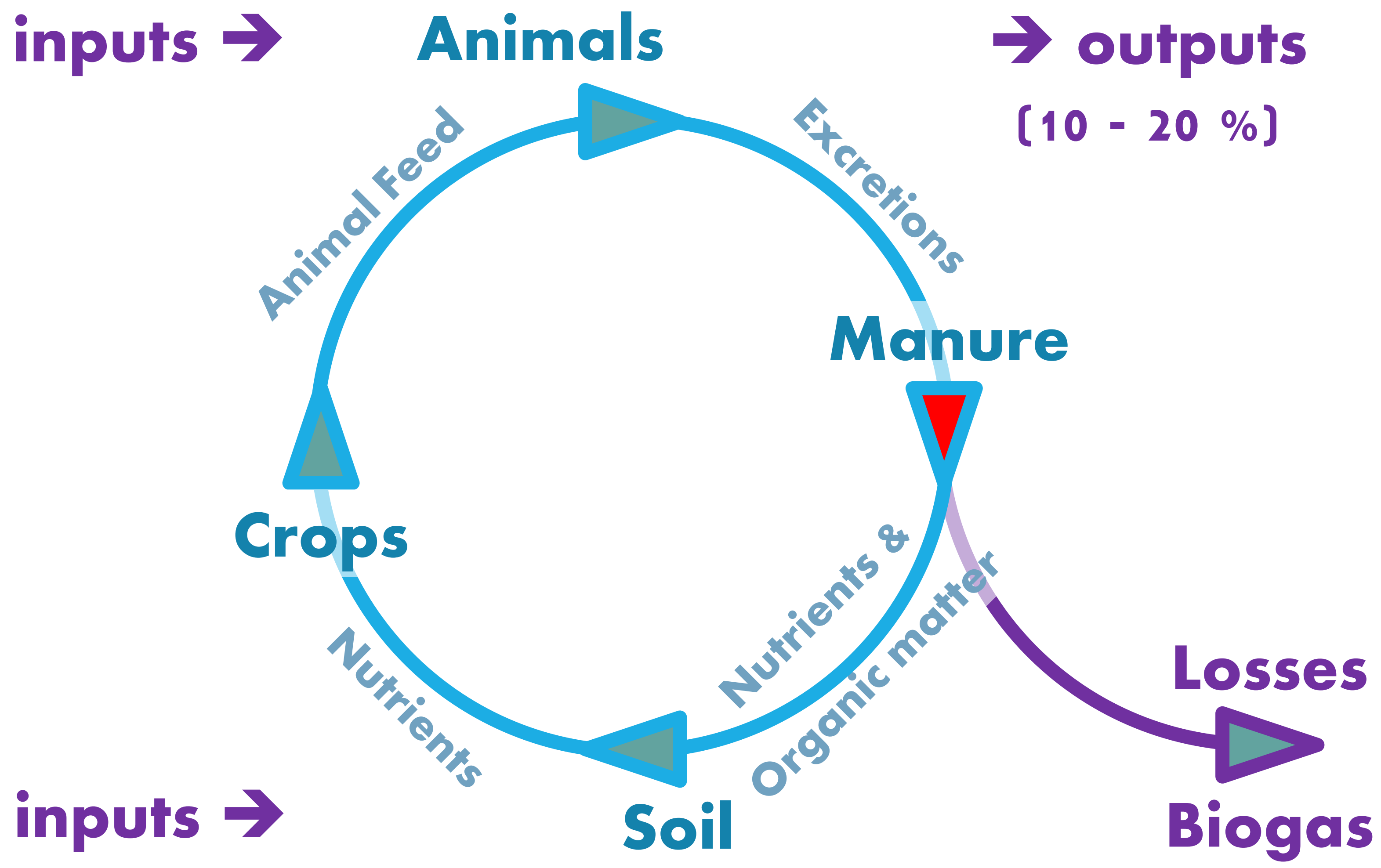
Ecological efficiency:

- unit of natural resource used per unit of output generated;
- unit of noxious emissions generated per unit of output generated.

Economic efficiency:

- minimize price of outputs (given quality and input prices), especially countries with high food insecurity prevalence.

CYCLE PRINCIPLE



GHG EMISSIONS ARE LOSSES

Methane

- CH_4 emissions are energy losses
- Total enteric methane emissions : equivalent to 144 Mt oil equivalent per year
- Total manure methane emissions: equivalent to 29 Mt oil equivalent per year

Nitrous oxide

- N_2O losses are N losses from manure and fertilizers
- Manure N_2O emissions (direct and indirect) from manure application on crops and application on pasture: 3.2 Mt of N

Carbon dioxide

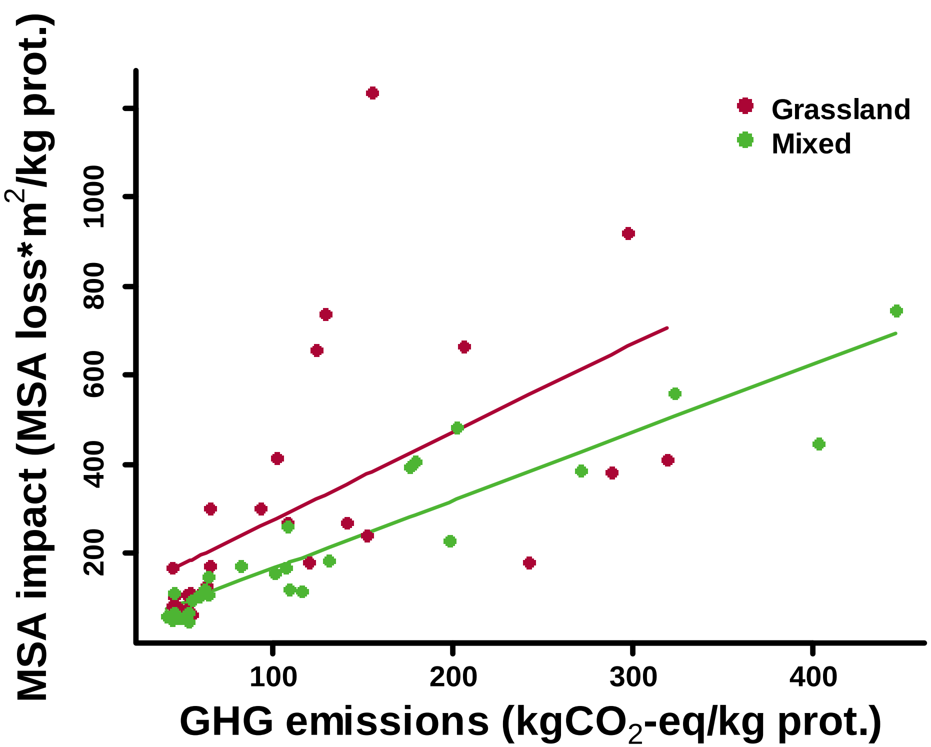
- CO_2 emissions are related to fossil fuel use and organic matter losses
- Soil organic matter is key to land productivity

➢ There is a strong link between Ei and resource use efficiency

SYNERGIES BETWEEN GHG MITIGATION AND BIODIVERSITY PRESERVATION

Synergies between the two performances across agro-ecological zones

For dairy cattle



MSA: Mean Specie Abundance

Teillard et al., 2014

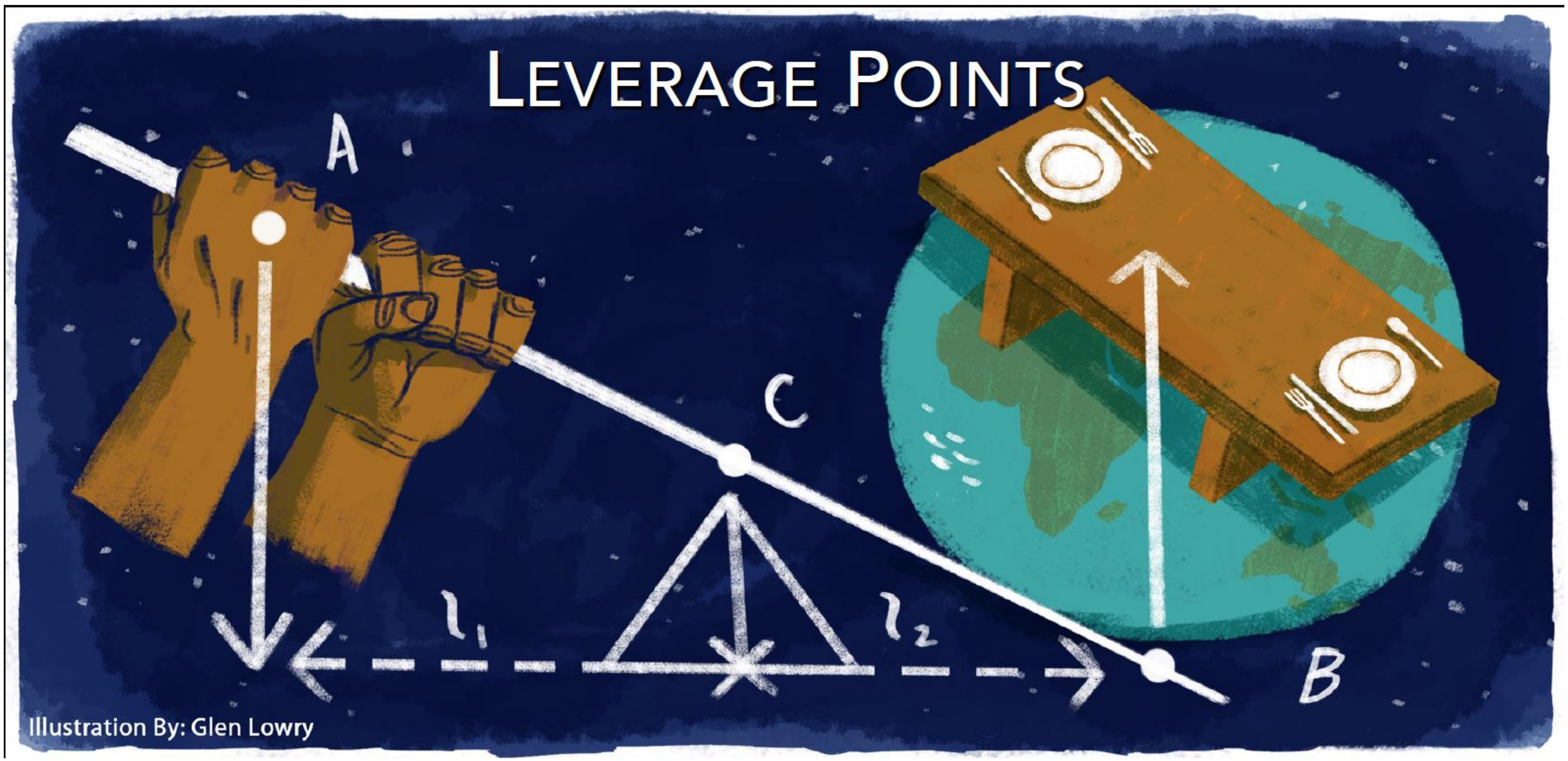
SOCIAL ADEQUACY

Food chains need to develop in a manner that suits societal ethical expectations.

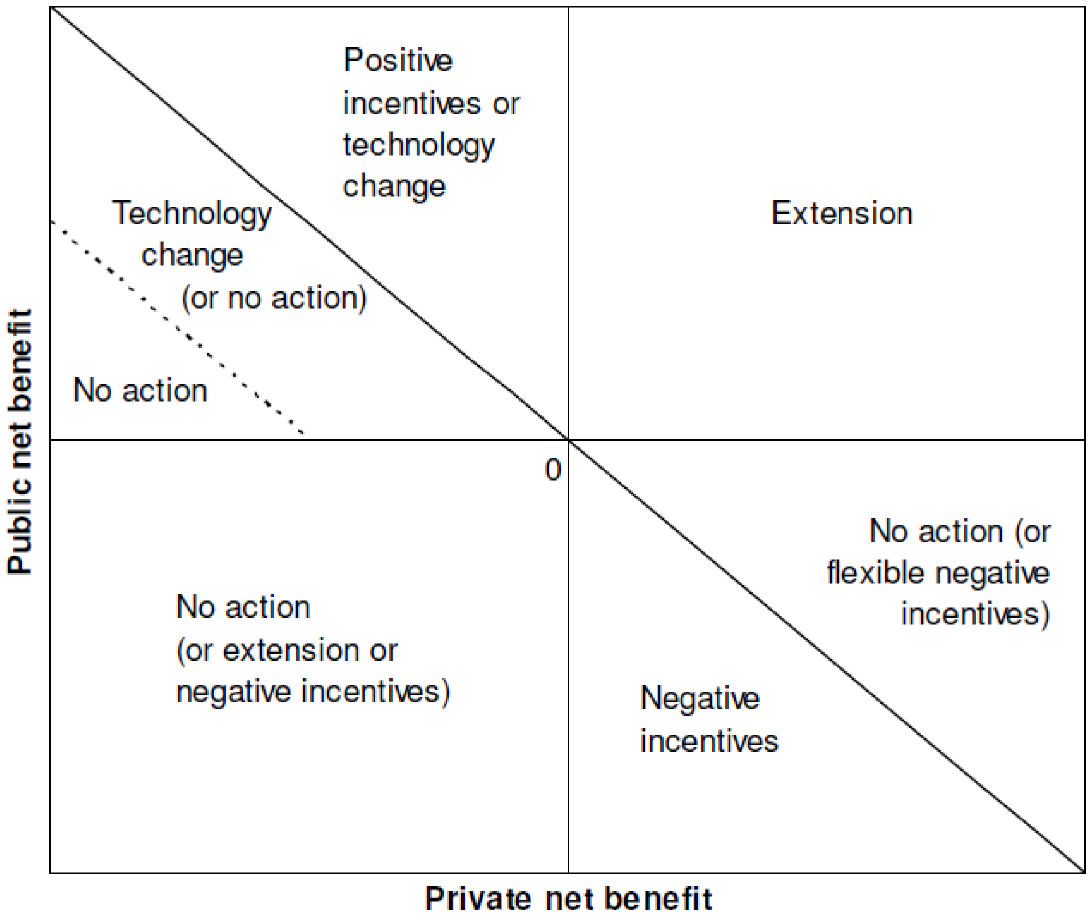
DRIVERS OF CHANGE IN THE FOOD CHAIN : FROM FORK TO FARM

RESEARCH AND DEVELOPMENT NEEDS

WHAT WILL TRIGGER CHANGE?



PUBLIC POLICIES: WHERE DO WE NEED TO FOCUS?



Pannel, 2008

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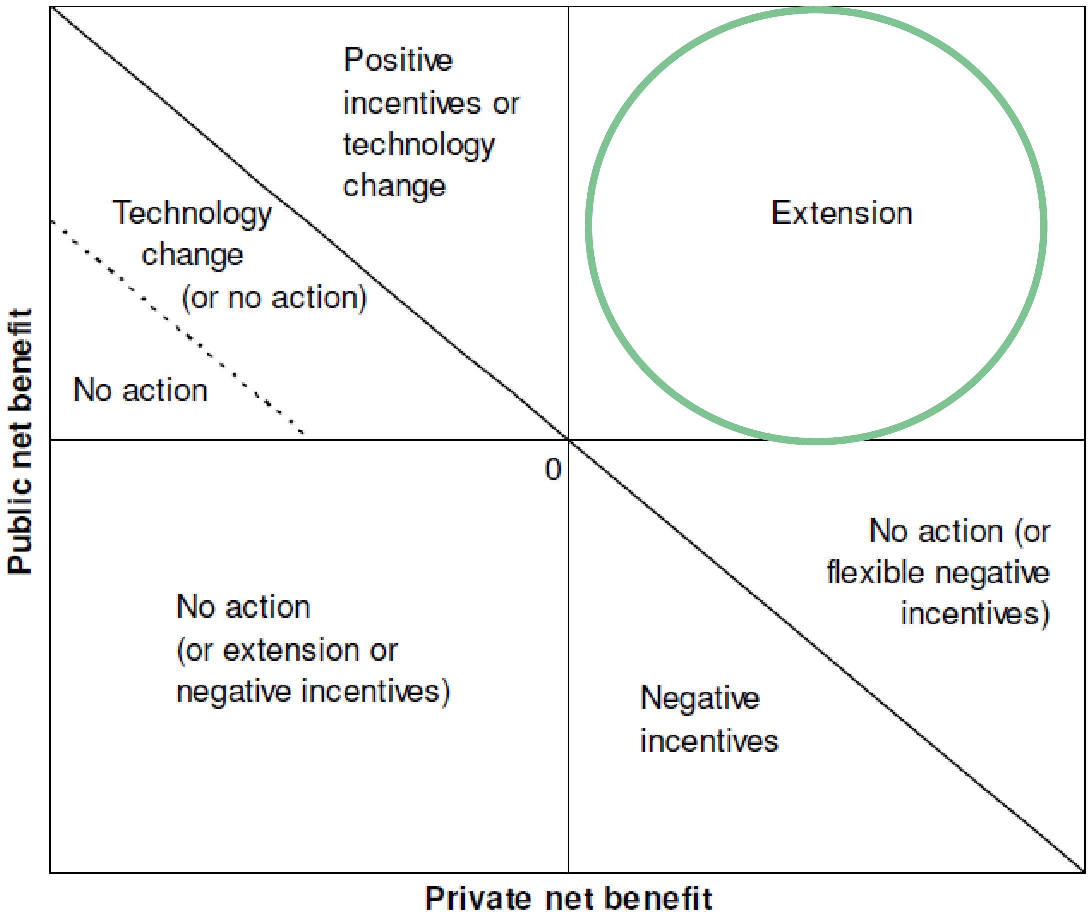
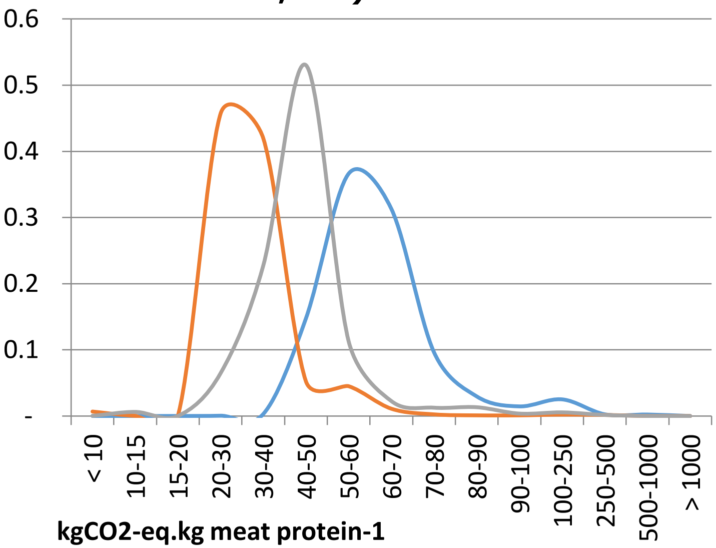


- Technology transfer
- Access to finance
- Risk mitigation
- Safeguard against trade-offs (water, animal welfare, …)



Pannel, 2008

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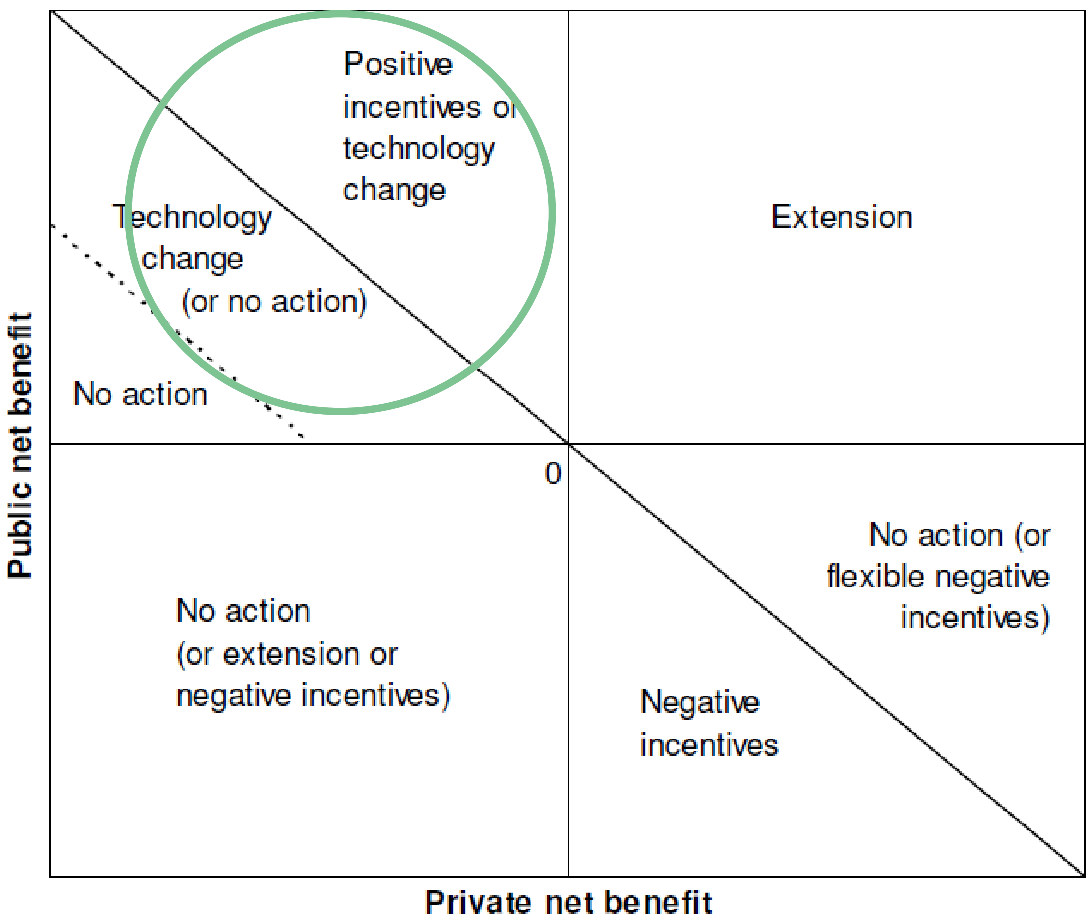
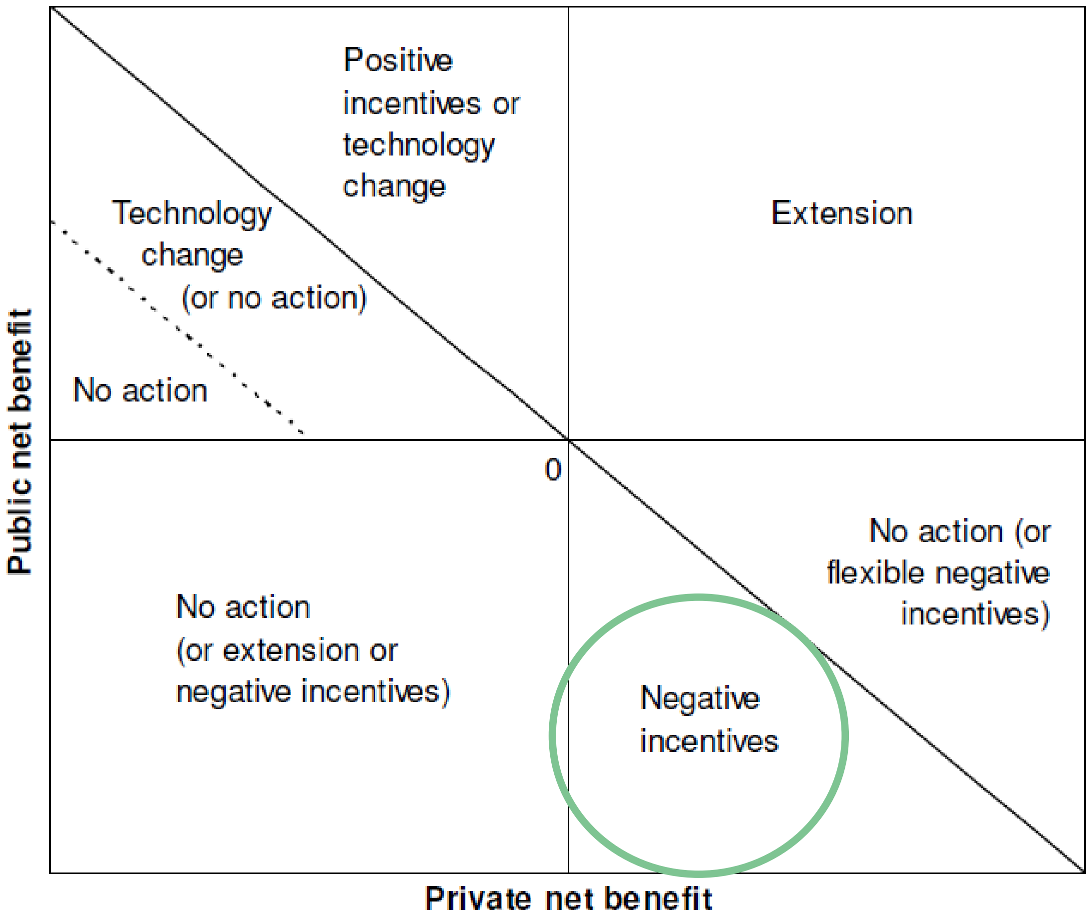


- Research
- C markets / payments for emission reduction
- Subsidies (e.g. biogas, renewable energy production)

PUBLIC POLICIES: WHERE DO WE NEED TO FOCUS?



- Regulations (e.g. on manure management, on agricultural land expansion)
- Price of resources (e.g. fossil fuel)

Pannel, 2008

RESEARCH NEEDS (I)

Broad picture:

- From field to farm to farming system to food system modelling

System level:

- Reconnecting specialized (large scale) crop and livestock production: manure, crop residues, food by-products.

Technology adoption and effectiveness:

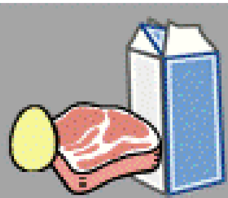
- Drivers of practice change, innovation processes
- Metrics for sustainability assessment and benchmarking

RESEARCH NEEDS (II)

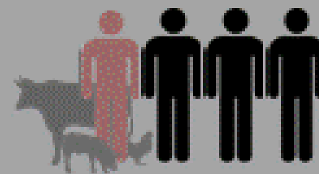
Field and animal level:

- Crop breeding for edible residues
- Rapid assessment of manure contend (NIR techniques)
- Manure processing, crop residues management

COMPELLING FIGURES



+70% in 2050



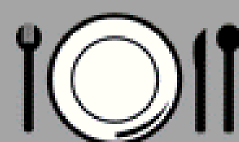
1 person out of 4

€

40% agri GDP

1 Billion

Poor livestock keepers



25% of proteins
13% of kcal

30% of land

14.5% of GHG

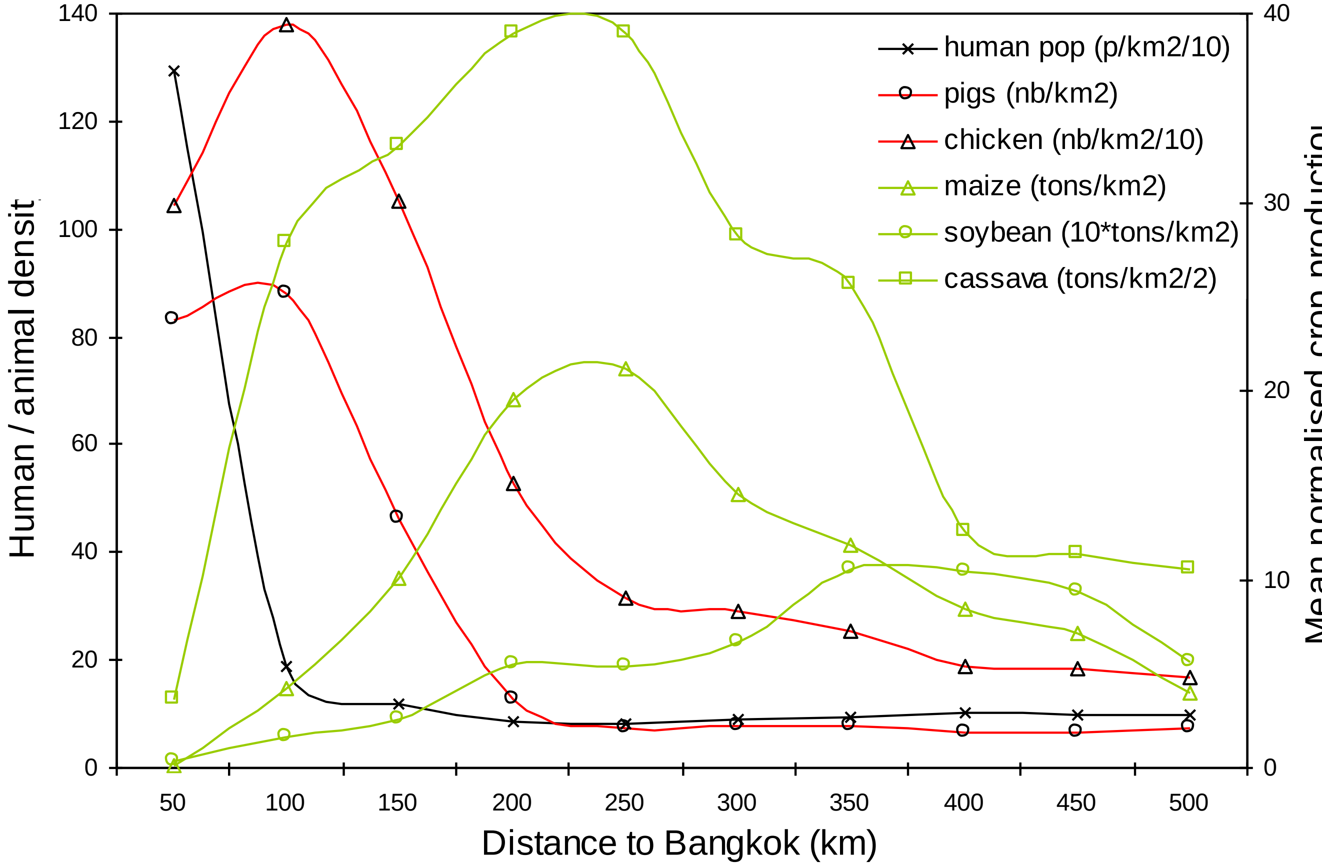
N

25% synthetic nitrogen

8 to 15%


Thank you
pgerber@worldbank.org

SPATIAL DISTRIBUTION OF HUMAN, LIVESTOCK AND CROP DENSITIES AT THE PERIPHERY OF BANGKOK



Gerber et al., 2005

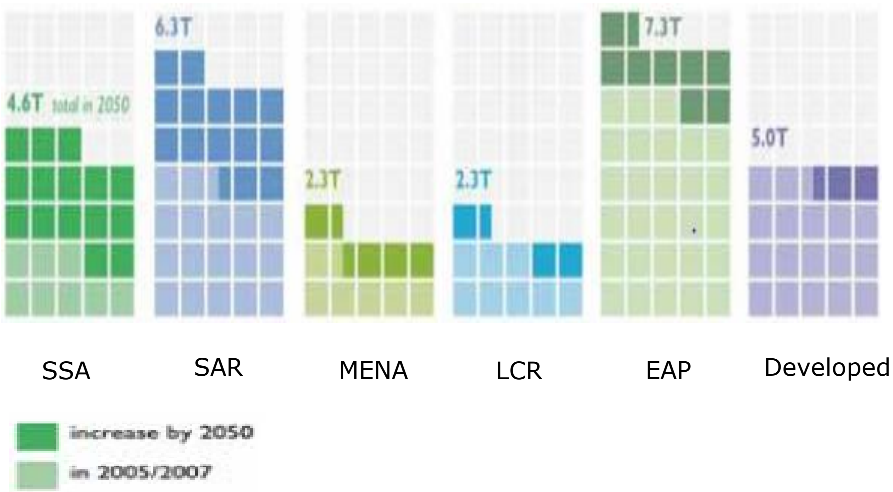
WHAT WILL IT TAKE - FEEDING 9 BILLION PEOPLE IN 2050

Changing Consumption

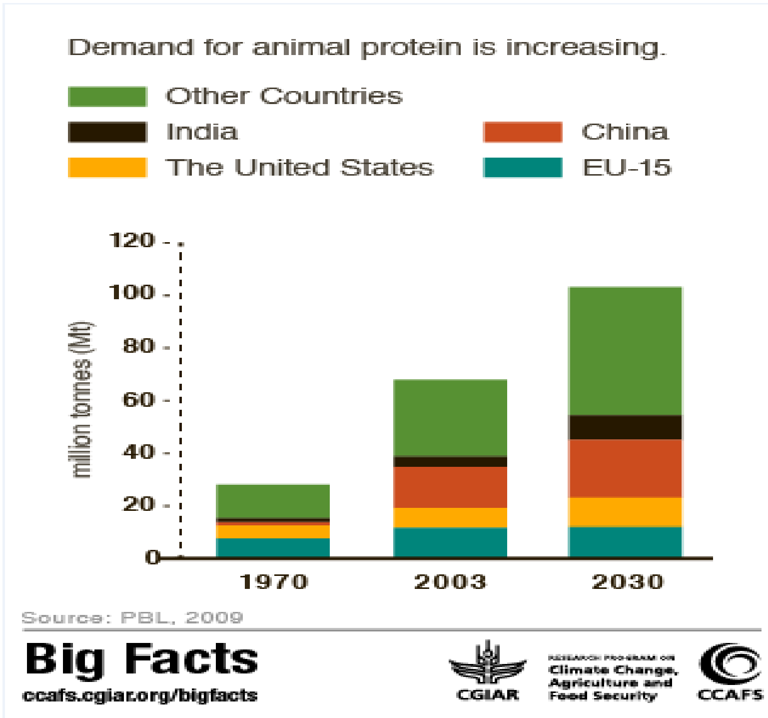
Food Consumption by Region 2005/07 vs 2050

Percentage Increase 05/07 – 2050

183%   81%   79%   43%   30%   11%

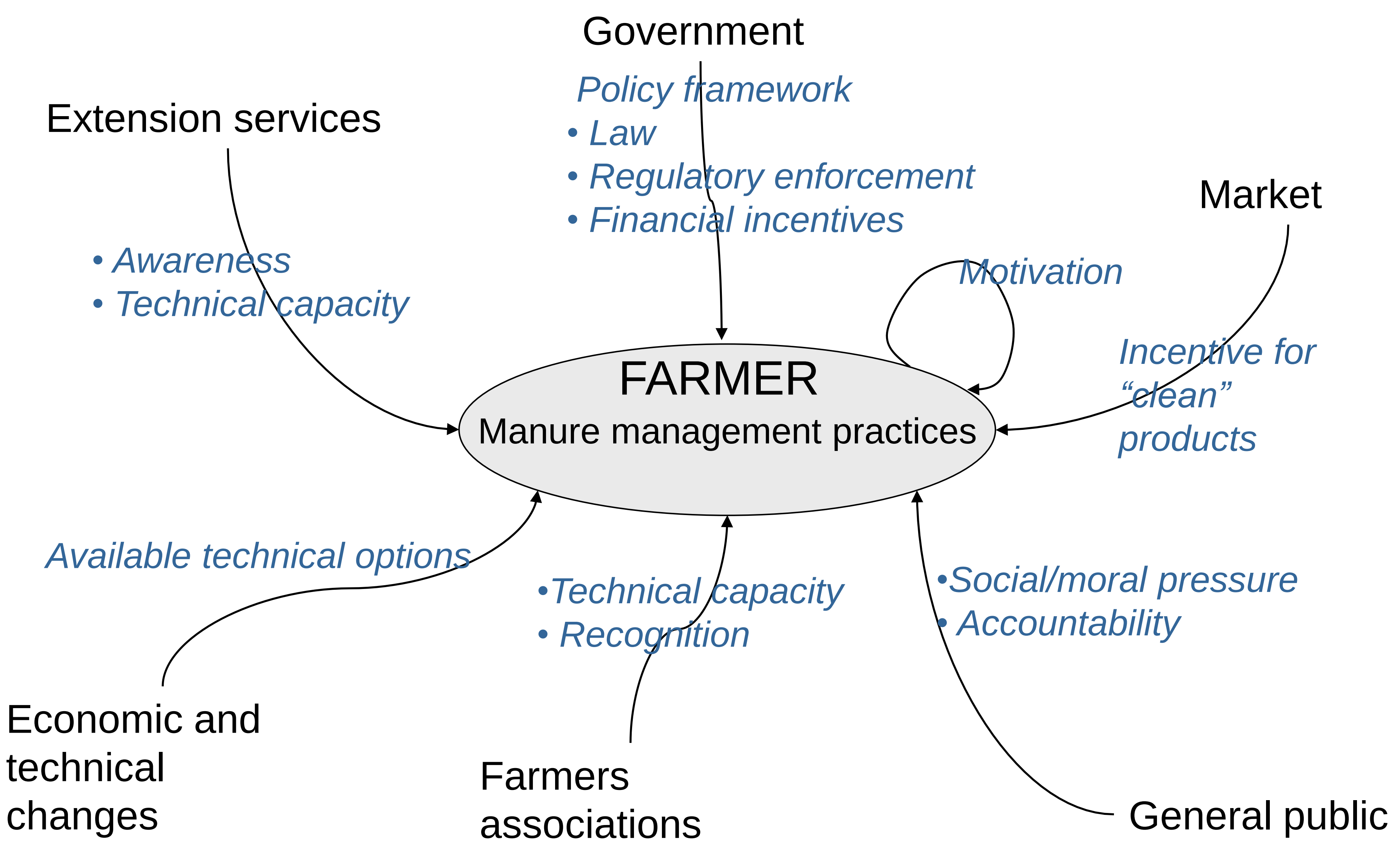


Changing Diets

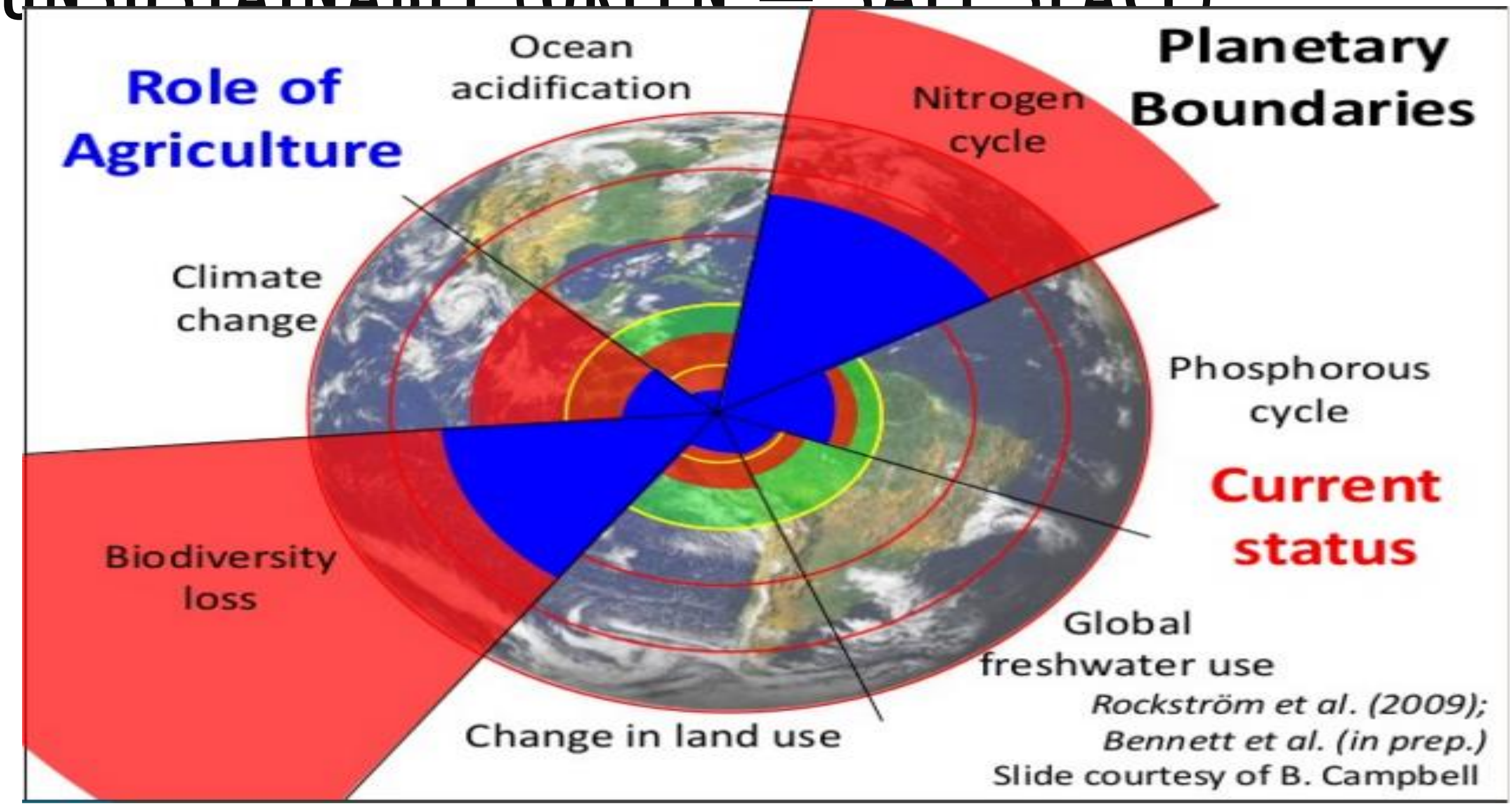


CEA 2013 based on FAO 2012, CCAFS 2015

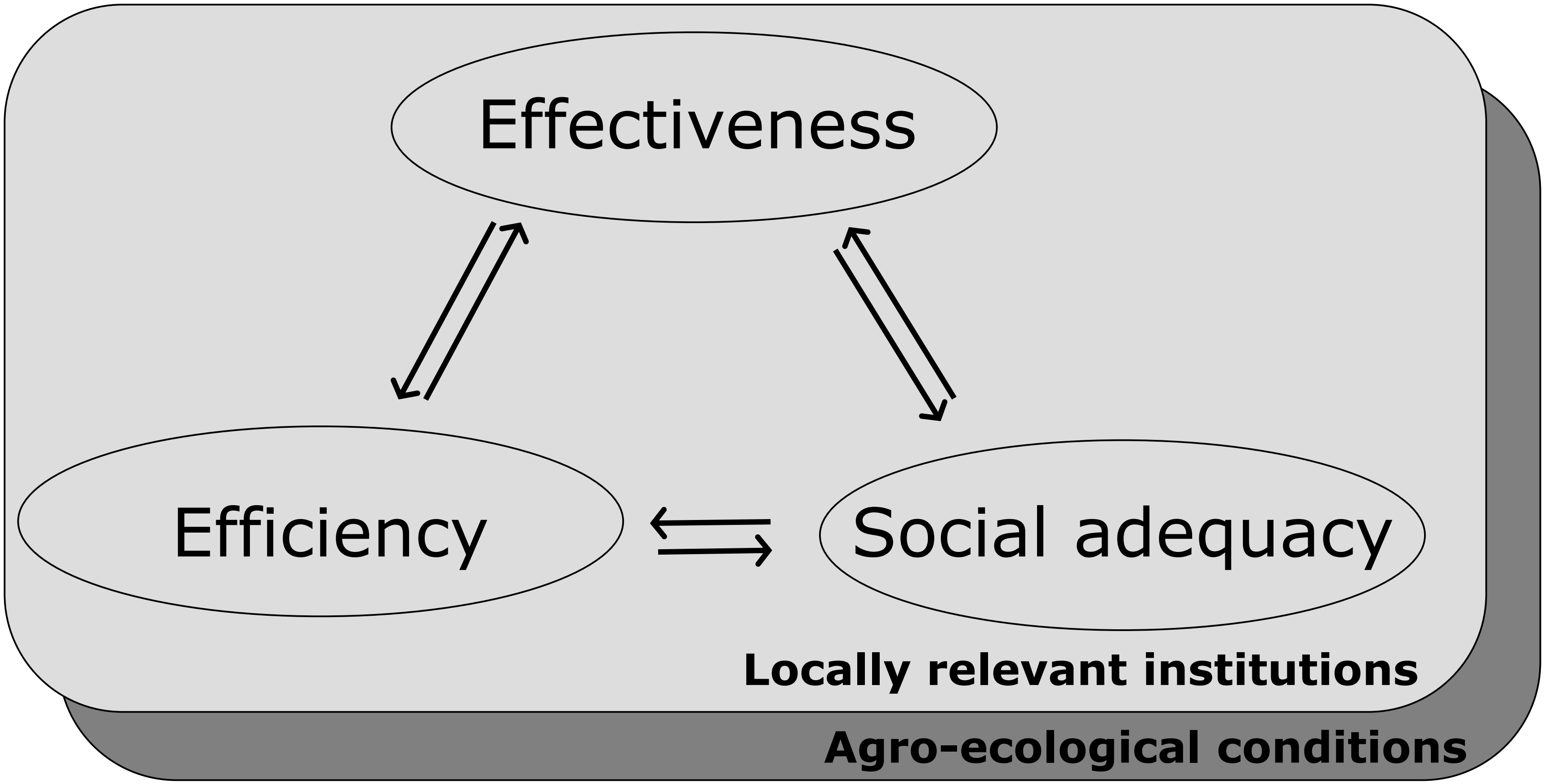
CHANGES IN MANURE MANAGEMENT PRACTICES, WHAT CAN MAKE IT HAPPEN ?



MEETING CURRENT DEMAND ALREADY UNSUSTAINABLE (GREEN = SAFE SPACE)

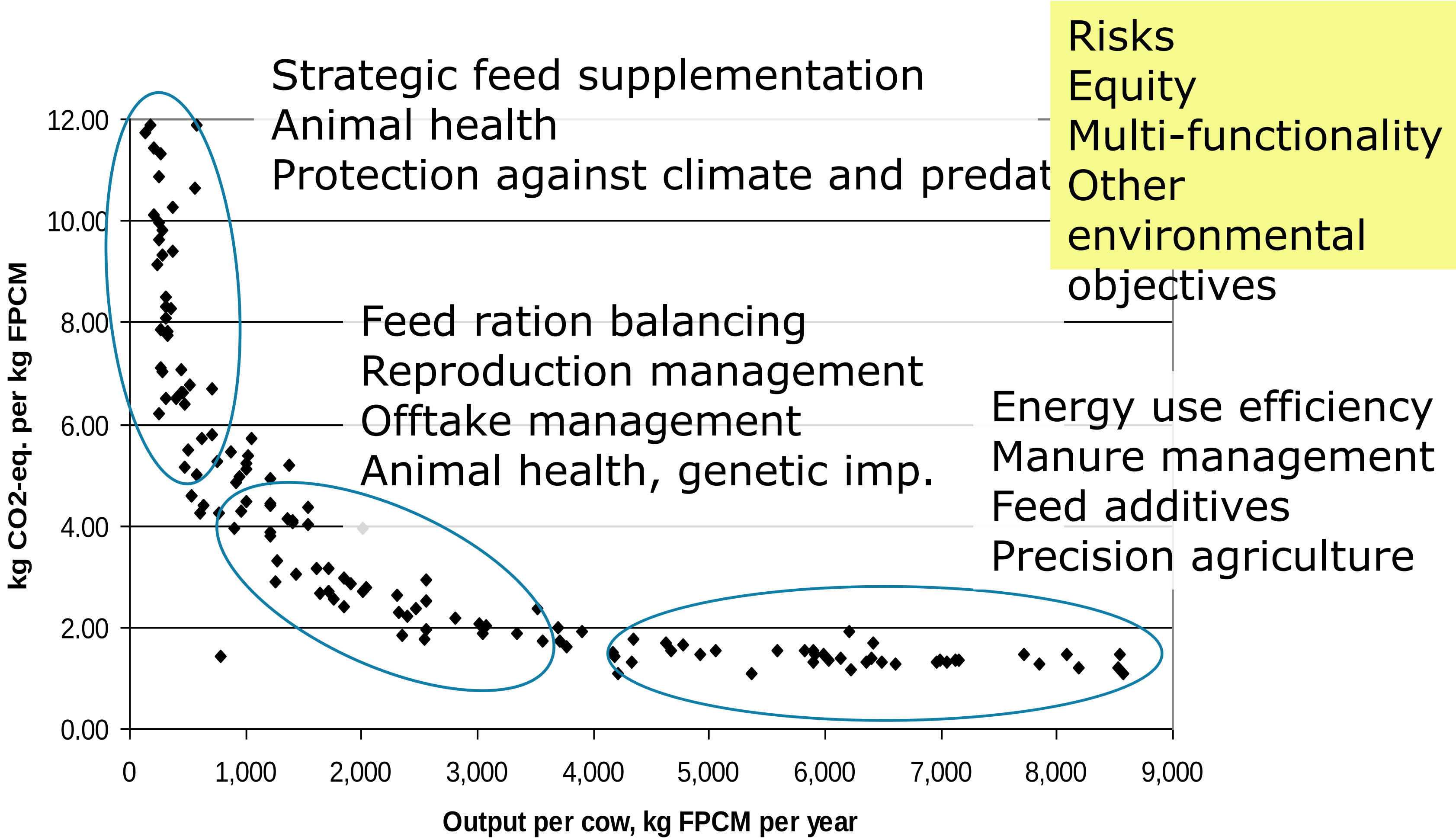


RESPOND TO DEMAND IN THE CONTEXT OF LOCALLY RELEVANT INSTITUTIONS AND AGRO-ECOLOGICAL CONDITIONS.



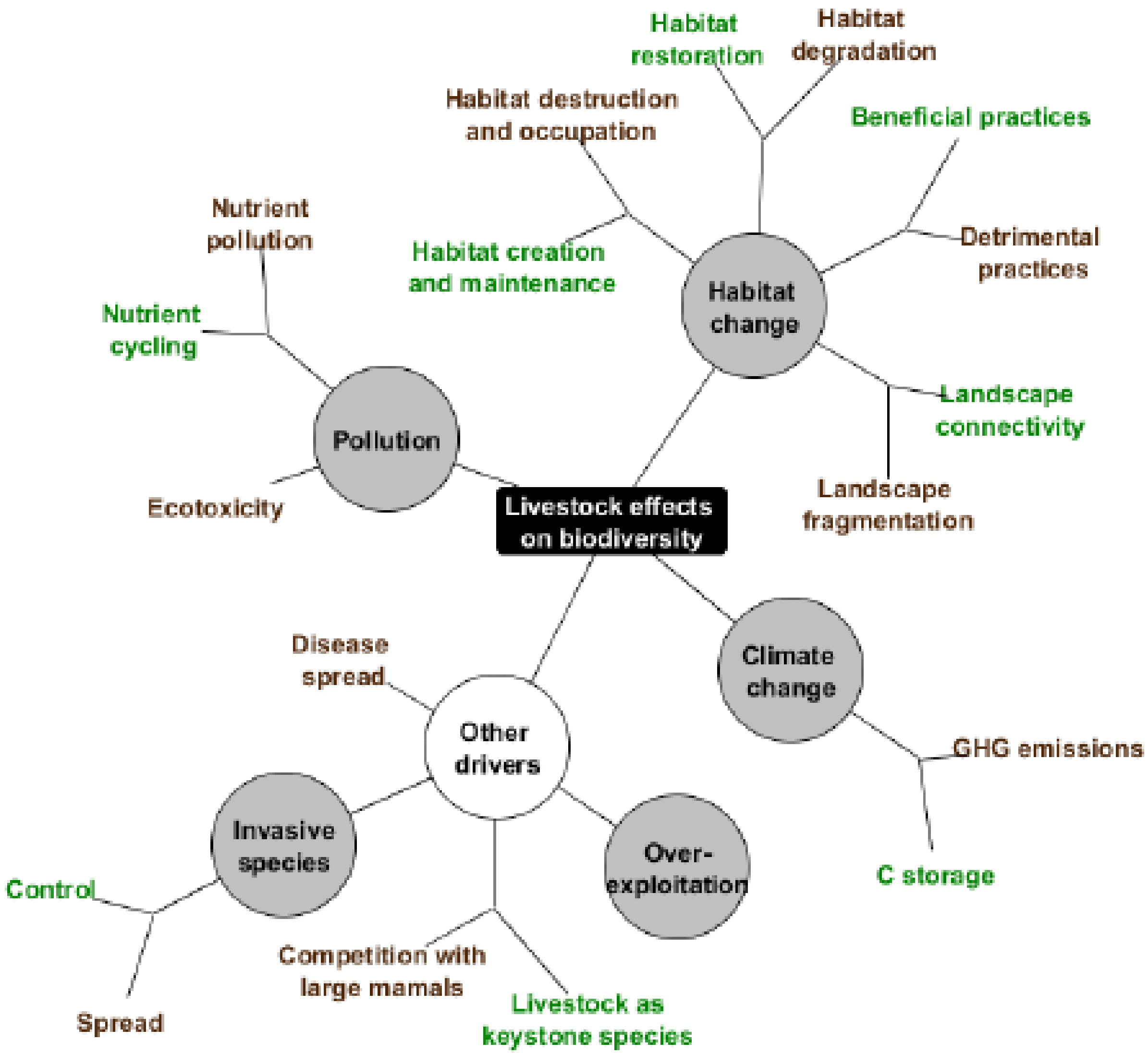
Diversity, adaptability, inclusive processes

RELATIONSHIP BETWEEN TOTAL GREENHOUSE GAS EMISSIONS AND MILK OUTPUT PER COW – MITIGATION OPTIONS



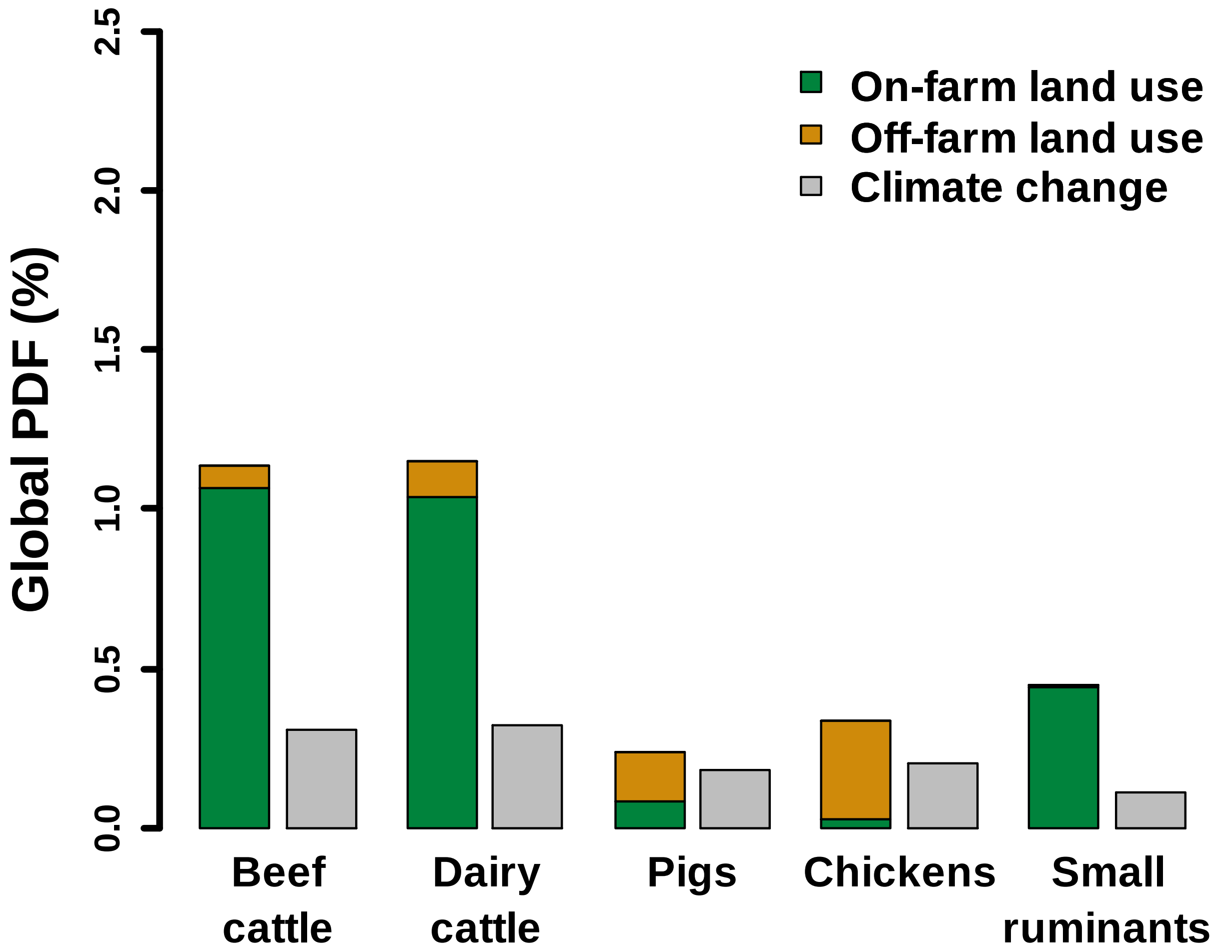
Gerber et al., 201

CATEGORIES OF INFLUENCE THAT LIVESTOCK HAVE ON BIODIVERSITY



LEAP, 2014

IMPACT OF ANIMAL PRODUCTION ON BIODIVERSITY – LAND USE AND CLIMATE CHANGE



PDF: Potentially Disappeared Fraction of species

POVERTY, HUNGER, CLIMATE AND CLIMATE SMART AGRICULTURE

WHAT IS THE CHALLENGE?

To build food systems that meet increasing demand while remaining profitable and sustainable in the face of Climate Change.

WHAT WILL IT TAKE?

1. ***Increasing productivity sustainably***
2. ***Enhancing the resilience of producers and supply chains***
3. ***Reducing Emissions***

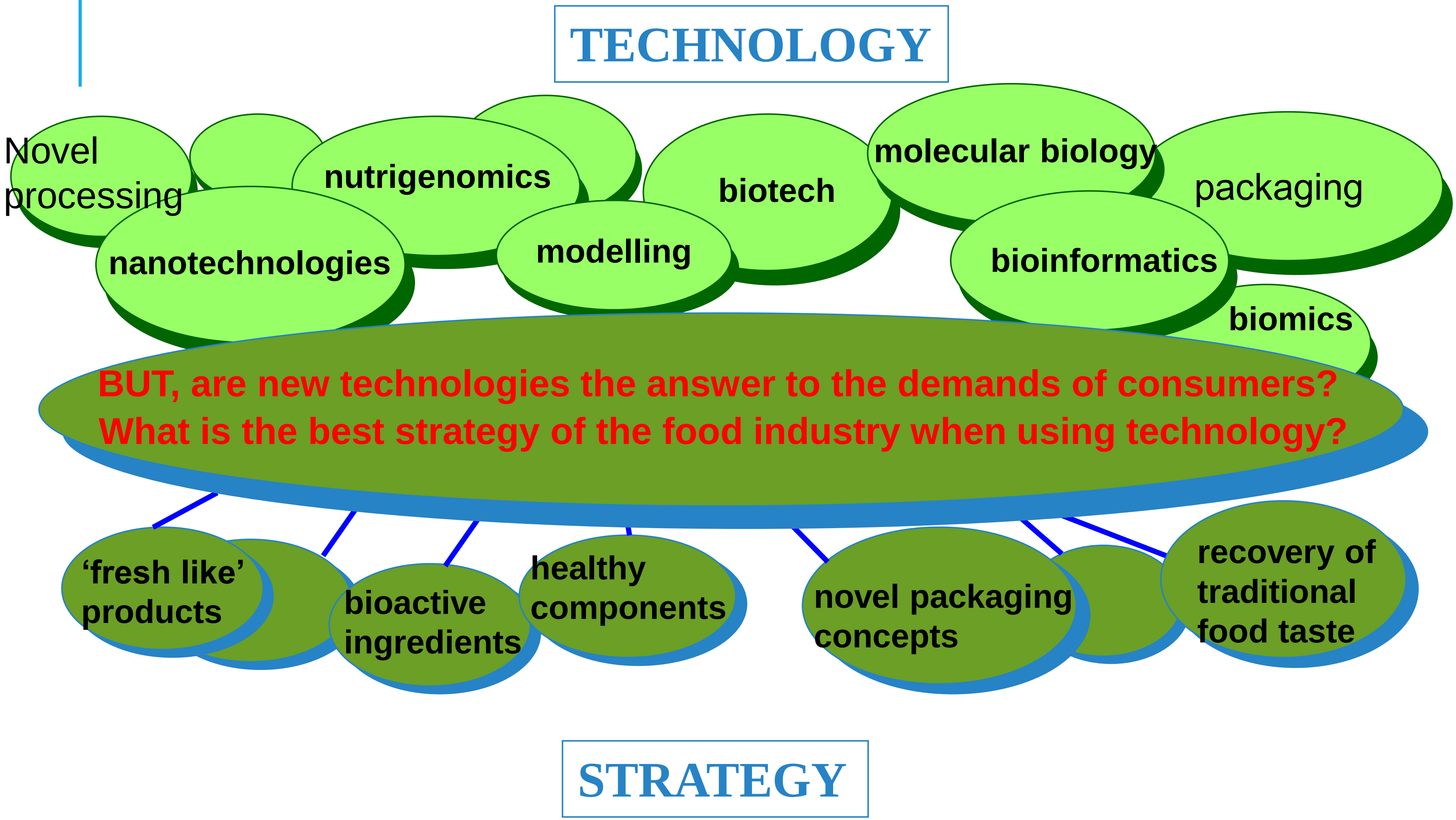
CAN IT BE DONE?

Yes, but we need to connect Climate Change with the bottom line of farmers and food businesses

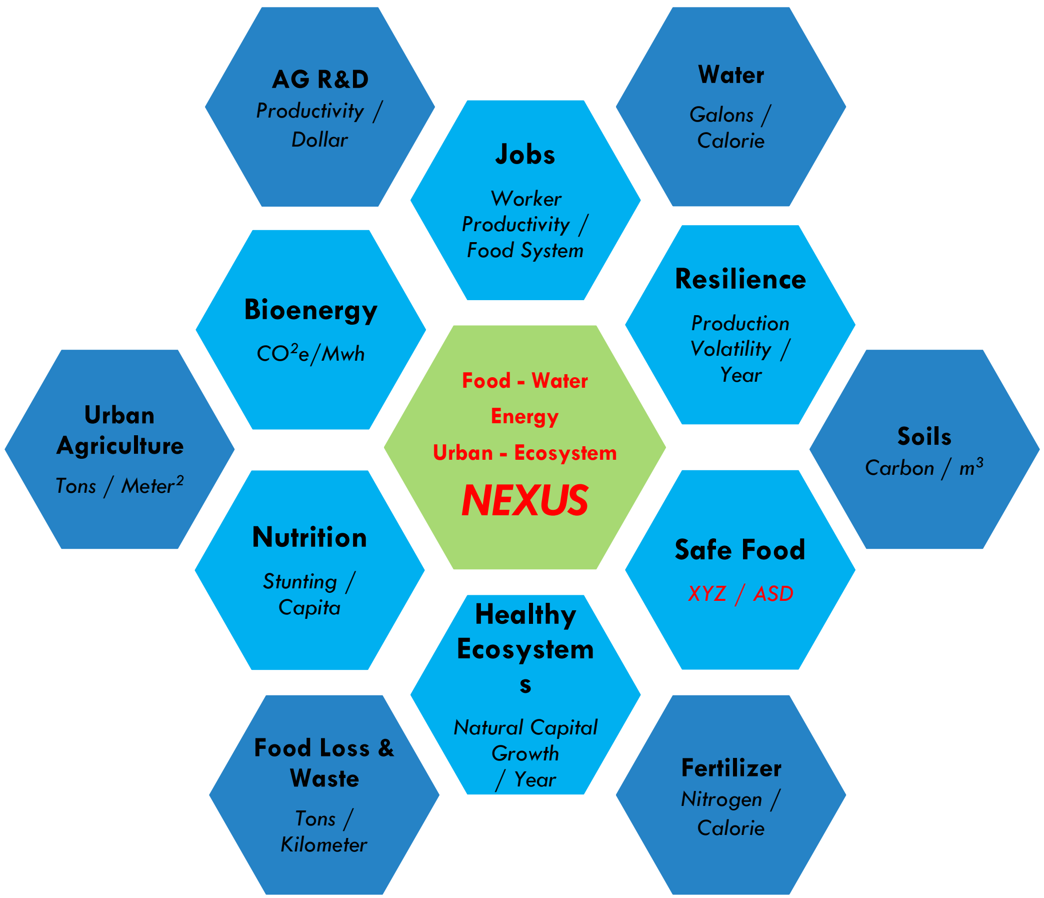
CSA = SUSTAINABLE AGRICULTURE + RESILIENCE - EMISSIONS

WORLD BANK GROUP
Agriculture

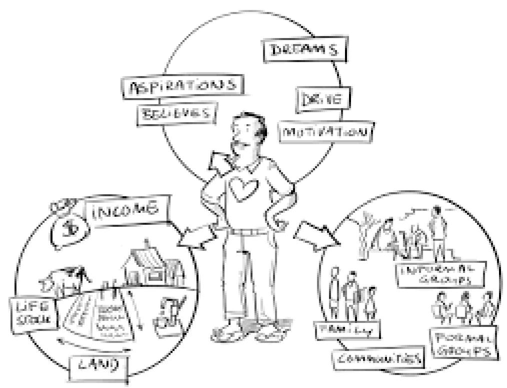
Effective tools for implementation



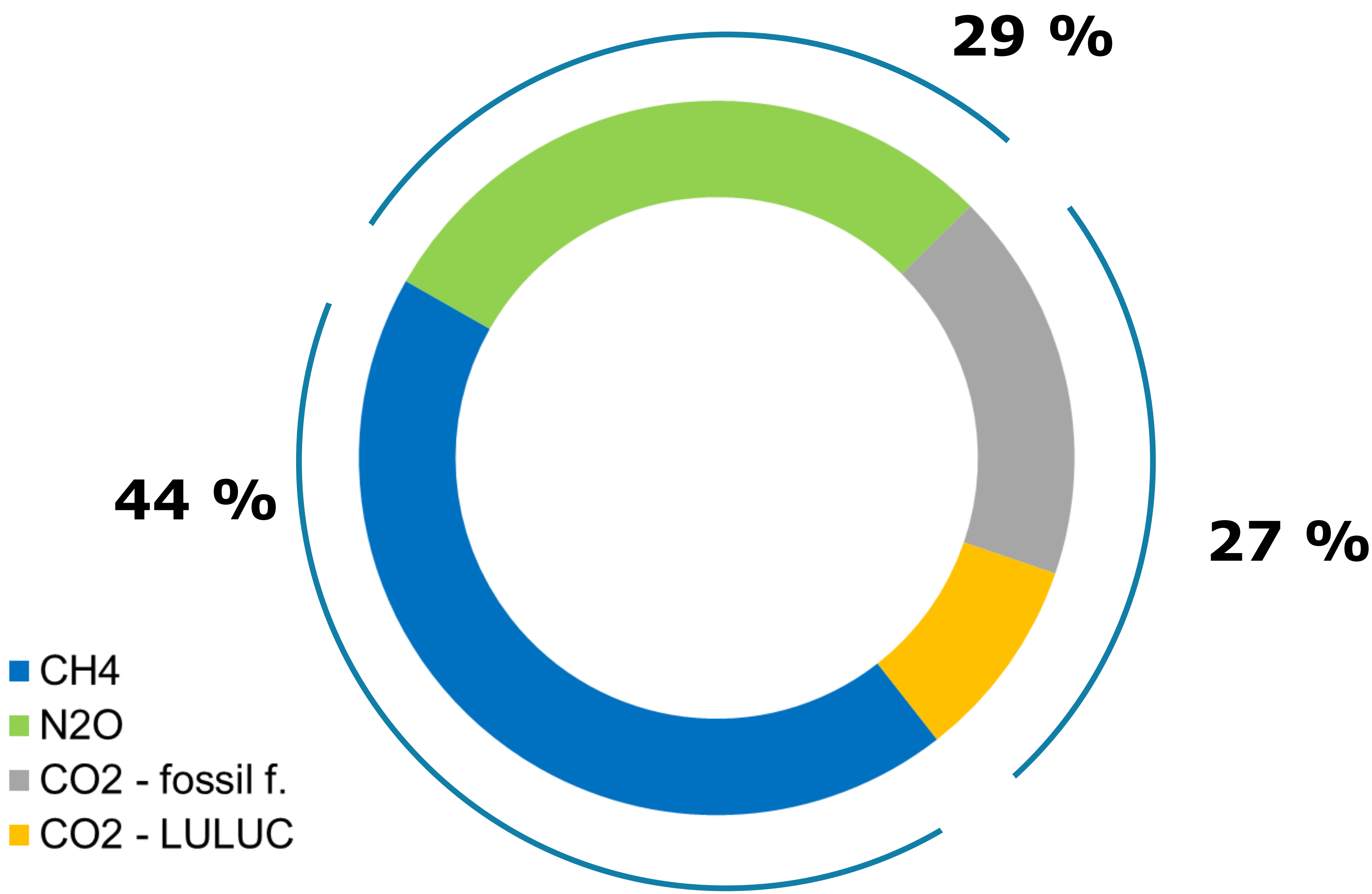
Visioning a Sustainable Food System for 2030 (work in progress)



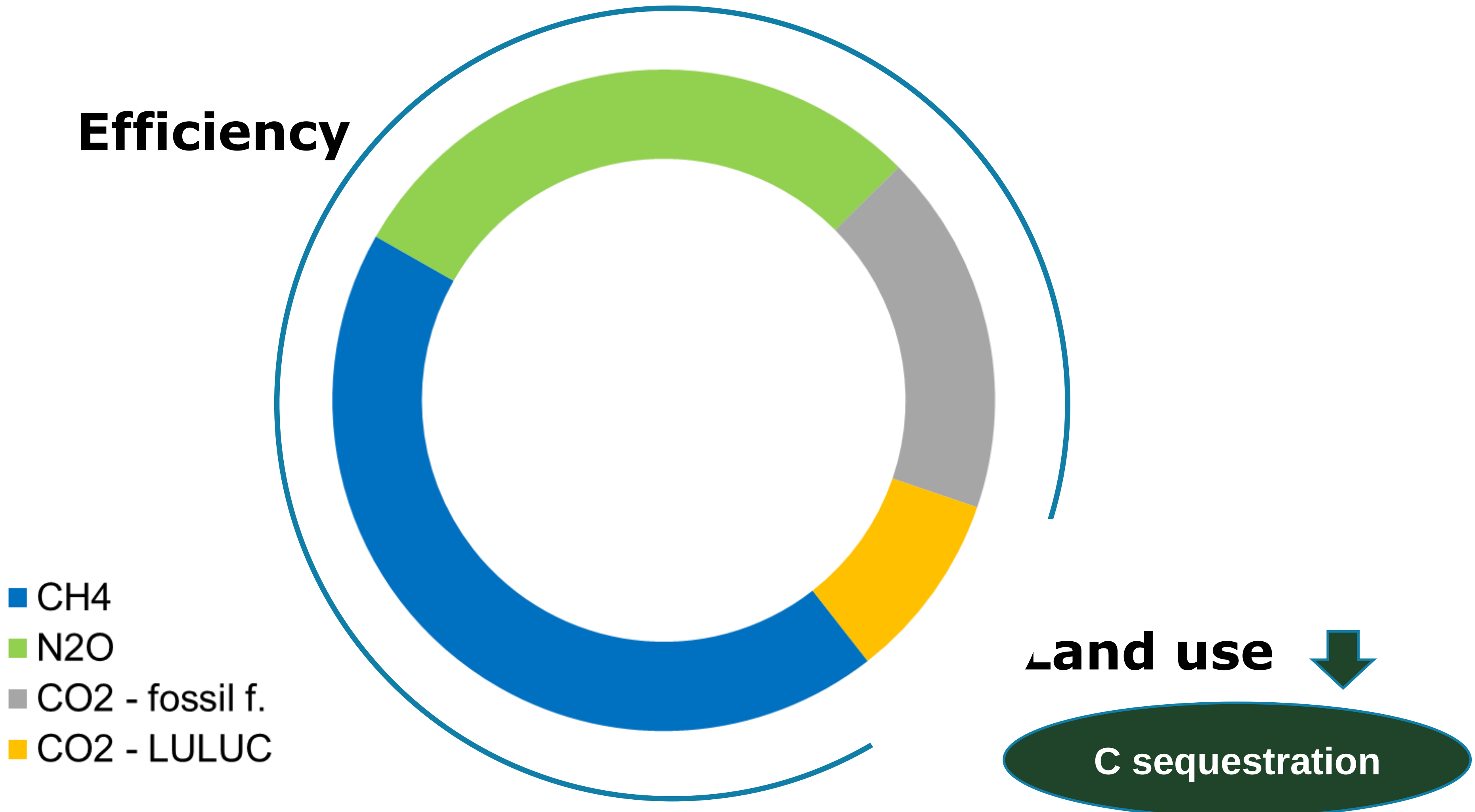
THE FARMER’S DILEMMA



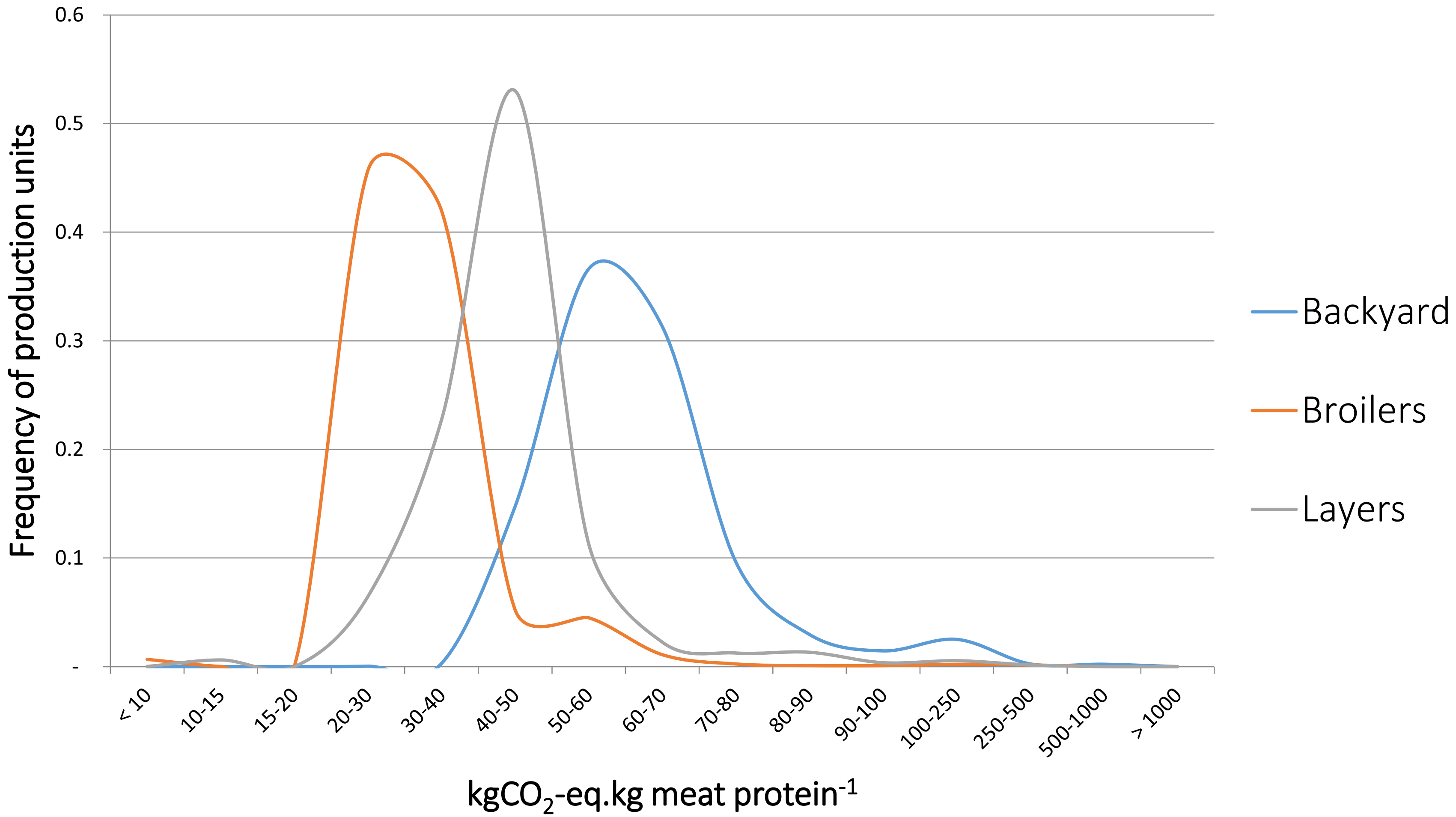
THREE MAIN GHG GASES



BROAD MITIGATION STRATEGIES

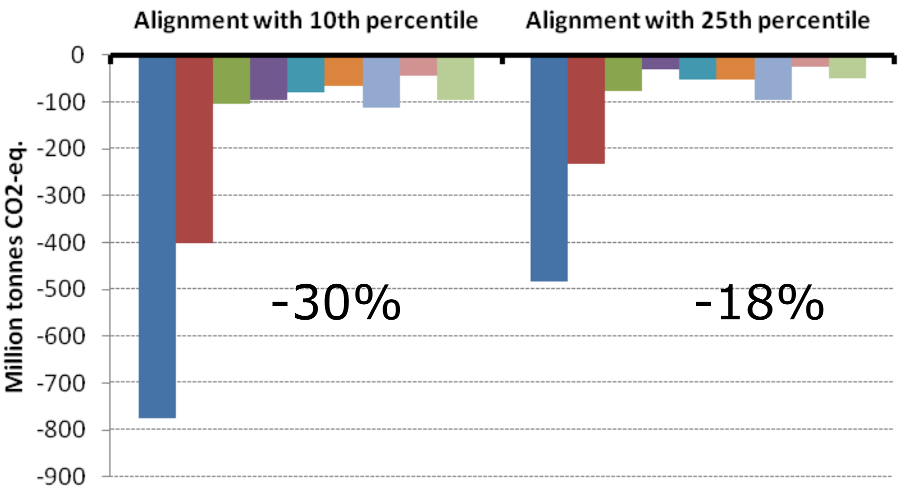


EMISSION INTENSITY GAP – CHICKEN MEAT IN EAST AND SOUTHEAST ASIA



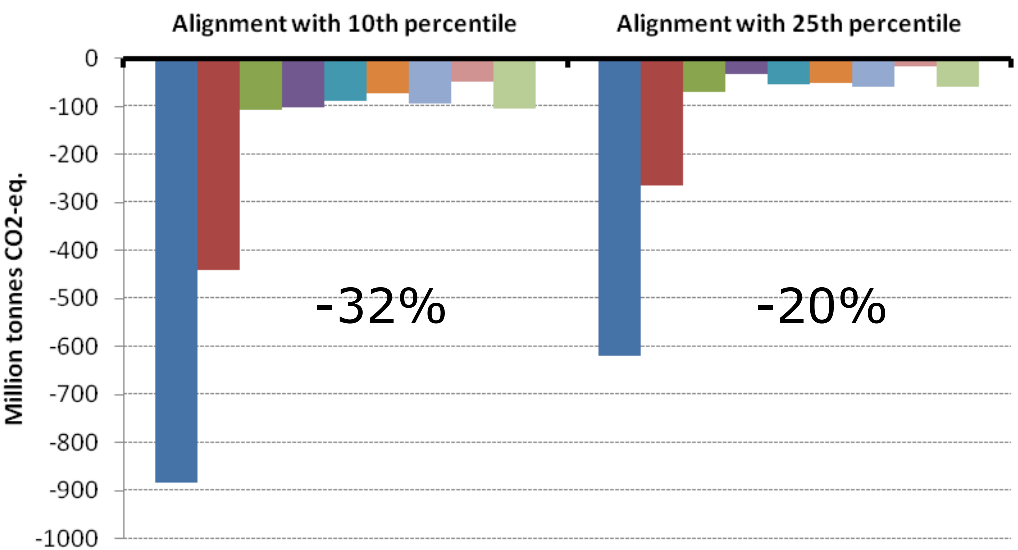
FAO, 2013

POTENTIAL MITIGATION IN THE LIVESTOCK SECTOR



No change in farming systems scenario, based on existing and applied technology

- 18% reduction in emissions (= 1.1 $GtCO_2$ eq.)
- 30% reduction in emissions (= 1.8 $GtCO_2$ eq.)

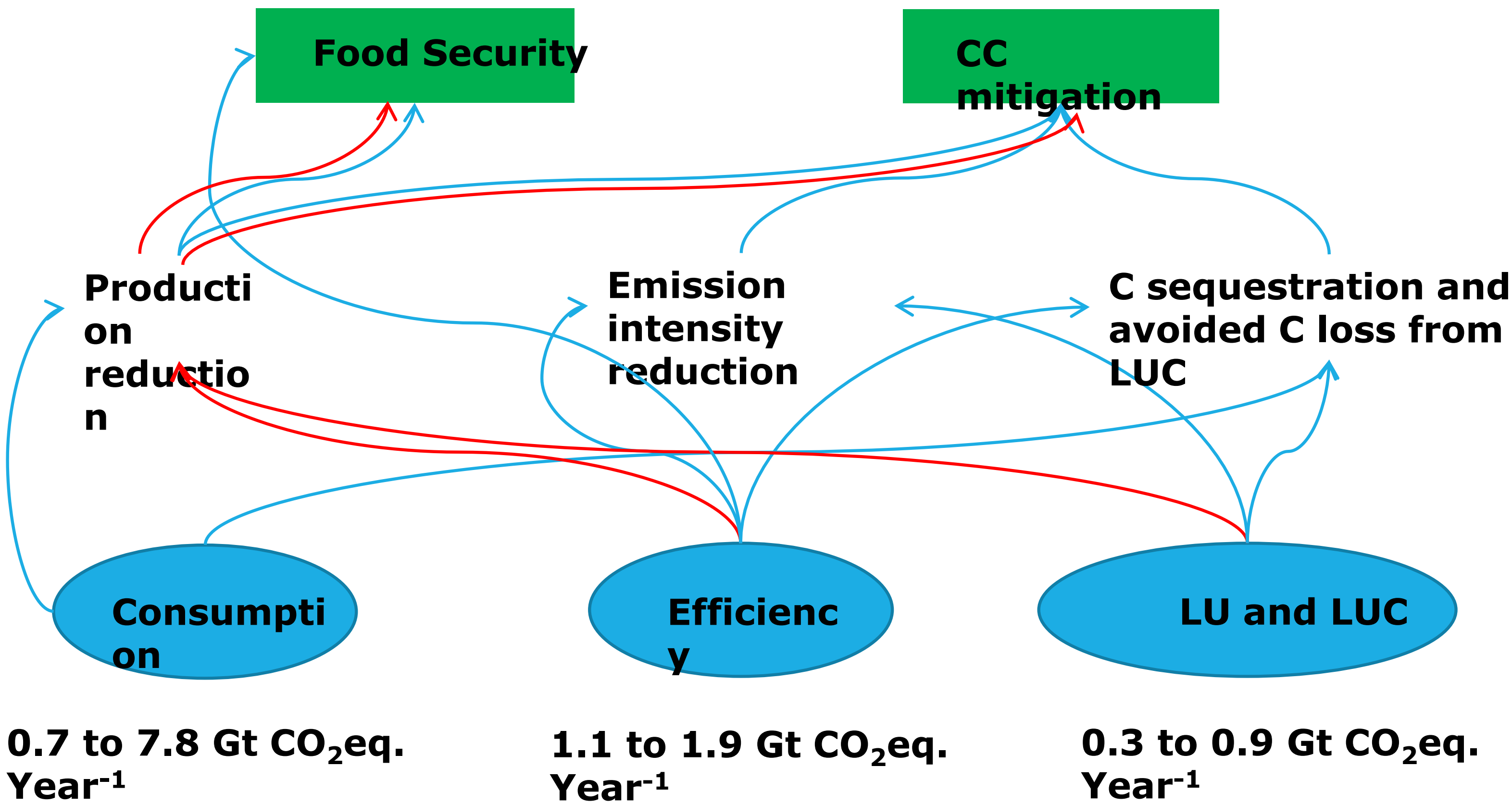


No change in farming systems scenario

- 20% reduction in emissions (= 1.2 $GtCO_2$ eq.)
- 32% reduction in emissions (= 1.9 $GtCO_2$ eq.)

FAO, 2013

RETHINKING LIVESTOCK SYSTEMS FOR FOOD SECURITY AND MITIGATION



2.1 to 10.6 Gt CO_2eq. $Year^{-1}$

LAND USE MANAGEMENT FOR C SEQUESTRATION IN PRACTICE

Interventions

- Grazing management, animal mobility
- Legumes introduction
- Sylvopastoral systems

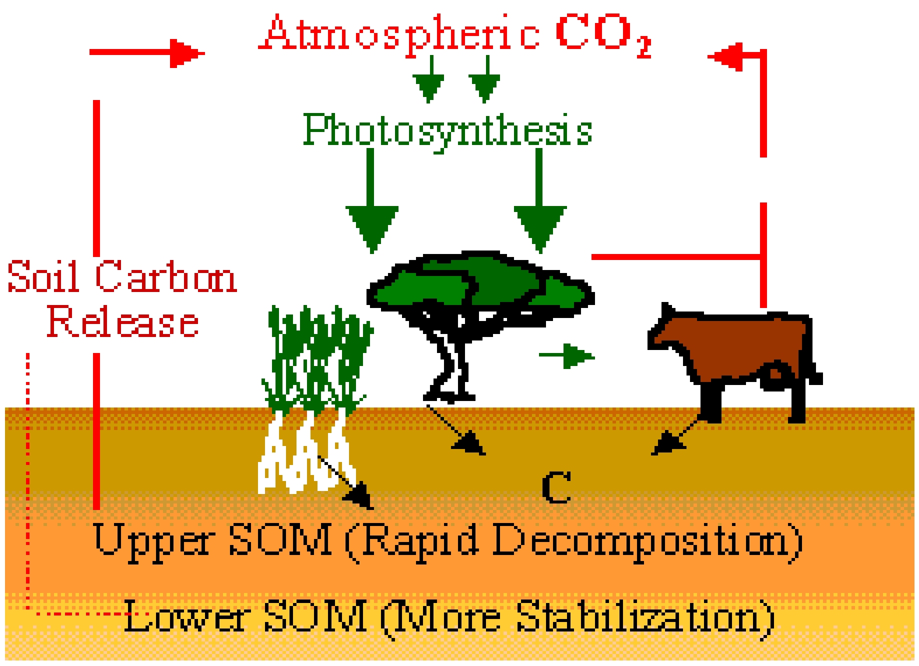
Synergies

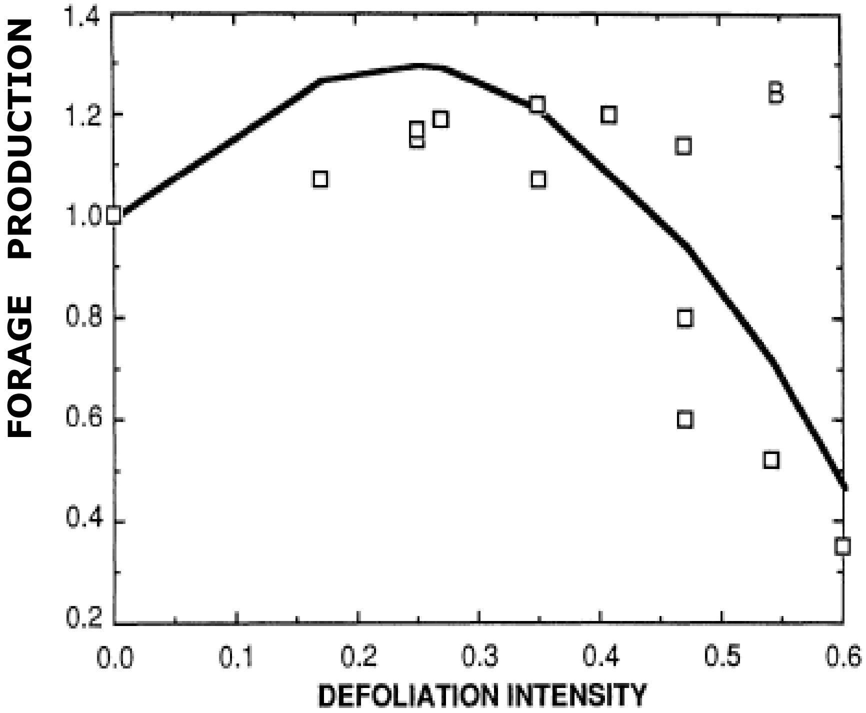
- Biodiversity conservation, water cycles

Limitation

- Saturation, reversibility
- Intervention costs are high (targeting, access, capacity development, monitoring)

SOIL CARBON SEQUESTRATION



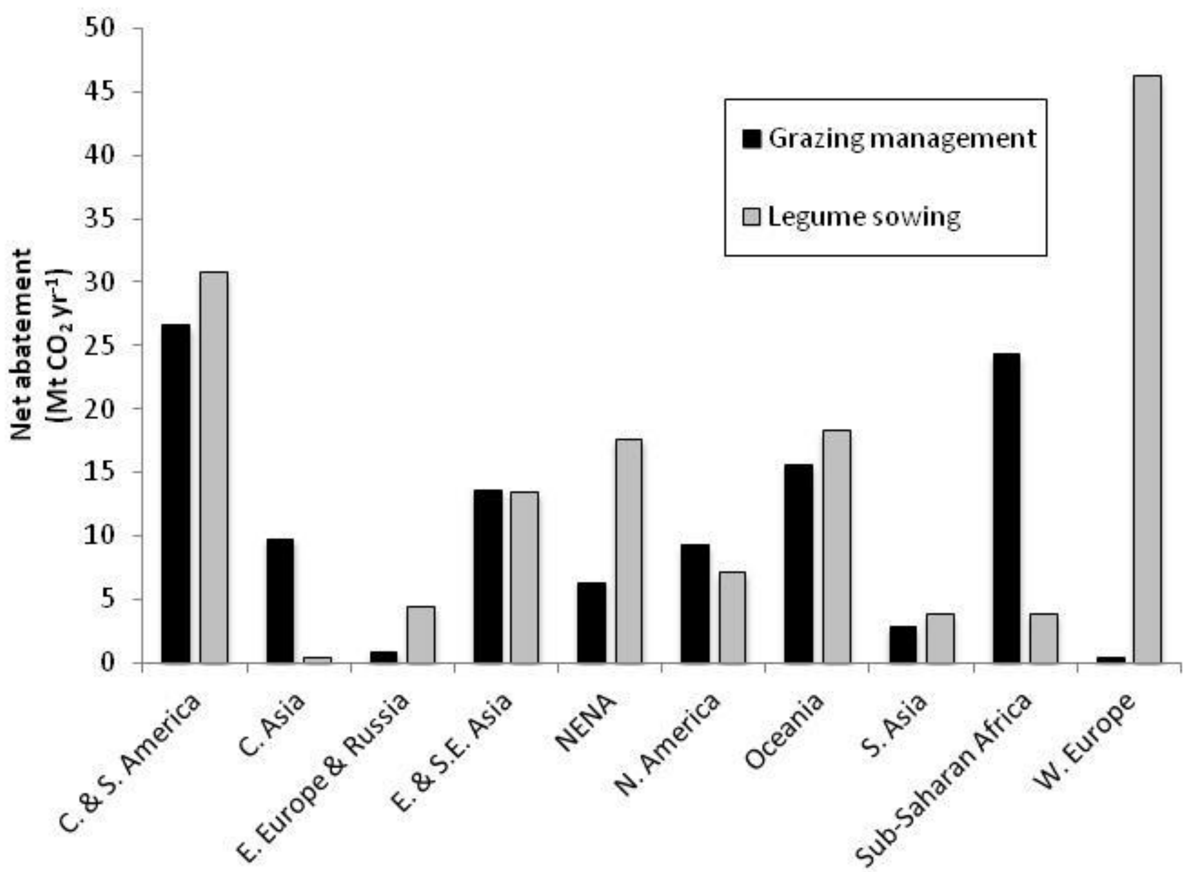


Tschakert, 2000

Holland et al. 2011

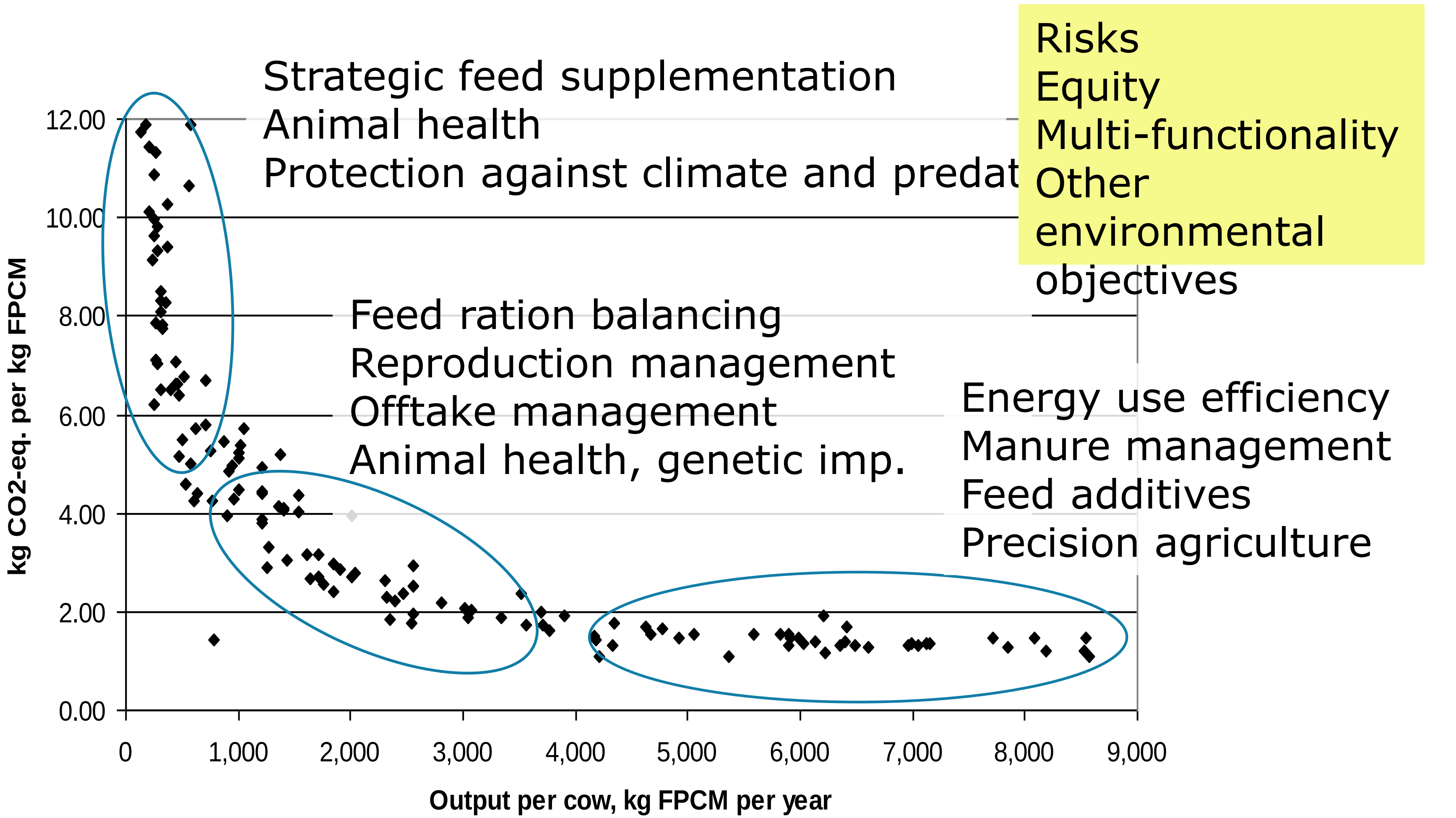
GLOBAL NET SOIL C SEQUESTRATION

- Grazing management = 110 $MtCO_2$ yr^{-1} (0.23 tCO_2 ha^{-1})
  - applied over 470 million ha
- Legume sowing = 147 $MtCO_2$-eq yr^{-1} (2.0 tCO_2-



Henderson et al., 2015

RELATIONSHIP BETWEEN TOTAL GREENHOUSE GAS EMISSIONS AND MILK OUTPUT PER COW – MITIGATION OPTIONS



Gerber et al., 201

LIVESTOCK AT THE WORLD BANK

US$41 Billion IBRD/IDA (2015)

Financial & Private Sector Development 22%

Transportation 17%

Energy 16%

Water, Sanitation, Flood Protection 11%

Health & Social 8%

Education 8%

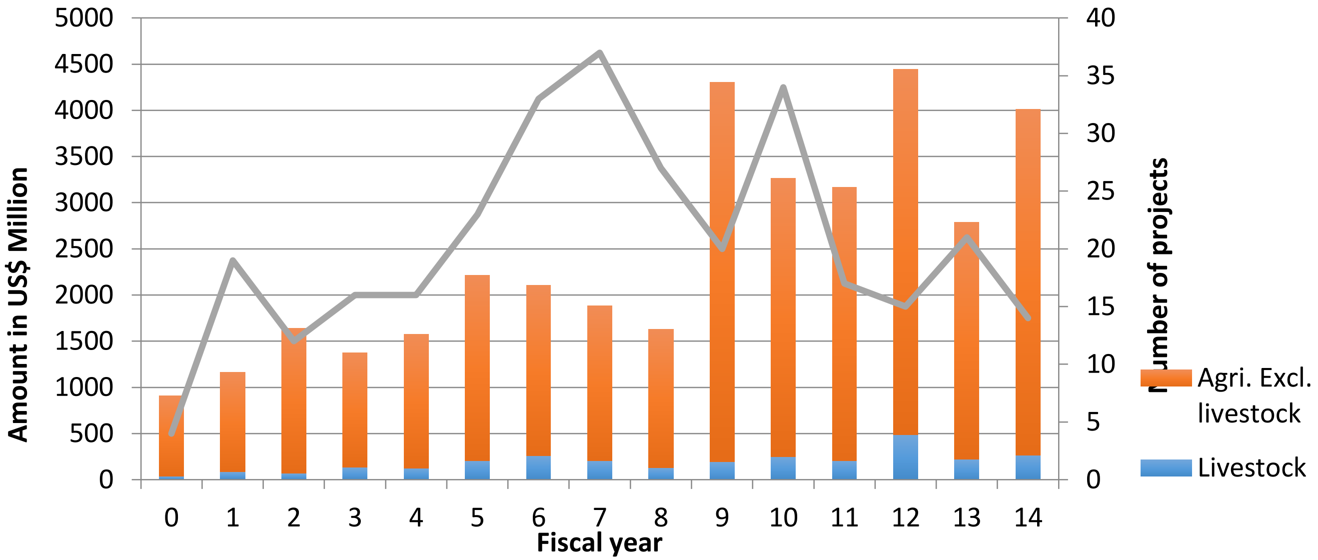
Agriculture, Fishing, Forestry 7%

Finance 5%

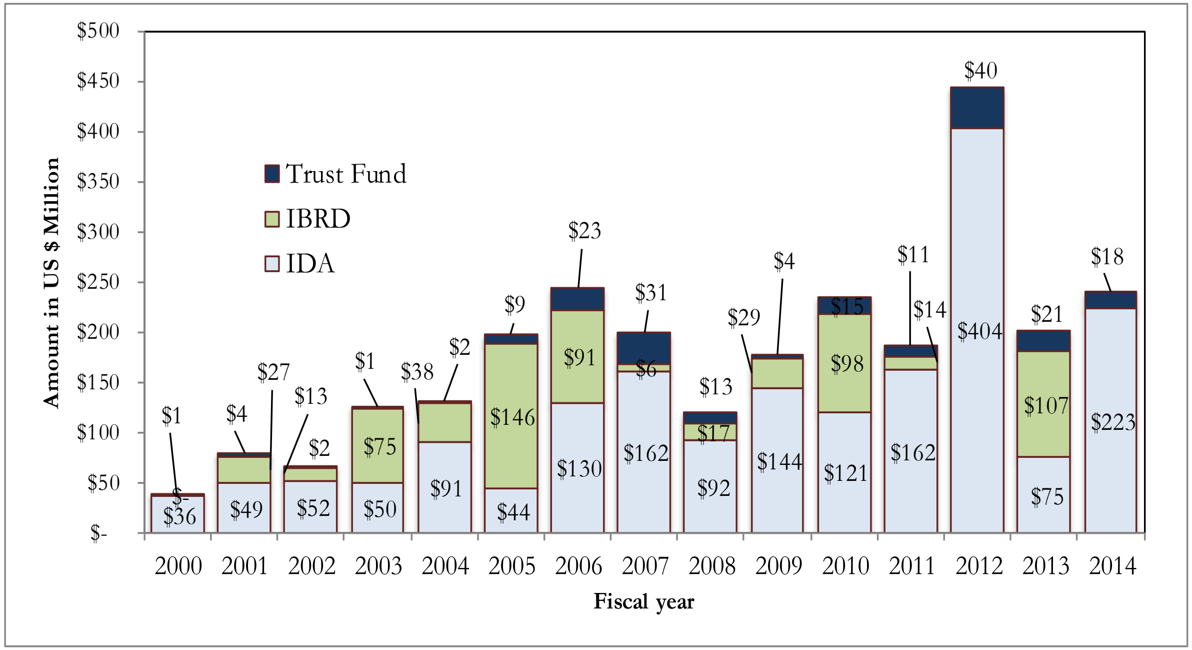
Industry & Trade 4%

Information and Communications 1%

ANNUAL WB COMMITMENT (IDA/IBRD/TF) IN LIVESTOCK WITHIN TOTAL AGRICULTURE SECTOR 2000-2014 (US $ MILLION)

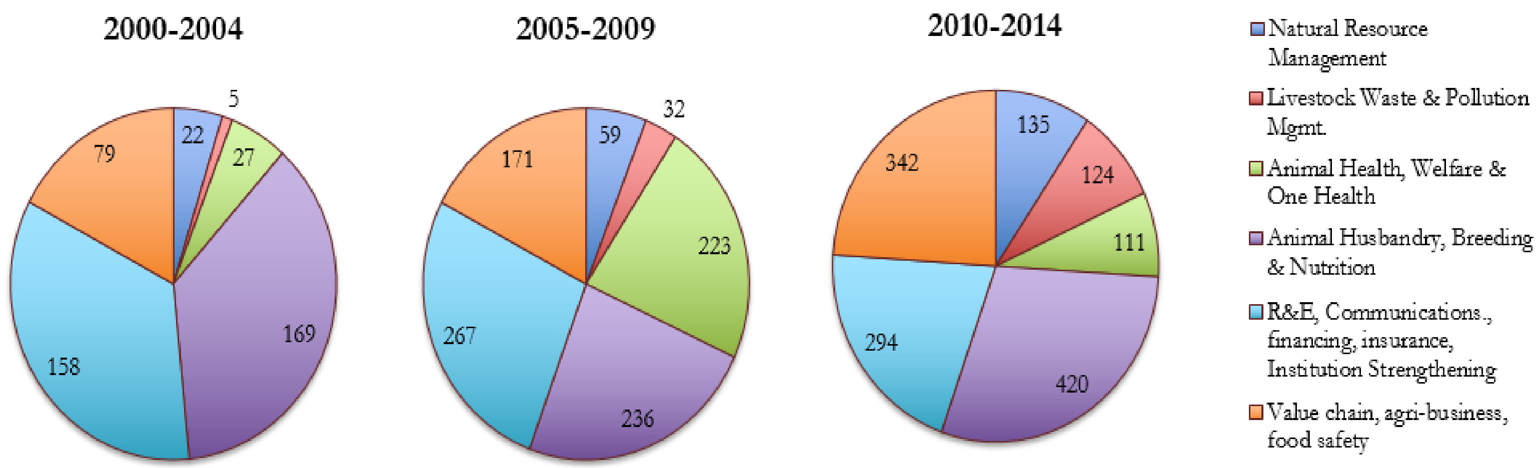


COMMITMENTS IN LIVESTOCK BY SOURCE OF LENDING

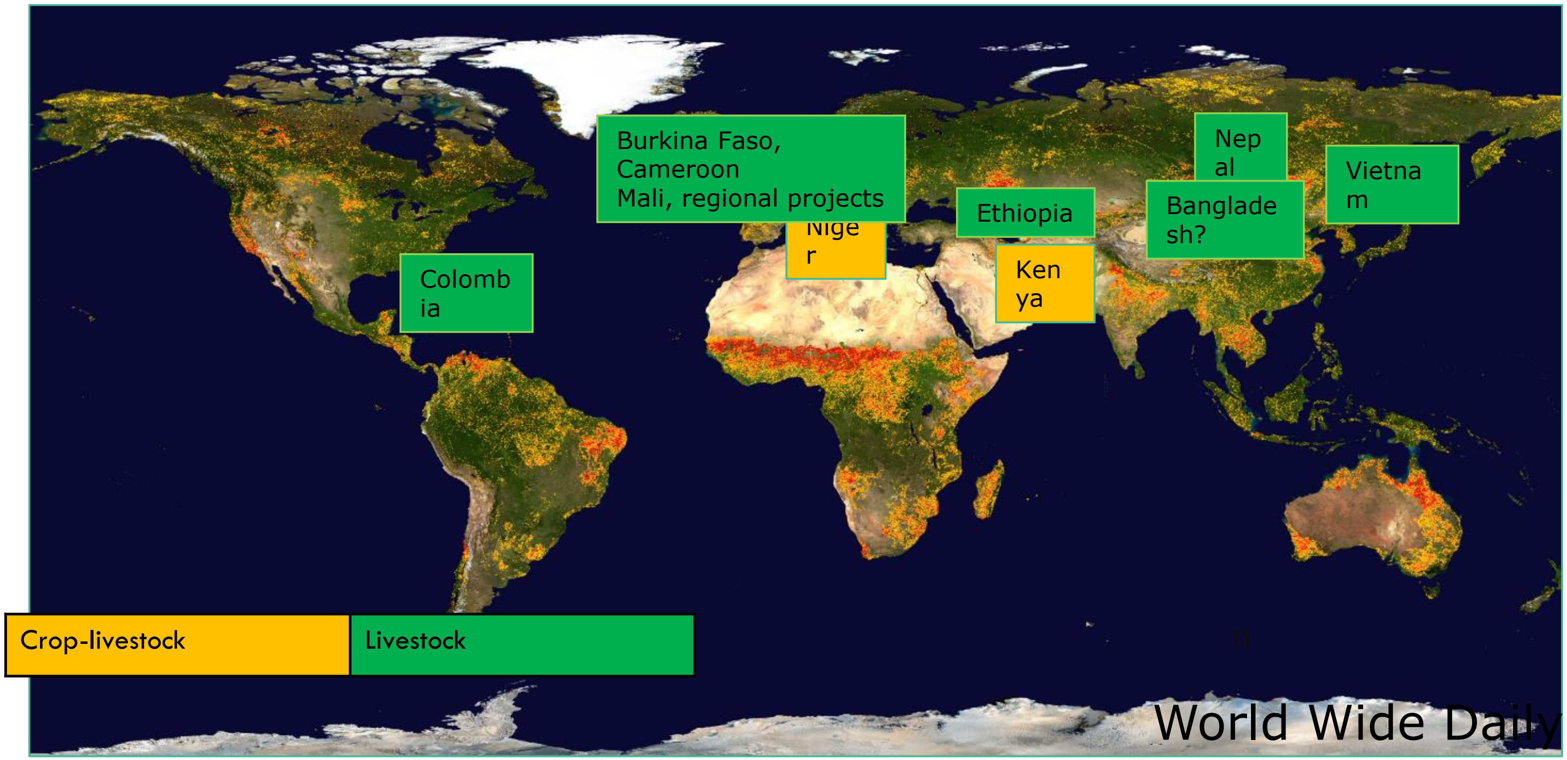


LIVESTOCK RELATED PROJECTS BY WB COMMITTED AMOUNTS 2000-2014

AGGREGATE WB COMMITMENT BY LIVESTOCK THEMES IN MILLION US DOLLARS



LIVESTOCK PROJECTS NOT INCLUDED IN THIS STUDY



World Wide Daily Drought Risk Map

EMERGING THEMES AND APPROACHES IN THE PORTFOLIO

Role of agri-business

Value chains

One health

Food safety

Adaptation to, and mitigation of climate change

Natural resource management

- A System approach addressing the many interfaces of livestock with global public goods

LIVESTOCK AT THE WORLD BANK

Growing portfolio

Focus on Low Income Countries in Africa and South Asia

Focus on poverty alleviation

Livestock intervention usually integrated in multi-area projects

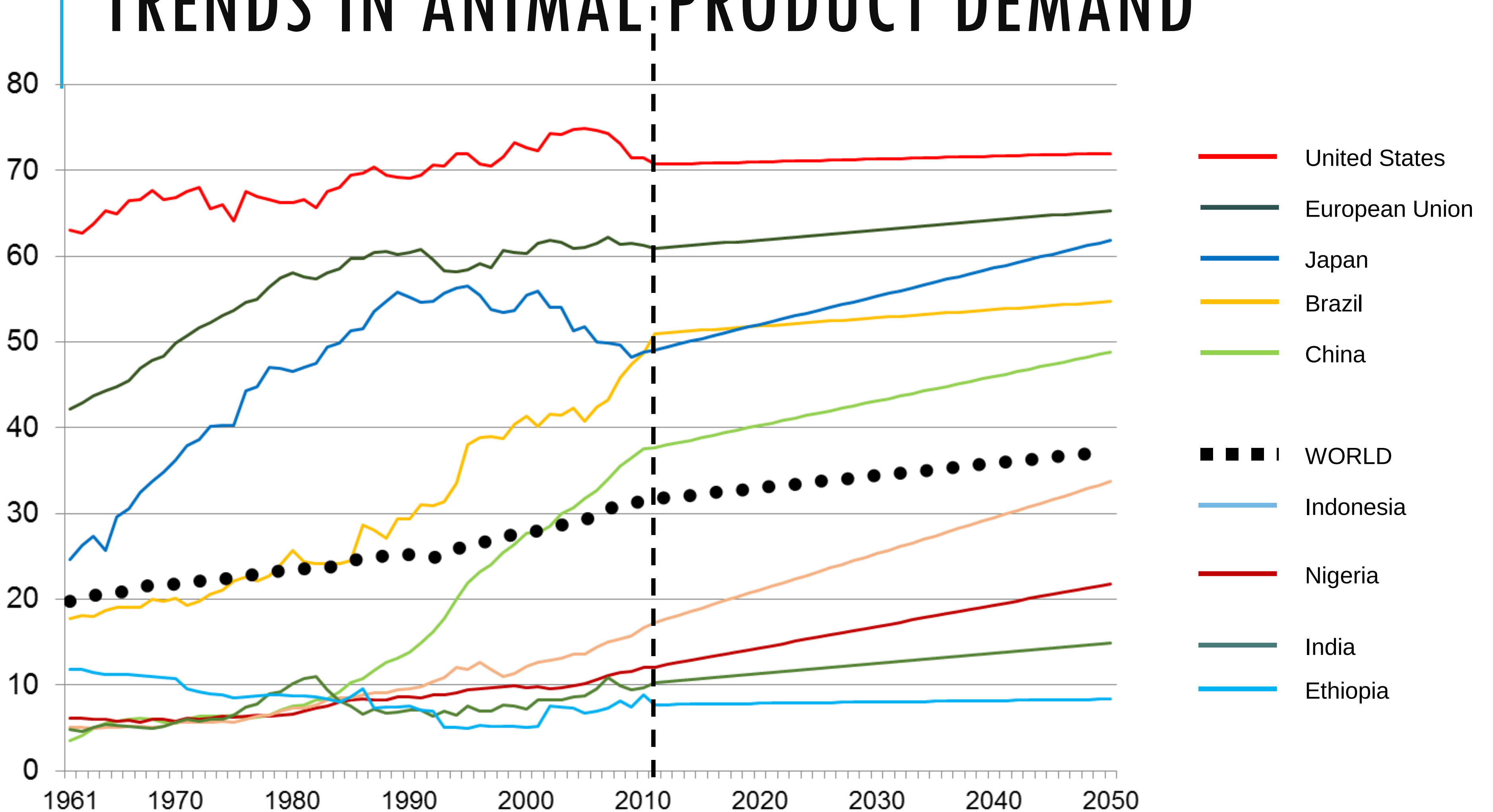
Increasing attention to objectives related to the SDGs.

THE DEMAND FOR LIVESTOCK PRODUCTS TO 2050

		Annual per capita consumption		Total consumption	
	year	Meat (kg)	Milk (kg)	Meat (Mt)	Milk (Mt)
Developing	2002 2050	28 44	44 78	137 326	222 585
Developed	2002 2050	78 94	202 216	102 126	265 295

Rosegrant et al 2009

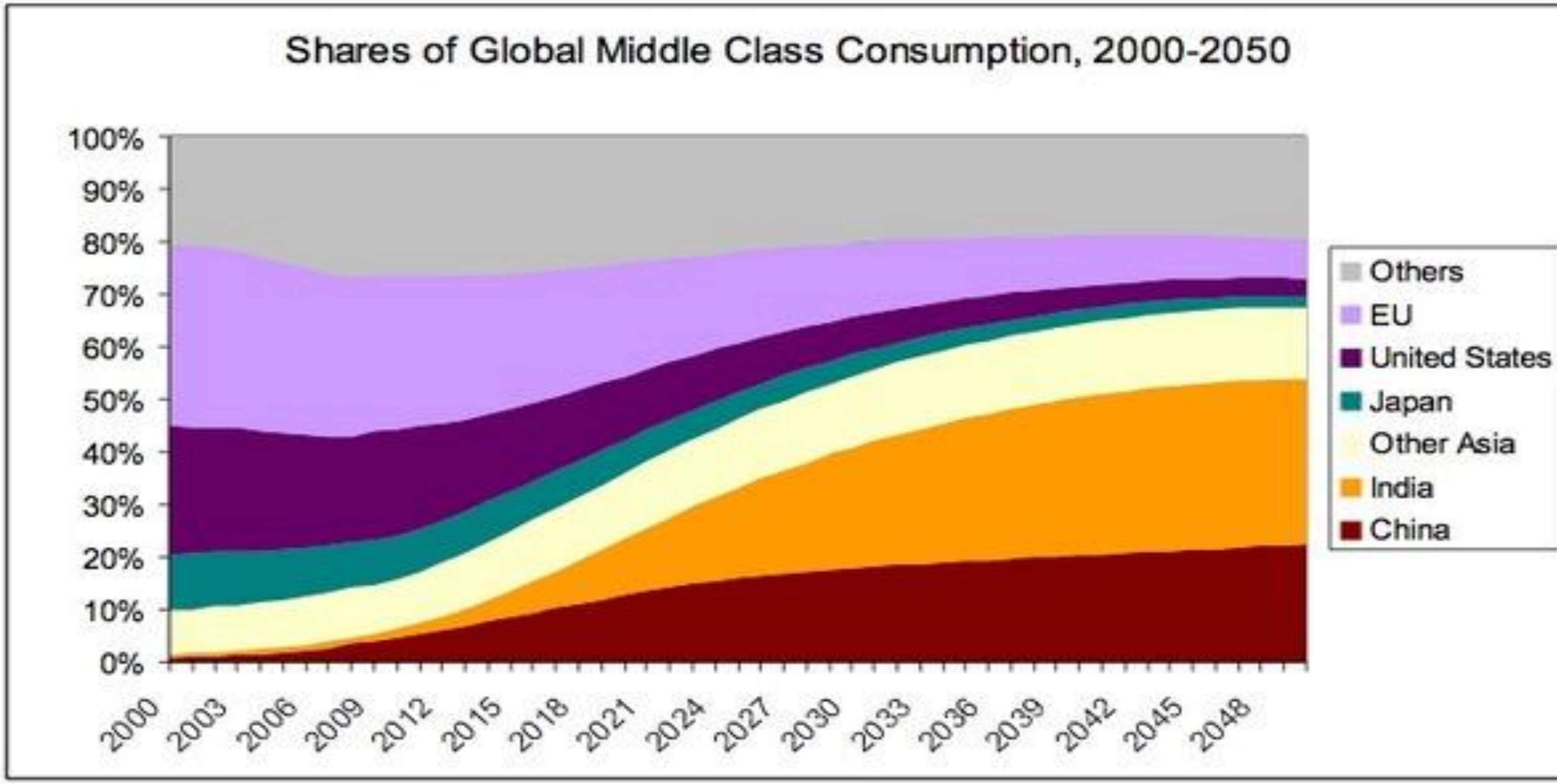
TRENDS IN ANIMAL PRODUCT DEMAND



Note: The Alexandratos & Bruinsma 2012 projections covered 2006-2050. Their trend result was carried forward here from the FAOStat actual data point for 2011.
Source: J. Ranganathan *et al., Shifting Diets,* Installment 11 of the *World Resources Report,* WRI, *forthcoming.*

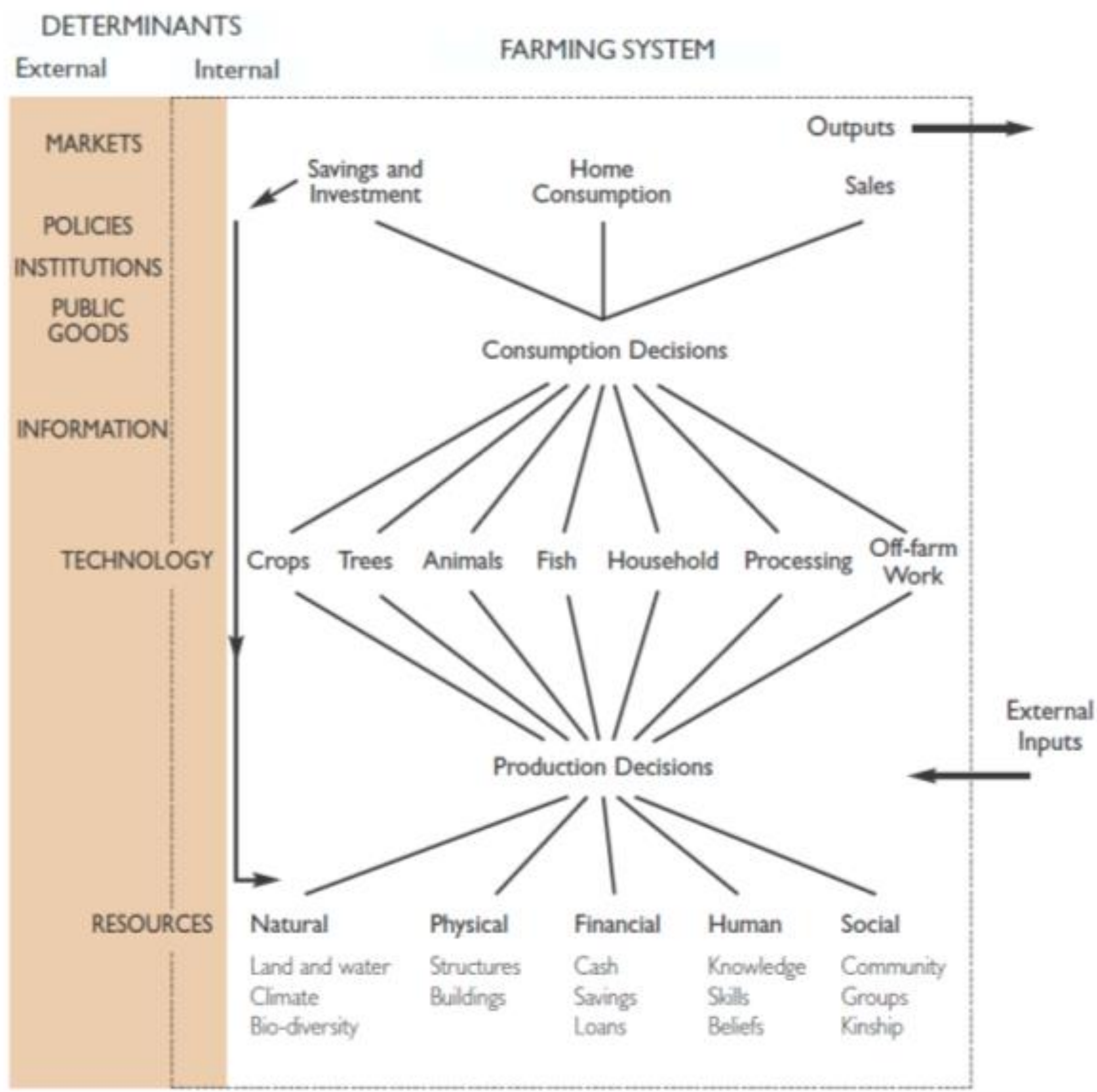
WRI, 2015; based on
FAO, 2015, and Alexandratos & Bruinsma, 201

Changing Wealth and its distribution is driving demand dynamics

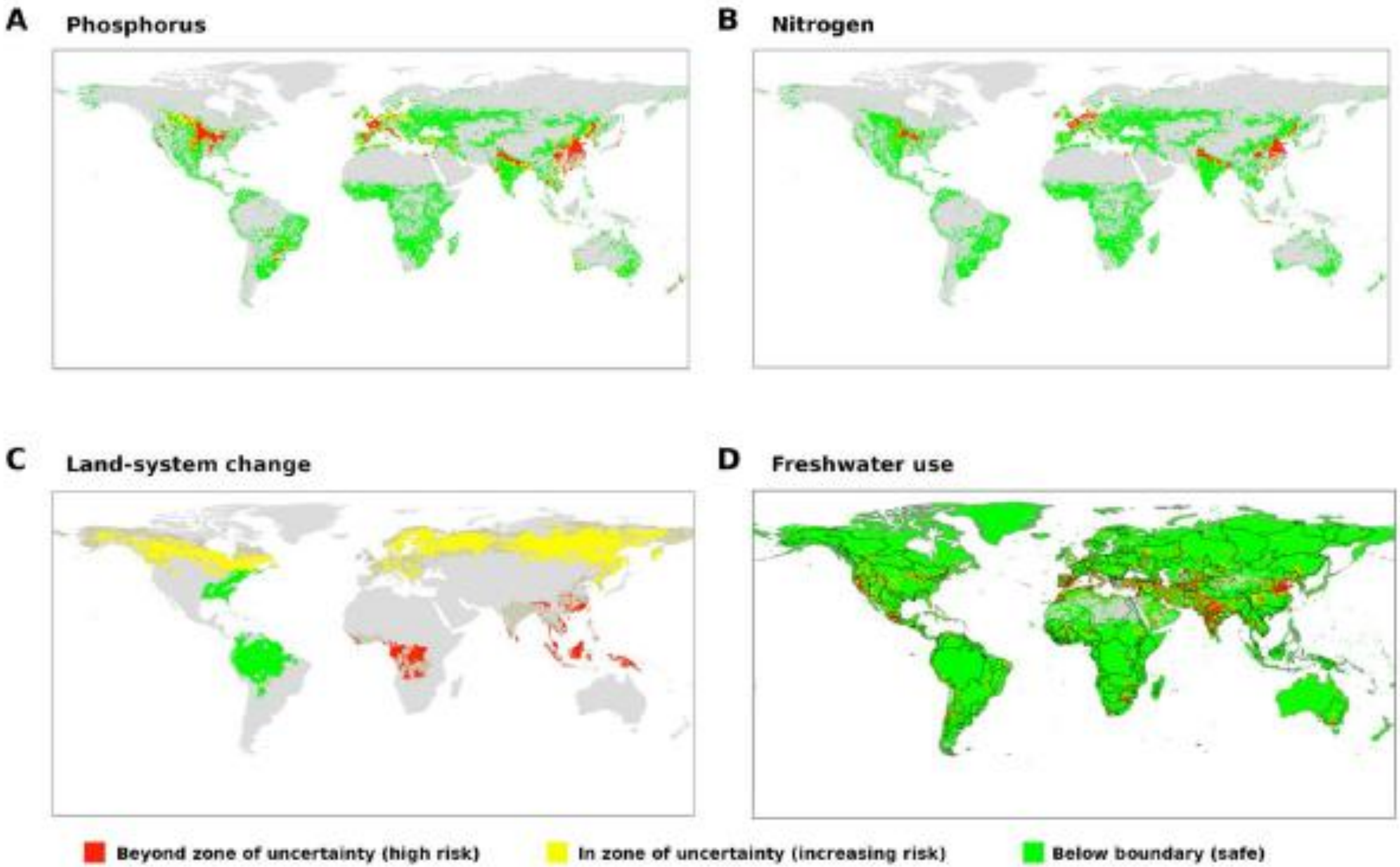


Kharas, 2011

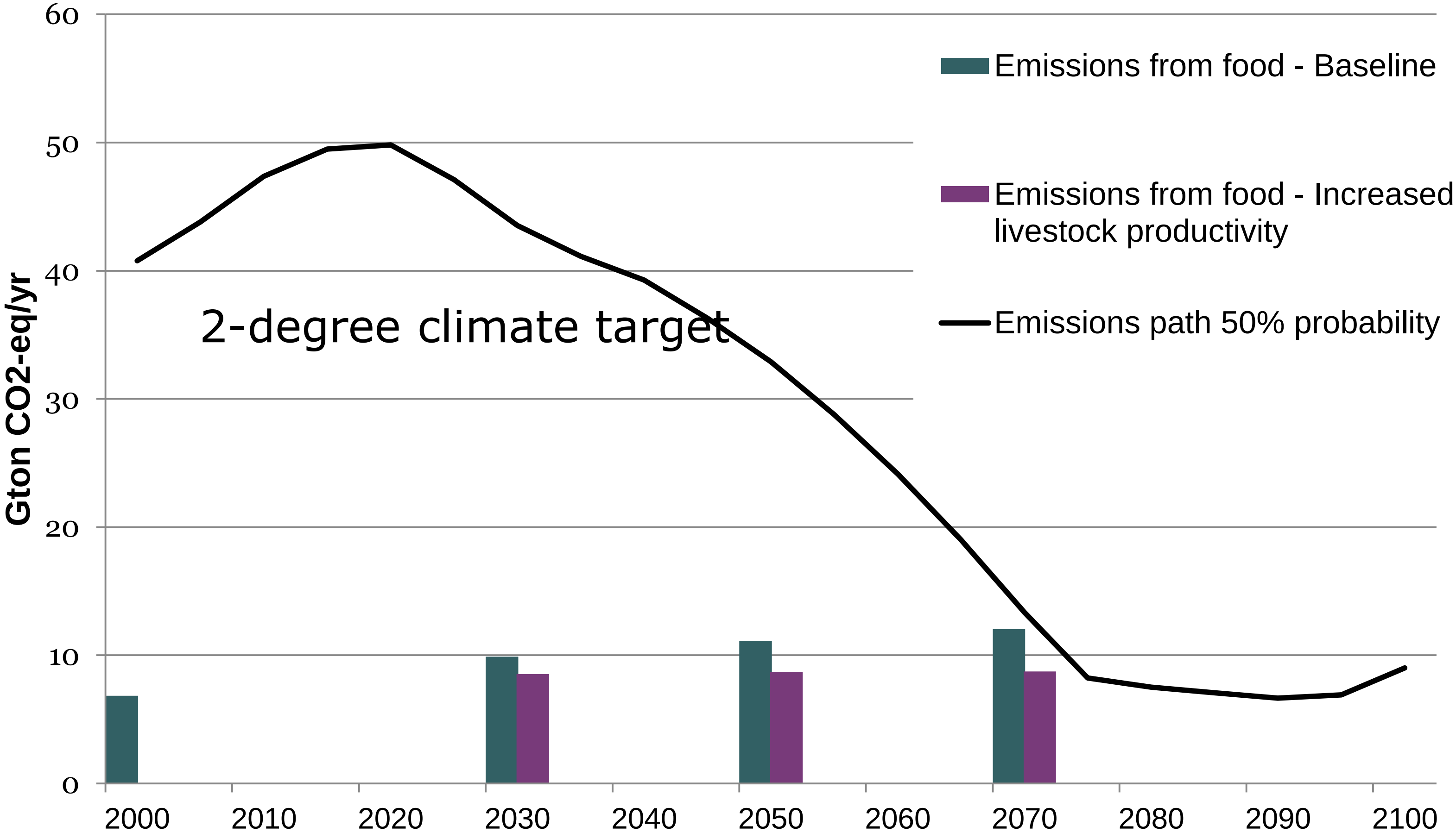
A SCHEMATIC REPRESENTATION OF FARMING SYSTEMS (DIXON ET AL., 2001)



Current status of key planetary boundaries

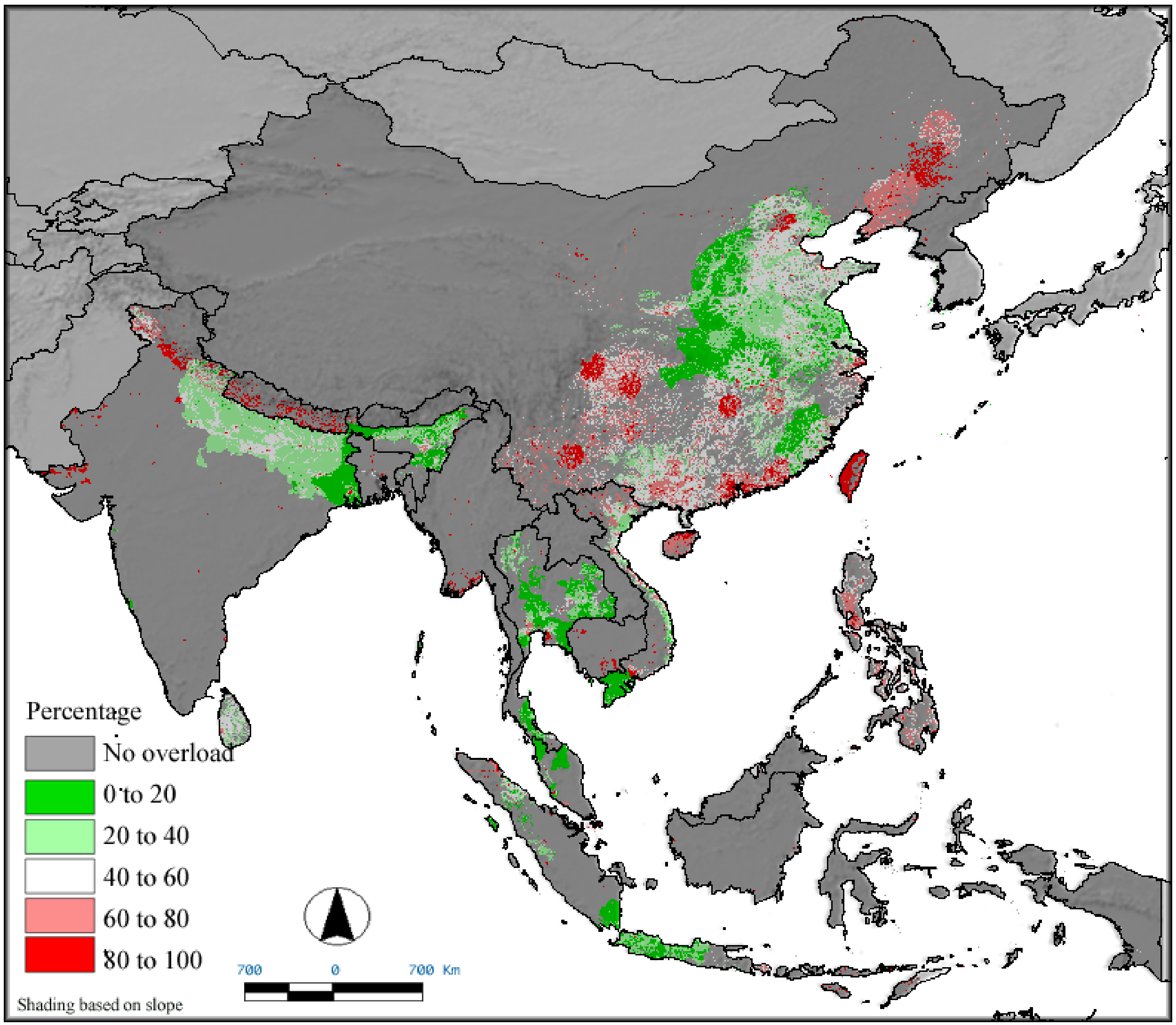


THE "GRAND CHALLENGE"



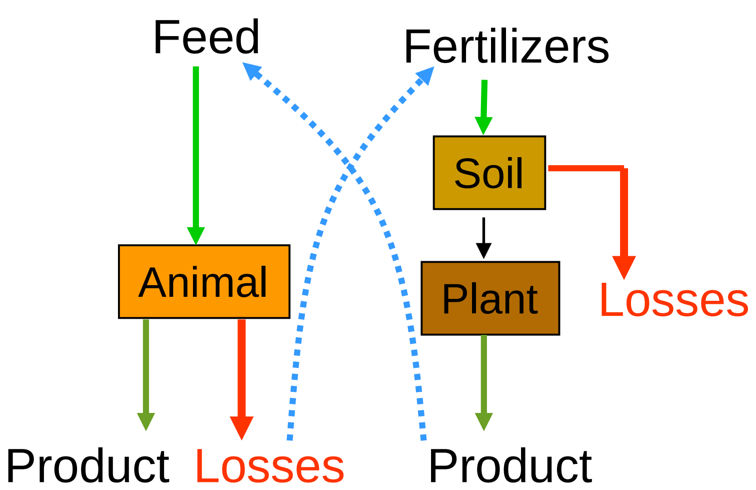
Source: Hedenus, Wirsenius, Johansson (201

Estimated contribution of livestock to total P_2O_5 supply on agricultural land, in area presenting a P_2O_5 mass balance of more than 10 kg per hectare.

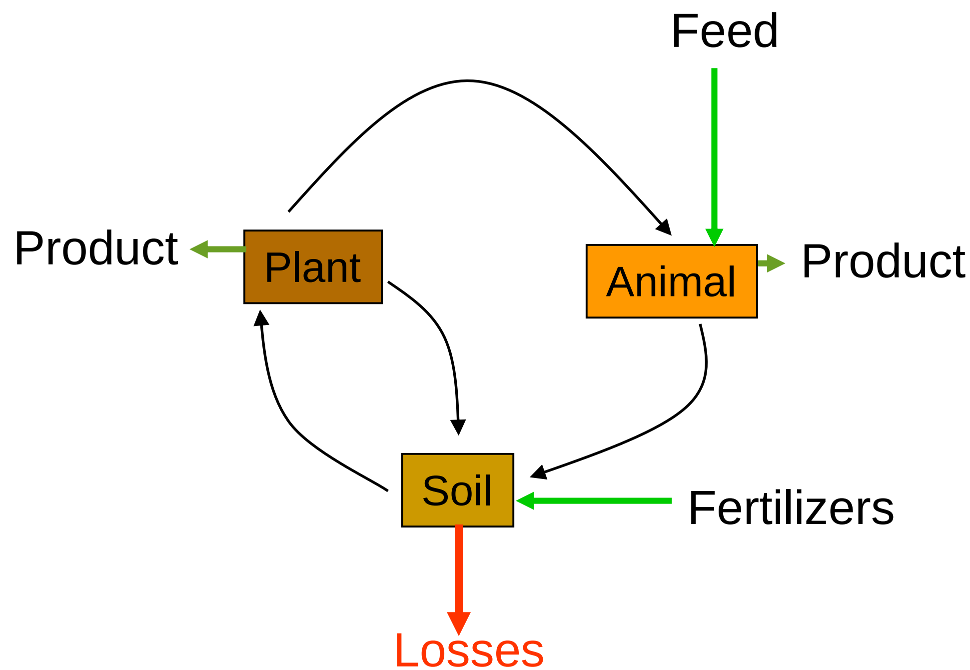


FAO, 2006

IMPACT OF LIVESTOCK ON WATER AND SOIL POLLUTION
NUTRIENT FLOWS IN FARMING SYSTEMS



SPECIALISED - INDUSTRIAL



MIXED

Adapted from Saleem, 1998

GLOBAL ASSESSMENT

Manure is utilised poorly by farmers,
40 – 60 % does not use dung, urine flows away

Main barriers for (small) farmers: awareness, knowledge, labour and investment opportunities

Awareness of the value of manure is limited, this also holds for local extension and policy makers

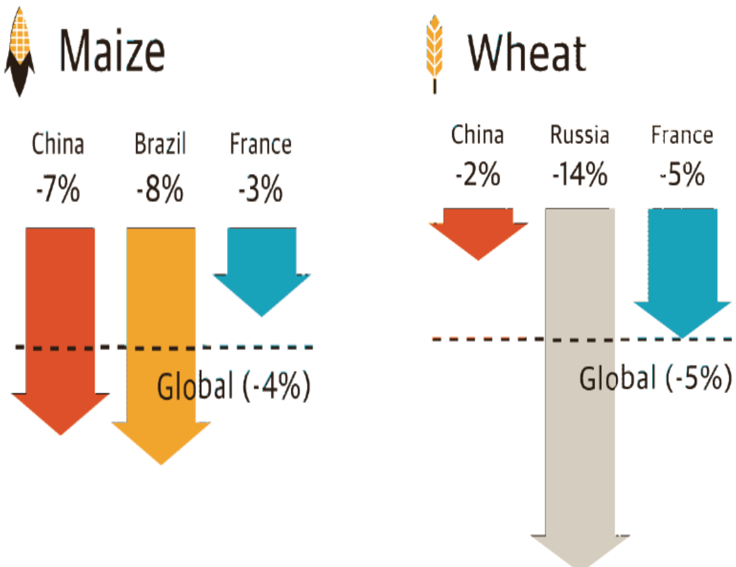
Policies are mainly driven by biogas, public health, pollution, *almost never by the fertilizer value*. Coordination is often lacking

Commercial input suppliers not interested

CLIMATE CHANGE IMPACTS ON FOOD SYSTEMS – WORSENING TOMORROW

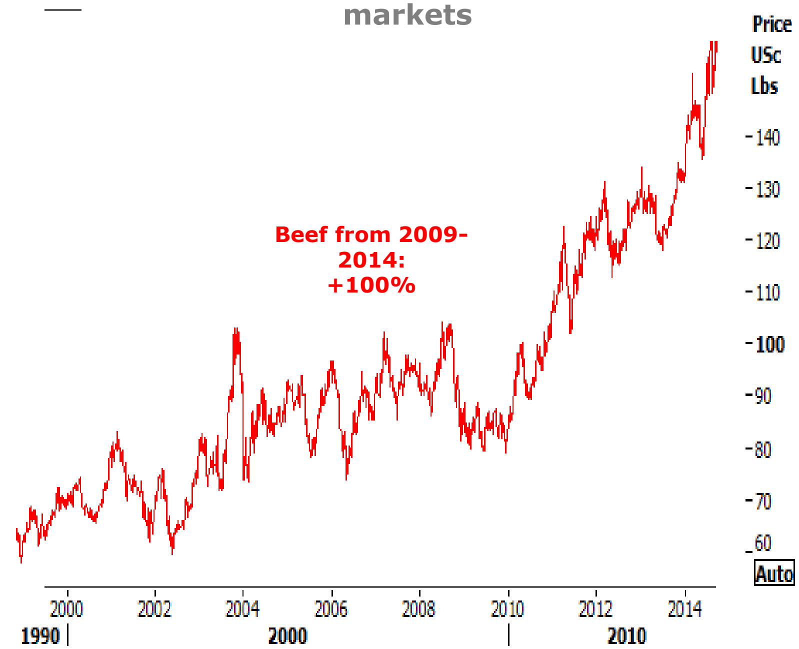
Decreasing

Maize and wheat yields show climate impacts



Increasing

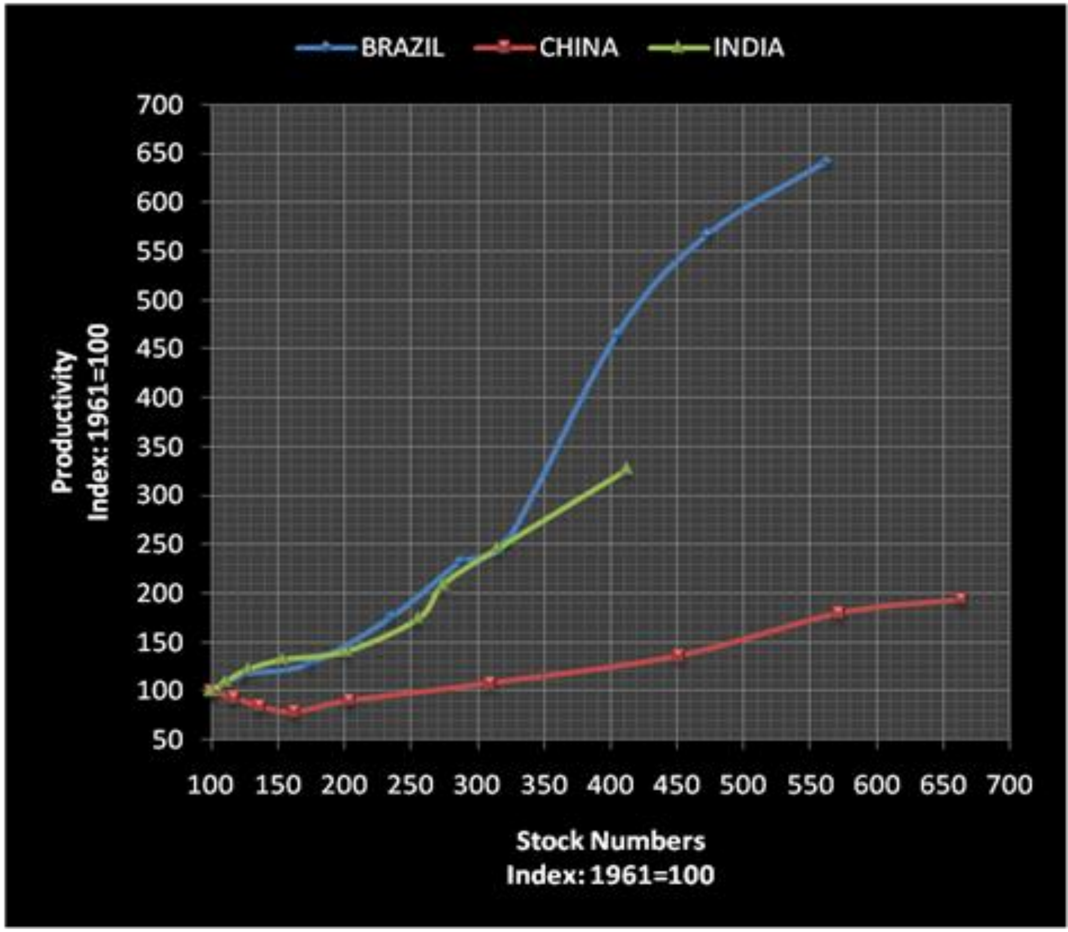
Price for beef increasing steadily due to pressure from feed and pastureland markets



CCAFS 2014; Reuters Eikon

WORLD BANK GROUP Agriculture

PRODUCTION INTENSIFICATION AND EXPANSION : MONOGASTRICS IN THE « BIG THREE » INDIA, CHINA AND BRAZIL



PASTURE DEGRADATION

Degradation of the vegetation cover resulting in :

lower productivity,

loss of SOM,

disrupted water cycles,

biodiversity erosion.

Immediate cause: management issue (graz pressure, fertilization, …)

Driven by:

Land availability

Limited awareness of environmental consequences

Lack of technical and financial capacity

ENVIRONMENTAL DEGRADATION

Between 30 -60% of agricultural land is degraded leading to loss of carbon stocks and emission of greenhouse gases

Livestock farmers are more vulnerable to climate change and or Variability