Overuse of Nitrogen:
Insights from the Chinese Experience

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Project partners

China

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China now:

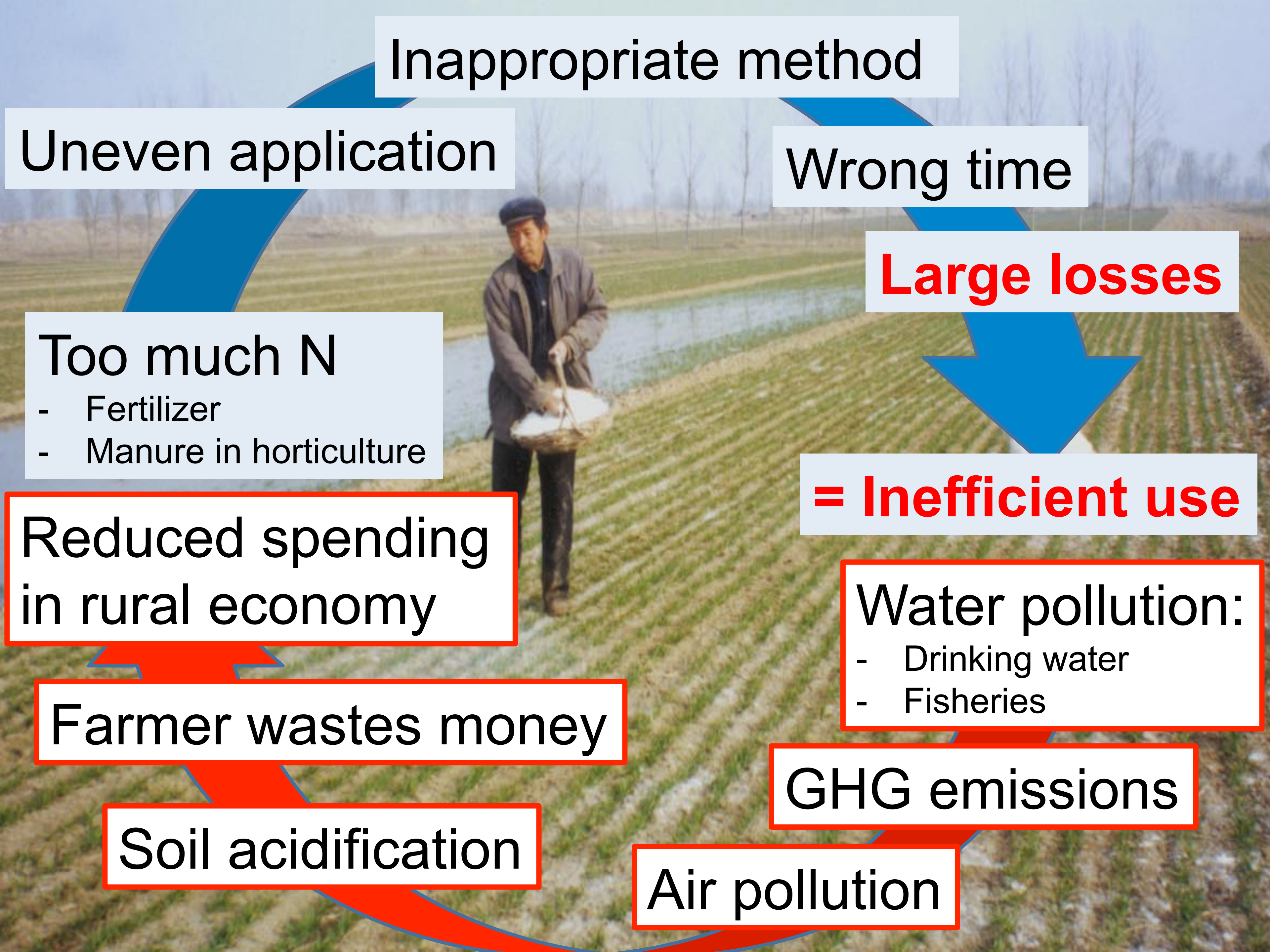
- Has >35% of world's N fertilizer manufacture & use
- Produces 20 Mt N in manure from livestock
- Produces >30% of global agricultural N_2O
- Produces 12% of global agricultural CH_4

and

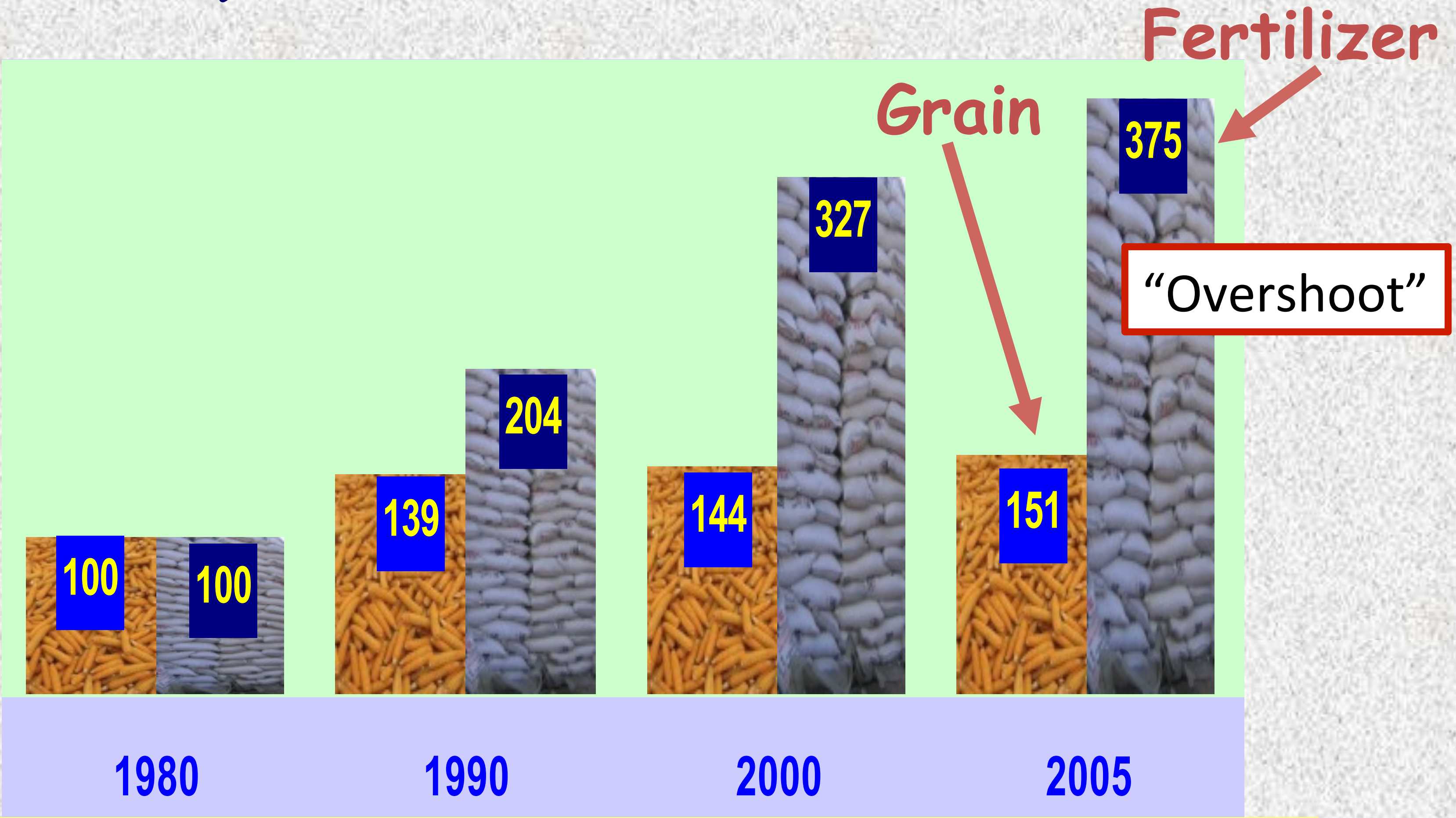
- Aims at 95% self sufficiency in basic foods
- Has 23% of global population
- But has only 7-9% of global arable land

Rio + 20 context

- UNEP (2011) Towards a Green Economy www.unep.org/greeneconomy
  - "... managed transitions away from "business-as-usual" … in farming"
- Chinese government
  - commitment to reduce carbon intensity by 40-45% by 2020 cf 2000 level.
  - measures in 12th 5 Year Plan (2011) for all sectors, including agriculture
  - commitment by Ministry of Agriculture to increase efficiency of use of fertilizers by 3%.
  - NDRC "Low carbon pilot zones" - 5 Provinces, 8 cities.


Inappropriate method
Uneven application
Wrong time
Large losses
Too much N
- Fertilizer
- Manure in horticulture
= Inefficient use
Reduced spending in rural economy
Water pollution:
- Drinking water
- Fisheries
Farmer wastes money
GHG emissions
Soil acidification
Air pollution

China fertilizer consumption and grain production (1980=100)



Considerable achievement
BUT inefficient use - quantity, timing

Fertilizer N "overshoot"

	Fertilizer N applied kg ha^{-1}		Excess %
	Optimum for region	Farmers average	
Rice (Taihu)	200	300	**50**
Wheat (Taihu)	153	250	**63**
Wheat (NCP)	128	325	**154**
Maize (NCP)	158	263	**66**

Ju *et al* (2009) *PNAS* **106**, 3041-3046

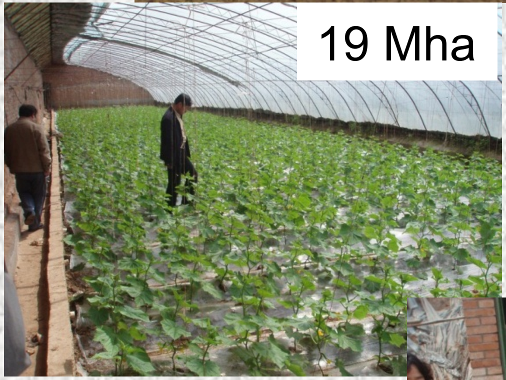
Fertilizer N "overshoot"

	Fertilizer N applied kg ha^{-1}		Excess %
	Optimum for region	Farmers average	
Rice (Taihu)	200	300	**50**
	102	174	
Wheat (Taihu)	153	250	**63**
	76	155	
Wheat (NCP)	128	325	**154**
	25	71	
Maize (NCP)	158	263	**66**
	52	108	

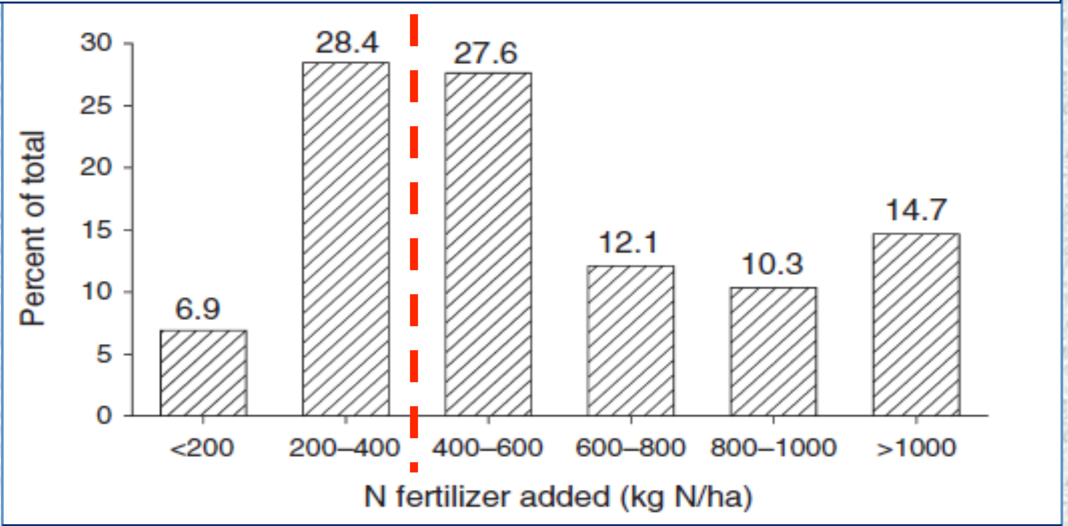
Fertilizer N loss to environment

Ju *et al* (2009) *PNAS* **106**, 3041-3046

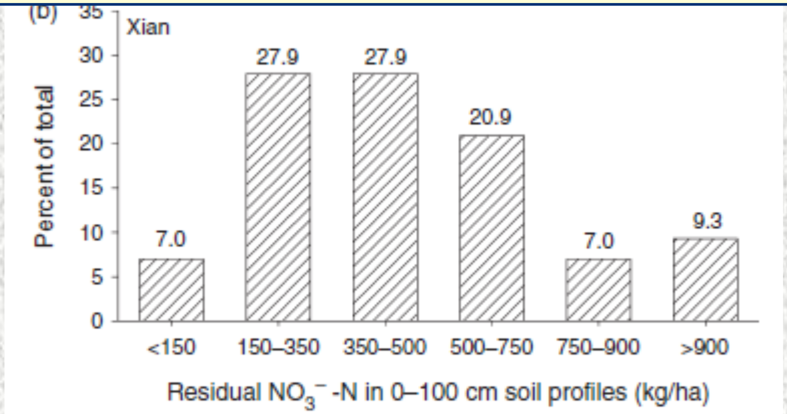
Fertilizer N rates, 116 greenhouses, Xian region, Shaanxi



19 Mha



65% of crops given > 400 kg N ha^{-1}
(37% > 600 kg N ha^{-1})
\+ *>700 kg N ha^{-1} as organic manure*



65% of greenhouses, > 350 kg residual NO_3-N ha^{-1} in soil

Zhou *et al*. (2010) *Soil Use and Management* **26**, 332-339

Algae in lakes and river estuaries:

from N and P

from fertilizers, manures

from industry and sewage

Taihu Lake

2007年太湖蓝藻爆发，影响饮用水安全

太湖蓝藻监测图像 2007年11月21日11时02分（北京时）

N "overshoot" – WHY?

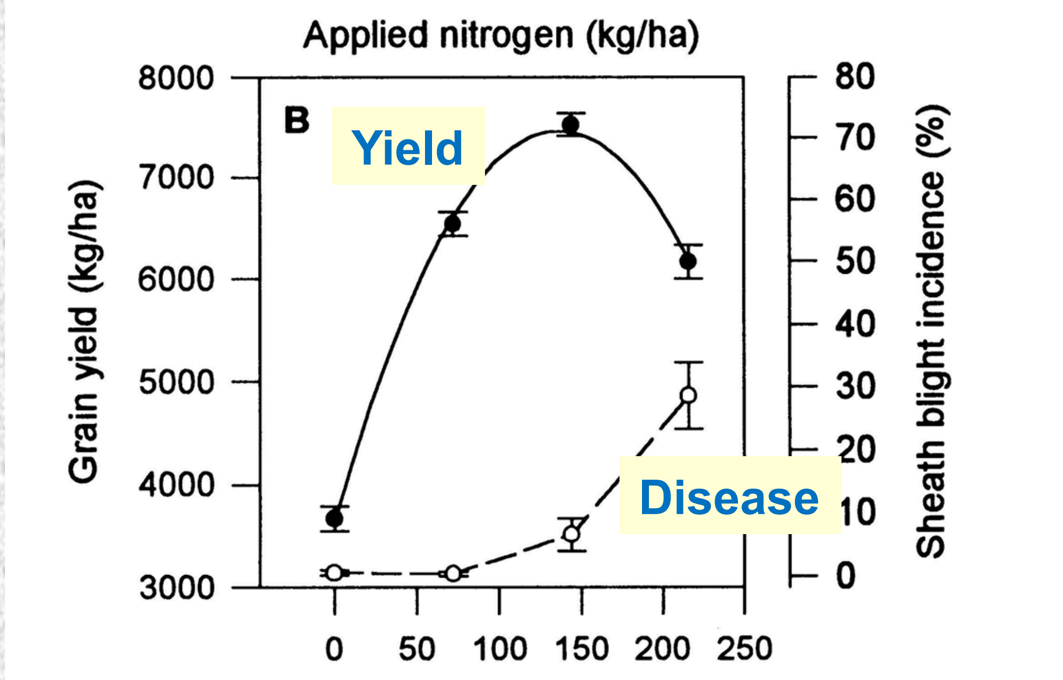
- Farmers and advisers in China responded to policies to boost food production.
- Fertilizer manufacture subsidised
- Food security achieved - ***now threatened by N over-use***
- Institutional fear of lost production by reducing fertilizer N rates – despite overwhelming published evidence showing no loss (or small gains!).
- 200 million farmers but mainly part-time (25-90% of income from off-farm work)
  - do not respond to classic extension methods
  - labour shortage at key times works against "best practice"

- ***Different policies and messages now required***

N Overuse **Optimum N**

Zhang, F.S., SAIN Policy Brief No. 2

N overuse and crop diseases: rice sheath blight



Cu *et al* (1996) Plant Diseases **89**, 1103-1108

China GHG emissions

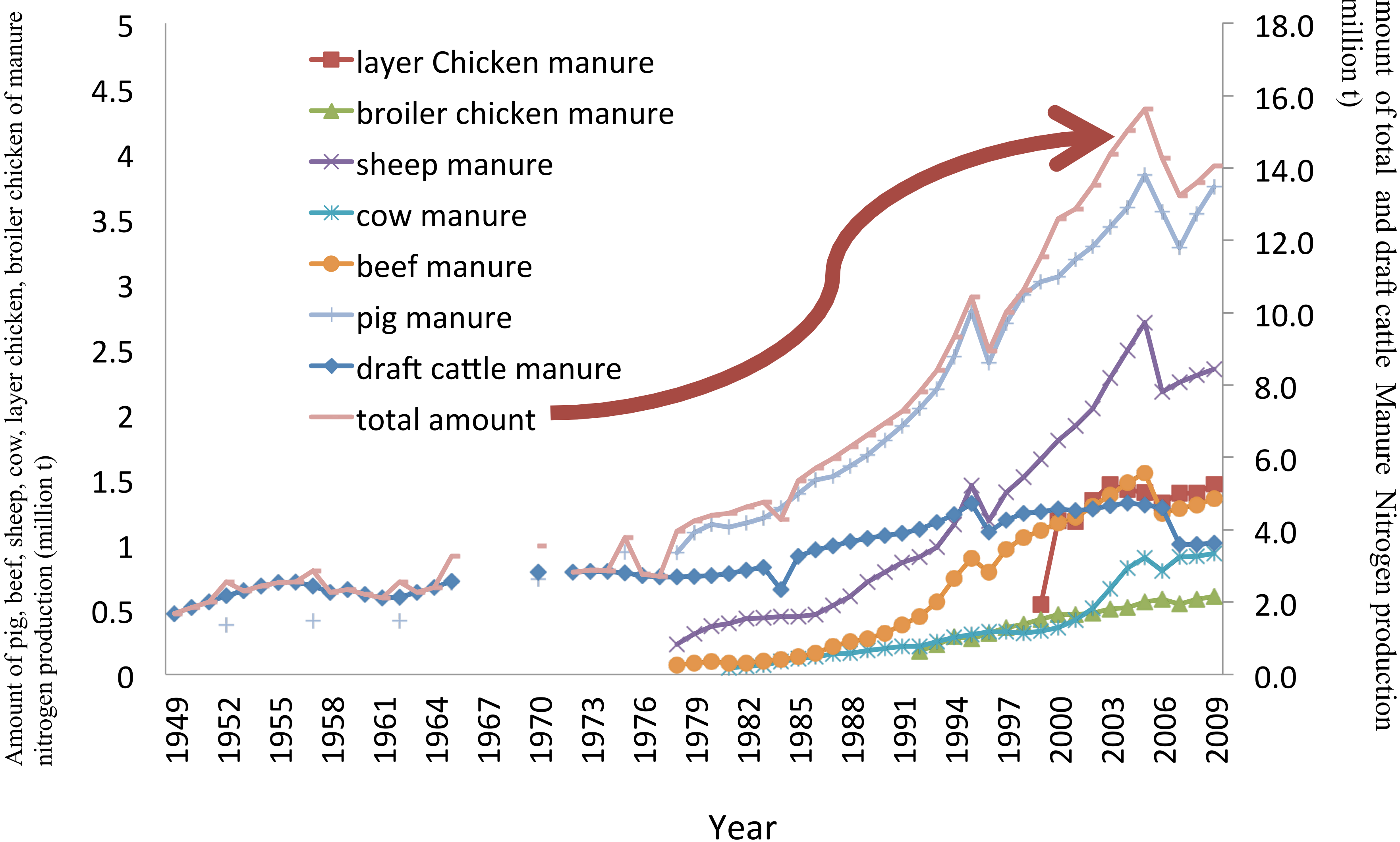
	Mt CO_2 eq *
China total	7230
Agriculture	1380 – 1640 (19 – 22%)

Reducing N fertilizer manufacture and use by 30%:

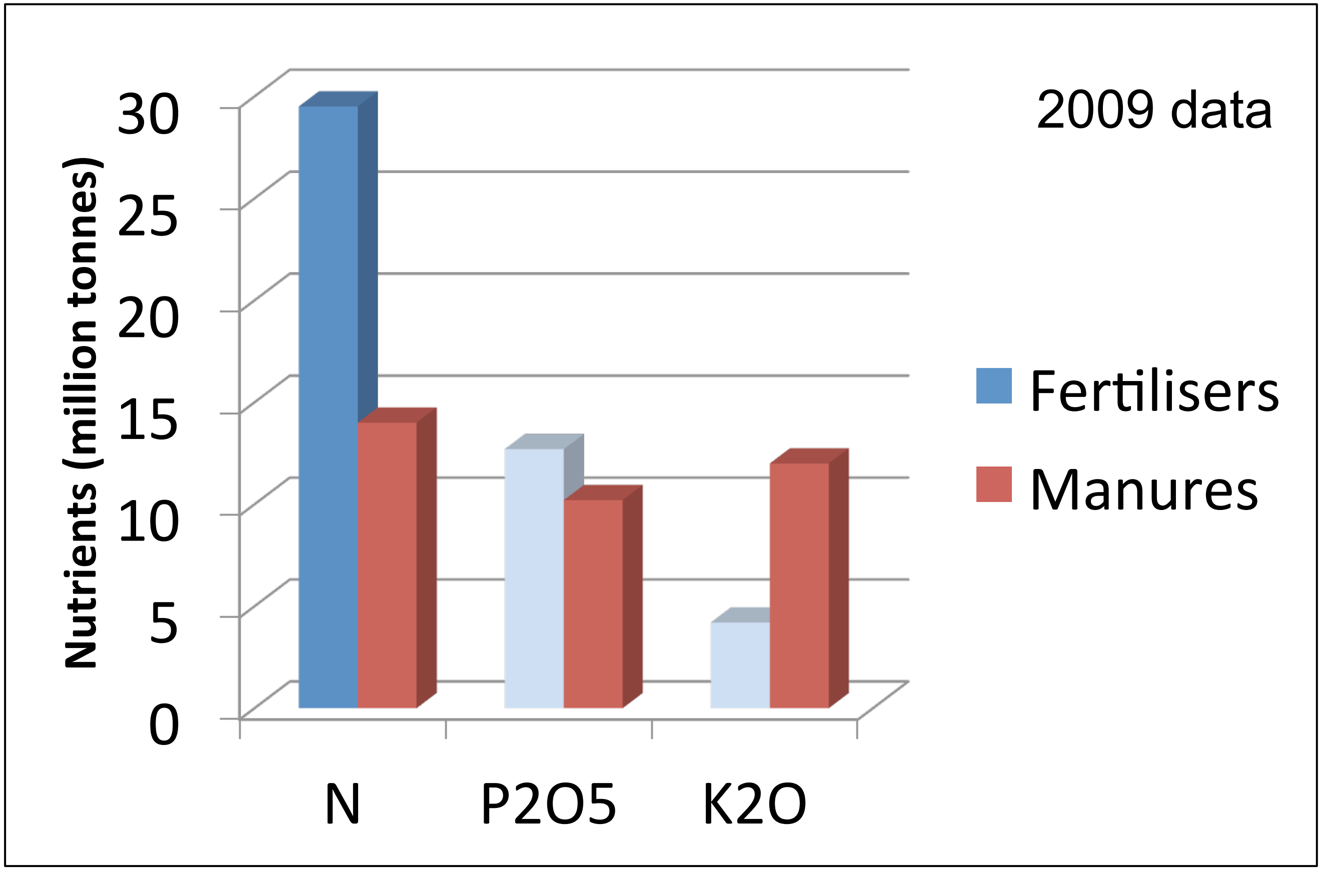
- Cuts ca. 3% of total national GHG emissions
- No loss of crop production

* From estimates in this project and published data

Manure nitrogen production of different livestock in China from 1949 to 2009



Jia wei et al., Unpublished



Sources:
Manure nutrients – SAIN review of Manure Use in China (MUC); Dave Chadwick (Rothamsted North Wyke) & Shen Qirong (Nanjing Agricultural University) - unpublished
Fertiliser nutrients- IFA (2010)

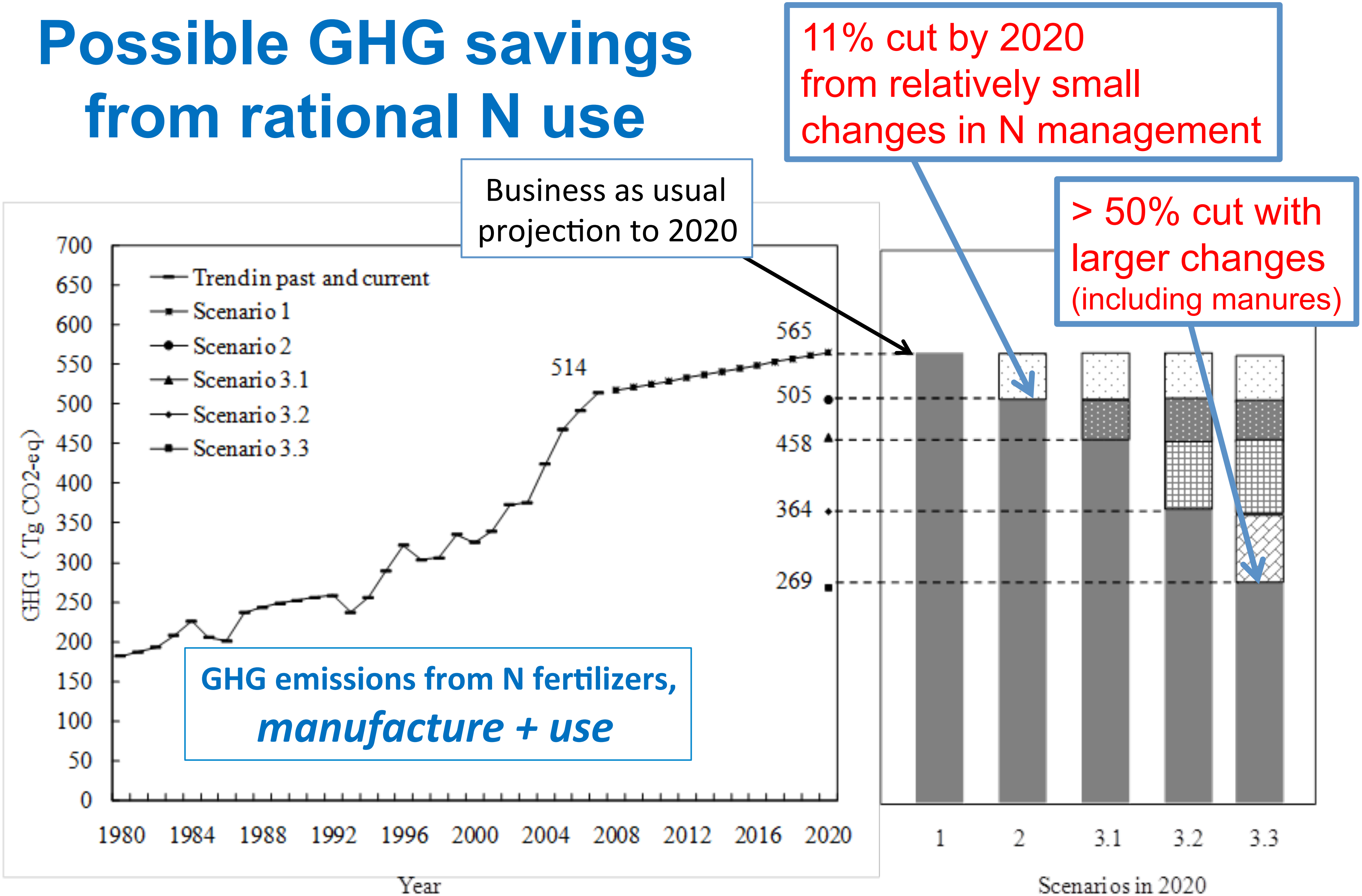
Vegetable - receive ca.25% of total chemical fertilizer and >50% of manure and commercial compost

	% livestock reared in CAFOs*		
	1989	1999	2009
Beef	0	18	21
Dairy	2	26	42
Sheep / goats	1	17	21
Laying hens	0	46	79
Broilers	0	63	85

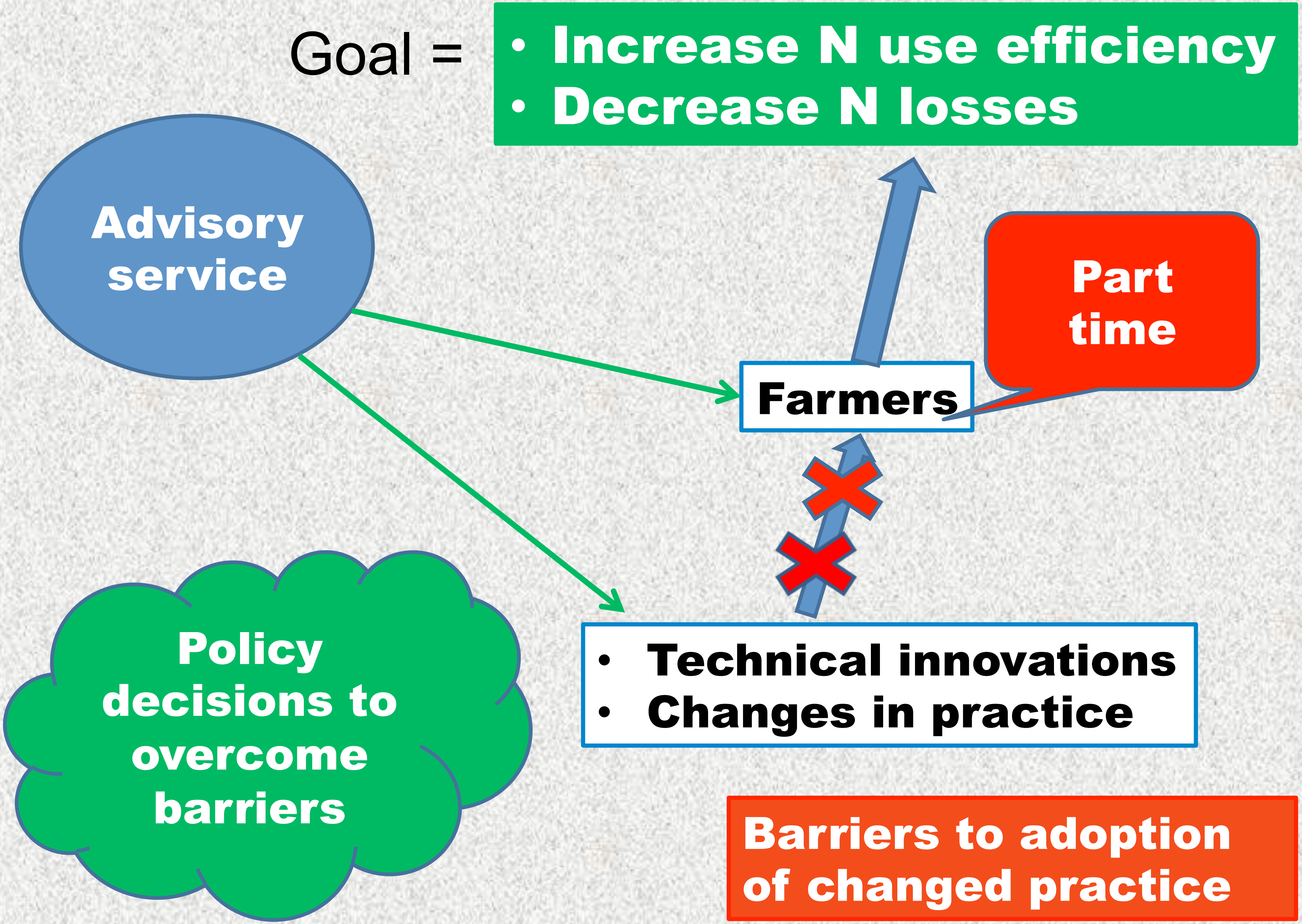
* Concentrated animal feeding operations

Source: MOA

Possible GHG savings from rational N use



Zhang Weifeng *et al* – (this project)


Goal =
• Increase N use efficiency
• Decrease N losses
Advisory service
Part time
Farmers
Policy decisions to overcome barriers
• Technical innovations
• Changes in practice
Barriers to adoption of changed practice

Sub-surface urea application

Policy or institutional changes to overcome barriers

Outcome:

Greatly decreased NH_3 loss

Targeting mechanisation grants to promote start-up of contractors

Barriers:

- **Machinery cost**
- **Part time farmers - labour shortage at time for max N use efficiency**

Lessons to learn from Chinese experience (1/2)

- At early stage of development, policies to encourage increased N fertilizer use are appropriate
  - but not for ever!
  - think ahead and adjust policies and institutional structures
  - changes can occur very fast – attempt to predict environmental challenges
- Plan at policy level
  - not simply a matter for farmers and extension staff!
  - responsibilities of fertilizer suppliers – information, training
- Part-time farmers
  - do not respond to traditional advisory approaches
  - labour shortages at key times – implications for management
  - economic priorities

Lessons to learn from Chinese experience (2/2)

- More effective communication methods for ***all*** farmers (Farmer Field Schools, “farmer trains farmer”)
  - develop appropriate range of methods for different groups
- Unplanned developments; e.g.
  - intensive vegetable production
  - large animal enterprises (CAFOs) – manure
  - benefits, opportunities, environmental impacts, regulation

Thanks for your attention

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www.sainonline.org (Policy Brief Nos. 1,2,5)

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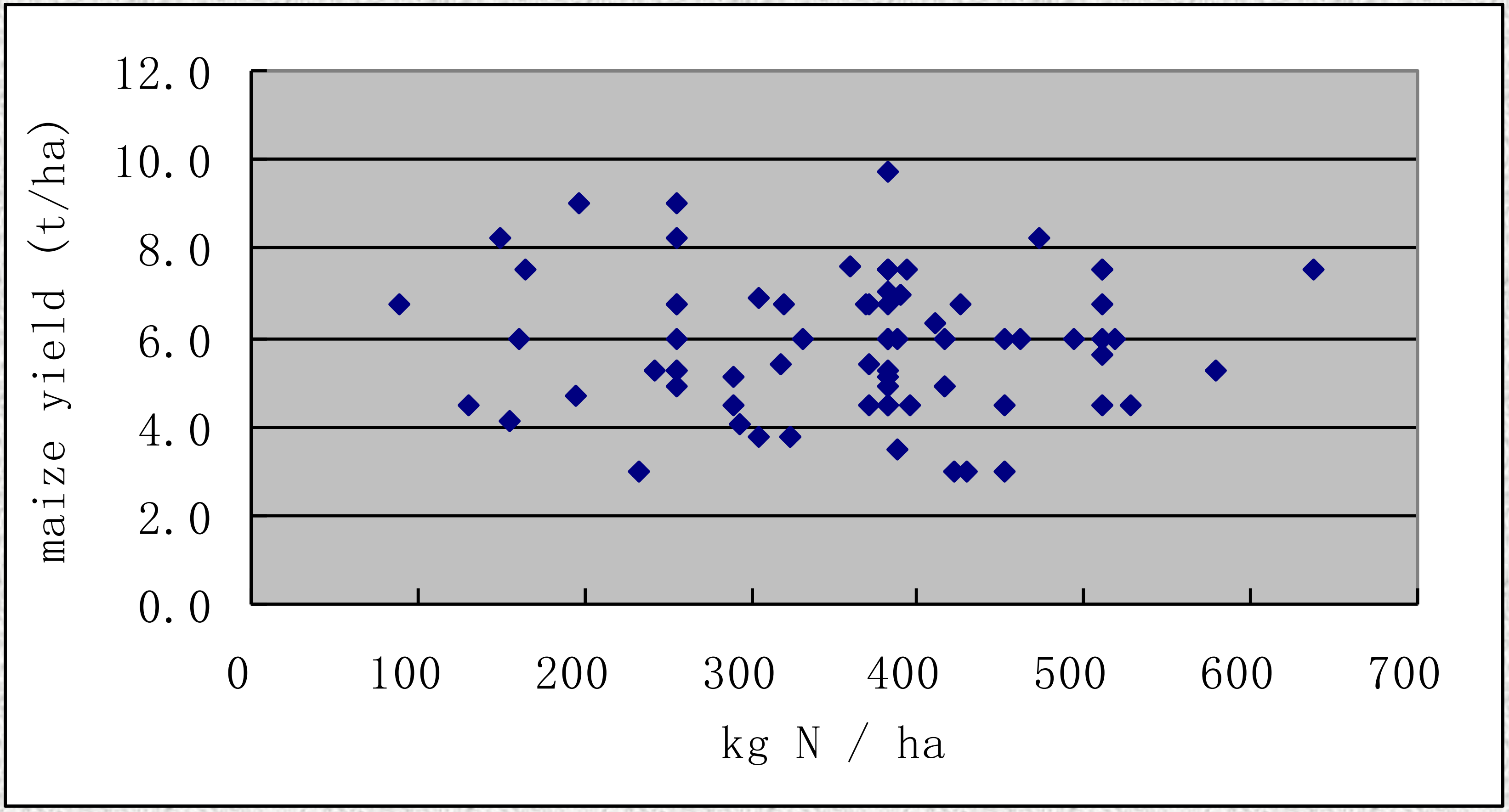
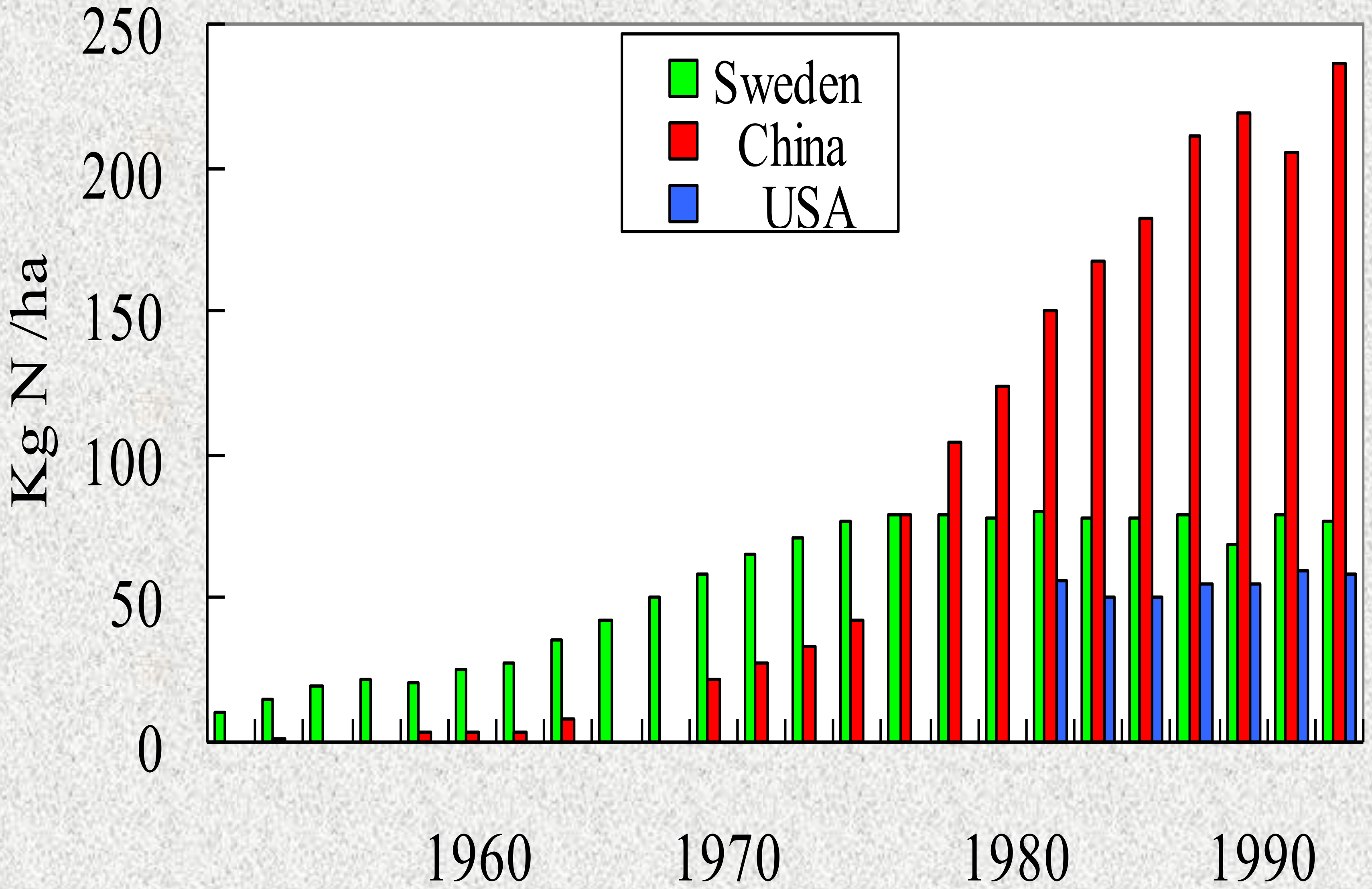
Extra slides

Recommendations for China

- Institutional acceptance of N over-use situation
- Fertilizer industry
  - remove energy subsidies
  - phase out highest GHG highest CO_2 emitting factories
  - responsibility for delivering information/training
- Promote role of contractors
  - appropriate application machinery
  - timing
  - training
- Urease and nitrification inhibitors (to overcome inappropriate timing)
- Manure
  - building regulations to include manure plans for new CAFOs
  - continued financial incentives for composting
  - improved labelling
  - contractors
- Integrate nutrient and water management and policies
  - "fertigation" where possible
- Greater use of nitrate-based fertilizers
- More appropriate advisory approaches

Maize, central Shaanxi





N fertilizer use per unit area

Economic benefits from INM Billion RMB/yr

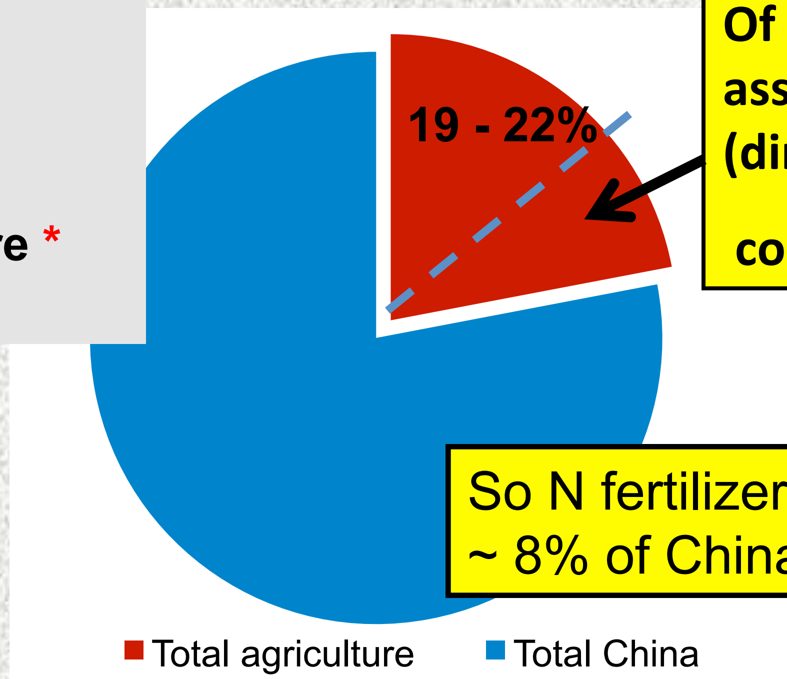
- Savings from expenditure on N fertilizer (10% by 2020) – 15 billion
- Reduced losses from pests and diseases (5-10% of crop production)- 15-30 billion
- Reduced eutrophication - 14-28 billion
- Total social & environmental benefits from carbon & N savings from 10 % reduction in N fertilizer use – 56-252 billion

CHINA - agricultural GHG emissions as percentage of total national emissions

Emissions, Mt CO_2 eq

Total China
7230 *

Total agriculture *
1382 – 1636



Of which 33 - 39% (at least) **associated with N fertilizer (direct + indirect).**

conservative estimate

So N fertilizer (manufacture and use) = ~ 8% of China ***total*** GHG emissions

* From estimates in this project and published data.
(Official figures due in 2011 or 2012)

Assuming 30% over-use,
Approx 3% cut in China's total GHG emissions
easily achieved from more rational N use.
- could be greater!