

Can China's overuse of fertilizer be reduced without threatening food security and farm incomes?

Policy simulations until 2030 with emphasis on regional differences

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Overview of presentation

Facts:

- Trends in fertilizer use
- Net nutrient surpluses
- Fertilizer-related pollution

Options for improvement:

- Agronomic assessments

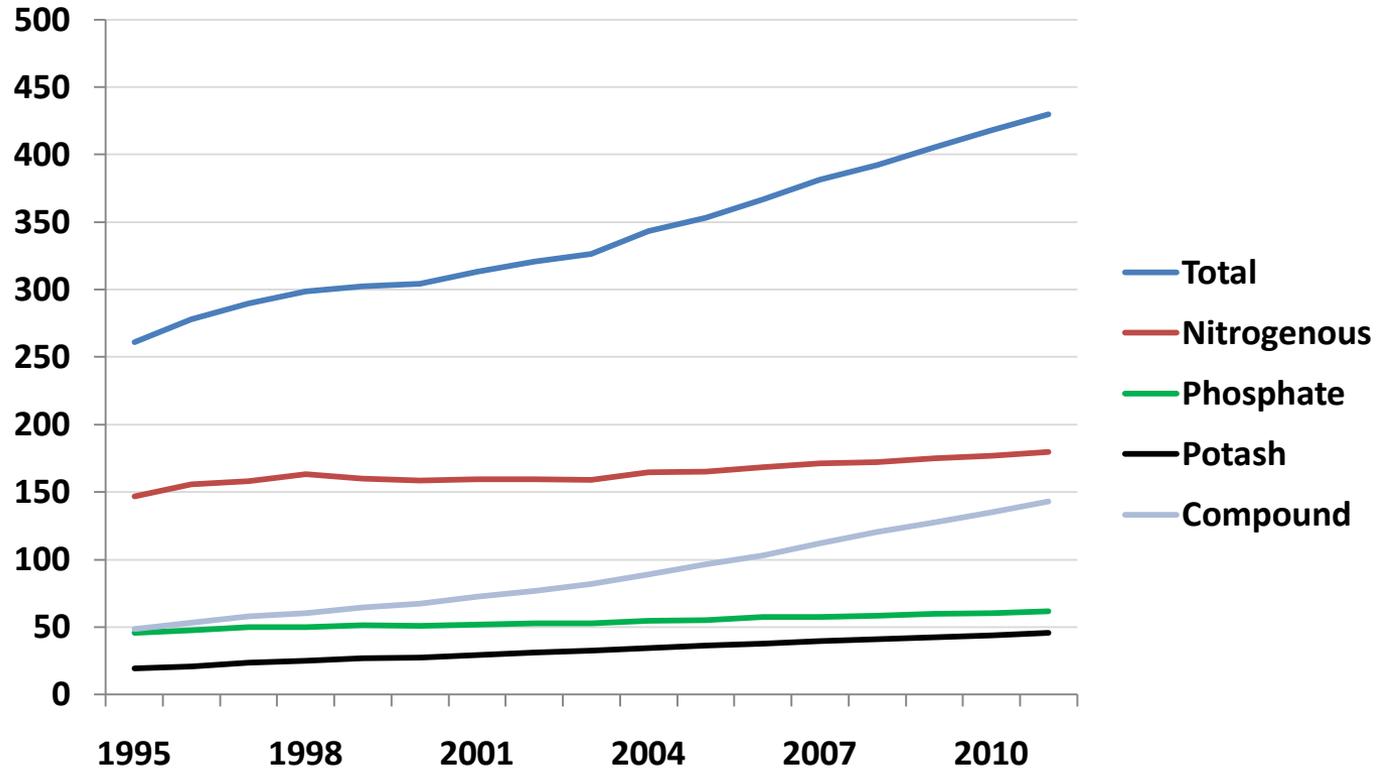
Welfare simulation with Chinagro model:

- Reference scenario
- Improved fertilizer scenarios

Concluding assessment

Facts (1): trends in fertilizer use

Chemical fertilizer use in kg per ha arable land (incl. orchards)

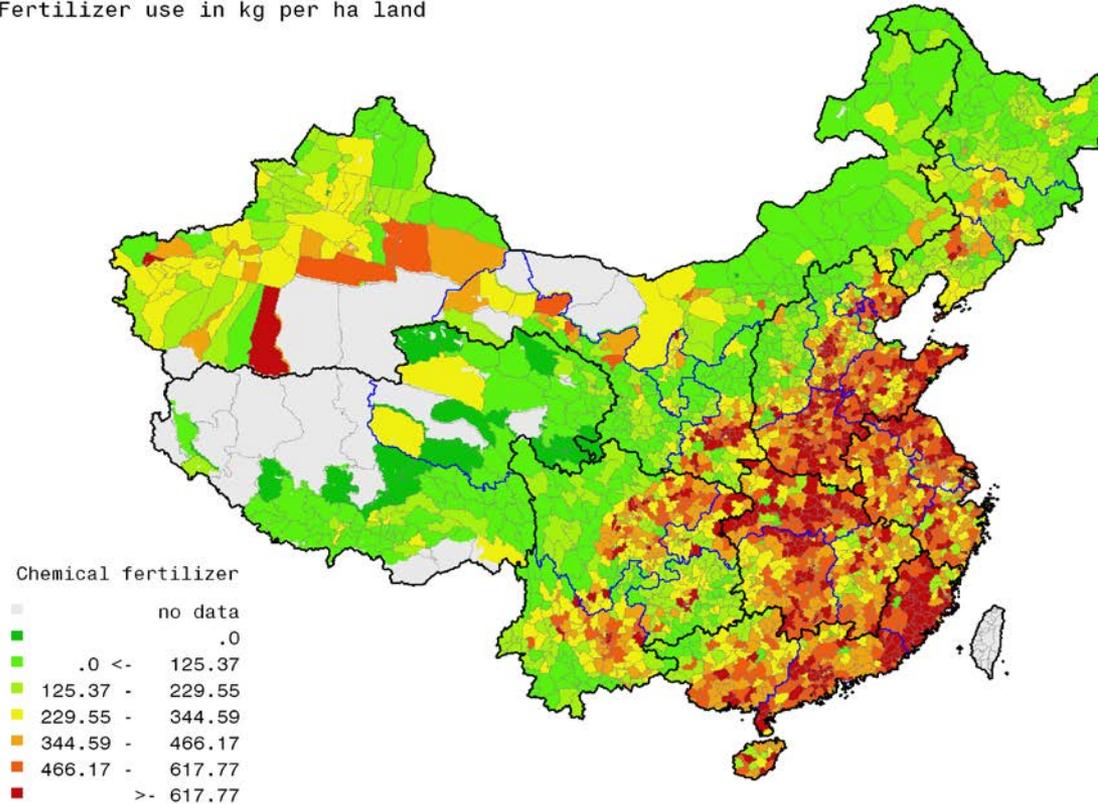


Chemical fertilizer use in kg/ha keeps on increasing

Source: NBSC (2012)

Facts (2): spatial picture chemical fertilizer use 2005

Year 2005
Chinagro data set
Fertilizer use in kg per ha land



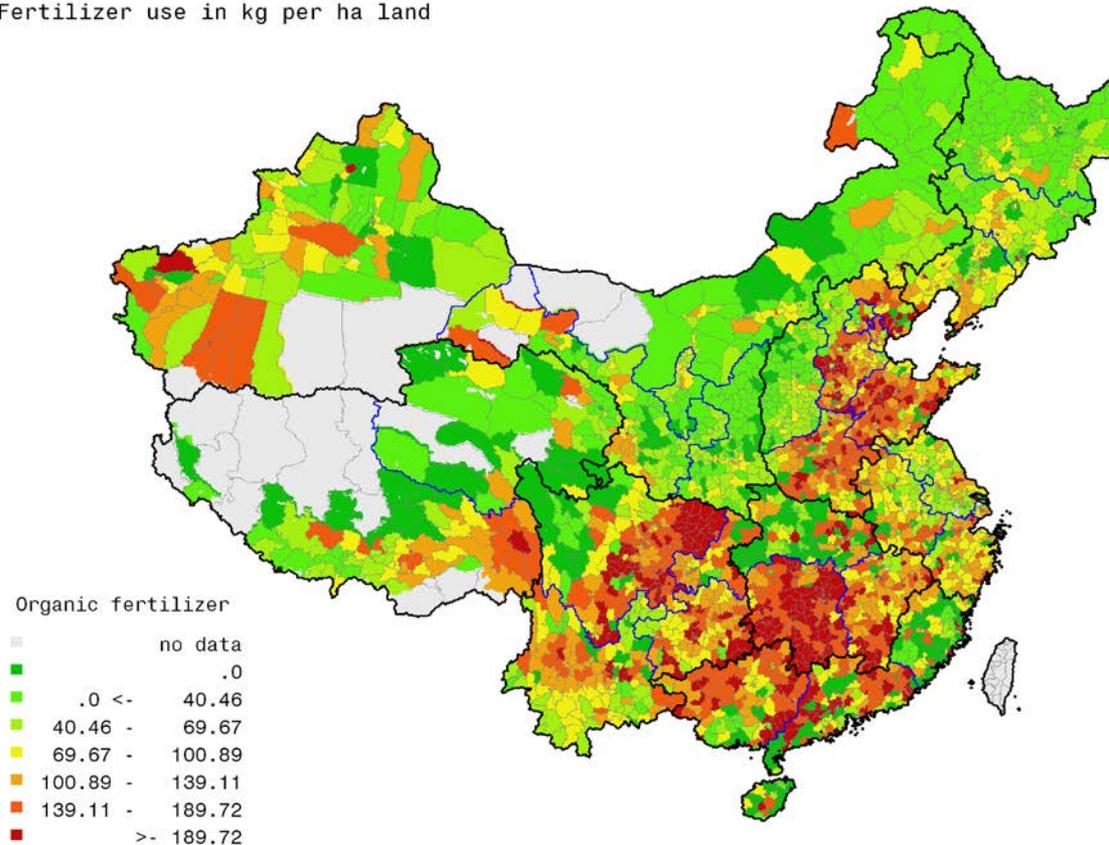
Many counties with over 600 kg/ha!

Facts (3): spatial picture organic fertilizer use 2005

Year 2005

Chinagro data set

Fertilizer use in kg per ha land



**Also substantial use of organic fertilizer:
more than 190 kg/ha nutrient in some counties**



Facts (4): net nutrient surpluses 2005

Nutrient (im)balances in kg per ha arable land, 2005, Whole of China

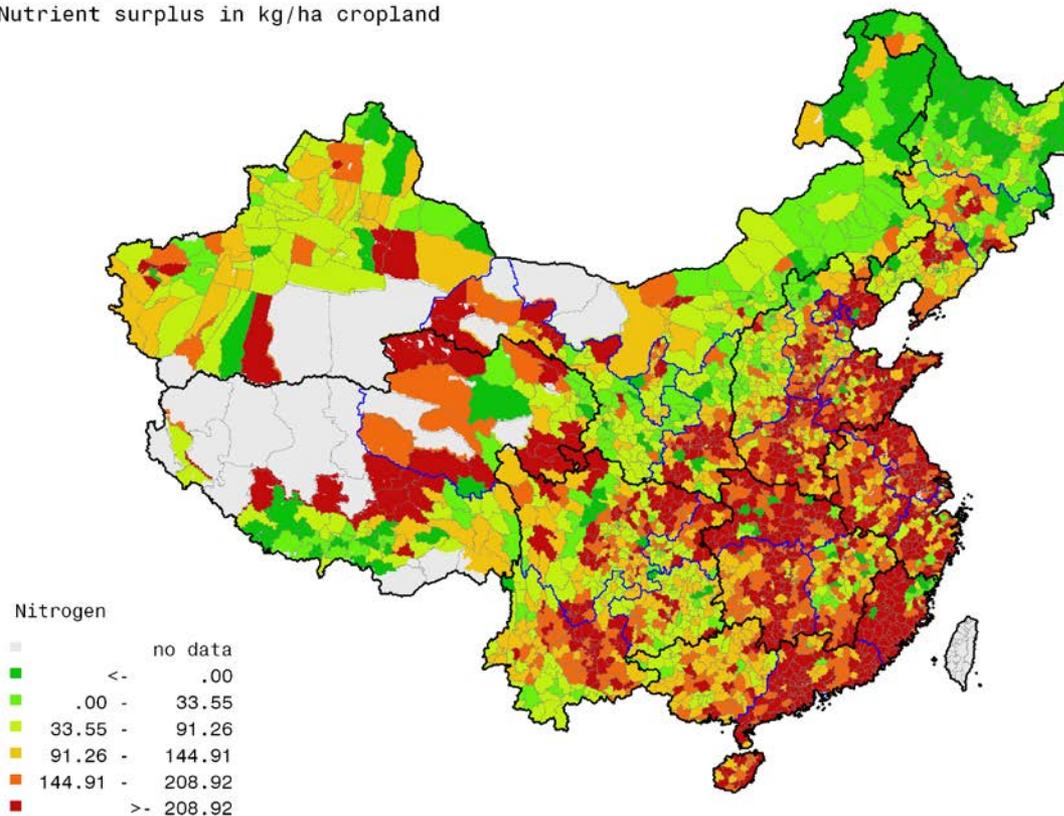
	N	P ₂ O ₅	K ₂ O
Application of animal manure (a)	31.5	23.0	26.0
Application of human manure (b)	11.3	4.7	2.8
Chemical fertilizer (c)	231.6	76.5	52.5
Fixation from the air (d)	10.6	0.0	0.0
Crop uptake (e)	162.6	62.3	170.2
Remaining on the land (f)	33.3	10.2	61.2
Net surplus = (a)+(b)+(c)+(d) +(f) -(e)	155.7	51.4	-27.7

Source: Chinagro data set

Significant surpluses of N and P₂O₅ but deficits of K₂O

Facts (5): spatial picture N surpluses

Year 2005
Chinagro data set
Nutrient surplus in kg/ha cropland



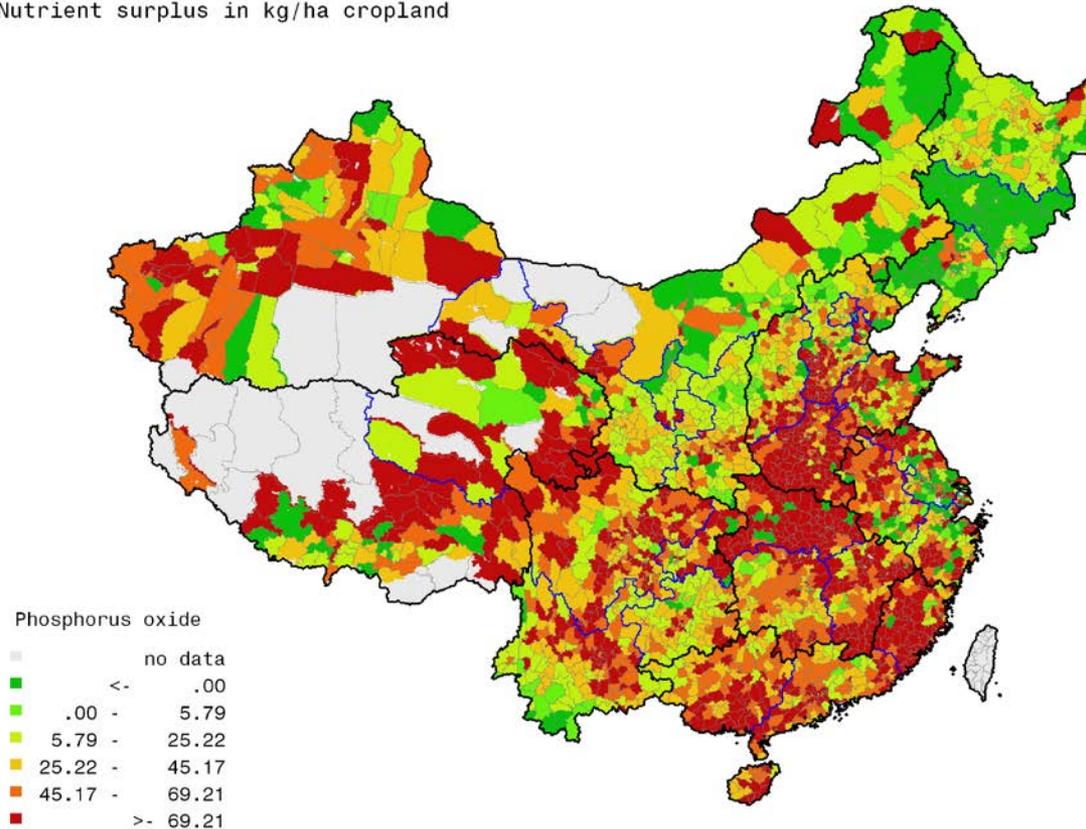
**Throughout China crop land has nitrogen surpluses
but hardly in Northeast**

Facts (6): spatial picture P_2O_5 surpluses

Year 2005

Chinagro data set

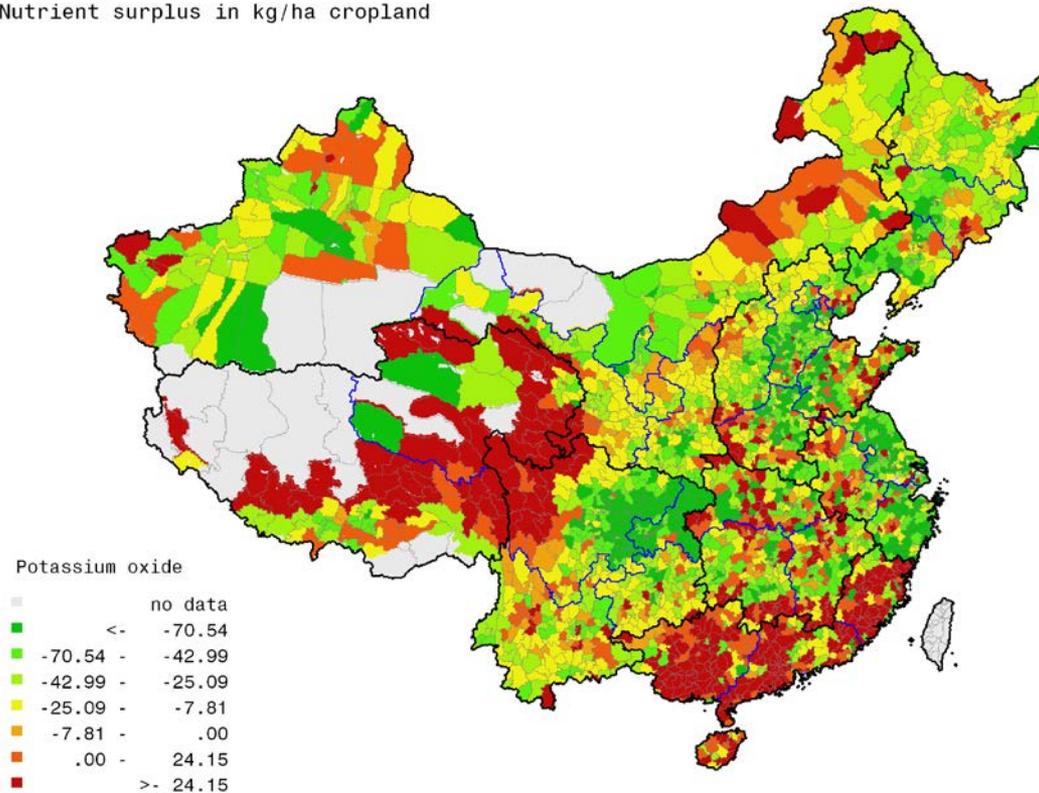
Nutrient surplus in kg/ha cropland



Throughout China crop land has large surpluses of phosphorus, but hardly in Northeast

Facts (7): spatial picture K₂O deficits

Year 2005
Chinagro data set
Nutrient surplus in kg/ha cropland



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Potassium deficits are prevalent on crop land throughout China except for the South and mountainous areas



Facts (8): fertilizer-related pollution

Widespread evidence is available on:

- **toxic nitrates from nitrogen surpluses in groundwater and surface water**
- **heavy metals from contaminated (phosphate) fertilizer in groundwater, surface water and soil**
- **eutrophication of surface waters due to nitrogen and phosphate surpluses**
- **contribution of nitrogen surpluses to acid rain and emission of greenhouse gases**
- **contamination of food and feed (and, hence, also manure) via traces of heavy metals from contaminated chemical (P) fertilizer**



Summarizing these facts:

- **Widespread overuse of fertilizer causes large surpluses of nitrogen and phosphorus oxide on crop land**
- **These surpluses lead to serious pollution of water, air and soil, and to contamination of food and feed**
- **There are no signs of change, so far**

Question then: is the overuse necessary for food supply and farm incomes?



Options for improvement (1): prevailing views in agronomic literature on China

1) Similar crop yields can be obtained at much lower fertilizer inputs (roughly halve), provided that:

- chemical fertilizer is applied more carefully**
- sufficient organic manure is used**
- sufficient crop residues are recycled**

2) Higher crop yields can be obtained if the same principles are followed with less reduction of chemical fertilizer and even more use of organic manure and recycling of crop residues

3) In particular, for maize, there is quite some scope for yield improvements along these lines



Options for improvement (2): towards welfare simulation

Follow-up question:

Assuming that the prevailing views in the agronomic literature of China can indeed be realized, i.e that

- farmers are willing to adjust their fertilizer management**
- industry is willing to adjust the fertilizer mix,**

what would it mean for farm incomes, food supply and nutrient surpluses?

To this end, we will formulate two improved fertilizer scenarios that will be analyzed with the Chinagro model



Welfare simulation (1): Chinagro model

- Focus on agriculture but embedded in full economy
- Spatial detail: agricultural supply by county (2885 counties)
- Farmers maximize net revenue at given resources, given prices of tradable commodities and given technical options
- Markets for 17 tradable commodities link producers to consumers and world market
- Also exchange of local commodities (manure, crop residues, household waste)
- Chinagro combines spatial detail with integration in broad market structure

(Jointly developed by CCAP, IIASA and SOW-VU)



Welfare simulation (2): reference scenario

Main scenario *assumptions* (period 2005-2030), a.o:

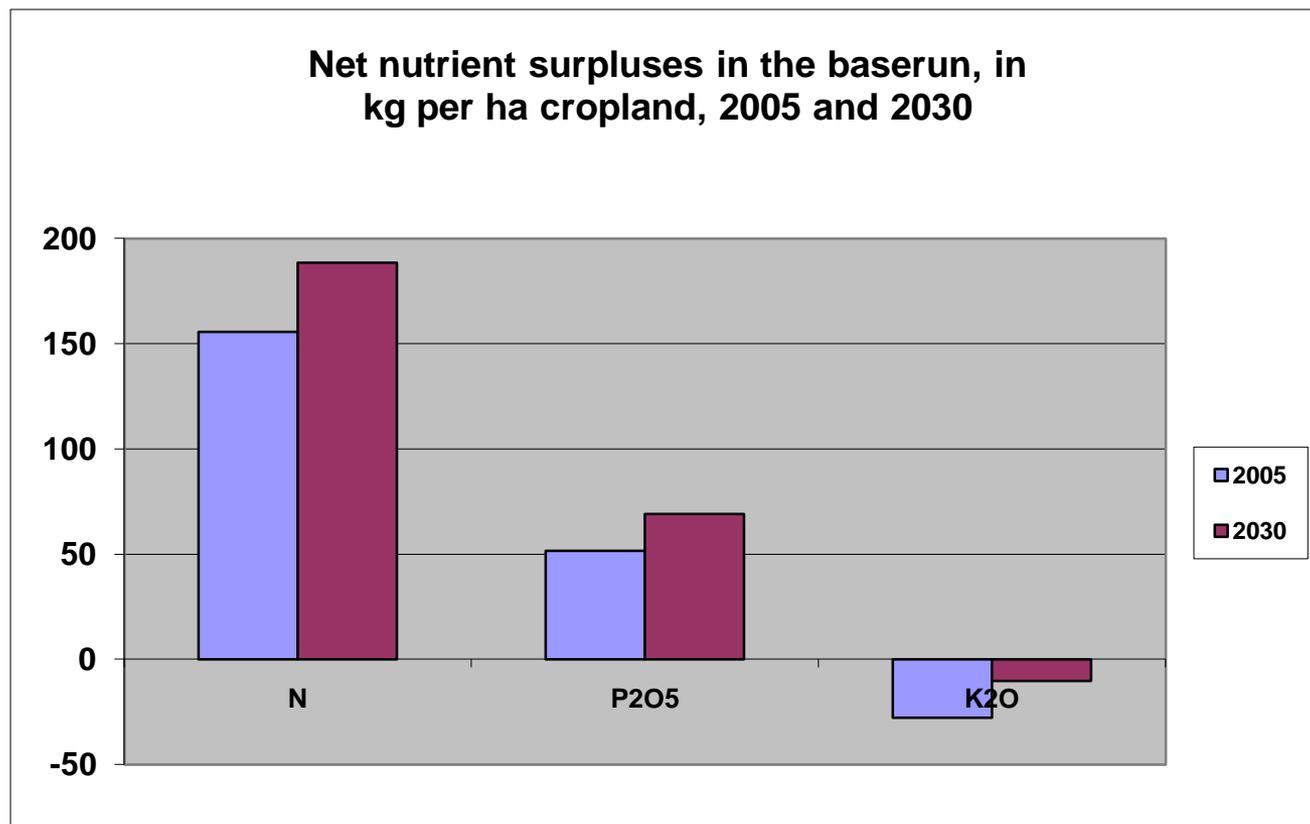
- Sustained non-agricultural growth
- Moderate population growth
- Steady improvements of crop yields but continuation of decline of fertilizer efficiency
- Continued intensification of the livestock sector
- Moderate crop land losses

Main model *outcomes* are reassuring:

- Steady growth of food intake (especially qualitatively) with reliance on world market mainly for feed (soybean, maize)
- Farm incomes rise by more than 3% annually, albeit especially thanks to the livestock sector
- Agricultural trade deficit is well manageable

But nutrient imbalances increase!!

Welfare simulation (3): trend in net nutrient surpluses in reference scenario



Surpluses of nitrogen and phosphorus keep on increasing but the potassium deficit falls



Welfare simulation (4): formulation of improved fertilizer scenarios

Based on the options outlined in the agronomic literature:

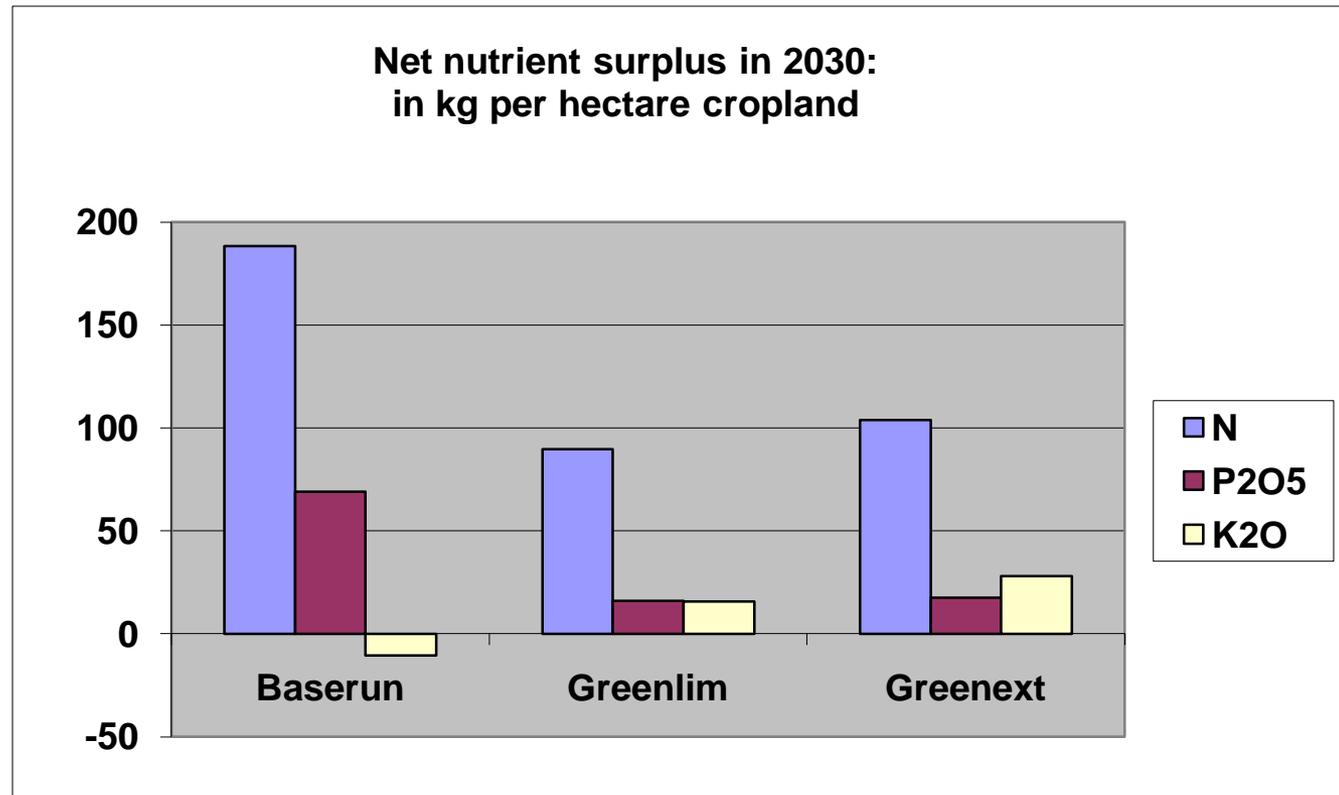
Greenlim:

- steadily improving fertilizer efficiency with more input of labor and organic manure (the latter exceeding a minimal level)**
- gradual shift toward 'prescribed' NPK composition**

Greenext:

- same assumptions as in Greenlim**
- in addition extra technical progress for grains (in particular maize) and more recycling of crop residues (at the expense of feed use)**

Welfare simulation (5): impact of the improved scenarios on the 2030 nutrient surpluses



Major reduction of the nitrogen and phosphorus surpluses while the potassium deficit disappears on average

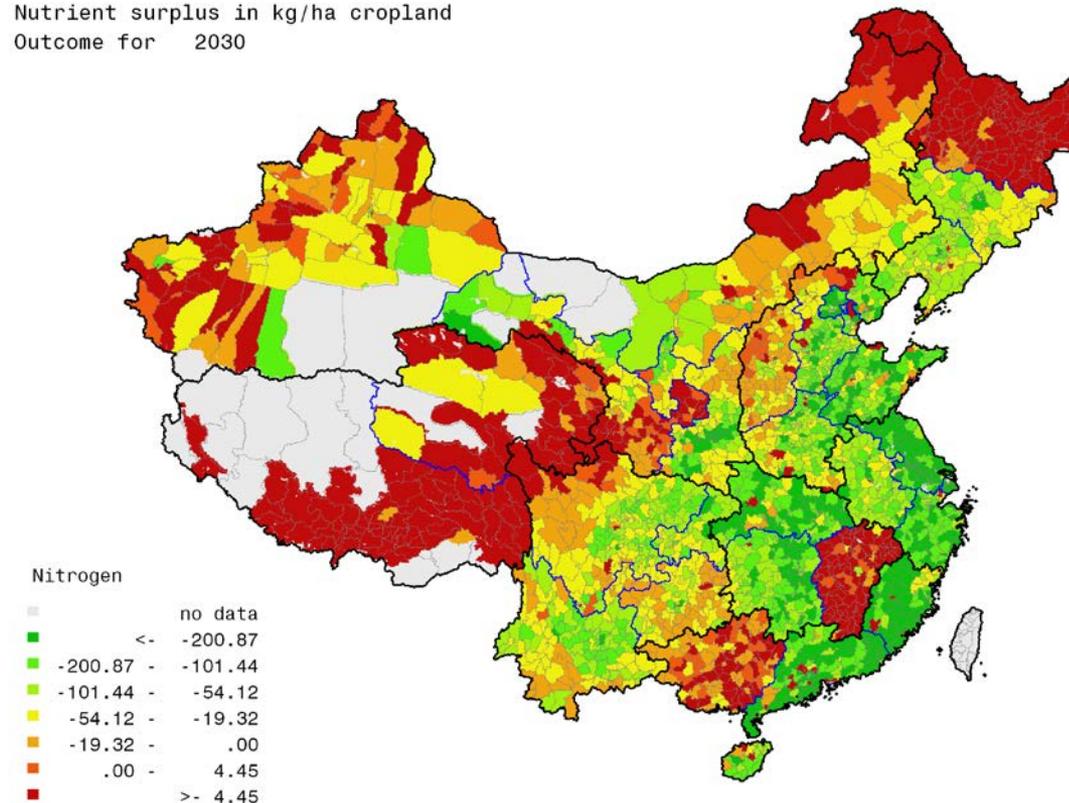
Welfare simulation (6): difference in 2030 nitrogen surplus between Greenext and Reference

Greenext - Baserun

Absolute difference

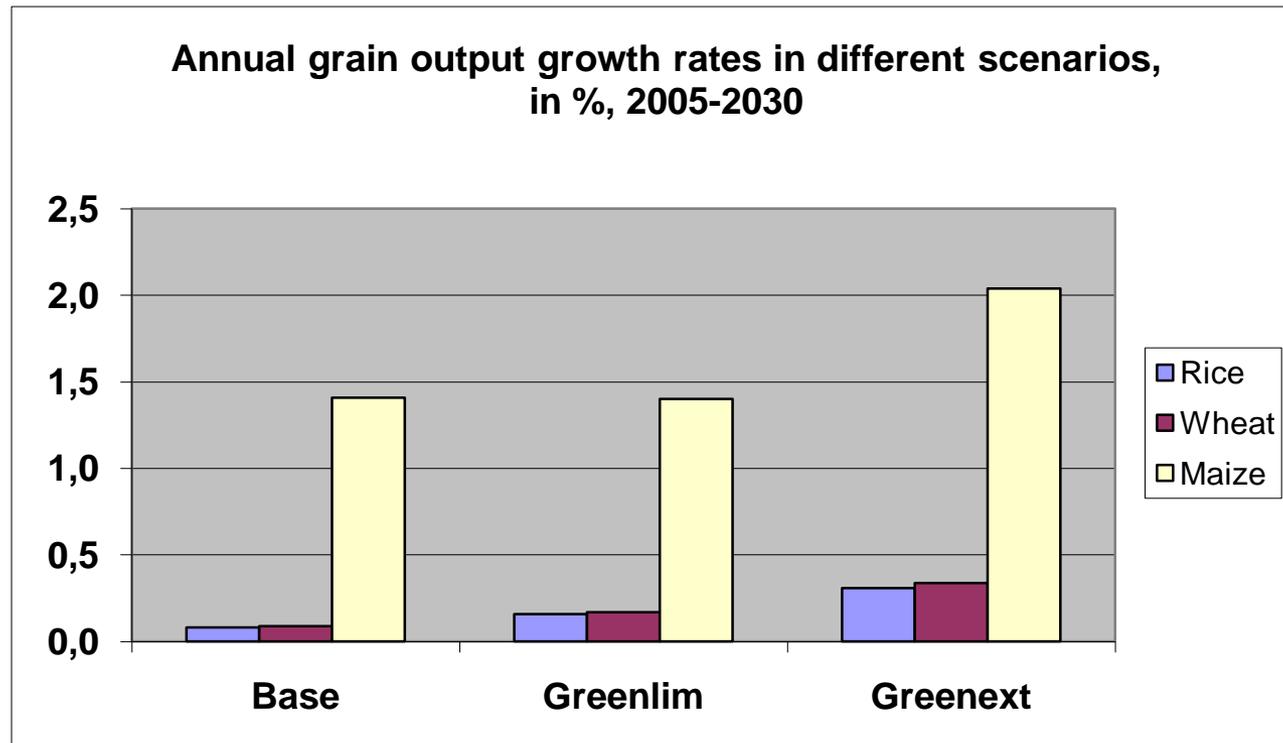
Nutrient surplus in kg/ha cropland

Outcome for 2030



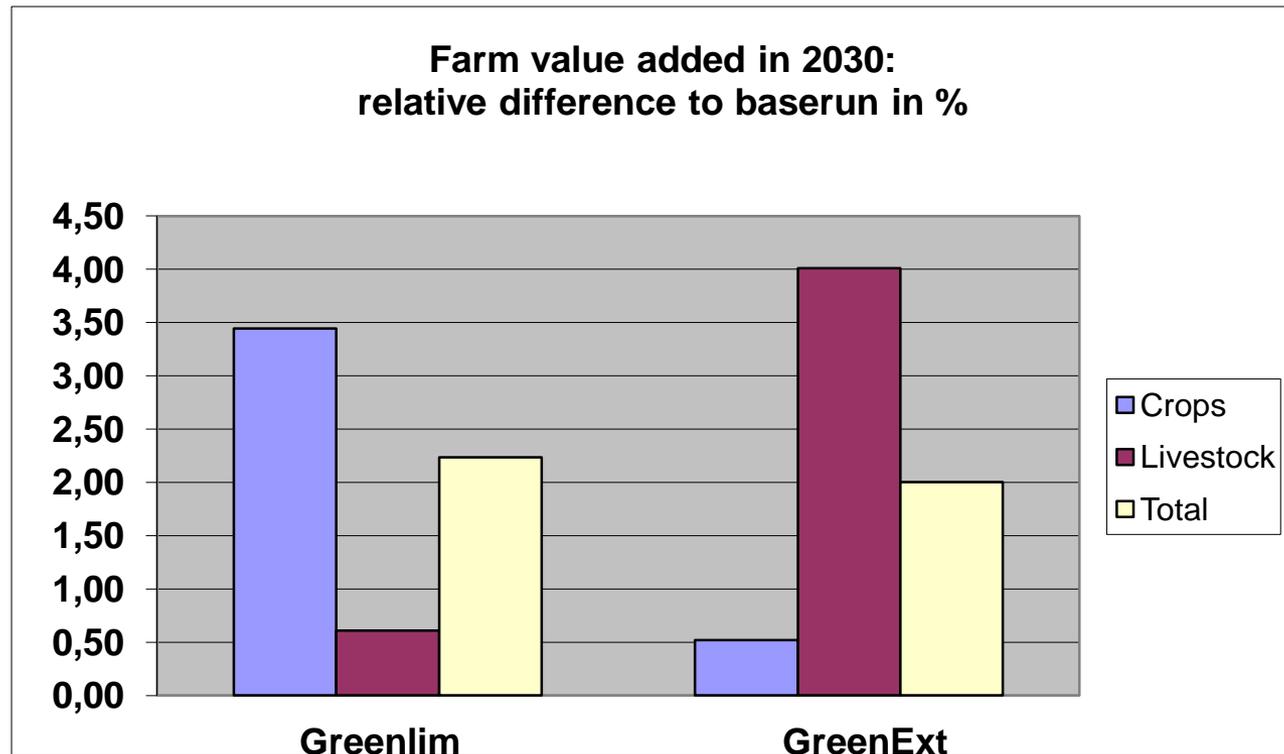
Improvements almost throughout China

Welfare simulation (7): outcomes grain production



No problems with grain supply

Welfare simulation (8): farm incomes in 2030 compared to reference scenario



Slight improvements but no boost to farm incomes



Message from the study

Drastic reductions of nitrogen and phosphate surpluses can be obtained without harming food security and farm incomes, provided that

- a) farmers improve their fertilizer management**
- b) the fertilizer industry offers more variety and produces cleaner.**

As such this message is not new or surprising but apparently it must be repeated again and again!