Impact of increasing feed, meat and biofuel demand on China's agriculture and environment:

Simulations of regional effects through 2030

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Outline

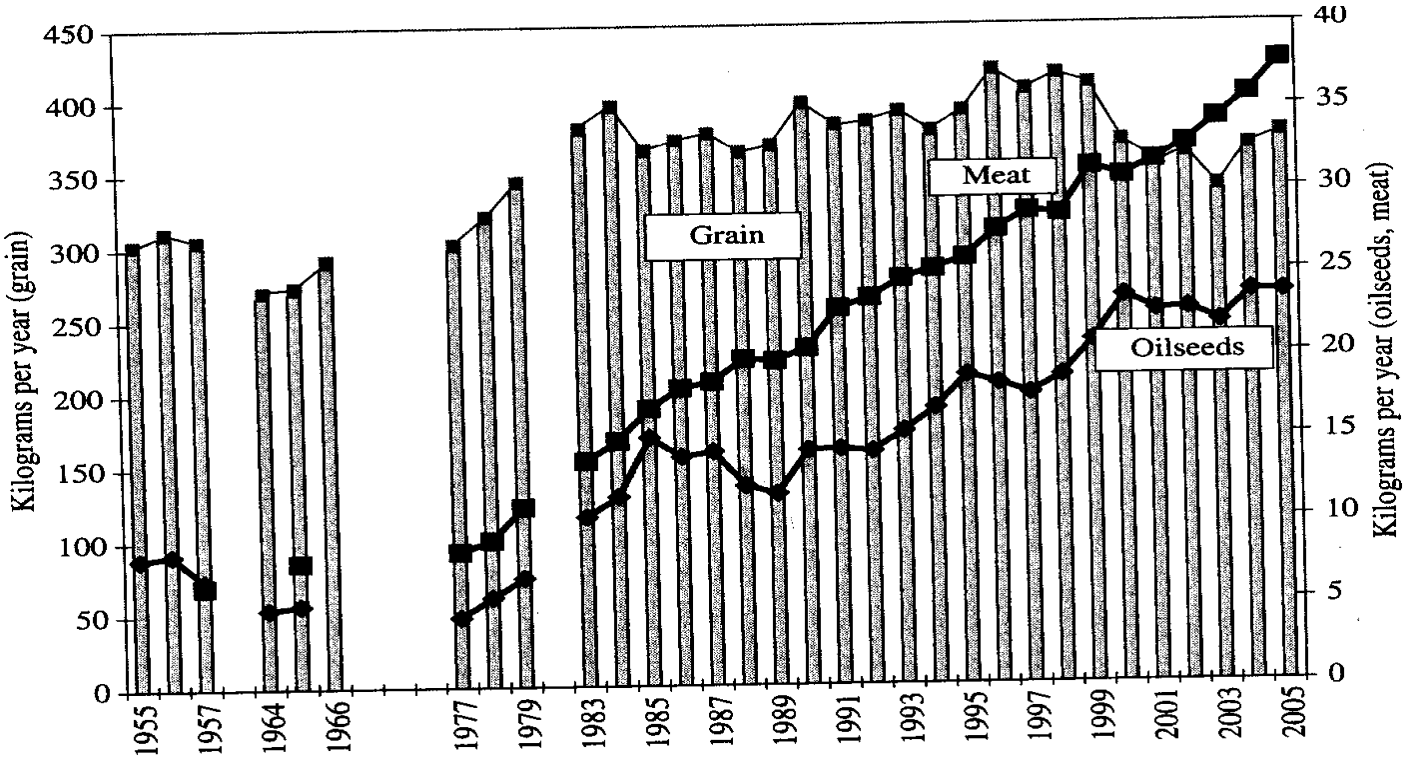
- Background
- Chinese agriculture today
- An overview of the Chinagro model.
- Baseline simulation through 2030, with emphasis on: foreign trade (food, feed), on-farm income, & environmental pressure
- Alternative scenario simulations: High world price, high livestock production, biofuel demand (work in progress)
- Spatial livestock production planning under risks and uncertainties (scenarios on livestock allocation)
- Concluding remarks.

1. Background

- Chinagro: “Policy decision support for sustainable adaptation of China’s agricultural to globalization”. EU 5th Framework “International Scientific Cooperation Project (INCO)”, from Oct 2001 to January 2005.
- Bridging fund by Dutch government & the CAS project on “Human Activities & Changes of Terrestrial Ecosystems in China.”
- Catsei: “Chinese agricultural transition: Trade, social and environmental impacts”. EU 6th Framework “Special Targeted Research Project (STRP), from January 2007 to December 2009.
- It is regarded by peers as an extraordinary success to win two EU FP5 and FP6 projects in sequence. It is an award to the continuous and fruitful collaborations between CCAP and IGSNRR on the China side and IIASA, SOW-VU, and SOAS in the Europe side (IFPRI in Washington DC and LEI in the Hague join the Catsei Project).

2. Chinese agriculture today

Figure 1. Agricultural output per capita, 1955-2005



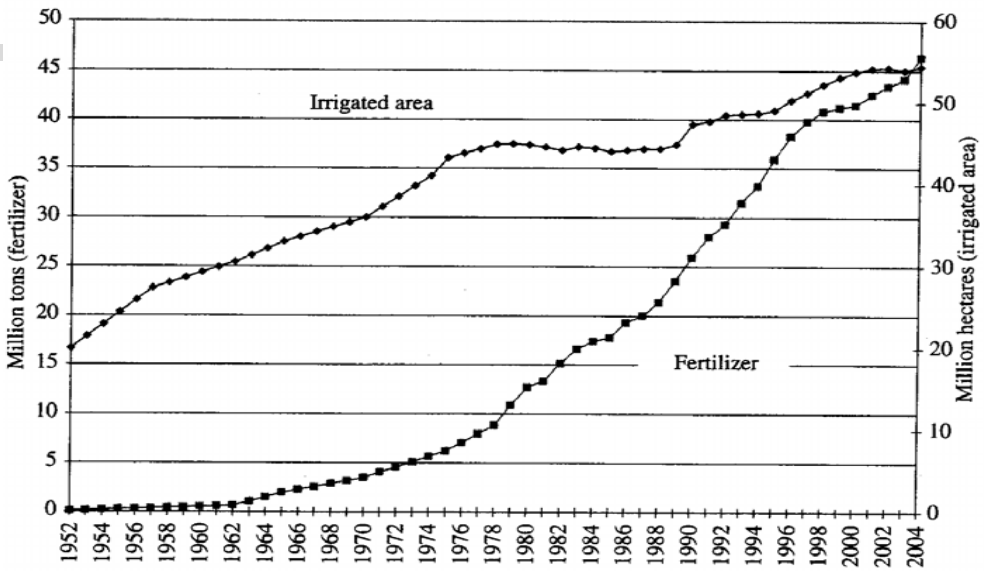
Source: Naughton (2007) compiles from *Statistical Yearbook of China* (various years).

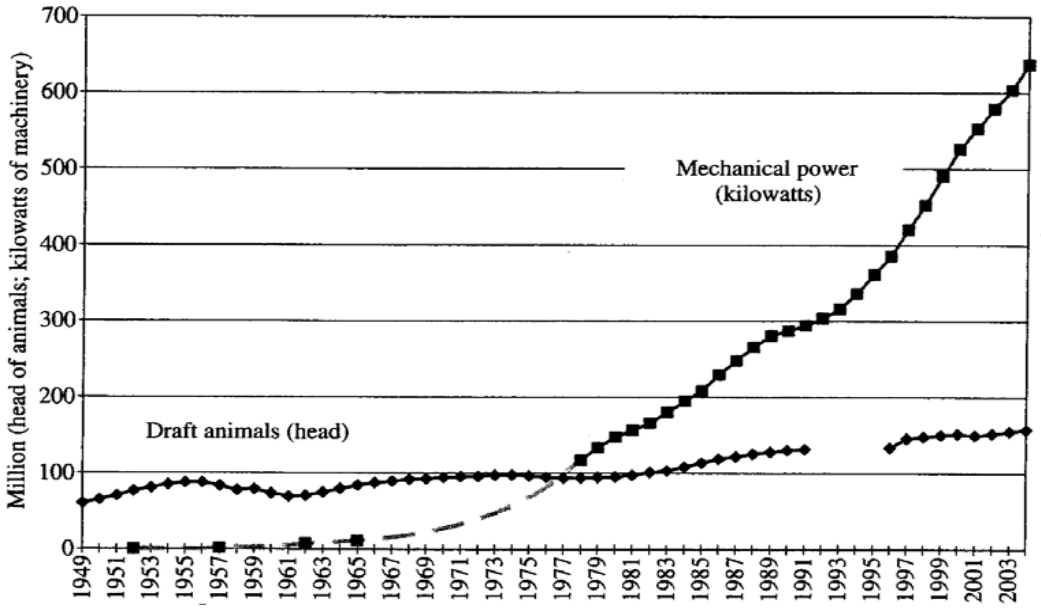
Note: Meat production is carcass weight, total production of pork, mutton, and beef. Official meat production data are adjusted downward in accord with the procedure in Ma, Huang, and Rozelle (2004).

Reference: Naughton, Barry (2007), *The Chinese Economy: Transitions and Growth*. MIT Press.

2. Chinese agriculture today

Figure 2. Fertilizer use, irrigation, and mechanical power





Source: Naughton (2007) compiles from *Statistical Yearbook of China* (various years).

Reference: Naughton, Barry (2007), *The Chinese Economy: Transitions and Growth*. MIT Press.

2. Chinese agriculture today

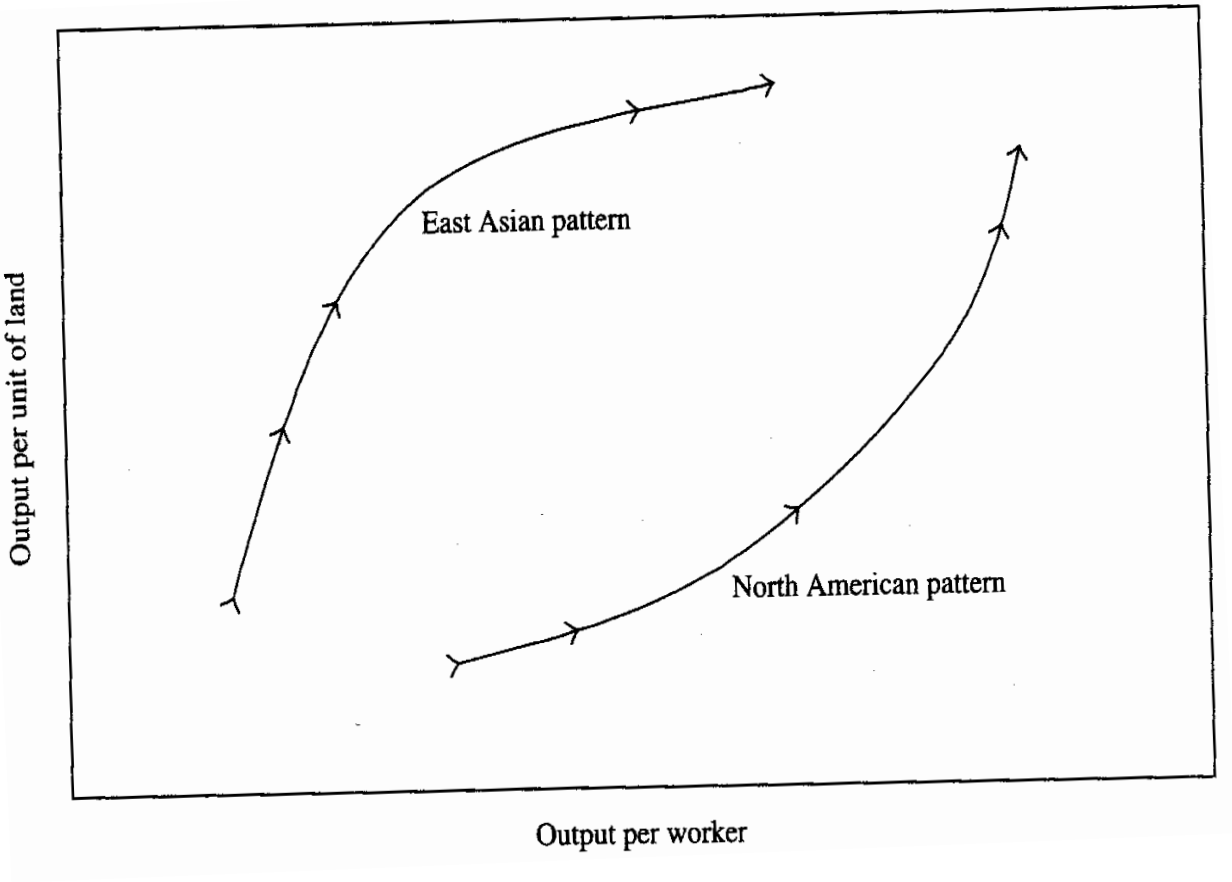
Table 1. Comparison of yields & inputs, 1997

	Unit	China	World	United States
Production per hectare				
Rice, paddy	Tons	6.2	3.9	7.0
Wheat	Tons	3.7	2.7	2.8
Corn	Tons	4.6	4.3	8.6
Soybeans	Tons	1.7	2.2	2.6
Fertilizer use per hectare	Kilograms	271	94	111
Farm worker per 100 hectare	Number	310	82	2
Land irigated	Percent	40	18	13
Tractor per 1,000 hectare	Number	7	18	27

Source: Naughton (2007) cites Gale (2002) “China at a glance: A statistical overview of China’s food and agriculture,” in USDA (2002), *China’s Food and Agriculture: Issues for the 21st Century*.

2. Chinese agriculture today

Fig 3. The different path of agricultural innovation in East Asia and North America



Reference: Naughton, Barry (2007), *The Chinese Economy: Transitions and Growth*. MIT Press.

3. An overview of the Chinagro model

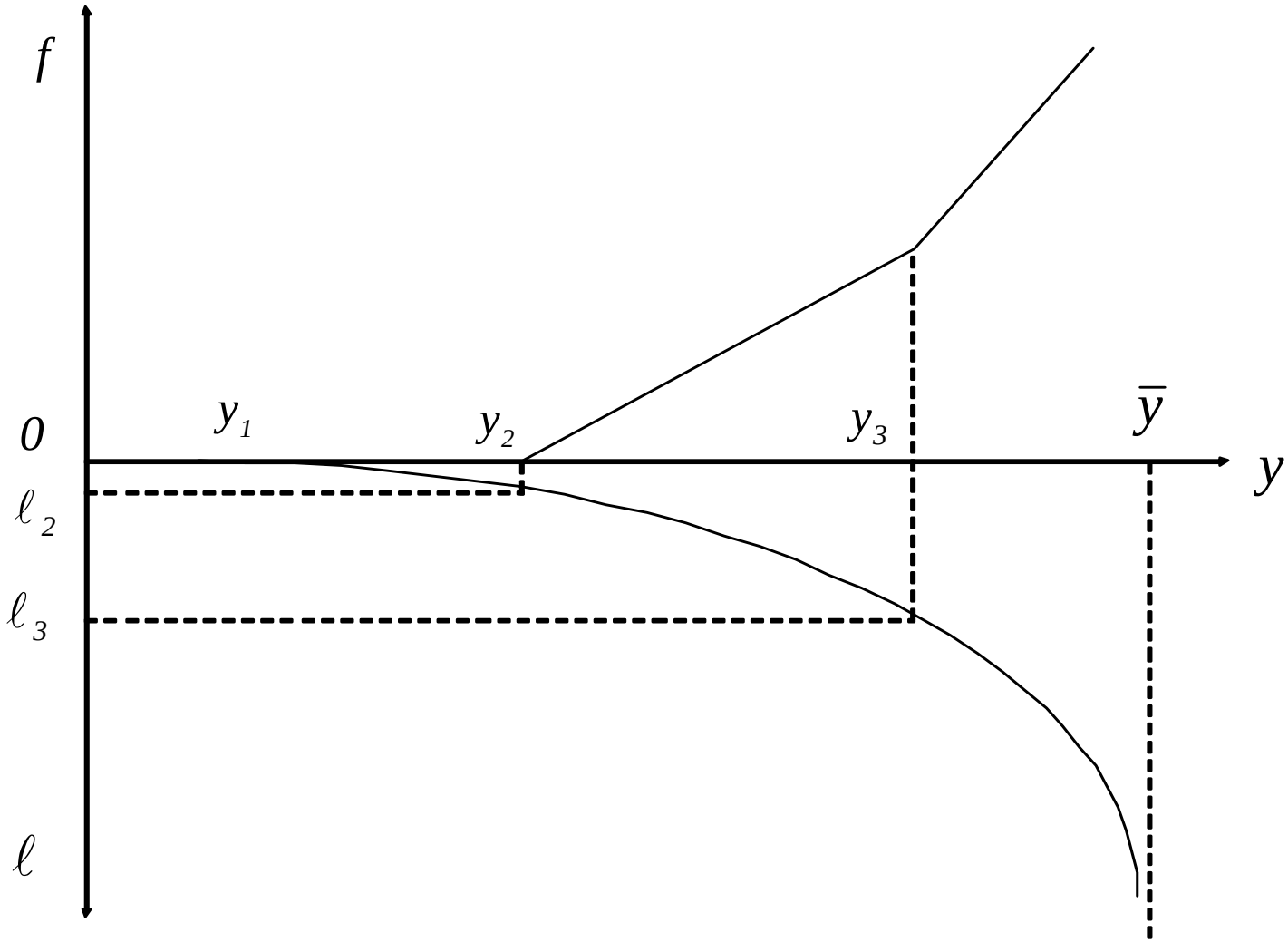
- General equilibrium model: consumers, producers, markets
- Focus on agriculture (non-agriculture largely exogenous)
- Supply at county level (2433)
- Demand at region level (8), with 3 urban and 3 rural classes
- Tradable and local commodities
- Market clearing for each tradable commodity (flows across regions and from/to abroad)

3. An overview of Chinagro model

Farm sector:

- Specified at county level
- 3 cropping types and 6 livestock systems, each with several activities
- Production function with two branches: one with labor input, and one with feed or fertilizer input (Fig. 5)
- Local and tradable inputs
- Land and livestock resources exogenous
- Endogenous labor shifts across land use types
- Maximization of net profits at given market prices

3. An overview of Chinagro model



3. An overview of Chinagro model

- Base-year 1997 (‘complete’ data collection)
- Validation in 2003 (‘replicate’ economy of 2003)
- Scenario simulations for selected years (2010, 2020, 2030)
- Scenarios are driven by a coherent set of exogenous driving variables

4. Base scenario: main driving forces

- Sustained high non-agricultural growth (6-7.5%)
- Moderate population growth (to 1460 million)
- Further urbanization (to 60 %)
- Hence, large demand increases for meat (almost doubling) and dairy (more than tripling)

- Loss of crop land (7 million ha), especially rainfed
- Further intensification of livestock sector
- Continued technical progress (0.5 - 1.0 % per year)

- Continued trade liberalization (tariffs and non-tariff barriers)
- Farm taxes abolished, and grain support introduced

- World agricultural prices derived from FAO-OECD projections

4. Baseline simulation results: trade (1)

Main imports 2030

Meat	Million ton	Share of domestic demand	Reference: world trade level, 2004 million ton
Beef, mutton	0.0	0 %	10.0
Pork	1.4	2 %	7.7
Poultry meat	0.7	4 %	10.3
Feed			
Maize	16.6	12 %	85.1
Carbohydrate feed	19.7	19 %	40.6
Protein feed	43.5	38 %	151.1

- → Feed import not excessive for China
- → but significant for world market and F4

4. Baseline simulation results: trade (2)

Main exports

Base, 2030

	Million ton	Supply share
Rice	3.7	2.8 %
Wheat	1.8	2.2 %
Vegetables	13.0	4.7 %
Fruits	4.9	6.3 %

- → Export potential for, especially, fruits and vegetables
- → Yet, this is an aggregate, absorption capacity specific markets needs to be studied
  - case studies CATSEI on market chain

4. Baseline simulation results: social

Can on-farm incomes follow non-agricultural earnings?

- Annual increases in value added from farming, per manyear:

cropping	3.7 %
livestock	4.6 %
all farming	4.1 %

- These are strong but fall behind rise in per capita non-agricultural incomes (6 to 7 % per year)

→ Confirming present concerns about urban-rural income distribution
  - especially because these agricultural growth rates differ strongly across regions
    - and land balances (+environmental pressure) point to supply constraints
    - no solution without rural based industrialization

4. Baseline simulation results: environment (1)

- Danger from fertilizer losses and unused manure surpluses?

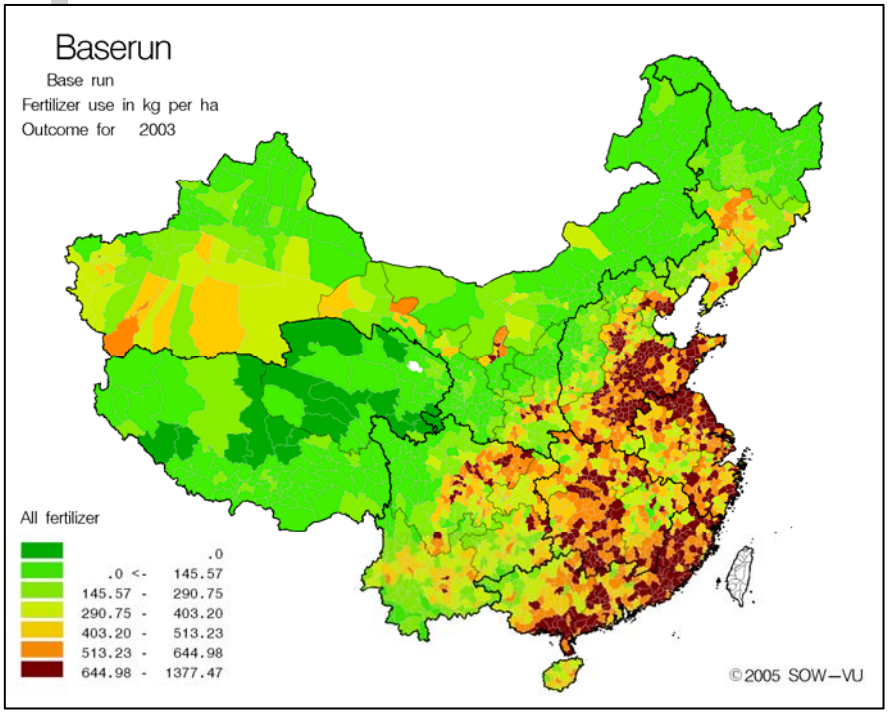
- In 2003:
- Fertilizer application quite high: on average 330 kg chemical and 70 kg organic nutrient per ha
- Manure supply of confined livestock about 33 kg nutrient per ha agricultural land (incl. pasture)

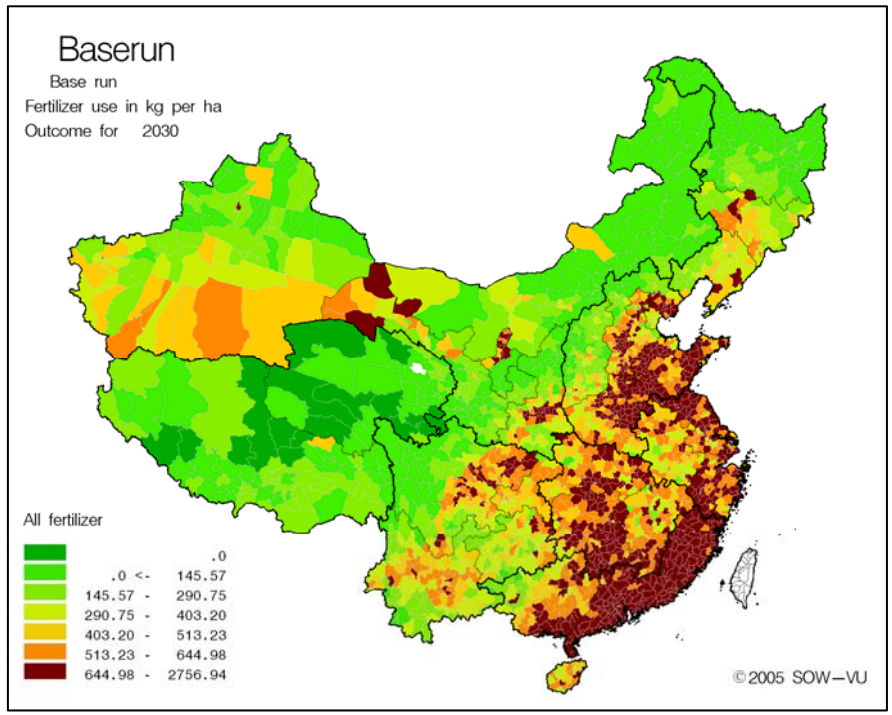
- Increases until 2030 (Figure 6)
- As such moderate overall but highest in areas with largest pressure

→ confirms serious concerns (Section 7).

4. Baseline simulation results: environment (2)

Figure 6. Fertilizer use in kg/ha, 2003 and 2030





5. High world price scenario: specification

This scenario studies how China's meat and feed imports would respond to high world prices

Reasons: F4!

- OECD-FAO takes about half of biofuel mandates to be met from non Generation 1 source (not so sure what this would be)
- Chinagro Baseline implies higher demand than assumed by OECD-FAO

Different from Base after 2010 for world prices:

- World prices of meat, maize and carbohydrate feed:
- 20% higher in 2030
- World prices other agricultural commodities:
- 10% higher in 2030

For imported and exported commodities, price changes are fully transmitted to farmers

- Enhanced Chinagro model will be more flexible in this respect

5. High world price simulation: foreign trade

Meat	Baseline	High world price	Reference 2004 World trade
Beef, mutton	0.0	0.0	10.0
Pork	1.4	0.0	7.7
Poultry meat	0.7	0.0	10.3
Feed imports			
Maize	16.6	8.6	85.1
Carbohydrate feed	19.7	18.2	40.6
Protein feed	43.5	42.8	151.1

- All meat in autarky (imports disappear)
- Feed imports less, but only maize strong reaction

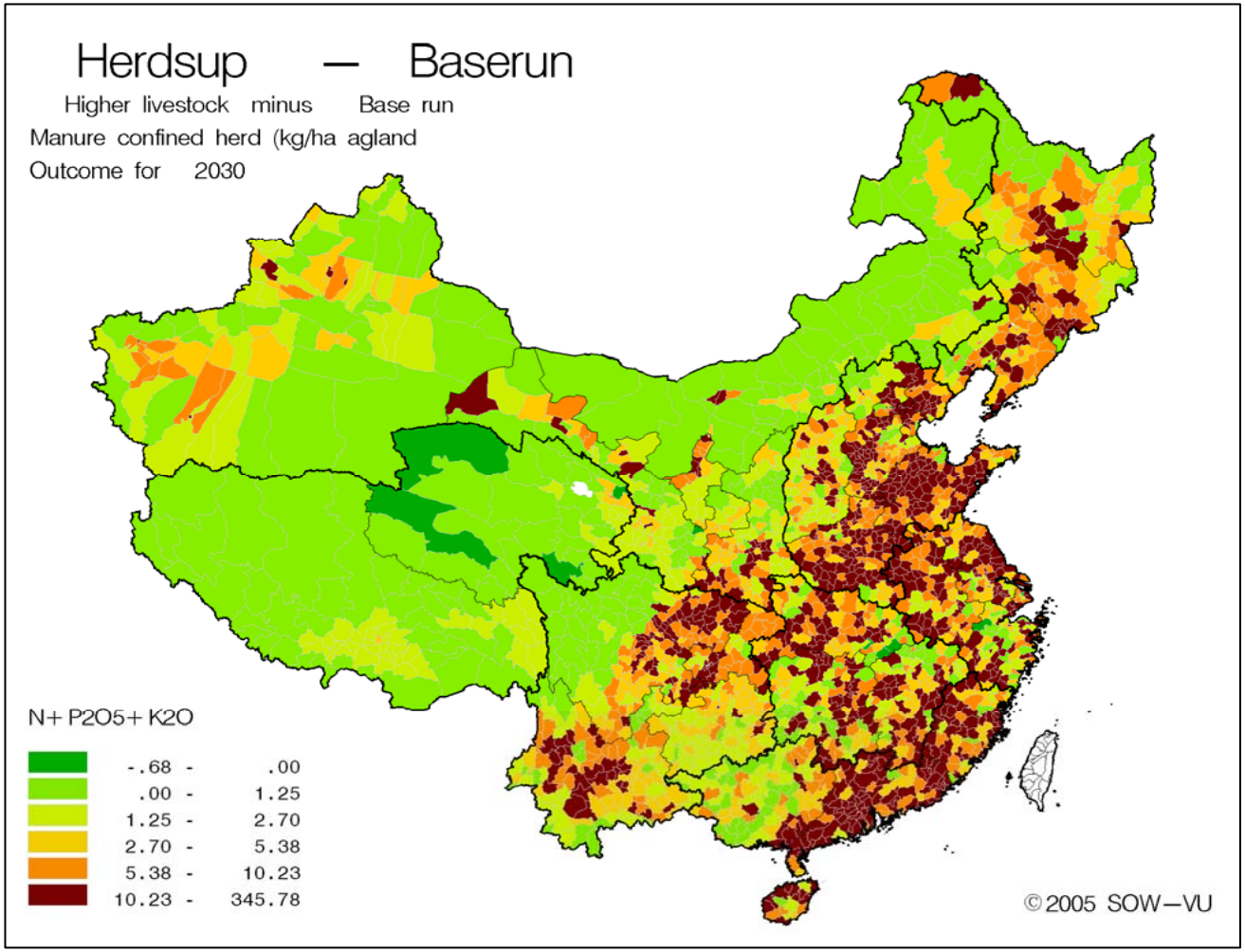
5. High world price simulation: impacts within China

In 2030, as compared to baseline:

- Agricultural trade deficit substantially lower
- Gains for crop farmers
- Livestock farmers have mixed results, because the feedcosts are higher and higher meat prices cannot compensate for this in all counties
- Average growth of farm earnings per manyear now 4.4% instead of 4.1% but still far below non-agriculture
- Environmental pressure changes little (spatially and in time)

- Losses for consumers due to higher prices:
  - Domestic supply does not respond fully
  - **Annual meat intake 2 kg per person lower**

6. High livestock: effects on manure discharge



Green counties are below the national average

6. High livestock scenario: evaluation

Issue:

would it be better to produce more meat inside China?

Answer not simple:

- trade-off between consumption and environmental pressure
- in addition, complicated effects on regional income distribution

7. Scenarios on livestock production allocation

S1. Demand Driving Scenario: Production increase in locations is proportional to ***demand potential*** ("gravity model" in trade theory).

S2. Sustainable Scenario: trade-off between pure economic efficiency and environmental risks:

- ✓ Socioeconomic, demographic, environmental risk and sustainability indicators and constraints reflect location-specific conditions and limitations (e.g. water and land scarcity, livestock density, urbanization level).
- ✓ Allocation of livestock beyond specified constraints may lead to disastrous consequences related to water and air pollution, Increasing chances of livestock disease outbreaks, threats to human health, which may incur high costs.

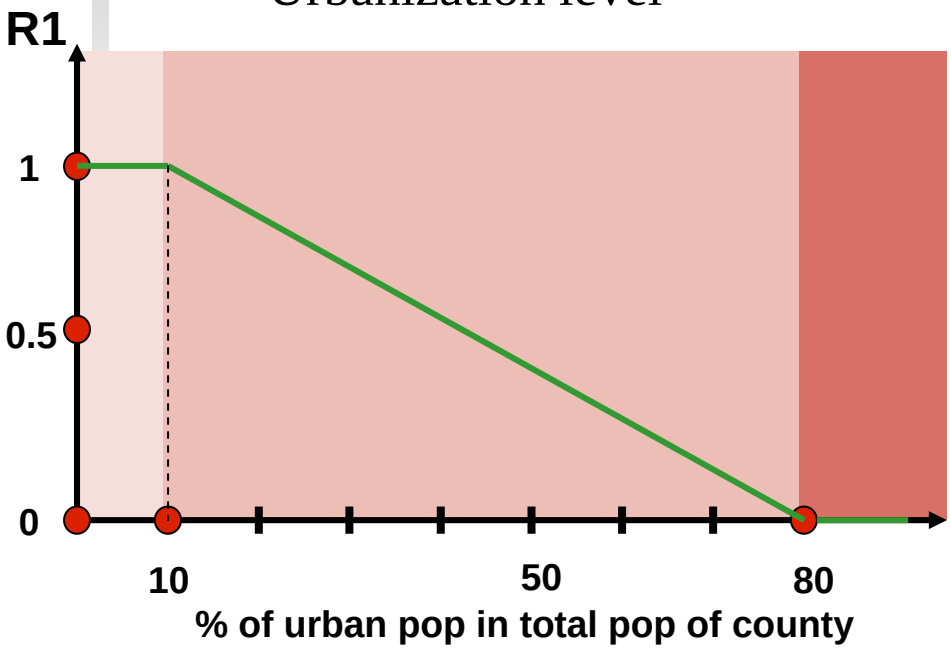
- ✓ The indicators and constraints are treated within priors or as explicit constraints/goals.
- ✓ Individual "weights" of indicators/constraints reflect the critical trade-offs, limitations and goals in locations.

7. Scenarios on livestock production allocation

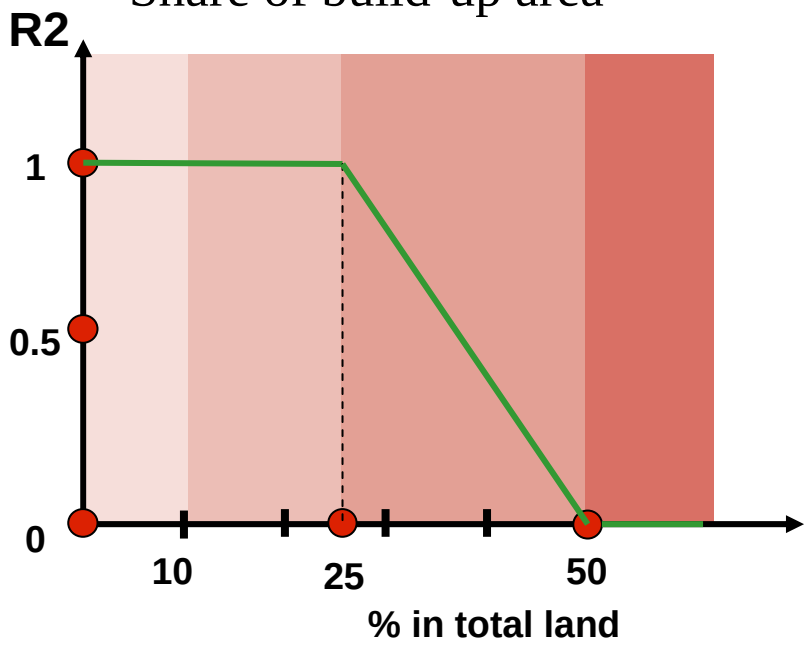
"Riskiness" of a location is determined by indicators and constraints.

This type of risk definition is often applied in environmental studies to define ambient standards

Urbanization level

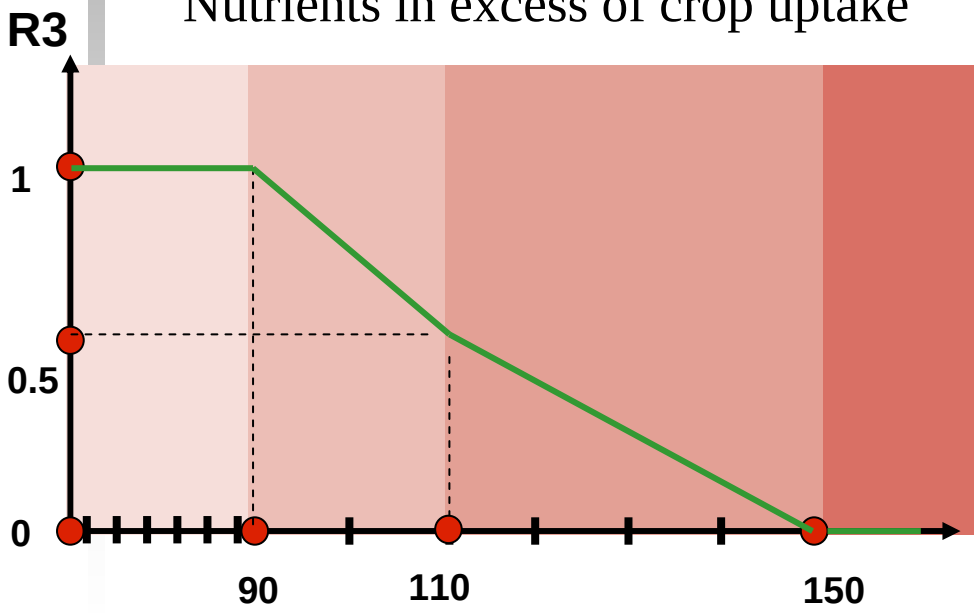


Share of build-up area



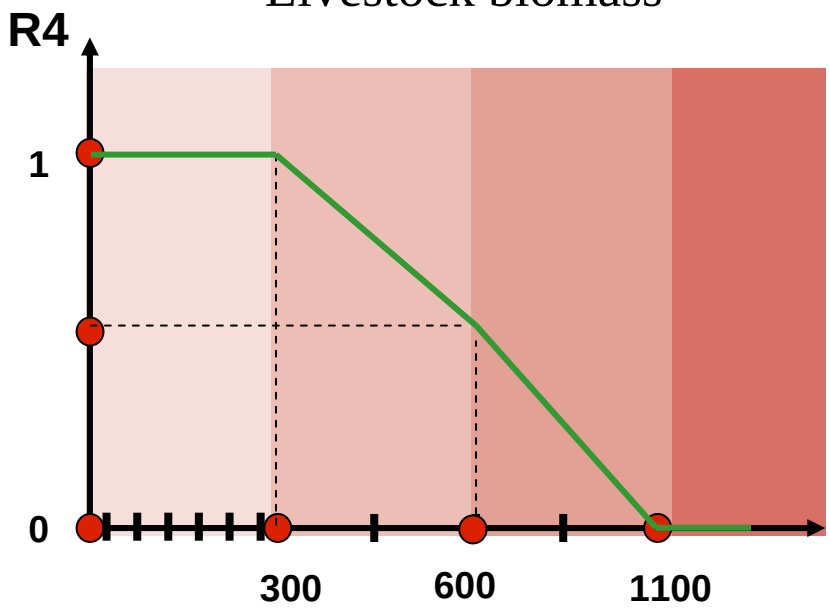
7. Scenarios on livestock production allocation

Nutrients in excess of crop uptake



Ratio of nutrients supply to crop nutrients uptake

Livestock biomass



kg animals biomass / ha cultivated land

Compound risk indicator: $\mathbf{R = max(R1, R2) \times min\ (R3, R4)}$

7. Scenarios on livestock production allocation

A comparison of two scenarios w. r. t. number of people in China's regions exposed to different categories of environmental risks

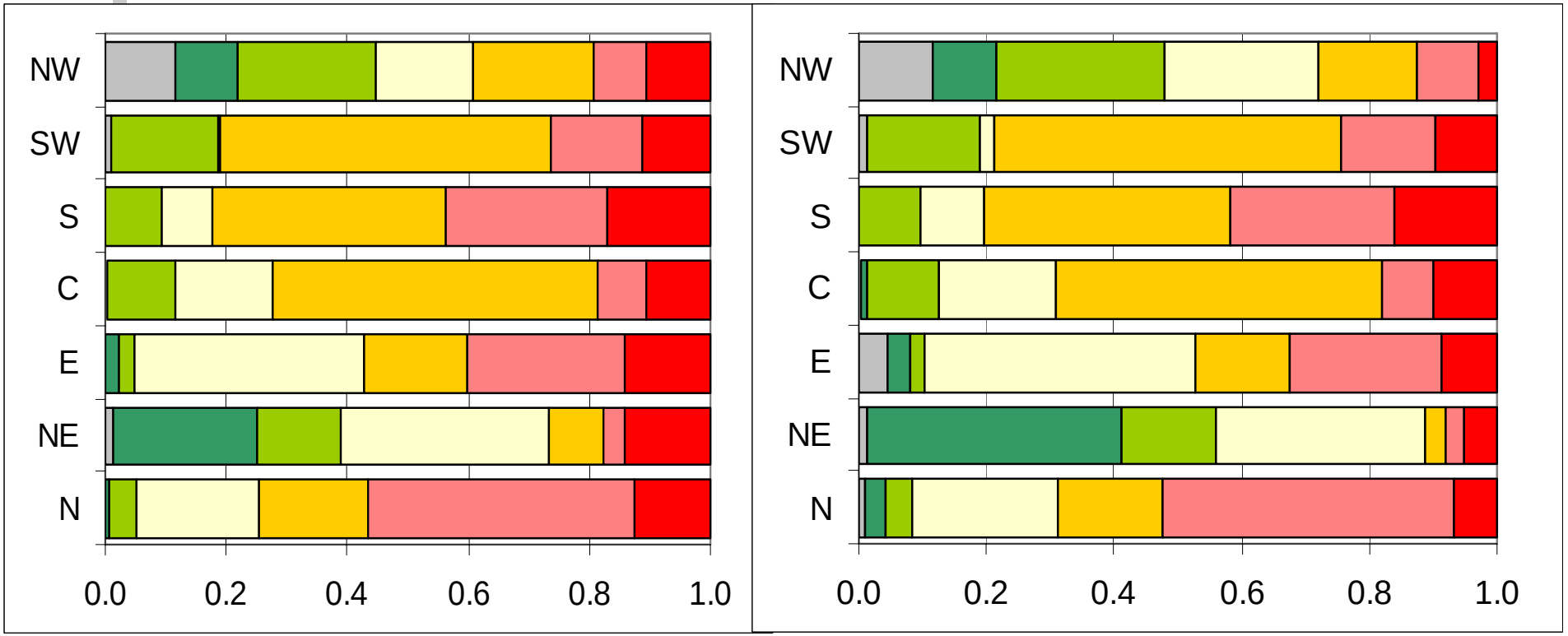


Figure 8. Relative distribution of population according to classes of severity of environmental pressure from livestock production in 2030: (a) demand driving scenario, (b) environmentally friendly scenario.

8. Concluding Remarks

- Intensified livestock system will play the leading role in meeting the increased demand for meat in the future. Pig, broiler and layer stock in intensified systems are expected to increase at least 2.5 times between 2000 and 2030.
- The “business as usual” scenario suggests a high correlation between geographic distribution of animals and population density. This may imply serious environmental problems caused by unused animal manure and losses in the application of fertilizer, especially in densely populated areas.
- We suggest a practical method for spatially explicit planning of production levels in given locations, which is based on a rebalancing algorithm and takes into account “weighted” combinations of criteria for sustainable livestock-production allocation and intensification.
- The research highlights the urgent demand for technological breakthrough in manure management (3rd generation of bio-fuel technology?).

Thank you for your attention