Nutrient management challenges of China

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UK China Sustainable Agriculture Innovation Network (SAIN)

Global Partnership on Nutrient Management (GPNM)
Outline

Overview of China’s agriculture and food security

Nutrients management: emerging challenges

Possible solutions for the future
Outline

Overview of China’s agriculture and food security

Nutrients management: emerging challenges

Possible solutions for the future
China’s Agriculture & Food Security – A success story

Grain production
(million ton)

Meat production
(million ton)
China’s Agriculture & Food Security – A success story

Grain per capita (kg)

Meat per capita (kg)
China’s Agriculture & Food Security – A success story

Number of undernourished persons (millions)

**World**

- 1995: 820
- 2000: 840
- 2005: 860

**China**

- 1995: 140
- 2000: 130
- 2005: 120

**Developing countries**

- 1995: 810
- 2000: 830
- 2004: 850

**Developed countries**

- 1995-1997: 20
- 2000-2002: 15
- 2004-2006: 10
Pollutants from China’s agricultural production

discharged into water systems

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>13.2 Mt</td>
<td>44% of nation total</td>
</tr>
<tr>
<td>Total N</td>
<td>2.7 Mt</td>
<td>57% of nation total</td>
</tr>
<tr>
<td>Total P</td>
<td>0.3 Mt</td>
<td>67% of nation total</td>
</tr>
</tbody>
</table>

from crop cultivation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N</td>
<td>1.6 Mt</td>
<td>59% of agriculture</td>
</tr>
<tr>
<td>Total P</td>
<td>0.1 Mt</td>
<td>38% of agriculture</td>
</tr>
</tbody>
</table>

from livestock

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>12.9 Mt</td>
<td>96% of agriculture</td>
</tr>
<tr>
<td>Total N</td>
<td>1.0 Mt</td>
<td>38% of agriculture</td>
</tr>
<tr>
<td>Total P</td>
<td>0.2 Mt</td>
<td>56% of agriculture</td>
</tr>
</tbody>
</table>

National pollution survey, 2010
China agriculture’s contribution to the economy and the environment

- **Staple grain self-sufficiency**
- **GDP**
- **Employment**
- **Total P**
- **Total N**
- **COD**
- **GHG**

<table>
<thead>
<tr>
<th>Metric</th>
<th>0%</th>
<th>20%</th>
<th>40%</th>
<th>60%</th>
<th>80%</th>
<th>100%</th>
</tr>
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<tbody>
<tr>
<td>Staple grain self-sufficiency</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment</td>
<td>40%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>Total N</td>
<td></td>
<td></td>
<td></td>
<td>60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40%</td>
</tr>
<tr>
<td>GHG</td>
<td></td>
<td></td>
<td>20%</td>
<td></td>
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</tr>
</tbody>
</table>
Grain production, synthetic nitrogen fertilizer inputs and cropped area 1978-2007
# Fertilizer N “overshoot”

<table>
<thead>
<tr>
<th>Crop</th>
<th>Optimum for region</th>
<th>Farmers average</th>
<th>Excess %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rice</strong> (Taihu)</td>
<td>200</td>
<td>300</td>
<td>50</td>
</tr>
<tr>
<td><strong>Wheat</strong> (Taihu)</td>
<td>153</td>
<td>250</td>
<td>63</td>
</tr>
<tr>
<td><strong>Wheat</strong> (NCP)</td>
<td>128</td>
<td>325</td>
<td>154</td>
</tr>
<tr>
<td><strong>Maize</strong> (NCP)</td>
<td>158</td>
<td>263</td>
<td>66</td>
</tr>
</tbody>
</table>

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

Overview of China’s agriculture and food security

Nutrients management: emerging challenges

Possible solutions for the future
Nutrient management emerging challenges: food demand

**Grain**
- 2007: 40 mt (8%+)
- 2020: 540 mt

**Meat**
- 2007: 10 mt (15%+)
- 2020: 80 mt

NDRC, 2008, Mid-long term food security plan
Nutrient management emerging challenges: food demand

The long-term decline in population growth rate

The chart shows the long-term decline in population growth rate from 1970 to 2030. The population growth rate has significantly decreased over time, with the highest growth rate observed in 1970 and the lowest in 2030.
Nutrient management emerging challenges: food demand

Change in Consumption pattern

Per capita grain consumption (kg/person)
Nutrient management emerging challenges: food demand

Change in Consumption pattern

Per capita non-staple consumption (kg per year)
Nutrient management emerging challenges: food demand

Change in sown areas of various crops (1980 as 100)
Nutrient management emerging challenges: food demand

Fertilizer consumption by crops during 1998–2008

<table>
<thead>
<tr>
<th>Year</th>
<th>Grain</th>
<th>Economic crops</th>
<th>Vegetable</th>
<th>Tea and fruits</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mt</td>
<td>%</td>
<td>Mt</td>
<td>%</td>
<td>Mt</td>
</tr>
<tr>
<td>1998</td>
<td>26.76</td>
<td>71.0</td>
<td>4.22</td>
<td>11.2</td>
<td>3.64</td>
</tr>
<tr>
<td>2008</td>
<td>28.72</td>
<td>57.8</td>
<td>5.66</td>
<td>11.4</td>
<td>9.41</td>
</tr>
</tbody>
</table>
Nutrient management emerging challenges: food demand

Contribution to increased fertilizer use in 1998-2008, (%)
Nutrient management emerging challenges: food demand

Livestock numbers in China

Since 2007, there are some changes in Statistical Definition.
Nutrient management emerging challenges: food demand

Manure generation in China
Nutrient management emerging challenges: food demand

Management of manures in China

• 3060 million tonnes (fresh weight) of livestock manure was generated in China in 2010.
  • The N, P2O5 and K2O content *ca. 14 million, 10.2 million and 12.0 million tonnes*, which worth *ca. 201,300M RMB*;
• Manure is commonly over-applied to horticultural crops, particularly greenhouse vegetables and fruit, which causes negative environmental impacts;
• The barriers for effective management of manure, compost and digestate include lack of labour to transport and apply to the field; lack of knowledge of the nutrient content and availability; and inadequate labelling of e.g. composted manure products;
Shrinking of China’s arable land (million ha)

Nutrient management emerging challenges: urbanisation
Nutrient management emerging challenges: urbanisation

Labour – lack of skilled and aging
Nutrient management emerging challenges: urbanisation

Rural urban labour migration

Change in Urban and Rural Population

Migrant Workers (million)

- Urban population %
- Rural population %
Nutrient management emerging challenges: urbanisation

Age of rural labours and migration workers

![Bar chart showing the age distribution of rural labour and migration workers.](chart.png)
Nutrient management emerging challenges: urbanisation

Rural income composition

Household Income and distribution (yuan, %)

<table>
<thead>
<tr>
<th>Dryland wheat system</th>
<th>Average</th>
<th>1st quartile</th>
<th>2nd quartile</th>
<th>3rd quartile</th>
<th>4th quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total income</td>
<td>9728</td>
<td>1664</td>
<td>6489</td>
<td>10442</td>
<td>20260</td>
</tr>
<tr>
<td>share of crop income</td>
<td>15</td>
<td>33</td>
<td>14</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>
Nutrient management emerging challenges: environmental goal

Towards resource efficiency & climate smart agriculture

By 2015, compared with 2010

• Agricultural COD reduced by 8%
• Ammonia nitrogen emission reduced by 10%;
• Fertilizer use efficiency increased by 3%
• Over 50% of intensive livestock farm or livestock raising community equipped with waste treatment facilities

MoA, 12th FYP
Outline

Overview of China’s agriculture and food security

Nutrients management: emerging challenges

Possible solutions for the future
Consequences of N overuse - from local to global

Wasted money – reduced net farm income

Soil quality
• Acidification

Water quality (including intl waters)
• Drinking water nitrate limit
• Eutrophication and algal blooms (with P)

Climate change
- N2O – powerful GHG,
- CO2 from N fertilizer manufacture
What can be done?  

*Not just technical advice!*

- Many/most farmers now part-time
- Non-farm work is more profitable & takes priority – so classic advisory approaches ineffective
- Labour shortage at key times
- Policies, financial incentives or regulation required to change behaviour
Example 1

**Increase N use efficiency**
**Decrease N losses**

**Barriers:**
- Machinery cost
- Labour shortage

- **Sub-surface N application**
  - new machinery
  - ammonia loss greatly decreased
- **Improved timing**
  - not all at planting time

**Policy decisions**
- Policies
- Financial incentives

**Improved training opportunities**

**Professional service providers (contractors)**
- Farmer cooperation
Example 2

- Increase N use efficiency
- Decrease N losses

- **N inhibitors**
  - increase N use efficiency by crop where timing of application is incorrect
  - decrease emissions to environment

- **Slow release fertilizers**
  - alternative to correct timing

**Barrier:**
- Increased cost

Policy decisions

- Change fertilizer subsidies
  - Subsidise increased cost *instead* of general fertilizer subsidies
<table>
<thead>
<tr>
<th>Outcome</th>
<th>Method of achieving</th>
<th>Policies required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased N applications</td>
<td>More effective information delivery to farmers</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Professional service providers promoted</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Fertilizer suppliers required to provide technical information &amp; training</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Consider regulatory approaches</td>
<td>✓</td>
</tr>
<tr>
<td>Change timing of N applications</td>
<td>Professional service providers</td>
<td>✓</td>
</tr>
<tr>
<td>Sub-surface placement</td>
<td>New machines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Professional service providers</td>
<td>✓</td>
</tr>
<tr>
<td>N inhibitors</td>
<td>Change subsidies – cover <em>extra</em> cost instead of basic cost of manufacture</td>
<td>✓</td>
</tr>
</tbody>
</table>
### Summary of recommendations (2 of 2)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Method of achieving</th>
<th>Policies required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycle manures</td>
<td>Continue to promote “organic fertilizers”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Better labelling</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Training</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manure management &amp; recycling included in planning of CAFOs</td>
<td>✓</td>
</tr>
<tr>
<td>Integrated water and nutrient policies, practices &amp; advice</td>
<td>“Fertigation” where appropriate. Subsidies for initial equipment costs.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slow release N</td>
<td>Change subsidies to cover <em>extra</em> cost</td>
<td>✓</td>
</tr>
<tr>
<td>Nitrate-based fertilizers</td>
<td>Fertilizer manufacture changes</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Safety in handling &amp; storage</td>
<td>✓</td>
</tr>
</tbody>
</table>
More details see SAIN Policy Briefs:

No1. Improved Nutrient Management in Agriculture – A Neglected Opportunity for China’s Low Carbon Growth Path

No2. Greater food security and a better environment through improved nitrogen fertilizer management

No5. Policies and technologies to overcome excessive and inefficient use of nitrogen fertilizer: delivering multiple benefits

No6. Improving manure nutrient management towards sustainable intensification in China

http://www.sainonline.org/english.html
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Acknowledgement
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