Fertilizer Consumption Trends in China vs. the Rest of the World

Patrick Heffer, IFA
Population of 1.4 billion → food security is a top priority

Chinese Government supports fertilizer consumption
   → encourages fertilizer production
   → subsidizes fertilizers at different steps

Fastest growing fertilizer market in past decades

Today, accounts for ~30% of global fertilizer use

Average application rate among the highest in the world

Prevalence of hunger halved between 1990-92 and 2014-16

... but environmental side effects
Historical Trend and Current Situation
Fertilizer Consumption (Mt nutrients)

<table>
<thead>
<tr>
<th>Year</th>
<th>China’s consumption</th>
<th>World consumption</th>
<th>China’s share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>1.0</td>
<td>31.7</td>
<td>3%</td>
</tr>
<tr>
<td>2000</td>
<td>34.7</td>
<td>137.0</td>
<td>25%</td>
</tr>
<tr>
<td>2013</td>
<td>52.7</td>
<td>180.8</td>
<td>29%</td>
</tr>
</tbody>
</table>

Source: IFADATA Online
High Application Rate and Unbalanced N:P:K Ratio

Average Application Rate (kg nutrients/ha)

- **China**: 428 kg/ha
- **World**: 115 kg/ha

Source: IFADATA Online + FAOSTAT

N:P₂O₅:K₂O Ratio

- **China**: K₂O: 0.19, P₂O₅: 0.32, N: 1.00
- **World**: K₂O: 0.27, P₂O₅: 0.37, N: 1.00

Source: IFADATA Online
Fertilizer Use by Crop in 2010/11

Source: Heffer, 2013

>30% applied to fruits & vegetables

~50% applied to cereals & oilseeds

9% applied to fruits

66% applied to cereals & oilseeds
China vs. West & Central Europe

Fertilizer Consumption ($Mt$ nutrients)

- Long history of agriculture and soil mining
- Followed by high application rates to rebuild soil fertility
- Positive nutrient balances for long periods
- Followed by plateauing demand
- Contraction in WCE since 1990s largely due to manure recycling

Similarity in trend with WCE 3 decades earlier (red and green areas)

Artifact: drop following collapse of FSU
Typical Evolution of Nitrogen Use Efficiency (NUE) over Time

Different countries are on different points on the curve.

NUE = \frac{N \text{ output}}{\text{Sum of N inputs}}
Patterns of Nitrogen Use Efficiency (NUE) and Surpluses ($N_{sur}$)

Recent Estimates of NUE

<table>
<thead>
<tr>
<th>Source</th>
<th>China</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lassaletta et al., 2014 (for 2009)</td>
<td>28%</td>
<td>47%</td>
</tr>
<tr>
<td>Zhang et al., 2015 (for 2010)</td>
<td>25%</td>
<td>42%</td>
</tr>
</tbody>
</table>

Low NUE in China due to:
- Price incentives (fertilizer-to-crop price ratio)
- Sub-optimal farming practices (extension, mechanization)
- Unique crop mix (fruits and vegetables)
Impact of the Crop Mix on Nitrogen Use Efficiency (NUE)

Source: Zhang et al., 2015

![Graph showing the impact of the crop mix on nitrogen use efficiency (NUE). The graph compares China's record with the USA's record, assuming the same NUE and yield as the USA. The efficiency and crop mix are indicated.]

### Table: Nitrogen Use Efficiency (NUE) by Crop Type

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Harvest N (Tg N yr⁻¹)</th>
<th>Input N (Tg N yr⁻¹)</th>
<th>NUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>13</td>
<td>30</td>
<td>0.42</td>
</tr>
<tr>
<td>Rice</td>
<td>11</td>
<td>29</td>
<td>0.39</td>
</tr>
<tr>
<td>Maize</td>
<td>13</td>
<td>28</td>
<td>0.46</td>
</tr>
<tr>
<td>Other cereal crops</td>
<td>5</td>
<td>9</td>
<td>0.53</td>
</tr>
<tr>
<td>Soybean</td>
<td>16</td>
<td>20</td>
<td>0.80</td>
</tr>
<tr>
<td>Oil palm</td>
<td>1</td>
<td>1</td>
<td>0.46</td>
</tr>
<tr>
<td>Other oil seed</td>
<td>4</td>
<td>10</td>
<td>0.43</td>
</tr>
<tr>
<td>Cotton</td>
<td>2</td>
<td>5</td>
<td>0.37</td>
</tr>
<tr>
<td>Sugar crops</td>
<td>1</td>
<td>5</td>
<td>0.19</td>
</tr>
<tr>
<td>Fruits and vegetables</td>
<td>3</td>
<td>25</td>
<td>0.14</td>
</tr>
<tr>
<td>Other crops</td>
<td>5</td>
<td>11</td>
<td>0.41</td>
</tr>
<tr>
<td>Total</td>
<td>74</td>
<td>174</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Source: Zhang et al., 2015
Adoption of Slow-and Controlled-Release Fertilizers (SCRFs)

Source: IHS, 2015

- Very fast growing market in China since 2007
  ~1.8 Mt of SCRFs (eq ~3.5% of the urea market)
- In addition, ~1 Mt of stabilized fertilizers were used in 2014 in China

Consumption of SCRFs in 2014 (kt products)

Source: IHS, 2015
Medium-Term Prospects
Main Drivers of Medium- and Long-Term Fertilizer Demand in China

- Demographics (population peak towards 2030)
- Robust but progressively decelerating income growth and related diet diversification (livestock products, fruits & vegetables)
- Rising feed imports (soybean and maize)
- Larger amounts of livestock manure available for recycling → virtual fertilizer imports
- Large area planted to fruits and vegetables
- Labour shortage → mechanization → supports BMP adoption
- Fertilizer capping policy
  - *How is it going to be implemented?*
  - *Reinforces trend observed since 2007*
- Agricultural production to grow faster than fertilizer demand → Improved fertilizer use efficiency
Medium-Term Fertilizer Demand Prospects in the Main Markets

- Demand reaches a plateau in China
- Marginal growth in the EU and the US
- More than half of the world market is ‘mature’
- Robust rebound in India
- Steady growth in Brazil
  (Latin America equals North America in 2019/20)
- Firm growth in the ROW
- Africa 4th contributor in volume

Source: IFA Agriculture, 2015
China’s Progressive Move Towards Zero Consumption Growth

China’s Year-on-Year Consumption Changes (%; 3-Year Moving Average)

<table>
<thead>
<tr>
<th>Year</th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>0.6%</td>
<td>0.0%</td>
<td>2.3%</td>
<td>0.7%</td>
</tr>
<tr>
<td>1980</td>
<td>2.1%</td>
<td>3.9%</td>
<td>7.4%</td>
<td>3.0%</td>
</tr>
<tr>
<td>1985</td>
<td>0.3%</td>
<td>0.3%</td>
<td>0.5%</td>
<td>0.3%</td>
</tr>
<tr>
<td>1990</td>
<td>-0.2%</td>
<td>0.6%</td>
<td>1.0%</td>
<td>0.1%</td>
</tr>
<tr>
<td>1995</td>
<td>4.9%</td>
<td>5.2%</td>
<td>8.4%</td>
<td>5.2%</td>
</tr>
<tr>
<td>2000</td>
<td>1.3%</td>
<td>1.8%</td>
<td>2.6%</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

Average annual growth rate between 2012-14 and 2019

Source: IFA Agriculture, 2015
Outlook for Slow-and Controlled-Release and Stabilized Fertilizer Use in China

2014:
- ~1.3 Mt nutrients
- ~2.4% of China’s fertilizer use

2019:
- ~2.3 Mt nutrients
- ~4% of China’s demand

Source: IHS, 2015
Long-Term Projections
Fertilizer Demand in China Projections to 2030 (Mt nutrients)

Assumptions bw 2010 and 2030:

- 1% drop in cropland area (to 169 Mha)
- Rising area planted to fruits & vegetables (+23%) to detriment of cereals (-15%)
- Yield increases of 0.7-1.0% p.a. for cereals; 1.3% p.a. for fruits & vegetables
- Improved agricultural practices: lower rates for N and P and higher rates for K

NB: Projections developed before China’s policy capping fertilizer demand growth
Global Fertilizer Demand Outlook

(\textit{Mt nutrients})

Outlook to 2030 under Baseline Scenario (\textit{Mt nutrients})

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2013</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>China's consumption</td>
<td>34.7</td>
<td>52.7</td>
<td>57.6</td>
</tr>
<tr>
<td>World consumption</td>
<td>137.0</td>
<td>180.8</td>
<td>233.3</td>
</tr>
<tr>
<td>China’s share</td>
<td>25%</td>
<td>29%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Key lessons:
- Declining impact of China on global fertilizer demand growth
- Anticipated drop bw 2020 and 2030 would partly offset growth elsewhere (SE Asia, Latin America, Sub-Saharan Africa)

Source: Integer and LMC, 2013
## NUE Changes Needed to Halve Global N Surplus between 2010 and 2050

### Table: Projected Changes (Mt)

<table>
<thead>
<tr>
<th>Region</th>
<th>Harvest N (Tg N yr⁻¹)</th>
<th>Input N (Tg N yr⁻¹)</th>
<th>NUE</th>
<th>Surplus N (Tg N yr⁻¹)</th>
<th>Projected harvest N* (Tg N yr⁻¹)</th>
<th>Target NUE</th>
<th>Required Input N (Tg N yr⁻¹)</th>
<th>Resulting surplus N (Tg N yr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>13</td>
<td>51</td>
<td>0.25</td>
<td>38</td>
<td>16</td>
<td>0.60</td>
<td>27</td>
<td>11</td>
</tr>
<tr>
<td>India</td>
<td>8</td>
<td>25</td>
<td>0.30</td>
<td>18</td>
<td>11</td>
<td>0.60</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>USA and Canada</td>
<td>14</td>
<td>21</td>
<td>0.68</td>
<td>7</td>
<td>19</td>
<td>0.75</td>
<td>25</td>
<td>6</td>
</tr>
<tr>
<td>Europe</td>
<td>7</td>
<td>14</td>
<td>0.52</td>
<td>7</td>
<td>10</td>
<td>0.75</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>4</td>
<td>6</td>
<td>0.56</td>
<td>3</td>
<td>6</td>
<td>0.70</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Brazil</td>
<td>6</td>
<td>11</td>
<td>0.53</td>
<td>5</td>
<td>10</td>
<td>0.70</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Latin America (except Brazil)</td>
<td>7</td>
<td>12</td>
<td>0.52</td>
<td>6</td>
<td>10</td>
<td>0.70</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Middle East and North Africa</td>
<td>3</td>
<td>5</td>
<td>0.48</td>
<td>3</td>
<td>4</td>
<td>0.70</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>4</td>
<td>5</td>
<td>0.72</td>
<td>2</td>
<td>9</td>
<td>0.70</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Other OECD countries</td>
<td>1</td>
<td>2</td>
<td>0.52</td>
<td>1</td>
<td>2</td>
<td>0.70</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Other Asian countries</td>
<td>8</td>
<td>19</td>
<td>0.41</td>
<td>11</td>
<td>10</td>
<td>0.60</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>74</strong></td>
<td><strong>174</strong></td>
<td><strong>0.42</strong></td>
<td><strong>100</strong></td>
<td><strong>107</strong></td>
<td><strong>0.67</strong></td>
<td><strong>160</strong></td>
<td><strong>52</strong></td>
</tr>
</tbody>
</table>

### Projected Changes bw 2010 and 2050 (Mt)

<table>
<thead>
<tr>
<th>Region</th>
<th>China</th>
<th>India</th>
<th>N. Am</th>
<th>WC Eu</th>
<th>Brazil</th>
<th>ROW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Projected</strong></td>
<td>-24</td>
<td>-6</td>
<td>+4</td>
<td>-1</td>
<td>+4</td>
<td>+9</td>
</tr>
</tbody>
</table>

THIS IS NOT A FORECAST. In their article, Zhang et al. argue that halving the global N surplus from 100 Mt N 2010 to 52 Mt N in 2050 would require increasing global NUE from 42% to 67%. In order to achieve this global target, NUE would have to increase from 25% to 60% in China during the same 40-year period. This would require reducing the total N input in China from 51 to 27 Mt N. The authors don’t discuss whether this projection is achievable.

Source: Zhang et al., 2015
In Summary

- In past decades, China has been the main engine of global fertilizer demand growth

- Decelerating demand growth since 2007, to be followed by plateau towards 2020, and possible drop (for N and P) between 2020 and 2030 (and beyond); K demand would increase steadily

- Among the highest application rates and lowest NUE levels in the world; partly due to large fruit and vegetable area

- Reflecting anticipated yield increases and plateauing N demand, NUE is expected (has started?) to rebound, following three decades later trend observed in developed countries

- NUE in China is expected to remain lower than in developed countries owing to its crop mix
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