Relieving agricultural GHG stress: the transition of staple food strategy in China

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August, 2017
Crop and livestock production is responsible for up to \( \frac{1}{3} \) total anthropogenic GHG emissions. (Vermeulen S. J., et al, 2013)

China accounts for 17\% of global agricultural emissions. (Kimberly M. C., et al, 2017)

Currently agriculture GHGs are not well studied on regional and national level.

- Difference on energy and material input
- Geographical difference
- Crop management
- Crop structure
Transition of Staple Food strategy in China

Fig1. Yields (10 thousand tons yr-1) for 3 staple crops

Fig2. Yields (10 thousand tons yr-1) for 4 staple crops

Ratio of potato: 12.7%(2006)→14.5%(2015)
Potato yield Increases: 47.1%(2006-2015)

Benefit of potato staple food
• more food for the population
• more healthy for consumers
• more income for farmers

Agriculture faces great challenges to ensure food security by increasing yields while reducing environmental costs.
Will the transition of staple food strategy in China contribute to GHG reductions? What about in global level?

- Difference on energy and material input
- Yield difference
- Crop management
- Crop structure
- GHG leakage
GHGs emission of planting systems

Life Cycle Analysis

Uncertainty (McKone T. E., et al, 2011)


**Main Data source**

<table>
<thead>
<tr>
<th>Crops</th>
<th>Region</th>
<th>Data</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>31 provinces (mostly in city level) in China mainland</td>
<td>Area harvested Production</td>
<td>China Rural Statistical Yearbook</td>
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<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td>Input of fertilizer and plastic film</td>
<td>Compilation of the National Agricultural Costs and Returns</td>
</tr>
<tr>
<td>Potato</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Life Cycle Analysis

System boundary & emission components

1. CH$_4$ emission during crop planting
2. N$_2$O emission during fertilizer application
3. GHG emissions during the production and transportation of agricultural inputs

Uncertainty identification
- CH$_4$ and N$_2$O emission factor
- Crop management practices

Function unit
- Production intensity (Mg CO$_2$e M kcal$^{-1}$)

GHGs emission of planting systems

Fig1. System boundary
Transition of staple food structure

**Production areas of planning**
- Rice
- Wheat
- Maize

**Yields of planning**
- Rice
- Wheat
- Maize

**Uncertainty**
- Unit yield of prediction
- Demand yields of prediction

**Yields of planning**
- Rice
- Wheat
- Maize

**Structure in 2020 before potato staple food strategy**
- Gap between crops is replaced by potato production

**Structure in 2020 after potato staple food strategy**
- Rice
- Wheat
- Maize
- Potato

Fig2. Potato staple food strategy development
GHG leakage due to staple food strategy

Causes of GHG leakage

Transition of staple food structure → Decline of native rice production → Increase of rice import → GHG leakage

Loyalty to rice of Chinese
High intensity of export countries

Main Data source

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<tr>
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<th>Region</th>
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<th>Sources</th>
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<tr>
<td>Rice</td>
<td>8 major import countries</td>
<td>Rice import rate</td>
<td>China customs information website</td>
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<td>Area harvested Production</td>
<td>FAOSTAT</td>
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<td>Applied fertilization rate</td>
<td>IFA</td>
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Outline

1. Introduction
2. Methodology
3. Results and discussion
4. Conclusion
Emissions status quo in 2015

• Total staple food GHG emissions in China:
  
  \[ 546.90 \pm 32.69 \text{Tg CO}_2\text{e yr}^{-1} (4.4 \pm 0.2\% \text{ of anthropogenic emissions}) \]

• Production intensity of staple food in China:
  
  \[ 0.45 \pm 0.13 \text{ Mg CO}_2\text{e M kcal}^{-1} \]

Methane: 72% of rice emission; 34% of all crops.
High intensity of rice: High Methane emissions due to flooding
High intensity of maize: High Nitrous Oxide and input emissions from fertilization rate

Fig3. Staple food greenhouse gas emissions and intensities of each crops in China
Emissions status quo in 2015

Highest production intensity:
- South China (rice plantation)
- Northwest, Northeast, and North China (high fertilization applied rate)

Fig 4. Staple food greenhouse gas emissions and intensities of each crops in China of each regions

Fig 5. Distribution of production intensity (g CO₂-eq kcal⁻¹) from staple foods in 2015
Fig 6. Distribution of production intensity (g CO₂-eq kcal⁻¹) from each staple foods in 2015.
Transition of staple food structure

Fig 7. GHG emissions (Tg CO₂-eq yr⁻¹) in 2020 for before and after transition of staple food structure from 4 crops.

Table 1. Uncertainty sources of scenario 1

<table>
<thead>
<tr>
<th>Uncertainty identified</th>
<th>ranges</th>
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</thead>
<tbody>
<tr>
<td>Potato yields</td>
<td>±10%</td>
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<tr>
<td>Unit yields</td>
<td>±10%</td>
</tr>
<tr>
<td>CH₄ emission factor of rice</td>
<td>Region specific</td>
</tr>
<tr>
<td>CH₄ emission factor of others</td>
<td>Crops specific</td>
</tr>
<tr>
<td>N₂O emission factor</td>
<td>Crops specific</td>
</tr>
</tbody>
</table>
Transition of staple food structure

With crop management
ISSM: higher yield with better nitrogen use efficiency

Fig8. GHG emission intensity (g CO₂-eq kcal⁻¹) for with or not crop management for 3 crops

Fig9. GHG emissions (Tg CO₂-eq yr⁻¹) of each scenario from 4 crops in 2020

222 million tons = 14.8% of reduction goal of China

China’s National Plan on Climate Change (2014-2020)
Transition of staple food structure

Fig10. GHG emissions intensity (g CO₂-eq kcal⁻¹) of rice for import countries

- GHG leakage:
  30.10 - 42.12 Tg CO₂e yr⁻¹ (exceed emissions reductions in native China)
1 Introduction
2 Methodology
3 Results and discussion
4 Conclusion
1. In 2015, total staple food GHG emissions in China was $546.90\pm32.69$ Tg CO$_2$e yr$^{-1}$; production intensity of staple food in China was $0.45\pm0.13$ Mg CO$_2$e M kcal$^{-1}$.

2. After transition of staple food structure, native GHG emissions of staple food in 2020 might reduce $25.06$ Tg CO$_2$e yr$^{-1}$ ($4.21\pm2.11\%$); further reduction (33.3-40.4%) could be achieved with crop management improvement.

3. GHG leakage due to potato staple food strategy could achieve $30.10-42.12$ Tg CO$_2$e yr$^{-1}$, which may exceed emissions reductions in native China.
Thank You!

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