Analysis of food self-sufficiency, area expansion and import/exports of cereals in Sub-Saharan Africa in 2050

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and entire GYGA team
### Current self-sufficiency ratios cereals

<table>
<thead>
<tr>
<th>Region</th>
<th>Self-sufficiency ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States of America</td>
<td>126</td>
</tr>
<tr>
<td>Eastern Africa</td>
<td>85</td>
</tr>
<tr>
<td>Southern Africa</td>
<td>86</td>
</tr>
<tr>
<td>Western Africa</td>
<td>81</td>
</tr>
<tr>
<td>Asia</td>
<td>93</td>
</tr>
<tr>
<td>Europe</td>
<td>109</td>
</tr>
<tr>
<td>Australia &amp; New Zealand</td>
<td>212</td>
</tr>
</tbody>
</table>

Self – sufficiency ratio = \( \frac{\text{Production}}{\text{Production} + \text{Imports} - \text{Exports}} \times 100\% \)

Data from FAOstat, averaged over 2003 - 2012
Current (2010) self-sufficiency cereal ratios

Grain supply-demand (IMPACT) ratios

Ratio

Burkina Faso
Ghana
Mali
Niger
Nigeria
Ethiopia
Kenya
Tanzania
Uganda
Zambia

IMPACT, 2012
### Growth in population and cereal demand - 2050

<table>
<thead>
<tr>
<th>Country</th>
<th>Population 2010 (million)</th>
<th>Population 2050 (million)</th>
<th>% Population increase</th>
<th>% Demand increase (IMPACT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burkina Faso</td>
<td>16</td>
<td>41</td>
<td>256</td>
<td>283</td>
</tr>
<tr>
<td>Ghana</td>
<td>24</td>
<td>46</td>
<td>192</td>
<td>295</td>
</tr>
<tr>
<td>Mali</td>
<td>14</td>
<td>45</td>
<td>321</td>
<td>372</td>
</tr>
<tr>
<td>Niger</td>
<td>16</td>
<td>69</td>
<td>431</td>
<td>459</td>
</tr>
<tr>
<td>Nigeria</td>
<td>159</td>
<td>440</td>
<td>277</td>
<td>312</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>87</td>
<td>188</td>
<td>216</td>
<td>291</td>
</tr>
<tr>
<td>Kenya</td>
<td>41</td>
<td>97</td>
<td>237</td>
<td>284</td>
</tr>
<tr>
<td>Tanzania</td>
<td>45</td>
<td>129</td>
<td>287</td>
<td>707 (364)</td>
</tr>
<tr>
<td>Uganda</td>
<td>33</td>
<td>104</td>
<td>315</td>
<td>536 (380)</td>
</tr>
<tr>
<td>Zambia</td>
<td>13</td>
<td>44</td>
<td>338</td>
<td>536 (516)</td>
</tr>
</tbody>
</table>

UN, 2012 and IMPACT, 2012
Cereal yield trends for Ghana, Nigeria, Ethiopia and Kenya

Yields of main grain crops in Ghana and Nigeria

Yields of main grain crops in Ethiopia and Kenya

FAOSTAT
Fertilizer use trends in Ghana, Nigeria, Ethiopia and Kenya

FAOSTAT
Trends in agricultural areas in Ghana, Nigeria, Ethiopia and Kenya

Harvest area of main grain crops in Ghana and Nigeria

- Maize-Gh
- Rice-Gh
- Sorghum-Gh
- Maize-Nig
- Rice-Nig
- Sorghum-Nig

Harvest area of main grain crops in Ethiopia and Kenya

- Maize-Eth
- Sorghum-Eth
- Wheat-Eth
- Maize-Ken
- Sorghum-Ken
- Wheat-Ken

FAOSTAT
## Trends in area increase (2002-2012)

<table>
<thead>
<tr>
<th>Country</th>
<th>Arable land area 2010 in million ha</th>
<th>Arable land area increase 2002-2012 in million ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burkina Faso</td>
<td>6.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Ghana</td>
<td>4.4</td>
<td>0.53</td>
</tr>
<tr>
<td>Mali</td>
<td>6.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Niger</td>
<td>15.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Nigeria</td>
<td>33.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>14.6</td>
<td>5.7</td>
</tr>
<tr>
<td>Kenya</td>
<td>5.5</td>
<td>0.55</td>
</tr>
<tr>
<td>Tanzania</td>
<td>11.6</td>
<td>6.6</td>
</tr>
<tr>
<td>Uganda</td>
<td>6.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Zambia</td>
<td>3.4</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Source: FAOSTAT
Possibilities to meet future demand

- Increase of crop yields
- Increase crop intensity (i.e. growing more crops per year)
- Increase of irrigation
- Area expansion
- Increase in cereal imports
Study objectives

1. Assess the degree of self-sufficiency for five main cereals in 10 SSA countries for different demand and supply scenarios in 2050, considering:
   • Increase in population
   • Changes in diet
   • Possible increases in yield levels
   • Changes in cropping intensity
   • Increase in irrigation

2. How much land expansion or imports can be avoided or are still needed?
Scenarios


2. Fulfil 2050 food demands on current cropping area with:
   
   i. actual yields (2050 - Ya)
   
   ii. yield increases till 50% of Yw (2050 - 50% Yw)

   iii. yield increases till 80% of Yw (2050 - 80% Yw)

   iv. actual yields with increased cropping intensity (2050 - CI)

   v. actual yields with increased irrigation (2050 - IRR)

   vi. Yield increases till 80% of Yw plus increased cropping intensity plus increased irrigation (2050 - all)
Data sources:

- Population data → UN 2012
- Demand → IMPACT 2012 (and a method based on Tilman, 2011)
  - Five cereals were expressed in maize equivalents based on caloric contents
- Actual, water-limited (or potential) yield and yield gaps → GYGA
- Cropping system intensity → GAEZ (Fischer et al. 2002)
- Current arable land areas and fractions of cereal crops → FAOSTAT
- Possible expansion of arable area → GAEZ (Fischer et al. 2002)
- Irrigation water → AQUASTAT
Absolute rainfed maize yield gaps in Ghana, Nigeria, Ethiopia and Kenya

Absolute yield gap = \( Y_w - Y_a \)

http://www.yieldgap.org
Relative rainfed maize yield gaps in Ghana, Nigeria, Ethiopia and Kenya

Relative yield gap = 
\[1 - \left( \frac{Y_a}{Y_w} \right) \times 100\%\]

www.yieldgap.org
Self-sufficiency ratios of cereals for different scenarios

Ghana

Nigeria

Ethiopia

Kenya
Self-sufficiency of cereals in West and East Africa for different scenarios
Extra land (versus 2010) needed if intensification does not happen

Ratio of required (IMPACT-based) relative changes in arable land area and of maximal arable land area versus the arable land area in 2010

Nigeria

Ethiopia
Rice area expansion (Van Oort et al., 2015)

Closing the yield gap alone is not enough to achieve rice self-sufficiency

1. Area expansion needed → where?
2. Or: accept continued import dependency
To achieve (cereal) food self-sufficiency in 2050 without expansion of agricultural area:

- in Burkina Faso, Mali, Ghana and Ethiopia:
  - ca. 80% yield gap closure needed

- In other studied countries:
  - in addition to closing yield gaps, maximizing cropping intensity and increasing irrigation will be essential

- a regional approach seems essential, but even then...
If a successful intensification is not achieved, the consequences in terms of cereal self-sufficiency and/or area expansion will be huge:

- levels of $< 100\%$ regional self-sufficiency are unprecedented
- area expansion to reach self-sufficiency with Ya is not possible in Ethiopia, Kenya, Niger, Nigeria and Uganda
- and... the current rates of agricultural land expansion until 2050 are not possible in: Niger, Ethiopia and Uganda
Implications

- 80% closure of yield gaps implies, in most cases, yield increases of (far) more than 100 kg/ha/year

- Closure of yield gaps requires:
  - Integrated understanding of the causes
  - Quantifying input gaps
  - Integrated design of improved farming systems
Theoretical framework:
Efficiency, resource and technology yield gaps

Silva et al. (in preparation)
From Yield gap to fertilizer N input gap

Calculated minimum required fertilizer N for sustainably attaining actual and 80% of water-limited potential yields in Africa (kg fertilizer N/ha/harvest; based on actual yields from Monfreda et al. 2008 and fertilizer N requirements (from Conijn et al. in prep.)
Thank you for your attention and for your contribution!