What Research for what agriculture?

Quelle recherche pour quelle agriculture?

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President
Millennium Institute Washington, USA and Biovision Foundation Zurich, Switzerland
Overview

1. Few facts and figures

2. Why do we need a new agriculture (and food system)?

3. What will drive the transformation?

1. Can it be done, and how/who

2. Conclusions
FAMILY FARMERS

Feeding the world, caring for the earth

Family farming is inextricably linked to national and global food security. Both in developing and developed countries, family farming is the predominant form of agriculture in the food production sector.

Family farming includes all family-based agricultural activities, and it is linked to several areas of rural development.

There are more than 570 million farms in the world of which over 500 million are family owned.

They are responsible for at least 56% of agricultural production.

agricultural  forestry  fisheries  pastoral production  aquaculture production
Family farmers work on a significant portion of the world's farmland.

- **North and Central America**: 83%
- **Europe**: 68%
- **Asia**: 85%
- **South America**: 18%

FAO, 2014
Family farmers manage their lands to sustain remarkably high levels of productivity despite having less access to productive resources such as agricultural inputs and support.

In Brazil, family farmers provide on average approximately **40% of the production** of a selection of major crops working on less than **25% of the farmland**.

Family farmers in Fiji provide **84% of yam, rice, manioc, maize and bean** production working on only **47.4% of the farmland**.

In the United States, family farmers **produce 84%** of all produce – totalling USD 230 billion in sales, working on **78% of all farmland**.

FAO, 2014
Family farming preserves traditional food products, while contributing to a balanced diet and safeguarding the world’s agro-biodiversity and the sustainable use of natural resources.

More than 3.5 billion people depend on rice for at least 20% of their daily calories

More than 1 billion people depend on rice production for their livelihoods

Family farms are the main source of rice production – especially in Asia

FAO, 2014
Average yield of crops

Average yield of crops in Chokwe (left) and Marracuene (right)

**Average yield**

- Average yield: Chokwe-Base
- Average yield: Chokwe-LEI
- Average yield: Chokwe-HEI
- Average yield: Chokwe-SmallHEI

- Average yield: Marracuene-Base
- Average yield: Marracuene-LEI
- Average yield: Marracuene-HEI
- Average yield: Marracuene-SmallHEI

MI, 2013
..introductory story (1)

Population below poverty line

Proportion of population below poverty line in Chokwe (left) and Marracuene (right)

proportion of population below poverty line (left)
- Chokwe-Base
- Chokwe-HEI
- Chokwe-LEI

proportion of population below poverty line (right)
- Marracuene-Base
- Marracuene-HEI
- Marracuene-LEI

MI, 2013
..introductory story (2)

PRIMARY INVESTOR COUNTRIES OF LAND INVESTMENTS IN AGRICULTURE

TARGET COUNTRIES FOR LAND INVESTMENTS IN AGRICULTURE

Source: Landmatrix.org, database filtered by confirmed cases of land investments in agriculture (including biofuels, sugar).

About Tableau maps: www.tableausoftware.com/mapdata
R&D challenges ahead – fix the current agriculture and food systems problems

• 842 million undernourished – 1.5 billion obese – 300 million diabetes type 2 cases, etc.  => health problem

• The industrial food system uses 10 kcal to produce 1 (empty)  => energy problem

• The conventional food system is a major part of the  => climate change problem

• Soil degradation, water shortages, biodiversity loss underlie food insecurity  => natural resource problem

• Industrial agriculture has emptied the rural areas instead of providing quality jobs  => social problems

Business as usual is not an option!
FAO World hunger map 2013
The main problems (too much production, too much waste)
The main problems (too little diversity, unsustainable consumption patterns)

Barilla, 2011
The main problems (consumption patterns)
The main problems (too much external / non-renewable inputs)

Global trends in cereal and meat production

Global total use of nitrogen and phosphorus fertilizers.

Increased use of irrigation

Total global pesticides production

SOURCE: Tilman et al., 2002

David Tilman et al. Science 2001
The main problems (too much GHG)

The industrial food system is responsible for 44-57% of all global GHG emissions.

- Agricultural Production: 11-15%
- Land use change & deforestation: 15-18%
- Processing, transport, packing & retail: 15-20%
- Waste: 2-4%
- Other - non food related emissions: 43-56%

Grain Unctad 2011
The main problem (too much damages)
The main consequences (Natural and human systems failing under pressure)

Reduced capacity of ecosystems to buffer from extreme events through loss of wetlands, forests, mangroves

Source: Millennium Ecosystem Assessment
The main consequences (Temperature and plant physiology)

For each plant species/variety, there is an optimal temperature for vegetative growth, with growth dropping off as temperatures increase or decrease. Similarly, there is a range of temperatures at which a plant will produce seed.
The main problems (too much GHG, less nutrients)

**High CO2 cuts crop nutrients**

Percentage under CO2 levels expected in 2050,

- **Zinc**
- **Iron**
- **Protein**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Zinc</th>
<th>Iron</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>-9.3</td>
<td>-5.1</td>
<td>-6.3</td>
</tr>
<tr>
<td>Rice</td>
<td>-5.2</td>
<td>-3.3</td>
<td>-7.8</td>
</tr>
<tr>
<td>Maize</td>
<td>-5.2</td>
<td>-5.8</td>
<td>-4.6</td>
</tr>
<tr>
<td>Soybean</td>
<td>0.5</td>
<td>-5.1</td>
<td>-4.1</td>
</tr>
</tbody>
</table>

**Source:** Nature
The main solutions

A paradigm change:

Transition to sustainable / ecological agriculture addressing the multi-functionality and resilience needs of small-scale and family farmers (eco-functional intensification, vs smart)

A fundamental shift in:

- Agricultural Knowledge Science and Technology
- Agri-food system policies & Institutions
- Capacity development
- Investments

A systemic and holistic approach

National multistakeholder assessments (IAASTD, Rio+20, CFS)
.....this in the 3 +1 areas of sustainable development
The main solutions: R&D
1. Paradigm change / all inclusive
The main solutions: R&D

2. System’s approach to problem analysis and solving, cause vs symptom)
The main solutions: R&D
3a. Beating the biotic stresses ie, closing the yield gap)
The main solutions: R&D
3 b: Beating the biotic stresses (improving soil fauna and flora, ie, organic matter)

Increase soil structure/ air spaces / SOM-SOC

• Turn the nitrogen in the air into nitrate and ammonium (air is 78% N)
• Soil carbon dioxide increases plant growth
• SOM helps plant and microbial growth through growth stimulating compounds
• Helps root growth, by making it easy for roots to travel through the soil
• Improves growth through easy access to deep nutrients and water

After Andre Leu 2014
The main solutions: Agroecological practices

<table>
<thead>
<tr>
<th>Year of Inception</th>
<th>Name of Practice</th>
<th>Geographical Location</th>
<th>Area of Environmental Conservation</th>
<th>Yield Increase/Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Rice-Duck Farming</td>
<td>Bangladesh</td>
<td>Soil Health, Pest Control</td>
<td>Raising ducks on paddy increased yields by 20%; Increased net income by 80%³</td>
</tr>
<tr>
<td>2006</td>
<td>Soil and Water Conservation - Zai</td>
<td>Burkina Faso</td>
<td>Soil Health, Erosion, Water</td>
<td>Rehabilitation of 200,000 - 300,000 hectares of land. Production of add’l 80,000 tonnes food/year³</td>
</tr>
<tr>
<td>2007</td>
<td>Fertilization Tree System</td>
<td>Zambia</td>
<td>Soil Health</td>
<td>Net profit increased from US$130 to US$309 per hectare³</td>
</tr>
<tr>
<td>2008</td>
<td>Agroforestry Tree Domestication Projects</td>
<td>Cameroon</td>
<td>Soil Health, Tree Domestication</td>
<td>Crop yields increase 100 - 200%²</td>
</tr>
<tr>
<td>2008</td>
<td>International Centre of Insect Physiology and Ecology</td>
<td>Kenya</td>
<td>Soil Health, Pest Management</td>
<td>Increased maize production from below 1t/ha to ~ 3.5t/ha⁴</td>
</tr>
<tr>
<td>2009</td>
<td>Nitrogen-Fixing Trees in Agroforestry System</td>
<td>Malawi</td>
<td>Water Retention, Land Use, Diversification</td>
<td>Increased yields from 1t/ha to 2 or 3t/ha³</td>
</tr>
</tbody>
</table>
| 2010              | System of Rice Intensification                         | Cambodia              | Lessen Fertilizers and Pesticides, Water Retention | Increase of rice yields from 30-150%. Reduced amount of seeds by 50-70%. Increased rice production from 3.82 million tons in 2002 to 7.97 million tons in 2010."
Main Solutions: beating the biotic stresses such as pests, weeds and soil fertility (systems appr.)
The main solutions: R&D
3b. Beating the biotic stresses ie, (Soil OM and N, and Water)

<table>
<thead>
<tr>
<th>% SOC</th>
<th>Organic N per hectare</th>
<th>SOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>2,400 kg</td>
<td>1.72%</td>
</tr>
<tr>
<td>2%</td>
<td>4,800 kg</td>
<td>3.44%</td>
</tr>
<tr>
<td>3%</td>
<td>7,200 kg</td>
<td>5.16%</td>
</tr>
<tr>
<td>4%</td>
<td>9,600 kg</td>
<td>6.88%</td>
</tr>
<tr>
<td>5%</td>
<td>12,000 kg</td>
<td>8.50%</td>
</tr>
</tbody>
</table>

1 % SOM = 160,000 litres (common level)
5 % SOM = 800,000 litres (levels pre farming)
Per ha (to 30 cm)

After Andre Leu 2014 Bhutan
The main solutions: R&D
3 c: Beating the biotic stresses (SOM)

Organic

Conventional

In 1995 – drought year
The main solutions: R&D

3 b: Beating the biotic stresses (SOM)
The main solutions: R&D
3 b: Beating the biotic stresses (SRI)
The main solutions: R&D
3 b: Beating the biotic stresses (SOM)

Faidherbia *albida*
The main solutions: R&D

3b. beating the biotic stresses biological / natural pest and disease control
The main solutions: R&D
3b. beating the biotic stresses promotion of pollinators
The main solutions: R&D
3b. beating the biotic stresses? GMOs?
Reductionism vs complexity (=resilience)
The main solutions:
3b. beating the biotic with less genetic diversity?

Extent of farmer choice for conventional (non-transgenic seed) from a survey of 6 seed catalogues for the southern midwest region USA, 2000 – 2011
(Monsanto, Syngenta, DuPont, Dow, Land O’ Lakes and Stine Seed)

David Quist, 2010 pers com
The main solutions:
3b. beating the biotic with less genetic diversity?
The main Solutions:
4. beating the biotic stresses through R&D + Edu

- Improve, expand extension services and capacity bldg
- Strengthen Institutions
- Emphasize local solutions
Is such a transition possible and how?

A systems model for the transition: scenarios from the UNEP GER ag chapter 2011

Global investments across sectors (2% of GDP, Stern report); 0.16% of GDP (141 Bn $/year) invested in agriculture for:

- **Pre harvest losses** (training activities and effective pest management with bio-products, IPM)
- **Ag management practices** (cover transition costs from till to no till, organic, agroecological agriculture, training, access to small scale mechanization and irrigation)
- **R&D** (research in soil biology and agronomy, crop improvement (orphan crops), appropriate mechanization, irrigation, and more)
- **Food processing** (better storage and processing in rural areas, efficient processing, marketing, less waste)
... the numbers: we can win-win-win by 2050

Investing 0.2% of total GDP ($141 Billion) / year

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Unit</th>
<th>Baseline</th>
<th>Green</th>
<th>BAU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural production</td>
<td>Bn US$/year</td>
<td>1’921</td>
<td>2’852</td>
<td>2’559</td>
</tr>
<tr>
<td>Crops</td>
<td>Bn US$/year</td>
<td>629</td>
<td>996</td>
<td>913</td>
</tr>
<tr>
<td>Employment</td>
<td>M people</td>
<td>1’075</td>
<td>1’703</td>
<td>1’656</td>
</tr>
<tr>
<td>Soil quality</td>
<td>Dmnl</td>
<td>0.92</td>
<td>1.03</td>
<td>0.73</td>
</tr>
<tr>
<td>Water use</td>
<td>Km³ / year</td>
<td>3’389</td>
<td>3’207</td>
<td>4’878</td>
</tr>
<tr>
<td>Land</td>
<td>Bn ha</td>
<td>1.2</td>
<td>1.26</td>
<td>1.31</td>
</tr>
<tr>
<td>Deforestation</td>
<td>M ha/ year</td>
<td>16</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Calories for consumption</td>
<td>Kcal/person/d</td>
<td>2’081</td>
<td>2’524</td>
<td>2’476</td>
</tr>
</tbody>
</table>

+ enabling conditions investments

... the numbers: we can win-win-win by 2050
Changing course in global agriculture:

«The Future We Want» (Rio+20 Declaration) recognized

- the fact that «a significant portion of the world’s poor live in rural areas»
- the role that agriculture plays in development
- the importance and utility of a set of Sustainable Development Goals (SDGs);
- and reaffirmed the necessity to promote, enhance and support more sustainable agriculture

§115 „We reaffirm the important work and inclusive nature of the Committee on World Food Security, including through its role in facilitating country-initiated assessments on sustainable food production and food security“
Conclusions

There are many innovative solutions to the challenges facing long term food and nutrition security

• promote sustainable agriculture methods
• assist family farmers in adapting to climate change and short-term climate variability (risks)
• promote policies to provide smallholder farmers with legal rights to land, facilitating access to markets and infrastructure
• providing women farmers with access to edu, info and inputs equal to those of their male counterparts
• Introduce full cost accounting

Substantial public investment for R&D, the re-orientation of research, education and development institutions. The private sector and the development community can also contribute to family farmers by supporting their multiple needs along the value chain
can the farmers do it alone? The consumers will have to help (true costs)

Thank you

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