The contribution of organic agriculture in the tropics to sustainable development
Beate Huber, Irene Kadzere, Christian Schader
Noah Adamtey, Laura Armengot, David Bautze, Johan Blockeel, Gurbir Bhullar, Harun Cicek, Christian Grovermann, Anja Heidenreich, Gian Nicolay, Amritbir Riar, Bernhard Schlatter, Monika Schneider, Brian Ssebunya
Smallholders (<10 ha) manage 80% of the farmland in Sub-Saharan Africa and Asia, supplying most of the food in these regions.
Focus on research in Global North, eg soil fertility

Meta-study on soil carbon with 74 global comparative studies

FiBL long-term DOK trial proved higher top soil carbon values for organically farmed soils compared to nonorganic production.

Source: Gattinger et al. 2012.
SysCom
Long-term Farming Systems Comparisons Trials in the Tropics

ProEcoAfrica/OFSA
Productivity, Profitability and Sustainability of Organic and Conventional Farming Systems: comparative analyses in Sub Saharan Africa

- What is the contribution of organic agriculture?
Content

SysCom
- Soil Fertility
- Biodiversity
- Productivity & Profitability

ProEcoAfrica/OFSA:
- Adoption of organic practices by farmers
- Productivity & Profitability
- Contribution to sustainable development

Conclusions
- Contribution of Organic Agriculture in the Tropics to Sustainability?
On-station trials
India

Long-term experiments

Treatments:
- BT Cotton (GMO)
- Conventional
- Organic
- Biodynamic
On-station trials
Kenya

Treatments:
- Conventional, high input
- Conventional, low input
- Organic, high input
- Organic, low input
On-station trials
Bolivia

Treatments:
• Conventional, monoculture
• Organic, monoculture
• Conventional, agroforestry
• Organic, agroforestry
• Organic, successional agroforestry
• Fallow
RESULTS FROM LONG-TERM EXPERIMENTS (SysCom)
Soil fertility

Soil organic carbon


- Soil carbon in organic is higher in High Input systems compared to conventional.
- Soil carbon is lowest in organic Low Input systems (soil depth 0-20cm).

Kenya

www.fibl.org
Soil fertility

Soil organic carbon

Soil carbon change (2007-2014)

- No significant change in soil carbon in conventional systems
- Significant increase of soil carbon in organic systems – higher soil fertility

Application of manure: Conv. and BT: application of farm yard manure (conv 5 t every second year, plus NPK; organic 8 t every year
Soil fertility

- Soil organic carbon

Long-term experiments

Soil carbon stocks (2015; after 6 years)

- Soil carbon in agroforestry and in organic systems is higher compared to monocultures / conventional (soil depth 0-10cm)
Biodiversity Conservation

- Earthworm biomass

Density of earthworms during cotton season (per m²)

- Density and biomass of earthworms in organically managed soils much higher.
- Earthworms contribute to soil stability and fertility

Source: Ledroit et al. (unpublished)
Biodiversity conservation

- Termites

Diversity and abundance of termites (3 seasons per plot)

- More diversity and abundance of termites in organic high input production system
- Termites contribute to soil stability and fertility

Source: Anyango et al. (unpublished)
Biodiversity conservation

Birds

- Agroforestry production systems have higher species richness of bird species compared to monocultures.
- Agroforestry is lower compared to fallow (secondary forest) of the same age.

Source: Naoki et al. (2017)

www.fibl.org
Yields

- Crop yields in high input systems

### Annual average yields (2007-2017)

- Maize yields similar in conventional and organic.
- Potatoes and green beans yields are lower in organic (pest and diseases!)

Source: Adamtey et al. (2016) & Bautze et al. (unpublished)
Crop Yield development

- Variation over years

Crop yield development (2007-2019)

- Yields vary substantially over the years
- Long-term experiments reflect the more realistic picture
Productivity & Profitability

- Crop yields and economic differences

- Long-term experiments

- **India**

  - **Annual average yields (2008-2014)**
  - **Annual average gross margin (2008-2014)**

- Cotton and wheat yields lower in organic, soybean yields equal
- Organic production systems can have equal or higher gross margins
Return on Investment

- Organic production systems have higher Return on Investment
- Organic production is highly relevant for resource poor farmer

<table>
<thead>
<tr>
<th></th>
<th>BD</th>
<th>Org</th>
<th>Conv</th>
<th>Bt-Con</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cotton</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Soybean</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wheat</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

India

Return on investment (2008-2014)

www.fibl.org
Higher cumulative yields in agroforestry systems.
Organic monocrop systems with lower yield compared to conventional monocrops.
Profitability & Profitability

- Revenues and costs of a young plantation (initial 5 years)

<table>
<thead>
<tr>
<th></th>
<th>Revenues (in US$)</th>
<th>Costs, without labor (in US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bolivia</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cocoa</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Revenue</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conv Monoculture</td>
<td>2,500</td>
<td>2,000</td>
</tr>
<tr>
<td>Org Monoculture</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Conv Agroforestry</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td>Org Agroforestry</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>1,250</td>
<td>1,250</td>
</tr>
</tbody>
</table>

- Revenues from cacao higher in monoculture compared to agroforestry.
- Revenues from by-crops in agroforestry overcompensate lower cocoa yields.
- Costs lower in agroforestry and organic systems: less fertilizer, less/no herbicides.

Source: Armengot et al. (2016)
Return on Labor

- Average of 5 years in young plantation (2010-2014)

- Higher Return on labor in Agroforestry Systems
- Exceeding national poverty line of 1.90 US$ day\(^{-1}\) (World Bank)
- But below minimum salary in Bolivia (8.7 $ day\(^{-1}\))

Source: Armengot et al. (2016)
Nutrition potential

- Calories of yields of the different crops

**Average calories per yields (2010-2017)**

- Higher calorie production in agroforestry systems
- More diverse nutrients in agroforestry systems
Resource use efficiency

- Renewable and non-renewable energy input

Average energy input (2010-2014)

Non-renewable energy inputs substantially higher in the conventional systems
Climate mitigation potential

- Above ground carbon (AGC)

Long-term experiments

<table>
<thead>
<tr>
<th>Bolivia</th>
<th>Bolivia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above ground biomass 2011 (after 2 years)</td>
<td>Above ground biomass 2015 (after 6 years)</td>
</tr>
</tbody>
</table>

Agroforestry systems has higher carbon mitigation potential than monoculture

Source: Schneidewind et al. (2018)
ProEcoAfrica/OFSA
2011 High level Decision on Organic Agriculture (OA) – by African Union (AU) Heads of States and Government

(AU Council Decision on Organic - at the 18th Ordinary Session, 24-28 January 2011, EX.CL/Dec.621 (XVIII))

- Mainstreaming OA into national agricultural systems by 2025
- Ecological Organic Agriculture (EOA) - initiative in response

Pillar I: Research, Training and Extension
e.g. SysCom Kenya, ProEcoAfrica, OFSA

Results from smallholder farms
ProEcoAfrica/OFSA - key research questions

- For organic and conventional smallholder farms, with respect to:
  - Productivity,
  - Profitability,
  - Sustainability,

1. What are the determining factors?
2. What are the key differences, if any?
3. How can farmers improve performance?

Comparisons based on farmers’ practices: >2,000 farms since 2014
Case study locations and reasons for selection

- Existing comparable organic and conventional farms
- Organic farms (≥3 years under organic)
  - Certified and non-certified
  - 6 entry organic crops from 7 sites

Ghana
- "Onion" Case Study
- "Cocoa" Case Study

Uganda
- "Coffee" Case Study Sites

Kenya
- "Macadamia" Case Study
- "Mango" Case Study
- "Cabbage" Case Study
Ghana

North-eastern Region
- Onion – non-certified
- Semi-arid zone
- 398 farmers (23% F)

Ashanti
- Cocoa – certified
- Humid zone
- 399 farmers (44% F)

Uganda

Kasese and Sheema (OFSA)
- Coffee – certified Fair Trade, Fair Trade Organic
- Humid zone
- 362 farmers (50.2% F)

Kenya

Kirinyaga
- Macadamia – certified
- Humid zone
- 282 farmers (23% F)

Machakos
- Mango – non-certified
- Semi-arid zone
- 296 farmers (50% F)

Muranga
- Cabbage – non-certified, Humid zone, 294 farmers (62% F)
Farm and field area measurements – GPS

“Cabbage” site  “Macadamia” site  “Mango” site

Average farm sizes:
• Ghana – 2.83 to 3.22 ha
• Kenya – 0.48 to 1.05 ha
Modelling of productivity & profitability – ProEcoAfrica (whole farm)

Productivity:
Physical outputs / Physical inputs

Profitability:
Monetary outputs - monetary inputs

Seedlings
Fertiliser
Compost
Water
Pesticides
Labour

Costs

Physical inputs

Monetary inputs

Physical outputs

Monetary outputs

Kgs, Litres, etc

Revenues

Seedlings
Fertiliser
Compost
Water
Pesticides
Labour

Costs

Physical inputs

Monetary inputs

Physical outputs

Monetary outputs

Kgs, Litres, etc

Revenues

www.fibl.org

12 March 2019
ProEcoAfrica data collected for 5 seasons (2014-17)
OFSA data collected *once* per site
Farming systems **re-classification** taking into account the **actual farm management**

<table>
<thead>
<tr>
<th>Reported use of prohibited Input(s) during study period</th>
<th>Organic</th>
<th>Non-organic / Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>O-O</td>
<td>C-O</td>
</tr>
<tr>
<td>Recruited as organic. No prohibited inputs reported</td>
<td></td>
<td>Recruited as conventional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No prohibited inputs reported</td>
</tr>
<tr>
<td>Yes</td>
<td>O-C</td>
<td>C-C</td>
</tr>
<tr>
<td>Recruited as organic Used inputs prohibited in organic</td>
<td></td>
<td>Recruited as conventional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used inputs prohibited in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>organic</td>
</tr>
</tbody>
</table>

**Initial farm categorisation (for farm sampling)**

Some of the reasons for practicing organic
- Health, profitability, market access, conviction of benefits
Top 10 crops based on land area occupied in ‘Cabbage’ Case Study (Kenya)

- Tea dominant.
- No major differences, but C-C farmers seemed to have > land under tea.
- Farm cropping characteristics are quite comparable.

Schader et al., in preparation; preliminary results, do not cite
Females tended to constitute a > % of the O-Os

- **Site differences**
  - O-O % highest in Macadamia site - both females and males.

- **Farming system differences**
  - Females constituted a > % of the O-O farmers in all sites.
  - Shift in practices: C-O and O-C.
Guidelines for Sustainability of Agriculture and Food Systems (SAFA)

- 4 Dimensions
- 21 Themes
- 58 Sub-themes with sustainability objectives
Good Governance

<table>
<thead>
<tr>
<th>CORPORATE ETHICS</th>
<th>Mission Statement</th>
<th>Due Diligence</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCOUNTABILITY</td>
<td>Holistic Audits</td>
<td>Responsibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transparency</td>
</tr>
<tr>
<td>PARTICIPATION</td>
<td>Stakeholder Dialogue</td>
<td>Grievance Procedures</td>
</tr>
<tr>
<td>RULE OF LAW</td>
<td>Legitimacy</td>
<td>Remedy, Restoration &amp; Prevention</td>
</tr>
<tr>
<td>HOLISTIC MANAGEMENT</td>
<td>Sustainability Management Plan</td>
<td>Full-Cost Accounting</td>
</tr>
<tr>
<td>SOCIAL WELL-BEING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRODUCT QUALITY &amp; INFORMATION</td>
<td>Food Safety</td>
<td>Food Quality</td>
</tr>
<tr>
<td>LOCAL ECONOMY</td>
<td>Value Creation</td>
<td>Local Procurement</td>
</tr>
<tr>
<td>DECENT LIVELIHOOD</td>
<td>Quality of Life</td>
<td>Capacity Development</td>
</tr>
<tr>
<td>FAIR TRADING PRACTICES</td>
<td>Responsible Buyers</td>
<td>Rights of Suppliers</td>
</tr>
<tr>
<td>LABOUR RIGHTS</td>
<td>Employment Relations</td>
<td>Forced Labour</td>
</tr>
<tr>
<td>EQUITY</td>
<td>Non Discrimination</td>
<td>Gender Equality</td>
</tr>
<tr>
<td>HUMAN SAFETY &amp; HEALTH</td>
<td>Workplace Safety and Health Previsions</td>
<td>Public Health</td>
</tr>
<tr>
<td>CULTURAL DIVERSITY</td>
<td>Indigenous Knowledge</td>
<td>Food Sovereignty</td>
</tr>
</tbody>
</table>
SAFA sustainability objective for the “Water Quality” sub-theme:

“The release of water pollutants is prevented and water quality is restored.”
Process flow SMART Farm Assessment

Farm Survey (appr. 2-3 h)  Analysis  Evaluation
On farm data collection
Performance of Arabica coffee farms in Uganda with respect to SAFA sustainability themes

Source: Ssebunya et al 2019
Performance of Arabica coffee farms in Uganda with respect to SAFA sustainability themes

Source: Ssebunya et al 2019
Performance of Arabica and Robusta coffee farms in Uganda with respect to SAFA sustainability themes

Source: Ssebunya et al 2019
Sustainable Development Goals (SDGs)
Linking SAFA and SMART to SDGs

Comparison at these levels offers a manageable and informative degree of differentiation
Contribution of conventional and organic coffee farming systems in Uganda to the SDGs

- Arabica Conventional
- Arabica Organic/Fairtrade
- Robusta Conventional
- Robusta Organic/Fairtrade

Based on Ssebunya et al. 2019
Conclusions:

No silver bullet

Organic agriculture has large potential to contribute to sustainable development

- Soil fertility
- Biodiversity Conservation
- Productivity & Profitability

For full exploitation major efforts are needed to tackle:

- Agronomic/technological challenges (lack of input, pest management)
- Capacity development for farmers (technical know how)
- Institutional/governance challenges (markets, agri-business)
- Policy challenges
Long-term experiments

Sources

Yield and Economic Performance of Organic and Conventional Cotton-Based Farming Systems – Results from a Field Trial in India

COCOA AND TOTAL SYSTEM YIELDS OF ORGANIC AND CONVENTIONAL AGROFORESTRY VS. MONOCULTURE SYSTEMS IN A LONG-TERM FIELD TRIAL IN BOLIVIA

Selección de diferentes sistemas de producción de cacao (Theobroma cacao, Malvaceae) por aves en Alto Beni, Bolivia - una prueba de cafetería en el campo

Selection of different cacao (Theobroma cacao, Malvaceae) production systems by birds in Alto Beni, Bolivia - a cafeteria experiment in the field

El cacao (Theobroma cacao, Malvaceae) es una especie nativa de Sudamérica, y se considera de biodiversidad. Se estudió el uso y hábitat, a través de una encuesta a nivel de campo, con el objetivo de determinar la biodiversidad de las aves y el uso de la fruta del cacao en diferentes sistemas de cultivo. El estudio se realizó en el departamento de Beni, Bolivia, donde se observaron diferentes sistemas de cultivo de cacao, como el monocultivo y el agroforestal. Se encontró una alta diversidad de aves, algunas de las cuales consumen la fruta del cacao. La información obtenida puede ser útil para el manejo sostenible de los bosques y el desarrollo de prácticas agroforestales que promuevan la biodiversidad.
This research could only be realized without our donors and partners

Farmers and Field Staff in Bolivia, Ghana, India, Kenya, and Uganda
Thank you very much for your attention!
EOA Pillars (https://eoai-africa.org/)

Research, Training and Extension
Value Chain and Market Development
Networking and Partnerships
Policy and Programme Development
Institutional Capacity Development
Long-term Experiment (LTE)
Bolivia

- Full sun system (Monoculture)
  - Organic
  - Conventional

- Agroforestry system
  - Organic
  - Conventional

- Successional agroforestry system
  - Organic (no external input)

- Sara Ana, Bolivia 2008/09 → 8th year of grow of cacao in 2017