Agroforestry: a tool for sustainable nutrition?
About the World Agroforestry Centre

(aka ICRAF)
Who are we?

• We are one of the 15 global research centres of the Consultative Group on International Agricultural Research (CGIAR)

• We are dedicated to generating and applying the best available knowledge to stimulate agricultural growth in developing countries, raise farmers’ incomes, and protect the environment.
  
  – **Our Vision**: a rural transformation in the developing world as smallholder households increase their use of trees in agricultural landscapes to improve their food security, nutrition, income, health, shelter, energy resources and environmental sustainability.

  – **Our mission**: generate science-based knowledge about the diverse roles that trees play in agricultural landscapes, and use this research to advance policies and practices that benefit the poor and the environment.
Our research priorities

1. Domestication, utilization and conservation of superior agroforestry germplasm.

2. Maximizing on-farm productivity of trees and agroforestry systems.

3. Improving tree product marketing and extension for smallholders.

4. Reducing land health risks and targeting agroforestry interventions to enhance land productivity and food availability.

5. Improving the ability of farmers, ecosystems, and governments to cope with climate change.

6. Developing policies and incentives for multi-functional landscapes with trees that provide environmental services.
Our participation in the CGIAR Research Programmes (CRPs)

- CRP 1  Integrated Agricultural Systems
- CRP 2  Policy research
- CRP 4  Health and Nutrition
- CRP 5  Land and Water
- CRP 6  Forests, Trees and Agroforestry
- CRP 7  Climate Change and Agriculture
Fruit & veg consumption

African facts

- Population growth has rendered fallowing impossible in many communities.
- Land overuse is depleting soil organic matter, soil carbon and soil microbiology.
- Consequently, across drylands Africa, soil fertility is dropping by 10-15% a year (Bunch, 2011).
- Deep poverty and logistical bottlenecks makes fertiliser unaffordable for most.
- Funding for fertiliser subsidies is scarce and fickle.

*Where will soil fertility, soil organic matter and extreme weather resilience come from?*
From trees.

Faidherbia Albida in teff crop system in Ethiopia.
Impact of fertilizer trees on maize yield under farmer management

<table>
<thead>
<tr>
<th></th>
<th>maize yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize only</td>
<td>1.30</td>
</tr>
<tr>
<td>Maize + fertilizer trees</td>
<td>3.05</td>
</tr>
</tbody>
</table>

2011 Survey of farms in six districts (Mzimba, Lilongwe, Mulanje, Salima, Thyolo and Machinga)
Long-term maize yield without fertilizer in a *Gliricidia* system
Farmer-Managed Natural Regeneration
Zinder, southern Niger in the 1980s

In FMNR, farmers will select the best shoots from trees regrowing naturally from stumps and eliminate the rest. This promotes the growth of vigorous new trees adapted to local conditions.
Today, there are 5 million hectares of millet production in *Faidherbia* parklands in Niger, producing 500,000 tons of extra grain a year!
Kantché district, Zinder, Niger

District of 350,000 people, with high tree on-field densities. Rainfall averages ca. 350 mm per year, typical of Sahel drylands.

Annual district-wide grain **surplus:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Surplus</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>21,230 tons</td>
</tr>
<tr>
<td>2008</td>
<td>36,838 tons</td>
</tr>
<tr>
<td>2009</td>
<td>28,122 tons</td>
</tr>
<tr>
<td>2010</td>
<td>64,208 tons</td>
</tr>
<tr>
<td>2011</td>
<td>13,818 tons</td>
</tr>
</tbody>
</table>

*Kantché produces grain surpluses even in drought years. This is mostly exported to northern Nigeria, providing cash revenue.*

_Yamba & Sambo, 2012_
Where will Africa’s nutrition come from?

From trees.
Harvest seasons

<table>
<thead>
<tr>
<th>Month/Species</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lemon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pawpaw</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jackfruit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passion Fruit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mango</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tamarindus indica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ximenia americana</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guava</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avocado</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhus vulgaris</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carissa edulis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syzygium cuminiil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Year-round supply**
- **Peaks in August and December**

Example from western Kenya
Homegardens and their function

Homegarden: around a homestead, complex agroforestry system, species mixture, often women-managed...

Homegarden functions

- **Production**
  - Subsistence: Fruits, Vegetables, Spices, Medicine, Staple food, Stimulants, Timber, Fodder
  - Commerce: Cash income

- **Services**
  - Socio-culture: Gifts, Sacrifices, Pride, Pleasure, Aesthetics, Employment, Socialising
  - Ecology: Habitat for wild flora + fauna, Pest + disease control, Nutrient cycling, Microclimate, Soil erosion control
# Trees in homegardens

## Results from three studies (50-60 HG each):

<table>
<thead>
<tr>
<th>Location</th>
<th>Humid Sulawesi</th>
<th>Semi-arid Sudan</th>
<th>Urban Niamey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean garden size (m²)</td>
<td>1070</td>
<td>1065</td>
<td>860</td>
</tr>
<tr>
<td>Portion of HG with trees</td>
<td>100%</td>
<td>92%</td>
<td>86%</td>
</tr>
<tr>
<td>Total tree species no.</td>
<td>113</td>
<td>53</td>
<td>63</td>
</tr>
<tr>
<td>Total fruit tree species</td>
<td>30</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>Other food tree species</td>
<td>10</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Mean fruit species/HG</td>
<td><strong>8.6</strong></td>
<td>5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

- High total fruit species number in urban gardens
- High mean fruit species number in humid area
- Under-utilization of indigenous fruit trees
Beware of ignorance!

Transformation of mixed HGs into:
→ commercial vegetable gardens
→ cacao/coffee gardens

Sulawesi

Nuba Mountains, Sudan (partly promoted by NGOs)

Niamey
### Vit A & C: indigenous beat exotics

<table>
<thead>
<tr>
<th>Species</th>
<th>Vit C (mg/100 g)</th>
<th>Vit A (mg/100 g)</th>
<th>Iron (mg/100 g)</th>
<th>Calcium (mg/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Adansonia digitata</em></td>
<td>150-500</td>
<td>0.03-0.06</td>
<td>1.7</td>
<td>360</td>
</tr>
<tr>
<td><em>Grewia tenax</em></td>
<td>N.A.</td>
<td>N.A.</td>
<td>7.4</td>
<td>610</td>
</tr>
<tr>
<td><em>Tamarindus indica</em></td>
<td>3-9</td>
<td>0.01-0.06</td>
<td>0.7</td>
<td>260</td>
</tr>
<tr>
<td><em>Ziziphus mauritiana</em></td>
<td>70-165</td>
<td>0.07</td>
<td>1.0</td>
<td>40</td>
</tr>
<tr>
<td>Mango</td>
<td>28</td>
<td>0.04</td>
<td>0.1</td>
<td>10</td>
</tr>
<tr>
<td>Orange</td>
<td>51</td>
<td>0.07</td>
<td>0.2</td>
<td>54</td>
</tr>
</tbody>
</table>

Domestication of Agroforestry Trees

- Tree-to-tree variation within a village population
- Simple and appropriate propagation technology
- Creation of early fruiting, low stature, productive cultivars with high quality and uniformity
- Cultivar meeting market specifications
- Fruiting
Quantification of Important Traits

Fruit morphology

- Kernel mass
- Shell mass
- Flesh mass

Individual trees

Mass (g)

Medicinal properties

Elite trees for selection

Average % inhibition of PPAR-δ (primary product of arachidonic acid metabolism in cells)

Fruit morphology

Essential oils

Edible oils and fatty acids

Techniques allow multiple trait selection
50+ species under Domestication

* Some of these have been approved by EU Food Regulations
Participatory Tree Domestication (PTD)

Put simply PTD refers to:

the means communities select, propagate and manage high-value indigenous fruit trees and medicinal plants and integrate them in the various farming systems,

Species for domestication are mainly selected encompassing indigenous knowledge and genetic selection based on scientific principles.

A strong partnership is developed with scientists, civic authorities and private companies.
SPECIES UNDER DOMESTICATION

- **Kola nitida**
- **Ricinodendron heudelotii**
- **Irvingia gabonensis**
- **Gnetum africium**
Afrotyrax lepidophyllus

Monodora myristica

Garcinia cola (Bitter kola)

Zanthoxylum macrophylla
### Nutritional benefits of indigenous fruits

<table>
<thead>
<tr>
<th>Species</th>
<th><em>Dacroydes edulis</em> fruit (88% dm)</th>
<th><em>Irvingia gabonensis</em> kernels (88% dm)</th>
<th>Maize grain (86% dm)</th>
<th>Rice grain</th>
<th>Cassava tuber (30-35%dm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>14</td>
<td>26-39</td>
<td>66-76</td>
<td>46-59</td>
<td>24-31</td>
</tr>
<tr>
<td>Fats/oils</td>
<td>32</td>
<td>51-72</td>
<td>2-6</td>
<td>1-2</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Protein</td>
<td>26</td>
<td>7.4</td>
<td>5-14</td>
<td>4-8</td>
<td>1</td>
</tr>
<tr>
<td>Fibre</td>
<td>18</td>
<td>1</td>
<td>1-3</td>
<td>1-4</td>
<td>1-2</td>
</tr>
</tbody>
</table>

Data on micronutrients, fatty acids, etc. in Leakey 1999, *Food Chemistry* 64, 1-14.
Harvest periods of selected priority indigenous fruit/nut species of West and Central Africa.

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irvingia wombolu</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cola spp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dacryodes edulis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garcina kola</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irvingia gabonensis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ricinodendron heudelotii</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RURAL RESOURCE CENTERS

Innovative approach helping farmers to be exposed to updated technologies in domestication and agroforestry. Demonstration plots helping farmers to acquire skills in producing NTFPs and marketing knowledge.
The concept of Rural Resource Centres
Differences with the classical agricultural extension approach

More scope for joint research, adaptation, training, sharing and diffusion of good practices and technologies

Better partnership between research, civil society organisations and farmers

More flexibility in activities, room for testing and adaptation

Gradual development

Efforts to be self-sustaining
Infrastructure

- Training hall and offices
- Small library
- Tree nursery
- Agroforestry demonstration plots
Activities

Learning from each other during study visits

Exchanging planting material between resource centres

Experimenting together with farmers vegetative propagation techniques on species prioritised by communities
Why agroforestry?

- Agroforestry lets farmers **grow more food, fodder and fuel** while managing agricultural landscapes for critical ecosystem services - sustainably.
- Agroforestry helps **curb greenhouse gas emissions** by slowing the conversion of forest to farmland and by sequestering more carbon on farms (in trees and the soil).
- Agroforestry can involve **hundreds of highly nutritious species**, many of which are still relatively unknown.
Malawi is one of African 16 countries (April 2012) that are implementing or setting up National Evergreen Agriculture Action Plans, and the seat of the World Agroforestry Centre's Southern Africa hub.

Malawi National Agroforestry Food Security Programme
Gliricidia, a leguminous coppice tree, interplanted with maize. The leaves are cut and turned over into the topmost soil layer, providing nitrogen and other nutrients.
Fertilizer tree options: from the short to the long term

- Relay Fallow intercropping (grain yield: 2-3 tons)
- Improved Fallows (grain yield: 3-4 tons)
- Gliricidia / Maize intercropping (grain yield 3-5 tons)
- Faidherbia/ Maize intercropping (grain yield 3-5+ tons)

Waiting period before benefit accrues:
- 1 year
- 2 years
- 3 years
- 5+ years
What trees give to farms:

- Increased **crop nutrient availability** in rainfed food crop systems
- **Improved microclimate** and soil water relations conveying greater adaptation to climate change
- Increased and more stable **food crop productivity**
- Increased **food micronutrient** availability (fruits)
- Enhanced **dry season fodder** availability
- Dramatically **increased carbon accumulation** in food crop systems: 6-10 tons of CO$_2$ per hectare per year are common
- Enhanced **biodiversity**
- **Reduced deforestation** due to on-farm fuelwood and timber production
Because it works, agroforestry is spreading across Africa, both from the grassroots and through government programmes.

Because the defining feature of these agroforestry fields is that they carry living vegetation all year around, we call this "evergreen agriculture".

This spread must be hugely speeded up to meet the needs of tens of millions of smallholder farmers.
The evergreen agriculture vision:

- EverGreen Agriculture is emerging as an affordable and accessible science-based solution to regenerate the land on small-scale farms and increase family food production and cash income.

- EverGreen Agriculture is a form of more intensive farming that integrates trees with annual crops. The vision of EverGreen Agriculture is to sustain a green cover on the land throughout the year, increasing food and fodder production sustainably.

- EverGreen farming systems feature both perennial and annual species (trees and food crops). The overall indicator of their effectiveness is building a healthy soil and environment, while increasing the resilience of the farm enterprise to a variety of risks. They deliver extended growing seasons, increased productivity, better water utilization efficiency, and drought resilience.

- Millions of women and men farmers in Zambia, Malawi, Niger, Burkina Faso, and other countries are already practicing EverGreen Agriculture, successfully restoring exhausted soils with richer sources of organic nutrients, and dramatically increasing both their crop yields and incomes.

- More countries are joining the Evergreen Partnership almost monthly: see http://evergreenagriculture.net for details and regular updates.
Governments: 16 countries are now engaged in EverGreen Agriculture
Government example: in December 2011, the Ethiopian PM announces national plan to raise 100 million Faidherbia trees in farmers’ fields
What must be done?
Grassroots: agroforestry in West Africa is expanding too slowly
Existing systems are not recognised for what they are (ex: *Faidherbia* agroforest *in* Senegal)

What’s wrong with this picture?

All the trees are old and risk declining soon. These lands are not being managed for replacement tree growth.
Growing Evergreen Agriculture on farms

- Offer support to countries launching evergreen agriculture programmes:
  - Help establish the right policies
  - Technical support to define and establish best systems
  - Boost extension services reach and quality
  - Research, develop and support the implementation of scaling up and scaling out to many millions of smallholders
    - Support to pioneer farmers, to national extension services, to NGOs and INGOs
  - Encourage more partnerships between research, development, and private sector institutions
  - Help spread the idea of “trees on farms” further at national and international levels
Building the science of Evergreen Agriculture

• Grow the science by encouraging research partnerships across the region to tackle key questions:
  • Develop systems adapted to as many agroecological regions as are encountered
  • Resolving complex policy issues
  • Enhancing targeting & scaling-up
  • Ensure quality tree genetics and plentiful tree seed supplies
  • Enhance tree propagation and establishment
  • Adapt to integrated production systems
  • Estimate potentials for climate change adaptation
  • ...
  •
Conclusion

Agroforestry and EverGreen Agriculture are

• fresh, low-cost approaches to land regeneration and food security that have their roots in Africa and are spreading across the tropics and that are

• being adopted by millions of smallholders.

• Poor households should be targeted over large areas to end hunger on small farms; working in the

• many nations that are creating the policy and institutional environments to favor adoption.

• Research is critical to underpin the acceleration of more widespread adoption
For more information

Patrick Worms, World Agroforestry Centre
Email: p.worms@cgiar.org
Tel: +32 495 24 46 11

www.worldagroforestrycentre.org
www.worldagroforestrycentre.org/evergreen_agriculture
http://evergreenagriculture.net/about-evergreen-agriculture