Towards sustainable forest management in western Africa

Info cards from the BIODEV project

Sari Pitkänen, Petteri Packalén, Ruben Valbuena, Markus Melin, Yohama Puentes Rodrigues, Piritta Torssonen, Teemu Vilppö, Javier Arevalo, John M. Koroma, Alain Tota Traoré
About the booklet

This booklet provides summarys about the activities of WP 1.4 of the BIODEV project. The WP was headed by Dr. Sari Pitkänen from University of Eastern Finland, School of Forest Sciences. Its focus was on sustainable fuelwood management.

*Title of publication:* Towards sustainable forest management in West Africa

*Authors:*  
Sari Pitkänen, Petteri Packalén, Ruben Valbuena, Markus Melin, Yohama Puentes Rodrigues, Piritta Torssonen, Teemu Vilppö, Javier Arevalo, John M. Koroma, Alain Touta Traoré

*Cover photos / Page 2 photo:* Markus Melin  
*Additional photos* taken by authors

*Layout:* Piritta Torssonen

*Printed on 9th of May 2016 for the project:*  
BIODEV - Building Biocarbon and Rural Development in West Africa

*Printer:* Grano Oy, Joensuu
BIODEV project WP 1.4 research results are utilized to develop sustainable wood fuel management in Burkina Faso and Sierra Leone.

**Present state of forest resources**
- Field measurements in Burkina Faso and Sierra Leone
- Excel calculation tool

**Utilization of wood fuel**
- Improved cooking stoves
- Experiments of charcoal -> improving production methods
- Excel calculation tool

**Wood fuel production**
- CAF (quantity of wood at CAF vs. outside CAF)
- "Wood fuel plantations"
- Agroforestry for wood fuel
- Excel calculation tool

→ **Scenario analysis of wood fuel production and utilization**
BOTH COUNTRIES SUFFER FROM DRASTIC DEFORESTATION RATES AND THE CONSEQUENCES ARE VERY SERIOUS

Causes

In both countries, named causes of deforestation have been expansion of agriculture, over exploitation of wood resources, population growth and bad land use policies.

Consequences

As protective canopy is lost and as roots no longer bind the soil, the deforested land is very susceptible to erosion, which often results in land degradation. Biodiversity is lost for both plants and animals. Source for important fuelwood is lost for households and for the industry. Ultimately, if the deforested land gets degraded, the land becomes unusable for agriculture as well → source of food is lost. In 2010 FAO forest cover for Sierra Leone was 38.1 % and 20.6% for Burkina Faso. Since then, the number has been further declining.
Between 1990 and 2010, Burkina Faso lost an average of 59,900 ha or 0.87% per year. In total, between 1990 and 2010, Burkina Faso lost 17.5% of its forest cover, or around 1,198,000 ha.

At the same time, Sierra Leone lost an average of 19,600 ha or 0.63% per year. In total, between 1990 and 2010, Sierra Leone lost 12.6% of its forest cover, or around 392,000 ha. From the 1950’s, the loss is over 70%.

Figure 1. Forest is lost much more than new one is planted in both countries. For Sierra Leone, the situation regarding forest loss is even more serious.
EXPERTS' ASSESSMENT ON WOOD FUELS IN BURKINA FASO

Table 1. Updated key information related to Energy in Burkina Faso

<table>
<thead>
<tr>
<th></th>
<th>Amount</th>
<th>(Year; Source)</th>
<th>Annual change (%)</th>
<th>(Year; Source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>17,590,000</td>
<td>(2014; WB 2016)</td>
<td>+ 2.9</td>
<td>(2014; WB 2016)</td>
</tr>
<tr>
<td>Urbanisation rate (%)</td>
<td>29</td>
<td>(2014, DESA 2014)</td>
<td>+ 5.87</td>
<td>(2010-2015; DESA 2014)</td>
</tr>
<tr>
<td>Energy consumption (toe)</td>
<td>1,857,600</td>
<td>(EASYPOL 2007)</td>
<td>+ 1.6</td>
<td>(2010; US EIA 2013)</td>
</tr>
<tr>
<td>Wood fuel production in m$^{3}$ (incl. wood for charcoal)</td>
<td>13,520,146</td>
<td>(2014; FAOSTAT 2015)</td>
<td>+ 1.4</td>
<td>(2011-2014; FAOSTAT 2015)</td>
</tr>
<tr>
<td>Charcoal production (tonnes)</td>
<td>654,594</td>
<td>(2014; FAOSTAT 2015)</td>
<td>+ 2.8</td>
<td>(2011-2014; FAOSTAT 2015)</td>
</tr>
</tbody>
</table>

Underlying drivers:

1. Poverty
2. Increasing Population
3. Lack of alternative energy sources
4. Unsound policies and lack of economic resources

Drivers of Deforestation:

1. Agriculture Expansion
2. Woodfuel exploitation
3. Land Deals
4. Droughts
Table 2. Categorized opportunities for wood fuel governance improvement (as cited by local experts)

**Alleviate rural poverty:** intensification of agriculture; NTFP promotion, promotion of assisted natural regeneration and agro forestry, development of policies to promote rural jobs.

**Improve natural resource management governance:** effective decentralization and community empowerment; changes in regulations; improve monitoring and fight corruption; improve regional and national cooperation

**Invest in resources:** training of stakeholders on SFM; promote scientific studies and capacity; address material needs

**Increase sustainable wood fuel production:** expansion of forest management units (CAFs); revise CAF management

**Energy efficiency:** improve charcoal conversion technique; promotion of ICS (Photo 2) and studies on their adoption; sensitization of rural population on rational energy use

**Alternative energies:** LPG and solar promotion; regional energy strategy; biogas and biofuels.

References:


EASYPol (2007). Analyse des impacts financiers et économiques de la filière bois-énergie organisée approvisionnant la ville de Ouagadougou [Analysis of the financial and economic impacts of the organization of supply of bioenergy for Ouagadougou].


Drivers of Deforestation in Sierra Leone

- Agricultural expansion
- Woodfuels
- Timber logging
- Urbanization
- Mining
- Hunting
- Rattam

Underlying Drivers:
1. Population growth
2. Poverty
3. Migration
4. Unsound policies

Methodology:
Literature review on relevant information connected to Energy in Sierra Leone (Table 1).
17 in-depth interviews to energy experts in the country. Most relevant information is summarized here.

Table 1. Updated key information related to Energy in Sierra Leone

<table>
<thead>
<tr>
<th></th>
<th>Amount</th>
<th>(Year; Source)</th>
<th>Ann. change%</th>
<th>(Year; Source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>6,316,000</td>
<td>(2014; WB 2016)</td>
<td>+ 2.2</td>
<td>(2014; WB 2016)</td>
</tr>
<tr>
<td>Urbanisation rate (%)</td>
<td>39.6</td>
<td>(2014; DESA 2014)</td>
<td>+ 2.75</td>
<td>(2010-2015; DESA 2014)</td>
</tr>
<tr>
<td>Woodfuel production (m3)</td>
<td>5,749,270</td>
<td>(2014; FAOSTAT 2015)</td>
<td>+ 0.8</td>
<td>(2011-2014; FAOSTAT 2015)</td>
</tr>
<tr>
<td>Charcoal production (tonnes)</td>
<td>421,577</td>
<td>(2014; FAOSTAT 2015)</td>
<td>+ 2.5</td>
<td>(2011-2014; FAOSTAT 2015)</td>
</tr>
</tbody>
</table>
Table 2. Categorized recommendations for wood fuels governance improvement in Sierra Leone (as cited by local experts)

<table>
<thead>
<tr>
<th>Alleviate rural poverty:</th>
<th>intensification of agriculture; swamps interventions for production (i.e. rice); promotion of agro forestry, development of policies to promote rural jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve natural resource management governance: community empowerment; changes in regulations; improve monitoring and fight corruption; improve regional and national cooperation</td>
<td></td>
</tr>
<tr>
<td>Invest in resources: training of stakeholders on SFM; promote scientific studies and capacity; address material needs</td>
<td></td>
</tr>
<tr>
<td>Increase sustainable wood fuel production: Implementation and proper management of wood lots, revise current forest management; national forest inventory</td>
<td></td>
</tr>
<tr>
<td>Energy efficiency: comprehensive energy plan, improve charcoal conversion technique; promotion of Improved Cook Stoves and studies on their adoption</td>
<td></td>
</tr>
<tr>
<td>Alternative energies: LPG and solar promotion; regional energy strategy; subsidies for alternative energies</td>
<td></td>
</tr>
</tbody>
</table>

References:
Methodology:
Literature review on relevant information connected to fuelwood value chain processes in Burkina Faso.

84 interviews to related fuelwood value chain stakeholders. Thus, harvesters, collectors and consumers (in Cassou) and transporters, traders and consumers (in Ouagadougou).

Figure 1. Fuelwood Value Chain for Ouagadougou and Cassou. n.a. = not answered

Most preferred tree species for fuelwood:
1. Detarium microcarpum
2. Crossopterix febrifuga
3. Anogeissus leocarpus
4. Pterocarpus erinaceus
5. Terminalia sp
6. Vitellaria paradoxa

Figure 2. Main Challenges faced by firewood value chain actors in Burkina Faso
Table 1. Main characteristics of Fuelwood Value Chain in Ouagadougou and Cassou area

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>MAIN CHARACTERISTICS</th>
</tr>
</thead>
</table>
| HARVESTING (Cassou) | • Mainly men  
                        • 100% belong to association  
                        • Main occupation: farmers  
                        • FW is harvested from CAFs  
                        • FW harvested per day: 4.9 steres  
                        • FW sold at 978 FCFA/stere (1.67 US$)  
                        • Self consumption: about ½ of harvested FW |
| COLLECTING (Cassou) | • Mainly men  
                        • 85% belong to association  
                        • Main occupation: farmers  
                        • FW collected per day: 5.2 steres  
                        • FW sold and price: 2.4 stere/day at 1055 FCFA/stere (1.80 US$)  
                        • Self consumption: about ½ of collected FW |
| TRANSPORTATION (Ouagadougou) | • Mainly women  
                        • 21% belong to association  
                        • Main occupation: wood sellers  
                        • FW transported: 1.3 stere/day  
                        • FW bought at: 93 254 FCFA/stere (159 US$)  
                        • FW sold: 1.4 stere/day at 279 703 FCFA/stere (479 US$)  
                        • Self consumption: less than ½ of transported FW |
| TRADE (Ouagadougou) | • Mainly women  
                        • 7% belong to association  
                        • Main occupation: wood sellers  
                        • FW bought at: 102 273 FCFA/stere (175 US$)  
                        • FW sold: 112 664 FCFA/stere (193 US$)  
                        • Self consumption: n.a |
| CONSUMPTION (Cassou and Ouagadougou) | • Mainly women  
                        • Main occupation: pito sellers, housewives, etc.  
                        • FW consumption: FW: 0.3 stere/day at 952 FCFA/stere (1.63 US$) |
In order to manage forests in a sustainable manner, information is needed about the forest structure, which can be gained through field measurements.

The BIODEV field measurements were done along with LDSF* measurements. 160 plots in a 10 x 10km grid, placed in 10 plot clusters (Fig. 2). One plot consisted of a big plot (0.1 ha) and sub-plots (0.01 ha) (Fig. 3).

From the big plots, every tree with a DBH > 10 cm was counted and the DBH measured. Height was measured for the smallest, the largest and for the median tree in relation DBH. Downed- and standing dead-trees were also measured and counted.

From the sub-plots, every tree/shrub, which had a DBH between 4 and 10 cm was counted. Their species were identified and DBH and height were measured for the median DBH tree.

Burkina Faso field measurements were completed between 1.12.2013 and 1.5.2014. Sierra Leone between 1.3. and 1.7.2014.

The field measurements gave valid information about the tree species distributions and the forest structure. This information was then used to derive attributes such as tree density, volume, amount of log wood, amount of fuel wood etc. This information was highly valuable when assessing the potentials for sustainable forest management and fuel wood use.

**DBH was measured** with diametertapes and calipers from the height of 1.3 meters (Fig. 5).

**Height was measured** with a Suunto hypsometer (Fig. 5).

**Plot coordinates were measured** and stored with Garmin Nüvi portable GPS-device (Fig. 6).

### KEY FIGURES BASED ON THE FIELD MEASUREMENTS

<table>
<thead>
<tr>
<th></th>
<th><strong>BURKINA FASO</strong></th>
<th><strong>SIERRA LEONE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average DBH (cm)</strong></td>
<td>Min 0 Max 40</td>
<td>Mean 14.5</td>
</tr>
<tr>
<td><strong>Average height (m)</strong></td>
<td>0    Max 11.7</td>
<td>Mean 6.2</td>
</tr>
<tr>
<td><strong>Average volume (m3/ha)</strong></td>
<td>0    Max 62</td>
<td>Mean 17</td>
</tr>
<tr>
<td><strong>Average stem count (trees/ha)</strong></td>
<td>0 1935 Max 470</td>
<td>Mean 533</td>
</tr>
</tbody>
</table>

**Most common tree species**

**BURKINA FASO**
- Anogeissus leiocarpus
- Vitellaria paradoxa
- Detarium microcarpum
- Burkea africana
- Combretum molle

**SIERRA LEONE**
- Pterocarpus erinaceous
- Gmelina arborea
- Combretum glutinosum
- Terminalia glaucescens
- Piliostigma thonningii

**Number of identified tree/shrub species**
- 54 (BURKINA FASO)
- 92 (SIERRA LEONE)
Improvements to current charcoal production methods would increase charcoal yield and reduce pressure to forests.

**IMPROVEMENTS TO BIOCHAR PRODUCTION METHODS:**

1. **Dry raw material**
   Raw material should be dried before processing to avoid energy and mass loss to boiling water in wood.

2. **Controlling raw material dimensions**
   Uniform dimensions of raw material to produce higher quality charcoal (“Finger rule”).

3. **Raw material selection and stacking**
   Proper selection of raw material (tree species) and stacking it right order decreases charcoal processing time, but increases charcoal yield.

Right dimensions for charcoal production "Finger rule": if fingers don’t cross (A) then split the wood (B).

- A) Too BIG size
- B) Right size
STUDY TO IMPROVE CHARCOAL YIELDS

**Pyrolysis process:**
- Pyrolysis reactor:
  - 10 liter stainless steel container
  - automatized process
- Final test temperatures:
  - 275°C and 350 °C
- Studied variables:
  - gross and net calorific value
  - mass and energy yields
  - moisture and ash content

**Sample tree species:**
Species were delivered from Sierra Leone
- *Afzelia africana* (AA)
- *Acacia manigium* (AM)
- *Dialium guineesis* (DG)
- *Gmelina arborea* (GA)
- *Lophira lanceolata* (LL)

Aims to improve production process to produce good and uniform quality charcoal

**FINDINGS**
Acacia manigium was the best tested species for improving energy yield in biochar production process (Fig. 1). It was also easy to control during pyrolysis process. *Afzelia africana* and *Dialium guineesis* are good for initiating the pyrolysis process because they ignite easily.

Fig. 1 Biochar process nominal temperature 275 °C (Fig. 1A) and 350 °C energy yield and mass yield expressed as % of raw material dry matter.
DEVELOPING CHARCOAL PRODUCTION: barrel pyrolizer AND INTRODUCING MIDGE

BARREL PYROLIZER

1. It will give better control of charcoal production process compared to conventional earthen mound method
2. It is easy to multiply to increase production capacity (no need to increase dimensions)
3. One load takes 70 kg of dry wood and provide optimally 30 kg of charcoal
4. It will significantly shorten the charcoal production process (estimated 6 to 12 hours total)
5. Heat of process is possible to use e.g. for cooking

- Steel barrel with tight lid
- A kiln for barrel
- Fire place at the bottom
- Tube inside barrel to let fumes escape down to fire
- Safety vent at lid to release pressure

- Process can be controlled by the fire for heating and barrel can be taken out of the kiln for cooling
- If pressure builds up too high inside the barrel it lifts the cap and vents fumes and prevents explosion
- Optimal raw material is dry wood less than 10% moisture content and processing temperature just about 300°C with 6 hours time.
- If raw material is wet, low density, and process is controlled badly process may provide 15 kg charcoal from 100kg wet weight wood.
The MIDGE (Modified Inverted Downdraft Gasifier Experiment) is the simplest, cheapest gasifier camp stove to make.

Inventor of MIDGE is Arthur Noll See detailed construction instructions: http://www.instructables.com/id/MIDGE-gasifier-campstove/

Needed equipments:
- 4 different sizes of cans
- 5-10 screws, metal wire
- Cutting pliers
- Hammer
- Punches with flat, pointed round hole heads
- Construction time about 1 hour

The MIDGE was tested with wood chips and charcoal to boil water.

Based on results wood chips is better fuel for the MIDGE as getting temperatures high enough to boil water required external draft and it is poorly suited to use charcoal as fuel.

The MIDGE is well suited to use small diameter and particle size biomass as fuel and combust it in clean and efficient manner.
**IMPROVED STOVES**

Technology that is easy to conceive and use, and is able to highly reduce energy, compared with the traditional three stones, in the same using conditions when talking about cooking food.

It is important to keep the natural resources in a sustainable limits by e.g. using cooking tools that reduce the consumption of firewood.

**Types of improved stoves:**
- Clay improved stove
- Ceramic improved stove
- Metallic improved stove
- Self cookers
IMPROVED THREE STONES STOVES (I3SS) TRAINING IN VRASSAN, KOU, DAO AND CASSOU AT 15.-16.11. and 29.11.-2.12.2014

Tiipaalga and University of Eastern Finland organized a training session for 21 women of 4 villages (Cassou, Vrassan, Gao and Kou) about the building technique, the using and the keeping of the I3SS. It was for sharing of experiences and bringing a positivity in the sustainable development of the forest and to reduce firewood consumption by households in the area in which the project has been realized.

Material for building the I3SS:
- clay (termitarium or any other clay that is elastic enough)
- cowpat or donkey dung
- straw
- stones
- water

I3SS made with clay compared to the traditional three stones stove allows to:
- Reduce or use less wood to cook food
- Canalize the heat produced by the combustion of the wood on the pot,
- Reduce the smoke because the combustion of wood is done in the best way
- Cook quickly
- Keep the heat in the stove even after the end of the cooking
- Protect women against the burnings while cooking
- Protect the fire against the wind and this ameliorate the quality of the combustion of wood.
WOODLOT TO PROVIDE ENERGY AND FOOD

WOODLOT

Provides the needed energy and food for the rural people.

John Koroma’s example of woodlot

John has planted successfully different tree and crop species to his woodlot. While he gets firewood from his woodlot, he gets e.g. pepper and beans for food. John established his woodlot in 2014, when he planted there Acacia and Gmelina arborea trees, pepper, beans and pineapples.

John says: “It is very encouraging how land have recovered for food and wood production and growth rates are very promising!”
### WOODLOT

<table>
<thead>
<tr>
<th>PLOT</th>
<th>3</th>
<th>2</th>
<th>4</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
</table>

### TABLE 1. PEPPER

<table>
<thead>
<tr>
<th>PLOT</th>
<th>DATE</th>
<th>NO. OF CUPS HARVESTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 4</td>
<td>20-09-2014</td>
<td>½-3 CUPS</td>
</tr>
<tr>
<td>1 - 4</td>
<td>26-09-2014</td>
<td>1-5 CUPS</td>
</tr>
<tr>
<td>1 - 4</td>
<td>10-10-2014</td>
<td>1-10 CUPS</td>
</tr>
<tr>
<td>1 - 4</td>
<td>2-11-2014</td>
<td>2½-15 CUPS</td>
</tr>
<tr>
<td>1 - 4</td>
<td>20-11-2014</td>
<td>2-12 CUPS</td>
</tr>
<tr>
<td>1 - 4</td>
<td>5-12-2014</td>
<td>1-8 CUPS</td>
</tr>
<tr>
<td>1 - 4</td>
<td>27-12-2014</td>
<td>1-3 CUPS</td>
</tr>
</tbody>
</table>

### CROPS

**Pepper** (see Table 1)

**Beans**
- Planting period: August 24 – September 10, 2014
- Harvesting period: November 18 – December 15, 2014

**Pineapple**
- Planting period: October 5 – 20, 2014
- Harvesting period: after 2 years of planting (2016)

### TREE SPECIES

**Acacia** (plot 1)

**Gmelina arborea** (plots 2-4)

**Pruning:**
- 1st September 5, 2014
- 2nd November 25, 2014
- 3rd February 5, 2015
- 4th June 15, 2015
- 5th August 25, 2015
- 6th October 18, 2015
- 7th January 5, 2015

Trees are planted for fuelwood. Prunned branches can already be used for fuelwood.
The development goal of the program is to achieve sustainable rural development with long term livelihood and environmental benefits to rural populations and the global community under climate change through high value biocarbon approaches.

University of Eastern Finland is coordinating WP 1.4 to improve fuel wood use efficiency and develop sustainable wood energy systems.

**HIGH VALUE BIOCARBON DEVELOPMENT**

Building biological or natural carbon through improved agroforestry and forestry management and tree planting, which are used to derive a broad range of development and environmental outcomes.

---

**Contact information of WP 1.4**

University of Eastern Finland, Faculty of Science and Forestry, School of Forest Sciences

Dr Sari Pitkänen, coordinator, sari.k.pitkanen@uef.fi
Dr Petteri Packalen, petteri.packalen@uef.fi
Dr Ruben Valbuena, rubenval@uef.fi
Dr Markus Melin, markus.melin@uef.fi
Dr Yohama Puentes Rodrigues, yohama.puentes@uef.fi
Dr Piritta Torssonen, piritta.torssonen@uef.fi
MSc Teemu Vilppo, teemu.vilppo@uef.fi

University of Helsinki
Dr Javier Arevalo, javier.arevalo@helsinki.fi

Njala University, Department of Physics and Computer Science, School of technology
John M. Koroma, johnkoroma2013@gmail.com (Info card x)

Tiipaalga, Burkina Faso
Alain Tousa Traoré, info@tiipaalga.org
Photos from miscellaneous BIODEV activities