Towards sustainable forest management in western Africa

Info cards from the BIODEV project

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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

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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

SUSTAINABLE WOODFUEL MANAGEMENT





SUSTAINABLE WOODFUEL MANAGEMENT

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 calculaton tool

→ **Scenario analysis of wood fuel production and utilization**



DEFORESTATION IN BURKINA FASO AND SIERRA LEONE

Info Card 1

SLASH AND BURN AGRICULTURE IN SIERRA LEONE

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.

FOREST CLEARED FOR AGRICULTURE IN BURKINA FASO

Numbers (FAO)

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%.

http://earthenginepartners.appspot.com/science-2013-global-forest

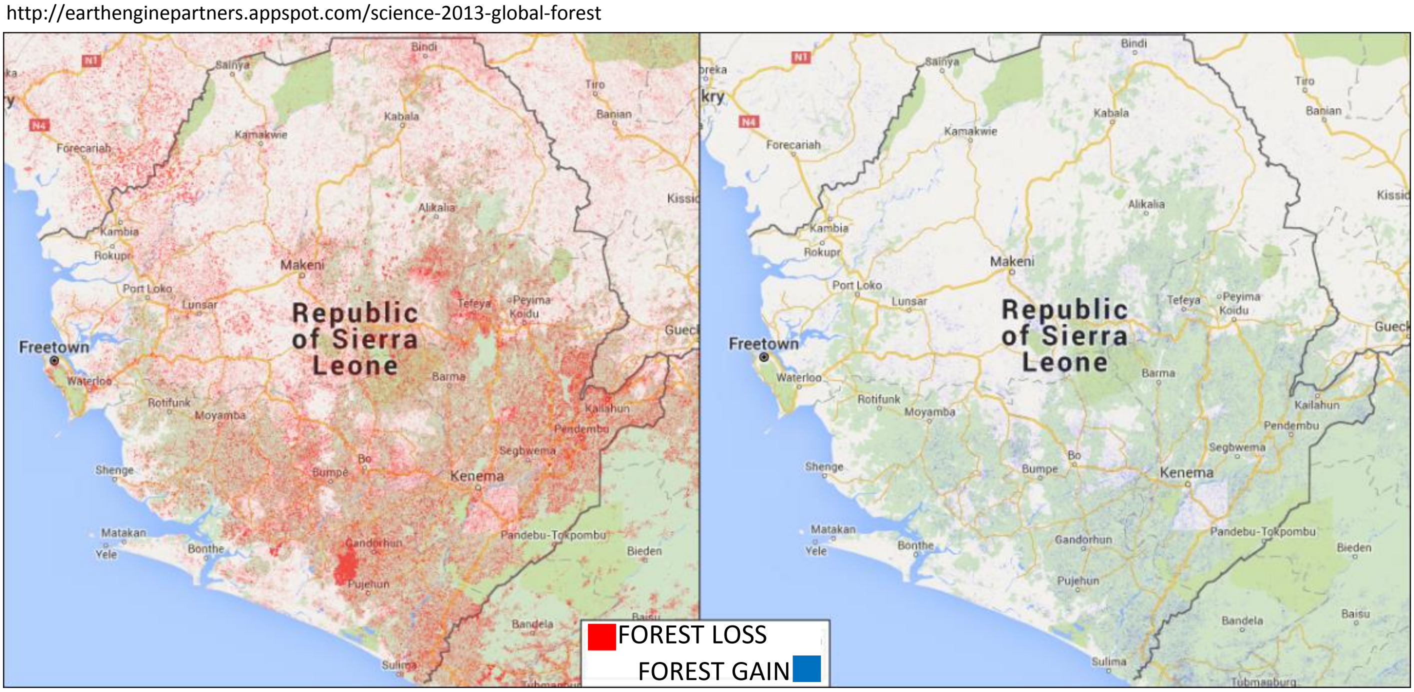

Figure 1. Forest is lost much more than new one is planted in both counries. For Sierra Leone, the situation regarding forest loss is even more serious

Underlying drivers

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

Drivers of Deforestation

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

	Amount	(Year; Source)	Annual change (%)	(Year; Source)
Population	17,590,000	(2014; WB 2016)	+ 2.9	(2014; WB 2016)
Urbanisation rate (%)	29	(2014, DESA 2014)	+ 5.87	(2010-2015; DESA 2014)
Energy consumption (toe)	1,857,600	(EASYPOL 2007)	+ 1.6	(2010; US EIA 2013)
GNI per capita (US $)	700	(2014; WB 2016)	+ 4.4	(2014; WB 2016)
Wood fuel production in m^3 (incl. wood for charcoal)	13,520,146	(2014; FAOSTAT 2015)	+ 1.4	(2011-2014; FAOSTAT 2015)
Charcoal production (tonnes)	654,594	(2014; FAOSTAT 2015)	+ 2.8	(2011-2014; FAOSTAT 2015)

Figure 2. FAFASO's representative showing different ICS. Photo: Arevalo.

Methodology:
Literature review on relevant information connected to Energy issues in Burkina Faso (Table 1)
13 in-depth interviews to energy experts in the country. Most relevant information is summarized here.

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.

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FAOSTAT (2015). Online Database. FAO, Rome. http://faostat3.fao.org/home/E
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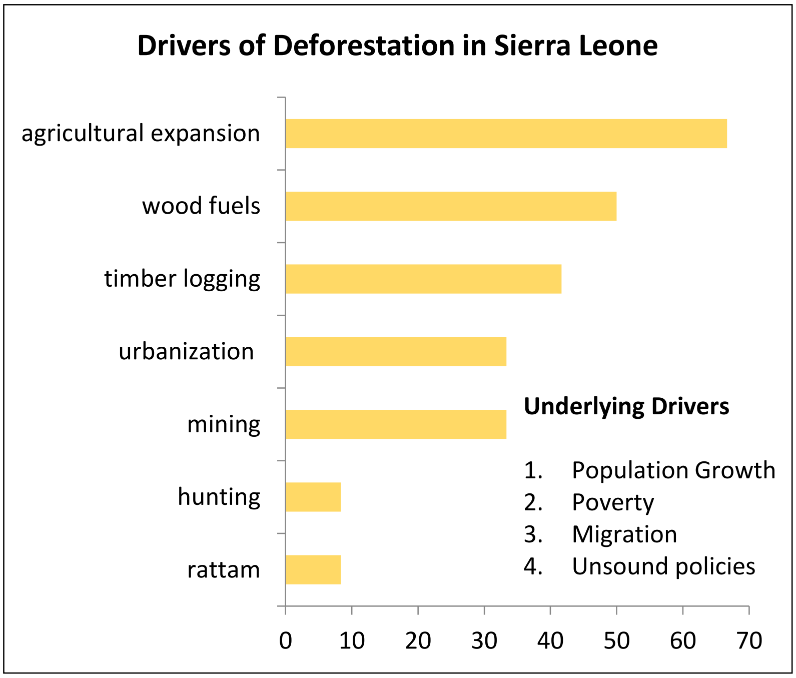
World Bank (2016) Databank. http://data.worldbank.org/

EXPERTS' ASSESSMENT ON WOOD FUELS IN SIERRA LEONE

Info Card 3



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

	Amount	(Year; Source)	Ann. change%	(Year; Source)
Population	6,316,000	(2014; WB 2016)	+ 2.2	(2014; WB 2016)
Urbanisation rate (%)	39,6	(2014; DESA 2014)	+ 2.75	(2010-2015; DESA 2014)
Energy Consumption (toe)	1,464,940	(2011; UNDP 2012)	+ 1.7	(2006-2011; UNDP 2012)
GNI per cap (US $)	700	(2014; WB 2016)	+ 13.3	(2011-2014; WB 2016)
Woodfuel production (m3)	5,749,270	(2014; FAOSTAT 2015)	+ 0.8	(2011-2014; FAOSTAT 2015)
Charcoal production (tonnes)	421,577	(2014; FAOSTAT 2015)	+ 2.5	(2011-2014; FAOSTAT 2015)

Table 2. Categorized recommendations for wood fuels governance improvement in Sierra Leone (as cited by local experts)

Alleviate rural poverty: intensification of agriculture; swamps interventions for production (i.e. rice); promotion of agro forestry, development of policies to promote rural jobs
Improve natural resource management governance: 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: Implementation and proper management of wood lots, revise current forest management; national forest inventory
Energy efficiency: comprehensive energy plan, improve charcoal conversion technique; promotion of Improved Cook Stoves and studies on their adoption
Alternative energies: LPG and solar promotion; regional energy strategy; subsidies for alternative energies

References:

DESA (2014). United Nations, Department of Economic and Social Affairs, population division (2014). World Urbanization Prospects: The 2014 Revision.

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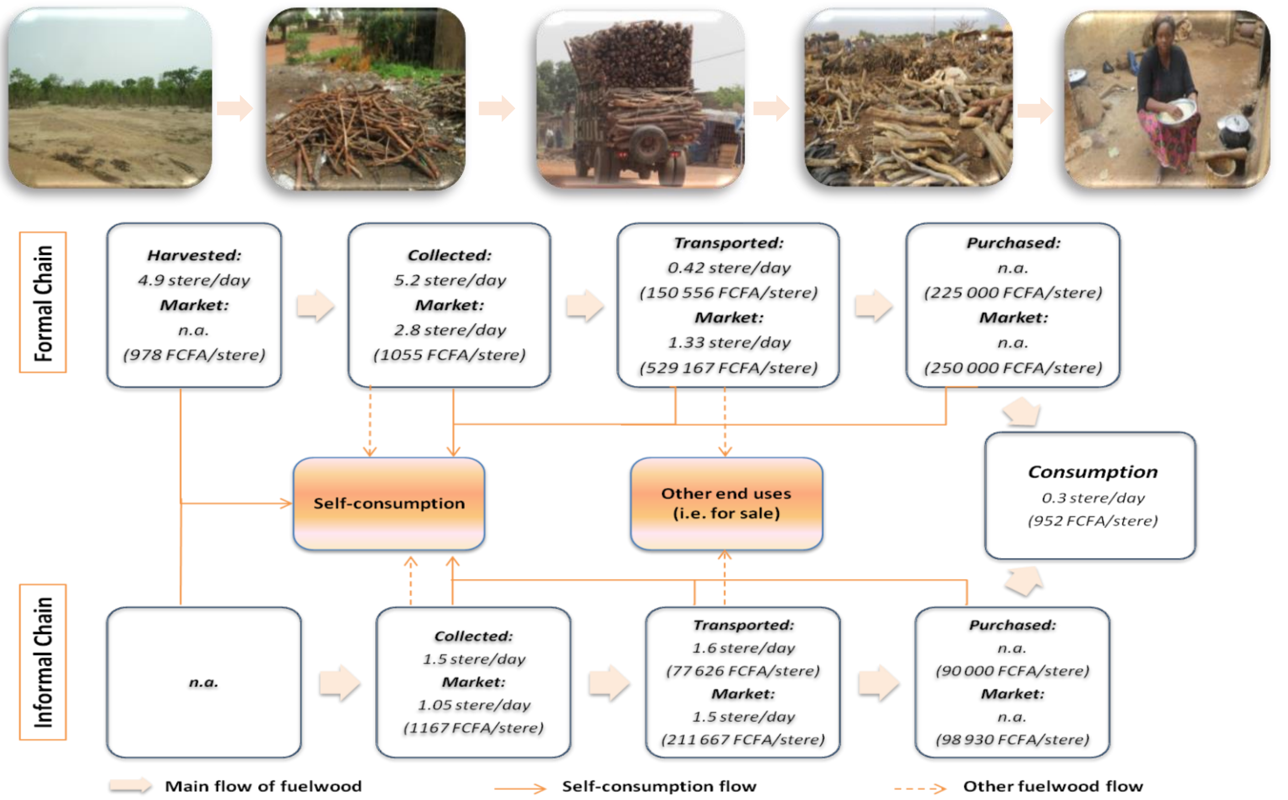
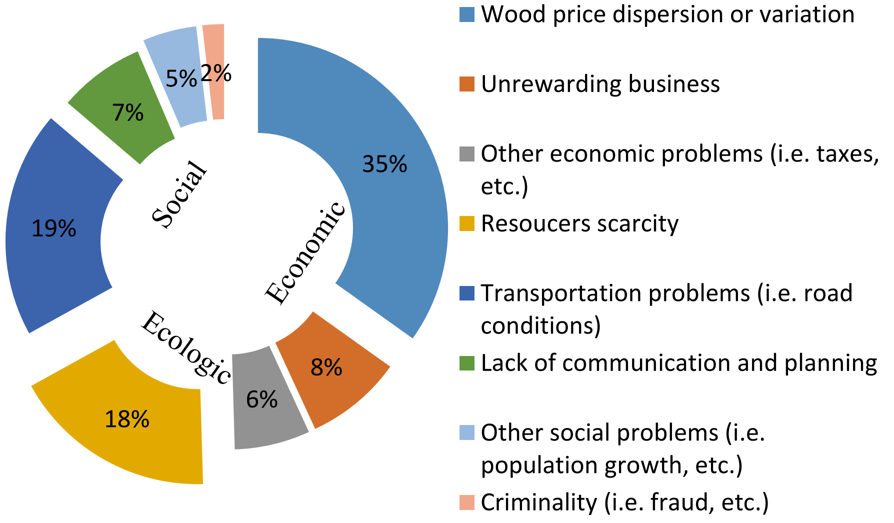


Figure 1. Fuelwood Value Chain for Ouagadougou and Cassou. n.a.= not answered

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).



Most prefered tree species for fuelwood:

1. *Detarium microcarpum*
2. *Crossopterix febrifuga*
3. *Anogeisus 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

PROCESS	MAIN CHARACTERISTICS
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$)

FIELD MEASUREMENTS IN SIERRA LEONE AND BURKINA FASO

Info card 5

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.

Figure 1

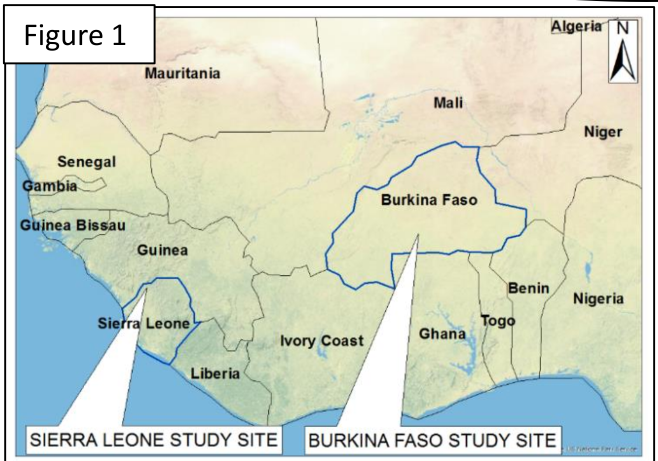


Figure 2

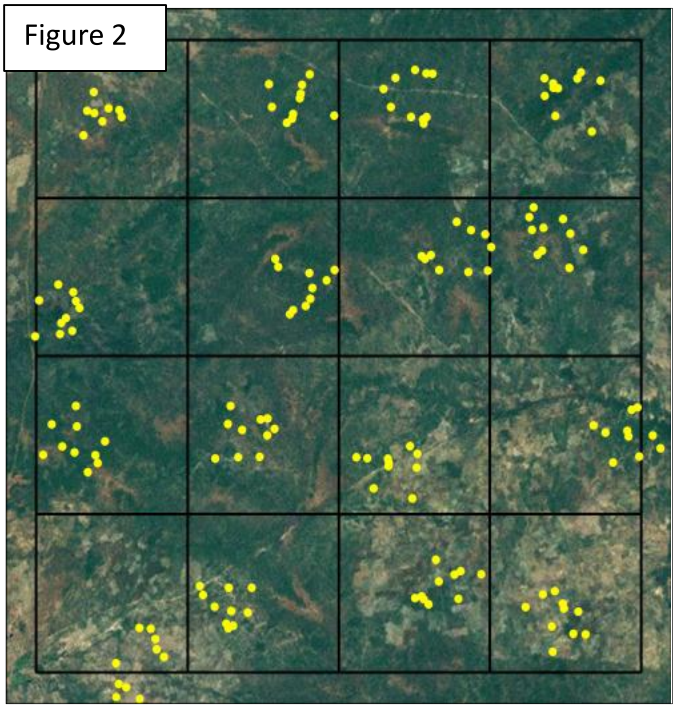
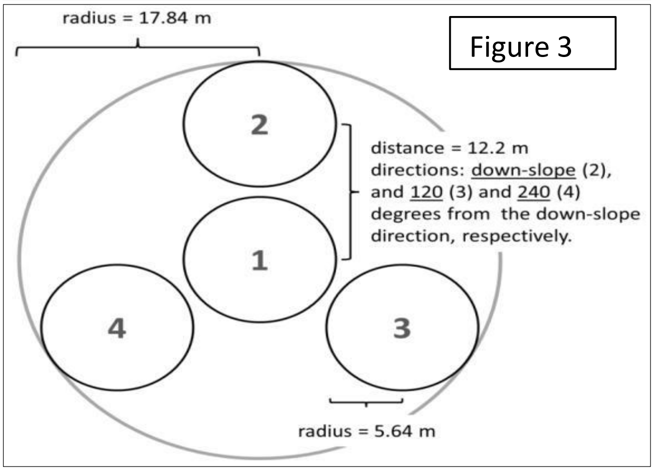


Figure 3



**Land Degradation Surveillance Framework* –

Vågen T, Winowiecki L, Desta LT, Tondoh JE. The land degradation surveillance framework field guide 2010.

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).

Figure 4

Figure 5

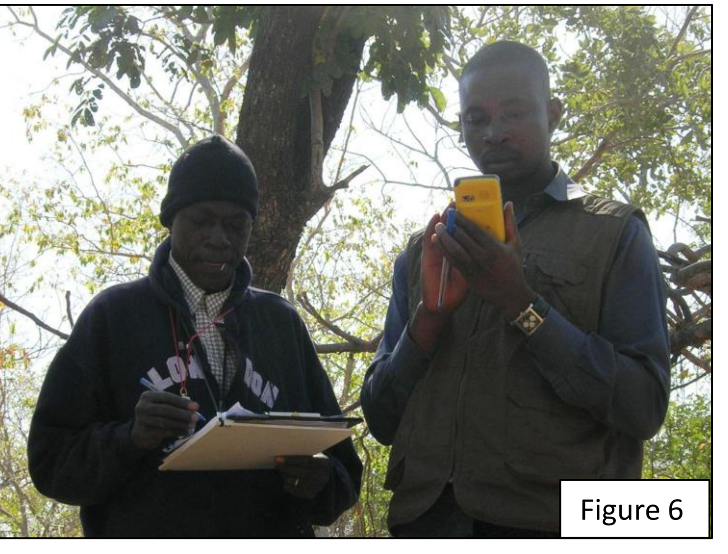


Figure 6

KEY FIGURES BASED ON THE FIELD MEASUREMENTS	BURKINA FASO				SIERRA LEONE			
	Min	Max	Mean	Median	Min	Max	Mean	Median
Average DBH (cm)	0	40	14.5	11	0	62	15.5	14.3
Average height (m)	0	11.7	6.2	6	0	15.8	8.2	8
Average volume (m3/ha)	0	62	17	16.1	0	325	60	54
Average stem count (trees/ha)	0	1935	470	533	0	3554	635	552

	BURKINA FASO	SIERRA LEONE
Most common tree species	*Anogeissus leiocarpus* *Vitellaria paradoxa* *Detarium microcarpum* *Burkea africana* *Combretum molle*	*Pterocarpus erinaceous* *Gmelina arborea* *Combretum glutinosum* *Terminalia glaucescens* *Piliostigma thonningii*
Number of identified tree/shrub species	54	92

IMPROVED METHODS FOR CHARCOAL PRODUCTION

Info Card 6

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 stackign it right order decreases charcoal processing time, but increases charcoal yield.

Improvements to current charcoal production methods would increase charcoal yield and reduce pressure to forests.

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

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.

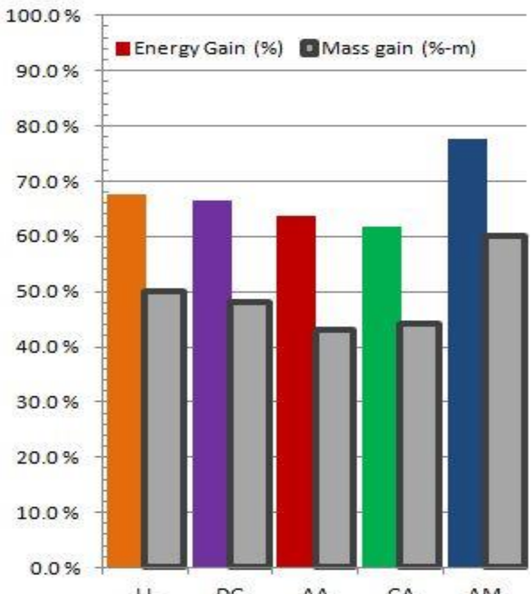


Fig. 1 A

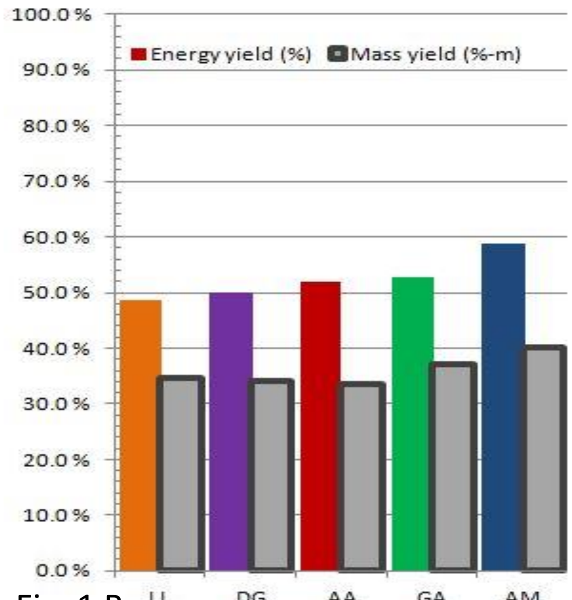


Fig. 1 B

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.

- ✓ 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

BARREL PYROLIZER

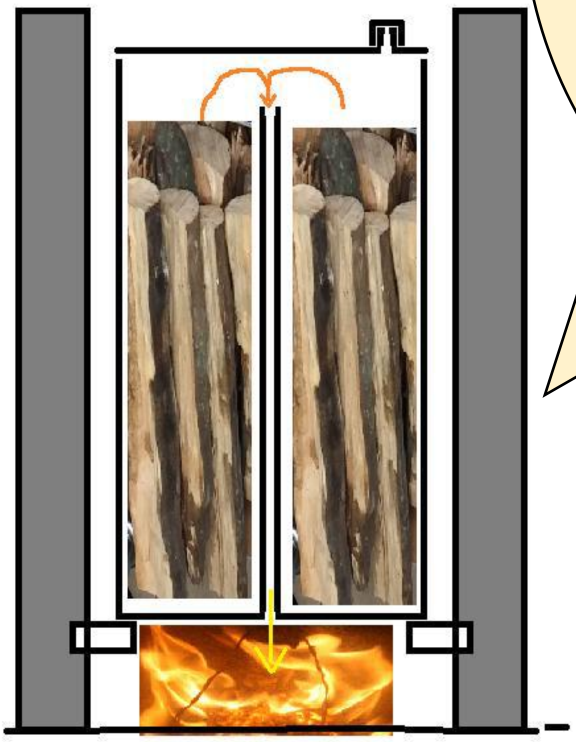
1. It will give better control of charcoal production process compared to conventional earthen mound method

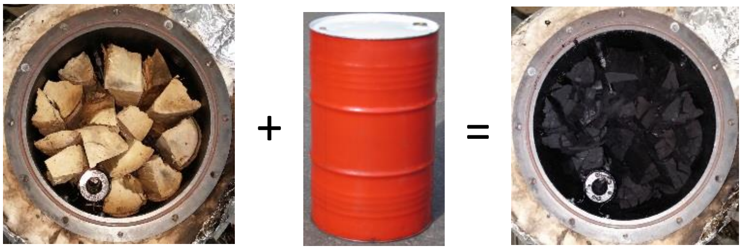
2. It is easy to multiply to increase production capacity (no need to increase dimensions)

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





- ✓ 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 wents fumes and prevents explosion
- ✓ Optimal raw material is dry wood less than 10% moisture content and processing temperature just about 300°Cwith 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.

MIDGE

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

Provides the needed energy and food for the rural people.

John Koroma’s example of woodlot

John has planted succesfully 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

PLOT 3	PLOT 2
PLOT 4	PLOT 1

TABLE 1.	PEPPER	
PLOT	**DATE**	**NO. OF CUPS HARVESTED**
1 - 4	20-09-2014	½-3 CUPS
1 - 4	26-09-2014	1-5 CUPS
1 - 4	10-10-2014	1-10 CUPS
1 - 4	2-11-2014	2½-15 CUPS
1 - 4	20-11-2014	2-12 CUPS
1 - 4	5-12-2014	1-8 CUPS
1 - 4	27-12-2014	1-3 CUPS

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
- Harvestin period: after 2 years of planting (2016)

TREE SPECIES

Acacia (plot 1)

Gmelina arborea (plots 2- 4)

Prunning:
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.

BIODEV

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.

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Notes

Photos from miscellaneous BIODEV activities