

Sustainable Woodfuel (charcoal and firewood) Systems in Tanzania

A Grassroots Training Manual



October 2018



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ACKNOWLEDGEMENT

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This manual has been compiled by: Njenga, M., Gasaya, O., Sabrina, C., Pesha, I., Jilala, Z., Pangal, R. Frumence, R., Chikawe, M., and Kimaro, A. Cover photo: charcoal in bags for transportation by bicycle in Mtwara, Tanzania, taken in March, 2017 by Mary Njenga.

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OBJECTIVES OF THE TRAINING

- Co-learning on systems approach and innovations for sustainable woodfuel among stakeholders involved in various aspects of the wood fuel systems at the grassroots level
- Gathering ideas about the content and delivery options for grassroots courses.

LESSONS, MODE OF DELIVERY AND RESPONSIBILITIES

This manual comprises of 6 modules which are delivered through lectures, discussions and demonstration and delivered through both trainers and trainees through a co-learning approach. The trainings are carried out at the grassroots level by the graduates of the trainers' course supported by other resource persons as required.

The training starts by a planning session that indicates the day and time of the training and the facilitators and trainees' responsibilities.

Table 1. Lessons on sustainable woodfuel systems, mode of delivery and responsibilities

Module	Lessons and mode of delivery	Date/Time	Facilitator
1	<p>Introduction to sustainable woodfuel systems</p> <p>1.0 Background information including woodfuel and the need to make it sustainable 2.0 Woodfuel systems approach 2.1 Components of woodfuel system, changes over time and gender differentiated roles in the woodfuel system 2.2 Components of woodfuel sustainability</p> <p><u>Delivery:</u> This lessons involves a lecture using the manual, questions and answer session and examples from the trainers and trainees from real live situations.</p>		
2	<p>Causes and effects of unsustainable woodfuel systems</p> <p>3.0 Causes and effects of unsustainable woodfuel systems</p> <p><u>Delivery:</u> This lessons involves a lecture using the manual, questions and answer session and examples from the trainers and trainees from real live situations.</p>		
3	<p>Interventions to make woodfuel systems</p> <p>4.0 Interventions to make woodfuel systems 4.1 Sustainable wood production for woodfuel</p> <p><u>Delivery:</u> This lessons involves a lecture using the manual, questions and answer session and examples from the trainers and trainees from real live situations. It also involves practicals and demostartions at a tree nursery where the trainees are taken through all the steps on establishing a tree nursery and transplanting of seedlings.</p>		
	<p>4.2 Improved charcoal processing using more efficient kilns.</p> <p><u>Delivery:</u> This lessons involves a lecture using the manual, questions and answer session and examples from the trainers and trainees from real live situations. It includes varieties of kilns, benefits and disadvantages of improved vs. traditional kilns and management of the areas after charcoal production. It also includes demonstrations with drawings on flip charts</p>		
	<p>4.3 Improved cooking practices and stoves.</p> <p><u>Delivery:</u> This lessons involves a lecture using the manual, questions and answer session and examples from the trainers and trainees from real live situations. It includes varieties of cook stoves, benefits and disadvantages of improved vs. traditional stoves and need for drying wood. It also includes step by step on production of an clay lines improved cook stove and demonstrations on a variety of improved stoves.</p>		
4	<p>Briquettes as an alternative source of biomass energy</p> <p>5.0 Briquettes as an alternative source of biomass energy</p> <p><u>Delivery:</u> This lessons involves a lecture using the manual, questions and answer session and examples from the trainers and trainees from real live situations. It also</p>		

		includes practical demonstrations on briquette production and use		
	Module	Lessons and mode of delivery	Date/time	Facilitator
5	Woodfuel trade and marketing	<p>6.0 Woodfuel trade and marketing.</p> <p>6.1 Marketing channel and consumer tree species preference</p> <p>6.2 Charcoal trading system and market chains</p> <p>6.3 Market research, Packaging, pricing and marketing</p> <p>6.4 Conditions of internal trade.</p> <p><u>Delivery:</u> This lessons involves a lecture using the manual, questions and answer session and examples from the trainers and trainees from real live situations.</p>		
6	Policy and regulatory framework	<p>7.0 Regulations in wood sourcing, charcoal processing, transportation and trade.</p> <p>7.1 Harvesting of forest products and required legal documents</p> <p>(a) Harvesting from government managed forests</p> <p>(b) Harvesting trees in Village Land Forest Reserve/Private owned forest</p> <p><u>Delivery:</u> This lessons involves a lecture using the manual, questions and answer session and examples from the trainers and trainees from real live situations.</p>		

MODULE 1

1.0 INTRODUCTION

- Woodfuel (charcoal and firewood) is the most common form of energy used for cooking and heating in Sub-Saharan Africa (SSA) and it is also used in small-scale businesses such as restaurants, bakeries, street food kiosks, brick making, drying produce such as tea and tobacco.
- In SSA more than 90% of the population relies on either firewood or charcoal
- Woodfuel provide about 90% of Tanzania’s cooking energy supply
- Charcoal is mainly consumed in urban areas while firewood is used in rural areas. In urban areas in Tanzania, about 70% of households depend on charcoal.
- Africa produce 62% of the global wood charcoal estimated at 52 million tons
- Tanzania ranked 7th in the world for overall charcoal production, accounting for roughly 3% of global charcoal production at over 1.6 million tonnes.
- Charcoal contributes over USD 2.7million (6.2 billion TZS) annually to the Tanzanian economy and is a major source of employment and income in both urban and rural areas

There is need to address unsustainable woodfuel processes as they cause negative effects such as:

- Emissions that are harmful to the environment. The emissions are generated in various stages of the value chain including cutting down of trees that otherwise absorb carbon dioxide cleaning the air, inefficient kilns used in charcoal production and utilizations of inefficient stoves.

Interventions exist for making woodfuel sustainable from a systems perspective such as:

- Sustainable wood production through sustainable forest, woodlands, shrublands management, sustainable community-managed woodfuel plantations, agroforestry and urban forestry
- Shift from traditional kilns to highly efficient kiln and shift from traditional stove to improved stove can result into reduction of Green House Gases (GHG) by 80% and 63% respectively and increased amounts of charcoal produced hence more income
- Addressing the different hot spots in the woodfuel value chain at the same time for example combining sustainable harvesting of trees on-farm for woodfuel and use of more efficient stoves result into higher impacts
- Recovery of organic waste including wood and other organic wastes and weeds for briquette production has benefits in reducing loss of trees and emissions, provision of additional fuel, and generation of income and employment

The three regions of focus in the trainings include Mtwara, Lindi and Pwani, Tanzania. Mtwara region has a population of 1,270,854 (male 599,648 and female 671,206), Lindi has 864,652 (male 414,507 and female 450,145) and Pwani has 1,098,668 (male 537,826 and 560,842) (URT, 2013). The consumption of charcoal in urban centres is 90, 85% and 80 for Mtwara, Lindi and Pwani respectively while in rural areas is 10, 15 and 20 for Mtwara, Lindi and Pwani respectively. Pwani is among the top three charcoal regions producers in Tanzania, after Morogoro and Tanga. Considering the demand in urban areas such as the city of Dar es Salaam the rate of deforestation needs to be addressed through sustainable woodfuel systems.

2.0 WOODFUEL SYSTEMS APPROACH

2.1 Concept of woodfuel systems, changes that have occurred and gender roles

In order to make charcoal and firewood (woodfuel) sustainable there is need to address all the stages of the system. The different stages of woodfuel systems include: (i) sourcing and harvesting of wood (ii) Processing wood into charcoal or firewood (iii) Marketing, trade and transportation (iv) Consumption or use as shown in Figure 1.

Figure 8: Definition of a woodfuel system



Figure 1: Definition and components of the woodfuel systems

The stakeholders during the SHARED workshops held in November 2017 at Mtwara, Lindi and Pwani gave their views on situation of woodfuel systems as follows

- Most trees for woodfuel is from farms and open land and the other from forests.
- In rural and urban areas woodfuel for household is 60% and other uses such as schools, hotels consume the other 40%.
- Energy for cooking in urban areas is 75% charcoal, 15% firewood, gas (5%) and kerosene (5%)
- Most charcoal producers use traditional earth kiln
- Most charcoal in rural areas is transported by bicycles from the sources due to inaccessibility and the other by motorbike and little is transported by vehicles
- Most charcoal is formal and legal (paid for licences) and less than half is informal.
- Charcoal is mainly produced in rural areas and used in urban areas
- Firewood is mainly used in rural areas

Figure 9: Visual description of the current charcoal system from sourcing and harvesting of wood to consumption.

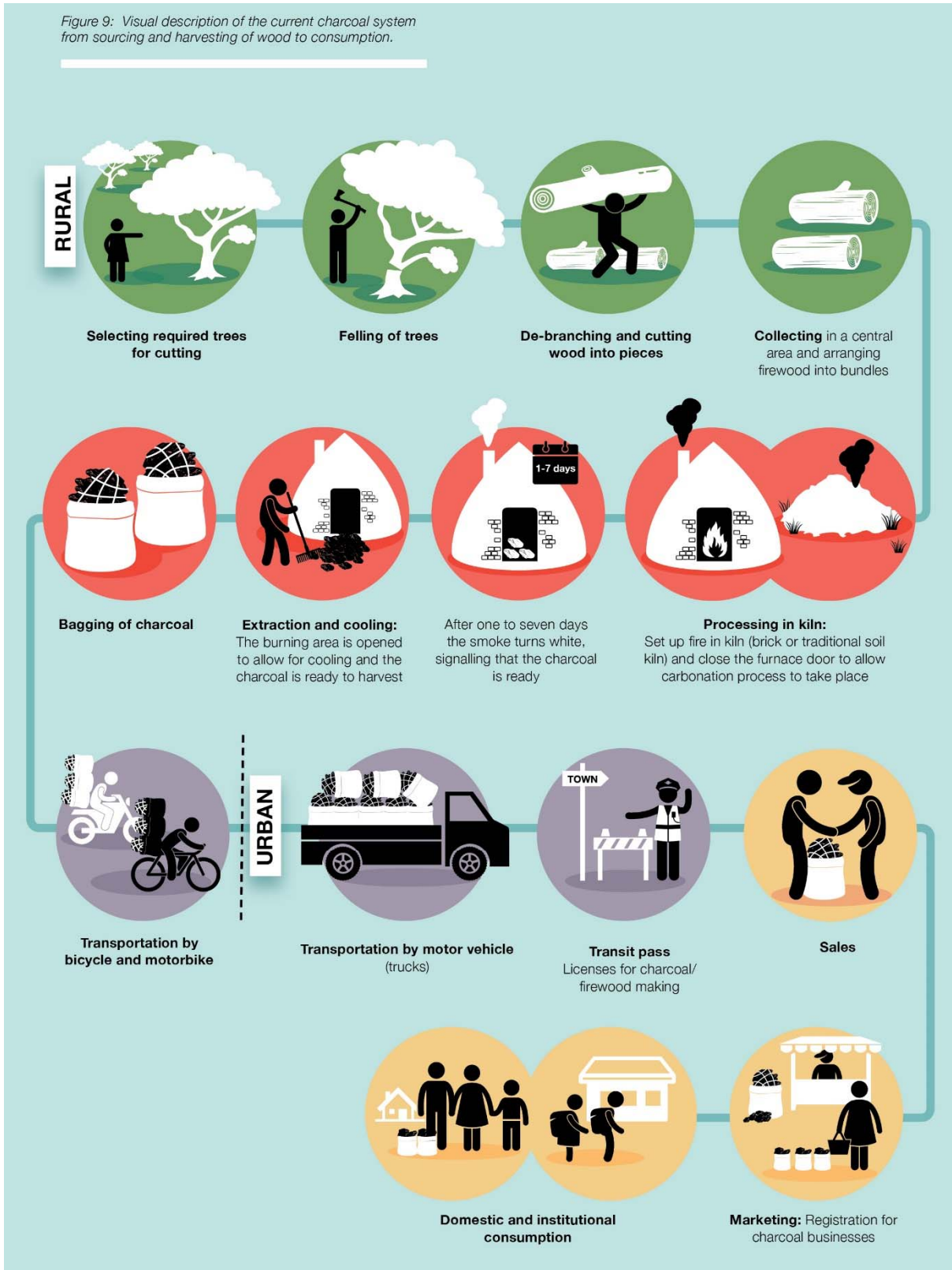


Figure 2. Current charcoal system from sourcing and harvesting of wood to consumption

Changes that have occurred over time in woodfuel systems

The participants of the SHARED workshop also stated that over time there has been changes occurring in the woodfuel systems some with negative and others with positive effects that need to be understood in order to make the system sustainable (Table 2.).

Table 2.Changes in the woodfuel systems over time and their negative and positive effects

		CHANGE/TREND	EFFECTS	EFFECTS BY 2030
WOODFUEL SYSTEM	Harvesting methods	⊕ Introduction of new technology in harvesting (chain saw) and improved accessibility	Due to harvesting of many trees in a short period of time	<ul style="list-style-type: none"> • Drought • Desertification • Disappearance of water sources • Water use conflicts
	Processing technologies	⊕ Low uptake but slowly growing to share knowledge on modern kilns		<ul style="list-style-type: none"> • Reduced local ecosystem degradation • Efficient production processes with the progression to modern kiln technology
	Transportation of woodfuel	⊕ Transportation changes (motorbike and trucks in urban areas and motorbike and bicycle in rural areas)	<ul style="list-style-type: none"> • Huge increases in urban demand and use of motorbikes for transport. • Large volumes of charcoal and woodfuel transported to urban areas. • Increased access to forest and demand of urban consumers being met has led to rapid increase in rates of deforestation. 	
		⊖ Large quantities of woodfuel can be transported by motorbike and bicycle, and more areas of forest (including protected forest areas) are accessible illegally by motorbike leading.		
⊕ Increase in job creation for motorbike drivers and bicycle transporters				
Home energy use and cooking technology	⊕ Transition from using more wood for three base stone cooling stoves to use of brick built stoves, and modern charcoal and gas stoves, up to 60% in urban areas.	Health impacts from air pollution within households, and burden of labour for carrying and fetching firewood for women.	<ul style="list-style-type: none"> • Reduction in over dependence of fuel wood and use of alternative energy forms electricity, gas and improved cooking technologies. • Women's empowerment with increased time (less time spent sourcing wood and cooking) for other income earning and child care activities. 	
	⊖ Use of improved cook-stoves not widespread. Many households still use three stone stoves and depend entirely on wood fuel			
	⊖ Lack of adequate access to alternative sources of energy to woodfuel			

⊕ positive change ⊖ negative change ⊕ neutral change

Gender differentiated roles in the woodfuel system

In order to understand woodfuel systems well and effectively implement interventions/projects to make them sustainable there is a need to understand gender roles in the whole systems. Figure 3 and 4 illustrate gender roles in woodfuel systems in Mtwara, Lindi and Pwani as described by participants during the SHARED workshops.

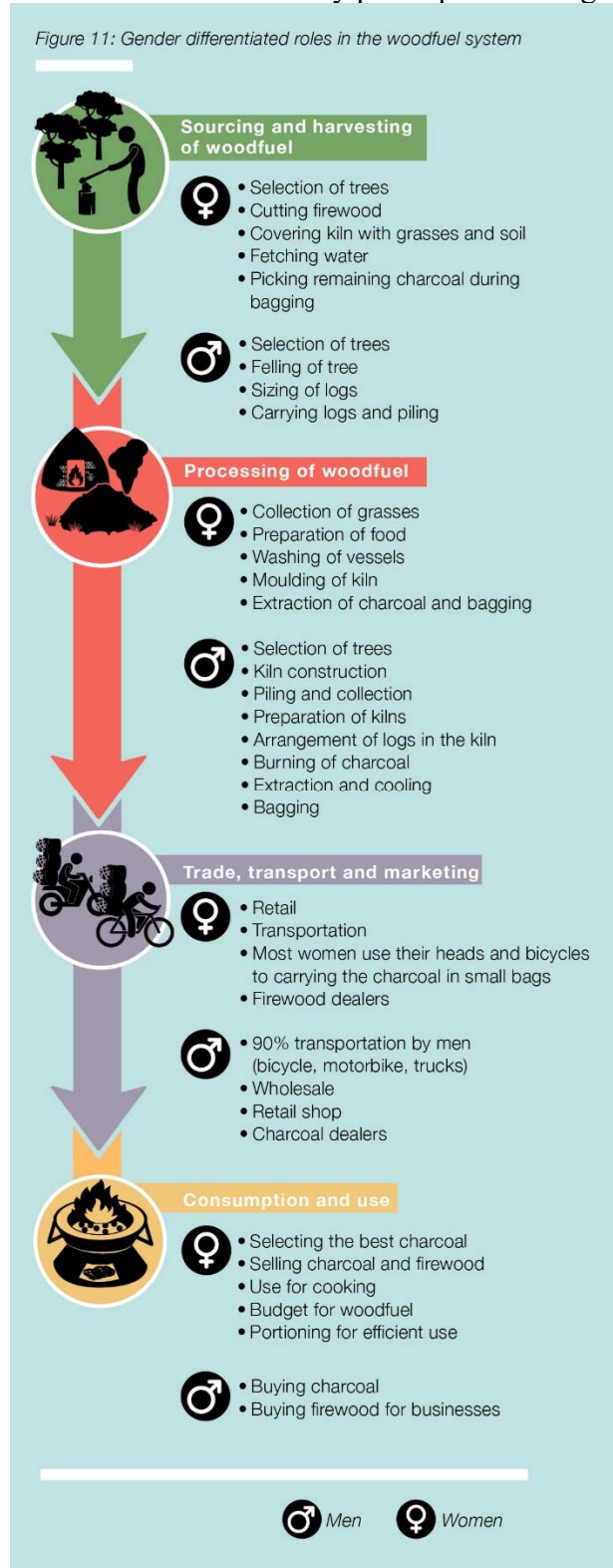


Figure 3: Gender differentiated roles in the woodfuel system



Figure 4. Photo: Hassan transporting charcoal in Mtwara and SHARED workshop participant Ntuki Sambo packing charcoal at her house

2.2 Components of sustainability in woodfuel systems

During the SHARED workshops held in November 2017 sustainability in woodfuel systems and how it can be enhanced was discussed under four areas that include social, economic, environmental and institutional/political as shown below.

Social sustainability

- Charcoal and firewood fits well within the cooking practices including food types cooked and stoves used by communities.
- Conservation of trees is carried out through beliefs
- Need for communities to understand the need for minimization of domestic and commercial consumption of charcoal and firewood through use of efficient stoves and reduced wasage of trees by use of effeciciet kilns.
- Its important to hold dialogue with the all stakeholders in the charcoal and firewood business.
- Stakeholders education through social networks on how to conserve the tree for benefits of the environment and other resources such as water.

Economic sustainability

- Introduction of modern forestry agricultural activities for increased production of trees
- Alternative livelihoods and income sources to reduce pressure on tree resources.
- Alternative activities such as cash and food crops to earn money for alternative sources to purchase other fuel types such as gas.
- Poverty alleviation through job creation.
- Prioritization in the national budget to address forestry issues including woodfuels
- Education and training for charcoal processers to enhance yield of charcaol hence more income.
- Support with modern and efficient kilns to produce charcoal.

Environmental sustainability

- Modern technology for charcoal processing i.e. efficient kilns to reduce wood wastage and emissions that cause air pollution and produce more charcoal with less wood.
- Increased tree plantations close to areas of demand for charcoal and firewood for example schools and prisons.
- Awareness raising and support to communities on planting trees to replace the old ones or those harvested.
- Afforestation programs and establishment of forest plantation for supply of woodfuel uses
- Sustainable harvesting of wood for fuel such as through resources assessment, inventory and harvesting plan for every district, cutting mature branches and leaving others to grow.
- Modern farming and soil and water conservation for cash crops and vegetable gardens.
- No cutting of trees near water sources
- Practice agroforestry by having trees intercropped with crops or pasture or in a small piece of land in the farm as woodlots.
- Awareness raising on impact of deforestation and people will take urgent action.

Institutional / political sustainability

- Preparation and reinforcement of by laws for sustainable woodfuel systems.
- Awareness and trainings supported by government on sustainable woodfuel systems.
- Training communities on how to raise awareness to others.
- Certification of woodfuel production, transportation and marketing.
- Increased access through subsidies for other source of fuels.
- Charcoal should be weighed according to actual weights and not in numbers of bags.
- Reduction of long procedures /processes of getting transport passes.

MODULE 2

3.0 CAUSES AND EFFECTS OF UNSUSTAINABLE WOODFUEL SYSTEMS

Participants during the SHARED workshops held in November 2018 analysed the causes of unsustainability in woodfuel and resultant effects and impacts as shown in table 3. The stakeholder considered sustainability across the four key dimensions, namely economic, social, environmental and institutional/political.

Table 3. Reasons for the unsustainability of woodfuel and resultant effects and impacts

Reasons the system is not sustainable	Effect	Impact
<ul style="list-style-type: none"> • Economic poverty among communities • Low education and high unemployment and poverty rates • No clear awareness among communities on effects of unsustainable practices • Harvesting and charcoal processing practices are not efficient • Communities do not adhere to government regulations • Low enforcement and corruption issues related to officers in implementation • Illegal harvesting of trees 	<ul style="list-style-type: none"> • Forests are diminishing at a very alarming / high rate • Deforestation • Excessive destruction of forest • Soil erosion • Low quality soil and extensive degraded land 	<ul style="list-style-type: none"> • Climate change: frequent droughts, floods • Low agricultural production • Food shortage and hunger • Shifting cultivation practices due to low land productivity

The session on implications of unsustainable woodfuel on natural resources, climate change and livelihoods starts with a discussion after which the trainer will summarise the lesson as follows:

Use of woodfuel energy is not in itself a bad thing. However, there are some concerns including unsustainability due to the methods used to harvest wood, inefficiency of the methods used to convert wood into charcoal and inefficiency in the use of woodfuel as discussed below:

(a) Unsustainable harvesting of wood

Unsustainable harvesting of wood such as cutting down of trees and shrubs for woodfuel without replanting results into:

- Land degradation through soil and wind erosion.
- Communities lose the benefits they derive from trees such as shade, woodfuel, building materials medicinal values, fruits and edible leaves, habitat for bees and for wildlife.

Charcoal has more impacts on trees than firewood harvesting for household use as the latter is mainly sourced from tree branches or dead wood while the former is commonly through cutting down of trees. Harvesting tree for firewood for commercial purposes may too have big impacts on trees.

(b) Burden on women and children in sourcing firewood from forests

- Women and their children carry the burden of sourcing cooking fuel.
- Sourcing firewood is a time consuming and exhaustive exercise that requires around two days per family per week.
- It strains the female body energy balance and thus affects women’s productivity.
- Firewood collectors are at risk of being attacked by wild animals and human beings.
- Young children involved in firewood collection often miss education opportunities, a situation that disproportionately affects girls.

- Carrying heavy firewood pieces loads on women and children's back or head risk spinal, head and leg injuries (Figure 5). Women in our neighbour countries do face the same challenge of spending more time in fetching firewood.
- Surprisingly women find firewood collection as an opportunity to socialize as they spend most of their time in farms while their male counterparts are able to spend time with friends in social places such as hotels and alcohol selling places. There are better ways for women to socialize.



Figure 5. Women from fetching firewood in Tanzania (left) and Kenya (right).

(c) Inefficiency charcoal production techniques (kilns)

- Wood or biomass wastage through the use of traditional inefficient kilns as shown in Figure 6 result into wood wastage elevate cutting down of trees and large areas of land is required to produce trees for charcoal.
- The traditional earth kilns result into land degradation and the opened-up areas is not covered resulting into soil erosion.



Figure 6: Traditional earth kilns in Tanzania

- Cutting down trees without replanting remove the carbon dioxide absorption benefits provided by trees (tree serves as the lungs that clean the air)
- Emissions from kilns increase carbon dioxide in the air.
- Increased carbon dioxide in the air increases temperatures resulting into climate change that cause drought and floods (Figure 7)
- The floods elevate prevalences of diseases such as malaria, kill people and animals (Lim, 2012).

- Drought cause crop failure, food shortage, water shortage, dust in the air
- Other effects include loss of biodiversity, loss of cultural beauty, soil erosion, reduced soil fertility.



Figure 7. Drought (Centre) and floods in dry lands of Eastern Africa (Right)

(d) Inefficient biomass utilization practices (inefficient stoves)

- Poor cooking techniques result in energy wastage and emissions.
- Traditional three stone open fire consume more fuel and produce more emissions compared to improved cooking stoves.
- Cooking in open fire with wet wood and in poorly ventilated kitchens results into smoke and soot.
- Some of the illnesses resulting from smoke in the kitchen include chronic obstructive pulmonary, lung cancer, eye problems, head ache, asthma, pneumonia, and stroke



Figure 8: Open fire traditional cooking stoves.

MODULE 3

4.0 INTERVENTIONS TO MAKE WOODFUEL SYSTEMS SUSTAINABLE

To make woodfuel systems sustainable it is critical to address the unsustainability and inefficiencies in all the stages of the current systems. Improving sustainability and efficiency in one stage has benefit on other stages.

During the SHARED workshops held in November 2017 the participants ranked the priority intervention to make woodfuel systems sustainable as shown in table 4.

Table 4: Prioritized interventions to make woodfuel systems sustainable across the three regions

	Number of votes
Pwani	
Awareness / education / training (sustainable tree harvesting, modern kilns, stoves, regulations, woodfuel system approach)	15
Review of forest Act (Forest Policy in 1998 and Act in 2002) – review in line with current situation...process is on-going	5
Tree planting (woodlots, plantations, nurseries)	4
Affordability / accessibility / availability of gas (cookers, accessories, gas) and alternative sources (electric, solar)	1
Alternative livelihoods (agriculture, fisheries, mushrooms, poultry, livestock)	4
Modern technology in charcoal making (kilns, tools)	0
Effective control and regulations (weighing, scales, database)	0
Energy saving stoves	0
Lindi	
Land use planning	6
Use of modern kilns	3
Awareness raising (improved stoves, woodfuel system, sustainable tree production, market opportunities, regulations, permits, taxes)	6
Recovery and reuse of resources to diversify source of energy	3
Formal groups for sustainable woodfuel formation and registration	2
Establishment of trees on farms (e.g. woodlots)	2
Rural road infrastructure improvement (village roads are poor especially during the raining season and increases costs of transport)	1
Capacity development	0
Mtwara	
Awareness and education /communication, (policy, by-laws, regulations, woodfuel system)	15
Alternative energy sources and woodfuel and energy mix	3
Land use plan	2
Forest plantations / woodlots	1
Support for improved stove producers (loans and capital)	1 vote
Village natural resource committees	0 votes
Governance and management (access to transport permits and transit passes)	0 votes
Marketing centres	0 votes

Awareness raising, education and training on sustainable woodfuel systems was ranked highly and hence the training responded to one of the major needs identified by the stakeholders.

4.1 Sustainable wood production for woodfuels

In this section agroforestry and community based forest management (CBFM) through farmer managed natural regeneration (FMNR) are described as sustainable means of producing trees for woodfuels. This addresses deforestation and land degradation associated with unsustainable cutting down of trees for charcoal and firewood. The session also trains farmers on tree nursery establishment and tree planting.

(a) Agroforestry

Agroforestry (AF) is agriculture with trees. It is a farming system that integrates crops and livestock with trees and shrubs

Different Agroforestry planting systems

- Improved fallow is the key in semiarid areas and should be promoted
- Tree-intercropping: Growing annual crops between rows of trees or shrubs. Examples of trees that can be intercropped with crops include legume plants such as *Leucaena spp - (mlusina)*, *Gliricidia sepium*, *Tephrosia vogelii*,
- Boundary plantings: Trees planted along boundaries or property lines to mark them well. Examples of trees species suitable for this system are *Grevillea robusta-* (mgrivea), *Albizia-(mtanga/mkenge)*, *fruits tree species*, and *Leucaena species-(mlusina)*.
- Contours: Planting trees on constructions made of earth, usually to conserve or control water erosion. Examples of trees species suitable for this system are *Gliricidia sepium*, and *Moringa oleifera trees*. Woodlot: An area planted trees for fuel, or timber.
- Shelterbelts: trees planted as windbreaks to protect valuable topsoil during wind blow, this planting system can also increase crop yields through increased soil moisture. Examples of trees species suitable for this system are *Casuarina-(mvinje)*, *Gliricidia sepium*, *Grevillea robusta*
- Living fences: Fences made up of living trees, or in which the entire fence consists of closely-spaced trees or shrubs. Examples of trees species suitable for this system are *Erythrina-* (mheveheve), *Gliricidia*

Benefits of agroforestry (AF)

- It can effectively influence short-term cash-flow over time
- It can increase crop yields.
- Provides woodfuel. E.g. pruning for firewood from timber or fruit trees (Figure 10), charcoal produced from wood harvested through community-based forest management practices.
- It can help sustain or even increase biodiversity.
- It reduces pressure on forest because it provides wood products from the farmland.
- It also reduces the need to use soil nutrients and fertilizers by improving soil fertility e.g. through trees that fix the carbon in the air making it available in soil and decomposition of fallen leaves and branches forming soil organic matter
- Strengthens agricultural resilience by increasing crop yields and offering better environment for farm animals
- Capture carbon dioxide in the air reducing global warming



Figure 9. *Gliricidia sepium* firewood harvested for sale at Molet village Kogwa district.

Challenges of Agroforestry

- Takes long before farmers can harvest products
- Requires intensive knowledge and technology during implementation.

(b) Farmer-Managed Natural Regenerations

Farmer-Managed Natural Regenerations (FMNR) is a farmer driven land-restoration technique that is applied for improvement of degraded agricultural lands, fragile pasture lands (agricultural landscape) and forested areas, through natural reforestation and agroforestry

FMNR on a forested land is similar to community-based forest management practices in Tanzania (CBFM). CBFM is part of participatory forest management approaches under the Ministry of Natural Resource and Tourism (MNRT).

FMNR is the farming practice that allows vegetation to regrow from seeds buried underneath or live tree stumps. This can be carried out in a crop land or pasture field encouraging regrowth of trees (Figure 10).



Figure 10: Left: Before FMNR become regular practices; Right: After adoption of FMNR. Photo: Rinaudo

One example of FMNR in Tanzania is Ngitili which is a traditional system in which farmers in western Tanzania set aside an area of standing vegetation (grasses, trees, shrubs, and forbs) at the beginning of the rainy season for grazing during the dry season when pasture is depleted (Figure 11).



Figure 11: Left: A degraded Ngitili; Right: A regenerated Ngitili in western Tanzania (Photo: Otysina)

The basics of FMNR practices include:

- Selection of desired tree stumps
- For each stump, 3-5 stems are chosen for growth.
- The tallest and straightest stems are selected and side branches removed to roughly half the height of the stem.
- The remaining stems are then removed culled.
- Regular pruning of any unwanted new stems and side branches give best results.

Steps in FMNR

- Step 1: Survey of the farm, noting how many and what species of trees are present.
- Step 2: Selection of stumps which will be used for regeneration
- Step 3: Selection of the best five or more stems to be saved and removal of unwanted ones. Prunings to remove tea unwanted stems provide farmers with firewood or fodder.
- Step 4: The area should be protected from livestock to allow regrowth of the trees.

Selection of tree species used in FMNR depend on following factors;

- The species occurring naturally
- Coppicing (production of multi-stems) ability of each species
- Local beliefs and values described to each species that might promote conservation
- Uses value of each species
- Characteristics such as thorniness, competitiveness with crops, and growth rate

Pruning rules

- Different tree species may require different pruning techniques and pruning tools.
- Always sharpen the pruning tool (axe, machete saw); and always cut upwards carefully as when cuts are made downwards the bark may be stripped from the stem.
- Avoid excessive damage as that may lower the plant's ability to regrow and may become an entry point for disease and insects.
- Stems should be pruned up to half way up the trunk while small, and up to two-thirds of the way up, once they are over 2 m tall. If too many side branches are pruned from the main stem it may be easily broken by livestock or strong winds.

Benefits of FMNR

- The stumps left for regrowth can be in a farmland or in pasture land.
- Provides firewood and building materials
- Contributes to land restoration by allowing trees to regrow

- Improve soil fertility, reduce soil and wind erosion
- Improve crop yields and animal production
- Increases biodiversity and cultural benefits
- Reduces dependence on pesticides as predators of crop pests increase.
- Improve local economy as wood availability increases (wood related supply for use/sale).
- Improve food security by providing edible leaves and fruits.

(c) Tree planting

Tree planting involves seedling production or sourcing and seedlings planting in the farms and record keeping is necessary.

Sourcing of seedlings can be carried out through establishment of own nurseries at farm level or through purchasing seedlings from other tree nurseries.

The following are steps in establishing and managing tree in nurseries and in the farms.

(1) Nursery establishment and management

A tree nursery is a managed site, designed to produce tree seedlings grown under favourable conditions until they are ready for planting. All nurseries primarily aim to produce sufficient quantities of high quality seedlings to satisfy the needs of users .

Importance of tree nursery and its role

- Seedlings and grafts are produced in nursery from which the fruit, orchards and ornamental gardens can be established (Ir. Anja de Feijter 2015).
- The nursery planting materials are available at the beginning of the planting season.
- This saves the time, money and efforts of the farmers to raise seedlings.
- Nurseries also ensures the production of quality planting material.
- It provides employment opportunities for technical, skilled, semi-skilled, unskilled labour
- Supplies seedlings to meet the fruit, pulp and paper, woodfuel, timber and other industries.

(i) Site Selection

Factors to be considered for raising a nursery

- Location of the nursery should be in a good and well-drained site.
- Near the settlement for easy management
- Well exposed to the sun but protected against severe heat
- Well protected against animal damage, strong winds.
- Near water sources

(ii) Preparation of equipment's required

Equipment checklist when establishing trees nursery includes the followings;

- Wheelbarrow or trolley for transporting materials within the nursery
- Spade or shovels for soil mixing
- A trowel for filling planting bags or pots with soil
- Polythene bags for germination of seeds and growth of seedlings
- Shading materials for covering nursery beds to protect seedlings from direct sun and strong winds
- Hosepipe with spray nozzle/a watering can for watering plants
- Spray bottles for irrigating very small, delicate seedlings.

- Cutters or scissors for pruning seedlings.
- Planting labels
- A notebook and pen for record keeping

(iii) Sourcing tree seeds

- Source seedlings grown from seeds collected in the same seed zone and elevation in which they will be planted
- Source good quality seeds.
 - (i) Matured trees found in local farms (ii) forest or public land as long one should collect from several number of trees to maintain diversity and (iii) bought from local seed suppliers, from NGOs, and from institutions such as Tanzania Tree Seed Agency (TTSA), (Tanzania Forest Services (TFS) and Tanzania Forestry Research Institute (TAFORI) offices.

(iv) Pre-treating seeds

Pre-treating seeds before it is planted by soaking in hot or cold water improve germination.

- The common known treatment methods include;
- Soaking seeds in hot water is done for those seeds with very hard seed coats until the seeds look swollen. Boil water and pours it over seeds in a container, and then leaves the seed in the water until the seeds look swollen. The hot water weakens the hardcover of these seeds for easy and speed germination process.
- Soaking seed in cold/cool water is recommended for those with soft seed coats. The time for soaking varies between 12-48 hours, depending on the tree species. Procedure: Soak the seeds in cold water and make sure all seeds covered with water, and then remove the floating seeds that show poor germination.
- Before soaking cracking the shell of the seeds is necessary mostly for leguminous seeds such as *Sesbania sesban* as they have a thick and hard seed coats.
- Cracking is done using a sharp knife, a nail cutter or stone and is to allow water penetration to accelerate the germination.

(v) Seed bed preparation

Nursery beds can be arranged either by raised on a flat bed, or can be set into a sunken bed (1 m by 1 m and about 10 cm deep).

Prepare a germination bed at most 1m wide, and its length will depend on the number of seeds to be sown, size of seeds and available space.

(vi) Potting

Potting is the process of filling polythene tubes or other special container used to plant seeds with proper soil compost/mixture (soil, sand and compost/manure). Soil-based mixture ratio comprises the following;

- 1/3 organic fertilizer/mature compost or leaf
- 1/3 forest/garden topsoil
- 1/3 sharp sand

Fill tubes with properly moistened mixture of forest soil, sand and compost/manure known as potting mixture. The polythene tubes with the mixture are then pressed down lightly to about 2 cm below the top. After all the tubes are filled with the mixture, they are then watered lightly before sowing seeds into it.



Figure 12: Farmers filling tubes with proper moistened potting mixture

(vii) Sowing seed

Sow large seeds 2cm to 3cm or twice of its thickness deep in the soil.

Sow small seeds by broadcast and cover them with a small amount of fine soil.

During planting more than one seed can be applied in a tube to ensure germination

The beds can also be covered with thatch or a plastic sheet till the seeds germinate.

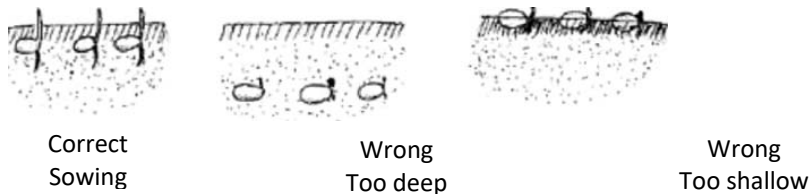


Figure 13: Proper sowing depth of seeds

(viii) Pricking out

It is the transplanting of seedlings into a polythene bag

- Make a deep and wide hole in the polythene bag or container for transplanting the seedlings.
- Pricking out is done for small seed, which normally sown by broadcasting and is best done when seedlings is two weeks old or when acquires two leaf set.
- During uprooting, hold seedlings at the base of the stem and pull it out gently from the mother beds.

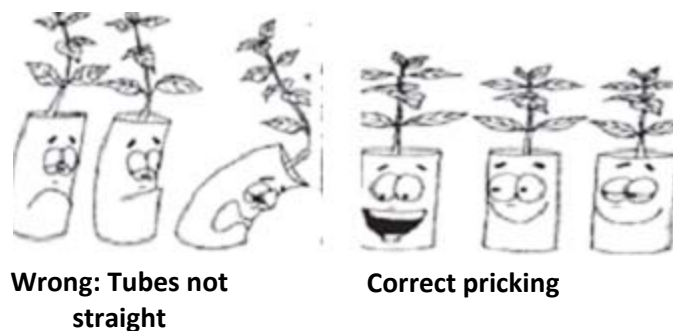


Figure 14: Proper pricking of seedlings

(ix) Watering

The amount of water required depends on the size of the nursery, the kind of soil, the species, and the irrigation method practiced.

Watering preferably in the mornings; the mid-day period will cause excessive evaporation.

(x) Shading

Use locally available materials such as grass, mats, or banana fibers for shade construction to protect the seedlings from direct sunlight for two to three weeks after pricking out.



Figure 15. Proper shading of seedlings in the nursery

(x) Weeding

Remove all the weeds around the beds with a small garden hand hoe and don't leave any rubbish around.

Frequent removal of weeds reduces competition for nutrients, water and light



Figure 16: Farmers performing weeding in their nursery at Laikala village, Kongwa-Tanzania

(xi) Application of additional fertilizers (nutrition)

Addition of fertilizers will give healthy and vigorous plants with good root and shoot system.

(xii) Seedling protection

Keep seedlings free from physical damage by maintaining the moisture between (90% to 95% humidity) and avoid direct sunlight to the seedlings cool (34° to 36° F). The major disease of nursery stage plant is too much shading and watering which causes the rotting of stem and root tissues at and below the soil surface (**damping off**), and is controlled through good sanitation (making sure that all the time the nursery is clean) conditions are necessary. Damping off may lead to insects' encroachment such as green grasshopper to the nursery that attack seedlings. Damping off is controlled through good sanitation (making sure that all the time the nursery is clean and not over watering or shaded).

(xiii) Transportation from the nursery to planting site

- Make sure the site where seedlings are to be planted is prepared.
- Cover seedlings during transport to shade and protect them.
- Take only as many seedlings to the field as can be planted that day.
- Handle bags gently and take precautions to minimize bouncing and sliding around on the bed of the truck.

- If weather is sunny, windy, dry, or warm, be sure to have something to keep seedlings protected (i.e. water, reflective tarp, damp mulch).
- Keep seedlings away from fuel and chemicals.

2. Seedlings planting in the field

- Seedlings should be planted during the rainy season to avoid some post-planting problems, such as drought and transplant shock.
- Seedlings should be planted when they are dormant, generally December-April, depending on local conditions.
- Planting season may be extended in areas in which irrigation is possible into all year around.
- The number of trees per acre depends on the spacing applied during planting (Figure 18).

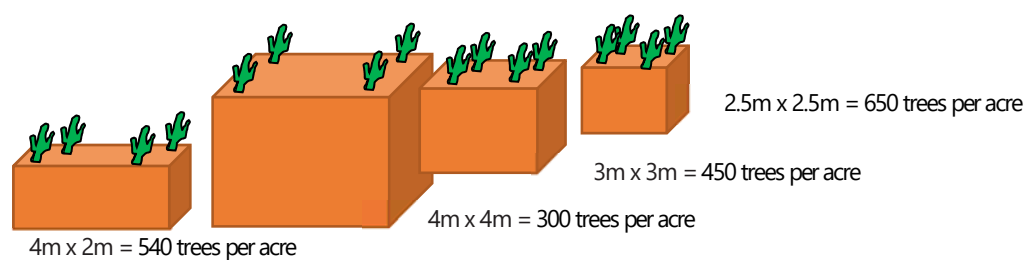


Figure 17 : This figure helps to determine the desired number of trees per acre during planting

3. Record keeping for nursery and planted trees in the farm

When the nursery has been established, it is important to keep records. Record keeping helps in planning, monitoring, and decision-making for improved nursery operations (Roshetko *et al.*; 2010).

There are three types of records nursery group may choose to keep in the nursery:

- Plant Development Records. This document on how each species is performing within the nursery. This involves having one separate datasheet for each batch of seed that comes into the nursery for each species, and recording data on seed source, germination, growth and transplanting/pricking out.
- A nursery inventory can describe the performance of the whole nursery at one point in time. This involves counting the number of seedlings for each species in the nursery and their stages of development. The records entries should be made at least every two months.
- Plant supply records help to record the number and quality of plants supplied to different planting sites or in the farm. They also contain information on dates of delivery, who received the seedlings and which site they were sent to. These help in monitoring survival of saplings in the farm.

4.2 Improved charcoal processing using more efficient kilns

There are different modern models of kilns that process charcoal such as Half Orange and steel ring drum (Figure 18).

Benefits of improved kilns:

- Produce more charcoal (25 – 35% yield of charcoal from the original weight of wood against 10 – 15% of traditional kilns.
- Reduced wood wastage and produce more amount of quality charcoal
- Reducing deforestation
- Reduced emissions
- Reduced land degradation. Compared to traditional earth kiln that needs digging of land which many times is left bare resulting into wind and soil erosion.

Challenges

- They require investment in terms of money for contraction
- They require knowledge on construction and operation
- Some of them are stationery hence need to move logs where they are constructed



Figure 18: Improved kilns for charcoal production –Half orange muddy bricks kiln, steel ring drum kiln

The half orange kiln used in Rufiji-Pwani region, was introduced by WWF to groups making charcoal in villages. It is stationery and constructed using bricks. It is applicable in the communal forests, farms, tree plantations where there is larger amount of wood for carbonization and also in saw mill industries.

The steel ring drum kiln is being used in the dry lands in Northern Kenya mainly by women. The drum kiln has several rings that are easy to remove and hence easy to move from one place to another. The fire is started from the top. The women after using them for a few months they achieved 22% yield of charcoal. That mean for every 100kg of wood used they produce 22kg of charcoal. The amount of charcoal produced will increase as they improve their skills on using them .

4.3 Improved cooking practices and stoves

Benefits of improved stoves

- Save fuel reducing workload in collecting firewood, reduce pressure on forests and saves income
- Most of them produce less smoke reducing health risks from illness associated to smoke and reduce soot (black stuff) on kitchen ceiling and walls
- Cook faster
- Gasifier stove turn firewood or other biomass fuel into charcoal that is used for another cooking or as biochar
- Those made with locally available materials are easy to construct

Challenges:

- Except for those made with locally available materials they are expensive to buy but the benefits in the long run are worthwhile
- Some need skills in proper use

Communities have been found to prefer stoves that allow families to maintain their cooking habits e.g. roasting maize, tubers, bananas or adjusting heat e.g. by pushing in or withdrawing firewood. Also enhance societal cohesion by allowing families to sit around fire.



Figure 19. Improved firewood stoves for use in institutions (a), for household use (b) and improved stove for charcoal (c)

The stoves A and B need local available materials for construction, but the charcoal improved stoves C need extra technology and both industrial and local materials during production. Some of these stoves need technical expertise during production but some do not.

The charcoal improved stove below is a product of two stove makers; Mr Baldwin F. Mpunga a metal stove producer and Ms Wasiya Abdallah a clay-muddy stove producer. The two were introduced to each other during the project work and they joined efforts and produced a metal stove with a clay liner as shown in figure 20 below. The clay liner helps in saving energy hence reduced amount of charcoal used in cooking.



Figure 20. Metal stove with a clay liner produced during the project by a female clay stove producer (Wasiya Abdallah) and male metal stove producer (Baldwin F. Mpunga).

Construction process of improved firewood Rocket- Lorena Stove.

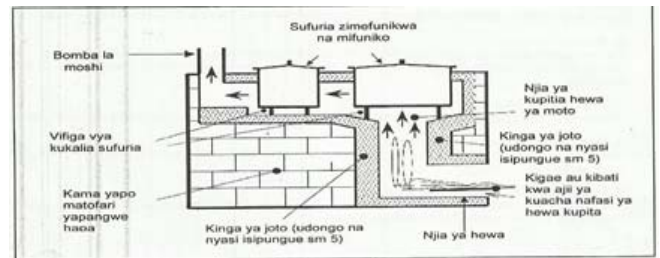
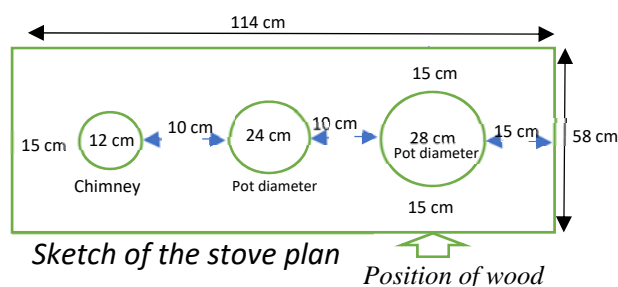
Production process will be detailed on the firewood improved stove called

The raw material

A

nthill soil or clay soil 20-30 buckets; dry chopped grass/rice husks/ground nuts shells/ 3-5 buckets; Mud bricks 25-35 depending on the size of the stove; Water depending on the amount of soil mixture prepared; 4 inches diameter PVC pipes/banana stems of the lengths (10cm size-2 for connecting between pots, 30cm size -1 for wood inlet, 35cm size-1 for fire chamber, 50cm size -1 for chimney);

Construction processes



Sectioned view of the two-pot Rocket Lorena

Figure 23. Sketch of two pot Rocket Lorena Stove



Figure 24. Step 1: mixing soil with dry grass; Step 2: wetting soil mixture; Step3: Setting stove base; Step 4: positioning pipes and setting pots; Step 5: covering pipes/banana stems with plastic bags for easy removal after construction; Step 6: construction of the stove to the level required; Step 7: connecting the chimney with firing chamber and reshaping the stove surface.



Stove is ready for use after seven days of construction

Figure 25. Step by step in producing a clay lined improved cook stove

MODULE 4

5.0 BRIQUETTES AS AN ALTERNATIVE SOURCE OF BIOMASS ENERGY

Briquettes are made from compacting dry biomass material into a solid unit that is used for cooking or heating just like charcoal or firewood. Some community members collect charcoal dust/fines from charcoal production sites or trading places. Some communities use a drum kiln to produce charcoal from weeds, twigs, organic waste, sugarcane bagasse, maize cob (Figure 26). Others use saw dust, rice husks, coconut shells, sunflower waste, groundnut shell, cotton stalks, among other crop residues.



Figure 26. Steps in carbonizing materials for briquette production.

The raw material are ground using traditional motor and pestle like that used to grind maize. If the raw material has low sticking capacity a binding agent such as biodegradable paper, soil, cassava starch, corn starch, molasses a sugarcane waste is used. They are compacted using bare hands or manual and electric machines and then dried under shade for less than 5 days depending on weather. After that they are ready for use to provide cooking and heating energy. The process is shown in the photo in figure 27. Further step by step illustration on producing briquettes is shown in figure 28.



Figure 27. Charcoal fines made from weeds from the farm is ground using traditional mortar and pestle and mixing it with casava porridge and moulding using hands into ball shaped briquettes by Bardwin F. Mpunga family in Tanzania.

Sourcing raw materials

- Briquettes can be made using different materials such as charcoal dust, which can be sourced from charcoal traders, cow dung, and other organic waste.
- Sourcing binders such as soil, paper (newsprints, printing paper, old exercises books) from institutions such as schools, offices. It is good if paper is sourced while shredded, if not it can be shredded by hand or using manual machines.
- Sourcing water from wells, rivers, tap, and borehole.

Producing raw materials

- In case charcoal dust is not available fresh organic by-products such as sawdust, organic waste can be carbonized into charcoal dust using a drum kiln.
- In case a binder is not readily available, organic residues can be composted
- Producing briquettes
- Sort and sieve charcoal dust, cow dung and compost to remove impurities
- Grind coarse particles of charcoal dust

Mix materials for different types of briquettes

(a)Charcoal dust + paper + water.

-Soak the shredded paper for 3 hours

-Mix charcoal dust with the soaked paper at 7:1 ratio (dry weight). Ratio may change depending on type of paper and size of particles of charcoal dust

(b)Charcoal dust + soil or cow dung or compost

-Mix charcoal dust +soil + water at 4:1 ratio

-Mix charcoal dust + compost + water at 4:1 ratio

-Mix charcoal dust + cow dung + water at 2:1-1:1 ratio

Binding test

- Squeeze the mixed material in the hand and hold it between the index finger and the thumb and shake. If it holds the binding agent is enough, if it falls apart add some more binding material.

Pressing or compacting briquettes

- Press or compact mixed material or slurry in recycled cans or bare palms
- Press or compact mixed material or slurry using manual metal or wooden press

Drying and packaging and utilization

- Place the briquettes on shelves, rooftops, or on ground.
- Package the individual pieces in tins, sacks or polythene bags.
- Are used like firewood or charcoal

Shredding papers



Drum kiln for carbonizing



Sorting raw materials and (b) grinding



Mixing materials and pressing



Drying and Utilization



Figure 28. Step by step activities in briquette processing

Benefits of briquettes

- Briquettes made from carbonized materials produce low emission during heating/cooking, hence reduces pollution.
- Making briquettes from waste help in conserving environment and reducing pollution from waste
- Briquettes are cheaper than other sources of energy
- It is a source of income for those manufacturing them for sale
- They burn evenly for a long duration.
- Reduce demand for charcoal and firewood hence controlling deforestation.

Challenges in briquettes

- Need skills to produce good quality briquettes
- Inadequate supply and high cost in sourcing raw materials and transportation affects adoption of large scale briquette production.

MODULE 5

6.0 WOODFUEL TRADE AND MARKETING

Marketing is defined as an activity, set of institutions and processes of creating, communicating, delivering and exchanging goods and services that have value for customers, clients, partners, and society at large. It is an integrated process through which companies build strong customer relationships and create value for their customers and for themselves.

6.1 Marketing channel and consumer Tree species preference

Marketing channels involve in the process of making a product or service available for use or consumption. Woodfuels producers like other producers do not sell their goods directly to the final users. Between them, there are middlemen performing a variety of functions, which constitute a marketing channel on the woodfuels system. Small scale charcoal producers sell their goods directly to the final users. Middlemen reduce the amount of work that must be done by both producers and consumers.

Trees preference is normally based on the species property to produce charcoal with high recovery percentage, high calorific value that attracts customers and hence more income to charcoal dealers since lighter charcoal with low calorific value has a problem of crumbling easily into small pieces or fines during transportation and consequently lowering market value. The quality of charcoal varies from specie to specie and is dependent on the method of carbonization. Large tree species (>20cm diameter) with high caloric values are the most preferred, due to the large quantity of dense and hard charcoal they produce.

6.2 Charcoal trading system and market chains

Trade in charcoal is conducted formally as well as informally. Under formal procedures trading chain begins with government-issued licenses for the harvesting of the forest resources, the transporting of the product involves officially licensed called transit pass and other necessary charges and taxes. The informal trading chain begins without official authorization, which is

essentially an illegal activity. Charcoal travelling through this informal chain is transported and traded illegally in attempt to avoid authorities, taxation and eventual penalties. The prices for wood products woodfuels vary according to region and supplier. Thus, there is no national common price.

Market chain is a process of following a product from production to consumer by looking at all points of the chain, prices, market demand and supply (trends), market constraints for the particular product.

Market chain analysis helps to identify;

- Operations of specific market channels while focusing on their growth potential,
- Activities and efficiency of actors along the chain,
- Business support services involved, and
- Policy and regulatory frameworks. Using the information from the analysis, opportunities and constraints can be identified within specific market chains.

Market chain provides a deeper knowledge of who wants a product or service, what they want, and at what price. Since woodfuels have different qualities this will help to produce something needed in the market instead of harvesting wood that will not sell in the market which is unnecessary destruction of conserved forests.

6.3 Market research, packaging, pricing and marketing

Charcoal prices depend on the size of the package used such as bags, for example in urban areas, there are bags of different sizes with different prices. High consuming customers including restaurants and commercial enterprises prefer the larger bags (i.e. 30 kilograms or more) are the most frequently purchased, which their prices are normally higher compared to medium sized packages of 15kg and below.

This is the process of planning for pricing, promotion and distribution of a product or service that will reach and satisfy customers and encourage them to return again to purchase that product or service in the future. One of the most pervasive demands on the forest of the Southern Tanzania Regions is for domestic energy. Many of the fundamental problems and issues are centred on the commercial and industrial component of forestry products; therefore proper policy formulation and sector strategies towards production of woodfuels and other related forestry products are needed for sustainable consumption and trade of primary forest products.

The woodfuels trading and wholesaling component of its value chain is the key point of intervention where regulatory and fiscal policy measures to achieve sustainability of charcoal and firewood production need proper implementation. Appropriate investment on improved infrastructural framework for the charcoal/firewood trade is needed, including:

- Building fixed charcoal/firewood trading sites, both at the intermediary level in the rural areas and in the urban areas where charcoal/firewood is supplied to the end consumer
- Charcoal/firewood markets in urban centres through which all of the charcoal/firewood needs to be transported,
- Increasing the number of fixed control posts to reduce the illegal dealers of woodfuels.

An improved infrastructural framework as proposed above will help to facilitate the implementation of new policy measures, for example:

- issuing and controlling permits,
- collecting taxes and fees,
- providing targeted capacity building sustainable harvesting and other elements,
- generating improved knowledge as regards market structures, quantities traded and consumed.

6.4 Conditions of internal trade

- Need for a registration document (registration is for individual, company or group);
- Need for a certificate of export of forest products;
- To have a license or certified copy of the forest harvest;
- Have a permit to harvest trees in natural forests Form FD. 1C
- Have a business license that includes Tax Payer Identification Number (TIN)
- Payment for the state's and local government tariffs as stipulated by the law
- Having a record of receipt and sale of forest products.
- Traders are required to pay the state tax for every 30 kg; 60 kg; 90 kg sizes of bags. Over 90 kg size of bag the trader will pay fine in accordance with the Forestry laws and Regulations.
- All councils are required to allocate special woodfuel sales centres (magulio) for charcoal in their areas.
- Every charcoal package to be transported with any instrument must be taxed by the Government and the vessel of transport must allow the inspection to be carried out effectively and efficiently.
- Good to have a bank account number with the company name and not personal account name.

MODULE 6

7.0 POLICY AND REGULATORY FRAMEWORK ON WOODFUEL

The Ministry of Natural Resources and Tourism through the Forestry and Beekeeping Department established a Forest Policy in 1998. Sustainable Harvest Guidance and the First Forestry Trade was developed in 2007. Citizens and stakeholders in general should be committed to engaging in the implementation of this guide, which has been provided for the purpose of ensuring sustainable use of resources for the benefit of current and future generations.

A guide for sustainable harvesting and forestry business that is harvested in natural forests focuses on stakeholders and the general public including;

7.1 Harvesting of forest products and required legal documents

Harvesting from government managed forests

- Identification and allocation of forest areas for charcoal, tobacco consumption, fisheries, bricks, mortar burning and baking each year.
- A harvesting license is required.
- Registration applications and licenses are submitted to Forestry Officers or District Forest Managers and discussed and approved by the District Harvesting Committee.
- Every Forestry Officer and District Forestry Manager need to have a list of harvesters and traders of mentioned forest uses.
- The Village Government should maintain a list of people who are involved in mentioned forest uses.
- The register should contain a record of the number of charcoal bags taken and signatures for each harvester.
- Every tree harvester for mentioned uses or similar business pays for the royalties as stipulated in the Table specified in the Forestry, Tender and Auction Code or Agreement specially based on the Forestry Law and its Regulations as well as the Procurement and Public Finance Act.
- The producer is required to contribute to the tree planting fee by paying 5% of the royalties and the funds will be allocated to the Forestry Fund (TaFF).
- Cutting of wood for charcoal production, tobacco drying, frying, blasting, mortar burner and baking should be done by choosing suitable trees for the same activity according to Forestry Law 323.
- Manufacturing of charcoal should be made using effective techniques, such as using semi-orange or Casamanse Kilns.
- The village government should ensure that environmental conservation is considered in the area of harvesting.
- The harvesting permit and the use of natural trees for industrial power generation shall not be provided.

Harvesting trees in Village Land Forest Reserve/Private owned forest

- Individuals are required to provide validity for forest / tree management through the Village Government and District Forest Officer.
- The harvesting applications should be sent to the relevant owner of the forest in writing and certified by the Village Government and Forestry Officer or District Forest Manager.
- Harvesting should be permitted once a tree inspection is carried out and certified by Forestry Officers that the trees have reached the harvesting level. District Forest Officer or District Forest Manager should measure the diameter of the tree before it is shattered.
- Harvesting should take place in accordance with the relevant forest management plan.
- The Client should have a Transit Pass - TP certification document recognized by the Forest Service Agency.
- Putting a mark of an approved hammer by the Agent on the stumps of all the harvested trees.
- Putting a hammer mark on both ends of the log.

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