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What makes sustainable charcoal, sustainable?

Since 2012, the Transforming Tanzania's Charcoal Sector (TTCS) project in Morogoro Region, Tanzania, has been piloting sustainable charcoal production from community-managed miombo woodlands. By October 2017, 22 villages in 3 Districts had adopted the model; had established village forest reserves covering 94,847 ha including 10,933 ha designated for charcoal production; and had earned over TZS 0.5 billion. This note describes the elements of the design of the 'sustainable charcoal' production model, that are intended to contribute to its sustainability. The note also identifies relevant research priorities.

What do we mean by 'sustainable'?

The United Nations defines sustainable forest management as 'a dynamic and evolving concept that aims to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of the present and future generations'. In keeping with the UN definition, the sustainable charcoal model aims to maintain the full complement of ecological, economic and social functions of miombo woodlands.

What is miombo woodland?

"Miombo' comprises those central, southern and eastern African deciduous woodlands dominated by the genera *Brachystegia*, *Julbernardia* and/or *Isoberlinia*, from the legume family (Fabaceae, subfamily Caesalpinioideae). The ground cover varies from a dense coarse grass growth to a sparse cover of herbs and small grasses. The miombo region has an estimated 8,500 species of higher plants, over 54% of which are endemic. Miombo covers approximately 2.7 million km^2 in regions receiving > 700 mm mean annual rainfall, on geologically old, nutrient-poor soils. Fires are a characteristic feature of miombo woodlands.' Adapted from: Campbell *et al.* 1996[1].

Ecological sustainability

Sustainable charcoal and miombo woodlands

The TTCS sustainable charcoal model has been developed as a forest management system for miombo woodlands. Miombo woodlands are a disturbance-tolerant ecosystem in which fire plays a complex and defining role. Miombo species readily regenerate from root / stump sucker shoots, or from coppice shoots from stumps and even branches.[2,3] To a lesser degree, regeneration also occurs from seedlings present in the grass layer, and from seeds. Miombo woodland is remarkable in its capacity to tolerate disturbance, including tree cutting. Provided that stumps, roots, seedlings, and seed sources are retained, the woodland will naturally regenerate. Management practices can be fine-tuned to enhance the regeneration process. For example, some research shows that coppicing is more abundant from plants cut higher up the stem, and from medium-sized stems.[4] Based on this finding, the TTCS model requires producers to cut stems above 50 cm, and only to harvest stems > 15 cm dbh. Regeneration is also more successful when cutting takes place shortly before the onset of the rainy season.

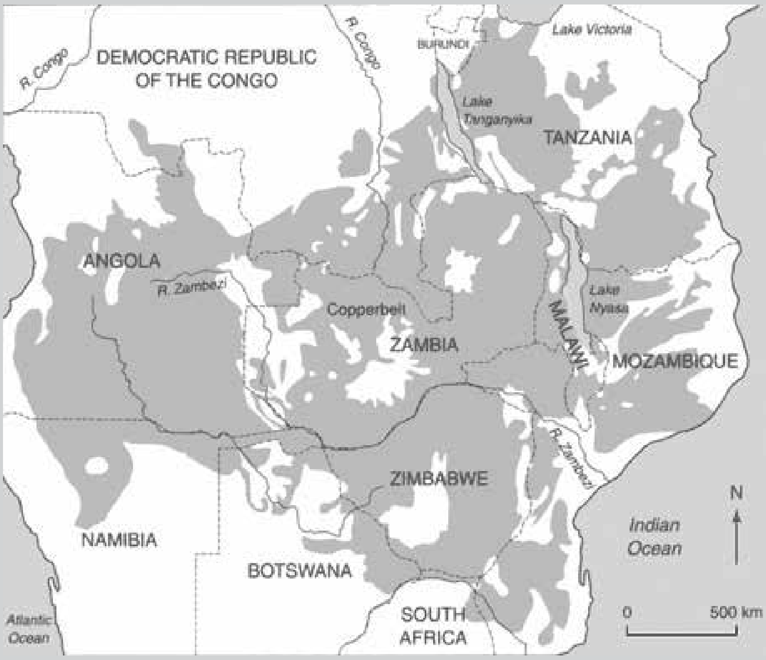
Protecting coppicing shoots and seedings from fire damage in the first 2 years after harvesting is important. In contrast, there is some initial evidence, from

research supported by the project, to suggest that light cattle-grazing may assist coppicing shoots by limiting competition from grasses and reducing subsequent fire intensity. Whilst the TTCS model has been designed for implementation in miombo areas, it is not a 'one-size-fits-all' model. It is important to have a basic understanding of the ecology of new production sites, in order to adapt the approach to specific localities. It may be possible to develop comparable models for other woodland types. For example, in Kenya, research suggests that charcoal can be produced sustainably from woodlands dominated by *Acacia drepanolobium*[5]

[1] Campbell, Frost and Byron. 2006. The Miombo in Transition. P 2.
[2] Chidumayo and Frost, 2006. Population biology of miombo trees. C. 3 in Campbell et al. The Miombo in Transition
[3] Luoga et al. 2004. Regeneration by coppicing of miombo trees in relation to land use. For. Eco. & Man. 189: 23-25.
[4] Luoga et al. 2004

How much miombo woodland is there in Tanzania?

The charcoal model is designed to work in miombo areas. Miombo is found in Central, Southern and Western Tanzania. Estimates of the area of miombo woodland, in Tanzania, indicate that there were approximately 462,548 km^2 of wet miombo, dry miombo and wet seasonal miombo in 1984. More recent forest assessments, have not distinguished miombo from other woodland types. For example, NAFORMA recorded 447,000 km^2 of woodland[6], including miombo and other woodland types such as the northern *Acacia - Commiphora* woodlands. Accurate data on the area of miombo on village land is needed to fully understand the potential for scaling up sustainable charcoal. In terms of forest land tenure, 45.7% of forest and woodland is on village land[7]. However, again, this classification does not distinguish miombo from other forest and woodland types. Further research, using the NAFORMA dataset, could generate an updated estimate of the area, distribution and tenure of Tanzania's remaining miombo woodlands. Miombo woodlands in Tabora, Singida and Kigoma Region are currently a deforestation hotspot[8]

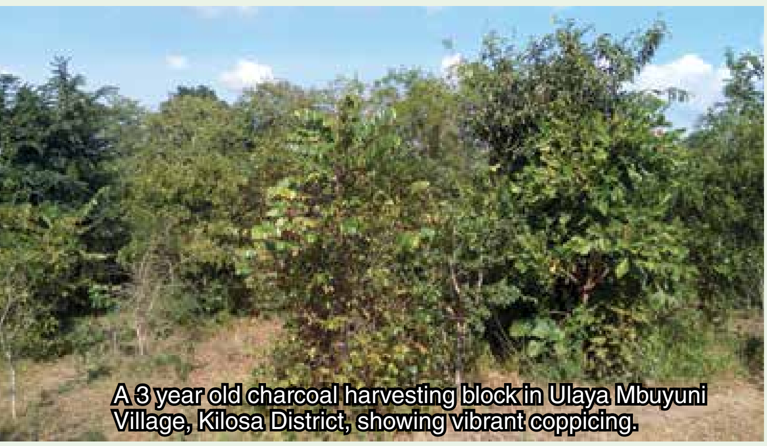


Map of miombo woodland in Africa, based on White, 1983.

The harvesting rotation is designed to reflect the regeneration capacity of miombo woodland.

Deciding on an optimal rotation, requires a value judgement as to what is meant by sustainable. Is it about returning an area to 'forest'? Or is it about maximising annual or average annual biomass increments? Or returning an area to its pre-harvest biomass and species composition? There are many different ways of looking at it, and ultimately the forest owner must weigh up the costs and benefits of the different approaches, and make a decision accordingly. In West Africa and Mexico, rotation periods of 9 – 15 years are applied in woodlands managed for charcoal production.[9]

Whilst in parts of Zambia, 20 – 30-year rotations are applied. In the case of the Tanzanian model, the project has adopted a rotation period of 24 years which is the time period with the highest average annual growth rate. This is a conservative approach, adopted in order to mitigate the risk that regeneration may occur more slowly in the project area, than in the miombo study sites, from which regeneration rates have been published. More long-term research is needed to assess the relative sustainability of different rotation periods. For example, research shows that miombo species will grow approximately 2.5 m within 6 years. Assuming trees are cut above 0.5 m, this means that within 6 years, a harvested area will have returned to 3 m, the minimum vegetation height required to meet Tanzania's official definition of forest.



A 3 year old charcoal harvesting block in Ulaya Mbuyuni Village, Kilosa District, showing vibrant coppicing.

Tanzania's Official Forest Definition

Tanzania's official forest definition: 'Forest' means an area of land with at least 0.5 ha, with a minimum tree crown cover of 10% or with existing tree species planted or natural having the potential of attaining more than 10% crown cover, and with trees which have the potential or have reached a minimum height of 3m at maturity in situ. URT, 2017. Tanzania's Forest Reference Emission Level submission to the UNFCCC.

Although, a harvested area could be considered 'forest' after 6 years, most stems would still be too small for charcoal production, based on a minimum harvestable stem diameter of 15 cm. Another approach would be to harvest at the point when the annual biomass increment

5 Okello et al. 2001. Growth, biomass estimates, and charcoal production of Acacia drepanolobium in Laikipia, Kenya. For Ecol Manage 142: 143–53.
6 FREL, 2017
7 NAFORMA, 2015. p. 40
8 FREL
9 Chidumayo and Gumbo, 2013. Energy for Sust. Dev. 17: 86–94

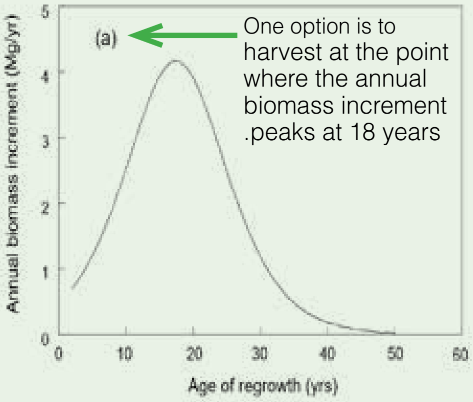


Figure 1: Annual biomass increment (Mg ha-1 yr-1) Source: Frost, 1996[10].

Another approach would be to aim to return to the pre-harvesting stand biomass. This could take up to 50-years or more.

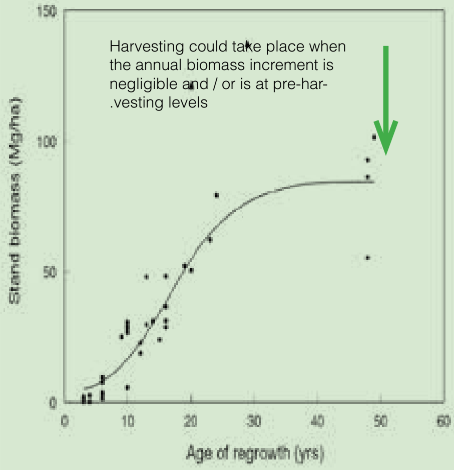


Figure 2. Stand biomass increases as a logistic function of the age of regrowth on miombo woodland coppice plots. Source: Frost 1996

However, doubling the rotation period would not result in a doubling in biomass. For sustainable charcoal production, it is unnecessary for trees to reach their maximum diameter. This is in contrast to timber, where a longer rotation is needed to reach a harvestable size.

Whilst the TTCS project has adopted a 24-year cycle, other projects could experiment and monitor the impact of shorter or longer rotations.

Promoting sustainability in the spatial distribution of harvesting areas

The TTCS Model recommends that a maximum of 20 % of the area of a Village Land Forest Reserve (VLFR) be designated for charcoal production. The other 80 % is allocated for protection or selective logging. Allocating only 20 % of the VLFR area for sustainable charcoal production, mitigates the risk of under-performance in regeneration, and / or failure to control other disturbances within the VLFR. For example, if regeneration did not occur as predicted, or some of the Forest Management Unit (FMU) were damaged by fire or illegal harvesting, the village could still revise the harvesting plan to incorporate additional areas, and thereby meet its targets. In this way, the project has embedded a risk mitigation strategy within the design of the model. Furthermore, the protective zones of the VLFR, provide areas in which the full suite of ecosystem services are protected. Further research is needed to identify the optimal balance between productive and protective areas, under different conditions, and to have a more precise understanding of the risks.

The harvesting plan for each FMU includes a 'checker-board' mapping of harvesting blocks. Each harvesting block within an FMU is 50 m x 50 m. The checker-board harvesting regime is designed to create a mosaic of woodland areas at different stages of regeneration. Each year 1/24 of the blocks can be harvested. The small area of the individual harvesting blocks, helps to mitigate potential risks of: erosion, habitat degradation for wildlife, and reduced seed dispersal into the harvested area. The TTCS model requires that a harvested block must have been regenerating for at least 10 years before the adjacent blocks can be harvested. The yield for each block is calculated based on an assessment of available biomass. The cumulative yield from each year's blocks establishes the annual charcoal quota for the village. The boundaries of the harvesting block are marked out by the Village Natural Resources Committee (VNRC). Producers are only permitted to produce charcoal within the designated block. Importantly, all other blocks need to be protected in order to allow the woodland to regenerate. This means excluding fire for at least the first two years after harvesting. Grazing of livestock is controlled; and agriculture is prohibited.

The checkerboard pattern of harvesting is visible in this satellite image of Ulaya Mbuyuni.

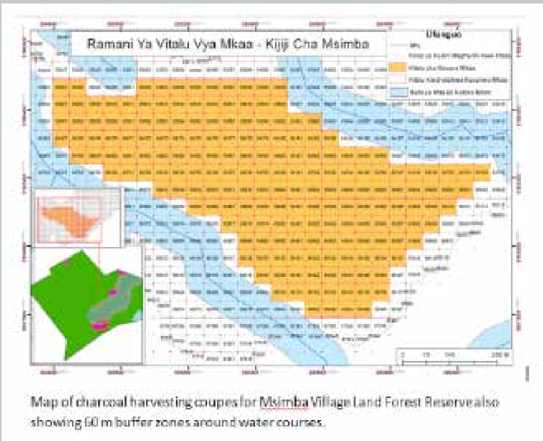


Figure 3. Planned harvesting blocks within a charcoal Forest Management Unit.

[10] Frost, P. 1996. The Ecology of Miombo Woodlands. In 'Miombo in Transition'. Ed. Campbell. P. 33 (Fig 2) & 34 (Fig 1).

Other measures designed to increase sustainability

The TTCS project has also guided villages to include various measures to enhance the environmental sustainability of the model, and mitigate potential environmental risks. These include the following:

- No harvesting of trees 15 cm diameter or less at breast height and at least 3 trees greater than 15 cm dbh must be left per 50 x 50 m harvesting block.
- Setting limits on the minimum distance to be maintained between water sources and harvesting areas.
- Limiting harvesting to slopes with a gradient < 30%.
- The model protects trees species that have a high market-value for timber such as Mvule, Mninga and Mpingo. Individual trees with obvious biodiversity value, such as nesting sites, are also excluded from harvesting.

Role of SCP in reducing deforestation

Central to the model's sustainability is its intention to reduce deforestation by providing an incentive to communities to maintain forest cover. The project has reduced deforestation relative to comparable areas in the same districts, and relative to historical rates. For example, the ten Kilosa District villages that joined the project between 2013 -15, have reduced their annual deforestation rates from -2.37% (2010-14) down to -1.91% for 2014 – 2015, and down to -0.78% within the Village Land Forest Reserves. This decline in deforestation rates in the project villages contrasts with an overall increase in deforestation in the rest of the Kilosa District from -1.93% in 2014 to -2.64% in 2016.

Energy efficiency

The project is promoting Improved Basic Earth Kilns, due to their potential to increase the efficiency of the carbonisation process, relative to traditional kilns.

Economic and social sustainability

The model is designed to be economically sustainable. Communities charge a fee for each bag of charcoal that is produced. Cumulatively the participating villages have earned TZS 0.3 billion in fees. Decisions about how the revenue to the village is spent, are made in village assembly meetings. A proportion of the village revenue must be re-invested in reserve management and overseeing the sustainable charcoal model. Costs include patrols and equipment for the patrol teams and VNRC members. The remainder of the fees is invested in community development projects. So far, communities have used their charcoal revenues for a range of projects including paying for universal health insurance for community members, class room construction, and accommodation for health workers.

Miombo woodlands play a vital role in the livelihoods of adjacent communities. They provide many different kinds of food for people including fruits, mushrooms, honey, vegetables and tubers. Miombo woodlands also provide building materials, medicines and material for tools, utensils and furniture. Safeguarding communities access to these resources is central to the sustainability of the model. Community members' rights to harvest are outlined in the management plans of the VLFRs. Many of these additional values are specific to miombo woodlands, and could not be replicated through reforestation using non-miombo species. Research from various countries in Africa, including Tanzania, has highlighted that community based natural resources management and maintaining access to woodlands, enhances communities' capacity to adapt to climate change.[11] Good governance and a commitment to participation, transparency, accountability and gender equality are also key elements of the social sustainability of the model.

Further research

Working with academic institutions in Tanzania, including Sokoine University of Agriculture and TAFORI, the project is conducting research on some of the key questions, including monitoring regeneration and deforestation, as well as looking at the impact of fire and grazing on the forest management units. The project welcomes collaboration with research institutions, and is committed to an evidence-based approach to improving and scaling-up the model. To find out more about the Transforming Tanzania's Charcoal Sector Project, please visit: http://www.tfcg.org/sustainablecharcoal.html

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[11] IPCC 2014 Climate Change: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. 22.4.5.6