School of Water, Energy and Environment (SWEE)
Environment and Agrifood

Final Report for Sue White Fund (SWF)

Sensing Charcoal Making and Understanding Links to Deforestation in Tanzania

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1.0 Project Overview and main objectives

1.1 Research context

- Charcoal business in Tanzania is widely spread
  - ✓ But the activity is not regulated, and the level and distribution of charcoal kilns are not well known
- Studies shows that charcoal making cause deforestation and pollution
  - ✓ But its emission and extent of deforestation associated with this activity is largely neglected.
- Under these backdrops, ambient air monitoring exercises coupled with source apportionment studies plus questionnaires and GIS analysis of forestry will be employed to understand the levels of emissions and distribution of charcoal kilns.

Results of the study will help to understand why the impacts of charcoal making are varied and will benefit the industrial partners for being linked with atmospheric data collection in developing countries. Further, the study will provide information that has the potential to reduce adverse effects of charcoal production to the local environment and catchments, and therefore benefit the community. Furthermore, the potential fine scale data derived from this study when combined via a GIS based study with data available on deforestation, water courses and population density will aid understanding of the links between charcoal making, deforestation and changes in the underlying fluvial systems.

1.2 Aim and objectives.

The aim of this study is to advance current knowledge on environmental impacts (i.e., deforestation and air quality) of charcoal making in Tanzania. The specific objectives are:

Objective 1. To develop a methodology to quantify charcoal production emissions in ambient conditions;

Objective 2. To identify areas of high-density kilns and changes in charcoal production around the East Usambara Mountains using GIS approaches;

Objective 3. To link charcoal production with catchment impact and degradation.

1.3 Research questions.

The objectives were translated into research questions as follows:

a) How to conduct controlled observational studies around charcoal making sites using traditional earth kiln techniques to generate a characteristic emissions factor for these activities. This research question will explore the use of emission factors to quantify emissions derived from a charcoal kiln and to differentiate them from other important sources such as transport and small-scale household burning around the experimental study and field site of East Usambara mountain.

b) How to use GIS based approaches and any existing data (such as broad swathe satellite data) to identify areas of high charcoal kiln density and changes in charcoal production around East Usambara Mountain.
c) How to identify areas of high charcoal kiln density around East Usambara Mountain using GIS based tools, link charcoal production with increased deforestation in the region and quantify impacts to forest around East Usambara Mountain.

2. Progress to date

There has been significant progress regarding data analysis, interpretation, research writing and submission of research.

Firstly, the data analysis involved the isolation of charcoal emission plumes from other regionally important sources, the identification of areas of high-density kilns and changes in charcoal production around east Usambara mountains using GIS-based approaches and the link of charcoal production with catchment environmental impacts. Findings indicated that the monthly mean concentrations of PM_1 during the pre-, during and post-charcoal production stages were 8 ugm-^{3}, 7 ugm-^{3}, and 9 ugm-^{3}, respectively. The findings indicate a decrease in the level of particulate matter during the charcoal production process, suggesting the existence of additional locally produced gases that contributed to the pollution in the surrounding environment. Further, the results showed lower values of CO and CO_2 during the charcoal production period. These were unexpected and may be due to lack of regular calibration of the instruments. The sensor used in the study was effective in identifying pollutants in tropical regions, despite calibration challenges. The sensor also proved useful at identifying representative pollution signals especially PM's. The study also identified the sources of pollutants and their trajectories, with southern-eastern winds being a significant factor. Human-induced activities and local emissions were found to contribute to the pollution. The study analysed the emission ratios of pollutants, but found insignificant links between CO and CO_2, as well as PM_1 and CO_2.

Furthermore, this study establishes a connection between charcoal production and negative effects on the East Usambara Mountain catchment area. The research findings show that humid forest regions had a significant concentration of proxy variables associated with charcoal production. The study also identifies differences in charcoal-making activities among different forest regions. The prevalence of dark patches indicates a high frequency of charcoal production in the area. The study also reveals a decrease in the quantity of charcoal-making activities between 2013 and 2015, followed by an increase from 2016 to 2019. The study estimates that a significant amount of charcoal was produced, resulting in the harvesting of many trees and the emission of CO and CO_2.

3. **Steps that may be put in place to control deforestation, reduce flooding and improve catchment management**.
   - To continue creating awareness on the drivers of deforestation such as charcoal making on the area through seminar presentations to villagers, local administrators and managers in the study area.
   - To continue promoting sustainable forest management and establish sustainable charcoal making activities.
   - To create awareness to policy makers who could influence the government and donors to be engaged in subsidizing an energy substitute such as Liquefied gases for cooking and heating.
   - To continue to strengthen the resource information base and air quality monitoring. A citizen scale technique is to be developed for detection of emissions and consequence of charcoal making into the community.
   - To set up sound regulation around charcoal making activities in Tanzania and development of approaches for sustainable charcoal production in Tanzania.
   - To investigate strategies to move toward non-fossil fuel sources in Tanzania to reduce pressure on the use of forest.

4. Career Development through SWF

Through SWF, I have acquired skills of searching and writing consultancy activities. Also, I have continued extending my professional network and am able to interact with multidisciplinary colleagues and through these for example, for the past three years, I have managed to secure consultancy work relating sustainable utilization of forest including training of local communities on sustainable charcoal making such as briquettes and agroforestry (Fig.1 and 2).

Figure 1: Participants learning tree nursery establishment and agroforestry practices as part of consultancy activities conducted to local communities from Morogoro, Tanzania.

Figure 2: Participants from charcoal cluster learning briquettes production as part of consultancy activities conducted to local communities from Morogoro, Tanzania.

Also, through the SWF and research project in general, I have managed to work independently from activity planning to execution of tasks with minimum supervision. This is a new skill that I have acquired and helps me in undertaking tasks and completing them in time. I have written several proposals that were submitted to various stakeholders for funding and managed to train my fellows on various skills acquired.

Furthermore, through the SWF I have continued using the most recent technology such as Miniaturised sensors for air quality monitoring, HYSPLIT 4 Model and ArcGIS. Therefore, this knowledge maintains my ability to perform multidisciplinary activities that will be necessary for environmental management in developing countries.

5. Conclusion and recommendation

Overall, the findings highlight the need for sustainable charcoal production practices to mitigate the negative impacts on the surrounding environment. The findings presented in this study demonstrate a mechanism that enables the characterisation of and differentiation between charcoal burning and production signatures. It is recommended that a citizen scale technique be developed for detection of emissions and consequence of charcoal making into the community. Further recommendations are to investigate strategies to move toward non-fossil fuel sources in Tanzania to reduce pressure on the use of forest; to set up sound regulation around charcoal

making activities in Tanzania and development of approaches for sustainable charcoal production in Tanzania.

Finally, many thanks should be continually conveyed to Sue's family for such a helpful and generous heart because without SWF financial support for this study it would have been impossible. I kindly suggest this effort to be continued to other fellows from developing world and enable them to be environmental champion for health living.