Promoting advanced technologies for sustainable charcoal and biochar production in Sub-Saharan Africa (SSA).


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Abstract

Fabricating a small-scale and cost-effective biochar/charcoal retort is most economical when farmers/producers have the materials on hand and the skills (i.e., welding) to manufacture it since inappropriate technologies affect the yield and quality of biochar. As farmers gain more knowledge and skills in manufacturing these different technologies at their convenience, they could make the right choices in subsequent years ahead and advocate sustainable agricultural practices. We analyzed existing technologies in Indiana and Ghana using desk study, questionnaires and interviews as we give recommendations on the design properties of some appropriate charcoal and biochar conversion methods for small scale usage based on their production and use variables.

Introduction / Background

- About 85%-90% of people in Sub-Saharan Africa depend on charcoal/firewood for cooking and other household activities (Kituyi *et al.,* 2002).
- These regions contribute 62% to global charcoal production (Dam *et al*., 2017).
- Almost 95% of charcoal produced in these regions is from earth mounds that are about 10-15% efficient and releases high amounts of Greenhouse gases (Dam *et al*., 2017).
- Earth mounds require about 10 tons of wood for every one(1) ton of charcoal produced.
- Inappropriate technologies like earth mounds result in poor-quality charcoal and deforestation (Obiri *et al.,* 2014).
- Meanwhile, about 80% of farmers are charcoal producers. Farmers practice fallowing, apply inorganic fertilizers and sometimes composting to maintain soil fertility.
- Unlike charcoal production which requires a larger to medium diameter wood, biochar can be produced from different feedstock (wood chips, agro-industrial residues and even charcoal wastes).
- Hypothesis: Increased fabricating skills and knowledge on existing biochar/charcoal technologies will improve sustainable livelihood in SSA.

Figure 1. Traditional Charcoal Earth Mound

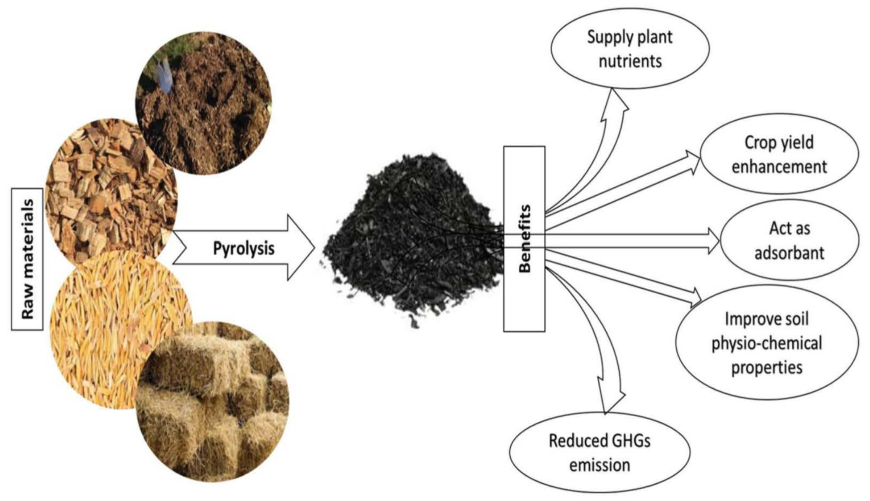

Figure 2. Potential Biochar application in Sustainable Agriculture (Gogoi et al., 2019).

Figure 3. An Open Burn Biochar Method

Materials and Methods: What contributes to selecting a technology?

Production and Use variables:

- Feedstock availability
- Cost of manufacturing
- Maintenance cost
- Skills and labor involved
- Equipment Type/Cutting list
- Temperature control
- Ramp and Hold Time
- Purpose and Scalability
- Application Rate
- Soil Type
- Climate

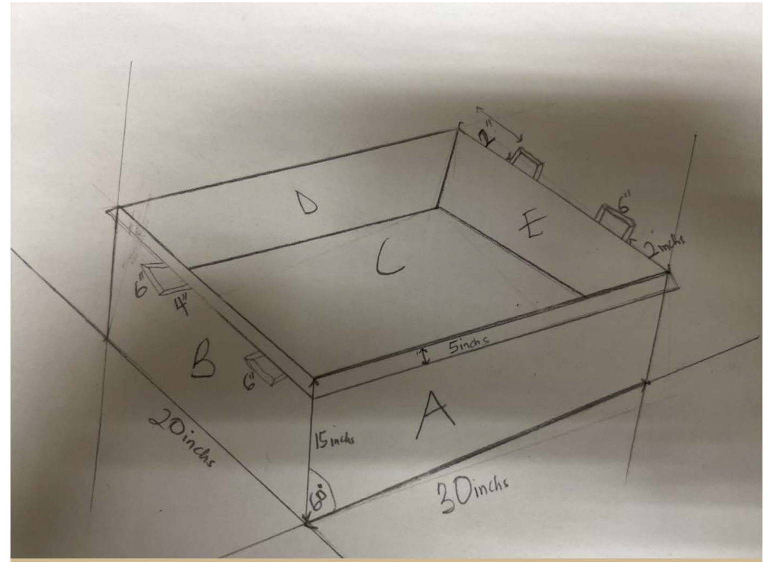
Figure 4. Sketch of an Oregon kiln- body

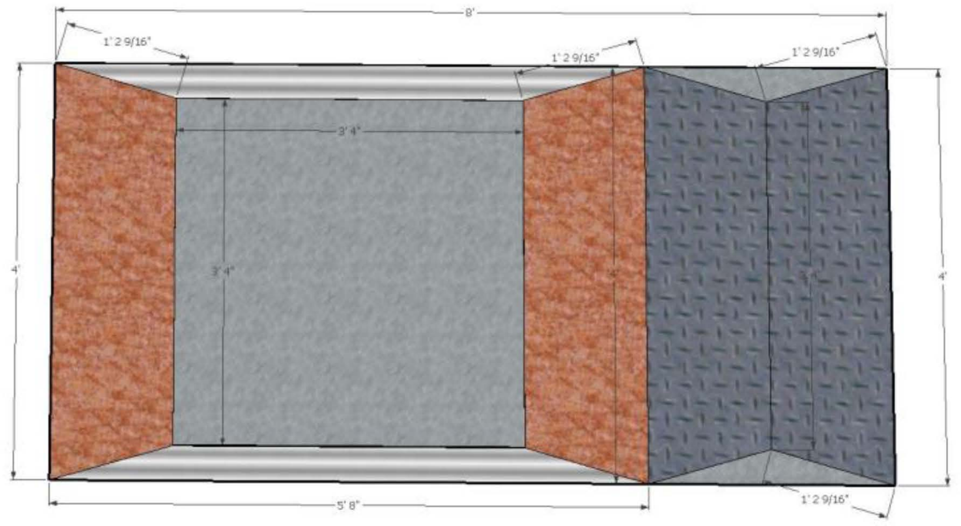
Figure 5. Designing idea using Sketchup pro- 2022

a. Materials/Cutting List:

1. 5'x8' x14ga sheet metal- kiln body
2. 5'x2' x14ga sheet metal- kiln sides
3. 3/8'' dia. Round, 24''long- handles
4. 25-litre Steel Drums- hold feedstock
5. ¼''3 ½'' Flat Bar, 8'' long- corner braces
6. ½'' steel eye hooks and bolts
7. Stainless Steel Bolts 8. Bricks

b. Methods

1. Desk Study,
2. Brainstorming and Design,
3. Prototyping and Manufacturing
4. Testing and Evaluation.


Figure 6. Mark dimension, cut parts and weld together


Figure 7. Bend thick materials if necessary for the preferred design

Results /Expected Outcomes: Selecting a Sustainable Technology

Based on efficiency (not wasting resources), efficacy (ability to produce desired results) and effectiveness (degree of success), and sometimes site restrictions/ limitations of technologies, an improved Dartmoor Dragon Kiln may be sustainable for both charcoal and biochar conversion.


Figure 8. Proposed design assemblage

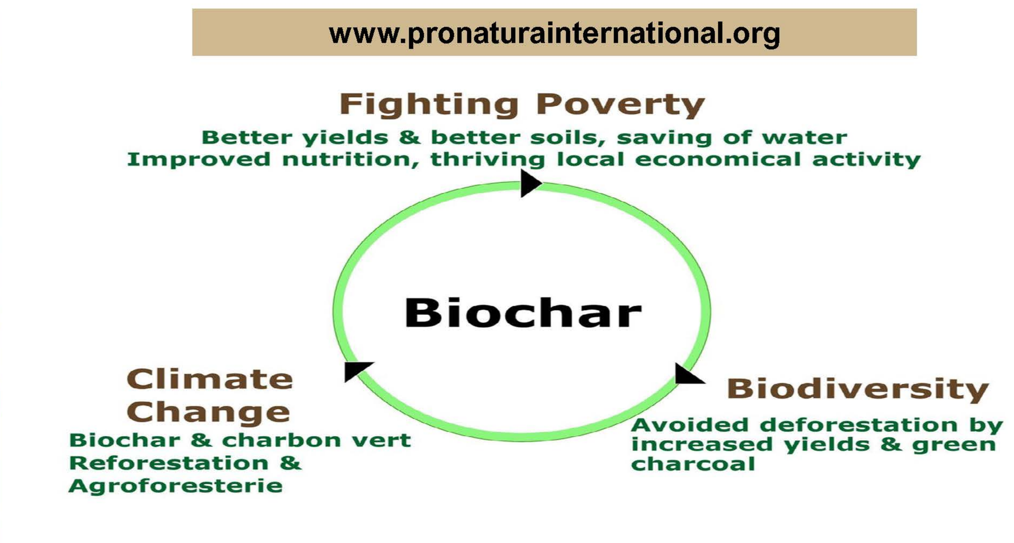

Figure 9. Benefits of Biochar in Sustainable Agriculture

Figure 10. Ring of Fire Kiln: Works as Oregon but covered with a lid.

Fig. 11. The Oregon Kiln: not good for charcoal due to feedstock restrictions(size and type) and limited temperature control.

Figure 12. Metal kilns: very efficient but expensive (appropriate for charcoal and biochar).

Figure 13. The Dartmoor Dragon Retort: good for biochar and can be designed for charcoal

Conclusions, Recommendations- Extension Plan

1. **Design and development must be based on ease-benefit matrix: Low Ease- High Benefit.**
2. **Using thicker fabricating materials correspond to a longer lifespan of kilns, adequate heat conservancy, but could be expensive.**
3. **Teamwork and collaborations among small, medium and large-scale industries will encourage community engagement.**
4. **Sustainability is more of attitude building than action taken.**
5. **Stakeholders should make use of the CATWOE approach in Tech. implementation.**

Proposed CATWOE Solution Diagram

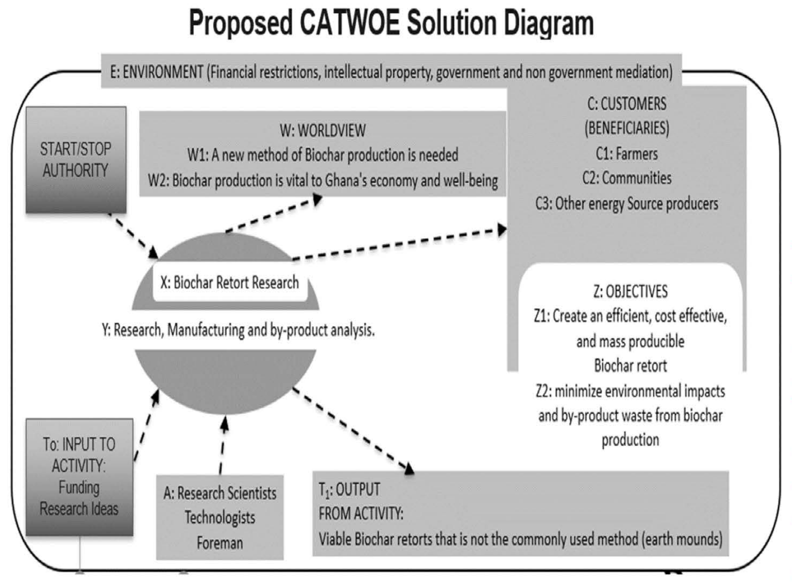
Figure 14. Relevant Systems model for Technology Implementation

i. Customers: Group 1- maximize benefit, Group 2- Minimize, Group 3- Choose to ignore
ii. Actors iii. Transformation
iv. Worldview v. Owners vi. Environment

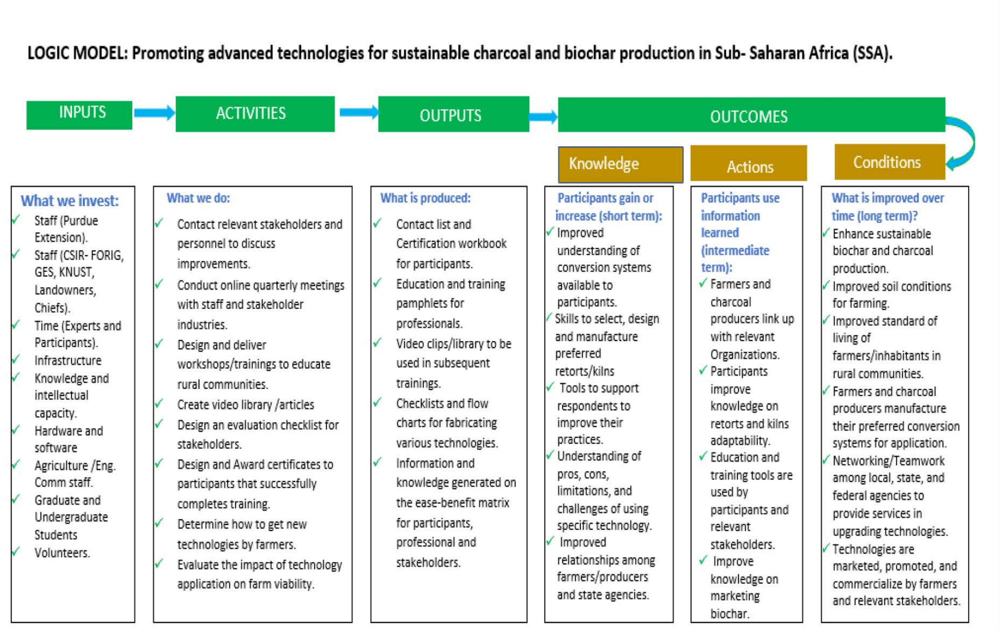
Figure 15. Logic Model for Extension Deliverables

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