Feasibility of Bioethanol Production from Cassava as an Alternative Cooking Fuel in the Bo Region of Sierra Leone

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Background and Situation

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Post-civil war, post-ebola country, 97% of population use wood to cook their meals

- Deforestation rate about .7%/yr (USAID 2010)
Introduce stoves to 0.01% of the population, or 1,000 households in Bo and other urban areas where people are otherwise buying firewood.

Introduce high-yield strain of cassava from SLARI that allows 20 tons/ha of production (current strain yields around 8 tons/ha).

Contract farmers to produce cassava on 500 hectares (1000 ha considered for current strain)

Create Organizational Model to determine staffing, budget, and partnership needs
Target Values

0.01% of population
1,000 households in Bo

Each family consumes 2-3 liters of ethanol each week

Ethanol Partners supply 156,000 liters/year

500 hectares of farmland producing cassava
Project Chain Analysis

Critical Path: Yellow Boxes

Gaps: Transportation, Cassava Processing
Desert Water Organizational Plan

Key:
- Sourcing Level
- Desert Water Staff
- Distribution Level

Flowchart:
- Executive Director
  - Cassava Processing Plants
  - Ethanol Production Plant Manager
  - Stove Producer
- Women Cooperative Leaders
  - Rural Communities
- Community Outreach/Capacity Building Coordinator
- Technical Operations Manager
- Marketing and Distribution Director
- Administration and Accounting Staff
- Local Ethanol + Stove Distribution Centers
- Urban Communities
Partner Map

**ETHANOL:** Mikeni Biofuel Plant and Sunbird Energy

**STOVES:** Cleancook AB

**Desert Water Social Enterprise**

**STOVE + ETHANOL DISTRIBUTION:** Urban Distribution Center - Partner Still Needed

**CASSAVA VARIETY DISTRIBUTION:** Ag Business Centers and FAO Sierra Leone

**CASSAVA PRODUCTION:** Green 4 Africa, and FAO Sierra Leone

**CASSAVA PROCESSING** Partner still needed
Gantt Chart

- Establish a market for stoves and ethanol
- Contract an ethanol production system
- Establish transportation system
- Empower cassava cooperatives

1. Feasibility Study
2. Ethanol Home Brew
3. Stove Testing
4. Stove Mini Pilot Study
5. Urban Advocacy on Dangers of Woodsmoke
6. Geographic Survey
7. Introduce SLARI Cassava
8. Rural Advocacy on Importance of Trees
9. Establish Market for Imported Stoves
10. Contract Bioethanol Plant
11. Establish Transportation System to Ethanol Plant
12. Enrichments and Further Trainings for Cooperatives
SWOT Analysis

**Strengths:** Necessary partnerships are underway

**Weaknesses:** potential for failure if market isn’t feasible

**Opportunities:** Existing ag extension infrastructure can be utilized

**Threats:** poor infrastructure including roads, potential for unforseen expense

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<tr>
<th>Strengths</th>
<th>Weaknesses</th>
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<tr>
<td>• Dynamic organizational leader</td>
<td>• High start up investment required for building ethanol production facility</td>
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<td>• licensed to operate in California</td>
<td>• Each leg of the project relies on the other-- fuel market is needed for cassava production, but intensive cassava production needs an end point/destination market</td>
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<td>• In-line with FAO and IITA mission; probable support from existing ethanol plant</td>
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<td>• Startup stoves and sticks already donated (need to confirm)</td>
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<td>• Existing Connections to farmer cooperatives</td>
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<td>• Women Farmers are already familiar with growing cassava</td>
<td>• Alcohol/ethanol may be a taboo in some rural areas</td>
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<td>• High demand if produced affordably</td>
<td>• Minimal infrastructure: roads, electricity, water</td>
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<td>• Similar initiatives begun in other countries</td>
<td>• Seasonal fluxes: droughts (may lower cassava production) and floods (roads may be impassible and harvest will be hard)</td>
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<td>• Existing ag business centers potential base for farmer collaboration and cassava purchase</td>
<td>• Other stove fuel sources -- solar?</td>
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<td>• Non-cooperation of Makeni/Sunbird biofuel plant?</td>
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<td>• Potential for unforseen project costs</td>
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Recommendations...

1. Partnership model rather than building ethanol and processing plants
2. Increase accuracy in budget (underway)
1. Do a pilot study for stove interest
1. Integrate the Desert Water staffing model
1. Mapping of feedstock sources, ethanol production and market destination
1. Failure Analysis
Tool 4: Risk Table

Desert Water has most control over
Risk Table: Implications

1. Robust Farmer Participation will be necessary for sustainability
2. Staff will be comprehensively evaluated before hiring, training will follow
3. Backup stove source will be identified, potential local partner producer will be identified
4. Fire hazard will be evaluated in feasibility study
5. Work with Ag business centers, FAO and Ministry of Ag to ensure access to natural/chemical fertilizers if higher production needed
Results:

Logframe flow chart for implementation plan

**Program:** Cassava Ethanol Logic Model (uses text boxes: add/change boxes and arrows as needed)

**Situation:** 95-99% wood-burning stove use in Sierra Leone results is pulmonary disease, deforestation and gender equity issues and necessitates a need for fuel alternatives. Cassava-based ethanol burns clean and can be a value-added opportunity for a crop already grown by women in cooperatives.

**Assumptions:**
- There are enough farmers and fallow land (500 ha) to adequately produce and process 20 tons/ha of cassava
- Future sizeable infusion of funds for ethanol plant construction
- Sufficient water available for ethanol production

**External Factors:**
- Government & country remaining peaceful
- Weather not being too severe
- Other similar initiatives possibly coming into start up
- Infrastructure and possibility of roads

**Outputs**
- Medium
  - Self-sustaining market for stoves and ethanol sold by local markets
  - Increased likelihood for women and less time spent wood collecting

**Outcomes**
- Long-term
  - Reduction in demand for wood biofuel
  - Steady output of 1 million L of ethanol per year, with capacity left to increase with demand

**Inputs**
- 50 stoves donated by Project Gaia and 600 L ethanol donated by Addax Bioenergy
- Student funding provided by Jastro & Blum
- UCD faculty may serve as advisors
- Possible partnership/collaboration with students from Nina University
- High-yielding cassava sticks provided by SLARI
- Further funding needed

**Activities**
- Summer: stove mini pilot study & survey with urban households
- Urban training on importance of deforestation and dangers of woodsmoke
- Summer: area mapping of target markets, supplier farms and geographic assessment (H2O etc)
- Summer: introduction of SLARI variety sticks through cooperative training & meeting
- Rural training on importance of trees to reduce extreme weather events
- Women cooperatives on 500 ha and their families (Matthews)

**Participation**
- 50 urban families (Paula)

**Outcomes Short**
- Demand for 100 L week by end of pilot study
- Demand outside of pilot study to buy stoves
- Clear identification of where to build ethanol production centers & how many
- Identification of individuals to work at centers and markets to sell fuel & stoves
- Knowledge of how to grow and process cassava for feedstock
- Commitment to growing SLARI cassava on 500 ha; begin planting on 200 ha (TBD)

**Activities**
- Establish stove market for imported stoves from Nigeria with local sellers that allow for layaway costs
- Establish regular pickup and transport schedule to production plants
- Run enrichments and further trainings for cassava farmer cooperatives to maintain incentives for high production

**Outputs**
- Demand
  - Customers, local sellers, people: Nigerian stove company
  - Construction: workers, planners, generator & kegomme sellers; yeast & mushroom suppliers; brewers & staff
Our Scope: Sequencing and Timeline

Winter Quarter: D Lab I
- confirm budget, apply for grants
- business plan/cleaner timeline
- determine scaling to more detail
- identify stove and ethanol plant designs
- identify supply chain for stoves
- identify cooperative capacity building needs and training curriculum

Spring Quarter: D Lab II
- design and build a stove
- test small scale ethanol production
- Design research questions for household surveys
- Design mini pilot-study for stoves

Summer: mini pilot study (test marketability of ethanol+stoves), household surveys and ground research, begin to forge relationships with cooperatives and other associations,

Fall and Beyond: Implement Desert Water Cooperative Structure, contract farmer co-ops, build bioethanol plant(s), set up local manufacturing system for stoves
Action Items For D-Lab 1

Write business and organizational plan for cooperatively-run social business enterprise

Risk table: assess severity and likelihood

Research: Perform a more rigorous meta-analysis of cassava bioethanol projects

Stakeholder Outreach: Stove Producers, UNFAO, Ministry of Trade and Industry, Adax Bioenergy/ Mali/Nigeria initiatives

Designing Mini-Pilot Study in Country

Grants: Find and apply for grant funding
**Timeline**

**Winter Quarter: D-Lab I**
- Complete Feasibility Study
- Continued Research of cassava + ethanol production
- Business Plan
- Grant application(s)

**Spring Quarter: D-Lab II**
- Stove and Ethanol Pilot
- Design In-Country Market Study

**Summer**
- In Country Pilot Study

**Fall and Beyond:** Implement Desert Water Cooperative Structure, contract farmer co-ops, build bioethanol plant(s), set up local manufacturing system for stoves