MIT D-Lab Design Review + Dinner
Off-Grid Chick Brooder - Cameroon

With
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• Aly Kombargi, MIT PhD candidate

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Off-Grid Brooder

Obala, Cameroon

Ahmad Zakka, Josh Maldonado, Aly Kombargi
Our Partners

Swiss foundation committed to scientific research of technological, health, and economic solutions in marginalized population of developing countries

Community Contacts:

Joël Jeanloz (African Solar Generation, formerly Antenna Foundation)
Lionel Wassoumi (African Solar Generation)
Carole Erlemann Menguei (President CDAS-BC)
Kathrin Witschi (Secretary/ Treasurer CDAS-BC)
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01 BACKGROUND
Poultry Sector In Cameroon

Poultry contributes **4% to Cameroon’s GDP**

**42% of all meat production**

320,000 jobs created in recent years

Source: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, OEC.world
Agriculture Sector In Cameroon

Agricultural sector 50% of export earnings

Agricultural sector 17% of the GDP

Employ between 70%–80% of the population

Small scale farming 70% of agriculture sector
Current Poultry Market

Disadvantages:
- Weakened Economy
- Reliance on Foreign Market
- Market dominated by inferior product
- Disappearance of local breeds

Advantages:
- Cheap and Quick supply of poultry

Diagram:

1. Foreign GMO chick supplier
2. Local Agriculture University
3. Small scale local poultry farmers
4. Local poultry distributors/ restaurant owners/ individuals

Arrows indicate the flow of supply and demand in the current poultry market.
Road to Cyclical

- Not a sprint but a marathon
- Small scale/ Low cost egg incubation
- Cost efficient chick brooding

Small scale local poultry farmers

Local Breeds → NON GMO

Local poultry distributors/ restaurant owners/ individuals
02
Designing the Brooder Box
Incumbent Solution

Burn firewood to keep chicks warm

- Disadvantages:
  - Pollution → Environmental/health concerns
  - Inconvenient → Farmers must rekindle fire several times a night
  - Dangerous → Farmers must sleep near chicks

- Advantages:
  - Cheap → Firewood easily sourced
  - Familiar → Farmers are accustomed and experienced in wood burning
  - Reliable → No reliance on external factors (grid, solar etc…)
## Design Requirements

<table>
<thead>
<tr>
<th>Design Requirement</th>
<th>What is measured?</th>
<th>How is it measured?</th>
<th>Target</th>
<th>Ideal</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interior Temperature</strong></td>
<td>Temperature in the chamber</td>
<td>Temperature sensors</td>
<td>30-33 °C somewhere</td>
<td>30-33 °C everywhere</td>
<td>ASG</td>
</tr>
<tr>
<td><strong>Time Between Maintenance</strong></td>
<td>Time that temperature is in range</td>
<td>Temperature sensors</td>
<td>8 hrs</td>
<td>12 hrs</td>
<td>ASG</td>
</tr>
<tr>
<td><strong>Humidity</strong></td>
<td>Average humidity in box</td>
<td>Humidity sensors</td>
<td>40-60%</td>
<td>40-60%</td>
<td>Literature review</td>
</tr>
<tr>
<td><strong>Ventilation</strong></td>
<td>Volumetric air flow through box</td>
<td>Anemometer</td>
<td>12 CFM</td>
<td>12 CFM</td>
<td>Literature review</td>
</tr>
<tr>
<td><strong>Operator Time</strong></td>
<td>Time to maintain box</td>
<td>User experience, calculations</td>
<td>1hr</td>
<td>30min</td>
<td>Estimate</td>
</tr>
</tbody>
</table>
Building: The Box

Tasks Accomplished

1. Recreated the brooder box in Fusion 360 at \(\frac{1}{4}\) volume
2. Built the box from \(\frac{1}{2}\) in. plywood and 1 in. XPS foam board
3. Created barriers to mark potential locations to place the PCMs and protect them from the chicks
Building: The Sensors

Tasks Accomplished

1. Installed **DS18B20 temperature sensors** and **DHT22 temperature and humidity sensors**
2. Monitored recorded sensor output using an **Arduino Uno**
3. Strategically placed sensors at measured distances from the PCM and within the PCM to monitor temperatures throughout the box
Building: The Sensors
Building: The Heat Source

1. Replaced initial firewood technique
2. Thermally-insulated wooden cabinet
3. Solar panels that store energy in batteries for heating with lamps
Building: The Heat Source

1. Replaced initial firewood technique
2. Thermally-insulated wooden cabinet
3. Solar panels that store energy in batteries for heating with lamps

1. Replaced lamp warming with heat released from phase-changing materials (PCMs)
2. Thermally-insulated wooden cabinet
3. PCMs: sodium sulfate decahydrate, tetradecanol, paraffin wax
Building: The Heat Source

\[ T[K] \]

- **Solid Phase**
- **Phase Transition**
- **Liquid Phase**

- **Time**

- **Thawing**

- \( T_1 \)
- \( T_f \)
- \( T_2 \)
Designing the Thermal Battery
Design - Thermal Batteries
Design - Thermal Batteries

Sodium sulfate & Tetradecanol
Water
Beeswax
Hybrid
04
Designing the Egg Incubator Box
Design - Egg Incubator

Controls:
- Temperature
- Humidity
- Rocking motion
The Project Today
New Partners

CDAS-BC (African Diaspora Council of Switzerland – Branch Cameroon)

Kathrin Witschi
Secretary/ Treasurer

Carole Erlemann Mengue
President/Founder

Interests
- Permaculture & Biological Agriculture
- Cultural Exchanges & Travelling
- Experimenting Small Scale Agro-Business

Interests
- Agriculture
- Professional Exchanges
- Social Reintegration
Data Collected In Research Box

- Styrofoam Insulation
- Stacked Design (floor heating)
- Aluminum Base Tray
- 10 Kg of Beeswax Thermal Batteries
Note: No Chicks In Box
Thermal Batteries Warm Over 21hr
Note: No Chicks In Box
Key Takeaways

- Inlet vent temperature > Chick height
  Temperature indicate heat losses
- ~8hr above target temperature on one charge (~2h charge time)
- ~5°C gain in box throughout night
- Thermal Batteries still warm after 21h

<table>
<thead>
<tr>
<th>Chick Space Over 30°C</th>
<th>Chick Space Over 29°C</th>
<th>Thermal Batteries Over 30°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>7h 48min</td>
<td>12h</td>
<td>+21h</td>
</tr>
</tbody>
</table>
Data Collected In Low Cost Box

- Taped Polypropylene Bags Insulation
- Flat Design (heat source with chicks)
- No Floor Insulation
Low Cost Brooder Box Empty Test

~8h

~2h
Key Takeaways

- Temperature near batteries > Chick height. Temperature indicates heat losses.
- ~2hr above target temperature on one charge (~2h charge time).
- ~5°C gain in box throughout night.

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<th>Chick Space Over 29°C</th>
<th>Near Thermal Batteries Over 30°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>2h</td>
<td>3h</td>
<td>8h</td>
</tr>
</tbody>
</table>
Low Cost Brooder Box Live Chicks Test

Inside T and Outside T versus time of day over 17 days of brooding

Note: 15 Chicks In Box
Temperature Gain In Brooder Box

Note: 15 Chicks In Box

Data Collected By CDAS-BC
- Survived Brooding process
- Weight comparison at 45 day
Brooder Box Comparison

**Low Cost Box**
- Price: ~10 USD
- Thermal Batteries (10kg): 40 USD - 70 USD
- Minimal build time
- ~2h @ chick height T > 30ºC on single charge
- 1.5 m² chick surface area

**Research Box**
- Price: >200 USD
- Thermal Batteries (10kg): 40 USD - 70 USD
- Significant build time
- 8h @ chick height T > 30ºC on single charge
- 1.4 m² chick surface area
Similar Technology Already In Use
Moving Forward

Commercial Dissemination

- Identify local entrepreneurs
- Determine appropriate business model and price point
- Procure backstock of beeswax for rapid distribution

Educational Dissemination

- Identify trainers
- Run a ToT (training of trainers)
- Procure backstock of beeswax for rapid distribution