Scalability and Economic Feasibility of Cool Storage Implementation in East Africa

An Analysis on Net Present Value

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Executive Summary

Twenty-three percent of perishable foodstuffs are lost due to lack of refrigeration in developing countries. For comparison, only 9% of perishable foodstuffs are lost for the same reason in developed countries (Kitinoja 2013). There are vast dissimilarities in the amount of cold storage space available per capita in developing vs. developed countries. On average, developed countries have 0.2 cubic meters per person of cold storage space whereas developing countries only have 0.019 cubic meters per person. Within this context, UC Davis’ D-Lab, has connected a team of students with GreenPath Foods, a startup within Ethiopia, and the Horticulture Innovation Lab, an international agriculture development program based out of UC Davis. Both clients have expressed a need to better understand how to assess the profitability of implementing cold room storage systems that rely on CoolBot technology within the East Africa Region. In order to meet this need, a detailed yet flexible tool has been programmed using Microsoft Excel to output the net present value (NPV) of a given cold storage system over a ten-year lifespan. This calculator takes into account the costs and potential revenues associated with the use of a cool room including: the cost of powering the cool room, transportation associated with moving the produce, cost of building the cool room, and the revenue generated from selling the produce. The calculator was tested using data provided by Ethiopia-based GreenPath Food’s avocado production system, the Horticulture Innovation Lab, the USAID Tanzania Agricultural Productivity Program (TAPP), and secondary resources. Results show that implementing a cool room within GreenPath’s current production plan is more profitable than the business as usual option; however, the overall NPV is still negative primarily due to scale issues. This implies that in order to be profitable, a cold storage system operator must reach a threshold scale to overcome initial capital cost. We try to estimate this threshold for GreenPath food.
Introduction and Problem Definition

Cool storage is one of the most important steps to maintaining the post-harvest integrity of many fruits, vegetables, and other perishable goods. Effective temperature management can improve produce quality, increase farmer incomes, and allow access to export markets. At the same time, cold storage is among the most energy intensive segments of the food value chain. Significant levels of refrigeration are needed to slow spoilage and maintain freshness. For these reasons, any decision maker faced with the opportunity to create a cool value chain should have the tools available to make informed decisions on the use of cool storage.

Thus, this paper seeks to meet the needs of our two clients in East Africa, GreenPath Food and the UC Davis Horticulture Innovation Lab. Cool room storage systems are a relatively new technology in Eastern Africa and the long-term economic viability of investing in such a technology is uncertain. Both our clients requested a detailed, yet scalable tool for assessing the profitability of a cool room storage system that uses CoolBot technology.

GreenPath Food, Inc. works with smallholder farmers in high-yield environmentally friendly agricultural practices to bring organic produce to Ethiopian national and international markets. Currently, GreenPath invests in nucleus farms in rural communities to train farmers on yield-enhancing practices, buy produce from farmers, and market produce to create a complete and efficient supply chain (GreenPath, 2015). GreenPath is a new company and is starting out by focusing on avocado production and has a particular interest in cool storage. They have plans to expand to other crops and regions in the future.

The Horticulture Innovation Lab is a University of California, Davis research unit funded by the United States Agency for International Development (USAID). It has been asked by the USAID Tanzania Agriculture Productivity Program (USAID-TAPP) to provide technical assistance in the post-harvest sector. USAID-TAPP is a five-year program that aims to increase smallholder incomes, improve nutrition, and expand markets through agricultural innovation and commercialization. The method of operation of USAID-TAPP is quite similar to that of GreenPath. USAID-TAPP develops clusters of commercial farms, smallholders, and
agribusinesses in areas with high agricultural potential. They are targeting fresh and processed fruit, vegetables, flowers, and spices in Arusha, Kilimanjaro, Lushoto, Morogoro, and Zanzibar (USAID-TAPP, 2015).

Methodology

In order to meet the needs of both GreenPath Foods and Horticulture Innovation Laboratory, the team decided to design and program a Net Present Value (NPV) calculator, in the form of an Excel spreadsheet, for the installation of a CoolBot powered cold storage room. The overall output is designed to decipher whether the installation of a cool room will be economically beneficial under different circumstances through the comparison of the NPV with and without a cool room. Variable crops, climates and business scales can all be taken into account. After a market analysis (Section III) of the region six specific crops were chosen for analysis: pineapple, potatoes, mango, avocado, tomato and citrus. Based on the requirements for a cold room installation set forth by the clients, the calculator was also programmed to account for the inclusion of: construction, transportation of goods to and from the cold room, power use of the AC unit, crop revenue and costs and employment costs. These five main categories were chosen due to their direct ability to change business operations. All assumptions made throughout these calculations are included in Appendix 3.

Specific variables based off the pilot cool room for GreenPath Foods were used to test the efficacy of the calculator. Many of the inputs were directly received from the client. However, the gaps in knowledge were filled with educated assumptions, a list of which can be found in Appendix A. While the assumptions detract from the exactness of the result, the calculator is engineered to be easily manipulated and can be changed to match all the specific needs of GreenPath once they receive the final product.

Construction

First and foremost, the cool room must be constructed or purchased. In the case where an already existing building is purchased and retrofit, the overall purchasing cost must be manually inserted in the final “Cost-Benefit Analysis” tab. However, if the client needs to build an entirely new structure, costs incurred from the structural, insulation, and outside layers of the walls, floors and ceilings can be calculated based on amount needed and market specific costs. Also, the capital cost of the AC unit, CoolBot system, off-grid generator and grid connection fee can be included in the overall cost. Auxiliary features such as windows,
shelving/storage units and entryways can be accounted for if the specific design requires. This portion also accounts for the maintenance costs of the building.

For the pilot project in Ethiopia, GreenPath provided the team with the type and amount of insulation panels, the building materials, and the plans for power supply. Assumptions were made for the amounts and costs of the materials, the cost of the AC unit and grid connection as well as the percent of the capital cost incurred from maintenance. In country building costs were extrapolated from Ethiopian Construction Proxy (ConstructionProxy 2014). Amounts of material, when not specifically provided, were inferred from the dimensions of the building and educated estimates for wall and floor thickness. According to the World Bank, grid connection cost in the East African region is between $100 and $200 (Maurer 2009). To provide the most conservative estimate, the team used the $200 value. A report from USAID states that 10 percent of the investment cost should be account for annual maintenance costs (USAID 2013).

**Transportation**

Costs due to transportation to and from the cold room must also be accounted for. Since not all business owners in the region own a private vehicle, the calculator accounts for the costs associated with either hiring a car or owning and operating one. If a company car is owned, the capital cost and fuel cost based on the distance per load and number of loads per year contributes to the cost. If a taxi or other form of transportation is used, the cost per trip is the only cost. It is important to note that this portion of the calculator does not account for variable load sizes and their potential impact on the fuel economy of the vehicle.

Currently GreenPath is using a bajaj as the main means of transport for the avocados. Bajaj or “rickshaws” are small, three wheeled taxis common in Africa, India and Southeast Asia. The bajaj are assumed to have a fuel economy of 35 km/L and have flat rate charges dependent on distance.

**Power Use**

In order to keep the room at the optimal storage temperature for different crops, variable power is needed. Jim Thompson provided the outline for this portion of the calculator. Specifically, the power demand is dependent on: room dimensions, R-values of the materials used, temperature gradient between inside and outside, respiration rate and specific heat of the
crop at the storage temperature, air infiltration rate, cost of power from the grid, fuel costs for a
generator and heat generated from lighting and workers (Thompson 2015). The “Crop Specific
Variables” tab provides the respiration rates at the ambient and storage temperatures, along
with the heat capacities and optimal storage temperatures for the six specific crops.

Heat transfer through the building walls, floor and ceiling was calculated using the
conductive heat transfer equation:

\[ Q = K \cdot A \cdot dT/s \]

\( Q \) = the heat entering or exiting (kW)
\( K \) = the thermal conductivity of the material (kW/m)
\( A \) = the area (m²)
\( dT \) = the different in temperature between the outside and inside (°C)
\( s \) = the material thickness (m)
\( *r\)-value = K/s*

Next, the amount of power needed to counteract the respiration of the crop was
calculated using the following equation.

\[ R = (m \cdot r_f (\varepsilon_o + \varepsilon_s)/2) \cdot t/24) + ((m \cdot \varepsilon_s) \cdot r_f) \]

\( R \) = power needed to counteract respiration rate of crop (kW)
\( m \) = mass of crop in the store room (kg)
\( r_f \) = r-value of the floor (m² · °C/kW)
\( \varepsilon_o \) = respiration rate of the crop at the ambient temperature (mg CO₂/kg · hr)
\( \varepsilon_s \) = respiration rate of the crop at the storage temperature (mg CO₂/kg · hr)
\( t \) = time (hrs)

The heat generated from the light bulbs was calculated by multiplying the total wattage
by the hours they operate per day.

To counter the air infiltration the following equation was used. The air exchange rate
was assumed to be 2 per hour. The enthalpy difference between the indoor and outdoor air,
with an average relative humidity of 80%, was assumed to be 58 joules per gram (Thompson 2015).

\[ I_o = \left( \frac{(l \cdot w \cdot h)}{h_r} \cdot H \right) / 3600 \cdot E \]

\( I_o \) = power needed to offset infiltration rate of air (kW)
\( l \) = length of room (m)
\( w \) = width of room (m)
\( h \) = height (m)
\( h_r \) = relative humidity (%)
\( H \) = enthalpy (kJ/g)
\( E \) = air exchanges (hr\(^{-1}\))

The heat generated by workers was calculated under the assumption that humans produce 1000 kJ per hour (Thompson 2015). The daily heat generated is then calculated by multiplying the number of workers and the hours worked in the cold room by the heat produced per person.

The sum of all the above variables in addition to the baseline energy demand of the cooling fan generates the overall energy consumption of the building. Since the electrical grid is not wholly reliable, the percent of time that the system is run off the grid versus a generator can be specified. The cost for grid electricity and diesel are evaluated to present the total yearly cost.

For the GreenPath cased test, the building materials and room dimensions provided directly from the client were used along with climate data from Butajira, Ethiopia and avocado specific variables.

**Crop Revenue**

Crop revenue is dictated by the amount of crop bought and sold by the company, the postharvest losses and the increase in selling price from wholesale cost. Different spoiling rates were found for the six specific crops with and without a cool room (Kader 2009, USAID 2013). Also, the different market buying and selling prices are indicated in the spreadsheet based on current economics of the region. Since the quality of the final product is assumed to increase with the use of cold storage, the sales price to the final vendor is assumed to increase 15 percent for all crops. There is no literature on this topic, suggesting further research be done on
the increased value due to cold storage.

According to The Postharvest Education Foundation 40% of fruits and vegetables are lost from the total harvest in developing countries. Twenty-three percent of the total losses can be attributed to lack of cold storage; therefore, it will be assumed that the percent loss of avocados will be 40% without the cold room and 17% with the cold room (Kitinoja 2013). GreenPath indicated that they buy the avocados for $.48 per kilogram from the farmers and sell them to the vendors for $1.05. The price without cold storage, discounted by 15 percent, is $.90. Also, based on their current number of trees and annual truckloads, a yield of 6,600 avocados per year was estimated.

**Employment Costs**

Salaries for the managerial and administrative workers, as well as the wages for daily workers are included. GreenPath stated that there is one manager and 2 daily workers. While the nominal value of the salary of the manager was not specified, the daily workers make $2.00 per day. Once GreenPath receives this tool, they can insert their values here for a more accurate NPV.

**Cost-Benefit Analysis**

All of the final costs calculated from the above categories are annualized over a 10-year period (the lifetime of the AC unit). All costs, except the construction cost, use an inflation rate of 7.70% for non-food items and 6.50% for food crops. The total annual cost is then subtracted from the total annual revenue (value) for each year in the 10-year period. Then using 7, 10 and 15 percent discount rates, the discounted value per year is calculated through the following equation.

\[
\text{Discounted value per year} = \frac{R - C}{(1 + R_d)^t}
\]

- \( R \) = yearly revenue ($)
- \( C \) = yearly cost ($)
- \( R_d \) = discount rate (%)
- \( t \) = change in time from initial time (years)
Finally, the total NPV for each discount rate is calculated with and without a cool room through summing all the discounted costs per year. The difference in these values alludes to whether cold storage can increase the profitability of the company.

The above protocol was used with all the GreenPath Foods specific values. The results are presented in the following section.

Results

The Net Present Value, over a 10 year period with a cool room and a discount rate of 10%, is calculated to be -$15,227.04. However, over the same period of time and at the same discount rate, the NPV for a similar business model without a cool room is calculated to be -$20,559.24. Table 4 demonstrates the variations of NPV via a sensitivity analysis.

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>NPV With Coolroom</th>
<th>NPV Without Coolroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>(7%)</td>
<td>$16,817.03</td>
<td>$23,905.67</td>
</tr>
<tr>
<td>(10%)</td>
<td>-$15,227.04</td>
<td>-$20,559.24</td>
</tr>
<tr>
<td>(15%)</td>
<td>-$13,169.17</td>
<td>-$16,347.00</td>
</tr>
</tbody>
</table>

Table 1. Sensitivity analysis of discount rates

In order for the Net Present Value of this system to break even, a number of variables can be modified. Given that Greenpath Foods is in their first year and production levels are still quite low, calculations were made to determine at what level they must buy and sell avocados, given current prices. This economic calculator shows that a quantity of nearly 11,000kg of avocados must be bought and sold each year in order to break even. Currently, Greenpath Foods is operating at a production level roughly half that amount, with 2015 sales predicted to be 6,600 kg of avocados.

By and large, the cost of construction materials ($7,060.91) is the biggest input cost for the system with a cool room. If the company was able to acquire the construction materials at no cost (perhaps as part of a USAID development project), the NPV with a discount rate of 10% automatically jumps up to $8,808. As a result of high up-front construction costs, annual maintenance and labor costs, a high volume of produce needs to be sold to offset costs since the only source of profit comes from charging a higher mark-up price for produce and losing fewer quantities postharvest.

Recommendations
In the process of creating this NPV calculator, we gained numerous insights into the intricate dynamics of accurately determining net present value of cool room use vs. business as usual. Central to the utility of the calculator is the ability for individual decision makers to apply the tool to their own management and production practices. It is therefore difficult to make general assumptions or recommendations on the use of cool rooms themselves. In the simulation described in this paper, incorporating data from GreenPath, we find cool room use generally advantageous over no temperature management.

Clearly, there is a demand-driven benefit and need for increased production of certain horticultural crops and improved cool storage capacity in Tanzania, Ethiopia, and East Africa broadly (See Section III). While there are small-scale interventions that this analysis did not discuss, the majority of cool storage systems require investment above and beyond the means of a typical smallholder. This means that companies and organizations such as GreenPath and USAID-TAPP are well positioned to initiate investments in cool storage and should be motivated to do so based on expected positive economic benefits.

As for recommendations on next steps in the development and use of this calculator tool, we believe first and foremost that there is a need to compare the tool to other models along with having agricultural production managers input their own data in order to “ground truth” the assumptions and provide feedback. Both of these steps will provide further insights into how the calculator can be adjusted to be more widely useful and accurate in almost any scenario.

Further, among the greatest advantages of cool room storage is the ability to offer off-season produce to consumers at premium prices and offer generally higher quality products. Price premiums for quality and seasonality are not fully incorporated into the calculator at this point. Currently, the main difference in “with cool storage” and “without cool storage” comparison is made solely on the basis of increased quantity from cool storage rather than price and quantity gains. With additional time and information the calculator should be improved to be more sensitive to quality and value gains through cool storage.

Each individual user of the calculator must also determine the degree to which they want to isolate cool room storage from the overall business plan. For example, in our calculator we included the rent associated with an international staff member who likely only contributes a small portion of time to actual management of cool storage. Thus, incorporating certain labor rents downwardly distorts NPV of the cool room system but not the business plan as a whole.
Net Present Value is a valuable tool in profitability analysis and was specifically requested by our clients. It is just one piece of the puzzle, however, and adding a short-term cash flow analysis to the calculator could prove useful. With high upfront investment costs and extremely high variability in agricultural production, early cash flow information is crucial, particularly for users that are unable to absorb negative profits and shocks.

Finally, improvements can be made in the range of information that the calculator is able to accommodate. Alternative power options, including off-grid, should become a selectable feature along with a greater diversity in crops. Currently, a calculator user can input quality and price information for any crop they wish to consider but cool storage parameters that affect overall profitability, such as storage temperature, will only automatically populate for the six crops currently included.

Overall, the calculator this project produced is an excellent initial tool with the potential to become even more useful by incorporating these recommendations. The calculator can be used to analyze price variations, input variations, and the introduction (or elimination) of subsidies. All of these features make the tool incredibly useful to decision makers in anticipating the profitability of cool room technologies in a wide range of scenarios. Furthermore, the built-in discount rate feature allows for increased sensitivity analysis. While not necessary within the scope of a D-Lab II project, the calculator should definitely continue to be developed to move beyond the current beta version into a tool with wide scale applicability.
Sources


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SECTION II: FEASIBILITY STUDY APPENDIX

Appendix 1: Excerpt from “Cool Rooms in Uganda Final Paper” from D-Lab I

“A. Agro ecology of Uganda

The country of Uganda lies on the Equator, and experiences temperatures between 15° and 30° Celsius. Over two-thirds of the country lies between 1000-2500 meters above sea level, and receives regular precipitation. In terms of land availability, of the total 241,548 square-km that comprise the country over three-fourths is available for either cultivation or pastureland (FAO Country Profile).

There are seven general agro-ecological regions, into which the country can be divided, with each having a specific set of socioeconomic and environmental characteristics (FAO). One important distinction to make regarding the regions under consideration for this project is the differential rainfall systems between the northern regions and the rest of the country. In the north, rainfall averages between 900 and 1300 millimeters annually and has one dry season and just one rainy season— a unimodal distribution. However, the rest of the country, such as the central region, experiences two rainy seasons and two dry seasons annually— or bimodal distribution (Basalirwa).

Although within this system, average rainfall is slightly higher, (1200-1500mm per year) the average temperature (25° C) is comparable in both the northern and central regions (CFSVA). The impact on farmers, given their geographical region, is the tendency for those in the north to cultivate drought-resistant crops that are more capable of withstanding a longer dry season. They are therefore more likely to favor the cultivation of annuals in the north for subsistence, rather than invest in the cultivation of riskier cash crops (CFSVA), which hinders their ability to move into commercial agriculture (Wortmann).

Although agricultural production varies by region, there are four main crops that are generally cultivated at the household-level. The most prevalent of these is maize, which has consistently been found to be the most widely produced crop in Greater Uganda. The other three crops vary by region, but include: cassava, sweet potatoes, sorghum, and kidney beans (CFSVA).

In the northern region of Uganda, maize and sorghum are typically the primary crops. Cassava and sweet potatoes are also cultivated, but their production is intentionally avoided in some sub-regions because of their vulnerability to theft from the field. Moreover, few households within the northern region were found to cultivate cash crops, such as: tea, coffee, tobacco, and sugarcane (CFSVA). This pattern of cultivation is similar in the central region as well, where cereals, such as maize are most widely cultivated. Within this region, roots and tubers are also extensively cultivated (CFSVA). However, the National Agricultural Research Organization of Uganda estimates a 20-25% post harvest loss for root and tubers, and a result of arthropod pests, micro flora, vertebrates, and man (NARO).”
Appendix 2: Climate and Geography Information: Kenya

Kenya is almost directly centered over the equator in eastern Africa. Temperature in Kenya is mainly affected by altitude. In the lowlands and near the coast temperatures typically swing between 27 – 31°C, while temperatures inland on vary from 21 – 25°C. The Western Plateau, coast and Highlands experience one long wet season that lasts from April to June. These areas experience the most precipitation with 1000 mm annually in the Highlands and coast and 1780 mm annually in the Western Plateau (African Studies Center 2015). East of the rift valley, on the other hand, there are two distinct seasons: one from March to May and the other from September to October. The majority of this area is arid/semi-arid and experiences less than 510 mm per year (African Studies Center 2015).
Appendix 3: Assumptions in Methodology and NPV Calculations

Cool Room Power Use Assumptions:
- The specific heat of adobe is 1.004.
- Direct solar radiation on the surface of the building will increase the temperature 2-5 degrees C.
- Above ground incoming crop temperature is equal to the ambient air temperature
- Avocados at 3-7C release between 20 - 50 mg CO2/kg*hr. At 20C the avocados will respire at a rate of 80 - 300 mg CO2/kg*hr.
- For short-term storage, without forced-air cooling capability, assume product temperature is the mean between inside and outside air temperature.
- With forced air-cooling, assume product is at half cool temperature for entire cooling period.
- Specific heat of food obtained from engineering toolbox (EngineeringToolbox 2015)
- Assume an air infiltration rate of 2 AC/h.
- Typical fuel use = 0.07 to 0.10 gallons per hour (0.28 - 0.40 liters/hr (Wikipedia 2015).
- 3600kJ/h=1 kW, temperature drop of product is assumed to be linear over time.
- Exterior heat loads are assumed to be constant over the 24h day.
- Assume an un-insulated concrete floor and soil temperature = air temperature; assumed R-value accounts for insulating effect of soil.
- Enthalpy difference between outside and inside air assuming 80% relative humidity in each and base case temperatures =58J/g.
- Heat from worker = 1000kJ/h.
- Calculation assumes room and previous days contents are at storage temperature and does not include cooling of current day's product.
- Cost for electricity in Ethiopia it is 8.81 cents/kWh (Advameg 2014).
- The generator is purchased used at a price of $1500.00.
- Connection cost to the grid costs $100 (Maurer 2009).

Transportation Assumptions:
- The majority of the avocado transport is done via taxi, which costs ~$2.50 per load.
- Two loads/month are brought to the cool room, and two loads per month are brought to the market.
- Taxi will get 35 km/L fuel (Wikipedia 2015).
- Fuel costs $0.97 per liter.
- The cool room is receiving 2 loads per month from the farm and delivering two loads per month to the market.
Cool Room Construction Assumptions:
• 1 quintal=100kg
• Construction Costs for supplies in Ethiopia were found on Construction Proxy (ConstructionProxy 2014).
• Thickness of cement coat on walls= 1/16 - 1/8 inch (StuccoGuru 2015).
• Specific Weight of cement: 3.175 (Mg/m^3) (StuccoGuru 2015).
• Assume mud brick was used for the building, and that the cost is the same as in Uganda (100UGX ($0.35)/ brick).
• Cost of AC unit is $600.
• Cost of CoolBot is $300.

Crop Revenue Assumptions:
• Quantity received (kg/year) is a rough calculation from GreenPath estimates: 244 trees x average production of 27.2kg per tree/per year = 6636.8
• Loss with and without cold room storage for Avocado, Mango, Citrus, and Pineapple comes from information obtained from UC Davis Cooperative Extension (Kader 2009).
• Loss with and without cold room storage for tomato and potato comes from information specific to East Africa from USAID (USAID 2013).
• Prices for Avocado in both the “buying cost” and “selling price with cold room” rows come from directly from GreenPath. Except for where otherwise noted, the same mark-up ratio that GreenPath uses was applied to the “buying cost” all crops to obtain the “selling price”.
• Buying cost for Mango is 5 Birr per kg (Rowlands 2008).
• Buying cost for Pineapple comes from an Ethiopian market research paper (Biazin 2014).
• Buying costs for Tomato and Potato come from USAID (USAID 2013).

Crop Specific Variables Assumptions:
• All information on this tab of the calculator, except avocados, was obtain from UC Davis Postharvest Produce Fact Sheets (Suslow 2013).
• 40% of avocados are lost from the total harvest, 23% of this can be attributed to lack of cold storage (Kitinoja 2013).

Cost-Benefit Analysis Assumptions:
• AC unit lifespan is ten years. This lifespan dictates the NPV analysis period.
• 2015 input prices for construction materials were used.
• For calculating NPV, for key costs like gasoline and avocado prices, we either used fixed prices or variable projected prices.
• Maintenance will be 10% of initial investment cost per year.
• Inflation rate is .08%.
• Labor costs are only estimated for the extra costs associated with building and maintaining the cold room, and the costs for transporting the crops are kept separate.
• Assuming that all the farms are one average distance from the cool room, and that there is no possibility for combining farm visits in one trip since we’re using a taxi cab and the storage options are not very high,
• We assume that GreenPath Food will buy the crops from the farmers at a certain rate (near market value) and markup this price to the buyer by 219%. The user of this tool can modify this markup rate.
• The company can charge a significantly higher price when selling produce from a CoolBot than the traditional supply chain due to higher quality and convenience to buyer.
• There will be a net benefit to the scaling up that is associated with using the CoolBot storage room system.
Sources for the Assumptions:

Advameg (2014). "Electricity cost per unit, total, historical (US cents per kWh) -


Maurer, L. (2009). Output-Based Aid in Ethiopia: Dealing with the "last mile" paradox in rural electrification, The Global Partnership on Output-Based Aid.


Section III: Background Information

Chapter 1: Climate and Geography of Four East African Countries

The goal of this chapter is to compile the geographic and climatic data for Tanzania, Ethiopia, Kenya and Uganda in order to better understand the implementation of Coolbots in these East African countries. Knowing these variables is important for understanding the hypothetical agricultural output of different areas as well as calculating the energy requirements needed to create ideal storing conditions in varying environments.

**Tanzania**

Tanzania is located just below the equator from 1 – 11° South. It can be broken into two basic regions: coastal and highlands. The coastal region experiences a larger temperature swing throughout the year of 17°-25° C, while the highlands only waver between 23° and 25° C (McSweeney). The highlands are 1000 to 1500 km above sea level (Ezilon 2014). For more detail on the topography of the country, see the map in Appendix A.

Tanzania has a wide range of soil types available throughout the country. The map in Appendix B displays this diversity. Cambisols make up 35.64% of the land area. This soil is considered good agricultural land to be used for both grazing and farming. Other soils in the region that have similar fertility include: Arenosols, Andosols, Fluvisols, Ferralsols, Luvisols, Nitisols, Chernozems and Phaeozems (MARI 2006). The combination of all these soil types compose 61.05% of the land, suggesting that more than half the land area could potentially be used as fertile, agricultural soil.

On average the country receives a total of 1000 mm of rain each year (Bank 2015). The map in Appendix C displays the average rainfall amounts across the country. The amounts are highly variable depending on the season, as displayed below in Figure 1. The Intertropical Convergence Zone (ITCZ) mainly dictates rainfall. This phenomenon causes the North and East
portions of Tanzania to experience 2 wet seasons, one from October to December and the other from March to May. On the other hand, the Southern, Western and Central areas only have one rainy season from October through April (Wikipedia 2015).

The above three variables (altitude, rainfall and soil lithography) work together to comprise the five agro-ecological zones of the country. There is the afro-alpine, which makes up 1% of the land area and is considered barren in terms of agricultural uses. Next, there is the humid to dry sub-humid region, which comprises 9% of the land. This land is considered to be suitable for intensive agriculture such as coffee or tea. Dry sub-humid to semi-arid land, 30% of the land area, is considered to be good farming and grazing land; however, regular burning may be necessary (Sarwatt 2000). Semi-arid land makes up another 30% (Sarwatt 2000). This land type is considered marginal for crop production outside of quick maturing grains. The final 30% is comprised of the arid land, which is mostly unsuitable for agriculture. Therefore only about 39% of the country has optimal growing conditions for crops (Sarwatt 2000).

Ethiopia

Ethiopia is located from 3.5°N- 14.5°N, and makes up a majority of the eastern horn of Africa. The entire country is landlocked. The East African Rift Plateau forms highlands in the northwest and southeast regions, partitioned by the Great Rift Valley (GRV) that cuts the country in half diagonally from the Northeast corner to the Southwest corner (Baker). This region is home to dozens of active volcanoes. The lowlands consist mostly of desert, while the highlands are more fertile. The highlands were once mostly forestland but fires have diminished the tree cover from 40% to 2.7% in the past 40 years; however, the soil is still fertile for cultivation (Baker). Temperature differs between the two altitude regions. The highlands, which range form 1000 – 3000 meters above sea level, drift between 15 and 20°C throughout the year.
while the lowlands are much hotter and stay between 25 and 30°C (McSweeney). A detailed topographical map of the country can be found in Appendix D.

There are five main types of soil found in Ethiopia. First there are euritic nitosols and andosols in the Western and Eastern highlands. This soil is formed volcanically, but can be managed to have medium to high agricultural yield (Marcus 2014). The Simien plateau contains mostly eutric cambisols and luvisols. They are highly eroded and generally have low nutrient retention but could be of medium agricultural value with intensive management (Marcus 2014). The Western Lowlands and Foothills are composed of clay vertisols. These soils are considered to be of high agricultural value and currently grow a significant amount of the country’s coffee crop (Marcus 2014). The Eastern Lowlands and Denakil Plain contain mostly saline soils. Due to lack of rainfall these soils are only useable for irrigation farming (Marcus 2014). The Denakil Plain also contains the fifth type of soil: lithosols. This soil is very shallow and the area lacks moisture so there is little opportunity for cultivation (Marcus 2014). For a more detailed breakdown of the soil types, see the geologic map in Appendix E.

Rainfall, similar to that in Tanzania, is mostly dictated by the ITCZ. The majority of the country, excluding the south, experiences one wet season from June to September. However, parts of the northern and central regions have a secondary, less intense wet season from February to May. The south, on the other hand, always experiences 2 distinct wet seasons, the first from March to May and the second from October to December (McSweeney). Average annual precipitation on the Central Plateau is about 1,220 mm while the westernmost region receives almost 2000mm per year (Encyclopedia 2015). The north region receives significantly less at 100 mm per year (Encyclopedia 2015). Figure 2 below displays the average annual rainfall across the country, while the map in Appendix F displays the spatial variations in precipitation throughout the year. The ITCZ is heavily affected year to year by variations in the Indian Ocean’s surface temperature, causing rainfall to vary considerably (McSweeney). This phenomenon has been the cause of frequent droughts and famine throughout the region.
Kenya

Kenya is almost directly centered over the equator in eastern Africa. The southeast coast lies on the Indian Ocean, and all other sides are landlocked. A small portion of Lake Victoria flanks the western border. The landscape of Kenya can be divided into 7 major regions. First there is the Coastal region which consists of coral sand, a narrow plain and a low plateau (African Studies Center 2015). Next there is the arid, erosional plain of the Southern Coastal Hinterland. The Eastern Plateau is between 300 and 900 meters high and is semiarid grassland. The Northern Plains region is an arid desert formed by the erosion of metamorphic soils (African Studies Center 2015). The Kenya Highlands flank the east and west sides of the GRV. The high altitude, cooler temperatures and higher amounts of precipitation characterize this region (African Studies Center 2015). The Rift Valley region bisects the country from north to south. A chain of lakes and some still active volcanoes litter the valley floor. Finally, the Western Plateau region consists of fertile highlands that slope to the shore of Lake Victoria (African Studies Center 2015). Temperature in Kenya is mainly affected by altitude. In the lowlands and near the coast temperatures typically swing between 27 – 31°C, while temperatures inland on vary from 21 – 25°C (New World Encyclopedia 2015). A topographical map of the country can be found in Appendix G.

Soil varies geographically across the country. The highlands that flank the GRV consist mainly of loamy soils (Orodho). These soils were volcanically formed and are therefore moderately fertile. Western Kenya is comprised mostly of volcanic and basement rock, interspersed with sedimentary deposits (Orodho). This area is considered to be very agriculturally productive. The North and Northeastern region, however, consists of shallow
sedimentary deposits that are generally infertile (Orodho). A detailed geologic map can be found in Appendix H.

Like the other East African countries, the ICTZ dictates the rainfall patterns and amounts for the different regions of Kenya. The Western Plateau, coast and Highlands experience one long wet season that lasts from April to June. These areas experience the most precipitation with 1000mm annually in the Highlands and coast and 1780 mm annually in the Western Plateau (African Studies Center 2015). East of the rift valley, on the other hand, there are two distinct seasons: one from March to May and the other from September to October. The majority of this area is arid/semi-arid and experiences less than 510 mm per year (African Studies Center 2015). Figure 3 below displays the average annual rainfall across the country; a more detailed map of the regional rainfall can be found in Appendix I.

![Average Monthly Temperature and Rainfall for Kenya from 1900-2009](image)

**Figure 3. Average Monthly Temp and Rainfall for Kenya from 1900-2009. (The World Bank 2015)**

**Uganda**

Previous D-Lab projects have defined the climate and topography of Uganda. This information can be found in Appendix J. Our team will be using this pre-existing work in order to compare the environmental situations of the four East African countries in question.

**Future Work**

In the coming weeks this information will be organized and categorized so that it can be included in the spreadsheet as a variable to indicate the economic viability of a Coolbot installation.
CHAPTER 2: ANALYSIS OF COOL ROOM STORAGE USES FOR COMMON CROPS IN ETHIOPIA, TANZANIA, AND THE EASTERN AFRICA REGION

INTRODUCTION

Cool and cold storage are important to maintaining the post-harvest integrity of many fruits, vegetables, and other perishable goods. Effective temperature management can improve produce quality, increase farmer incomes, and allow access to export markets. For these reasons, both of our clients in Ethiopia and Tanzania are interested in knowing more about opportunities in creating cold value chains for a variety of crops. This chapter will look at which crops are best suited for cool storage and prioritize among these crops in terms of regional feasibility and degree of value added from cool storage.

CLIENTS SUMMARY AND NEEDS

GreenPath Food, Inc. works with smallholder farmers in high-yield environmentally friendly agricultural practices to bring organic produce to Ethiopian national and international markets. Currently, GreenPath invests in nucleus farms in farming communities to train farmers on yield-enhancing practices, buy produce from farmers, and market produce to create a complete and efficient supply chain (GreenPath, 2015). GreenPath is a new company and is starting out by focusing on avocado production and has a particular interest in cool storage. They have plans to expand to other crops in the future.

The Horticulture Innovation Lab has been asked by the USAID Tanzania Agriculture Productivity Program (USAID-TAPP) to provide technical assistance in the post-harvest sector. USAID-TAPP is a five-year program that aims to increase smallholder incomes, improve nutrition, and expand markets through agricultural innovation and commercialization. The method of operation of USAID-TAPP is quite similar to that of GreenPath. USAID-TAPP develops clusters of commercial farms, smallholders, and agribusinesses in areas with high agricultural potential. They are targeting fresh and processed fruit, vegetables, flowers, and spices in Arusha, Kilimanjaro, Lushoto, Morogoro, and Zanzibar (USAID-TAPP, 2015)
MAJOR CROPS

In the context of increasing smallholder incomes and high value production, horticultural crops, and particularly fruit tree crops, play an important role. These crops are also among the most perishable making proper cool storage crucial for maintaining high quality and nutritional integrity. Some of the main perishable crops in both Tanzania and Ethiopia include avocados, bananas, citrus, mango, papayas, pineapples, tomatoes, cabbage, and other brassicas (Honja, 2014).

For the purpose of this sector paper, I have chosen to focus on mango, citrus, pineapple, and tomato due to similar production practices in Tanzania, Ethiopia, and East Africa, degree of value added by cool storage vs. no temperature management, and overlapping client interests. GreenPath is currently working exclusively with avocados with the expressed interest of expanding.

CURRENT PRODUCTION AND MARKET CHARACTERISTICS

The main sales channels for Horticultural crops across East Africa include direct sale to consumers, retailers and supermarkets, such as shop-rite, wholesalers, and small retailers and kiosks (Honja, 2014). East African producers are also well positioned to access Middle East and EU markers if current bottlenecks, including post-harvest management, can be overcome. Regional trade is also an important factor, particularly for Tanzania, which sends a significant amount of horticultural product across the border to Kenya. Below is a summary of current production and market characteristics for selected crops in Tanzania and Ethiopia highlighting opportunities for demand-driven interventions in cool storage.

Mango

Mango makes up 50% of all tropical fruits produced worldwide and presents specific opportunities with a growing Middle East market that is relatively easy to reach from East Africa. Total production in Tanzania is estimated around 317,000 tons per year (Match Maker Associates, 2011) and around 500,000 tons per year in Ethiopia (Honja, 2014). In both Tanzania and Ethiopia, significant loss occurs post-harvest due to inadequate storage facilities.

In Ethiopia, similar to Tanzania, potential in both local and export markets is high but factors related to supply, quality, and institutional arrangement in the value chain result in high transaction and related costs (Honja, 2014). The Netherlands Development Organization
selected mango as a commodity for investment based on ‘potential market opportunity’ and ‘outreach to small holder farms.’ Furthermore, in East Africa mango has the potential for high added value through proper management and a long-term comparative advantage due to the seasonality of mango production compared to other high producing regions such as South and Southeast Asia (Honja, 2014).

This situation creates the opportunity for companies and organizations such as GreenPath and USAID-TAPP to intervene at crucial steps along the value chain, including post-harvest. Mango production presents a particular opportunity for GreenPath, which currently focuses on Avocado production. With similar post-harvest handling needs, heat transfer characteristics, and fruit size, many of the practices and handling processes GreenPath is currently developing for Avocado can be directly applied to mango without additional investment or training.

**Tomato**

Tomato production is higher than any other horticultural crop in Tanzania with a total production of 129,578 tons, representing 51 percent of the total horticultural production (Tanzania Agricultural Sample Census, 2003). In Ethiopia, tomato is both a livelihood crop and is in one of the regional export crops with annual total production of 55,635 tons (FAOSTAT, 2010).

Despite importance and potential, tomato production across East Africa is sub-par. Most farmers still depend on rain-fed farming and input costs remain high. Lack of storage and preservation facilities force farmers to sell product immediately. At the same time, demand for high quality tomatoes is growing broadly, particularly in higher end hotels and supermarkets (SCF, 2008). Given the production possibilities, growing markets, and documented quality improvements through cool storage, tomato is one of the crops that should be prioritized.

**Pineapple**

A recent 2011 study of the pineapple subsector encourages optimism for future market demand. There is a growing market for pineapple products globally and especially in the Middle East and Djibouti, regions that prefer East African crops. Smallholder farmers have already been accustomed to working with pineapple as a cash crop in mixed farming systems for decades and with virtually no fertilizer use, the organic fruit is a comparative advantage of Ethiopian
pineapple production. Similarly, national consumption is on the rise as a result of national growth in tourism and expat preferences (Drost and Wijk, 2011).

In Tanzania, one study found post-harvest losses for pineapples of up to 50% when fruit are harvested during rainy conditions and stored without being protected from sun and rain (Match Maker Associates, 2011). This presents a noteworthy opportunity to significantly increase marketable production through simple post-harvest interventions.

**Citrus**

In Tanzania, Orange is the main citrus fruit grown and traded in significant quantities and is one of the leading fruit sub-sectors in Tanzania with annual production around 194,978 tons per year (Tanzania Agricultural Sample Census, 2003). A 2011 study showed annual production in three surveyed regions to be between 157,274 and 284,216 tons, demonstrating the quick growth of the sector in the past 10 years. There are both private sector and government initiatives in Tanzania to construct international fruit markets and direct processor purchasing mechanisms, including in USAID-TAPP intervention zones, that would suggest advantages towards collective cool storage facilities (Match Maker Associates, 2011). Similarly, in Ethiopia citrus production is higher than almost all other fruit crops excluding banana and mango. Orange and lemon are the most significant citrus crops in Ethiopia with total annual production around 350,000 and 55,000 tons respectively (Honja, 2014).

**Post-Harvest Needs of Selected Crops**

It should come as no surprise that the post-harvest storing and handling needs are not uniform across crop species and vary according to a number of different physiological and market characteristics. Fruits and vegetables differ in their sensitivity to chilling injury, in their respiratory behavior during ripening (climacteric vs. nonclimacteric), respiration rate, relative perishability, ethylene production rates, and other characteristics. Physiological characteristics like ethylene production rates may help determine which crops can be cool stored and transported together while respiratory behavior indicates whether a fruit will ripen after harvest (climacteric) or not (nonclimacteric). Marketing demands will be constrained by relative perishability under ideal and sub-ideal storage conditions and effects of cooling delays, which is important information in environments with intermittent power supply. Table 1 provides
detailed information on the post-harvest characteristics and handling needs of the previously described crops plus avocados.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Optimum Temperature</th>
<th>Optimum Humidity</th>
<th>Respiration range at 13°C (ml CO2/kg-hr)</th>
<th>Ethylene production range at 13°C (ul C2H4/kg-hr)</th>
<th>Respiratory Behavior</th>
<th>Chilling Sensitive?</th>
<th>Allowable Cooling Delay (hours)</th>
<th>Potential Storage Life (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avocado</td>
<td>5-13°C</td>
<td>90-95%</td>
<td>25-80</td>
<td>&gt;100</td>
<td>Climacteric</td>
<td>Yes</td>
<td>12</td>
<td>2 to 4</td>
</tr>
<tr>
<td>Mango</td>
<td>10-13°C</td>
<td>90-95%</td>
<td>15-22</td>
<td>0.2-1.9</td>
<td>Climacteric</td>
<td>Yes</td>
<td>--</td>
<td>2 to 4</td>
</tr>
<tr>
<td>Citrus</td>
<td>3-8°C</td>
<td>90-95%</td>
<td>3 to 5</td>
<td>&lt;0.1</td>
<td>Nonclimacteric</td>
<td>Yes</td>
<td>16-24</td>
<td>4 to 8</td>
</tr>
<tr>
<td>Pineapple</td>
<td>7-13°C</td>
<td>85-90%</td>
<td>5 to 8</td>
<td>&lt;0.2</td>
<td>Nonclimacteric</td>
<td>Yes</td>
<td>--</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Tomato</td>
<td>7-15°C</td>
<td>90-95%</td>
<td>7 to 9</td>
<td>1.2-1.5</td>
<td>Nonclimacteric</td>
<td>Yes</td>
<td>16</td>
<td>&lt;2</td>
</tr>
</tbody>
</table>

Source: UC Davis Postharvest Technology Fact Sheets

**CONCLUSION & RECOMMENDATIONS**

Clearly, there is a demand-driven benefit and need for increased production of certain horticultural crops and improved cool storage capacity in Tanzania, Ethiopia, and East Africa broadly. While there are small-scale interventions that this sector paper did not discuss, the majority of production and storage systems require investment above and beyond the means of a typical smallholder. This means that companies and organizations such as GreenPath and USAID-TAPP are well positioned to initiate investments in cool storage and should be motivated to do so.

This chapter describes only a few of many opportunities. Other crops, particularly more perishable vegetables that may fit well into an intercropped orchard systems, should be explored and evaluated as more information comes in from clients. Providing our clients with a full menu of perishable horticultural crops and their postharvest handling needs will prove beneficial as each look to scale their impact across the region.
Chapter 3: Summary Of Avocado Market Trends in Eastern Africa

GLOBAL OVERVIEW

The global demand for avocados has seen a rapid rise in the past decade. This is especially the case in the United States, with estimates predicting that U.S. consumption will reach 2 billion pounds in 2015 (FreshPlaza, 2015). According to the Food and Agricultural Organization of the UN, world production of avocados has increased more than fourfold over the past 40 years, with production at 4.2 million metric tons in 2012 (UNDP, 2014). Of this total production, over one million metric tons were traded on the international market (ITC, 2014). Increasingly, the US will look towards new markets to reach their demand. In the United States, 80% of the domestic demand for avocado is for the Hass variety. The Hass has advantages over other varieties in regards to yield, richer flavor, higher oil content and longer shelf life (UNDP, 2014).

In response to growing demand in the US and Europe, African countries have rapidly increasing the production of avocados. From 2005-2012, avocado production in Africa has grown but at an uneven rate. By volume, the leading export producing countries are Kenya, South Africa, Rwanda and Cameroon. It is important to note that globally, the major driver for avocado production is domestic consumption (UNDP, 2014).

THE AVOCADO MARKET

In agriculture-based countries, many layers of intermediaries between producers and consumers are common in the marketing of agricultural commodities, leading to inefficiency, inflated prices and longer transit times and costs (World Bank 2008). Producer shares in final consumer prices are as low as 35 to 60% in Africa (IFPRI 2013). Throughout the supply chain from producers to end consumers, cold chain management is crucial for fresh avocados. This includes their entire journey from farm to table, from the initial packing houses to the refrigerated container trucks that transport the produce to the shipping terminals, through to the storage facilities at these terminals, onto actual shipping vessels and containers, and finally on to the importers and distributors that must clear the produce and transport it to the
markets/retail outlets. Related to this are increasing important traceability standards which require an efficient controlled supply chain and internationally accepted business standards. Strict control of all links in the cold chain is important in order to maintain the high standards necessary for high quality avocados.

While tariff regulations can be prohibitive, it is often the non-tariff barriers that restrict countries from successfully entering the large developed markets. Many of these barriers revolve around different types of standards, including food health and safety issues, food labeling and packaging, organic produce certification, quality assurance and other standards and grades. If eastern African countries expect to export avocados in high volume on the international market, they must ensure consistently high quality avocados in consistently high numbers to meet these standards.

![Graph: World avocado production trend (2000 - 2012) in '000mt](source: FAOSTAT)

ETHIOPIA

**Economic Overview**

Population: 97 million
GDP per capita: $1,300
Agriculture is 47% total GDP
6,000km paved roadways and 38,000 km unpaved roadways
The banking, insurance, telecommunications, and micro-credit industries are restricted to domestic investors, but Ethiopia has attracted significant foreign investment in textiles, leather, commercial agriculture and manufacturing. The state owns all land and provides long-term leases to the tenants; land use certificates are now being issued in some areas so that tenants have more recognizable rights to continued occupancy and hence make more concerted efforts to improve their leaseholds. While GDP growth has remained high, per capita income is among the lowest in the world (CIA World Factbook, 2014).

The majority of farmers in Ethiopia are smallholder farms. These farms are often fragmented, produce mostly for own consumption and generate only a small marketed surplus. Large farms are not widely spread in Ethiopia and their contribution to total agricultural output is less than 4% of total domestic production. In 2009, fruit crops made up 0.4% of total area cultivated by smallholders in Ethiopia, which represents a 4.1% growth in 5 years (Taffessee, et al., 2011).

**Status of Avocado Production and Sales**

In 2012, Ethiopia produced 25,000 metric tons of avocados, representing a growth rate of 1.7% over the previous 5 years (UNDP, 2014). Avocados were unknown to both producers and consumers in Ethiopia until the 20th century, when they were introduced in 1938 and cultivation gradually increased around the country (Shumeta, 2010). The primary reason for the rise in avocado production area is due to the better market value and potential for profit among smallholder farmers. In 2008, the average farmer earned roughly $110 USD in avocado sales alone (Garedew and Tsegaye, 2010).

**Key Problem Areas**

Top constraints to yield and productivity growth are low levels of irrigation and input use, soil degradation, inadequate agricultural research and constraints in market development (Taffessee, et al. 2011). Seasonal variation in production leads to fluctuating prices over time and there tends to be a monopolistic market in which sellers meet very few buyers. Currently
there are limited linkages between producers and other actors of the fruit value chain (IPMS, 2010).

TANZANIA

Economic Overview
Population: 50,000,000
GDP per capita $1,700
Agriculture: 28% of total GDP
7,100 km paved roadways and 79,000 unpaved roadways

Tanzania has largely completed its transition to a liberalized market economy, though the government retains a presence in the telecommunications, banking and energy sectors. Agriculture provides 85% of exports and employs about 80% of the work force. The government has increased spending on agriculture to 7% of its budget. Major donors have provided funds to rehabilitate Tanzania’s infrastructure, including rails and ports that are important trade links for inland countries. The financial sector has expanded and foreign-owned banks account for roughly 50% of the banking industry’s total assets. Competition among these banks has led to improvements in the efficiency and quality of financial services, through interest rates are still relatively high. All land is owned by the government, which leases land for up to 99 years. Proposed reforms to allow for land ownership, particularly by foreigners, remain unpopular (CIA World Factbook, 2014).

Status of Avocado Production and Sales

Tanzania has started to export avocados to the EU market where demand is relatively high. The country has all the required agro-climatic conditions needed to grow the fruit, there is strong support from a development partner, namely USAID. Furthermore, a strategy to develop horticulture in Tanzania is in place. Tanzania Association Horticulture Association (TAHA), a private sector enterprise, is quite strong and effective in promoting the sector. The government has prioritized development of transport and energy infrastructure, and is supportive to both internal and export horticultural produce trade (UNDP, 2014). Africado Company Limited began
pioneering the commercialization of Tanzania’s emerging export crop in 2010. The company currently works with 2,500 smallholder farmers to produce 14 tons of avocados for the export market (Kimati, 2015).

**Key Problem Areas**

Road conditions are poor between March and July, which is peak avocado harvesting period. Changing climate patterns contribute to an ever-decreasing water supply and farmers have unreliable access to water for irrigation. Oftentimes there is limited area for farm expansion, and the cost of the certification required to access the export market is very costly (UNDP, 2014).

**KENYA**

**Economy Overview**

Population: 45,000,000  
GDP per capita: $1,800  
Agriculture is 29% total GDP  
11,000 km paved roadways and 150,000 unpaved roadways

Low investments in infrastructure threaten Kenya’s long-term position as the largest East African economy. International financial lenders and donors remain important to Kenya’s economic growth and development. The country has chronic budget deficits and inflationary pressures combined with rapid currency depreciation occurred in 2010-2011. Recent terrorism threatens Kenya’s important tourism industry. In conjunction with Ethiopia and South Sudan, Kenya intends to begin construction on a transport corridor and oil pipeline in 2014 (CIA World Factbook, 2014).
Status of Avocado Production and Sales

Kenya leads the African continent in total avocado production, boasting 186 metric tons produced in 2012 (UNDP, 2014). This shows as 12% increase in just 5 years, the highest of all avocado-producing African nations. About 70% of these avocados are grown by small-scale farmers, and up until recently, most of the fruit was sold in the local market or occasionally exported to the Middle East (Mark, 2013). With the advancement in refrigerated container technology, the feasibility, cost and attractiveness of sea transport have improved considerably. The Maersk Lines has introduced the new refrigerated containers which have improved the viability of long distance export of avocados. Due to this technology advancement, 1,000 containers were shipped to Europe in 2013, totaling roughly 100 million avocados (Mark, 2013).

Key Problem Areas

Kenya has well developed infrastructure for fresh produce handling and transport, which is either by ship or air cargo. Despite this, even mature exporters like Kenya sometimes face challenges in meeting market requirements. Before the establishment of oil processing plants in 2005, nearly 40% of all domestically produced avocados went to waste each year.

UGANDA

Economy Overview
Population: 36,000,000
GDP per capita: $1,500
Agriculture is 23% total GDP
3,300 km paved roadways and 16,800 km unpaved roadways

Economic reforms have been ushering in an era of solid economic growth based on continued investment in infrastructure, improved incentives for production and exports and lower inflation. The global economic downturn hurt Uganda’s exports and GDP growth has largely recovered due to past reforms and sound management of the downturn. Oil revenues and taxes will become a larger source of government funding as oil comes on line in the next
few years. Instability in South Sudan is a risk for the Ugandan economy. Unreliable power, high energy costs, inadequate transportation infrastructure and corruption inhibit economic development and investor confidence (CIA World Factbook, 2014).

**Status of Avocado Production and Sales**

Since 1985, export earnings from fruits and vegetables have been growing steadily. This is due solely to increased output of crops exported, accompanied by a gradual rise in prices. Uganda’s primary markets are the United Kingdom, Belgium and Sweden (FAO, 2002). The government of Uganda has been implementing economic reforms geared at restoring economic growth development. These reforms centered on economic liberalization and privatization of public enterprises, with the aim of promoting private sector participation. A key objective is to modernize the agricultural sector by taking into account its comparative advantages, which means diversifying and intensifying the production of high market value crops for export (FAO, 2002).

**Key Problem Areas**

While avocados can generally be found at the market year round, the prices can vary considerably. During the high season of March through July, when avocados tend to be harvested, high volumes flood the markets, bringing the prices down. Farmers are not able to earn as much money due to these decreased prices. Avocados tend to be scarce between August and December, therefore farmers can charge higher prices at the market (Katende, 2012).
Chapter 4: Social Factors affecting Cool Room Proliferation

Introduction

In making a guide for assessing the feasibility of installing a cool room in a given area we need to find what factors affect that feasibility and how they affect that feasibility. Using the four lenses of sustainability: economic, social, environmental, and technical; these factors will be established. In general, for a cool room to be feasible for an area, stakeholders must have the incentive to build, use, and maintain the cool room and they must have the capability to build, use, and maintain the cool room as well. Without either, cool rooms will not scale up sustainably. The cool room itself has its own needs such as building materials and energy. Even with stakeholder incentives and capabilities present, if the needs of a cool room cannot be met in an area, a cool room cannot be built and used. It is also not just a matter of whether or not a factor of feasibility is present but also the extent and the certainty of those factors present. This chapter will examine some of those factors of feasibility within the East Africa Region, Tanzania and Ethiopia in particular, through the social lens. First however, it will attempt to establish the general factors affecting cool room proliferation within the social context.

The Social Lens

Through the social lens, the feasibility of a cool room in an area is determined by who the key stakeholders are, what their goals are, and what kind of environment they exist in. If the key stakeholders have the capability and the incentive to build and use a cool room and if the environment is conducive to this, then a cool room will be built and used. So who are these stakeholders, what are their goals, and what is the environment that they exist in? These are the questions that need to be answered in order to assess the feasibility of cool room technology within a given region. More than this, answering whether or not if there are some generalizations to be extrapolated from specific cases is important for constructing a guide. The process of constructing this guide will involve several iterations. This first iteration will be made using several assumptions and will have to be tested to determine whether or not those assumptions were correct. These assumptions will be
stated within the guide. The next section will delve into who the key stakeholders are and what are their goals.

**Key Stakeholders**

To find the key stakeholders within cool room feasibility, one must first examine who would be a stakeholder. In regards to cool rooms, stakeholders would be individuals or organizations whom would be affected – positively or negatively – by the installation and use of cool rooms. In addition, *key* stakeholders would be stakeholders whom would be directly and/or heavily affected by the installation and use of cool rooms. Within this definition, the amount of people and organizations whom could possibly be identified as a key stakeholder is staggering. To aid in this, an organizational structure is used to eliminate the overwhelming nature of this task. The organizational structure used in this paper is differentiating key stakeholders by level of organization: from individual to global; and by primary motivator: profit/income or altruism. Note that the profit/income or altruism structure is more of a gradient than a dichotomy. This structure is ultimately arbitrary and the identified key stakeholders can be arranged into whatever organizational scheme deemed fitting.

On the individual level, farmers fall into the income motivator category whilst donors fall into the altruistic category. The farmer seeks to improve their income so that they can provide for themselves and their families while the donor seeks to assist in that goal whilst also pushing for their own social agenda whether it be focused on sustainability, religion, or something else. In relation to the cool room, the farmer would use it if it improved their income and the donor would support it if they thought it would improve the income of farmers in developing countries. On the smaller organizational level, small businesses fall into the profit motive side while NGOs fall into the altruistic side. Small businesses, like the farmer, wish to increase their profits. NGOs on the other hand, have goals that are not as straightforward as the small businesses. NGOs exist primarily off of the charity of donors, without that they could not exist. As a result, NGOs must have goals that attract the charity of donors. In the context of cool rooms, a business would only install and use a cool room if it helped its bottom line while an NGO would install a cool room if it and its donors believed the cool room would be an effective tool towards helping achieve the NGO's and by extension, the donor's goals. Outside of individual and smaller
organization level, there lie large businesses that may be international and governments all the way from local to national to global. Large businesses have the capability of reaching markets farther away than what the individual and small businesses are capable of, as such the incentive for large businesses to invest in cool chain storage is that much higher for the sake of bringing produce from one area to another far away. Depending on the structure of the government, how decisions are made, and its accountability determines how well it actually serves the people. With this being said, it is difficult to generalize what incentives governments have in proliferating cool rooms.

It was identified by the 2011 D-Lab I, Uganda group and through our talks with Horticulture Innovation Lab that it was going to be organizations of individuals and not individuals who were going to be the key proliferators of cool rooms. This was due to the amount of capital and knowledge required to build a cool. With this being said, the section on the social/political environment will focus on the environment surrounding those organizations rather than on the environment surrounding the individual.

The Environment

Considering this guide will be made more for organizations rather than individuals, this section of the paper examining the factors within the social/political environment will look at what factors facilitate the proliferation of cool rooms and what factors are obstacles to the proliferation of cool rooms in Tanzania and Ethiopia whilst having the NGO or business as the focus.

The questions to be answered for each area are: what NGOs or businesses would have a large stake in the implementation of cool rooms and what would facilitate or impede the implementation of cool rooms in those areas. The NGOs and businesses that would have the highest stake are those that deal with farmers and the production and sale of perishable produce.

The NGOs and businesses that would have a large stake in implementing cool rooms are those that have to do with agriculture. The presence of such NGOs and businesses can be found by examining the number of NGOs registered with the governments of Tanzania and Ethiopia, by examining the percentage of GDP derived from agriculture, and by the amount of people involved in agriculture. As shown by the list provided on the website of Ethiopia’s Ministry of Agriculture, Ethiopia contains many NGOs and cooperatives involved
in agriculture.\textsuperscript{2} Within Tanzania there are over 60 registered NGOs working on agriculture.\textsuperscript{3} Though 85\% of Ethiopia’s population is employed in agriculture, only 47\% of its GDP is comprised of agriculture. Tanzania has a grosser digression with 80\% of its labor force in agriculture and only 27.6\% of its GDP coming from agriculture. For comparison, the United States only has 0.7\% of its workforce involved in agriculture whilst agriculture accounts for 1.1\% of its GDP.\textsuperscript{4} Within the United States, the dependence on agriculture is far less and is flipped in the sense that less people generate more GDP within agriculture than in Tanzania and Ethiopia. These statistics show the potential for increasing incomes through the integration of technology within the developing economies.

As for obstacles and conduits, for the fiscal year of 2014/2015, Tanzania’s government is planning on installing cold rooms at key air and sea ports.\textsuperscript{5} This in conjunction with cool rooms being installed throughout the region could establish a cold chain supply which has the potential to improve the profits generated from producing horticultural products. Ethiopia, being a land-locked country has a difficult time getting produce to a sea port considering that it can take up to ten hours to get past the border to get to Djibouti. With this being said, since 2012 the Ethiopian government has invested in cold storage and has cold room storage operating in its larger airports.\textsuperscript{6}

\textbf{Conclusion}

Cool room proliferation has great potential to improve the incomes of farmers in developing countries. For this proliferation to occur a key stakeholder who has the ability and the incentive to install cool rooms need to be present. The guide our group is attempting to construct will help determine the feasibility of installing cool rooms for those interested stakeholders. A part of that guide is looking at the components necessary to proliferate cool rooms in the social/political context, which is what this sector paper examined. This will be used in conjunction with the group’s other sector papers and with additional research to construct the guide. Upon constructing the guide, it should be used to examine case studies and see if the guide predicted success in the cases that had success and failure in the cases that had failure.
Sources


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Appendix A: Topographical Map of Tanzania (Wikipedia 2015)
Appendix B: Map of the Soil Types in Tanzania (MARI 2006)
Appendix C: Map Depicting Average Annual Rainfall in Tanzania (The World Bank 2015)
Appendix D: Topographical Map of Ethiopia (Wikipedia 2015)
Appendix E: Map of the Soil Types in Ethiopia (EuDASM 1972)
Appendix F: Map Depicting Average Annual Rainfall in Ethiopia (The World Bank 2015)
Appendix H: Map of the Soil Types in Kenya (PWRC 2015)
Appendix I: Map Depicting Average Annual Rainfall in Kenya (The World Bank 2015)