



Kenya Cold Chain Assessment
Global Cold Chain Alliance





Table of Contents

| | |
|---|----|
| Table of Contents | 2 |
| List of Acronyms | 3 |
| Executive Summary | 4 |
| Introduction..... | 6 |
| Overview | 7 |
| The Macroeconomic View of Kenya | 8 |
| Snapshot of Kenya’s Agriculture Sector..... | 9 |
| Critical Cold Chain Drivers | 10 |
| Consumer Demand in Kenya | 10 |
| Government Regulations & Standards..... | 12 |
| Access to Finance & Investment..... | 15 |
| Cold Chain Logistics..... | 15 |
| Postharvest Handling | 15 |
| Processing | 19 |
| Transportation..... | 20 |
| Cold Storage..... | 23 |
| Retail..... | 26 |
| Final Observations & Conclusion..... | 28 |
| References | 30 |
| Attachment I: Cold Chain Logistics Recommendations..... | 33 |
| Attachment II: GCCA report on Technologies | 35 |



List of Acronyms

| | |
|-----------|--|
| 3PL | 3 rd Party Logistics |
| BRC | British Retail Consortium |
| EAC | East African Community |
| EU | European Union |
| FAIRS | Food and Agricultural Import Regulations and Standards |
| FAO | Food and Agriculture Organization |
| HACCP | Hazard Analysis Critical Control Point |
| G&A | General & Administrative |
| GAIN | Global Alliance for Improved Nutrition |
| GCCA | Global Cold Chain Alliance |
| GDP | Gross Domestic Product |
| GNI | Gross National Income |
| Hort CRSP | Horticulture Collaborative Research Support Program |
| ICT | Information and Communication Technologies |
| IARW | International Association of Refrigerated Warehouses |
| IACSC | International Association for Cold Storage Construction |
| IFAD | International Fund for Agricultural Development |
| IRTA | International Refrigerated Transport Association |
| KFC | Kentucky Fried Chicken |
| KALRO | Kenya Agricultural and Livestock Research Organization |
| KMFRI | Kenya Marine and Fisheries Institute |
| KPA | Kenya Port Authority |
| KEPHIS | Kenya Plant Health Inspectorate Services |
| KSH | Kenyan Shillings |
| MALF | Ministry of Agriculture, Livestock and Fisheries |
| QSR | Quick Service Restaurants |
| PV | Photovoltaics |
| PVoC | Pre-Export Verification of Conformity |
| PAC DBIA | President's Advisory Committee on Doing Business in Africa |
| SACCO | Saving and Credit Cooperative Organizations |
| SME | Small and Medium Enterprises |
| USAID | United States Agency for International Development |
| VAT | Value-Added Tax |
| WFLO | World Food Logistics Organization |



Executive Summary


Cold chain is an essential component of an efficient food supply chain. A commercially sustainable cold chain would allow farmers to diversify production to include high-value perishable crops, link them to regional and international markets, and increase earnings. In addition, cold chain facilities would create opportunities for labor, services, and value-added processing for horticultural products. The creation of the cold chain would also bring additional economic benefits to related industries.

According to the Food and Agriculture Organization (FAO), almost one third of all food produced globally is lost or wasted every year. Countries in Sub-Saharan Africa have been found to lose as much as 36% of their harvested food; up to 94% of these losses are due to inefficient supply chains during harvest, processing and distribution. While cold chain is not a panacea for food loss, it can help reduce post-harvest losses and increase food security in developing countries.

The cold chain industries in advanced economies did not surface overnight. Although many developed nations take for granted the fact that they can purchase safe, high-quality food from around the world without traveling beyond their nearest grocery store, the industry has matured and developed within the previous 60 years. Initially, this growth took place in fits and starts, led in equal measure by consumer demand and government enforcement, combined with access to finance, a thriving economy, innovation and thought leadership. The cold chain industries that developed were a response to the specific drivers and context within these consumer-driven nations.

It is within this context that one should consider the development of cold chain in Kenya, which is the largest and most dynamic economy in the East African Community (EAC) and serves as the business, logistics and financial hub for the region. Kenya has a relatively large and diversified private sector. It has an entrepreneurial population, expanding labor force and a growing middle class. Kenya also pioneered mobile -based money and remained a global leader in this area since. As is the case with other Sub-Saharan African countries, agriculture continues to be the backbone of the Kenyan economy, remaining the major contributor to the GDP and employing the majority of the population, which is composed of smallholder farmers. The Kenyan Government is also working to realize Vision 2030, the country's development plan, which includes a focus on infrastructure development. Consumer demand along with access to energy and transportation infrastructure are critical factors to cold chain development.

Some cold chain industry and infrastructure exists in Kenya and is supported to an extent that is not mirrored across Africa or even within neighboring countries. The cold chain system in Kenya emerged in fits and starts, responsive to the particular needs and demands that are driving it. For example, Kenya is one of the biggest exporters of cut flowers, accounting for 38% of imports into the European Union (EU). This strategic industry has developed relatively advanced cold chain systems, while those established for horticulture and other temperature-controlled foods such as meat and dairy, are ad-hoc, dependent on retail and wealthy consumers. In other words, these respective cold chains developed in response to two markets, one driven by investment in strategic exports and the other by growing local consumer demand, bolstered by growing purchasing power and middle class. Moreover, the existing cold chains in Kenya are vertically




integrated to meet specific business needs and do not have wider economic impact. Likewise, food safety standards for exports follow international best practices, while products destined for local consumption incur temperature abuse at all links of the cold chain. There is also a lack of awareness in the domestic market of the benefits of cold chain and therefore lack of widespread consumer demand for safe, quality food that is backed by government enforcement of food safety regulations.

In addition, growth of multinational quick service restaurants (QSRs) is another key driver for the cold chain industry. Many QSRs are committed to expanding operations throughout the African continent including in the Kenyan market. The growth of QSRs is also a clear sign for future demand for third party logistics (3PLs) services as retailers look to maximize profits and reduce costs. As experts in logistics and distribution, 3PLs can implement checks and balances within the supply chain to assist farmers and processors better meet the demands of foreign and domestic markets. Currently, there are no 3PLs in Kenya. However, even entry of one 3PL into the market would be a sign of a more mature market.

This rapid, two-month assessment revealed a number of recommendations, many involving the need for additional, targeted research and information. This report details recommendations for each cold chain driver, as well as the specifics links within the cold chain from postharvest to retail. Generally, they can be summarized as follows:

- **Regulations/Enforcement.** To create a transparent and accountable system for cold chain operators through a harmonized system and enforcement of regulations that also eliminate illegal fees.
- **Public Awareness and Education Campaign.** To develop consumer awareness on nutrition and food safety benefits of cold chain and promote knowledge on how to store and cook cold and frozen food.
- **Access to Finance.** To reduce cost of financing and provide access to technical assistance for SMEs in order to further the development and investment of cold chain infrastructure including tools and equipment.
- **Technology.** To meet the specific challenges within Kenya, global innovations can be piloted and supported to develop smart and scalable designs and business models. A number of technologies are also recommended in this assessment.
- **Training.** To strengthen and develop cold chain links and business skills from postharvest, processing, transportation cold storage, to retail. A number of no-cost to low-cost post-harvest practices are recommended in this assessment including the use of the flower industry as a guide for best practices on cold chain linkages for other temperature sensitive products.

None of these themes are specific to Kenya and could apply broadly to a number of developing countries. Improvements take time and typically rely on government commitments and international development aid. While this assistance is necessary and an important part of the process, there is a third, highly sought-after source for growth which is private investment. The key to unlocking the potential within any economy lies within the private sector because without it, long-term growth cannot be sustained. And yet the timing and attractiveness of investment opportunities in general, and in this case, in Kenya are constrained by a number of factors. Based on the assessment, **return on investment (ROI) is predicted to take eight to ten years for**



large scale projects. Investment into small equipment and technologies by SMEs is likely to yield much more immediate returns. Foreign direct investment is usually attracted by an ROI of three years or less. Before considering any other constraints, it must be noted that investment into the Kenyan cold chain is a long-term endeavor.

In Kenya, the reward for investment has the potential of being great, but also fraught with risk. Refrigerated warehouses and trucks are expensive to build or acquire, and start-up costs require long-term commitment to recoup investment expenses. Investors are deterred by higher costs or longer delays related to government bureaucracy and confusing rules and regulations. Navigating these rules, combined with legal and illegal fees throughout the process, is particularly daunting for an industry that is capital intensive.

Moreover, aiming to develop a commercially viable cold chain needs to be carefully balanced with important government policies aimed to assist smallholder farmers to reduce food loss and increase prices. The government and private sector need to work together to ensure sustainable cold chain operations. Supporting one and overlooking the other can lead to difficulties for investors to recover both investment and operational costs. Planning and design of facilities is likewise critical. If not planned properly, the building of new cold storage facilities will do nothing to improve the cold chain since they would sit empty, be used for dry storage, or would cease to function due to inadequate routine maintenance. Therefore, smart designs and scalable approaches is recommended to grow with the Kenya economy.

Introduction


The Global Cold Chain Alliance (GCCA) represents the warehousing, construction, and transport industries engaged in temperature-controlled logistics. Supporting our mission to grow the industry and lead the cold chain are four core partners:

- International Association of Refrigerated Warehouses (IARW): the 3rd Party Logistics (3PL), temperature-controlled warehouse industry's association.
- International Association for Cold Storage Construction (IACSC): the association for experts in the design and construction of temperature-controlled facilities.
- International Refrigerated Transport Association (IRTA): the temperature-controlled transportation and logistics industry's association.
- World Food Logistics Organization (WFLO): the nonprofit foundation that develops education and research for the industry and provides cold chain advisory services that empower economic development and strengthen the global cold chain.

GCCA serves more than 1,300 companies in 75 countries who serve the food industry by providing third-party, temperature-controlled supply chain services. Over 40 percent of members are outside North America.

Cold chain development in East Africa was first prioritized by the business community under the U.S. – East African Community (EAC) Commercial Dialogue. In February 2015, U.S.

Department of Commerce Deputy Secretary Andrews and the EAC member governments agreed to launch the Cold Chain Assessment Initiative in East Africa. The President's Advisory Council



on Doing Business in Africa (PAC-DBIA) subsequently prioritized cold chain development in its April 2015 *Recommendation Report*.

Within this context, Kenya was identified as the country with high potential, based on current infrastructure and market size. As a result, GCCA, in collaboration with the Department of Commerce, undertook a rapid assessment of the cold chain infrastructure in Kenya during the August-September 2015 timeframe.

Overview


Cold chain refers to the management of the temperature of perishable products in order to maintain quality and safety from the point of slaughter or harvest through the distribution chain to the final consumer. The links of the chain span postharvest, transport, processing, storage, and retail, ensuring that perishable products are safe and of high quality at the point of consumption. According to Dr. Lisa Kitinoja, the founding member and President of Postharvest Education Foundation, “few other interventions can so dramatically maintain the visual quality and nutritional value, and increase shelf life and the ultimate market value of fresh foods as much as simply holding the foods at a lower temperature” (2013 p. 3).

Failing to keep product at the correct temperatures can result in a variety of negative attributes including, among others, textural degradation, discoloring, bruising and microbial growth. On the other hand, a quality product leads to a satisfied customer, greater demand, and overall protection of public health and reduction in the waste of limited natural resources (land, water, and other inputs) required for agricultural production. A modern cold chain would allow farmers to diversify production to include high value perishable crops that increase earnings. In addition, cold chain facilities would create opportunities for labor, services, and value-added processing for horticultural products. The creation of the cold chain would also bring additional economic benefits to supporting industries related to high-value horticulture.

At the same time, developing the global cold chain is a “force multiplier” that generates exports and opens new markets for multiple sectors over an extended period (Department of Commerce, 2015, p. 5). However, due to the complexity of the linkages throughout the chain, building and strengthening cold chain systems require coordinated and comprehensive efforts from government, industry, academics, and the international development organizations.

Methodology

The following cold chain industry-led report provides a basic assessment of current cold chain infrastructure in Kenya, as witnessed by research, observation, site visits, and interviews. A literature review conducted in advance of site visits formed the initial assumptions and recommendations, which were then explored and tested during the assessment. The research began with a review of specific macroeconomic and agricultural characteristics, before examining auxiliary issues critical to drive cold chain development. These include consumer demand, government regulations, and access to financing. The study then considers the specific links in the cold chain, beginning at postharvest and moving to transport, storage, processing and



retail, resulting in a comprehensive assessment and inventory of infrastructure, facilities, and support services necessary to the economical operation of an efficient supply chain for temperature controlled products. Recommendations are outlined for each cold chain link and are summarized in the executive summary.

As with any assessment, the scope of the activity was limited by team size: one expert on the ground with GCCA support over a six week period. The GCCA technical cold storage and design expert targeted in-country research focused on Nairobi and Mombasa. This research was backed by data from local government statistics offices, local businesses involved in cold chain and temperature controlled based enterprises, and research documents from non-governmental sources. As such, the recommendations include multiple areas where additional research and information would be beneficial. Please also note interviews did not include government officials. Therefore, a future opportunity to collaborate would be welcome.

The assessment of cold chain in Kenya could lead to the construction and operation of modern cold chain infrastructure, which would have a significant impact on small-scale producers and on the local economy in Kenya. A more targeted research focused on all the links within a specific perishable product across a cold chain has not yet been completed. Based on the assessment and consultations, a close assessment of the cold chain links across the flower industry in combination with a select horticultural product could result in recommendations for specific interventions on developing scalable cold chain infrastructure that could interlinked or be potentially replicated in other products for export.

The Macroeconomic View of Kenya

Kenya has the largest and most dynamic economy in the East African Community (EAC) and serves as the business, logistics and financial hub for the region. It has one of the largest and most diverse local private sectors on the continent. Nairobi, the capitol, is the largest city between Cairo and Johannesburg. Comparatively to other countries in East Africa, Kenya's economy is much better linked to the other African and global economies in terms of investment flows and trade. Kenya is one of only two EAC countries (the other being Tanzania) with sea ports and serves as a gateway to both landlocked neighbors and gives it a competitive advantage in terms of international trade. Kenya is also the region's major exporter and importer of goods. The country's transport system, including roads, the port of Mombasa, and the airports, is more advanced than those of most other Sub-Saharan countries in the region including Ethiopia. The port of Mombasa is half way between the Port of Durban in South Africa and the major Middle East ports which serves as a gateway to East and Central Africa. Inland transportation is provided by truck and train, and special railtainer services operate from the port to inland container depots. This provides ample opportunities for cold chain.

According to the World Bank, Kenyan growth rates as measured over the past five years are strong (between 5-6% annually), and projections through 2017 show increases to 6.6%. Consumer price inflation has steadily improved from 14% in 2011 to 6.9% in 2014. The 2014 rates show inflation at 8%. The real interest rate, which is the amount of interest an investor can expect to receive after accounting for inflation has ranged from 8-11% over the past three years. The estimated population in Kenya is approximately 45.5 million people and classifies income

level as lower-middle. Lower-middle means that it has a Gross National Income (GNI) that falls within the range of \$1,045-\$4,125. By comparison, other countries that fall within this range include Egypt, Indonesia, Morocco, Nigeria, Senegal, and Ukraine. According to the International Fund for Agricultural Development (IFAD), a specialized agency of the United Nations, more than three quarters of the population live in rural areas, depending on agriculture for their income. Poverty has declined over the past 10 years, from 47% in 2005 to range between 34-42% in recent years (Danish Trade Union 2014). The IFAD notes this sustained high growth has led to a tripling of the population over 35 years, increasing pressure on resources and leaving people particularly vulnerable to food insecurity, compounded by inadequate rural infrastructure and an absence of technology diffusion. Poverty and food insecurity are particularly severe in the country's arid and semi-arid lands, which have been affected by recurrent droughts.

In terms of labor force, Kenya has a relatively mobile, well-educated and entrepreneurial workforce. The Danish Trade Union Council for International Development Cooperation's 2014 Kenya Labor Market Profile places unemployment at 9.2% in the formal sector, a figure that increases to 17% when targeted to youth. Due to the difficulties of finding employment in formal sectors, the informal economy is a growing alternative for the labor force. The United States Agency for International Development (USAID) published its own assessment of the workforce for Kenyan Youth in 2014, stating that only 1.3 million people work in the formal sector compared to over 12 million who work in the informal economy. The USAID assessment included a preliminary exercise to determine the sectors with the most potential for growth in formal sector jobs. Topping the list are dairy, livestock, horticulture, health care services with energy and clean technology, metals, machinery and repair, construction, information and communication technologies (ICT), and rural retail rounding out the recommendations. The extensive impact of cold chain touches upon all of these sectors, directly or indirectly.

Education is a strong indicator of a professional workforce. In Kenya, while academic education is prioritized, the country lacks vocational training leading to a gap in needed skills for those trying to enter the labor market. Other important factors to consider when looking at Kenya's competitive labor force is that the country has had some of the highest minimum wages in the East Africa region. Trade unions are common, although difficult to report on accurately as the country determines how to count unions forming in the informal economy.

Snapshot of Kenya's Agriculture Sector



Produce arriving to local market during a rain storm.

Agriculture plays a pivotal role in Kenya's economy and in the country's development strategy, representing 30% of the GDP in 2014 with value-added agriculture increasing annually over the past five years (FAO). Because agriculture is the backbone to Kenya's economy, it is important to invest and develop this sector. The need for improvement in the supply chain infrastructure is imperative for increased participation in global markets.

Cold chain can play a significant role in advancing agriculture production and ultimately in the development of Kenya's economy.

The top agricultural productions include bananas, mangoes, milk, meat, maize, and potatoes, with high levels of production and consumption of dairy products. The agricultural sector is plugged into global and regional markets, and the country is a world leader in the export of tea, coffee and horticultural products. According to the Kenya's Export Promotion Council, horticulture continues to be one of the fastest growing sub sectors among Kenyan exports with annual growth at more than 7%. Products include cut flowers, vegetables (green beans, sugar snaps, snow peas, okra, chili and eggplant), fresh fruits (avocadoes, mangoes, pineapples, passion fruits, bananas, and strawberries), processed fruits (see above), and herbs and spices (lemon grass, basil, dill, oregano, parsley, rosemary, thyme, and sage).



One stand offering fruits and vegetables at a local market in Nairobi.

The majority of production in Kenya relies on small farms, operated by individual farm households who have neither the means nor the incentive to invest in additional resources for cold storage. The average Kenyan farm is less than two hectares. These men and women often participate in subsistence farming as the primary source of livelihood with little knowledge or capacity on appropriate postharvest handling practices, packaging, labeling and grading, and storage. Farmers are further constrained by a lack of access to market information. Moreover, they are significantly constrained by weak and sometimes non-existent transportation infrastructure to physically link them to the consumer. Rural farms have also limited access to electricity or irrigation (der Lans, Snoeck, de Boer, and Elings, 2012 & USAID). All these compounding factors including a lack of on-farm cold storage facilities forces farmers to sell their produce immediately to the nearest geographic market, leaving them with little bargaining power and resulting in seasonal variations for products (Alila & Atieno, 2006).

Critical Cold Chain Drivers


In addition to critical macroeconomic factors in Kenya, the auxiliary issues critical to driving cold chain development include consumer demand, government regulations, and access to finance.



Adhering to improved practices will raise the cost of fruits and vegetables which means Kenyan consumers must be willing and able to bear this cost.

Consumer Demand in Kenya

Cold chain infrastructure is expensive. The countries that utilize the safest, highest-quality, advanced systems are the wealthiest countries. Some of the cost of providing a product with temperature control from farm to fork can be recouped by increases in available quantities for sale as waste is reduced. Food loss occurs throughout the chain, translating into economic loss for the farmer, the trader, the wholesaler or the



retailer. However, at least a portion of the cost is passed on to the consumer. Therefore, a question of fundamental importance concerns the consumers. Are Kenyans willing to pay more for products that have benefitted from cold chain? There are two important factors that impact Kenyan consumer spending decisions, one is cultural food preference and the other is disposable income.

Currently, the average Kenyan consumer buys directly from farmers or in markets where products are never refrigerated. Products are transported as quickly as possible to local markets or roadside stalls that can be rented. These consumers cannot afford the higher quality products, and most express a preference for what is considered fresh food over frozen processed food. In terms of nomenclature, fresh does not carry the same connotation as it does in many developing countries where fresh foods benefits from cold chain. In Kenya, fresh food is the food that is consumed as close to harvest or slaughter as possible. By comparison, this fresh food is understandably cheaper and is regarded as tastier and healthier. Less understandable is the finding by the 2014 Euromonitor International report showing that frozen processed food category has a bad reputation for getting spoiled quickly. This could be related to the breakdowns in the existing cold chain that negatively impact frozen processed foods.

The other critical factor that impacts consumers' spending decisions is purchasing power. Disposable income levels in Kenya are increasing; however, the levels still remain at a minimum while the cost of living is relatively high due to political instability and the global financial crisis (Euromonitor, 2014). There have been increases in minimum wage, but the increases have benefitted the urban areas more than the rural farmers. According to *Business Daily Africa* from May 1, 2015, the average pay set for the agricultural industry was 6,054 KSH a month, with unskilled workers receiving 4,854 KSH monthly. The latest changes raise average minimum wages in the agricultural industry to 6,780 KSH, with unskilled workers getting 5,436 KSH. In urban areas, the minimum wage increases to between 13,592 KSH and 17,199 KSH. While there is a slight increase in the minimum wage for workers in the agriculture industry, it is still extremely low for the vast majority of Kenyans provided that more than 70% work in this sector.

However, Kenya is one of the fastest growing markets in Africa with an emerging middle class. A 2011 Nielsen snapshot on Kenya cites a rising GDP per capita is usually cited as an indication of growing consumer income. Domestic consumption seems to be at the center of Kenya's economic expansion, as private households are seeking and receiving loans with greater success (*Financial Times*, November 2013). Measured as a percentage of GDP, household consumption expenditure is around 80%. The increases in minimum wage referenced above facilitate the increase in consumer income and an emerging middle class. Therefore, based on the review of consumers in Kenya, it was assumed that Kenya's rising disposable income will lead to an increasing ability and willingness by Kenyan consumers to pay for high quality products.

Assessment Observations:

In order to gauge whether or not Kenyan consumers are willing and able to pay for the food traveling through the cold chain, an assessment should be conducted that focuses exclusively on this aspect. This assessment is focused on cold chain infrastructure, therefore the information on Kenyan consumer behavior is anecdotal. However, during assessment meetings, local perception

of fresh food was maintained to mean food that has been recently harvested or slaughtered. At no point did the assessment reveal a preference for frozen or temperature controlled food.

Recommendations:

- Design and launch a public education campaigns on: (1) nutritional benefits of frozen food; (2) properly defrosting and cooking with frozen products; and (3) food safety and the health benefits of an unbroken cold chain.

Government Regulations & Standards

The lack of clear food safety regulations is often cited as a concern in developing countries. Of equal importance is enforcement of existing regulations. The existence of one without the other hinders transparency and facilitates corrupt practices to undermine public health and safety. This section examines current practices next to existing regulations and enforcement.

Agriculture policy in Kenya is determined by the Ministry of Agriculture, Livestock and Fisheries (MALF) with five strategic objectives for the agriculture sector:

- 1) Create an enabling environment for agricultural development
- 2) Increase productivity and outputs
- 3) Enhance food security
- 4) Improve market access and trade
- 5) Strengthen institutional capacity

Supported by two research organizations, the Kenya Agricultural and Livestock Research Organization (KALRO) and the Kenya Marine and Fisheries Institute (KMFRI), the MALF also works through a number of specific projects. So far, one project focuses on small-scale horticulture development, and none currently deal explicitly with preventing or reducing food loss.

The Agriculture, Fisheries and Food Authority Act (No. 13 of 2013) in Kenya came into effect in January 2014 with the intention to consolidate laws on regulation and promotion of agriculture; to provide for the establishment of the Agriculture, Fisheries and Food Authority; and to make provision for the respective roles of the national and county governments in agriculture (excluding livestock). The impact of this act on consolidation and clarification of regulations and responsibilities is not easy to measure at this point of time. Nevertheless it should be stated that the positive effect of policies without adequate and consistent enforcement will be negligible.



The existence of sound regulations is half of the battle. Enforcement of regulations will lead to a lasting and widespread changes.

In addition, the Kenya Bureau of Standards (KEBS), a statutory body established under the Standards Act (CAP 496), provides standardization solutions for sustainable development. KEBS is mandated to provide standardization and conformity assessment services, achieved through the promotion of standardization in commerce and industry, the provision of testing and calibration facilities, and product and system certification. KEBS also undertakes educational work in the practical application of standards, and maintains and disseminates the International System of Units (SI) of measurements.

As mentioned in the consumer demand section, most local consumers buy products directly from farms or roadside shops where livestock and poultry are slaughtered by hand in the open. Such practices yield obvious concerns for food safety. According to Oloo Jeo, writing for the African Journal of Food Agriculture Nutrition and Development (2010), the responsibility for coordinating the agencies involved with food safety in Kenya rests with the Department of Public Health (DPH) under the Ministry of Public Health and Sanitation. Laws exist to enforce these food safety regulations including the Food, Drugs and Substances Act (Chapter 254), the Public Health Act (Chapter 242), and the Meat Control Act (Chapter 316). However, food-borne diseases remain a major problem, often attributed to the informal food industries. It is estimated that the informal food industries account for at least 80% of the supply to the domestic markets.




Navigating regulations can impede or slow the growth of local businesses.

Other factors impacting business owners are government red tape and illegal fees. For example, some regulations are counterproductive to growth, such as applying levies per package as opposed to weight. This practice, cited by *Business Daily Africa* in November 2014, encourages using and overfilling large bags, leading to increased food damage and loss. However, the Government of Kenya is working to enhance the attractiveness of trade. The Global Alliance for Improved Nutrition (GAIN) produced a report in 2009 that summarizes the Food and Agricultural Import Regulations and Standards (FAIRS). According to this report, exporting U.S. commodities and food products to Kenya can be quite straight forward, because of a 2005 Kenyan initiative called the Pre-Export Verification of Conformity (PVoC). Once certified by a Kenyan-contracted agent in the United States, the exports may enter the Kenyan market with great certainty and at minimal risk of rejection or unanticipated import requirements. In

addition, government policies to promote commercial, market-oriented and profitable agriculture to raise incomes and increase food security are supported through high levels of public expenditure.

In addition, corruption remains a problem according to Transparency International's Corruption Perception Index, which ranked Kenya 145 out of 175 countries in 2014. If business owners are fined or given a violation for sanitary or health issues, a bribe is often sufficient to alleviate the fine. There is no period of time for fixing the situation or penalty for non-compliance. This leads to loss of revenue through corruption for those who cannot afford to expand their businesses or



provide quality products through best management practices. It also opens the door where the threat of fines can impact even those complying with regulations and best practices.

Assessment Observations:

During the assessment, it quickly became evident that most businesses consider any government involvement as having a negative impact on business. Many asserted that to successfully operate a business in Kenya, one should stay off the government’s radar. While there is a natural tension between business and regulations in most countries, the basis of this assertion was tied to illegal fees. There was a reluctance to discuss simple questions concerning regulatory agencies, but one company revealed that the cost of illegal fees ranges from 10% to 15% of the top line revenue. This is equivalent to the General & Administrative (G&A) expenses in most third party warehouse operation in the United States.

Certain companies implement corporate policies that do not allow for the payment of illegal fees. However, practically speaking, this can delay delivery of products for up to one week, resulting in angry customers and decreasing product quality. Such breaks in the chain only undermine efforts to demonstrate improved product quality and food safety that should result from cold chain, obviating any progress made to strengthen consumer demand. The businesses who pay for the illegal tariffs do not suffer from a delay in product delivery, but their business growth is constrained by such payments. In either scenario, the illegal fees charged also causes the SME’s to operate below a profit. This corruption leads to a decrease in revenue and burdens the operations of SMEs facilitating the entrance of low-quality, rotten products and potential disease to enter the market.

The Government of Kenya should focus on harmonization and streamlining of existing regulatory laws that are enforced at the lower levels of operation to improve food safety and best practices. In addition, it should be noted that GCCA was unable to meet with any government officials during this rapid assessment. While cold chain and the reduction of food losses are supported by the government, opportunities exist to work with the government and better educate policy makers on the unintended effect that some regulations can have on food quality and safety.

Recommendations:

- Conduct more research to understand government regulations and standards in Kenya related to agriculture and temperature controlled products.
- Ensure that regulations are enforced so that products adhere to safety standards for consumption in domestic and international markets.
- Increase attention to government support to reduce informal payments and create best practices. For example, consider the use of mobile or electronic systems to reduce informal fees.
- Harmonize and streamline agriculture and temperature controlled product regulations, and manage their development and enforcement processes to ensure an accessible, systematic, transparent and inclusive business environment.

Access to Finance & Investment

Shortage of capital is often cited as a constraint to explain why most small to medium sized business owners are not able to provide a modern cold chain. According to the article, *Private Equity & Venture Capital in SMEs in Developing Countries*, the persistence of an “equity financing gap” is not surprising for SMEs. In Kenya, most SME’s rely on family and friends to stay in business, microfinance from banks such as Equity, Kenya Women Finance Trust, and Kenya Commercial Bank, or statutory bodies such as the Kenya Investment Authority (KenInvest) that have the main objective of promoting investments in Kenya through the implementation of new investment projects and providing after care services. However, the cost of financing is expensive ranging from 13% to 18% annually, making it very difficult to profit from the cold chain. This creates shortcuts in best practices and deviations from standard operating procedures leading to lower quality products. To assist in growth in cold chain, for example, the Indian government provides financial assistance for cold chain development.

Assessment Observations:

While conducting the assessment, the lack of access to capital and the high cost of financing were not explicitly mentioned by interviewees. However, when observing other developing countries in Africa, access to finance and investment were important concerns for business owners. Kenyan SME’s are using Saving and Credit Cooperative Organizations (SACCOs) and family and friends to invest in their small businesses. The interest rate offered by SACCOs vary around 8% per annum whereas interest rates from the banks are 15.75% (according to the Central Bank of Kenya as of July 2015). Discussions with larger agribusinesses revealed that they are usually part of global conglomerates. These arrangements allow them access to low-cost financing, precluding the need to rely on local banks or other financing schemes.

Recommendations:

- More information should be gathered to better understand access to investment in Kenya.
- Reducing the cost of financing businesses in the cold chain will likely lead to the adherence of standard operating procedures.
- Technical assistance for cold chain can mitigate some level of risk for SMEs and increase the probability of successful investments.

Cold Chain Logistics


Cold chain logistics includes multiple steps starting with postharvest and ending with the consumer. Each link of the cold chain faces challenges that reduce the quality and nutrition of food products and ultimately the value potential.

Postharvest Handling

The majority of food waste in Sub-Saharan Africa occurs during production, handling, and storage (World Resources Institute 2009). Production is the



Most farming in Kenya is completed by smallholder farmers.



aspect of the supply chain that occurs during and immediately after harvest on-farm. Postharvest handling involves the steps taken to pack and cool fresh food products immediately after harvest or slaughter. Control of biological ripening and deterioration of fresh fruits and vegetables usually relies upon cold temperatures and reducing the production and action of the plant ripening hormone ethylene.

There is no substitute for the use of cold temperatures and gentle handling to reduce postharvest losses of fresh fruits and vegetables, and these handling technologies must be considered pre-requisites to use of any shelf-life extending technologies. As such, these practices are where appropriate cold chain interventions begin. Postharvest practices can involve a myriad of techniques that range from no-cost to low-cost to highly advanced and costly systems for precooling and cooling. As referenced previously, there is a pervasive lack of information among farmers on best practices so even the low or no-cost techniques are not widely practiced. International development projects are working to ameliorate this, but much remains to be done.

GCCA, through its education and research arm, the WFLO, has extensive experience in promoting best practices for postharvest handling globally. Most research on postharvest losses in Kenya relate to staple crops such as rice, maize and legumes and does not focus on the temperature-sensitive fruits and vegetables. The following information is extrapolated from WFLO experience working across Africa and around the world.

The moment that a product is harvested, biological ripening and deterioration begin. There are four simple pre-requisite postharvest technologies that should be adopted before more advanced technologies are implemented, which include improved containers, field packing, shade from farm to market, and evaporative forced air pre-cooling.

Improved containers: The containers typically in use for handling horticultural crops in Africa are baskets, sacks and wooden crates. All of these are a source of damage due to the roughness of the materials, are often over-filled and when stacked provide little protection to produce. Improved containers could include fiberboard liners for locally made crates or high quality plastic crates, with proper venting, which are stackable, nest-able, easy to clean and reusable.

Field packing: Field packing can often eliminate the need for a packinghouse, and can greatly improve the speed of postharvest handling, while reducing costs and waste. Workers typically utilize simple hand carts designed with one wheel in front, and they can push this cart before them in the field as they gather fruit or vegetables at harvest time. Workers must be well trained in how to identify the proper maturity and quality of the produce they are harvesting, and can pack it immediately into cartons or plastic crates. If the cart is designed to hold two crates, the worker can also sort while he or she is harvesting and field pack two quality grades during one pass.

Shade from farm to market: Shade can greatly reduce the temperature of any produce handled outdoors. Deep shade can be provided by permanent structures or by adding overhangs or awning to existing buildings, or can be provided with lower cost, more portable means. Market umbrellas are one option, and using marketing booths or tents to shade assembly points, packing

operations or retail marketing is another. During transport, loads should be covered with light colored tarpaulins that reflect heat and help prevent contamination from dust, birds and debris.

Evaporative forced air-cooling: Pre-cooling is used to remove field heat and reduce the temperature of fresh produce before it is shipped or placed into storage. Each type of produce has a different recommended "lowest safe temperature" – for example for optimum shelf life vegetables such as cabbage and carrots should be stored at or near 32 F (0 C), while tomatoes and peppers should be stored at 55 F (13 C) or above. In Africa it is relatively unusual to find cold storages operating at 32 F (0 C), and the cost of cooling most horticultural crops to their lowest safe temperature may not be economically feasible if the planned marketing period is short.

However, it is often possible to decrease the gap between the ambient temperature and the recommended temperature for most crops by utilizing low cost approaches to pre-cooling. Evaporative coolers are best suited to lower humidity regions, since the degree of cooling is limited to 2 to 4 F (1 to 2 C) above the wet-bulb temperature. A cooling pad of wood fiber or straw is moistened and air is pulled through the pad using a small fan.


An evaporative cooler can be combined with a Forced Air (FA) cooler for quick cooling of small lots of produce. For application in rural locations, this simple technology can be further modified to utilize solar power or a 12 volt battery to run the fan and water pump.

Assessment Observations:



The maturity of the flower industry in Kenya reflects heavy foreign investment.

Smallholder farms in the horticulture and flower industries were observed for postharvest practices where it was found that between the two industries, the flower farms were utilizing the best practices in farming. This is attributed to the fact that the floriculture industry in Kenya has been recognized as an established, mature industry supported by foreign investment mostly from the European Union (EU). The majority of the flowers grown in Kenya are exported to auction in Holland where they are distributed to retailers around the world. The floriculture industry has developed a cold chain system, which results in an added value for the end users. The suppliers focus on tracking time and temperature at every level of the supply chain to ensure a quality product.



These characteristics are not uniquely found within the floriculture industry. There are horticulture farms that also operate under best practices, but these are only the farms that are growing products for export, mostly to the EU. An estimated 90-95% of horticulture products are destined for export to the EU. In these cases, both the floriculture and horticulture farms are following best practices including the Hazard Analysis Critical Control Point (HACCP) management system. The important of HACCP are numerous. It is a preventive approach of that not only improves food safety management but also complements other quality management systems. In the end, HACCP provides businesses with a cost effective system for control of food safety ideally throughout the cold chain. The observed employees appear very knowledgeable on how the products should be handled during postharvest.

While the horticulture farms in Kenya follow best practices for the export market, the horticulture farms that produce vegetables and fruits for domestic consumption do not meet these standards. There are a number of practices that should take place during production or pre-harvest. Because cold chain begins with postharvest practices, these practices are not included in this assessment. However, improvement in pre-harvest and production practices would improve domestic production and could be further examined elsewhere.

Smallholder farmers producing for the domestic market have no formal training in best practices, and they lack access to this kind of training. Consolidators (buyers) in the supply chain have tried to create a business by sourcing from local farmers in both flowers and horticulture products to sell in the export market, but they cannot find farmers who have the capacity to adopt practices that would meet international standards and produce a product for a profitable return. Because the cold chain infrastructure at the farm level has not been developed, the consolidators are also taking a loss on the products due to shrinkage during transportation.

Recommendations:

- Procure cold chain technologies at the farm level and train workers and operators to raise productivity and reduce postharvest loss. See Attachment 2: *Appropriate Post Harvest Technology for Africa: 8 Simple Tools and Techniques*. The recommended storage at proper temperature would help guarantee the longest shelf life possible while maintaining the taste and quality of the product.
- Work with local associations, development agencies, and community based programs to help farmers understand best practices and utilize industry best practices within Kenya. Include stakeholders along the supply chain including retail associations, Kenya Agricultural and Agribusiness Association, Horticulture and Flower Council, among others, as well as development partners such as USAID.
- Use the floriculture industry in Kenya as an example to guide other temperature-sensitive industries on the development of systems and linkages across the cold chain. For example, use the principal that FlowerWatch uses to monitor the flower industry and duplicate that model to other food commodities using the Global Food Safety Initiative (GFSI) accepted programs. The GFSI is an industry-driven global collaborative platform to advance food safety. See website: <http://www.mygfsi.com>.

Processing

The majority of Kenyan businesses working in processing are SMEs that lack the financial resources to invest in: 1) increased knowledge about how to access markets and 2) the infrastructure and practices required to meet export requirements. While many development agencies offer assistance to complement government support of SMEs, accessing this support is also not widely understood. Access to foreign markets such as the EU is difficult to enter due to trade barriers that cause a decrease of investment in processing on a large scale. Such barriers include tariff escalation due to value addition for agricultural products. Processed products in Kenya attract Value-Added Tax (VAT) which must be paid first and claimed after export through a reimbursement process.

Some foreign markets do have brokers in place to source products from Kenya and East Africa. These sourcing companies have already established standards and regulations along with locally trained individuals in Kenya that follow best practices. Products for the local market though are not held to the same standard because the local market cannot afford the cost of value addition services. The SME processors follow the minimum local government regulations for quality and safety because they lack capacity for global standards and training in HACCP or EU standards. However, processing procedures in Kenya have been gradually elevating to global standards due to export market customers. The larger firms are now following modern handling procedures and compliant to global standards.

Assessment Observations:

Processors observed during the assessment range from the largest to the smallest operations. The facilities varied in types of food, from frozen ready to cook to seafood and to the meat sector. Processors that have entered the ready to cook and eat market in Kenya produce mostly frozen burgers, vegetables, and chapatis (a thin pancake of unleavened whole-grain bread cooked on a griddle for the domestic market). They have shown strong growth in the last few years, with one facility experiencing almost 500% growth in the past two years since they have entered into the ready to cook sector. It is anticipated that this will be the trend for the next several years.


A large seafood processor in Kenya with eight facilities was viewed during the assessment. It follows best practices around the world including HACCP and British Retail Consortium (BRC) standards. Their products ship mostly to the EU but some products go to Australia and Japan, 60% and 40% respectively.

The assessment also included observations of poultry processing, including one of the largest poultry processors in Kenya where it was observed that best practices and HACCP compliance were followed throughout the supply chain. As with the other large

processors, they have refrigerated transportation and state that the only break in the cold chain is the distance between refrigerated transport and the receiving dock or entrances at the retail



Some processing facilities adhere to high quality safety measures.



destination. The smaller processors did not meet the same standards. The walls and construction of the facilities were not up to standard. Best practices were written, but implementation was not present in the facilities. However, in some cases, the processors are not responsible for the final handling of the products; products were transferred to modern facility in Europe, thus mitigating risk for the products being handled.

Outside of the specific processing facilities, additional concerns were addressed. Importation bans on certain commodities has strangled competition; this has had a particularly strong impact on poultry. Price distortion is occurring due to government interference and the existence of monopolies which is reflected by higher prices of certain commodities. Larger purchasers of processed products have the ability to ensure access to better quality so SMEs are not able to enter into markets and provide competition. General practices occur regularly that should be considered unacceptable, not only by authorities but by consumers. Local butcheries hang livestock/poultry in the open air exposing the meat to insects, debris, and people. Tree stumps provide chopping blocks for meat products, creating a situation where meat gets trapped in the creases and wood fragments, facilitating the spread of bacteria.

Recommendations:

- Increase SME capacity and knowledge on export requirements and the process for reaching foreign markets. For example, French beans, from exporters like VegPro and AAA Growers, and flowers, whose supply chains are managed by FlowerWatch, are models for the principals for maintaining cold chain for the export market. However, business services for proper documentation and requirements for entry into foreign markets are crucial along with understanding trade agreement to best maximize the potential of that particular market.
- Elevate local markets to higher standards by promoting best practices and improve capacity in supply chain management and food safety regulations through training.
- Expose SMEs interested in processing products for foreign markets to modern design and build facilities and best practices so they can see firsthand a properly implemented processing facility. This could be done through a trade or a reverse trade mission to a foreign market, including a visit to a proper cold chain facility in a developed market. Also a University-level agricultural program would help position the younger generation to look at agricultural as a viable commercial career.

Transportation

Food products often travel through many intermediaries before reaching consumers, which increases the likelihood of breaks in the cold chain and increases cost. The price of diesel in Kenya is a particular concern. Currently, diesel prices in Kenya are 12 cents more than prices in the United States according to Global Petrol Prices. Travel time between Mombasa and Nairobi is approximately three times the cost of the same distance traveled within the United States. This can cause food products and customers to suffer.



Transportation is often the most challenging link of the cold chain with refrigerated trucks requiring frequent maintenance and spare parts.

Another challenge is lack of access to adequate repair services for the different modes of transportation. Repair services for reefer trailers and refrigeration compressors outside of Nairobi or Mombasa are scarce. Parts have to be imported causing in escalation in the cost of. Keeping inventory of parts is not common because of consumers' low income levels; therefore, parts are ordered when needed, causing a negative impact for every level of the cold chain. In addition, there is limited access to reefer carriers with cooling capabilities that are designed for transportation in small markets.

While examining transportation for bananas in Kenya, the problems are also evident. It was observed that bananas are transported by wheel barrows, motorbikes, oxcarts, small vehicles, or carts (otherwise known as *Mkokoteni*) from the farms and mini bulking sites to bulking sites. The mode of transportation to urban wholesale markets is hired and at times shared by a group of traders due to high costs. The transport is by dry closed trucks or pickups, and is done in the evening when the temperatures are low. At the market end, push carts are used. The assorted modes of transportation do not allow for proper cold storage during transport causing a loss in nutrients and quality.

Assessment Observations:

Refrigerated transport can involve air, ocean, rail, and road. Intermodal transportation such as road and rail are common in most countries, especially for domestic consumption, where air and sea are used for export markets. Therefore, most of this assessment targeted refrigerated transport on roads with additional comments from observations in the Port of Mombasa.

All of the farmers and processors visited provide their own refrigerated transportation. The floriculture industry claims that 100% of the products are transported with refrigeration. However, the horticulture industry believes only 60% of the products are transported with refrigeration. Over the past five years, refrigerated transportation has increased from 40% to the current levels of 100% and 60% respectively.

Within the United States and in developed economies, cold chain thrives as a result of third party logistics (3PLs). These organizations specialize in the esoteric and complex knowledge required for transporting and storing multiple temperature-controlled commodities. Generally, they enable businesses to focus on their core competencies; they remain at the forefront of innovative energy

and cost-saving techniques; and they have access to an existing network of distribution resources. As experts in logistics and distribution, 3PLs can implement checks and balances within the supply chain to assist farmers and processors better meet the demands of foreign and domestic markets. GCCA generally considers the presence of multiple 3PLs to be an indication of a mature and advanced cold chain. The emergence of one is a reflection of progress in a developing country.

In Kenya, 3PLs are nonexistent. Broadly, there is a lack of capacity in the country to handle any refrigerated products combined with poor infrastructure and equipment. As a result, food producers, farmers, and pharmaceutical companies invest vertically into the value chain, creating their own transportation and networks. Although this creates a knowledgeable management team, it is not efficient, and businesses face costs that they could otherwise avoid.

The transport businesses and vendors that do exist are fragmented and could benefit from improved communication that would enable backhauling. One of the most effective ways to reduce transport costs, backhauling simply entails utilizing trucks on both ends of a haul. For example, a reefer truck can be filled with mangos that are destined from farm to market, but if it returns empty, an opportunity to cut costs is missed.


The companies that do invest vertically do so in order to export commodities, mostly to the EU. In these cases, the in-house transportation departments follow time and temperature tracking, utilizing a temperature monitoring and alert system called Temp Tales. HACCP procedures are followed consistently throughout transport and vehicles are properly sanitized. However, when observing SME's who produce for local markets, refrigerated trucks are nearly nonexistent for the vast majority of produce. Understandably, this is attributed to a lack of capital that would be required to make a large investment.

As a result, the main mode of transport for smallholder farmers are carts on which farmers pack large quantities of products in stacked bags. Not only are they lacking refrigeration, but the method of packing prevents air flow which is a no-cost alternative that can at least provide some cooling. Some vendors, approximately 10 – 15%, do have refrigerated trucks. This is a positive development, but the cold chain is still broken and the products still suffer temperature abuse because upon arrival in the market, they are stored and sold in unrefrigerated stalls.



The Port of Mombasa is located approximately 500 kilometers from Nairobi.

In addition, “cess”, which is a tax on the movement of agricultural products, has emerged as another factor that has a negative impact on the transport of agricultural products in Kenya. The rate and application process are arbitrary, depending on discretion and implementation of the local authority. Such a system allows for undue tariffs and illegal fees on producers. The Kenya National Federation of Agricultural Producers previously proposed the government repeal the cess tax.



The assessment provided an opportunity to learn about the Port of Mombasa, and the challenges faced for business shipping cargo for export. The Port of Mombasa has five berths that are used for containerized cargo, but only one x-ray machine. This causes a bottleneck in moving products in and out of Kenya. Customs officials operate at the port, but not during the same hours as the Kenya Port Authority (KPA) which handles the other docks at the port. This scheduling conflict contributes to further cargo delays for x-raying and loading, which add costs in time, fuel, and damage to the equipment. Such costs get passed on to the consumer.

Globally, transport is the most difficult and expensive link in the cold chain. While the situation is no different in Kenya, there have been some improvements. Shipping companies are working with local suppliers of export products to encourage maritime shipment which is less expensive than air shipment. This will reduce costs for companies and consumers if the challenges faced by the Port of Mombasa are addressed. Technology has also advanced. For example, some companies are now using a container that can be removed and still maintain certain gas levels. This is beneficial because certain gases cause ripening, so maintaining the appropriate amount of oxygen in the container can prevent further ripening.

Recommendations:

- Support the development of modern 3PL providers/ fuel saving technologies to reduce costs. 3PLs help maintain checks and balances within the supply chain. Uberize the logistical management to save fuel and time (If possible with traffic conditions).
- Provide training on successful business ownership and operation for profitable distribution and transportation with a particular focus on how to use appropriate technology to increase efficiency.
- Develop more resourceful approaches to transport in order to reduce bottlenecks and costs including the use of backhauling, consolidation and less than truck load management schemes. Another suggestion may be to use a fleet of small trucks could collect produce from small holder farmers across Kenya and then bring the produce to a strategically placed mobile refrigerated reefer that could then move the produce to a processing facility.

Cold Storage

The need for cold storage is apparent in Kenya, but how to profit from it is not as easily ascertained. The majority of production in Kenya relies on smallholder farmers, who produce small quantities throughout the country. There are not many potential investors for a large scale modern cold storage and competition for processing food products in bulk is also currently minimal in Kenya. Cold storage faces multiple challenges including current capacity, connectivity to power and transportation infrastructure.

According to an analysis conducted for cold storage technology in Kenya, only 18% of households in Kenya are connected to the grid (Alexiades, Sanchez, Lekashman, & Muse 2014). The majority of the Kenyan population obtains their energy from biomass, and there is a clear need to expand the energy infrastructure across the country (Kiplagat, Wang, Li, 2011). Backup generators are required in all of East Africa and the cost of diesel is extremely high at 98.50 KSH a liter which is equivalent to 3.75 USD per gallon, while current prices in the United States are

approximately 2.66 USD a gallon. Daily power outages across Kenya can lead to temperature variation and equipment strain that is typically not experienced in a developed country.

Since most areas in Kenya do not have adequate access to power grids, it is difficult to build a facility outside of the main metropolitan zones. This also makes the cost of cold storage expensive for both businesses and consumers. Moreover, the existing power services are not reliable, with daily outages and power surges that can put unwarranted stress on compressors, evaporators and all other systems in operation that run on electricity. The use of backup generators is common to ameliorate the impact of outages. This in turn impacts the repair costs and capital expenditures on new cold storage facilities in Kenya due to access and unpredictability of connectivity in Kenya.

Most storage and ripening facilities of wholesalers are made from corrugated sheet and lack electricity, water, and produce handling infrastructure. Traders rent rooms or stalls that they use for storage, ripening, and display. Cold chain capacity on how best to handle food products and access to human capital that has been exposed to extreme temperature and training in best practices of warehouse management is nonexistence.

Low cost storage options are also becoming available to farmers in Kenya through support from initiatives like USAID's "Feed the Future" and non-governmental organizations. For instance, the CoolBot system (controller, air conditioner, insulated room and electricity) which cost about 2,000-3,000 USD, is less than half that of commercial cold storage units and has already been successfully introduced in Bangladesh and India. The CoolBot itself can cost as little as 150 USD when purchased in partnership, for example, with the Horticulture Collaborative Research Support Program (Hort CRSP) at University of California in Davis. Power generation can come from photovoltaic (PV) solar panels, which are becoming increasingly affordable. This is particularly attractive for rural areas with little connectivity to the power grid.

Assessment Observations:




When vertically integrated, cold storage warehouse operations often do not follow best practices.

As with transport, the cold storage industry would benefit from 3PLs which could provide multi-commodity cold storage facilities. What currently exists are relatively advanced cold stores dedicated to the floriculture industry with some use for horticulture products that are primarily shipped to the EU. While not designed or built using the most advanced technology, these facilities are operated to a higher standard. Beyond this, there are some processors, retailers, and farmers who have cold rooms or cold storage facilities. These are

vertically integrated; that is, they are built and operated to meet their specific business needs and processes.

In some cases, these facilities are relatively advanced. For example, a beef and pork processor with the largest private cold storage warehouse uses individual prefabricated rooms that are



located strategically within the processing facility to maximize efficiency in handling for their business. Similar to transport, such vertical integration in cold storage results in increased costs for investment industry-wide for the temperature controlled products. These inefficiencies limit Kenya's commercial activity in domestic, regional and international markets.

Most of the warehouses that currently exist are established for the export market and are therefore set up for products that will be transported via air freight. The prime example of this is the flower industry in Kenya. The related facilities contain transport racks on the ground and use air pallets to facilitate shipping by planes, which resemble what is known as a cross-dock program. Cross-docking means that inbound products are loaded almost directly into outbound transport vehicles with almost no storage in between. These facilities are set up for export. This means that refrigerated cargo for road freight would be difficult to ship and store in these existing facilities.

From an operational point of view, these facilities are well maintained and follow general best practice standards for exporting such as HACCP, GlobalGap and BRC. Because these facilities are focused on floriculture, Kenya Plant Health Inspectorate Services (KEPHIS) is on site to approve procedures. Facility operators are also members of the FlowerWatch program that helps maintain compliance to EU standards for the floricultural industry. All these factors help to ensure proper temperature monitoring and consistent quality of product is maintained. In addition, all of the facilities observed have backup generators and are trying to find alternative solutions for power consumption to save money and resources.

For domestic consumption, there are smaller firms with cold storage, but they are in need of training on proper cold room operations. For example, many of the smaller facilities visited, did not properly place the thermometer in the cold room for optimal temperature readings. The smaller cold storage facilities are not designed and built in a manner that is favorable for bringing products to the retail level. Buildings are not operated with handling equipment and primarily rely on manual labor. While manual labor is inexpensive relative to equipment, it results in additional product damage due to inconsistent handling that cause breaks in the cold chain. Simple examples are doors are left open causing temperature abuse or boxes are dropped during handling.

Recommendations:

- Identify and implement alternative energy sources for cold storage facilities
LNG gas (LNG is not explained in the report) can help with newer technologies for off the grid power.
- Solar power for farm level and collection level cold storage.
- Improve infrastructure and management for optimal results in the cold chain. Insulated panels rather than concrete are the optimal choice of building material for cold storage.
- Make available low cost technologies for local farmers to provide cold rooms such as Coolbot and solar power. Coolbot technologies provide low cost cooling for horticultural products while solar powered coolers can provide small cold storage for many commodities.



Retail

When examining cold chain in a developing country from a retail perspective, hotels, supermarkets and restaurants are the main sources of information. According to GAIN (2012), typical Kenyan food retailers rely on local importers to meet their needs. Kenyan importers will likely continue increasing imports to meet growing consumer demand, however local production of consumer-ready food products will also increase. Most such retailers have cooler and cold rooms such as refrigerators and freezers for storage of food products, but lack the proper processing and handling techniques for preparing and cooking food


Specifically looking at the fruits and vegetables supply chain, USAID (2013) developed a report that stated the most significant constraints faced by retailers were lack of cold storage in marketplaces, poor infrastructure, and seasonality of supply as well as price fluctuations and volatility. This means that even if retailers have their own infrastructure in place, locally sourced products are already damaged from inadequate postharvest, processing, transport and storage practices. The cold chain is not a panacea for food loss. While it can prevent further deterioration, it cannot fix damaged products. This is commercial loss for Kenya.

Most fresh fruit and vegetables in markets are displayed under ambient conditions, which expose them to high temperatures. This causes the softening and shriveling of fruits and vegetables making the produce unmarketable. However, the middle class in East and Southern Africa is rising, which means that retail sales, especially for supermarkets (as opposed to local markets), are expected to grow. The growth of supermarkets is important as they will demand and require high quality produce. This demand is critical to the installation and use of temperature controlled systems. According to the FAO Assessment on Food Losses (2014), this growth in supermarkets will reduce the costs associated with the processing and wholesale sectors and help reduce food safety problems as well as food loss.

Multinational quick service restaurants (QSRs) have committed to expanding operations throughout the African continent because it is viewed as the “new frontier.” QSRs are competing with local franchises such as Galito’s, Chicken Inn, and Pizza Inn and making great headway. The fast food behemoth Yum Brands has opened multiple Kentucky Fried Chicken (KFCs) franchises in Kenya. The Subway sandwich chain is planning to open 20 stores in Kenya over the next six years, while Domino’s Pizza Inc. plans to open more than two dozen outlets in Egypt, Morocco, Kenya, and South Africa. QSR growth has proven to be a key driver for cold chain industry growth in many emerging markets. The growth of QSRs throughout many of Africa’s larger economies is a clear sign for future demand for 3PL services as retailers look to maximize profits and reduce costs.

Assessment Observations:

The medium to large supermarkets, hotels, and restaurants follow good cold chain practices within their establishments. They have programs in place to verify the safety of the food ranging from temperature checks to sanitation schedules, which all fall under HACCP management program. One of the retail companies observed is in the process of implementing food safety standard ISO 22000 as a program which best fits that particular industry. The company also has blast chillers and cold rooms to provide storage for frozen and chilled products. They currently operate 43 restaurant outlets in Kenya and Uganda. Other retail companies have very efficient



measures in place to secure products that are sold to the customers. Staff observed at one hotel were professionally trained and understood how to maintain the cold chain. This same hotel sources fruits and vegetables locally from farmers, but implements quality control measures in-house to ensure food safety.

One QSR franchisee stated that they have opened eight stores in the past two years and the demand is outpacing the ability to build. However, they are facing problems tied to the cost of importing food products, including a 75% taxes on rice and a 30% tax on other food items. It was indicated that everything in the restaurant is 30% higher than what prices in the United States would be because of duties on food. This QSR is not able to use local potatoes for fries because they are the wrong kind, but other restaurants are not having issues with Kenyan produce. In some cases, sourcing depends on the corporate quality control requirements that the franchise must follow, which prevent the use of substandard produce.

Companies in the retail sector also stated that higher prices exist because of a lack of processors that handle beef, chicken and pork. The meat industries also suffer from importation bans and monopolies, which in turn increases the price. This causes the market size to decrease as consumers cannot afford to purchase these products. This issue is of concern, but it must be addressed with caution as the importation of livestock from other countries could devastate the local economy, precluding the development of value-added processing and other services. Some allowance must be made to ensure the development of competitive sectors at each link in the cold chain.

Outside of the more advanced supermarkets, restaurants, and hotels, the retail sector needs improvement. For example, chilled display cases are broken down and freezers are old and not working properly. Doors are left open by patrons and employees do not understand the cost associated with the excess energy being used, food wastage due to leaving a cold display case open. The lower end markets represent 80% of Kenya and pose a significant need for basic food safety principles to be taught at the grass root level.

Recommendations:

- Engage in industry-led advocacy to understand the logic of high import duties on food. Franchise owners stated that there is a 30% tariffs on imported food commodities with no understanding for reasons for these measures. These tariffs drive up prices for the local consumer.
- Provide education for proper handling of cold chain commodities and sanitation guidelines for SMEs. It would help to ensure that local shops and small retail outlets understand that cooling units must remain on or food spoilage will rise and cause sickness. Sanitation issues lead to disease and infection.
- Support initiating the Global Food Safety Initiative (GFSI) in Kenya to train vendors. The largest retail supermarkets in the world have initiated the GFSI in 2007 to establish a global standard for food safety and handling practices. Retail within Kenya should demand their product to be certified through these programs. <http://www.mygfsi.com>.



Final Observations & Conclusion


Most literature cites challenges involved with agriculture and reducing postharvest loss, which yields the conclusion that cold chain is needed. In other words, it is often presented as the solution in and of itself, but there is much less research on the how. With a growing middle class in Kenya, greater attention on supply chains and productivity of products, as well as public investment in development of cold chains and logistics for fresh produce will be required. The assessment was able to fill these gaps by focusing on critical areas revealed by existing literature and articles.

One glaring issue is that most of the stakeholders involved in the cold chain do not take ownership of the entire cold supply chain. In developed markets the retail sector oversees the food safety programs that each link in the cold chain follows in order for the products to be allowed in the retail space. However, this is not the case in Kenya. Processors take the role of maintaining food safety controls that verify if best practices have been followed. With limited refrigerated transportation and by visiting local supermarkets, the products have clearly been through a broken cold chain. As examples: snow builds up on freezing units, which indicates hot products were placed in freezers; frost builds up on commodities suggesting that thawing took place to some degree then refreezing; or display cases are dripping with water due to open doors and no gases in the system. These results are found at every level of retailers in Kenya.

Based on observations, the break is more than likely in the transportation and warehousing link of the cold chain. This is due to the hours of transportation on rough terrain which causes harm to the products in some manner, either temperature or physical damage. Investment in road infrastructure is needed for food safety and decreasing travel time. Information sharing is also not a reality in Kenya. The information along the entire supply chain needs to be dispersed to each link, which is not easily executed in Africa. Power outages and limited access to computers in rural areas make it difficult to communicate. However, text messaging has become the easiest way to disseminate information in Kenya.

There is a general lack of knowledge and capacity around the cold chain industry in Kenya. Public information related to food safety is necessary to educate Kenyans about the role of proper refrigeration and its impact on nutrition and quality. This will play an important role in providing quality food for the households. The absence of knowledge and capacity is combined with an educational approach that focuses on academics and less on technical or vocational skills. Any companies seeking to invest in Kenya should anticipate that a high level of training will need to be provided for workers. This assessment revealed the needs for training in business management for cold chain facilities, postharvest handling techniques, best practices for food safety and handling, accessing foreign markets, improved processing, supply chain logistics operations, and cold storage design and operations. It addressed infrastructure needs and alternative methods for developing the cold chain. Addressing these areas will enable an increase in the development of human capital.

Kenya is already looking into the future and how to escalate human capital with their Vision 2030, and this assessment revealed that the country is on track to achieving a modern cold chain. However, there is still a lot of work to do in training and implementation of proper cold chain



infrastructure. Demand by the younger generation in Kenya for quality products is increasing, which will put pressure on key stakeholders to develop a modern cold chain. Because it is becoming a necessity in developing markets, investment in infrastructure and an increase in the quantity of products being produced should encourage higher standards.

That is to say, the development of a viable, advanced cold chain will take time via the gradual growth of business by mainly small entrepreneurs, just like in the United States. Currently, an investor's best chance at a profitable business within the Kenyan market is in partnership with a local broker who has the connections to wealthy markets that serve the consumers that are willing and able to pay for cold chain. Investing in the development of a local business and demonstrating its profitability can set an example for the others, creating a more attractive playing field for future foreign capital, and proving the market's ability to support the investment. Once local food distributors start building and operating successful cold storage facilities, Kenya will be attractive to the foreign investor.

References

- Alexiades, A., Sánchez, J.I., Lekashman, K. & Muse, W. (2014). Cost and commercialization Analysis for Cold Storage Technology in Kenya. *UC Davies*.
- Alila, P. O., & Atieno, R. (2006). Agricultural Policy in Kenya: Issues and Processes. *Future Agricultures*. Retrieved from http://r4d.dfid.gov.uk/PDF/Outputs/Futureagriculture/Ag_policy_Kenya.pdf
- CESS. (n.d.). *The Business Advocacy Fund*. Retrieved from <http://www.businessadvocacy.org/issue009a.html>
- Electricity cost in Kenya. (2015). [Electricity cost calculator tool and tables]. Retrieved from <https://stima.regulusweb.com/>
- Euromonitor International (2014). Frozen Processed Food in Kenya [Abstract]. Retrieved from <http://www.euromonitor.com/frozen-processed-food-in-kenya/report>
- FAOStat. (2011). [Top import data and graphs on Kenya]. Retrieved from <http://faostat.fao.org/desktopdefault.aspx?pageid=342&lang=en&country=114>
- Food and Agriculture Organization of the United Nations (FAO). (2014). *Case Studies in Small-scale Agriculture and Fisheries Subsectors, Food Loss Assessments: Causes and Solutions*. Rome, IT. Retrieved from http://www.fao.org/fileadmin/user_upload/save-food/PDF/Kenya_Food_Loss_Studies.pdf
- Global Petrol Prices. (2015). [Kenyan diesel price data and graphs]. Retrieved from http://www.globalpetrolprices.com/Kenya/diesel_prices/
- Homer, Karen. (2014, March 27). Ice-Cold Innovation to Reduce Postharvest Losses. *Feed the Future*. Retrieved from <http://www.feedthefuture.gov/article/ice-cold-innovation-reduce-postharvest-losses>
- Horticulture. (n.d.). Export Promotion Council. Retrieved from http://epckkenya.org/index.php?option=com_content&task=view&id=68&Itemid=79
- KenInvest. (2015). *About KenInvest: The Organization*. Retrieved from <http://www.investmentkenya.com/about-keninvest/the-organization>
- Kenya Bureau of Standards. (2014). *About KEBS*. Retrieved from <http://www.kebs.org/index.php?opt=aboutkebs>
- Kiplagat, J., Wang, R. & Li, T. (2011). Renewable energy in Kenya: Resource potential and status of exploitation. *Renewable and Sustainable Energy Reviews* 15, 2960-2973.
- Koigi, Bob. (2014, November 25). Kenya loses the bulk of its food yields to poor logistics. *Business Daily*. Retrieved from <http://www.businessdailyafrica.com/Kenya-loses-the-bulk-of-its-food-yields-to-poor-logistics/-/1248928/2534938/-/item/0/-/3i4wl3z/-/index.html>

- Manson, Katrina. (2013, November 25). From snacks to houses, consumers lead Kenya's growth story. *The Financial Times*. Retrieved from <http://www.ft.com/cms/s/0/6a168d64-5049-11e3-9f0d-00144feabdc0.html#axzz3hqxjSNiM>
- Mbuthia, Edwin. (2015, May 1). Kenya's statutory minimum wage raised 12 per cent. *Business Daily*. Retrieved from <http://www.businessdailyafrica.com/Kenya-raises-minimum-wage-12-per-cent/-/539546/2703210/-/1450yhh/-/index.html>
- Oloo, Jasper. (2010). Food Safety and Quality Management in Kenya: An Overview of the Roles Played by Various Stakeholders. *AJFAND Online*, 10(11). Retrieved from <http://www.ajol.info/index.php/ajfand/article/view/64283/52077>
- Rural poverty in Kenya. (n.d.). IFAD. Retrieved from <http://www.ruralpovertyportal.org/country/home/tags/kenya>
- The Nielsen Company. (2011). *Nielsen Emerging Market Insights Country Snapshot: Kenya*. Nairobi, KE. Retrieved from <http://www.nielsen.com/content/dam/nielsen-global/ssa/docs/nielsen-emi-kenya-snapshot.pdf>
- The Office of the United States Trade Representative (USTR). (2012). *The 2012 National Trade Estimate Report on Foreign Trade Barriers*. Washington, DC. Retrieved from https://ustr.gov/sites/default/files/NTE%20Final%20Printed_0.pdf
- The Postharvest Education Foundation (PEF). (2013). *Use of cold chains for reducing food losses in developing countries* (PEF White Paper No. 13-03.). La Pine, OR: Lisa Kitinoja.
- The Republic of Kenya. (2013). *Laws of Kenya: Agriculture, Fisheries and Food Authority Act* (No. 13 of 2013). Nairobi, KE: National Council for Law Reporting. Retrieved from [file:///C:/Users/abrondy/Downloads/Agriculture%20Fisheries%20and%20Food%20Auth ority%20Act%20No.%2013%20of%202013%20\(1\).pdf](file:///C:/Users/abrondy/Downloads/Agriculture%20Fisheries%20and%20Food%20Authority%20Act%20No.%2013%20of%202013%20(1).pdf)
- The World Bank. (2015). [Economic indicator data and graphs on Kenya]. Retrieved from <http://data.worldbank.org/country/kenya>
- Ulandssekretariatet LO/FTF Council. (2014). *Kenya Labour Market Profile 2014*. Danish Trade Union, Council for International Development Cooperation. Copenhagen, DK. Retrieved from http://www.ulandssekretariatet.dk/sites/default/files/uploads/public/PDF/LMP/Imp_kenya_2014_final_version.pdf
- University of Nottingham. (n.d.). Cold Chain Opportunity Assessments. Retrieved from <http://naturalleader.com/wp-content/themes/natlead/images/CRC3656-ColdChainOpp.pdf>
- USAID. (2013). The fresh fruit and vegetable markets of East Africa: *An assessment of regional value chain actors, activities and constraints in Kenya, Tanzania and Uganda*. Retrieved from http://d3n8a8pro7vnmx.cloudfront.net/eatradehub/pages/83/attachments/original/1378732967/FFV_Markets_of_East_Africa_final_approved_and_compressed_July_17_2013.pdf?1378732967

- 
- USAID. (2014). *Workforce Connections: Kenya Youth Assessment*. Washington, DC. Retrieved from https://d3n8a8pro7vhm.cloudfront.net/fhi360/pages/348/attachments/original/1427227963/Kenya_Youth_Assessment_Final_Report.pdf?1427227963
- USDA Foreign Agricultural Service. (2009). *Kenya Food and Agricultural Import Regulations and Standards – Narrative: FAIRS Country Report*. Global Agricultural Information Network (GAIN): Mary Onsongo. Retrieved from http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Food%20and%20Agricultural%20Import%20Regulations%20and%20Standards%20-%20Narrative_Nairobi_Kenya_10-15-2009.pdf
- USDA Foreign Agricultural Service. (2012). *Kenya Retail Foods: 2012 Kenya's Retail Food Sector Report*. Global Agricultural Information Network (GAIN): Carol N. Kamau. Retrieved from http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Retail%20Foods_Nairobi_Kenya_11-8-2012.pdf
- U.S. Department of Commerce. (2015). *2015 Top Markets Report Cold Chain: A Market Assessment Tool for U.S. Exporters*. Washington, DC: International Trade Administration, Industry & Analysis (I&A).
- U.S. Department of State. (2013). *2013 Investment Climate Statement – Kenya*. Bureau of Economic and Business Affairs. Retrieved from <http://m.state.gov/md204669.htm>
- Van Der Lans, C., Snoek, H., de Boer, F. & Elings, A. (2012). Vegetable Chains in Kenya: Production and consumption of vegetable in the Nairobi metropolis. *Wageningen UR*. Retrieved from <http://edepot.wur.nl/216710>



Attachment I: Cold Chain Logistics Recommendations

Postharvest Handling

1. Procure cold chain technologies at the farm level and train workers and operators to raise productivity and reduce postharvest loss. See Attachment 2: Appropriate Post Harvest Technology for Africa: 8 Simple Tools and Techniques. The recommended storage at proper temperature would help guarantee the longest shelf life possible while maintaining the taste and quality of the product.
2. Work with local associations, development agencies, and community based programs to help farmers understand best practices and utilize industry best practices within Kenya. Include stakeholders along the supply chain including retail associations, Kenya Agricultural and Agribusiness Association, Horticulture and Flower Council, among others, as well as development partners such as USAID.
3. Use the floriculture industry in Kenya as an example to guide other temperature-sensitive industries on the development of systems and linkages across the cold chain. For example, use the principal that FlowerWatch uses to monitor the flower industry and duplicate that model to other food commodities using the Global Food Safety Initiative (GFSI) accepted programs. The GFSI is an industry-driven global collaborative platform to advance food safety. See website: <http://www.mygfsi.com>.

Processing

4. Increase SME capacity and knowledge on export requirements and the process for reaching foreign markets. For example, French beans, from exporters like VegPro and AAA Growers, and flowers, whose supply chains are managed by FlowerWatch, are models for the principals for maintaining cold chain for the export market. However, business services for proper documentation and requirements for entry into foreign markets are crucial along with understanding trade agreement to best maximize the potential of that particular market.
5. Elevate local markets to higher standards by promoting best practices and improve capacity in supply chain management and food safety regulations through training.
6. Expose SMEs interested in processing products for foreign markets to modern design and build facilities and best practices so they can see firsthand a properly implemented processing facility. This could be done through a trade or a reverse trade mission to a foreign market, including a visit to a proper cold chain facility in a developed market. Also a University-level agricultural program would help position the younger generation to look at agricultural as a viable commercial career.



Transportation

7. Support the development of modern 3PL providers/ fuel saving technologies to reduce costs. 3PLs help maintains checks and balances within the supply chain. Uberize the logistical management to save fuel and time (If possible with traffic conditions).
8. Provide train on successful business ownership and operation for profitable distribution and transportation with a particular focus on how to use appropriate technology to increase efficiency.
9. Develop more resourceful approaches to transport in order to reduce bottlenecking and costs including the use of backhauling, consolidation and less than truck load management schemes. Another suggestion may be to use a fleet of small trucks could collect produce from small holder farmers across Kenya and then bring the produce to a strategically placed mobile refrigerated reefer that could then move the produce to a processing facility.

Cold Storage

10. Identify and implement alternative energy sources for cold storage facilities
LNG gas (LNG is not explained in the report) can help with newer technologies for off the grid power. Solar power for farm level and collection level cold storage.
11. Improve infrastructure and management for optimal results in the cold chain. Insulated panels rather than concrete are the optimal choice of building material for cold storage.
12. Make available low cost technologies for local farmers to provide cold rooms. Coolbot technologies provide low cost cooling for horticultural products. Solar power cooler can provide small cold storage for many commodities.

Retail

13. Engage in industry-led advocacy to understand the logic of high import duties on food. Franchise owners stated that there is a 30% tariffs on imported food commodities with no understanding for reasons for these measures. These tariffs drive up prices for the local consumer.
14. Provide education for proper handling of cold chain commodities and sanitation guidelines for SMEs. It would help to ensure that local shops and small retail outlets understand that cooling units must remain on or food spoilage will rise and cause sickness. Sanitation issues lead to disease and infection.
15. Support initiating the Global Food Safety Initiative (GFSI) in Kenya to train vendors. The largest retail supermarkets in the world have initiated the GFSI in 2007 to establish a global standard for food safety and handling practices. Retail within Kenya should demand their product to be certified through these programs. See website: <http://www.mygfsi.com/>.

Appropriate Postharvest Technology for Africa: 8 simple tools and techniques

Corey Rosenbusch, Lisa Kitinoja and Richard E. Tracy

Global Cold Chain Alliance (GCCA) and World Food Logistics Organization (WFLO)

This project proposal has three objectives:


- 1) To extend the marketing period and improve market value and consumer access to nutritious, healthful and safe fresh fruits and vegetables in sub-Saharan Africa.
- 2) To dramatically reduce damage and waste of fresh fruits and vegetables by providing access to simple pre-requisite and enabling technologies from farm to market in sub-Saharan Africa.
- 3) To add value and significantly extend fruit and vegetable shelf-life by providing produce handlers with information and plans for building inexpensive low-tech solar drying technologies and promoting proper packaging of dried products in sub-Saharan Africa.

Background

Staple foods such as grains and root crops form the basis of most sub-Saharan Africans' diet, while horticultural crops are an important source of plant nutrients, vitamins and minerals that are essential for human health and well being, particularly for children and pregnant and nursing women. Field studies have shown that 40 to 50% of horticultural crops produced in Africa are lost before they can be consumed, mainly due to high rates of bruising, water loss and subsequent decay during postharvest handling. The postharvest chain includes all the steps between harvesting and consumption, including sorting, cleaning, packing, storage, transport and processing.

All this waste makes the lives of farmers very difficult, as they often receive low prices for their foods, since marketing intermediaries know that the foods they handle will lose a lot of value before they can be sold to consumers. Most small farmers use a price taker marketing strategy whereby they grow a commodity and offer it for sale to the highest wholesale bidder in the marketplace. This marketing strategy usually means that farmers receive low prices because when they have product for sale, so does every other farmer and there is a glut of particular produce commodities in the marketplace. Implementing simple postharvest technologies can help small farmers store product and enable them to potentially get better prices by selling during off peak production times. Use of postharvest technologies to reduce fruit and vegetable losses enhances farming sustainability by reducing demands on natural resources (water, fertilizers and labor) used to grow horticultural crops. Last but not least, most of Africa's farmers are women. When women are assisted to earn more money by the crops they produce, they tend to invest in their families (providing more food, preventative health care and education for their children).

Historically, production agriculture (increasing yields or growing new crops) has received the majority of attention in development efforts in sub-Saharan Africa. While this aspect of



agriculture is important, much of these investments are largely wasted when a crop is lost during postharvest handling before it can be eaten or sold. Therefore more emphasis is needed on improving postharvest handling practices to improve the health and welfare of persons living in sub-Saharan Africa.

Postharvest Technology

Assuring the quality, safety and marketability of fresh fruits and vegetables requires that everyone involved in the postharvest handling chain handle product appropriately. There is no one technology that can substitute for proper postharvest handling all along the distribution chain, as quality is the result of doing each handling step correctly. The quality of fresh fruits and vegetables are at their peak immediately after harvest and no postharvest technology can enhance produce quality but only serve to slow quality deterioration and postharvest losses.

There are two strategies that may be used to slow fruit and vegetable quality losses and extend postharvest life:

- 1) slow the biological ripening and deterioration process and/or
- 2) substantially transform fresh fruits and vegetables by food processing technologies (e.g. drying, canning or freezing).

Control of biological ripening and deterioration of fresh fruits and vegetables usually relies upon cold temperatures and reducing the production and action of the plant ripening hormone ethylene. There is no substitute for the use of cold temperatures and gentle handling to reduce postharvest losses of fresh fruits and vegetables and these handling technologies must be considered pre-requisites to use of any shelf-life extending technologies.

Described below are two novel technologies; one that slows biological ripening and deterioration and one that relies upon substantial transformation of fruits and vegetables by indirect solar drying to significantly enhance their postharvest life. In addition, six simple pre-requisite technologies that provide for gentle postharvest handling and temperature control are listed and described in this proposal.

Technology 1: SmartFresh® - delayed ripening and spoilage technology

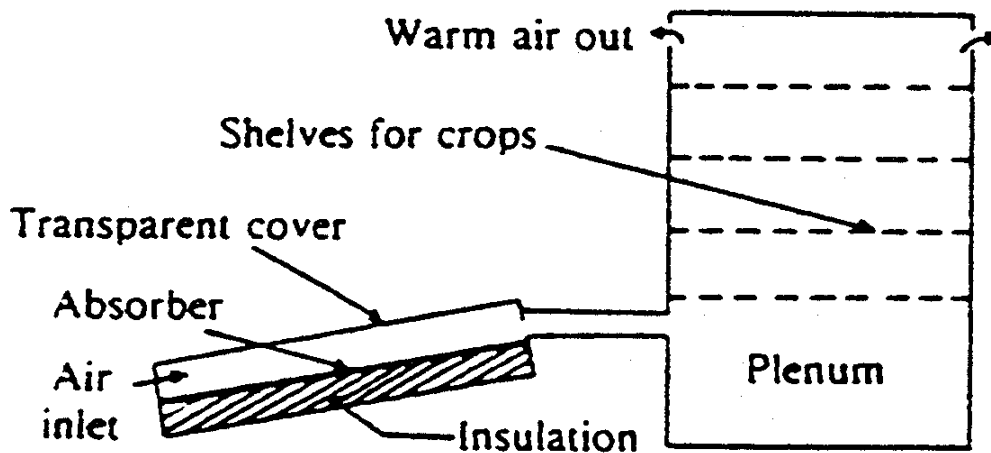
Fruit and vegetable ripening, programmed cell aging/death and ultimately spoilage losses are triggered by the plant hormone ethylene, which is synthesized by all fresh fruits and vegetables. After control of temperature, control of ethylene biosynthesis and action is the most important means of extending the postharvest shelf-life of fresh fruits and vegetables. Recently, a chemical compound 1-MethylCycloPropene (1-MCP), which is commercially marketed as SmartFresh®, has begun to be used extensively to extend the postharvest shelf-life of fresh fruit and fruit-vegetables. SmartFresh® is applied at the parts-per-million or parts-per-billion level to fresh fruits and vegetables postharvest, either as a gas (generated onsite by mixing tablets with water) or via an aqueous solution to block the action and production of the plant ripening hormone ethylene. The compound is extremely safe, environmentally friendly and highly effective at extending the postharvest shelf-life of many fresh fruit and fruit-vegetables. The majority of apples available today in the North American marketplace are commercially treated with SmartFresh®. SmartFresh® could be used to effectively extend the shelf-life of fresh fruits and vegetables in developing regions particularly if used in combination with pre-requisite

postharvest best practices such as use of appropriate field packing, packaging materials and cooling technologies.

The major hurdles to implementing adoption of this technology in sub-Saharan Africa are:


- A determination of what African crops and stage of development whereby SmartFresh® technology could be used to successfully extend product shelf-life and hence reduce postharvest losses.
- Overcoming regulatory registration hurdles for use of this compound on food products in Africa, as there is little financial incentive for AgroFresh (a subsidiary of the Rohm and Haas Company) to register this product in developing economies.

In preliminary discussions with AgroFresh they have indicated that they would potentially be willing to assist in providing technical assistance to identify promising SmartFresh® applications for fruit and vegetable crops grown in sub-Saharan Africa and provide the compound free of charge for use in sub-Saharan Africa. While not a substitute for proper postharvest handling and cooling, this new technology could play a significant role in reducing postharvest losses and enhancing the sustainability of horticultural production in sub-Saharan Africa, if used in combination with pre-requisite postharvest best practices.



Technology 2: Improved solar drying

Drying technologies to preserve fresh fruits and vegetables by reducing the products' water activity (i.e., moisture available to support the growth of spoilage microorganisms) have been used for millennium. However, use of direct solar drying can result in quality problems and damage when produce overheats, gets wet or is contaminated by insects or other common pests. Indirect solar driers are constructed so the sun shines upon a solar collector (a shallow box, the insides painted black, topped with clear plastic or a pane of glass), which heats air which then moves into the drier and upward through a stack of four to six trays loaded with produce. The indirect nature of the improved drying process illustrated below is less likely to cause problems



due to overheating, and protects the produce from dust, insects and unexpected rain. There are many such units in use around the world, but most are poorly designed and result in new problems due to their size (too large or too small), interior design (poor air flow, high static pressures), cheap materials (plastic sheeting breaks down and quickly becomes opaque) and lack of temperature control (too slow drying can allow fungi to attack exposed surfaces). This project proposes to modify existing indirect solar drier designs and provide one uniform, efficient, low cost design that is sturdy and appropriate for Africa.

Dried horticultural crops, grains and legumes and related food products must be packaged and stored properly in order to achieve their potential shelf life of up to one year. Dried products must be packaged in air-tight containers (glass or plastic bottles or sealed plastic bags). Postharvest handling, transport and marketing of processed products can be much simpler and less costly than for fresh products, since refrigeration is unnecessary. Dried products take up much less space than their fresh equivalents, further reducing transport and storage costs.

Pre-requisite Postharvest Technologies

There are 6 simple pre-requisite postharvest technologies that should be adopted before technologies such as SmartFresh® or improved solar drying are implemented. If adopted in Africa, these pre-requisite postharvest technologies in-and-of themselves would have an enormous impact on peoples' earnings, nutrition and health.

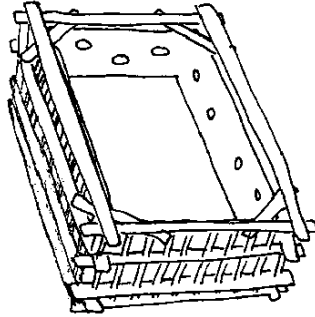
- 1) Improved containers
- 2) Field packing
- 3) Shade from farm to market
- 4) Evaporative forced air pre-cooling
- 5) Low energy cold storage
- 6) Small-scale cold transport

Pre-Requisite Technology 1: Improved containers

The containers typically in use for handling horticultural crops in Africa are baskets, sacks and wooden crates. All of these are a source of damage due to the roughness of the materials, are often over-filled and when stacked provide little protection to produce. Improved containers for the purpose of this proposal include:

- Fiberboard liners for locally made crates, if these are in existence in the locale
- High quality plastic crates, with proper venting, which are stackable, nest-able, easy to clean and reusable

UC PTRIC and WFLO engineers would need to take a look at local containers in use, then design a liner that would suit any locally made crates. Liners would cost very little and provide protection from abrasions and cuts. This practice has been successfully implemented in Egypt and Morocco.



Liner in Palm rib crate (Egypt)



Liner in Wooden crate (Morocco)

Plastic crates are proposed to be promoted as the ultimate long term solution for reducing damage and waste of horticultural crops. Plastic crates can be cleaned and sanitized easily, thereby reducing the chances that the postharvest diseases that cause decay or the pathogenic organisms that cause food borne illness will be passed along the marketing chain. Various states in India have implemented subsidy programs to assist growers and handlers to purchase their own crates while others have attempted business owned systems where users rent or leave a deposit on the crate whenever they need to use one. PepsiCo uses this type of system worldwide for their beverages, and CHEP Int'l uses this system for international RPCs for marketing fresh produce.

The UN has already done some work in designing plastic crates that can be stacked when oriented in one direction, while nesting if turned 180 degrees. This type of design reduces the cost of transporting empty crates because you can stack 5 or 6 empty crates in the space of one full crate. This project proposes to identify an existing container with appropriate design characteristics or to design a new container that will be universally acceptable, that can be readily manufactured at a reasonable price and be extended to all areas of Africa.



Example plastic crate

Pre-Requisite Technology 2: Field packing

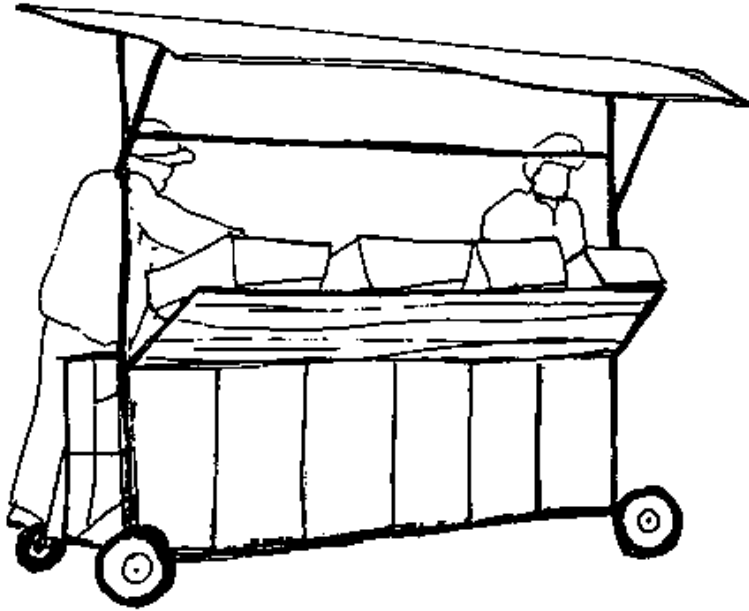
Field packing can often eliminate the need for a packinghouse, and can greatly improve the speed of postharvest handling, while reducing costs and waste. Workers typically utilize simple hand carts designed with one wheel in front, and they can push this cart before them in the field as they gather fruit or vegetables at harvest time. Workers must be well trained in how to identify the proper maturity and quality of the produce they are harvesting, and can pack it immediately into cartons or plastic crates. If the cart is designed to hold two crates, the worker can also sort while he or she is harvesting and field pack two quality grades during one pass.

Pre-Requisite Technology 3: Shade from farm to market

Shade can greatly reduce the temperature of any produce that is being handled outdoors. Deep shade can be provided by permanent structures or by adding overhangs or awning to existing buildings, or can be provided with lower cost, more portable means. Market umbrellas are one option, and using marketing booths or tents to shade assembly points, packing operations or retail marketing is another. During transport, loads should be covered with light colored tarpaulins that reflect heat and help prevent contamination from dust, birds and debris.



Larger sized mobile carts have been used in California for field packing grapes and vegetables. The initial cost is higher, but several workers can use the same work station, then move the cart by pushing it along the edge of the field to the next section of the field whenever they are ready to harvest and pack more crops. This technology has the added benefit of providing shade over the working area.



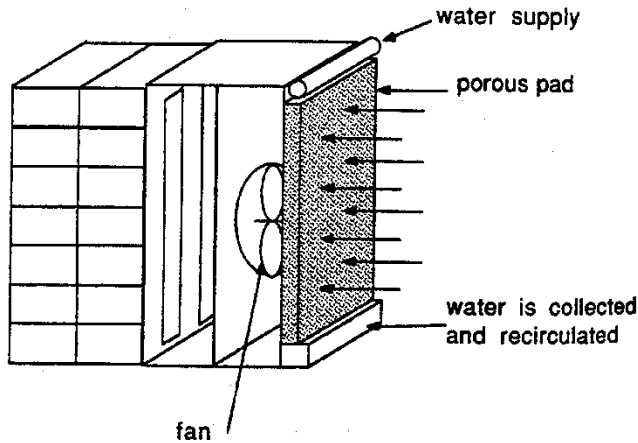
Pre-Requisite Technology 4: Evaporative forced air pre-cooling

Pre-cooling is used to remove field heat and reduce the temperature of fresh produce before it is shipped or placed into storage. Each type of produce has a different recommended "lowest safe temperature" – for example for optimum shelf life vegetables such as cabbage and carrots should be stored at or near 32 F, while tomatoes and peppers should be stored at 55 F or above. In Africa it is relatively unusual to find cold storages operating at 32 F, and the cost of cooling most horticultural crops to their lowest safe temperature may not be economically feasible if the planned marketing period is short.

However, it is often possible to decrease the gap between the ambient temperature and the recommended temperature for most crops by utilizing low cost approaches to pre-cooling. Evaporative coolers are best suited to lower humidity regions, since the degree of cooling is limited to 1 to 2 C (2 to 4 F) above the wet-bulb temperature. A cooling pad of wood fiber or straw is moistened and air is pulled through the pad using a small fan.

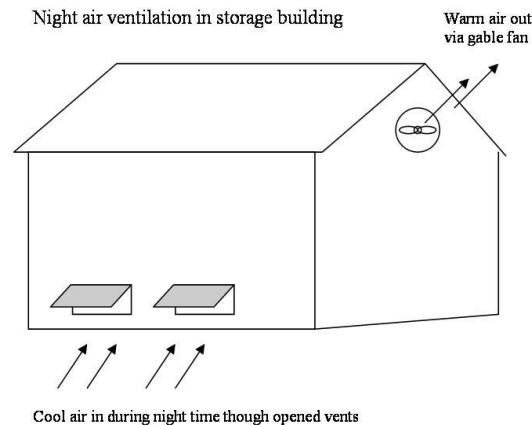
An evaporative cooler can be combined with a forced air (FA) cooler for quick cooling of small lots of produce. Air is cooled by passing through the wet pad before it passes through the packages and around the produce. The air can be cooled to within a few degrees of the wet bulb temperature of ambient air. In the example shown here, 0.5 gallon of water per minute is dripped onto an 8 square foot pad, providing enough moist air to cool up to 14 crates of produce in 1 to 2 hours. Water is collected in a tray at the base of the unit and re-circulated.

For application in rural Africa, this simple technology can be further modified to utilize solar power or a 12 volt battery to run the fan and water pump. In the cut-away view shown below, air is pulled through the wet pad and provides a source of cool moist air that then is forced through the crates of produce stacked on the other side of the plenum box. Each unit is one module, and as more cooling capacity is needed, the grower or marketer would add another FA unit.



Pre-Requisite Technology 5: Low energy cold storage

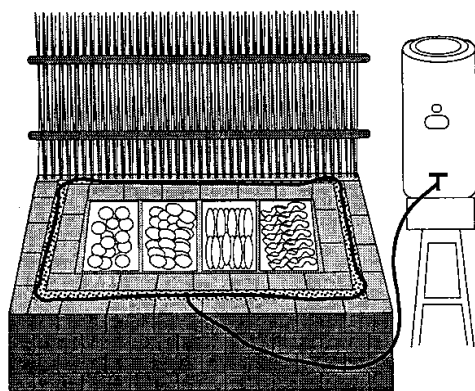
Refrigerated storage structures are relatively expensive to build and operate, and most small famers do not have access to these facilities. There are a few low energy methods that can be used to help reduce the temperature in storage and keep produce in better condition for a longer period of time than typically encountered in Africa. Storage structures can be cooled by ventilating at night when outside air is cool. Cooler air can often be found during the night-time in the dry season, or at higher altitudes. For best results, air vents should be located at the base of the storage structure. An exhaust fan located at the top of the structure pulls the cool air through the storeroom. Vents should be closed at sunrise, and remain closed during the heat of the day.



The low cost cooling chamber illustrated below is constructed from locally made bricks in India. The cavity between the walls is filled with sand and the bricks and sand are kept saturated with water. Fruits and vegetables are loaded inside, and the entire chamber is covered with a rush mat,

which is also kept moist. During the hot summer months in India, this chamber is reported to maintain an inside temperature between 15 and 18 °C (59 and 65 °F) and a relative humidity of about 95%.

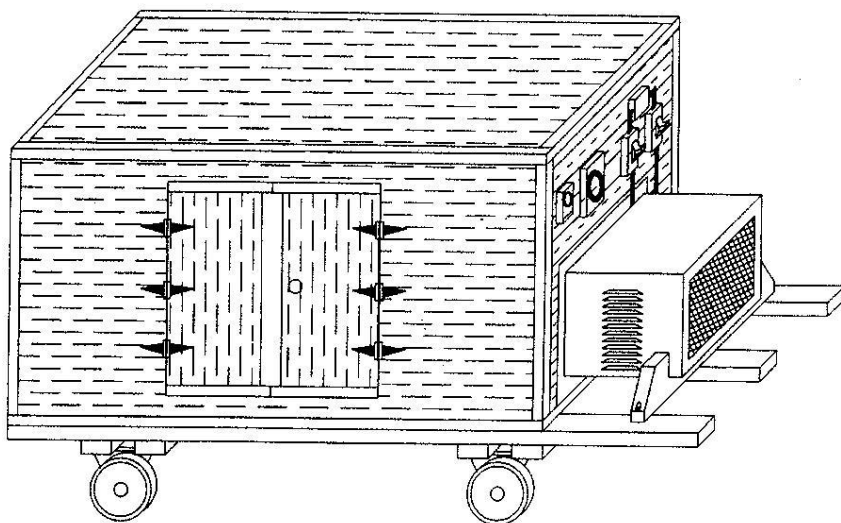
The developers of this technology called it an "Improved Zero-Energy Cool Chamber" because it uses no external energy. A larger version of this chamber was constructed in the design of a small round cold room, and needs only the addition of a small water pump and a ventilation fan at the roof line (similar to the attic fans used in US homes). Since a relatively large amount of materials are required to construct these cold storage chambers, they may be most practical when handling high value products.



Source: Roy S.K. 1989. Postharvest technology of vegetable crops in India. Indian Horticulture. Jan-June: 7678.

Pre-Requisite Technology 6: Small-scale cold transport

The small portable cooling unit illustrated below uses a 12,000 BTU/hr (1 ton) 110 volt room window air conditioner to cool air inside an insulated box. The cool air inside the front of the box is forced through the produce by a pressure fan in a second wall inside. The return air passes under a false floor to the front of the box.



The "Porta-cooler", as it was named, was built by a cooperating team at USDA, Beltsville, Maryland, to cool highly perishable berries and other air cooled produce. The approximate cost



in 2002 was \$US 1200, but the cost can be considerably lower if it is built locally in Africa using local materials and a used air conditioning unit. Complete plans and a materials list are available on the internet on the ATTRA website (<http://www.attra.ncat.org>).

More recent versions of this technology have been made to fit on flatbed trailers or wagons, in pick-up truck beds and as a trailer unit that can be pulled behind a horse, oxen or by a small tractor. The cooled box can be loaded with produce at the field and transported directly to the market, or the produce can be held for temporary storage before marketing. Either way, the cold box provides a low cost source of cooling for perishables. These units are currently in use in Ghana for collecting and transporting high value vegetables by farmers who have formed grower/exporter associations.

Some key questions on the potential for postharvest interventions:

| Proposed Postharvest Technology | Crops that would benefit | Potential to scale up to many farmers? | How many might benefit? | C/B analysis available? | Simple enough to repair, use by next generation? | Key constraints? |
|---|--|--|--|---|---|---|
| Improved Containers: Plastic crates | All hort crops | yes | All* | yes | yes | Systems for ownership, return, cleaning |
| Liners for existing crates | All | yes | All* | yes | yes | Designs to match local needs |
| Use of Shade | All | yes | All* | yes | yes | Weather (wind) |
| Field packing | Many F & V | yes | All* | yes | yes | Training of workers |
| Evaporative FA cooling | All but onions, garlic | yes | Unlimited* | yes | yes | Training of workers |
| Low energy cold storage: Brick/sand structures | All but onions, garlic | yes | Unlimited | yes | yes | Relatively high cost, Financing |
| Low energy cold storage: Night Air ventilation | All | yes | All* | yes | yes | Climate (need cool nights) |
| Small scale cold transport | All | yes | unlimited | yes | yes | Relatively high cost, Financing |
| Improved Solar drying | Many F & V | yes | Unlimited* | yes | yes | Training of workers |
| Improved packaging for dried products | All | yes | All* | yes | yes | Training of workers |
| SmartFresh® | Fruit & Fruit Vegetables | yes | All | no | yes | Regulatory approval |
| Notes | Grains and legume crops would also benefit from shade, improved packages | Easy to try on small scale before investing. Can also be extended beyond Africa. | How many farmers are there in Africa? * Especially beneficial to women. | ROIs are positive, Pay back periods are quite short, can be weeks or months | Designs have few moving parts, are designed to be constructed locally | All these technologies would require support by local training activities |