YieldWise Innovation Scan Phases I and II Report for PYXERA Global

The Global Knowledge Initiative
YieldWise Innovation Partner
December 2016

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Developed by: The Global Knowledge Initiative

In partnership with: PYXERA GLOBAL

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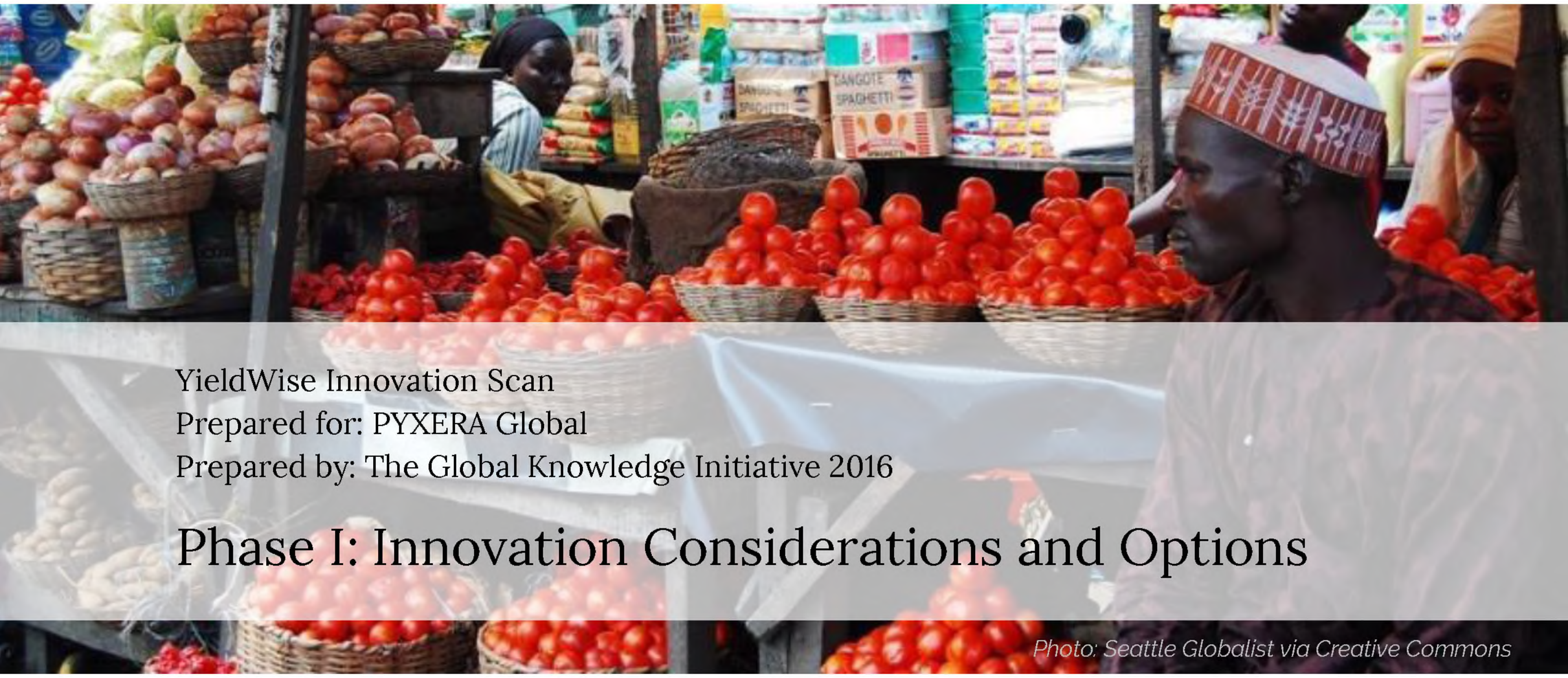
About this Report:

This report is one of three Innovation Scan reports produced in 2016 to support the YieldWise Initiative, a Rockefeller Foundation supported effort to demonstrate a halving of post-harvest food loss in Sub-Saharan Africa. The Global Knowledge Initiative (GKI) — the YieldWise Innovation Partner — conducted a two-phase Innovation Scan process to address a pressing innovation request from each of the YieldWise Implementing Partners — the Alliance for a Green Revolution in Africa (working to reduce post-harvest loss in Tanzania's maize value chain); PYXERA Global (working to reduce post-harvest loss in Nigeria's tomato value chain); and TechnoServe (working to reduce post-harvest loss in Kenya's mango value chain). In Phase I, GKI investigated possible innovation options and key decision-making considerations. In Phase II, GKI used feedback from the Implementing Partners to delve more deeply into specific innovation opportunities poised to positively impact their ongoing YieldWise efforts.

The following report presents consolidated Innovation Scan findings (Phases I and II) on the innovation request presented by PYXERA Global: How might we best support Nigerian smallholder farmers who want to dry tomatoes as a secondary market opportunity? For more information on the Innovation Scan process GKI undertook, see Appendix IV (p. 22).

Acknowledgements:

Renee Vuillaume, GKI Program Officer, researched and authored this report. It was supported by Amanda L. Rose, GKI Senior Program Officer and YieldWise Innovation Partner Team Lead; Krystal Werner, GKI Intern; and Ritse Erumi, GKI Doctoral Fellow.



YieldWise Innovation Scan
Prepared for: PYXERA Global
Prepared by: The Global Knowledge Initiative 2016

Phase I: Innovation Considerations and Options

Photo: Seattle Globalist via Creative Commons

Innovation Opportunity of Focus:

How might we best support Nigerian smallholder farmers who want to dry tomatoes as a secondary market opportunity?

In the first half of 2016, a tomato shortage racked Nigeria due to destruction caused by *Tuta absoluta*, a tomato leaf-mining moth, and, speculatively, to market shifts attributable to the emergence of the Dangote tomato paste processing facility in Kano State. As a result, domestic prices of fresh tomatoes rose by 200-500%. With annual demand for tomatoes at about 2.3 million metric tons, domestic production — 1.8 million metric tons — fails to meet demand, especially given that approximately 40% of production is lost before reaching consumers. In an effort to reduce loss, establish an alternative to the volatile fresh market, stabilize smallholder farmer income, and, ultimately, build a more resilient tomato value chain, drying of tomatoes is being considered by PYXERA Global, the YieldWise Implementing Partner in Nigeria.

Drying is the oldest preservation technique used for agricultural products. Drying provides an excellent way to preserve nutritional content, particularly for tomatoes, even during months of storage. At a basic level, drying uses a heat source to vaporize moisture in products, which prevents the growth of bacteria, yeasts, and molds, and lengthens shelf life. Drying also reduces the weight and volume of the product, which makes it easier and cheaper to package, store, and transport. It is, however, an energy intensive processing method. Fruits and vegetables require hot air between 45˚C and 60˚C for safe drying. This can be achieved from a natural or artificial heat source. There are advantages and disadvantages of both, but, generally, natural heat sources (e.g., the sun) require a reliable and concentrated supply of energy, whereas artificial heat sources (e.g., an oven) require a stable fuel source (e.g., electricity, petrol, or biomass) and larger investment.

There is a well-established international market for dried tomatoes, particularly for high-quality sun-dried tomatoes, in the U.S. and Europe. International markets are primarily supplied by large-scale industrial processors from regions with abundant sunshine, limited and reliable rainfall at certain times of the year, average temperatures between 45˚C and 60˚C, and low humidity. Traditionally, Italy and Turkey have supplied the majority of the world's dried tomatoes. Yet, as demand rises, new producers are entering the market from the Middle East and Asia, most notably Tunisia, Jordan, Kyrgyzstan, Afghanistan, Uzbekistan, India, and China.

Demand for dried tomatoes is also rising in Nigeria. According to 2016 local and national news stories, dried tomato businesses are expanding in Katsina and Kaduna States in Northern Nigeria. It is becoming more acceptable, and even preferred, to use dried tomatoes to cook stew, as dried tomatoes produce a thicker stew than fresh tomatoes. Buyers are coming from as far as Niger and Benin to buy Nigerian dried tomatoes from central markets. Seller can earn as much as N20,000 for a 100 kg bag of dried tomatoes when fresh tomatoes are scarce, but price can fall to as low as N10,000 at other times of year. By contrast, fresh tomato prices fluctuate wildly between N6,000 and N30,000 for a large basket throughout the year.

Traditionally in Nigeria, farmers have dried excess or damaged tomatoes in small batches in the open sun on mats, rock surfaces, or mud roofs. The process can be slow — up to 8 days depending on temperature and humidity — and result in high rates of spoilage due to contamination and bacterial growth. While smallholder farmers might not easily access high-quality international markets, there is evidence that Nigerian smallholder farmers are beginning to adopt improved methods of drying tomatoes. That said, in a study conducted by researchers from the University of Nigeria, Nsukka in 2011, only 2% of farmers surveyed were aware of solar crop dryers at the time. Of those, none had used or even seen a solar dryer; their knowledge came from word of mouth or literature.

With rising demand comes innovation. Opportunities exist to introduce technologies and processes that improve the efficiency and output quality of smallholder farmers' tomato drying efforts. PYXERA Global, having aggregated 466 farmers through the first half of 2016, is in a prime position to engage farmers and promote the adoption of drying technologies in line with their current activities. PYXERA Global invited the Global Knowledge Initiative (GKI), the YieldWise Innovation Partner, to support their exploration of the smallholder tomato drying innovation space. This report, therefore, aims to showcase those drying technologies that carry the most potential for process improvements, adoption by smallholder farmers, and fit within PYXERA Global's YieldWise activities. The Global Knowledge Initiative (GKI) undertook this analysis as part of our Innovation Scan process for YieldWise, described in brief in Appendix IV on p. 22-23. This Phase I report aims to inform PYXERA Global of the current solar-drying innovation space, and tee up our exploration of more specific innovation opportunities in the follow-on Phase II report (p. 10-17).

Considerations for Decision Makers:

No "one size fits all" or truly "off the shelf" drying technology exists to fit the needs of smallholder farmers. Context is far too important. Instead, there are a host of factors with which decision makers must contend as they select and support the adoption of a particular drying technology (or multiple drying technologies). A few of the most important considerations follow below.

1. **Nature of the tomato value chain.** Of the 3,000 tomato varietals cultivated around the world today, only a handful are suitable for drying. The varietal impacts whether, when dried, the tomato retains its nutrient content, flavor, color, structure, solids content, and texture. The PYXERA Global team should, first and foremost, assess the optimal tomato varietal for drying in Nigerian conditions. Additionally, temperature, rainfall, humidity, cloud coverage, wind speed, and the reliability of each, impact

drying. A number of drying technologies we reviewed are designed to mitigate for suboptimal drying environments. There are also advances in auxiliary technologies, such as low-cost humidity and temperature sensors, that could help farmers to better monitor drying and storage conditions and react before their tomatoes spoil.

2. **Farmer goals for drying.** When promoting a drying method to smallholder farmers, it is critical to understand: farmers' chief objectives for drying (e.g., to process surplus tomatoes that would otherwise spoil; to provide domestic markets with an alternative to fresh tomatoes during the off-season; to access high-end export markets) and how farmers are willing to engage in drying (e.g., as an alternative at-home processing option; as a professionalized cooperative business approach; by contracting the sale of fresh tomatoes to an industrial drying facility). If PYXERA Global aligns their strategy to address such goals and preferences, it is more likely that farmers will adopt the drying technology, investing their own time and resources into the activity.

3. **Farmer training.** The importance of teaching farmers how to properly use, maintain, and possibly build a new technology should not be overlooked. The process of drying tomatoes is a time-consuming job requiring high standards of hygiene and cleanliness. Farmers will need to learn about food hygiene and safety, adequate preparation (quality tomato selection, washing sanitation, and slicing), technology use and maintenance, quality control, packaging, storage, and marketing. It is recommended that PYXERA Global work with its private sector input providers, technology distributors, and/or buyers to develop training modules for dried tomato processing, with an aim toward food safety and quality.

4. **Market demand**. Given increasing local and international demand for dried tomatoes, there is potential to sell both through domestic and export channels. However, decision makers should align farmers' activities with buyers' quantity, quality, price, transportation, and timeline requirements. As a first step, it will be important to investigate the willingness of domestic or international buyers to source from smallholder farmers, and whether YieldWise smallholder farmers are able to compete with other domestic and international sellers. Whichever market pathway is preferred, it is crucial to clearly understand the buyer, their preferences, and the expected price for the dried tomatoes.

5. **Cost of and incentives for introducing drying.** Experts agree: making a new processing method work in a new context is less about the system and tools used, and more about the transaction costs and incentives at play. As such, PYXERA Global will need to determine how best to implement a new technology. This includes: assessing (non-monetary) transaction costs, resource outlays, and new skills required by smallholders; identifying who will pay for what aspects of the technology in the short and long term; specifying what incentives (e.g., premium payments for high-quality dried tomatoes; using farmers' sales history as a track record with which to access finance; increased market access and deepened buyer-producer relationships over time) are needed to drive uptake of the new technology; and understanding the disincentives and risks which might slow or thwart uptake.

6. **Contextual fit and smallholder realities.** An innovation is not a solution until it is put in context. As such, context is inherent to innovation decision making. Important

contextual factors with which decision makers must contend include the profile of smallholder farmers to be engaged (e.g., resource base; risk appetite; business/market savvy); availability of relevant technologies, including skilled persons to construct and repair them; transportation options for dried tomatoes to markets or fresh tomatoes to drying facilities; and the local policy/regulatory environment pertinent to strengthening horticultural value chains, the technology taxation regime, agricultural financing, etc.

There are other factors with which decision makers must contend when implementing measures for tomato drying, including: timeline and flexibility of implementation; additional labor requirements or labor market impacts; and appropriate financing options. Each of the above considerations warrant more context and stakeholder analysis in advance of selecting a drying technology for smallholder tomato farmers in Nigeria.

Summary of Innovation Options Reviewed:

Drying methods vary from simple to sophisticated; from sun- to solar- to mechanized-drying. Drying methods can be classified into five categories: open sun or natural, direct solar, indirect solar, hybrid solar, and mechanized. In general, the further you move from low to high technology, the more controlled the drying conditions (e.g., temperature, humidity, air speed, and contaminants) and the better the quality of dried product. Each method of drying can be carried out at a small-, medium-, or industrial scale. Typically, however, a method lends itself more naturally to a particular scale, given its inherent resource and training requirements.

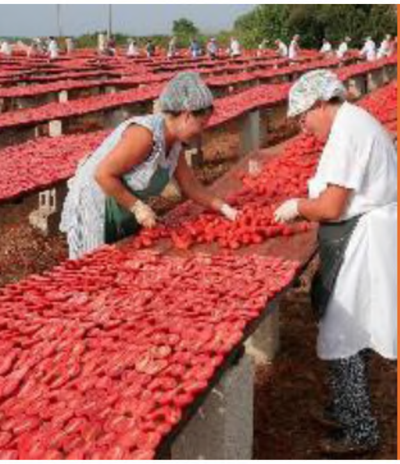
Open Sun or Natural Drying	Direct Solar Drying	Indirect Solar Drying	Hybrid Solar Drying	Mechanized Drying
The crop is placed on the ground or raised trays in the sun and left for a number of days to dry. This is the most rudimentary, but common, method of drying. Without proper sanitation control, sun-drying can produce a low quality output. There is a high risk of contamination by pests, dirt, and bacteria; and loss due to rain or spoilage.	The crop is placed in a simple enclosure with a transparent cover, whether glass or plastic. Heat is generated by absorbing solar radiation on the product itself. This method reduces contamination and leads to a higher quality product, but often requires as much time as sun-drying and can discolor or burn the crop due to direct sun exposure. The enclosure can be made cheaply with local materials.	The crop is placed on trays or shelves in an opaque or translucent enclosure. Air is heated in a separate unit, called the solar collector. The hot air then naturally circulates or is blown by fan into the drying chamber holding the crop. The drying time and quality is improved over the direct solar dryer, but the capital investment and maintenance costs are often higher.	The hybrid solar dryer combines features of direct and indirect solar dryers. The crop is dried by both direct solar radiation and pre-heated air from a separate solar collector.	Mechanized dryers use electricity or fuel as the source of heat, creating a type of oven for the crop to be dried in. I t is the most efficient and easily controlled method of drying. However, it likewise is the most capital intensive.

GKI reviewed innovation options under each of the five drying methods, implemented at either small-, medium-, or industrial-scale. Below, we offer a brief summary of the most interesting, compelling, and viable technological innovations. They are organized by color into the five drying methods (per the table above), with scale (small, medium, or industrial) specified in the title. These innovation options reflect *translational* innovations that have demonstrated value in other settings. Given the complexity of the environments in which PYXERA Global works, we address attributes such as affordability, feasibility, and maturity when possible.

It is important to note that we do not include advanced drying technology in this review. Emerging advanced methods include modified atmosphere, dielectric, heat-pump-assisted, microwave-assisted, microwave-vacuum, osmotic, or low-pressure superheated steam drying. These methods require significant start-up and operating costs, sophisticated mechanical and electronic components, and advanced training, making them unsuitable for the current smallholder context in Nigeria. In general, however, these new technologies seek to enhance and more precisely control output quality; pasteurize and sterilize the product; reduce energy consumption in order to reduce costs and environmental impact; or more efficiently harness renewable energy sources (e.g., solar, wind, biomass).

Finally, we present this list, not as an exhaustive review of available drying innovations, nor as a statement of the *only* options PYXERA Global should consider at this time. Rather, we present a range of technologies to *illustrate what might be possible* in the case of the tomato value chain in Nigeria. We ask that you please refrain from viewing these options in isolation. The discrete elements of a drying business are often packaged into unique *suites* of tools and processes tailored to meet specific market requirements and contextual realities. Efforts to build interest in drying tomatoes; to address start-up and long-term financial costs associated with tomato drying operations; to build trust and loyalty in farmer-buyer relationships; to provide relevant training to farmers and other value chain actors — each of these vital priorities should be taken into account as PYXERA Global moves forward. That said, fully elaborating this suite of tools, processes, and resources falls outside the scope of this Innovation Scan.

Key:
Open Sun / Natural Drying
Direct Solar Drying
Indirect Solar Drying
Hybrid Solar Drying
Mechanized Drying

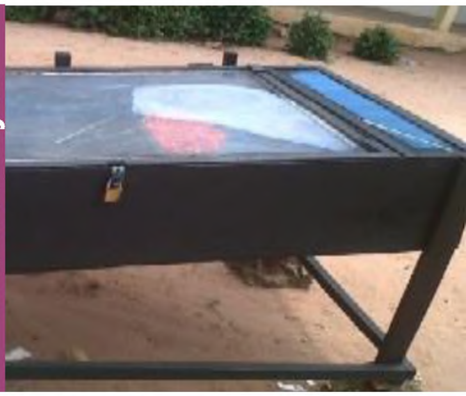


Industrial Sun Drying

Industrial sun drying is common in warm, dry areas. In recent years, new industrial-scale sun-drying operations have emerged in low- and medium-income countries. For example, in Tunisia, about 50,000 metric tons of dried tomatoes are produced annually. Once cleaned and cut, tomatoes are placed on plastic nets 1 meter above the ground for 3 days. The dried tomatoes are packaged in 10 kg boxes and exported to Italy. Since 2013, Tunisia and Italy have participated in a joint program to promote knowledge exchange on the sun-drying process. Sun drying is a risky option, as the drying tomatoes are exposed to pests, dirt, bacteria, mold, and rain. Additionally, exposure to higher temperatures can cause hardening of the dried product. However, with rigorous pre- and post-processing standards and quality control, assurances can be made to the safety and quality of the final product. Drying stations can be built on raised tables with mesh trays or on the ground with polypropylene (i.e., grain sac) material. Typically, 15 kg of fresh tomatoes yield 1 kg of sun-dried tomatoes. Additional requirements include: transport for fresh tomatoes to the industrial drying site; proximity to the washing station; sufficient land to serve as the drying site; and functioning farmer groups or networks to serve as "processing" groups.

Small-Scale Cabinet Dryer

Solar 'cabinet' dryers take produce off the ground and use a plastic or glass covering to protect the product and increase the drying air temperature by concentrating thermal radiation. It is the most mature and widely available solar drying technology. Unfortunately, cabinet dryers often take as long to dry as sun drying (up to 3 days) due to their low average air speed and, as a result, moisture removal. They can usually be constructed using relatively cheap, local materials. The Institute of Agricultural Research (IAR), in Samaru, Kaduna State has a new affordable cabinet dryer that boasts construction cost beginning at N15,000. Researchers at the Department of Agricultural Economics, Extension and Rural Development, Imo State University, Owerri, Nigeria also developed a locally fabricated cabinet dryer in 2015. This dryer (pictured at right) dries tomatoes in 70 hours (compared to 71 hours for a sun-dried sample); is constructed with a glass cabinet and steel conductor sheet; and holds about 5 kg of fresh tomatoes.



Small-Scale Chimney Dryer

The chimney dryer is made up of a long 'table' for the tomatoes and a chimney at one end. The tomatoes are placed on mesh trays along the length of the table. A clear plastic sheet is placed over the trays and table, which creates a tunnel that traps solar energy, heating the air and reducing its relative humidity. The low-humidity heated air removes moisture from the product; warm moist air leaves the dryer through the chimney. The drier is designed to allow little space between the tomato trays and the clear plastic covering them. This forces the air to flow through a small area, thus generating high air speed over the product. Compared to the cabinet dryer, this technique offers more uniform and rapid drying (e.g., tomatoes dry in 2 days instead of 3-5), producing export-quality dried tomatoes. The model presented at right was designed and tested by the UC Davis Horticulture Innovation Lab. It can hold 6 kg of fresh tomatoes and can be built with local materials for $50-$60 USD, but the design is easily modifiable. Initial tests show that the chimney dryer efficiently dries tomatoes even in cloudy or rainy weather, and is capable of drying other produce (mangoes, bananas, sweet potatoes, potatoes, onions, fresh greens and herbs, and fish). There have been challenges, however, in translating the design and construction to local manufacturers. The UC Davis design is currently being funded by USAID to dry apricots in Uzbekistan; tomatoes, bananas, and mangoes in Bangladesh; and maize and groundnuts in Tanzania; among others.

Medium-Scale Greenhouse Dryer

A medium-scale greenhouse dryer works like the traditional cabinet dryer, but it is large enough for people to enter. A model was developed in 2010 by the Department of Agricultural Engineering, at Ahmadu Bello University, in Zaria. The greenhouse was built using local materials for N55,000 (about $350 USD in 2010). The researchers were able to dry 60 kg of fresh tomatoes in 58 hours, compared to 124 hours in open sun. The design exhibited efficient drying even in the rainy season, and the polythene cover top lasted for 8 months until thermal and UV stress punctured it. The Nigerian Women Agro Allied Farmers Association (NIWAAFA) is also piloting a medium-scale greenhouse dryer. They are engaging farmer cooperatives, and are working with the Central Bank of Nigeria's Anchor Borrowers program, which meets about 70% of farmers' financing needs. The chief concern with a medium-scale operation is joint ownership. According to researchers at the University of Nigeria, Nsukka, most farmers reject the idea of communally owned dryers, preferring commercialized systems that link payments with quantity supplied. Their concerns include managing periodic maintenance and establishing a drying schedule that suits all farmers. There are instances in which unresolved conflicts led to the dryer being neglected and the business collapsing.

Small-Scale Concentrated Solar Dryer

The Concentrated Solar Dryer combines the use of indirect solar drying with concentrated thermal radiation using mirrors. Pictured at left, the mirrors harness and redirect solar radiation to the tomatoes in the drying chamber. Currently, both Michigan State University's Global Center for Food Systems Innovation and University of California, Davis' Horticulture Innovation Lab are testing the efficacy of the Concentrated Solar Drying technology. Both research centers have developed models that can be built from low-cost, locally available materials, and both are piloting their models in Uganda. Their initial trials indicate that drying time is reduced by around 20% compared to traditional cabinet driers. Subsequent plans are to study how the technology affects household savings, market access, food security, and quality of life for farmers.

Small-Scale Solar Conduction Dryer

Developed by Project SCD, which operates out of India, the Small-Scale Solar Conduction Dryer (SCD) is the first solar dryer in the world that uses all modes of heat transfer: conduction, convection, and radiation. It claims the same efficiency as direct solar dryers, but at 50% the cost per kg yield. Additionally, it maintains 45% more nutrients than direct solar dryers, as the produce is more effectively shielded from the sun's thermal radiation. The Project SCD dryer pictured at right has a 10 kg fresh tomato capacity, costs $200 USD to build, and has a self-proclaimed 10-year lifecycle. Project SCD's design was the 2013 Dell Social Innovation Award Grand Prize winner from a pool of 2600 innovations. At present, there are 650+ SCDs operating successfully in India and Kenya. However, they are only currently manufactured in India and are, thus, being exported to Kenya. Project SCD also works to establish the supply chain for dried tomatoes, working with farmer groups, processing companies, and financers. For example, they are partnering with IFAD, the World Bank, General Mills, Bayer Agriculture, Tata, and Unilever to develop supply chains for dried tomatoes in India and Kenya.

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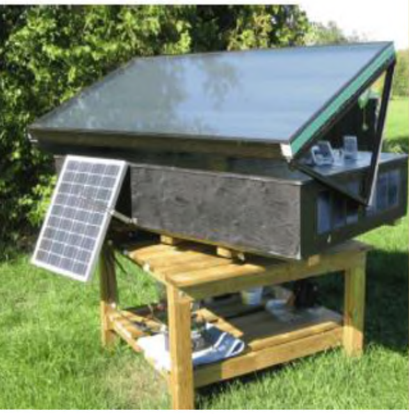
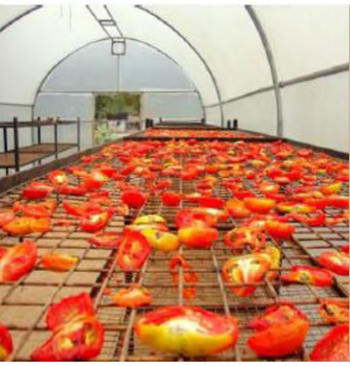


Small-Scale Hybrid Solar Dryer

The Small-Scale Hybrid Solar Dryer is built with a standard tray dryer and an additional energy source for use during cloudy days and at night. Several experimental designs exist, using electric, biomass, or solar power as the additional energy source. This hybrid approach dramatically reduces drying time (to around 24 hours) and improves the quality of the final product. However, significant questions remain as to whether smallholder farmers can afford and access a reliable energy source. Additionally, more sophisticated technical skills are required to operate and maintain the dryer. The example at right is the Solar-Flex Dryer, which was designed in Canada, fabricated in China, and piloted across Africa and India. Initially built as a medium-scale technology in 2005, the example at right is the 3rd generation technology, which has been designed for smallholder farmers. It can process 20 kg of fresh tomatoes, requires a photovoltaic solar panel and fan, and costs $1,600 USD per unit. It has also been used to dry coconuts and onions in India; tomato, banana, pineapple, and apple in South Africa, and fish in Liberia. Currently, there are 4 units operating in Nigeria through Alvan Blanch, Inc.



Medium-Scale Hybrid Biomass Dryer

The Medium-Scale Hybrid Biomass Dryer is similar to the Medium-Scale Greenhouse Dryer, with one notable exception: the walk-in greenhouse is coupled with a biomass heater that ignites after 5:00 PM in order to maintain the temperature inside the dryer during the night. This functionality allows it to reduce the drying time to 24 hours, compared with 58 hours in the case of the standard solar greenhouse dryer. The model at left was piloted in Tamil Nadu, India. It can dry 50 kg of fresh tomatoes, with output quality being superior to traditional greenhouse dryers, due to the consistent temperature and humidity maintained at all times. In the pilot, the biomass heater was fueled by coconut fronts, shells, and husks, however any plentiful low-moisture biomass, such as dry banana leaves, would work. This option presents the same concerns and considerations as the Medium-Scale Greenhouse Dryer, as cooperative ownership would likely be required.

Industrial Dehydrator

Dehydrated tomatoes are different than sun-dried tomatoes, distinguishable by a lower moisture content. A dehydrated tomato will have <5% moisture content, whereas a sun-dried tomato will have between 15-18% moisture content. Virtually all dehydrated tomatoes are dried in ovens, because reducing moisture to such a degree requires higher temperatures and lower humidity than solar radiation can provide. Most industrial dehydrated tomatoes are dried in ovens at 60°C – 70°C for about 6-8 hours. It is a very energy intensive process, and requires at least 22 kg of raw material for 1 kg of finished product. Dehydrated tomatoes are primarily used as industrial ingredients and must meet very high standards of quality and production. Industrial dehydration may seem utterly infeasible for the Nigerian context, but there is evidence that the sector is slowly emerging in neighboring countries. For example, a private company, Malisol, has established a tomato dehydrating facility in Mali as a joint venture between two Dutch-owned companies, a Niger-based seed company, and a European buyer. They are using a resistance-heated oven supplied by electricity. In most dehydration facilities around the world, however, steam generated from a boiler is used to supply heat to the drying ovens.

Industrial Spray Dryer

Spray-drying transforms liquid state food (i.e., pulp) into dried particulate form. After pulping the tomatoes, which removes skin and seeds, additional drying agents are added to the liquid, such as starch, Arabic gum, and malt dextrin. The liquid tomato is then passed through a hot-air stream and rotary disk atomizer, which produces powder. Dehydrated tomato powder holds promising market potential. It is easier to store, transport, and package than dried tomatoes, and has a longer shelf life. However, spray drying is a very expensive technique, mainly because it requires a lot of equipment and energy, and must be carried out at an industrial scale. That is not to say that Nigeria is prematurely exempt from this budding sector. In India, the 6th largest tomato producer in the world, large farmer cooperatives are experimenting with processing tomato into powder, which can later be used to make sauce, ketchup, chutneys, soups, and baby foods. Additionally, Swedish graduate students in the Food Innovation and Product Design program at Lund University have developed a dried, powdered, shelf-stable fruit and vegetable product that can be used in humanitarian relief efforts after natural disasters or distributed in low-resource areas with reduced access to fresh produce and/or refrigeration. They are marketing the final product as FoPo Food Powder. They are now looking to distribute it through commercial and government-supported ventures. The group is currently running a pilot program in Manila, drying calamansi, a citrus fruit that is a surplus in Manila but unavailable in other places. They are developing a partnership with the UN's Initiative on Food Loss and Waste in order to broaden their scope to other countries.

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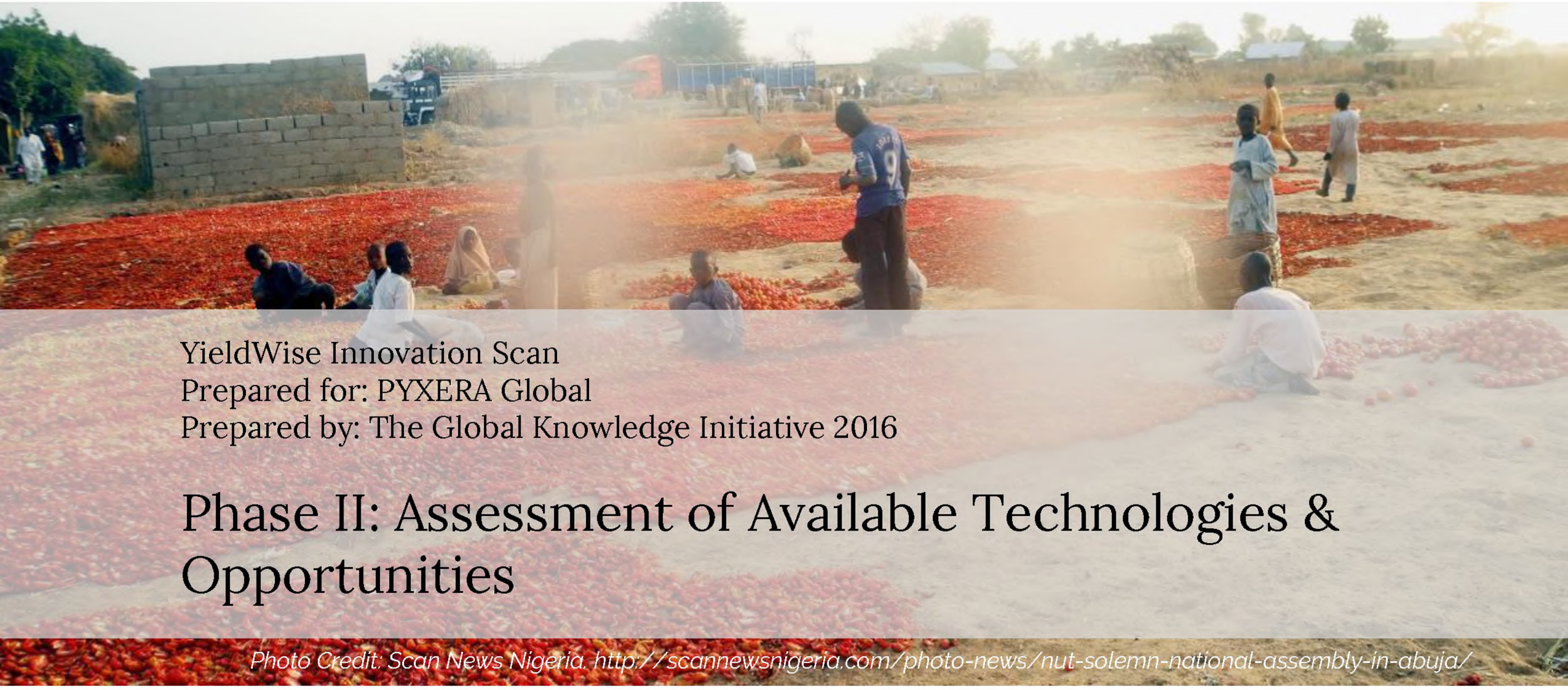

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Prepared by: The Global Knowledge Initiative 2016

Phase II: Assessment of Available Technologies & Opportunities

Photo Credit: Scan News Nigeria. http://scannewsnigeria.com/photo-news/nut-solemn-national-assembly-in-abuja/

Phase II Objectives & Selections:

For the second phase of the Innovation Scan, GKI conducted an in-depth review of promising innovation options from Phase I. PYXERA Global selected two technologies for further consideration from the ten options highlighted in the Phase I report: the small-scale cabinet dryer and the medium-scale greenhouse dryer. PYXERA Global selected the small-scale cabinet dryer because it is a low-tech, low-cost option particularly well-suited for individual farmers currently engaged in natural sun drying, who have comparatively large farms, and can self-finance their acquisition of the dryer. PYXERA Global selected the medium-scale greenhouse dryer with an eye toward encouraging farmers to aggregate their crop and help farmer associations build their capacity as profit-making entities. Aggregation of farmers and their outputs serves as a key pillar of the YieldWise approach supported by PYXERA Global as a YieldWise Implementing Partner.

PYXERA Global considered the small-scale cabinet dryer and the medium-scale greenhouse dryer to be simple technologies that would be easy to use and enable farmers to access new markets by producing a high-quality dried product. Ideally, this would include export markets for dried tomatoes. Both options represent versatile technologies that would allow farmers to dry many other crops in addition to tomatoes. Additionally, PYXERA Global hoped that the medium-scale greenhouse dryer could serve as a multi-purpose technology—to both dry horticulture products and grow tomatoes year-round—in order to help reduce the seasonal volatility in the tomato industry in Nigeria.

Subsequently, GKI conducted additional research and reached out to experts, companies, and non-profit organizations working with these two types of technologies to gain a deeper understanding of the dryers and analyze their viability for PYXERA's needs.

Medium-Scale Greenhouse Dryers

Based on additional research, GKI concluded that currently available medium-scale greenhouse dryers do not seem to be a viable option for drying tomatoes. At present, no evidence exists to substantiate that greenhouse drying operations have been successful at a commercial level. GKI could not identify an organization manufacturing, distributing, or promoting medium-scale greenhouse dryers. Moreover, greenhouse dryers were unable to offer the complementary function as a year-round growing facility. Each of these functions (drying and growing) requires opposite environmental conditions (temperature, humidity, air flow, etc.), and thus, separate technical specifications. Lastly, researchers at the University of Nigeria, Nsukka explained that most smallholder farmers reject the idea of communally owned dryers, preferring commercialized systems that link payments with quantity supplied. Their concerns include managing maintenance and establishing a drying schedule that suits all farmers. There are instances in which unresolved conflicts led to the dryer being neglected and the business collapsing. The Nigerian Women Agro Allied Farmers Association (NIWAAFA), which is currently piloting a medium-scale greenhouse dryer with farmer cooperatives in Kano State, confirmed this assertion. NIWAAFA explained that collective ownership has been largely unsuccessful in their pilot. Thus, this report does not present medium-scale greenhouse dryers for further consideration by PYXERA Global.

Small-Scale Solar Dryers
Additional research offered various potential opportunities in small-scale solar dryers for PYXERA Global. As conveyed in the Phase I Report ("Summary of Innovation Options Reviewed", p. 6), drying technology can be categorized as, (1) open sun or natural drying, (2) direct solar drying, (3) indirect solar drying, (4) hybrid solar drying, or (5) mechanized drying. Small-scale dryers that fit into categories (2) direct, (3) indirect, and (4) hybrid are often similar, with overlapping characteristics. Each could meet PYXERA Global's desire for a low-cost, easy to use dryer which can be individually owned and dry multiple crops. Researchers who specialize in drying technologies have developed dozens, if not hundreds, of iterations of small-scale technologies in, or on a spectrum between, these three categories. Thus, GKI considered small-scale technologies that fit into these three categories in Phase II, comparing key criteria (cost, output quantity, output quality, ease of use, accessibility, etc.) across the most viable technology options.

Comparing Potential Pathways to Impact: Two Scenarios

Through extensive research, GKI found no "best option" that fit the preferences of PYXERA Global, largely due to the fragmented and immature nature of the solar drying industry. Numerous research projects have been conducted over the last 30 years to identify drying technologies with the best technical specifications for a given context. As emphasized in the Phase I report, context is the fundamental determinant of a technology's success – an innovation is not a solution until it is put in context (Lamb 2016). As such, context is inherent to innovation decision making. Important contextual factors include: the profile of smallholder farmers to be engaged (e.g. their resource base, risk appetite, business/market savvy); the availability of relevant technologies, including skilled persons to construct and repair them; transportation options for moving dried tomatoes to markets and/or fresh tomatoes to drying facilities; the local policy and regulatory environment pertinent to strengthening horticultural value chains, such as the technology taxation regime; available agricultural financing options; and climate considerations.

In addition to context-specific alignment, GKI searched for evidence of successful scale achieved by a drying company or project. Although Nigeria has a long history of drying crops, including tomatoes, drying technologies are nascent and the market requires significant development. As PYXERA Global has limited experience with drying projects, GKI honed in on technologies that had 1) demonstrated success in multiple contexts and 2) accompanying support and training services provided by a corresponding company or organization, which would help ensure ongoing assistance to PYXERA Global.

With these two considerations in mind (context and scale plus service), PYXERA Global could choose to pursue one of the following two scenarios. **Scenario I: Develop a customized technology with a Nigerian research partner**. This would allow PYXERA Global to partner with researchers or organizations who have a deep understanding of the local context and could design a drying technology to suit PYXERA Global's needs. This would likely take one or more years to move from concept to scale. PYXERA Global might also need to find additional partners to support technology distribution and training, and market development. **Scenario II: Source an existing technology from an established international organization.** This would allow PYXERA to quickly introduce a technology to its farmers without the need for additional testing and design. Ideally, the international organization would also support PYXERA Global distribute the technology, train farmers, build new markets, and other additional functions critical to success. Whichever scenario PYXERA Global chooses to pursue, they will need to exert significant effort to ensure that the partnership is a success for tomato farmers and the YieldWise initiative in Nigeria.

Scenario I: Nigerian Partnership

There are numerous research studies and pilots of small-scale dryers that have been conducted Nigeria, primarily by researchers from universities and government ministries. GKI identified and reached out to those who might prove helpful to PYXERA Global. Unfortunately, many of the primary researchers proved unreachable. GKI spoke with two sources: researchers in the Department of Agricultural and Bioresources Engineering at the University of Nigeria, Nsukka, and a representative of the Nigerian Women Agro Allied Farmers Association (NIWAAFA). A list of additional Nigerian experts in drying technologies is provided in Appendix II (p. 19).

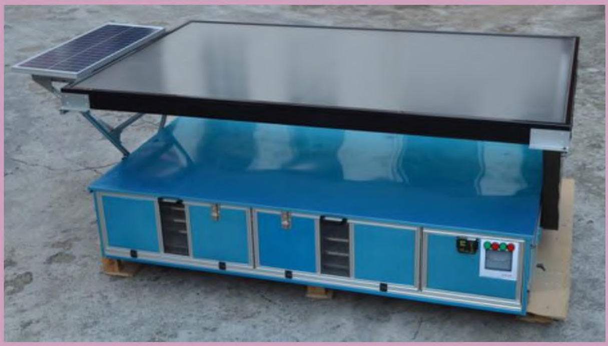
Researchers in the Department of Agricultural and Bioresources Engineering at the University of Nigeria, Nsukka have designed and piloted several dryers. For example, a solar rice dryer with a capacity of 2 tonnes per batch and a construction cost of N6,000,000; a passive solar dryer with a capacity of 50 kg per batch and a construction cost of N300,000; a small-scale active solar dryer with a construction cost of N130,000; and a passive integral solar dryer with a capacity of 80 kg and a construction cost of N400,000. The primary aim of this research is to train students in design, but the researchers would be interested in working with a partner who has knowledge of local markets and small-holder preferences in order to distribute their technologies in Nigeria.

NIWAAFA is a women-founded, Nigerian NGO non-governmental organization that focuses on agriculture and the integration of women in the governance of agriculture, recognizing that women comprise 60 to 70 percent of Nigerian farmers. They are currently working in 3 communities of Kano state with one dryer per community. The dryers are owned by a cooperative of approximately 25 women. Their dryer is a medium-scale cabinet dryer, which is fabricated locally and costs approximately N350,000. It runs on electricity, however there is a clear intention to develop a solar dryer that is large enough to encourage cooperative management and increase the output quantity of dried tomatoes, as the current model is only able to dry 100 kg of tomatoes. Additionally, the organization has identified a need to integrate trainings on packaging and preservation, as the post-drying process has been problematic. While there is a domestic market for dried tomatoes, the organization also struggles to secure a buyer for the farmers.

Scenario II: International Sourcing

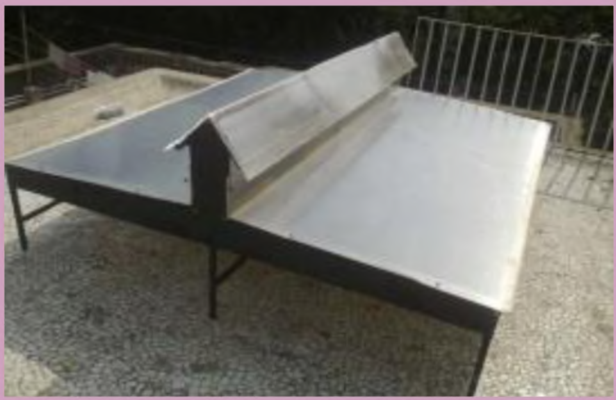
GKI identified small-scale solar drying technologies produced by three international organizations as potential options for PYXERA Global to consider. Currently, the organizations (listed below) do not operate in Nigeria, but each is actively looking to expand its business across the region. Their technologies have all emerged out of rigorous, multi-year test phases and ensure a high-quality dried product that could be sold domestically or through export channels. However, each varies in terms of size, operational efficiency, technical intensity, cost, market penetration, business model, and other criteria. The following boxes provide a brief overview of the technologies, including descriptions of how they work, and where they have been used before. The table of page 13 summarizes some of the key features of each technology, such that they can be easily digested and compared. GKI presents a Criteria Matrix on page 14 to help decision makers assess these organizations and their associated technologies across a set of criteria relevant to PYXERA Global's stated goals.

Malnutrition Matters



Malnutrition Matters is a Canadian-registered, non-profit organization producing two models of dryers, the Solarflex and the Quad Solarflex. After 5 iterations of the current product, Malnutrition Matters believes the Solarflex dryer maximizes operational efficiency and quality at an affordable price point. The Solarflex raises the internal temperature to 25-30 degrees above the ambient temperature, maintaining ideal micronutrient levels. The Solarflex dries 15-20 kg of tomatoes in approximately two days. The Quad Solarflex has 4 airflow collectors joined under a large cabinet that utilizes an electric A/C fan to strengthen the airflow. Malnutrition Matters is a social business focused on food security for rural markets. They partner with large NGOs and multinational organizations such as the Food and Agriculture Organization of the United Nations (FAO), United Nations Development Programme (UNDP), International Fund for Agricultural Development (IFAD), African Union, and African Development Bank (AfDB). For example, in 2016 they began a project in Ghana with the Ministry of Trade and Industry (funded by Afdb and IFAD) to dry pineapple, greens, coconut, and fish.

Science for Society



Science for Society is a 4-year old, India-based company focusing on developing energy efficient post-harvest solutions; they offer five different technologies for drying crops. Three of their products are solar dryers and two are energy efficient electric dryers. Their solar conduction dryer (SCD) is a smaller-scale solar option that has been utilized for horticultural crops, such as tomatoes and mangoes. Winner of the 2013 Dell Social Innovation Award Grand Prize, the SCD is claimed to be the most efficient small-scale solar dryer in the world, and as the first dryer to use conduction, convection, and radiation as heat sources. Preferred levels of color, moisture content, and lycopene are maintained through the drying process. The SCD has been adapted to cater to rural farmers' demand by eliminating all moveable or breakable components, such as fans, wires, and glass, and by enhancing the aesthetic appeal. The business has seen 50 percent growth over the past year, and are currently in partnership with the Bill & Melinda Gates Foundation and the UK Department for International Development (DFID) in Kenya (and exploring cassava in Nigeria). They also are working with Gates and the United States Agency for International Development (USAID) in India to increase rural dietary diversity. With GrainPlus in India and Tanzania, Science for Society also works to establish the supply chain for dried tomatoes. Their standardized 1-year implementation process begins by fostering a local market for dehydrated products, and then training on drying technologies using local crops. The company then trains lead farmers to provide ongoing support and sensitization in their communities. Finally, they set up a revolving fund as well as link farmers to local commercial banks. To start, farmers pay 20% upfront and 80% through the revolving fund. Science for Society also provides support for packaging and labeling, as well as identifying local distributors to support future sales.

The Society for Energy, Environment & Development (SEED)

The Society for Energy, Environment & Development (SEED) is an India-based NGO that has developed and sold solar dryers for over 10 years. SEED offers six commercialized solar cabinet dryers of 8 kg to a 400 kg capacity to accommodate varying climatic conditions and user's preferences. SEED's primary customers are entrepreneurs, aggregators, and organized farmer groups. For example, in Tanzania, the government set up an "innovation/incubation zone" at the point of aggregation and processing for farmer groups to create a value-added product and essentially become a small and medium-sized enterprise (SME). Sales typically occur in partnership with a local organization, such as a government body, local NGO, or charity that can serve as the primary liaison and provide ongoing support and training when necessary. SEED's trainings and product design emphasize the processing and packaging of high quality, hygienic dried commercial produce that prioritizes maintaining maximum nutritional value and uniformity in color, texture, and appearance. In India, SEED processes and packages dried products for market, such as tomato powder, fruit and nut bars, dried fruit rolls, and nutritional beverage powders.

Organization and Product Details			
	Malnutrition Matters	**Science for Society**	**The Society for Energy, Environment & Development (SEED)**
Description	A Canadian non-profit organization marketing two solar dryers, the Solarflex and the Quad Solarflex	A 4-year old, India-based company focused on energy efficient post-harvest solutions and offering five drying technologies	An India-based NGO selling six commercialized solar cabinet dryers (from 8 kg to a 400 kg capacity) and with 10 years of experience
Organization location	Canada	India	India
Organization class	Non-profit organization	Private company	Non-governmental organization
Technology	Solarflex Dryer & Quad Solarflex	Small-scale solar conduction dryer (SCD)	Small- to medium-scale cabinet dryer with solar panels
Drying method Open sun or natural, direct solar, indirect solar, hybrid solar, and mechanized	Indirect hybrid solar dryer	Direct solar dryer	Direct hybrid solar dryer
Capacity	15 - 20 kg (Solarflex) or 100 kg (Quad Solarflex)	10 kg	8 kg, 25 kg, 50 kg, 100 kg, 200 kg, or 400 kg
Drying time	Approx. 48 hours	Unknown	10 - 12 hrs (200 kg model)
Cost	$1,600 - $1,900 per unit (Solarflex) $3000 to ship 16-25 units from China	$200 USD ($100 per m^2; can be built to suit)	$5,000 - $6,000 USD (200 kg model)
Recommended ownership model	Individual	Individual	Individual or cooperative, depending on size
Technology components	Solarflex: 5 m^2 drying surface with 8 aluminum trays; plywood and steel cabinet; solar panel; back-up battery; 4 fans; corrugated steel solar collector	2 m^2 drying unit	Glass window; solar panels; temperature, moisture, & humidity controls; stainless steel trays; solar-powered fans; electrical backup
Manufacturer location	China	India	India
Distributor location	Kenya and Ghana via India	Kenya via India	India
Markets	India, South Africa, Liberia, Ghana, St. Lucia	8 countries, including India, Nepal, Tanzania, Kenya	India, Malaysia, Tanzania, Mauritius
Number of sales through 2016	30 units	1,100 units	Unknown
Processed Products	Coconut, onion, tomato, banana, pineapple, apple, and soury fruit, fish	Tomato, greens, onions, fruits, fish	86 products, including tomato, mango, fish, spices, herbs, and other horticultural crops

Comparison Criteria			
	Malnutrition Matters	**Science for Society**	**The Society for Energy, Environment & Development (SEED)**
Stage of Adoption Start-up; Expansion; At scale	Start-up	Expansion	Expansion
Cost	$1,720 - $2,088 USD per unit (w/ shipping) for order of 16-25 units	$100 USD per m^2 (can be built to suit)	$,5,000 - $6,000 USD (200 kg model)
Sanitation & Quality Nutrient retention, food safety, shelf life, taste, and retention of color and texture	Indirect solar radiation maintains color, texture, and micronutrient quality. Enclosed system keeps produce free from dirt, pests. Dried product stores for 1 year in sealed package.	Their trials and studies demonstrate that dried product has preferred color, moisture content, and lycopene level for dried tomatoes.	Dried product has uniform color, texture, and appearance. Direct solar radiation may degrade nutrient content and texture. Enclosed system keeps produce free from dirt and pests.
Business Model Manufacturing, distribution, sales, and financing options	Fabrication and distribution from China. Would be willing to establish local distribution channel in Nigeria. Financing options unavailable.	Fabrication and distribution from India. Partner with Bayer to ensure quality materials and a standardized product. Would work to establish local distributors in Nigeria.	Fabrication, distribution, and sales processed through India. Financing options unavailable.
Local Support Organizational support available during rollout, training, and continued operations	Delivery and 1-day training on setup, operation, and small business skills. Continued support is limited to installation guides and manuals. Support technicians are based in Kenya, South Africa, and Canada.	1-year standardized training process, which includes fostering a local market, training on the technology, sensitization of dried crop uses, and ongoing support and maintenance.	Initial support provided for assembly and training-of-trainer for local leaders. Processing, marketing, and technical support contingent upon local partners. (Support of processing can be incorporated into partnership.)
Operational Efficiency Quantity, drying time, and control of temperature, air flow, and moisture content	Dries 15-100 kg in 48 hours. Swivel function allows unit to rotate to track the sun.	Maintains control of microbial growth, nutrition, moisture content, and temperature.	Dries produce in 10-12 hours. Solar panels and electrical back-up provide stable temperature, air flow, and moisture control.
Adoption Potential Ease of use, maintenance requirement, local fabrication potential	Fans are the only mechanical component. Successful pilots in Ghana and Liberia demonstrate viability in West Africa markets. Local training model needs improvement.	No breakable parts or fuel source. Can be made with local materials, but a central manufacturer is recommended. Science for Society provide 1 year of in-country support to establish supply chain.	Strong technical skills required to operate dryer. Requires maintenance technicians and availability of replacement parts (fans). Limited technical support is available from India via phone.

Low Level   Medium Level   High Level

Conclusion:

The goal of this Innovation Scan is to guide PYXERA Global through the implementation considerations of and options available for a solar-drying initiative with its tomato farmers in YieldWise. During Phase I, GKI presented a range of drying technologies for use at different scales and outlined the important factors with which PYXERA Global must contend as they select and support the adoption of any drying technology. From this, PYXERA Global refined its preferences in accordance with the technological boundaries and contextual factors that bear most heavily on a solar-drying initiative's success in Nigeria. GKI then conducted a second phase of the Innovation Scan in order to provide PYXERA Global with additional information on specific technologies and the organizations promoting them.

In Phase II, GKI identified two approaches that PYXERA Global could take to implement a solar-drying initiative in Nigeria, identified as **Scenario I** and **Scenario II**. **Scenario I** – a customized solar dryer designed in partnership with a Nigerian research institution – is likely not viable for short-term implementation. PYXERA Global would need to take the time to design a new technology or adapt a tested technology in collaboration with a chosen Nigerian research institution. This should also include time for piloting and refining the design. While not suitable for immediate adoption of a technology by YieldWise farmers, Scenario I presents a local partnership model that puts a premium on addressing the contextual factors distinct to tomato farmers in Nigeria. PYXERA Global would be able to learn from and work closely with Nigerian researchers who have in-depth knowledge of the solar-drying history in Nigeria. With Scenario I, PYXERA Global would also be embarking on a long-term system-wide effort to build the solar-drying industry in Nigeria. Systemic change is more likely to succeed through local partnerships and context-specific innovation.

Scenario II – sourcing a pre-existing drying technology from an international organization – holds potential should PYXERA Global desire to act quickly and with external support beyond the technology design stage. The international organizations outlined in Phase II offer tested technologies that could be introduced as-is to farmers in Nigeria. PYXERA Global can be reasonably assured that the technology design, materials, and performance are sound and reliable. However, there could arise contextual challenges from bringing in an external technology. PYXERA Global would need to work independently, or possibly with the technology provider, to mitigate or remedy these challenges in order to ensure adoption. However, with multiple years of experience in the solar-drying industry, the international organizations profiled in Phase II could provide valuable support to PYXERA Global in designing and implementing a tomato-drying initiative in Nigeria. Depending on the organization, support could include technology distribution, technology maintenance, farmer training, community outreach, marketing, buyer identification, and other aspects of implementing a solar-drying initiative.

In choosing between Scenario I and Scenario II, PYXERA Global should consider the long-term implications for the YieldWise initiative and the tomato value chain in Nigeria. Whichever scenario is preferable, PYXERA Global will need to continue vetting the technologies and organizations as they move forward. GKI hopes that this Innovation Scanning process serves as a valuable input into PYXERA's decision-making process. We welcome the chance to discuss these findings and recommendations with the PYXERA Global team. We also stand ready to connect PYXERA Global to potential technology providers and other experts as requested.

Appendix I: List of Experts Consulted

Over the course of this Innovation Scan, the following experts provided valuable insight and context that featured in numerous ways in this report. With gratitude, we acknowledge their contributions:

- Chioma Ume, OpenIDEO, United States
- Dr. Don Mercer, University of Guelph, Department of Food Science, Canada
- Dr. Klein Ileleji, Purdue University, JUA Technologies International, LLC, United States
- Hart Jansson, Malnutrition Matters, Canada
- Jim Thompson, Horticulture Innovation Lab, University of California, Davis, United States
- Lizzy Igbine, Nigerian Women Agro Allied Farmers Association (NIWAAFA)
- Lisa Kitinoja, The Postharvest Education Foundation (PEF), USA
- Michael Reid, Horticulture Innovation Lab, University of California Davis, United States
- R. Shymala, General Secretary, Society for Energy, Environment and Development (SEED), India
- Nwoke O. Okala, Department of Agricultural and Bioresources Engineering, University of Nigeria, Nsukka, Nigeria
- Vaibhav Tidke, Science for Society, India

Appendix II: List of Additional Experts in Nigeria

The following Nigerian experts and institutions have experience with drying technologies. Where possible, we list a project or publication associated with the expert or institution. These experts might prove helpful to PYXERA Global if consulted, but GKI is unsure of the current state of their projects, as our attempts to contact most experts or institutions were unsuccessful.

Abubakar Tafawa Balefa University, Bauchi

Mr. Abur with Dr. Dan-Dakouta and Dr. Egbo, School of Engineering and Engineering Technology, "Food Security: Solar Dryers and Effective Food Preservation."

Adamawa State University, Mubi

Dr. Medugu, Department of Physics, "Performance study of two designs of solar dryers."

Ahmadu Bello University, Zaria

Dr. Suleiman, Department of Agricultural Engineering

Bayero University, Kano

Umoh, Idiongo Bassey and Dr. Isa Garba, Department of Mechanical Engineering, "Design, Construction and Experimental Evaluation of a Double Slope Solar Dryer in Kano Nigeria."

Federal Ministry of Science and Technology, Nigeria

Abdulmalik I.O., Hydraulic Equipment Development Institute (HEDI), National Agency for Science and Engineering Infrastructure (NASENI), "Appropriate Technology for Tomato Powder Production."

Imo State University, Owerri

J.I. Igbozulike and C.O. Kabuo, Department of Food Science and Technology, "Contingency Evaluation of Performance of a Cabinet Solar Dryer Using Fresh Tomato."

Michael Okpara University of Agriculture, Umudike

Akachukwu B. Eke, Department of Agricultural and Bio-Resources Engineering, College of Engineering and Engineering Technology

University of Uyo

A. Folarin Alonge, Department of Agricultural and Food Engineering, "Development and Evaluation of A Medium Scale Direct Mode Passive Solar Tomato Dryer."

The Federal University of Agriculture, Abeokuta

Dr. Bolaji, Department of Mechanical Engineering, "Performance Evaluation of a Solar Win-Ventilated Cabinet Dryer."

University of Nigeria, Nsukka

Dr. Nwoke Okala, Department of Agricultural and Bioresources Engineering, "Analysis and survey on the application of solar dryer in eastern Nigeria."

Dr. Ojike, National Centre for Energy Research and Development, Credentials and Publications

Dr. Eze, National Centre for Energy Research and Development, "Studies on the Effect of Different Solar Dryers on the Vitamin Content of Tomato (Solanum lycopersicon)."

Dr. Okoroigwe, National Centre for Energy Research and Development, "Comparative evaluation of the performance of an improved solar-biomass hybrid dryer."

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Ngulu, Odette. "Using Animated Explainer Videos for Training on Solar Drying Fruits and Vegetables to Mitigate Postharvest Losses." *OpenIDEO*. N.p., 2016. Web. 29 Aug. 2016.

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Value Added Tomato Processing in Mali: An Examination of Possibilities for the Irrigated Zone in Baguineda. N.p., 2008.

“Swedish Designers Are Turning Fruits and Veggies Into a Nonperishable Powder.” *Smithsonian.com*. N.p., 2015.

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Appendix IV: Background on the YieldWise Innovation Scan

The global agricultural innovation landscape is vast. Actors continually generate new ideas relevant to the challenge of reducing post-harvest food loss in Sub-Saharan Africa. There is much to learn, adapt, and apply from other industries and sectors. Staying abreast of innovations opportunities requires an ongoing, purposeful scanning mechanism. As the YieldWise Innovation Partner, the Global Knowledge Initiative (GKI) scans for **adjacent innovations** poised to add near-term value to YieldWise, as prompted by innovation requests submitted by Implementing Partners and The Rockefeller Foundation. In this way, GKI will serve as a dedicated "innovation prospector" for YieldWise.

Adjacent Innovation Defined

Pursuing "new to the organization" tools, processes, etc., that push organizations to put their core capabilities to new use.

(per the *Innovation Ambition Matrix)*

Transformational Innovation Defined

"Developing breakthroughs and inventing things for markets that don't yet exist."

(per the *Innovation Ambition Matrix)*

GKI also will run an Innovation Scan to explore **transformational innovation** possibilities that signal potential to bring about wide-spread impact within the field of post-harvest food loss, and agricultural development more broadly. Beginning in early 2017, GKI will run a series of future-oriented innovation ideation workshops and conduct exploratory research into game-changing trends and opportunities. Thus, our full Innovation Scan will enable YieldWise and its Partners to explore innovation from two distinct but complementary perspectives: adjacent and transformational innovation.

Innovation Attributes Guiding our Scanning Process:

Why does the distinction between adjacent innovation and transformational innovation matter for our scanning process? Namely, they are characterized by different attributes, which propel the scanning process in distinct directions. Transformational innovations, for example, "cause far-reaching changes, affect several branches of the economy, and give rise to entirely new sectors" (Scrase, Stirling, and Geels). Examples of transformational innovations include self-driving vehicles, Internet-of-things technology, 3D printing, and others. These game-changers rarely come along, but when they do, we feel their effects quite dramatically.

Attributes of Adjacent Innovation to guide scan

- Alignment with current practice
- Affordability
- Feasibility of use given prevailing conditions
- Sustainability
- Strategic fit within YieldWise
- Potential for impact on Partners' stated need

Adjacent innovations are distinct from transformational innovation in ways that matter a great deal for YieldWise; they likely will feature more heavily than the rare-but-high-profile transformational innovation in the efforts of YieldWise Implementing Partners. Adjacent innovations align with and build on current practice in an organization, industry, or sector. For example, they are those innovations that readily map to the strategic objectives of YieldWise, and have potential to impact Partners' stated requests. Given the unique environments in which the YieldWise Implementing Partners work, attributes such as affordability, feasibility,

Innovation Opportunities of Focus:

In the first round of scanning for adjacent innovation opportunities, GKI sourced requests from YieldWise Implementing Partners as a starting point. Each of the Implementing Partners — the Alliance for a Green Revolution in Africa (working to reduce food loss in Tanzania's maize value chain); Pyxera Global (working to reduce food loss in Nigeria's tomato value chain); and TechnoServe (working to reduce food loss in Kenya's mango value chain) — presented a single, pressing innovation request. These requests — and the innovation opportunities they represent — are described in greater detail in the following pages. In summary, the innovation requests focused on the following issues:

- For the mango value chain in Kenya: ***How might we enhance the traceability of mangoes produced by smallholder farmers in Kenya?***
- For the tomato value chain in Nigeria: ***How might we best support Nigerian smallholder farmers who want to dry tomatoes as a secondary market opportunity?***
- For the maize value chain in Tanzania: ***How might we leverage information and communication technologies (ICTs) to scale extension and training solutions that support behavior change among smallholder farmers?***

On the surface, these requests might seem quite dissimilar. But once you unpack them, common themes and issues emerge, which point to the core objectives of the YieldWise initiative. Indeed, each request directly connects to broader YieldWise priorities, such as:

- How might we ensure large buyers are able to source locally and sustainably from aggregated smallholder farmers? (Intermediate Outcome, M&E Framework)
- How might we help smallholder farmers meet the quantity, quality, and consistency of requirements of buyers? (YieldWise Strategy Component)
- How might we support targeted innovative technologies in specific value chains? (YieldWise Strategy Component)

GKI's Process for Innovation Scanning:

Upon receiving the Innovation Scan requests from YieldWise Implementing Partners, GKI held a series of consultative conversations with the Partner teams and The Rockefeller Foundation to clarify the requests, gather background, and understand Partners' objectives for the scan process. Our team then undertook a thorough analysis of the "challenge space" represented by each of the requests. We took a broad view of the issues raised by Partners in an attempt to not preordain a particular innovation / solution path. We analyzed the issues from various perspectives; reviewed a diverse set of resources; and spoke with experts knowledgeable in the value chains and challenge areas of focus. We pushed our team members to reframe the requests provided, such that the true drivers of change were put front and center.

Why such an emphasis on understanding the challenge space? In the YieldWise value chains and countries of focus — where smallholder farmers dominate production, operating conditions are tough, and technology adoption is often an uphill battle — translating innovation into impact is as much (or more) about context and incentives for change, as about the technology. Without a clear understanding of the many factors at play — socioeconomic, cultural, political, geographic, market-based, educational — innovation-led initiatives tend to fall short of their goals. Worse, such initiatives can divert precious resources away from the very real, yet unglamorous, work of incremental progress being made on farms, in aggregation centers, and in processing facilities within YieldWise on a daily basis. For these reasons, GKI presents "considerations for decision-makers" for each of the innovation requests. These serve as our attempt to lay out some (though not all) of the most important factors bearing on the effectiveness of innovation-led initiatives.

In Phase I, our team honed in on particular innovation options that offer interesting, compelling ideas for each request and also account for the "considerations for decision-makers". The innovation options look a little different for each challenge, and thus are presented in a slightly different format. These options were not meant to be exhaustive, nor are they full elaborated in this report. Rather, they represented a starting point for brainstorming and further contextual and stakeholder analysis, in which GKI supported the YieldWise Implementing Partners in Phase II of this Innovation Scan.

Looking ahead, GKI will share this report with our YieldWise Implementing Partners and The Rockefeller Foundation. Then we will co-design next steps with Partners. This may involve follow-on conversations with proponents of the innovation options; or additional steps that work best for our Partners. We aim to align our process to the decision-making needs and timelines of our Partners, and thus welcome their close collaboration as we move forward.

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