Seeking to improve productivity, food safety, and economic value for the smallholder farmer
Most smallholder farmers in Sub-Saharan Africa and Southeast Asia manage multiple types of livestock and agricultural activities, typically on less than two hectares of land. Food may be produced for family consumption as well as for sale in local markets. Livestock animals are often living in very close proximity.

The extreme of this is the in-city farm, wherein several kinds of crops, a dairy animal, and poultry may be kept in a very small area adjacent to the family dwelling. For many farming families, the health, diversity, and productivity of croplands and livestock are vitally important to life itself.

Common Challenges
Smallholders often suffer from an insufficient supply of water, which is essential to crop and livestock productivity. And seasons of drought can mean very lean times for families. Women and children must fetch water from distant wells and water points—enough to support their families, animals and crops. Unfortunately, this time-intensive chore competes with schooling and other potentially profitable employment.

Farmers may be literally standing on top of available water—seven meters or more below ground. Commercially available pumps can access this water, but the cost of ownership and operation puts them beyond reach for farmers who make only a dollar or two per day. Global Good is working on more affordable pumps that run on solar power—a plentiful commodity during dry seasons and droughts. We’re also working on water distribution and better methods for transporting water from supply points to farms.

Lack of reliable electricity is also a concern. Even those on the grid experience surges, blackouts, and brownouts. And solar power is often insufficient during the wet season when crops and livestock are at their most productive time.

Without power for refrigeration, getting quality milk from farm to market becomes a real challenge. Once farmers take milk from a cow, bacteria can double every 20 minutes at ambient temperatures. So early morning milk intended for sale must be rushed to regional collector-chillers before it reaches the point of rejection for bacterial quality concerns. Milk collected in the evening, lacking refrigeration, often cannot be sold, so any amount that exceeds the nutritional needs of the family cannot go toward income to purchase other nutritious foods.

Additionally, molds, fungi, and the toxins they produce present significant spoilage problems in the absence of a means for rapid and consistent drying.
of crops for food and feed. Global Good is working on possible solutions to assist with cold storage and transport of milk, as well as crop drying — all without the need for a reliable power grid.

**Practical Solutions**

Ideally, smallholders will be able to easily adopt new technologies and innovations into existing practices and systems and be able to use them with regionally available resources.

For example, our artificial insemination cold-chain system—which helps farmers to cross-breed their herds for better productivity and disease resistance—provides a significant improvement within existing procedures already practiced by inseminators in these regions. And we’re looking at new ways to adapt that system, and cold-chain systems for vaccines, to use more readily available coolants in developing nations.

Smallholder farmers are very resourceful. They are experts at mitigating risk inherent in their businesses. Global Good works with them to provide technology options that complement their specific needs and appropriately takes into account the real challenges that come with living in low-resource settings.

**Looking Ahead**

The pages that follow describe several projects in various stages of development, from early investigation to actual commercialization. Please feel free to contact us for further information regarding any of these topics.
**AI Shield**

*Improving cattle conception rates with cold-chain equipment innovations*

Improved artificial insemination (AI) could enable more successful cross-breeding for farmers who want to obtain cattle with both locally resilient genetics and higher milk yields. Current AI cold chain methods, which use submersion in liquid nitrogen to keep semen cold, offer only limited thermal protection over long distances. Global Good’s AI Shield™ protects bull semen in transport from cold chain breaks, and thus improves conception rates. AI Shield can also reduce evaporative waste of expensive liquid nitrogen.

**The Need**

Until used in inseminations, bull semen must be stored and transported continuously at temperatures well below freezing. Existing transport containers do this by storing the semen in containers directly cooled by liquid nitrogen (LN). In certain countries in Asia and Africa, due to limited LN supply and long distance between supply points, maintaining a proper cold chain is a challenge for distributors and AI service providers. Also, technicians may inadvertently expose the semen to higher temperatures when pulling storage straws out of the canisters. Unwanted freeze-thaw transitions decrease the viability of the semen for fertilization. And this, in turn, limits conception rates and the ability to breed for better outcomes.

**The Invention**

The patent-pending AI Shield lines the walls and bases of existing standard canisters with a material that absorbs liquid nitrogen, and therefore helps to insulate the bull semen from ambient temperatures. The device is manufactured from sintered metal, aluminum rods, and the absorbing material.

AI Shield helps to maintain stable temperatures inside the semen straws to prevent accidental freeze-thaw transitions when canisters are held for periods a few seconds longer than optimal above the frost line. This temperature stability mitigates or reduces potential damage from improper handling. The AI Shield’s added insulation factor may also result in liquid nitrogen savings.

**PRODUCT STATUS**

- The AI Shield has a working time of up to 17 days.
- The invention is patent pending and is being commercialized in Africa and South Asia.
- Manufacturing partners currently include Worthington Industries and Indian Oil. Additional manufacturing and distribution partners are being explored.

**AI SHIELD TEMPERATURE STABILITY**

Here are the temperatures recorded at the middle of the semen straw while lifted from the canister for 60 seconds — for a standard canister and for AI shield. The slight temperature increase in the AI shield line is imperceptible.

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*AI storage straws are lifted from the canister for use in the field.*

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The Mazzi Can

Clean and effective storage of milk to strengthen farmer linkages to formal markets

Many smallholders practicing subsistence farming rely on milk as an essential source of daily income. Use of the Mazzi™ milk container, less expensive than metal cans and readily cleanable, can improve the quality and quantity of milk successfully delivered to market, resulting in higher incomes for farmers. Mazzi can be manufactured locally for better affordability.

The Invention

The durable, 10-liter Mazzi container was invented specifically to streamline the collection, storage, and transport of milk to help smallholders maximize their income.

The Mazzi has a very wide funnel, which can be secured to its top for capturing milk directly into the container and thus reducing risk of contamination. The dark color of the funnel provides a visual contrast to the milk and makes it easier to identify signs of udder infection, such as mastitis. The sieve-like opening on the funnel also limits spillage if the container is kicked over or dropped. The interior of the container can be easily cleaned, thanks to a large opening and no inaccessible areas that could otherwise retain contaminants.

The tethered lid provides a leak-proof seal after milking and also allows the Mazzi containers to be stacked during transport. Single Mazzi containers can easily be carried by hand or stacked or roped onto bike, truck, or animal. Volumetric markings on the translucent container support fair price negotiations.

The Mazzi is made from food-grade plastic that has earned regulatory approval from the US FDA, Kenya Dairy Board, and other national authorities.

PRODUCT STATUS

- Studies of Mazzi usage show as much as ten-to-one reduction of bacterial count compared to typically used Jerry cans.
- Mazzi is in its fourth generation of development. It is currently manufactured in Kenya and Ethiopia, and being made available in select markets.
- Please contact Global Good if you are interested in being a manufacturing or distribution partner.

The Need

Millions of smallholder dairy farmers rely on milk for both household subsistence and family income. Unfortunately, in large part they lack available, affordable options to safely collect, store, and transport milk to collection centers or other buyers.

Metal cans are generally too expensive. The more affordable plastic “Jerry cans” tend to break easily, are difficult to clean, and must be replaced often. They are not designed specifically for milk storage and transport, and are rejected by many milk markets. As a result, valuable milk often spoils or spills before it can be sold.

SMALLHOLDER MILK LOSS

In the overall diary value chain, the farmer incurs the majority of milk loss — often due to spillage and container-related contamination.

<table>
<thead>
<tr>
<th>Milk Losses in the Dairy Value Chain</th>
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<tbody>
<tr>
<td>On-Farm Loss</td>
</tr>
<tr>
<td>Primary Collection</td>
</tr>
<tr>
<td>Secondary Collection</td>
</tr>
<tr>
<td>Transport &amp; Sale</td>
</tr>
</tbody>
</table>

Rapid Assessment of Milk Bacteria
An efficient and effective tool to test milk quality at point of collection

Global Good is developing a simple, affordable diagnostic test that is sensitive enough to quickly provide meaningful information on the bacterial load in milk. Such a test could enable farmers to more readily recognize the transmission of mastitis disease between cows and work towards reducing spoilage in the milk they produce. It may also enable differentiated payments to smallholder farmers according to milk quality, thus providing incentive for better practices for milk collection, storage, and transport.

The Need
Commercial milk processors often lack the confidence to source milk from smallholder dairy farmers because of uncertainty about the milk quality – especially relative to bacterial load. Thus, smallholders are often unable to sell into higher-value markets where they can fetch higher prices. Collectors and processors may be able to afford industry standard tests. However, as they are testing milk after it has been pooled, their results cannot help to identify how much of the discovered bacterial is attributable to any specific farmer. In order to incentivize milk quality and decrease practices that promote spoilage and the spread of mastitis, there must be an affordable, rapid test for the presence of bacteria in milk at the point of collection.

The Invention
Global Good is developing a test to enable in-the-field measurement of bacterial levels in milk. This simple analytic procedure will provide a rapid, semi-quantitative reading to broadly detect diverse bacterial species with high sensitivity. Proof-of-concept experiments show that the planned “colorimetric” method is effective—using color intensity to correlate with the concentration of bacteria or the degree of milk spoilage.

The test will provide results within ten minutes of sampling, detecting down to 1,000 Colony Forming Units per milliliter (cfu/mL) without the need for any additional instrumentation. Furthermore, the test will be broadly applicable to non-dairy milk and other liquids.

PRODUCT STATUS
- Field assessments to shape product design are being carried out in Sri Lanka, Ethiopia and Morocco.
- The invention is in product development phase, focusing on sensitivity, quantitation, storage conditions, and test format.
- Manufacturing and distribution partners are being explored.

THE NEED FOR ASSESSMENT
IV Laboratory measured the bacteria in 600 milk samples stored in Jerry cans by Kenyan smallholders. A majority of the samples exceeded normal grade ranges. Affordable bacteria assessment will help toward greater awareness and systemic improvements.

<table>
<thead>
<tr>
<th>Milk Grade by TVC bacteria (cfu/mL)</th>
<th>Percentage of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I Below 200,000</td>
<td>18%</td>
</tr>
<tr>
<td>Grade II 200,000 to 1,000,000</td>
<td>18%</td>
</tr>
<tr>
<td>Grade III 1,000,000 to 2,000,000</td>
<td>8%</td>
</tr>
<tr>
<td>Out of Range Above 2,000,000</td>
<td>56%</td>
</tr>
</tbody>
</table>

Bacteria measured as Total Viable Count (TVC) in colony-forming units per milliliter (cfu/mL).
Lift Pumps for Intermediate Depths

Affordable pumps to access water between 7 and 20 meters below ground level (mbgl)

For smallholder farmers, year-round access to water would promote cross-seasonal production that could effectively double agricultural output and increase resilience, food security, nutrition, and income. But for millions of smallholders, the underground water table is at a depth that cannot be affordably accessed through existing expensive water lifting solutions. A low-cost pumping system capable of lifting water from as deep as 20 meters has the potential to improve livelihoods by providing year-round water for crops and livestock.

The Need

At least 10 million Sub-Saharan African farmers are situated over underground water that they are unable to affordably access because it is located too far down for typical suction pumps. The inability to access this water in all seasons is stunting Africa’s production capacity for crops and livestock. Global Good and its partners have identified a market need for a pump that is capable of lifting water from depths of 7 to 20 meters, at sufficiently low capital and operating cost and with sufficient pumping capacity to cover the costs by irrigating at least one quarter acre of crops, or to provide water for livestock.

The Invention

To meet the need, Global Good is developing a solar-powered lifting and pumping technology for accessing water down to 20 meters in depth. The technology has been explicitly designed for affordability. The goals is to provide a device at a price that can be recouped by the farmer within 12 to 18 months.

A groundwater access system requires multiple components: a pump to lift the water, a motor to actuate the pump, and an energy source to power the motor. Global Good’s innovations are intended to optimize the pumping system for maximum efficiency, minimizing the solar energy needed and hence the operating equipment required, thus improving the affordability of the pump. The use of solar energy avoids the need for costly petrol or diesel fuels and capitalizes on the availability of sunlight during drought seasons when pumping is needed most.

Global Good has also been exploring cost-efficient borehole siting technologies to increase the success rates in finding ideal well-drilling locations. Such technologies could work in conjunction with the intermediate depth lift pump by reducing the total cost of siting, drilling, and accessing water.

PRODUCT STATUS

- Market and field assessments to shape initial product design and launch will focus on regions of sub-Saharan Africa that have groundwater at 7-20 meter depth and have experienced crop and livestock losses due to drought.
- The pump device project is currently in research, design, and development mode by the Intellectual Ventures Lab.
- Please contact Global Good if you are interested in becoming a co-development, manufacturing, or distribution partner.

ACCESSIBLE WATER

Affordable pumping systems will enable access to available water in majority of Sub-Saharan Africa.

Fertilizer Contents Detection
Validation of fertilizer contents to deter adulteration and enhance yields

A reliable, handheld device to validate fertilizer contents will help intermediaries in the fertilizer supply chain, such as rural agro-dealers, to reject supply that does not meet the packaging claims. This will help to support the sale of only quality product. This idea holds great potential for significantly reducing adulteration, and will ultimately benefit the agricultural yields of smallholder farmers who allocate scarce resources to costly inputs, such as fertilizer.

The Need

Adulteration of fertilizer is a problem commonly found in countries supply chains for agricultural inputs are weak. In one West African country, the International Fertilizer Development Center found that nearly half of fertilizers sold there lacked the claimed nutrient content and a quarter had no package labeling regarding the type and concentration of nutrients. Fertilizers that have been adulterated with sand or sawdust fail to deliver the expected yield improvements and incur devastating effects on smallholder farmers who take substantial monetary risks when investing in fertilizer.

Properly labeled and validated fertilizers will enable smallholders to select reliable inputs that will help to correct soil deficiencies and best improve crop outputs. Supply chain intermediaries, such as rural agro-businesses, fertilizer suppliers, and farmer cooperatives have an incentive to sell quality product to enhance their sales, but they need a field-friendly tool to readily verify fertilizer contents.

The Invention

Global Good is developing a low-cost, battery-operated, handheld spectrometer to enable convenient detection of fertilizer contents. The objective is to be able to measure bulk fertilizer components to verify labeled ingredient claims. The planned device will report on the content of the available fertilizer components within approximately +/- 5 to 10% of the labeled level of nitrogen and other elements.

PRODUCT STATUS

- Market and field assessments will shape initial device design and launch. These may focus on Zambia, Nigeria, Kenya, Tanzania, Uganda or Ethiopia.
- The device is currently in research, design, and development mode by the Intellectual Ventures Lab and is anticipated to be commercialized by 2018.
- Please contact Global Good if you are interested in being a co-development, manufacturing, or distribution partner.

IN-MARKET DISCREPANCIES

In Uganda, fertilizer supply may be associated with the MAAIF (Ministry of Agriculture, Animal Industry and Fisheries), UNADA (Uganda National Agro-Input Dealers Association), or neither. In-market testing of (labeled) 17% Nitrogen fertilizer indicated a wide variance in Nitrogen content across all supplier types.


Soil Nutrient Diagnostics
Understanding soil composition to guide mitigation measures for improved yields

Soil health is critically important to crop yields and to the nutritional health provided in crops. Global Good is developing a field-friendly diagnostic tool to help agricultural extension workers better understand soil deficiencies and support corrections through improved crop management practices and appropriate fertilizer advice. The information obtained from this technology may also guide farmers on the best crops for their soil type. A more precise understanding of soil health will also increase the efficiency and effectiveness of smallholder investments in agricultural inputs.

The Need
Understanding soil health is essential to farm management. However, in Sub-Saharan Africa, little information about soil nutrition is available. Broad-scale soil mapping systems, such as AfSIS (Africa Soil Information Service) or EthioSIS (Ethiopian Soil Information System), are mainly effective at an institutional level for guiding regional policy recommendations. However, smallholder farmers would benefit from individualized soil recommendations for their specific plots of land, and from the ability to get updates after interventions. Understanding soil health can result in improved crop yields, improved willingness to pay for appropriate agricultural inputs, and more efficient use of labor to manage crops.

The Invention
Global Good is developing a low-cost, handheld soil-nutrient spectrometer for use in low-resource settings by governments as well as retailers and NGO-affiliated and private sector agricultural extension officers advising smallholder farmers. The device is based on spectroscopic methods that measure signals from soil components and identify them based on their unique spectral signatures.

The device is intended to operate on batteries and be able to withstand rugged conditions, such as heat, humidity, rain, and dust. It will bring the performance of existing lab-based soil tests to the field, thus enabling immediate feedback to the farmer on soil nutrients to inform improved crop management. In addition to supporting individual farmers’ decisions, it will support the broader, public good through the sharing of soil data with existing mapping efforts.

Product Status
- Market and field assessments to shape initial product design and launch may focus on Zambia, Nigeria, Kenya, Tanzania, Uganda or Ethiopia.
- The device is currently in research, design, and development mode by the Intellectual Ventures Lab and is anticipated to be commercialized by 2018.
- Please contact Global Good if you are interested in being a co-development, commercialization, or field partner.

Soil Analysis and Fertilizer Payback
Awareness of soil quality supports investment in fertilizers that best complement the smallholder’s specific plot. Shown below, the crop value gained from adding nitrogen fertilizer depends on the carbon content in the soil.

Control of Toxins through Drying

Biogas-powered drying to control moisture and toxin levels

Inadequate drying of crops or inadequate storage can lead to growth of harmful fungi which can result in accumulation of mycotoxins (e.g., aflatoxins and fusariotoxins) correlated with health problems such as stunted growth. Additionally, wet grain and legumes can foster vermin population, which leads to a temptation to add pesticides that may be toxic upon consumption. To prevent such toxins from entering the food and feed value chain, Global Good aims to develop farm-level biogas/solar-powered dryer/sterilizer devices to control moisture and mitigate spoilage.

The Need

Reliable control of moisture and fungi in crops is critical to the prevention of mycotoxin deposition and can reduce other toxin risks. However, in certain parts of Asia and Africa, there are few ways to control moisture and molds given climate and limited resources for crop management, post-harvest drying, and storage. As a result, toxin levels in crop products that are used for food or feed in these regions can be high, and climate change may be increasing the risk, contributing to poor human and animal health and nutrition. Crop rejections by processors and restricted ability to export also limit economic development. Improved all-season drying methods for low-resource environments may decrease toxin deposition and aid in the elimination of fungus. Improved moisture monitoring methods can enable better decisions and price negotiations thus incentivizing the use of improved drying.

The Invention

Global Good is exploring development of low-cost moisture-monitoring solutions along with an affordable hybrid solar/biogas-powered drying system that may also function as a spore and mold sterilizer. The system may be used at the farm level to provide farmers with means to increase crop marketability and nutrition value of locally used feed and food — perhaps eventually for fruits, vegetables, meat and fish. It may also be used near to the farm in an ecosystem whereby farmers are connected with traders, millers, feed companies, or food processors to provide real-time feedback and response to toxin levels.

The system may also be able to use cast-off aflatoxin-contaminated materials as biofuel with the added benefit of helping eradicate fungus and remediate toxins while generating heat.

Drying methods vary considerably in developing nations.

PRODUCT STATUS

- The device is currently in research and ideation mode by the Intellectual Ventures Laboratory.
- Market and field assessments to shape initial product design and launch may focus on Southeast Asia and/or East Africa.
- Please contact Global Good if you are interested in co-development, commercialization, or field partnership.

TEMPERATURE AND MOISTURE EFFECTS

Molds and pests in stored grains propagate more rapidly in the presence of increased moisture. Higher temperatures can accelerate the growth.

Source: Csiro Ecosystems Sciences
Remediation of Aflatoxin in Crops and Feed

Safeguarding the food supply chain via treatment of contaminated crop materials

Aflatoxin, considered a significant threat to food safety, is a widespread problem in regions of the world that lack sufficient tools for adequate drying and storage of crops. Global Good is working with partners to develop novel methods of remediating fungal toxins in contaminated feed and feedstocks through protein-mediated toxin deactivation methods. This will help to reduce toxicity effects on animal feed efficiency and productivity and ultimately reduce toxin entry into human food chains via animal-derived foods such as milk.

The Need

Low-resource areas often lack tools for early detection and prevention of aflatoxin deposition. This lack contributes to contamination in overall food and feed systems. Food processors, millers, and feed companies at the end of the value chain sometimes reject aflatoxin-contaminated crops. However, the rejected material is often subsequently sold to local buyers or fed to animals. Preventing re-entry of these toxins into animal feed or use as food is critically important to human and animal health and nutrition. Current industrial methods of aflatoxin remediation may require large amounts of energy and extreme chemical conditions that are unsuitable for farms and processors in low-resource settings. More effective means of remediation are needed to keep toxins out of animal feed.

The Invention

Global Good is co-developing proteins that could irreversibly bind and inactivate aflatoxins, targeting superior performance over existing solutions for remediating aflatoxin in feed. We are also exploring alternate remediation methods, including adaptation of the conditions used in industrial processes by providing for enzymatic catalysis or other more accessible conditions in low resource settings. This approach may also enable use of the resultant treated material in value-added applications such as fertilizer or biofuel generation.

PRODUCT STATUS

- Global Good is seeking co-development, field testing and commercialization partners.
- The binding protein-based remediation is being co-developed in the Intellectual Ventures Laboratory and a collaborating laboratory.

BINDING AFLATOXINS

Industry studies show that clay product additives in cow feed reduce the level of aflatoxin in the milk produced.

Millions of people suffer and die each year in developing countries from causes that humanity has the scientific and technical ability to solve. Global Good is a collaborative effort between Bill Gates and Intellectual Ventures to address this. We take on some of humanity’s toughest problems through the power of invention by drawing on resources normally reserved for commercial pursuits in the developed world. Global Good combines IV’s unique invention prowess with the expertise of leading humanitarian organizations, forward-looking governments, and commercial partners that share our vision. Together, we invent, develop, and deploy commercially-viable technologies aim to improve life in developing countries.