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 or peri-urban 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 even small crop-lands and small numbers of 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 health and productivity. And often-unpredictable seasons of drought can mean very lean times for families. Typically in many places, 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.

Yet smallholders may be literally standing on top of available water located seven meters or more below ground. Commercially available pumps can access this depth, thus making water available to wealthier farmers who can afford such pumps. But the cost of ownership and operation puts such pumps 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 who are on the power 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.

Unreliable cold chain causes many problems for safe handling of fruits and vegetables, meat, fish, and other food products. For example, getting quality fresh milk from farm to market can be a real challenge. Once a farmer has collected a cow’s milk, its bacteria level can double every 20 minutes at ambient temperatures. So early morning milk intended for sale must be rushed to a regional collector-chiller before it reaches the point of rejection due to excessive bacterial content. Lacking refrigeration, milk collected in the evening often cannot be sold, so any amount remaining after meeting family nutritional needs 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. Unseasonal rains or the need to harvest early to avert pest and diseases problems may present significant spoilage challenges. Reliance on solar energy for crop drying is not sufficient, especially in view of climate change. Global Good is working on possible solutions to empower farmers to deal with these challenges despite the inability to rely on the power grid.

**Practical Solutions**

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.

Ideally, the innovation and technologies we work with should be easily adoptable into existing practices and systems so that entrepreneurs such as smallholders will be able to use them with regionally available and appropriate resources.

For example, our artificial insemination cold-chain system—which aims to enable farmers who want to crossbreed their herds for better productivity and disease resistance—provides a significant improvement within the procedures already practiced by inseminators in these regions. And we’re looking at new ways to adapt that system, and vaccine cold-chain systems, to utilize coolants that are more readily available in low- and middle-income nations.

**Looking Ahead**

The pages that follow describe several projects in various stages of development, from early investigation to actual commercialization. Feel free to contact us for further information on any of these topics.
Intermediate-Depth Lift Pumps
Improving water availability for livestock and crops

For smallholder farmers, access to water for irrigation promotes cross-seasonal production that may effectively double agricultural output and increase crop resilience, food security, nutrition, and income. Unfortunately, the water table for millions of smallholders is at a depth that cannot be affordably accessed through existing water-lifting solutions. A low-cost irrigation pumping system capable of lifting water from deeper than seven meters could significantly improve livelihoods by enabling a shift from rain-fed to irrigated crops and a potential extension of the growing season.

The Need
At least 10 million Sub-Saharan African farmers are situated over subterranean water that they cannot affordably access because it is too deep for typical suction pumps. The inability to access this water impedes year-round production capacity for crops and livestock. Global Good has identified a market gap in the need for pumps capable of pumping from a 7 to 20 meter depth at sufficiently low purchase price and operating cost, and capable of irrigating at least 0.25 acres of crops or to provide water for livestock.

The Invention
Global Good is investigating ways to improve upon solar-powered lifting and pumping technologies for accessing water down to 20 meters deep.

Accessing groundwater requires multiple components: a pump to lift the water, a motor to actuate the pump, and an energy source for the motor—all of which must be optimized in an efficient affordable design that is suited to the type of land under cultivation. We’re seeking to make this technology portable for farmers who have security concerns, work multiple dispersed plots, have insecure land tenure, or whose rents may rise with permanent installations. Current cost estimates for technologies under consideration allow for the typical smallholder’s need to recuperate the pump purchase cost in less than 18 months. We’re also exploring an accompanying decision-support tool to provide guidance for farmers and the financial institutions that assist them in acquiring pumps or other irrigation technologies. Farmers and financiers alike can benefit from having a better understanding of the potential risks and rewards of various investments in irrigation equipment.

PRODUCT STATUS
• The device is currently in research, design, and development mode by the Intellectual Ventures Lab.
• Market and field assessments in Sub-Saharan Africa aim to inform initial product design and launch.
• Please contact Global Good if you are interested in becoming a commercialization or distribution partner.

INCREASED WATER ACCESS
Water below seven meters, too deep for common suction-based systems, will be more affordably accessible with new pumping solutions.
Irrigation as a Service

Improving food security and economic benefits with mechanized on-demand watering

In sub-Saharan Africa, the gaps between actual and potential crop yields are among the highest and most geographically extensive in the world. Only 3% of cultivated land in sub-Saharan Africa is equipped for irrigation, even though about 30% of Africans living on agricultural land have access to nearby surface water or shallow groundwater. Transition from watering cans to mechanized irrigation pumps could significantly extend the growing season and increase dry-season productivity. Global Good is investigating an innovative solution to enable cross-seasonal irrigation.

The Need

Surveys of smallholder farmers in several East and West African countries found that between 70 and 90% of irrigation is conducted using manual water lifting and transport (e.g. hauling buckets). This time-intensive and laborious approach limits the scale of production and incurs a significant opportunity cost for other agricultural and entrepreneurial pursuits and (often) girls’ education. Farms using mechanized irrigation methods see as much as double the crop yield compared to farms using human-powered irrigation. Mechanized irrigation also enables irrigation of larger areas than what can be hand-watered. Despite the potential benefits in yield and total production, the capital cost of purchasing irrigation equipment precludes many smallholder farmers from adopting mechanized methods.

The Invention

Global Good aims to provide smallholders a practical and affordable alternative to manual irrigation by developing a service-for-hire irrigation model. We are exploring a water pump device that is powered by the engine of a motorcycle and can be readily attached to (and detached from) the motorcycle. In this service-for-hire model, the motorcycle operators would irrigate smallholders’ plots when paid to do so. Thus, the farmers will be able to obtain the benefit of mechanized pumping without the high equipment-cost risk, and concurrently the motorcycle operators can diversify their income.

Motorcycles are already widely available in many parts of rural Africa where they are commonly employed as transportation for hire. The use of motorcycles as a power source allows the pump to be cheaper and smaller than a typical motor pump while addressing the common challenge of unreliable electricity supply in remote areas.

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Grain Moisture Assessment

Tools to improve nutritional value, food safety, and economic benefits

Awareness of moisture levels in grains and grain legumes can help farmers predict and prevent fungal growth, thereby reducing the likelihood of toxin deposition, nutrition detriment, and other effects of spoilage. Global Good is developing robust, affordable moisture meters to provide rapid feedback to farmers and market aggregators, aimed at enabling them to make informed decisions on best timing, durations, and methods of crop drying and storage.

The Need

Human and animal diets rely heavily on grains, such as rice, sorghum, millet and maize, as well as grain legumes such as cowpea, groundnut, and soya bean. However, inadequate drying and storage practices for these food crops, especially in warm and humid climates, can lead to fungal growth and mycotoxin deposition causing spoilage and loss of nutritional and economic value.

To predict potential fungi and mycotoxin levels in purchases from smallholders, large-scale grain buyers will assess moisture levels in the grain and legume crops and adjust the price that they pay accordingly. The farmers are at a disadvantage because they lack the means to independently determine the dryness of their crops. For the farmers and smaller aggregators, available moisture meters are prohibitively expensive and impractical; their parts are difficult to replace and they require frequent calibration and specialized knowledge to interpret results.

The Invention

Global Good has been developing affordable hand-held devices for moisture measurement, supporting users in key decisions for drying, storing, and selling grain.

Our farmer-focused device, which we aim to see deployed first, will improve on the design and user interface of an existing very-low-cost equilibrium hygrometer product type. It will support decisions for drying and storing crops whether for sale or home consumption. Global Good prioritizes the development of this device because of its potential positive impact for smallholders.

The devices will operate well in low-resource conditions, functioning properly in dusty environments, high temperatures, and high humidity. They will run on batteries and require little or no additional instrumentation or sample preparation.

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Improved Crop Drying

*In the face of uncertain weather, controlling toxins to reduce losses and increase food quality*

Inadequate drying of crops can lead to spoilage, loss of food supply, and decreased income. Moisture remaining in harvested crops supports growth of fungi that can spoil crops and cause accumulation of mycotoxins correlated with human and livestock health problems such as stunted growth. Wet grains and legumes also foster vermin populations, so farmers might apply pesticides, introducing chemical toxins into feed and food value chains. To help prevent these problems, Global Good aims to develop a farm-level dryer to control moisture and mitigate spoilage.

**The Need**

Unreliable weather patterns and the effects of climate change are increasing the risk of farmers being unprepared for damaging conditions, for which traditional methods of sun drying can be unreliable and ineffective. Yet many parts of Asia and Africa, lacking resources, have no alternatives for controlling moisture and molds. As a result, moisture-driven toxin levels in crop products used for food or feed in these regions can be high. Rejection of spoiled crops by market traders, aggregators, and processors limits the farmers’ potential for economic development, including the ability to export. These concerns indicate the need for more effective all-season drying methods suitable to the specific requirements of these at-risk farmers.

**The Invention**

Global Good is exploring development of low-cost systems that can function off-grid and can be used to dry multiple types of crops regardless of weather conditions. Such systems are intended to be used at the farm level or as close to farm gate as possible to provide farmers with the means to increase both the market acceptability and nutritional value of crops, and to complement other diagnostic tools in ecosystems where real-time feedback is given on toxin levels that are affected by drying. While the initial focus is on typical farm crops, innovations may potentially be applicable for meat, fish, and a wider range of horticultural crops. An ideal drying system may also enable producers to utilize aflatoxin contaminated materials as biofuels for generating electricity, thus efficiently redirecting materials that would otherwise be wasted or perhaps consumed despite high levels of contamination.

**PRODUCT STATUS**

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

**WEATHER DEPENDENCY**

For solar drying of maize crops, it is ideal to have at least five consecutive rainless days. This image represents regions across Ghana showing, for an average year, the number of days during maize harvest season that a farmer could have chosen to begin crop drying with five consecutive dry days following thereafter.

Solar drying methods are helpful but are limited by weather dependency

<table>
<thead>
<tr>
<th>Region</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Source: Ghana Regions: Occurrences of five consecutive dry days in maize harvest season, 30-year average.
Fungal spoilage in crops causes many problems, from negative effects on food quality and palatability— affecting market value—to serious health hazards such as mycotoxin deposition. Awareness of unseen fungal spores in crops at point of harvest or earlier, and awareness of fungus growth risks in storage, can enable farmers to make better choices about harvesting, drying, and storage so as to prevent fungus-related losses. Global Good is developing an inexpensive rapid test to detect and quantify the risk of toxin deposition by fungi in crops at an early stage when farmers can still control the outcomes.

Families in low-income countries rely on grains as a main source of caloric intake and legumes as a major source of protein. These crop types are harvested and dried at seasonally limited times, then stored and sold or consumed over subsequent months. In storage, grains are particularly vulnerable to growth of fungi that can cause damage, especially in conditions of moisture and heat.

Current practices only test for the presence of harmful fungi and mycotoxins upon aggregation, processing, and export, far from the farm gate. If contamination is discovered at later stages, conscientious buyers will likely reject the contaminated batches and may blacklist all the producers in a suspect source area to avoid further contamination and loss. Nevertheless, rejected batches are still sold at lower prices into other market channels, often for consumption by the poorest people or for animal feed. So contamination can still enter the food chain via fungi in grains fed to livestock that pass along toxic compounds in milk and meat. And farmers are not enabled to take preventative measures even if they want to do so.

The Invention

Global Good is developing a low-cost rapid feedback diagnostic test, for use closer to the farm gate, to detect mycotoxin-producing fungi such as Aspergillus and Fusarium or the toxins they produce. Effective for use during the growth and harvest process as well as during storage, the test could provide information to help farmers reduce or prevent fungi-caused spoilage. We’re also exploring hazard prediction using the weather and pest and disease incidence. Ultimately, improved remediation of crop fungi can enable smallholders to sell better quality product, which is safer to consume and commands a higher price at market. Global Good is also exploring other applications for this technology, including the ability to test farm soil for the presence of harmful fungi, thus enabling interventions at an even earlier stage in the agricultural cycle.
Aflatoxin Remediation in Animal Feed

Reducing toxins in livestock feed for animal health and human food safety

Aflatoxin, which is present in crops and considered a significant threat to food safety, is a widespread problem in areas where climates and farm practices foster the growth of aflatoxin-producing Aspergillus flavus. Global Good is working to develop novel methods to remediate aflatoxin contamination of crops destined for animal feed in low-resource settings. Deactivation or removal of toxins is aimed to help improve the quality of animal products—such as milk, eggs and meat—to reduce the level of toxins that enter the human food chain and also improve animal health and productivity.

The Need

Low-resource settings often lack the needed tools for detecting and preventing aflatoxin deposition early in the supply chain, which contributes to subsequent contamination in overall food and feed systems. While food processors, millers, and feed companies can reject aflatoxin-contaminated crops, this same rejected material might still be sold to informal markets and then will still be consumed by people or fed to animals. Avoidance of this practice is critically important to human and animal health and nutrition.

Animals that consume aflatoxin-contaminated food may absorb or metabolize the toxins and then release the toxins into outputs such as milk. The addition of aflatoxin-adsorbing clays to cattle feed is a common mitigation practice, but is of limited effectiveness, especially in view of high or unknown levels of contamination in low-resource settings. Industrial methods of aflatoxin remediation require large amounts of energy or 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 and the human food supply.

The Invention

Global Good is co-developing proteins intended to irreversibly bind and inactivate aflatoxins. This work is targeting superior performance over existing solutions for remediating aflatoxin in feed. Addition of rumen-suitable proteins to cattle feed, for example, could improve many farm outcomes such as better productivity (e.g., milk volumes, calf weight, quantity of meat), decreased illness, thriving calves, and enhanced market access—all while decreasing the amount of aflatoxin in animals and animal products. Global Good is also exploring the use of insects to detoxify feed, particularly for poultry and aquaculture applications.

PRODUCT STATUS

- Global Good has partnered with a co-development laboratory and is seeking testing partners for the field and for scale-up development.

- If you are interested in commercialization or field partnership, please contact Global Good.

MYCOTOXIN PREVALENCE

Fungal-borne mycotoxins are found in a wide variety of foodstuffs in the farm-to-food supply chain. This table lists just a few examples of the many types of mycotoxins that affect commonly grown and consumed crops in sub-Saharan Africa and elsewhere worldwide.

<table>
<thead>
<tr>
<th>MYCOTOXIN TYPE</th>
<th>PRINCIPAL FUNGAL SOURCE</th>
<th>FOODSTUFFS AFFECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin B1, M1</td>
<td>Aspergillus flavus</td>
<td>Dairy, Maize, Groundnuts</td>
</tr>
<tr>
<td>(also B2, G1, G2)</td>
<td>and A. parasiticus</td>
<td></td>
</tr>
<tr>
<td>Fumonisin FB1, FB2</td>
<td>Fusarium</td>
<td>Maize</td>
</tr>
<tr>
<td>Deoxynivalenol (DON)</td>
<td>Fusarium graminearum and F. culmorum</td>
<td>Wheat, Maize, Barley</td>
</tr>
</tbody>
</table>

Soil Nutrient Diagnostics
Accessible timely analysis for more effective agricultural practices

Soil health is critically important to farm-yield productivity and to the nutritional quality of the crops. Global Good is developing field-friendly diagnostic tools to help better understand soil potential and deficiencies. These tools will enable extension workers to better assist farmers with improved soil and crop management practices and appropriate advice. The resulting more-precise understanding of soil health is intended to increase the efficiency and effectiveness of smallholder investments in fertilizer and other agricultural inputs.

The Need

In parts of Africa and southeast Asia, soil nutrition information is only sparingly available to smallholder farmers and extension workers. Broad-scale soil mapping efforts, such as AfSIS (African Soil Information Service), can be effective for guiding policy recommendations at a regional level. But smallholders could also benefit from farm-specific recommendations for the soils on their individual plots, as well as feedback after implementing interventions. A clearer farm-specific understanding of soil health and means to increase nutrients and avert erosion can lead to targeted selection of appropriate agricultural inputs and the willingness to pay for them to obtain improved farm outputs.

The Invention

Global Good is developing a hand-held soil analysis device for use by agricultural extension officers from government, private sector, and NGO-related organizations. This nutrient-detecting spectrometer will measure reflectance/absorbance signatures of components in the soil.

Intended for various applications in low-resource settings, the battery-operated device will withstand rugged conditions, such as temperature extremes, humidity, rain, and dust. Providing lab-quality soil testing in the field, it will give farmers immediate feedback on key soil characteristics to inform improved crop management.

The device will support consultation with farmers about the land and crops they are farming. And, with farmer permission, it will share on-farm findings with the soil information databases of existing mapping efforts, available for public good. Collective agronomic and fertilizer recommendations may provide greater utility when data from these soil analysis devices can feed into and draw upon a “smart farming” data analysis and decision support system for improving locally adapted outputs.

PRODUCT STATUS

- The soil assessment device is currently in research, design, and development mode by the Intellectual Ventures Lab.
- Market and field assessments to shape product design and launch may focus on Tanzania, India, or Ethiopia.
- Please contact Global Good if you are interested in being a co-development, commercialization, or field partner.

SMART FARM CONNECTIVITY

Improved on-farm soil analysis coupled with regional soil information databases aim to provide smallholders with more effective recommendations for soil amendments.

Source: Intelligent Device research group, Global Good
Rapid Assessment of Milk Bacteria

Effective testing of milk bacterial load at the point of collection

Bacteria of many kinds can grow in milk and cause off-odors and flavors, deterioration of nutritional quality, and in-processing characteristics for making cheeses, yogurts, and other products. Milk buyers commonly reject milk that may have heavy bacterial loads. Global Good aims to develop a simple, affordable test that is sufficiently sensitive to rapidly provide smallholder farmers with meaningful information on the total bacterial load in milk. Such a test could enable informing and incentivizing bacteria avoidance practices in the collection, storage, and transport of milk in low resource settings, supporting better livestock health and stable income.

The Need

Large-scale dairy companies may resist buying milk from smallholders due to the prevalence of poor, inconsistent milk quality. Of primary concern is the bacterial load in the milk, which may be particularly high due to farm practices that unknowingly allow rapid spoilage and spread infections such as mastitis.

In low-resource settings, sufficiently sensitive testing for milk from multiple sources is often only available after milk has been centrally pooled. Milk collectors are unable to use that type of testing to inform which farmers are providing the lowest or highest quality milk; they cannot provide helpful feedback to promote best practices that would discourage spoilage and reduce the spread of mastitis while also increasing the milk’s quality and market value.

The ability to test milk with rapid information closer to the farm gate would enable the collectors to objectively identify higher quality milk and pay for it accordingly. Farmers would be rewarded for implementing better livestock health and sanitation practices, and could also gain fuller economic and nutritive potential from their farm outputs.

The Invention

Global Good aims to develop a simple, low-cost test to measure the total bacterial load in milk at various points of collection and aggregation in the milk supply chain. The test could provide a rapid, semi-quantitative reading regarding the presence of bacterial high loads, even if there are multiple species involved, possibly differentiating bacteria types. The targeted test will help grade milk at various levels of bacteria, providing results in less than 15 minutes and detecting from tens of thousands to millions of colony-forming units per milliliter. The test may also be applicable to non-dairy milk and other fluids, such as juices and vegetable pastes.

PRODUCT STATUS

- The invention is in ideation and product development phase.
- Field assessments in Sri Lanka, Ethiopia, and Morocco will help shape product design.
- Global Good is exploring potential manufacturing and distribution partners.

MILK BACTERIA AWARENESS

IV Laboratory measured the bacteria in 600 milk samples stored in Jerry cans by Kenyan smallholders. (Jerry cans are discouraged by the government and many milk buyers but are still often used for milk.) 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).
**Oestrus Detection**

*Improving the timing of artificial insemination for better herd genetics*

To improve herd genetics for better livestock health and farm productivity, farmers will cross-breed their cattle with preferred breeds via artificial insemination (AI). However, the attempt to attain pregnancy is only successful if the AI procedure is correctly timed in accordance with the female’s oestrus cycle. Global Good has been developing an affordable, field-robust tool to enable farmers to accurately detect cattle oestrus. Such a technology is generally unavailable to cattle farmers in settings where resources are limited and small numbers of cattle are confined to small areas.

**The Need**

Farmers worldwide seek the advantages of artificial insemination to intentionally select for the traits needed in their particular circumstance. For any artificial insemination program, accurate and reliable detection of cattle oestrus is critically important. However, current methods in low resource settings may depend on unreliable indicators of oestrus to determine when to call an artificial inseminator. This can result in improperly timed and failed artificial insemination attempts and the loss of the farmer’s expenditure on costly bull semen. Furthermore, because of gestation timing, the farmer will not know quickly whether or not the attempt was a failure—which increases the calving interval, further decreasing the potential return on investment.

With a loss of confidence in the otherwise beneficial artificial insemination approach, the farmer might subsequently seek to obtain pregnancy using local bulls, which do not offer genetic improvement.

**The Invention**

Global Good is modifying and improving upon an existing device type commercially available in Europe. We aim to make it more rugged, low-cost, and appropriate for detecting oestrus in tropical and sub-tropical cattle breeds and crossbreds—whether or not the animals are in herds. The device senses electrical resistance and other characteristics of the cervical mucus to detect and signal bovine oestrus. Global Good aims to investigate the feasibility of the product and its effectiveness in tropical and sub-tropical cattle, while also working to dramatically reduce the cost and increase measurement reliability.

**PRODUCT STATUS**

- The device is currently in research, design, and development mode by the Intellectual Ventures Lab.
- Please contact Global Good if you are interested in co-development, commercialization, or field testing partnership.

**AI TIMING CHALLENGES**

In order to achieve successful conception, the AI process must be well timed. Ideally, the procedure should occur just a few hours after the onset of oestrus in the cow.

Successful AI can improve herd health and productivity
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. The AI Shield device 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 distances 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 the 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 storage straws 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 the straws 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. Contact Global Good if interested.

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.

Cryostorage for Livestock Inputs

Alternative methods for ultra-cold transport of semen and vaccines

Smallholder farm productivity and income depend largely on having resilient, productive dairy cattle. Toward those ideals, farmers employ Artificial Insemination (AI) to improve herd genetics and vaccination to prevent disease. The necessary supplies for both of those processes require ultra-cold cryogenic storage and transport. However, in low-resource settings, cold-chain logistics often fail due to an unreliable supply of liquid nitrogen, the main coolant used for maintaining cryo temperatures. To overcome this problem, Global Good is inventing cryogenic equipment that uses more widely available carbon dioxide to create the required superchilling.

The Need

East Coast Fever (ECF) is a serious infectious disease of cattle in Sub-Saharan Africa. It causes death in more than 80% of infected animals and, where endemic, it causes the loss of more than a quarter of all cattle every year. This tragedy is magnified as ECF particularly affects the breeds that deliver the greatest milk productivity. The loss can be greatly reduced through vaccination, but ECF vaccines become ineffective if not kept at ultra-cold temperatures.

Furthermore, milk output—and hence food supply and income—can be improved through crossbreeding with more productive cattle types via artificial insemination (AI). And, similar to vaccines, bull semen for AI must also be kept continually in cryostorage. The cryo cold for these supplies is generated by use of liquid nitrogen (LN₂) but in many countries with limited resources, the infrastructure supporting LN₂ supply is unreliable.

The Invention

To reduce reliance on variable, limited supplies of LN₂, Global Good is developing a device that can readily generate dry ice for cryogenic cold storage. The novel approach utilizes carbon dioxide (CO₂) which is widely available in low-resource settings as needed by suppliers of food and carbonated beverages. Conveniently converting bulk-tank carbon dioxide into dry ice, the invention works in conjunction with a super-insulated dewar designed for optimal performance for rural environments and the long hold times necessary for vaccination and AI fieldwork.

Specifically invented for use in low-resource settings, this device could enable more options for vaccination technicians and AI professionals to offer their services over longer hold times corresponding to greater distances from distribution centers.

PRODUCT STATUS

- Field assessments in Uganda, Malawi, and Tanzania are evaluating the effectiveness of dry ice as an alternative to liquid nitrogen.
- This invention is in product development phase with prototypes in field testing and ongoing improvement.
- Global Good is exploring codevelopment options with manufacturing and distribution partners.

SUPPLY AVAILABILITY

Illustrated here is a typical supply chain situation as observed in 2016 in Tanzania. In the scenario shown, fully functional CO₂ supply remains continuously available in regions where the LN₂ supply is unreliable.

Source: Intelligent Device research group, Global Good
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 that is 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, which reduces 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 Kenya Dairy Board.

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 crack 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. Valuable milk often spoils or spills before it can be sold.

PRODUCT STATUS

- Studies of Mazzi usage show as much as ten-to-one reduction of bacterial count compared to Jerry cans.

- Mazzi is in its fourth generation of development. Manufactured in Kenya and Ethiopia, it is available globally and has been distributed to customers in India, Pakistan, Morocco, Peru, and Sri Lanka.

- Please contact Global Good if you are interested in being a manufacturing or distribution partner.

SMALLHOLDER MILK LOSS

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


[Graph showing milk losses in the dairy value chain: On-Farm Loss (54%), Primary Collection (14%), Secondary Collection (3%), Transport & Sale (29%)]

Fertilizer Contents Validation

*Increasing confidence for investment in farm-productivity inputs*

With the use of a reliable, handheld device to validate fertilizer contents, intermediaries in the fertilizer supply chain, such as rural agro-dealers, could reject supply that does not meet packaging claims and thus support the sale of quality products. Such a device would bring potential for significantly reducing adulteration, to benefit the agricultural yields of smallholder farmers, who allocate scarce resources to costly inputs, such as fertilizer.

The Need

Fertilizer adulteration is a problem in many countries where subsistence farming dominates and supply chains for agricultural inputs are weak. In one West African country, the International Fertilizer Development Center found that nearly half of the fertilizers sold there lacked the appropriate nutrients and a quarter had no package labeling regarding the type and concentration of nutrients.

In some scenarios, fertilizers are adulterated with sand or sawdust. As a result, these fertilizers do not provide the expected yield improvements, resulting in devastating consequences for smallholder farmers who take on substantial financial risk when investing in fertilizer.

Properly labeled and validated fertilizers will enable smallholders to select inputs that will best complement their crop choices and will help to correct deficiencies in their soils. Supply chain intermediaries—such as rural agrobusinesses, fertilizer suppliers and blenders and farmer cooperatives—have an incentive to sell quality product to enhance their sales, but they need a field-friendly tool to readily verify contents.

The Invention

Global Good aims to develop a low-cost, battery operated, handheld tool for detecting fertilizer contents. The objective is the ability to measure bulk fertilizer components in order to verify labeled ingredient claims. The device will report on the content of the available fertilizer components within approximately +/- 5-10% of the labeled nitrogen and other elements. Fertilizer and other agronomic recommendations could present greater utility by feeding the analysis into a “smart farming” system.

PRODUCT STATUS

- The device is currently in research, design, and development mode by the Intellectual Ventures Lab.
- Market and field assessments to shape initial product design and launch may focus on Zambia, Nigeria, Kenya, Tanzania, or Ethiopia.

EXAMPLE DETECTION TECHNOLOGY

For fertilizer analysis, Global Good is considering several types of devices. One possibility is the use of portable spectroscopic devices that apply Near Infrared (NIR) waves to quickly obtain detailed information about contents of fertilizer compounds. In this experimental example, mapping against specified spectral features, several chemical components are identified.

Source: Intelligent Device research group, Global Good
Millions of people suffer and die each year 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 more affluent economies. 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 to improve life in low-income nations.