I. Executive Summary

Abstract

**Kulisha** aims to revolutionize fish feed in Kenya. Aquaculture is booming worldwide and has the potential to be the future of protein, but conventional feed for aquaculture farms is made from wild-caught forage fish. These fish are caught using unsustainable practices that destroy marine habitat and harm rural fishing communities. Additionally, the commercial feed available in East Africa is inaccessible and prohibitively expensive for most rural farmers, requiring them to formulate their own from omena—a wild-caught fish similar to anchovies.

Kulisha, named after the Swahili verb "to feed", is a feed company that produces a low-cost, high-quality protein base made from insects as an alternative to omena. We grow, harvest, and process the insects, targeting small-scale fish farms. Kulisha is founded on the three targets of addressing a significantly underserved market segment in the aquaculture industry, supporting economic development and growth in emerging markets, and creating environmentally sustainable solutions to food insecurity.

The Problem

With a growth rate of 8% a year, aquaculture is the fastest-growing form of food production in the world (Subasinghe 2005). In 2012, farmed fish outpaced beef production for the first time (Marshall 2013). However, most fish feed currently used in the world is dangerously unsustainable, as it is derived from ocean-caught fish such as sardines, herring, and anchovies, which are then manufactured into a protein base called fishmeal. These organisms are caught using highly destructive commercial fishing practices such as trawling and purse seine fishing, which result in the deaths of whales, dolphins, and turtles as bycatch. Indigenous communities are often affected as traditional fishing livelihoods cannot compete with huge foreign interests. Moreover, over 90% of the world's fisheries are either fully-exploited, over-exploited, or collapsed, and our oceans simply cannot support the rate at which we are removing fish from them.

In Kenya, aquaculture has grown almost tenfold from 4,900 MT in 2009 to nearly 48,800 in 2013, and is projected to continue increasing to reach a production of 450,000 MT by 2030 (Mohamed 2015). Along with many other developing countries, Kenya has prioritized fish production—primarily tilapia and catfish—as a cheap way of providing protein to a rapidly growing population. However, there is a huge lack of affordable, nutritious, and sustainable fish feed. In a survey of nearly 200 fish farmers in Kenya, the problem most frequently mentioned
was lack of access to fish food, and was listed twice as much as the second biggest problem (water quality). Feed often accounts for 60-80% of a farmer’s costs. Manufactured feeds are not widely available, so most feed is mixed on-site in small batches from local crops, which is both inefficient and nutritionally inadequate. Even when farmers are able to purchase feed, it is not uncommon for it to be up to 30% gravel (Mirera 2015). There is an evident and urgent need for a more sustainable and nutritious form of fish feed.

The Idea

Kulisha will produce a low-cost, high-quality protein replacement made from insects for use in fish feed, primarily targeting small-scale rural farmers. Insects are great for use in feed production; they require very little land and water to raise, contain high proportions of protein, fat, and micronutrients, and can be easily dried and stored. In particular, black soldier flies are the ideal insect. Unlike regular house flies, they are non-buzzing, non-biting, and are not vectors of disease. In their larval stage, they feed on organic matter and can eat a wide variety of feedstocks, from kitchen scraps to chicken manure. As the larvae mature, they consume this organic waste ravenously for 2-4 weeks before reaching the prepupae stage, at which point they are at optimal nutritional content and can be harvested. They are then dried and ground into a fine protein-rich meal that can be used as a raw input for the manufacturing of fish feed pellets. Using insects as the primary protein source also makes biological sense—in the wild, young fishes’ diets consist almost exclusively of insects, and insect meal promotes natural growth and assimilation of nutrients without the need for hormonal additives. Numerous studies have already documented the viability of the use of black soldier flies in fish feed (Adewolu et al 2010, Bondari & Sheppard 1981) and the 2012 FAO report “Edible Insects: Future prospects for food and feed security,” states that “the use of black soldier fly prepupae as animal feed should be seriously considered” (van Huis et al., 2012).

We have partnered with a number of researchers and business leaders to prototype and develop this venture. Because this is a heavily biological research-focused initiative, we have partnered with the International Center for Insect Physiology and Ecology (ICIPE) in Nairobi, specifically with Dr. Chrysantus Tanga. He is currently running a BSFL operation in Nairobi and one of our employees will be shadowing his operation from 8am-12pm every Monday and Friday. We are also working with Dr. Philip Taylor, a researcher at the University of Colorado—Boulder specifically researching BSF breeding. He is also looking into commercialization of BSFL at his startup MadAg. One of our team members, Catherine, worked with him closely in his facility this past summer. This enabled us to maintain weekly communication with the
MadAg team and collaborate on research, ideas, and innovations. In addition, we’re collaborating with Sagana, the largest fish hatchery in Kenya to conduct feed trials.

Throughout the next year, we aim to raise $350,000, such that come May 2017, we will be prepared to scale to a Phase II facility in which we plan to produce five tons of dry weight insect protein per week.

II. Progress To Date

Kulisha has made excellent progress to date. Our first round of funding, from fall 2015–summer 2016 exceeded our goals and we raised $85,000 of non-dilutive financing. Among these are the following awards and prizes:

- first place in the Michigan Business Challenge out of 102 initial teams
- winner of the Thought For Food Challenge out of over 400 teams from 105 countries
- two of ten selected fellows in the Brown Social Innovation Fellowship
- winner of the UCLA Anderson School of Management Knapp Venture Competition
- one of ten finalists in the Total Startupper of the Year competition

Arriving in Kenya at the beginning of June with just an idea, we have progressed to independently operating a fully-functioning prototype facility. We have impacts in two key areas: the community and the environment.

On the community level we have hired 3 full-time employees—Joseph, Lunalo, and Ishmael. These employees have been paid wages of $2060 (monthly minimum wage in Nairobi is $110), excluding additional benefits such as computers, lunch, internet, travel, etc. Two of these employees are fully committed to the project and have signed employee contracts to lead operations in our pilot facility until June 2017 (and have expressed interest in staying on longer) when we plan to begin scaling to a commercial operation. We have also supported local businessmen and women such as Margaret, who runs a food delivery service, and Joseph, who owns a business that designs and constructs greenhouses for small-scale agriculture operations. We have paid out over $7,800 to small entrepreneurs like these two, and will continue to support local businesses, sourcing labor and materials locally whenever possible.

We recently had our first colony regeneration of 15 kilograms of live larvae, which is over 100,000 individual larvae, from an initial colony of 837 neonatal larvae. While this puts us slightly behind our schedule to have had two colony regenerations and harvest 19 kilograms of larvae, we are only approximately 4 weeks behind due to non-ideal ambient conditions, and licensing issues upon arrival, both of which have been fixed. We plan to have our second full colony regeneration and initial harvest in early October. However, despite our delay, we have not gone without creating impact at an environmental level. From our initial colony, we have diverted 38 kilograms of organic waste that would ordinarily fill overflowing landfills in a city facing one of the most drastic sanitation crises in the world. Not only does this help mitigate the negative externalities to slum dwellers, which make up nearly 60% of Nairobi’s population, but it also prevents waste from anaerobically decomposing and emitting methane, a greenhouse gas 25 times more potent than carbon dioxide. Our 38 kilograms of organic waste removal has prevented 2.5 kilograms of methane emissions from being released into the atmosphere (Brown 2013)—the equivalent in methane of what a typical car generates after driving 113 kilometers (U.S. Department of Energy 2016). By October we plan to have diverted an additional 152 kilograms of organic waste. By November, when we’re fully operational, we plan to be diverting 25 kilograms of organic waste a day, with 180 operating growing units in 18 sq. meters of space.
Additionally, we have created a waitlist for our first customers. While we are still building our colony and haven’t made our first sale yet, we have many interested buyers. We will be selling our product at 100 Kenyan Shillings (KSH) per kilogram. This converts to about 1 USD. Current *omena* (a small lake fish used as protein) prices are around 140 shillings per kilogram and is the only protein source with a complete amino acid profile available to small scale farmers. Current sellers also mix their *omena* with various fillers such as sand and gravel, which can consist of up to 30% of the product. Not only is this wasting farmers’ money, but it also decreasing the digestibility of their feed. Soon 2-3 identified farmers will be able to fully replace *omena* with BSFL meal. This will not only save them money, but result in much more consistent and predictable yields.

*Omena, current low quality and unsustainable protein, that is currently being used by one of our potential customers*

Our first customer will be a school for orphans in Meru, Kenya. They farm fish and pigs as a way to feed the students as well as to make some extra money. To source protein, they are currently driving a truck eight hours to Lake Victoria simply to ensure that they’re getting high quality protein. We hope to simplify this process and work with them to see how our product functions, what we can improve, and how it compares to what they’re currently using.

Our impact extends beyond the creation of protein and its associated benefits. There is also impact potential in the insect frass, or poop. This has two primary uses. It can first be compressed and used as a briquette, a sustainable alternative to charcoal which is used as the primary source of fuel for households throughout the country. Using charcoal is deeply unsustainable and causing deforestation throughout not only the country, but also the continent. The second potential use of our frass is that it can be turned into an organic fertilizer for farmers.

Finally, it is worth noting our impact in the relationships we built, which is difficult to quantify, but nonetheless significant and valuable. We spent much of the summer simply meeting with and speaking to farmers, entrepreneurs, and other stakeholders. We received overwhelming enthusiasm and validation for the idea; many people were inspired by what we are doing, and we foresee that many will turn into partners moving forward. We have continued to stay in contact with these individuals and look forward to reconnecting with them upon our return to Kenya.

An example of one of these critical partnerships that we built was with Paul Kimani, the director of Happy Feeds, which is the company that currently owns the contract to manage the waste for a local brewery, East African Breweries. We decided to pursue using 100% spent brewer’s grains as our feedstock to remove the risks of working with a post-consumer feedstock,
have a reliable supply of waste, and to ensure that our inputs are consistent, resulting in a consistent, high-quality end product. We were able to come to an agreement with Paul to sign a contract guaranteeing us the right to buy a consistent supply of waste at a pre-agreed upon price.

Through this relationship we also learned that Happy Feeds operates a small feed mill near Nairobi with current production around 3 tons per day. Paul is dissatisfied with his current protein source and was extremely interested in sourcing protein from Kulisha after we build our Phase II site that will produce more consistent and larger production volumes. We are currently discussing the possibility to co-brand with Happy Feeds so that we can utilize the existing distribution and sales networks that Happy Feeds has built while enabling us to focus on our core competency of insect production. This will also allow us to build a strong brand by working with a reputable feed miller, and it helps Happy Feeds by allowing them to show that they’re using a superior and more consistent protein in their feed.

III. Implementation Plan & Timeline

As described in detail above, we have completed what we consider Phase I. We have a functional prototype facility, have validated that we can successfully grow these insects, and are conducting extensive research and development over the coming year in order to prep for Phase II. Phase II will begin in May 2017, whereupon Eric, Viraj, Maya, and Arjun will have graduated and will move to Kenya to work on the venture full time. At this time we will begin building a scaled facility, capable of producing five tons of BSFL meal per week, which will be our primary operational facility starting upon completion (projected September 2017). We view this as a mid-level scaling effort where we can continue to learn about BSFL growth and biology, but on a larger scale and with a greater level of financial sustainability. This mid-scale facility will be instrumental in continuing to develop our understanding of the biological aspects of the process as well as the refining of our business model, preparing us for another scaling effort. Meanwhile, our existing smaller greenhouse will remain as an experimental unit in which we will continue to carry out experimental testing. This next-level scaled BSFL operation can be broken into seven key sections: 1) Pupation 2) Breeding 3) Hatchery 4) Nursery 5) BSF Growth 6) Harvest 7) Colony Regeneration.

In order to prepare for this massive scaling effort, we have brought together a team at Brown University that will be specifically looking into the small scale and specific aspects of 1-4 of the large scale BSFL operation. They are working closely with the Brown University Greenhouse and have been granted access to temperature- and humidity-controlled growing chambers in order to conduct an independent research study testing several types of feedstocks, larval densities, hatching conditions, and harvesting mechanisms.

For aspects 5-7, we have created a team here at the University of Michigan more focused on mechanical innovation and automation. The team is led by Michigan professor Jesse Austin-Breneman, an expert on small-mid scale new venture manufacturing operations in emerging markets with experience in Kenya. His team will be focusing on evaluating different designs and levels of automation. This consists of exploring and adapting existing technologies to meet our needs and doing an in depth economic analyses of various levels of automation versus manual labor of our facility. This is structured as an independent study with one Masters student working under Jesse.

In addition to this team working under Jesse. We also will work with a Bluelab discovery team. This team will focus on implementing the small scale research that the Brown University
team does. This will allow us to integrate that research into our larger system design and will also be guided by Jesse. The Bluelab team will work closely with our team at Brown University to ensure that we are maximizing both projects. We have also begun talking about potentially beginning a project next semester that focuses on increasing the amount of data tracking technology in our facility, and looking into creative ways to analyze that data that will give us a reliable way to continue to test new assumptions and develop and improve our system.

At the University of Michigan we will also be focusing on financing this operation. We will be working with Michigan professors Dr. David Brophy, a professor with decades of private equity and venture capital experience and Jim Price, a serial entrepreneur that has successfully launched and exited several tech enabled businesses. With these two professionals, we will work to create a new business plan, 5 year funding requirement, and financing strategy under the structure of Jim’s New Venture Creation Program.

Finally, one of our employees is working closely with Dr. Tanga at the International Center for Insect Physiology and Ecology, shadowing researchers and assisting with data collection and implementation of systems there. This will allow us to collaborate with a leading research institution in data and strategy sharing, mutually benefitting both parties. In addition, in early 2017, we will begin conducting feed trials at Sagana Hatchery. We’re working with Dr. Mary Opiyo, who works at both Sagana and the Kenya Marine and Fisheries Institute (KMFRI), to develop a series of field trials that will test the effect of our product on fish growth at several different life stages. The test will substitute omena, the most common current protein, with BSFL at various levels between 0-100% while maintaining a crude protein of 30%. This enables us to test what is the best protein at a gram for gram basis. Michigan professor Dr. Jim Diana is helping to guide these studies and has experience working in aquaculture in Africa.

Deliverables for these three project teams above will be completed at the end of December, at which point we will revisit project goals for the following year and update the proposed budget.

This mid-scale facility will be our primary production site. During this time, we will scale up to a production of 5 metric tons of dried BSFL meal per week while validating key biological metrics and assumptions and starting sales with a small handful of initial customers. Progress during this period will be measured in production yield and sales. Looking forward, into the next five years, we plan to build a Phase III full-scale facility capable of producing 50 tons of dry weight BSFL meal per week.

As we continue to scale up production, we will shift our go to market strategy towards targeting large feed millers, similar to Happy Feeds, as opposed to working directly with small
scale farmers. This simplifies the logistical complexities of distribution and working with so many customers, and allows us to outsource that aspect of the business to a miller that is much more well-equipped and experienced in dealing with those challenges. This will also allow us to much more comfortably predict inventory and production requirements which will simplify our supply chain and reduce inventory costs. However, we are able to maintain our brand through co-branding efforts, and our product is still reaching small-scale farmers.

IV. Budget

Entering the summer, we had allotted a total budget of $20,000 for all expenses from June through August. With thorough planning and preparation we managed to adhere to it flawlessly, spending a total of $19,359.58. We tracked and categorized all of our expenses in an attempt to minimize our burn and identify high expense categories that we can improve upon in the future (see figure below). This budget, though relatively modest, allowed us to construct and operate a fully-functional pilot greenhouse over the course of the summer. In this facility we successfully validated that we could, in fact, grow and breed BSFL that could be scaled to a commercially viable level. We have since incorporated as a Kenya Company Limited By Guarantee (the equivalent of an American LLC) which we plan on continuing to operate with our current full time employees through May. We are allocating approximately $1100/month to run the facility, $915 of which will go towards paying employees and other employee benefits.

Come December 2016, we plan on having a much more in depth and accurate budget and financing strategy as a result of the outcomes of the four project groups taking place in the fall (at Brown University, the University of Michigan, and ICIPE). We currently anticipate financing needs of $350,000 for the next year. During that year, we believe that we can finance this company primarily through grants and competitions. We have raised approximately $85,000 of non-dilutive financing this way, approximately $31,000 of which will remain by the time scaling commences in May 2017. We have prepared a funding opportunity list for the next year, through which we plan to meet or exceed our funding goals. This list includes 65 competitions, entrepreneurship challenges, food and agriculture related grants, and fellowships with thorough
notes on the specific requirements of each application, detailing the timeline process, prize money, and a two-tiered pipeline for writing and editing applications. Some of the larger funding opportunities include:

- OpenIdeo Food Waste Challenge; a $25,000 opportunity
- The Brown University Embark Fellowship; a $50,000 opportunity
- Echoing Green Entrepreneurial Fellowship; a $90,000 opportunity
- The Africa Food Prize; a $100,000 opportunity
- The Blue Economy Aquafeed Innovation Challenge; a $750,000 opportunity

As well as dozens of entrepreneurial competitions with total prizes of over $500,000 and various grants from large non-profits totalling in the millions of dollars. If we fail to raise the necessary capital through non-dilutive funding, we plan on taking dilutive funding from an impact investing firm such as the Eleos Social Venture Fund, with which we have already begun building a relationship. If we exceed our funding goals we will continue to invest into the production capacity of our facility.

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The above budget describes our initial expected startup costs. With funding level at 53% of the proposed level we would be able to complete our growing facility, including the breeding chamber, hatchery/pupation area, nursery, and refinery and exclude the equipment for post-processing. Given this reduced level of funding, we would scale back slightly in the breeding area and hatchery/pupation section to allot funds for the permits, land leasing, water, electricity, and labor. The running of the growing facility is the most critical aspect of this second phase, and given 53% of the proposed funding, we would still be able to fund this production process. However, because we are in a manufacturing business, if we want to successfully complete all critical functions of the business at the 5 ton per week production level that we’re aiming for, we need to meet our funding requirement 100% and are willing to do that even if it incurs costs or liability such as taking debt or equity based financing. In a scenario where we under no condition would be able to meet our funding goal, we would choose to build a smaller facility, aiming to produce 1-2 tons of dry BSFL per week. Due to the high startup cost requirements for this asset heavy, manufacturing-like business, we are requesting the full $50,000 from the Dow Distinguished Awards Program in order to move forward.

V. Team
The student members of our team bring disparate backgrounds and disciplines together to imagine a more sustainable aquafeed industry. Eric is a business student at the University of Michigan Ross School of Business. He co-founded an education startup called Graduate, and is an editorial assistant for the social entrepreneurship website NextBillion.net. Mohammad is a Masters student also at the University of Michigan in the Ross School of Business and College of Engineering. He was vice president of the University of Maryland Entrepreneurial Society and moreover has extensive experience in engineering and design. Maya was born and raised in Costa Rica and is studying Environmental Science at Brown University. Her academic focus examines food security, food systems, and how they intersect with an increasingly unpredictable climate. Viraj, Lunalo, and Arjun are from Kenya. They speak Swahili and have developed working relationships with many people in various environmental and political circles in their home country. With a background in Environmental Conservation and Natural Resource Management at the University of Nairobi, Lunalo has a deep understanding of Kenya's environmental pressures. His experience and exposure have allowed him to develop excellent relationships with farmers and establish trust among the agricultural community. Viraj is studying Environmental Science at Brown University and has worked to strengthen marine protected areas off the coast of Kenya. By working in the environmental realm in Kenya, he has developed key partnerships with valuable organizations such as the International Center for Insect Physiology and Ecology. Catherine also attends Brown University and is studying Mechanical Engineering. Her expertise is in mechanism design and rapid prototyping. She is part of the team at Brown University conducting the studies on breeding, pupation, grow-out, and harvesting in the fall. Arjun studies Mechanical Engineering at UCLA and is passionate about advancing technology for sustainable development. His family is involved in logistics businesses throughout Kenya and offers relationships with various distribution and transportation resources. Joseph and Ishmael are two of the hires that we’ve made in Kenya and they are extremely intelligent and committed people. They have already established themselves as integral parts of our team and have added value using their creativity in our insect production facility. Katie and Jon both have experience in working on engineering projects in developing countries. Their commitment and work ethic has been proven and we are extremely excited to begin working with them. Katie studies computer science at the University of Michigan and is extremely interested in looking into agriculture technology solutions and our potential to collect and utilize big data. Jon Studies Industrial Operations Engineering at the University of Michigan and was heavily involved in the creation and implementation of a solar dryer in a developing community.
A variety of backgrounds, skill sets, and connections are represented on our core team, and thus far, we have found that these complement one another to achieve our goals. We have also found the mentorship and guidance of various professionals and professors as a key reason for our success moving forward. As we’ve been moving forward with production and data collection, however, we’ve found that one skill in which the team is lacking is data analysis and software engineering. At the heart of it, we are a biological business; our core competency is insect production, and, as such, we are a data-heavy company. We’re currently tracking myriad metrics, from humidity levels to feedstock moisture content to hatching rate of eggs. We’ve been collecting a huge amount of data and, in the next phase of scaling, are looking to incorporate automatic data collection technology into our facility. We would definitely like the next addition to the team to be someone with experience in data and software engineering and have begun to have informal conversations with interested individuals who might fit this role, including Michigan professor Dr. Sanjeev Kumar. Currently, we are working with him as an advisor. He is an expert in big data analysis and arduino technology creation and utilization. Although there is no formal agreement right now, we plan to work with him in the winter of 2017 to create a project team that will take the facility designs created by Jesse, Mohammad, and the Bluelab team and add data collection technology so that, moving forward, we can improve our tracking of key biological metrics. This will give us greater transparency and clarity into how input parameters that we choose to experiment with will impact our growth and production. We plan on the working with the Bluelab team to execute this, however this is a project that still needs to be fleshed out and thought through more.

Sources Cited

"Interview with David Mirera." Personal interview. 22 Nov. 2015.
"Interview with Owen Sensor." Personal interview. 1 Dec. 2015.