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“The Role of Poultry on Food Insecurity in Mozambique”

By:

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Advisor: Dr. Amy Farmer

**An Honors Thesis in partial fulfillment of the requirements for the degree Bachelor of
Science in Business Administration in Finance.**

Sam M. Walton College of Business

University of Arkansas

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This honors thesis is approved for recommendation.

Faculty Advisor:

Dr. Amy Farmer

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In order to conduct this research experiment, a multi-person team of university faculty, a Cobb representative, myself, and fellow undergraduate peers were put together. Dr. Kidd, director of the Center of Excellence for Poultry Science and head of the Department of Poultry Science at the University of Arkansas, was at the head of the team and led the way in communicating with the farm, establishing the project, and helping us get started the first couple days in country. Dr. Butler, the representative for Cobb, also helped with project development and much needed insight into what the chick development process was supposed to look like. Just as Dr. Kidd, Dr. Butler was only in country for the first few days of the project but was crucial in helping compare the processes seen at New Horizons to what was expected at Cobb. The third member of the team was PhD candidate Joe Hiltz who was crucial to ensuring that the project was able to be completed from start to finish. Along with this, Joe has an extensive background in poultry, and he played a critical role in assistance as he had been on this trip before and could give insight into what to expect and how to handle any unforeseen circumstances. Along with the three faculty members in the group, I was joined by fellow undergraduate students Ashley Miller and Grace Lehfeldt, the latter of which would become my thesis partner. Our roles were to help in preparation for the experiment and then be the main ones in charge of running the experiment, gathering data, and analyzing that data when in Mozambique. After the conclusion of the project and trip, Grace and I then continued analyzing the data in order to transform and present our findings as a partnered thesis to the University of Arkansas' Sam M. Walton College of Business. Without the help of all these team members and the university professors, Dr. Nalley and Dr. Farmer, who were in charge of the Mozambique program, this research and subsequent thesis could never have been feasible.

Introduction

Hunger, poverty, and starvation in developing countries are some of the most prevalent challenges facing the world today but many people outside of these areas are not fully aware as to just how bad it is. In the country of Mozambique, where the following research took place, food insecurity levels are rampant, and many different groups/companies are trying to change that. Through a service-learning study abroad program in the summer of 2019, my group and I worked with the local company New Horizons to research ways in which poultry production for both the company and their rural out growers could be improved. By doing this, our goal is to create more efficient poultry practices throughout all stages of the growth cycle in order to produce larger chickens and thus, a larger profit. Through the research and development of this project and subsequent thesis, the positive role of poultry on food insecurity will be shown and recommendations for future project improvements will be discussed.

I. Literature Review

In developing countries around the world, the issue of food insecurity and the problems associated with it continue to be a focal point for many governments and outside organizations. With all the time and effort already being poured into this issue, many people are surprised when they learn that up to 45% of childhood deaths are in some way caused by malnutrition. Looking at Mozambique in particular, the Borgen Project, a non-profit company fighting poverty and starvation in Africa, noted that “almost half of children under age five are malnourished, and 42 percent have stunted growth” (Crowley, 2017). With issues like these occurring in multiple areas around the world, the focus shifts on how to fix the food insecurity problem for good. According to an article published by the U.S. Global Leadership Coalition, many people such as activist Bill Gates and scientists from the University of California at Davis believe that poultry could be the best solution.

Poultry is quickly becoming one of the leading ways to battle food insecurity because of its ability to fight both hunger and poverty at the same time. Past studies conducted in countries with similar poverty and hunger levels to Mozambique have shown that positive effects can be seen rather quickly. For example, a study put on by the UN Food and Agriculture Organization (FAO) showed that after an implementation of household-poultry development throughout the rural areas of Nigeria, in only six years’ time, this household-poultry sector accounted for 94% of total poultry in the country. During this same decade, “the consumption of poultry products in developing countries has grown by 5.8 percent per year” (Guene-Bleich, FAO). So as poor rural households increase their levels of poultry production, there is a resulting drop in both hunger and poverty. When programs like the one just mentioned are implemented in developing countries, poultry can also play a role on community development. In another study put on by the FAO named The Bangladesh Model, researchers noted how the increased levels of household poultry farms improved local communities because eggs were sold in nearby towns allowing for higher income levels. These higher income levels then allowed for purchases of things such as vaccinations and better feed which in turn improved chick mortality creating a cycle of improved development for the community.

One of the best examples of household poultry evolving into a success story can be seen in India with their Backyard Poultry Programme (BYP). Established in the rural village of PedaKodapalli, this community has around 100 households with a majority of the population being poor and working in the agricultural sector. With work beginning in 2016, a breeder farm

was established to ensure local production and to create a regular supply of eggs for the community to work with. In a short time of only 4-5 years, this community has begun reaping many benefits as a result of the work done through the poultry program. According to an article from the AME foundation, the establishment of this backyard poultry has resulted in “the local communities [being] able to consume eggs and meat produced in their backyard on a regular basis [and] the chicken and eggs produced in the backyards are healthy compared to commercially produced chicken, thus ensuring better health to the families” (Kanukolanu, 2021). Along with this, the locals who raised the chickens were able to make an even better living through the selling of these chicks and chickens. Looking at the examples of poultry implementation, in both Nigeria mentioned earlier as well as here in India, past data and projects have shown that successfully implementing these strategies is doable and has created lasting benefits for many communities around the globe.

After noting past research and the positive effects resulting from poultry development, implementing new strategies in developing countries can bring about many challenges as well. In an article posted to the World Poultry Science Journal, one of the major challenges to poultry and its effect on food insecurity/development has to deal with the prevention of widespread disease. When an outbreak happens “effective disease outbreak responses occur where prior agreements have been made between producers or their representatives and relevant government agencies. Such agreements are usually made with commercial poultry producers with little attention given to family poultry producers” (Alders, 2012). This means that, in the occurrence of an outbreak, these rural family farms may not receive the resources needed to keep their chicks alive. In order to combat this, the author believes that control measures that account for these types of farms and do not threaten food insecurity, are more likely to succeed. While poultry can play a role on food insecurity all over the globe, the continent of Africa poses some unique challenges in comparison to other places. In an article posted to WattPoultry, a news-source for the global poultry industry, some of the major challenges include inadequate resources, high price of feed materials, and the ability to grow on tough land. One of the biggest ways to fight these issues is with proper government intervention such as building roads to allow for better poultry transportation or utilizing economies of scales to balance out prices. Being able to successfully navigate the challenges that come along with poultry development in developing countries can lead to great successes as mentioned with South Africa in the article. Through the use of poultry, broiler production has grown over 38% in the last ten years but “the growth [was] predominantly through many small-scale producers entering the market” (Oosthuysen, 2013). By addressing all the challenges posed by the poultry production industry, South Africa was able to successfully use poultry to address their issue of food insecurity.

Implementation of these poultry farming techniques can be a critical starting point for recharging the economy of Mozambique. As mentioned, almost half of children in Mozambique are malnourished, which in large part, is due to the effects of a weak economy. Having such a weak economy has plagued Mozambique’s ability to grow and has resulted in even more challenges such as wide-spread corruption and inadequate property rights protection. According to the CIA’s world-fact-book, 46.1% of the population lives under the world poverty line and the country’s total 2019 GDP equaled \$14.964 billion as opposed to the USA’s 2019 total of \$21.43 trillion. Establishing a strong poultry farming presence might just be one of the ways to improve the overall economy in Mozambique. Currently, 74% of the country’s labor force is already working in the agriculture sector, mainly dealing with the plant sugarcane. Transitioning away

from sugarcane and into poultry could be a valid alternative because of the opportunities in poultry and the rising troubles in selling sugarcane. According to an article posted in June 2020 by AfriBusiness News, a real-time African business website, sugarcane farmers in Kenya “need more money to revive [their] dying mills” (AfriBusiness, 2020). With the sugarcane sector slowing dying throughout Africa and in Mozambique, the poultry industry may be an equitable alternative for such a large number of agriculture workers. Seeing these issues and the opportunities for the future, New Horizons stepped into Mozambique wanting to make a difference.

Officially establishing their presence in Mozambique in 2005, New Horizons, or Novos Horizontes as spelled in country, is a chicken company whose goal is to succeed in the poultry industry while helping the local community along the way. According to their website, “most of the workers are locals who, for reasons of opportunity and within the scope of Social Responsibility, the company prefers that they are part of it” (New Horizons, 2020). One of the ways in which New Horizons achieves their mission is through the use of out-growers, or community members who raise chickens for New Horizons on their own land and retain some of the profit when they are sold. By doing this, New Horizons’ is able to sell chickens for their own revenue as well as promote community development by creating jobs, an income, and even food for some of the poorest and most food-insecure people in the world. In terms of growth, the use of these out-growers has risen significantly from its origins in 2007 as they now “currently have 151 families in the program, of which 115 have their own infrastructure and the remaining 36 use NHM infrastructure, and all families are residents of the Rapale district” (New Horizons, 2020). While New Horizons has seen the growth in their company over the years, challenges such as slow supply chain, uneducated workers, and government corruption has made turning a consistent profit challenging. What these struggles highlight is that even with strong growth and innovative business techniques, the overall economy in Mozambique makes successful financial growth hard to sustain.

Past research and scholarly studies have shown that food insecurity is still a very real issue throughout the world, but successful poultry production in both the commercial and rural sectors can result in decreased levels of overall food insecurity. Organizations such as the Borgen Project, the United Nations, and even countries such as South Africa all believe that poultry can have a long-lasting positive impact on food insecurity and have already begun plenty of work. New Horizons has been an example of the good poultry has already been doing in Mozambique, but a struggling economy makes the successes slower to come by. We hope that with our project we can also successfully show the benefits of poultry production and identify ways in which local farmers can overcome the challenges associated with it.

II. Background

In terms of food insecurity, the country of Mozambique is up there at the top of the list for being most insecure. According to the most recent findings put out by the 2020 Global Hunger Index, Mozambique ranks as the fifth hungriest country in the world. While the problem of hunger in Mozambique is still one of the biggest issues they face, the country has actually seen recent success in combating the problem. As recently as 2015, Mozambique successfully accomplished one of their development goals of cutting the number of food-insecure citizens in half. The overarching problem is that even after such great improvements in the area of food insecurity, they still rank bottom five in the whole world. With hunger, poverty, and lack of

development being noticeable themes throughout Mozambique, discovering and addressing the issues that cause these deficiencies is crucial to fostering community development.

In as recently as 2019 most of the Mozambique population was living in rural poverty and was labeled as “food-insecure,” 63.47% to be exact according to data provided by the World Bank. Of these citizens, many rely on subsistence farming and live based off of what they can provide for themselves. When these people do come in contact with extra money to spend on groceries, one of the most common food purchases is chicken. As the number of rural citizens continues to drop, the demand for store-bought chicken continues to grow. The problem surrounding this is that Mozambique has had continual trouble with being able to import enough chicken to account for the rising demands. In a 2016 study put on by the non-profit organization TechnoServe, it showed that in as early as 2004 two-thirds of broiler chickens being sold in Mozambique were being imported from Brazil. Adding to this, of those chickens being imported, many were expired by the time they were put onto store shelves due to Mozambique being a developing country and the supply chain being sub-par. Even though the chickens being sold from Brazil were often past their shelf-life, they were still selling more than chickens grown in country simply because they were cheaper. To combat this, Mozambique began investing in their own domestic chicken production with the hope of creating a thriving poultry industry that would shift consumption, create jobs, and foster development throughout the country.

Looking to address this issue, the purpose of this thesis project was to work a local company named “New Horizons” in order to establish a successful poultry development plan in the surrounding community of Nampula, Mozambique. In order to assist in this mission, my team and I developed a project in which we would test and analyze different stages of the poultry development process with the goal of noting any deficiencies and providing recommendations to the management of New Horizons. These would include testing different feeds to find which one fostered the best growth in chicks, measuring variables such as temperature at different stages of the process, and interviewing both company farmers and local out-growers to gain insight into the feelings of the community. We believe that if we can provide substantial evidence to company management about what works, what does not work, and why, then we would be able to successfully analyze and improve the way in which the company can use poultry farming to combat food insecurity. Through the development and implementation of this thesis project, my team and I hoped to analyze the way in which poultry is being produced and raised by both the farm and the out-growers with the intention of providing data-backed recommendations on how to improve poultry development, and thus community development in Nampula.

III. The Project

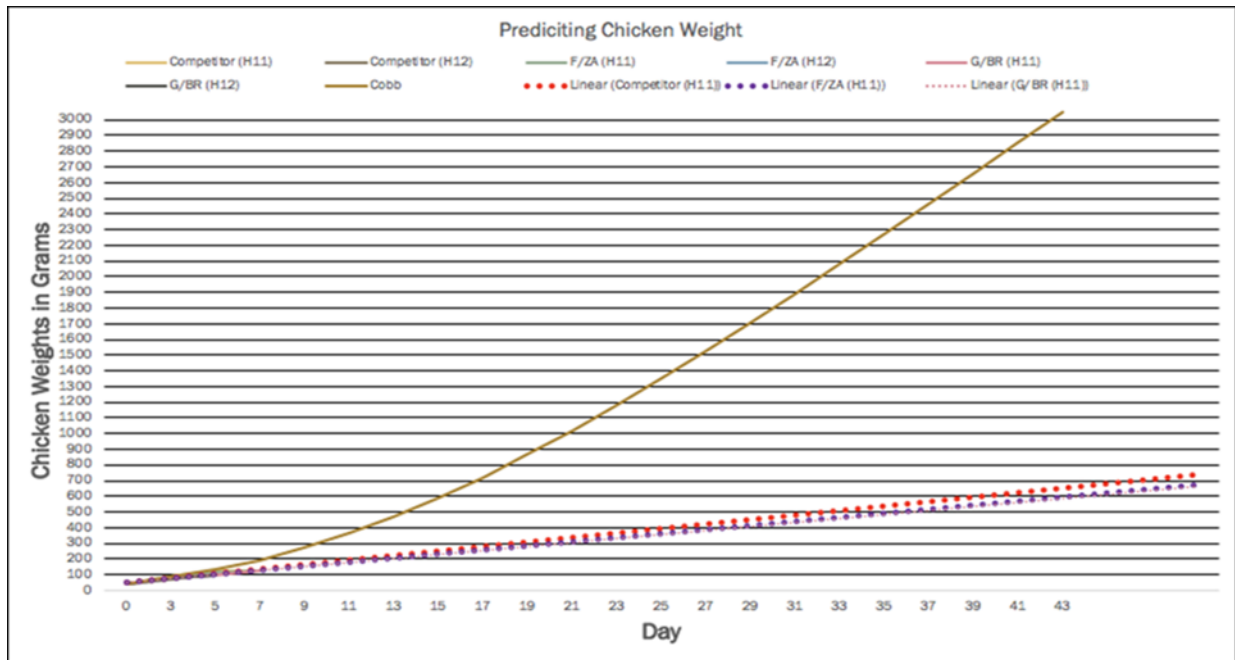
Once again, the overall purpose of this research project was to find ways in which New Horizons could improve their chicken development enabling them to grow larger chickens, bring in a larger profit, and start tackling the issue of food insecurity in the surrounding community of Nampula, Mozambique. In order to conduct this project, it had to first be divided into two separate experiments. The first was an experiment that tested three feed formulas on broiler chickens. This experiment compared the effects of three different feed formulas on average chicken weight gain. The purpose of the feed experiment was to use the results to help determine the best feed choice for New Horizons. The second experiment focused on gathering data to better understand how temperature was affecting the process of raising chickens during each stage of the chick development cycle.

In order to run the first experiment looking at different types of feed, we used two chicken houses (houses 11 and 12) at the Frango King Broiler Farm and three different types of feed. To begin, each house was divided into three separate brooding areas, or pens. Each pen was assigned a different feed. The feeds that we tested were as follows: Francious feed from South Africa (feed F), Gamma feed from Brazil (feed G), and the competition feed (feed C). All other factors influencing the chicks, besides the feed, were to remain the same in each pen. The vision of the experiment was that all chickens would experience regular feeding, frequent movement of the feeders, normal water pressure, adequate lighting for rest, and tarps rising from the bottom up to regulate wind and temperature, so that the only variable factor was the feed. However, nothing ever goes exactly how you think it will in Mozambique, so these factors did end up having some effects on our results.

At the beginning of the experiment, we placed approximately 20,000 chicks in each house, for a total of 40,000 chicks. The average starting weight per bird was 42 grams. On day 3, in house 11, the average weight per bird was 88.89 grams for feed F, 87.99 grams for feed C, and 76.27 grams for feed G. In house 12, the average day 3 weights per bird were 74.12 grams for feed F, 72.98 grams for feed C, and 73.66 grams for feed G. At this stage in the experiment, the Francious and Gamma feeds were performing at a 14.3% difference. We continued to collect data on the average bird weights in each pen on days 5 and 7 as well. With that information, we were able to compile the following two graphs:



The first graph is a linear depiction of average bird weights starting on day zero and going through day seven. The blue line that reaches the highest is the Cobb standard for bird weights on those days. You can tell by looking at the graph that the weights for the new feed formulas were on track with the Cobb standard through day three and even kept in close proximity through day five. However, after day five, the weights began to plateau, and we noticed that birds were not growing. Based on these results, we concluded that water pressure, air quality, and exposure to bacteria played a large role in skewing the data, making it difficult to truly pinpoint which feed was best for the farm.



The second graph is a linear regression which predicts how the chickens would continue to grow through day forty-three (kill day). This was based on the weights we gathered in the first seven days. We also included the Cobb standard in this graph to compare where we predicted the chickens would be to where Cobb expects them to be. The difference was drastic, but there were many factors that played into chicken stress at the broiler farm.

When raising chicks there are four main factors that affect feed conversion, or the ability to process food into growth: feed, light, air, and water. If any of these variables fail, are lacking, or fail to be controlled adequately, it can cause stress amongst the chicks. These higher stress levels lead to the burning of calories which causes more weight loss rather than the desired weight gain. During our time at New Horizons, we examined each of the four factors in the broiler houses noting where they were doing well and where there were areas needing improvement.

The first factor/stressor affecting the chicks' feed conversion is the quality of the feed itself. In order to examine feed quality, we tested the composition of two samples of the white maize used in all of the farm's feed. Poor feed can stress the GI tract and have a large impact on weight gain. It is also important for feed to have a low moisture percentage. Less moisture in the feed means there is more protein, and more protein means more weight gain. New Horizons max level of moisture allowed is 14%. The first sample was usable with a moisture content of 12.7%, though not ideal. The second sample had a moisture content of 14.2%, rendering it unfit for use.

The second stressor that was assessed is light. Currently, most of the out growers and even the broiler houses at the farms use what is known as a 24-hour light system. This is where the broiler houses have lights on all day long and the chicks are not exposed to darkness. While this is fine for the first few days of the growth cycle, according to Cobb standards, once the chicks are in the 100–160-gram weight range, they should be moved to 12 hours of light and 12 of dark. Following this, after about 22 days, the number of "dark hours" should decrease by 1 until the kill day. In order for this to work, daylight can be used during the day to light the pens

and lightbulbs used at night. Not only is a following a timed light schedule better for the chicks, but it also saves money. The following chart details the Cobb Standard for lighting and has been attached for reference if needed:

COBB Broiler Management Guide

3. STANDARD LIGHTING PROGRAM - OPTION 3

- Stocking density: <14 birds/m²
- Average daily gain: >60 g/day
- Slaughter weight: >3.0 kg

Age days	Hours dark	Hours change
0	0	0
1	1	1
100-160 grams	12	11
22	11	1
23	10	1
24	9	1
29	8	1
30	7	1
31	6	1
Five days before kill	5	1
Four days before kill	4	1
Three days before kill	3	1
Two days before kill	2	1
One day before kill	1	1

The third factor that was studied was the stress produced by air in the broiler houses. It must first be noted that air quality includes both ventilation and temperature throughout the houses. Ventilation is important because it minimizes CO₂ levels in the house. Top half ventilation allows for good airflow and prevents a draft from blowing directly onto the chicks. Air quality also means minimizing fluctuations in temperature. One idea we had was to cut the charcoal heaters currently being used in half. This will double the heaters available and make it easier to have a more even temperature distribution throughout the house, rather than a few hot spots and cooler temperatures in between the heaters. The initial mortality we saw early on in our feed experiment can be attributed to transportation from the hatchery. Out of the 40,000 placed, 810 died at the start, putting the mortality rate at 2.1% on day 0. With the open back truck and the chicks packed as tightly as they were, the crates on the outside edges were exposed to cold temperatures while the ones in the center suffered from too high of temperatures and deadly CO₂ levels. While this did not have a direct effect on the feed experiment, the issues caused by poor air ventilation resulted in over 800 chick’s worth of lost revenue.

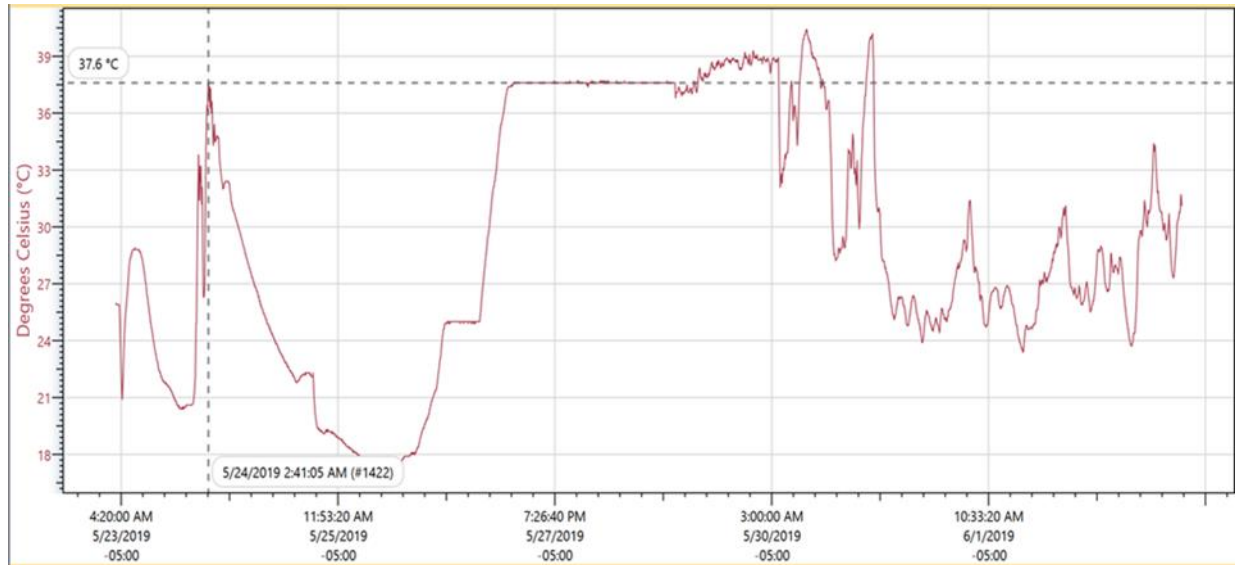
The fourth and final stressor is water quality. The water pressure at Frango King was much higher than Cobb’s standard. With the pressure as high as it was, chickens were having a difficult time getting a drink. Reduced water intake means reduced feed intake resulting, of course, in reduced weight gain. At day 3, Cobb recommends a pressure of 160 ml/mi from their water lines. Frango King’s water lines matched this by measuring in at 160 ml/min on day 3. On Day 12 however, water pressure should be 50 ml/min, but it actually measured out to 500 ml/min at the farm. This pressure was so high, it was the equivalent to a human being taking a sip from a fire hydrant, pointing to a much-needed fix in the water lines. Along with the water pressure being way too strong, the water lines themselves were also dark with grime. This buildup of grime in the water lines is a breeding ground for bacteria and disease, which can severely impact chicken growth and potentially caused increased mortality rates.

After the conclusion of our feed experiment and subsequent data collection, my group and I gave New Horizons four recommendations. First, the water lines need to be disinfected

between each new shipment of chicks and the water pressure needs to be lowered as quickly as possible. Second, lowering the water pressure should help to decrease the moisture content in the litter which will improve the litter quality. Third, we recommended a temperature-controlled transportation process for the chicks to prevent the high mortality rates that were seen on Day 0. The fourth and final recommendation was that there needs to be a set list of SOPs that is completed before each house has chicks placed in it. Included in the Standard Operating Procedures needs to be the disinfection of water lines, feeders cleaned out, and migration fences set up 24 hours ahead of chick delivery. From the data that was collected and what we saw firsthand at the farms, we believe that if these recommendations were to be taken then New Horizons would see their data promote a more accurate finding to the feed experiment and prevent the data from being skewed to the levels we saw. All in all, if preventative measures can be taken early on to address the above-mentioned stressors, then a more accurate feed experiment could be run, and more definitive results could be given to management about which feed is best for poultry development.

The second experiment we conducted focused on tracking the temperature of eggs from the breeder house through the hatchery and then eventually to the broiler farm with the purpose of assessing the negative effects that differing temperatures can have on embryo development and subsequent chick mortality. In order to do this, we compiled six fake “data collecting eggs” that would be placed in the hatchery and then be left with all the real eggs to go through the entire development process. While this multi-day process from breeder house to broiler farm occurs, the data eggs would be recording their temperature for every single minute they were in use. After allowing the eggs to sit through the whole nine-day process, each egg had over 16,000 data points which were then turned into a graph to help better explain the findings.

We began the project on May 23 (5/23) by placing all six of the data eggs in their respective breeder houses. The data eggs were each placed in separate areas of the houses to ensure that their nine-day process would be unique to the eggs surrounding them and prevent two eggs from producing the exact same data. Along with this, the data eggs were created to look almost identical to the real eggs so that employees would not notice them or treat them any differently. This was to ensure that the eggs would record what was actually happening in regard to temperature and prevent any possible untrustworthy findings. After a few days in each of the three locations, nine days total, the eggs were then recovered from the broiler farms and the data recorded. By knowing the exact location of the eggs throughout the whole process, we were then able to compare the recorded temperatures of the data eggs at certain locations/times to what the recommendations are from Cobb. After recording, analyzing, and transferring the data onto a single graph (seen below) we then presented our findings to the New Horizons’ management team noting areas in which the temperatures were too high, too low, and recommendations for how to address the problems.



What the results from this experiment showed was that there was a consistent issue in having temperatures being too high early on in the egg development cycle and temperatures too low during the chicks' time in the broiler houses. Looking at the first few days of egg development, the biggest factor contributing to poor temperature control had to do with transportation. During the earliest stages of embryo development, the eggs are supposed to be kept at a cooler temperature to prevent early embryonic development and thus early hatching. However, the data from the eggs showed that temperatures reached above 33 degrees Celsius on the way to the hatchery and above 39 degrees Celsius on the way to the broiler farms. These warmer temperatures in-route to the hatchery are concerning because if the inside of the eggs become too warm then the embryos inside start to develop and grow. This leads to what is called a "poor hatch window" in which a group of chicks are hatching at random times rather than all at once, and this results in higher levels of chick mortality. Too high of temperatures on the way to the broiler farms is a reason for concern because the chicks may overheat or suffocate due to CO2 intake. These data recordings of high temperatures are concerning for New Horizons because too high of temperatures causes death which results in less meat to sell and lost revenue for the company.

In contrast to temperatures being too high in the early stages of development and transportation, the data also pointed to the lack of heat in the broiler farms. According to the Cobb standard, temperatures in the broiler houses are supposed to be 32-34 degrees Celsius with variations of no more than 2 degrees at a time. What the recordings from the data eggs revealed was that temperatures in the broiler houses during the experiment were between 25 and 35 degrees Celsius. While at some points the temperature in the broiler houses was where they needed to be, for the most part they were too cold. When this happens, chicks spend more time huddled up, trying to get warm, rather than eating and drinking so that they can develop to their fullest potential. The wide fluctuations from hot to cold is also cause for concern because these sharp temperature changes create stress amongst the chicks. As with being too cold or hot, stress prevents the chicks from eating and drinking which also prevents development to the fullest potential. After noting the temperature issues during the different stages of the development cycle, the next step became finding solutions to the problem.

Following the conclusion of the experiment and subsequent data collection, my group and I gave New Horizons four more recommendations to the ones from the first experiment. First, we suggested having on site cooled storage at the breeder houses to prevent early embryonic development while the eggs wait to be picked up. Second, was having temperature-controlled transportation so that temperatures will not negatively affect the eggs/chicks. Third, eggs should immediately be placed on plastic racks at the hatchery to prevent the stacking and overheating of eggs while they wait to be placed. Lastly, we suggested that the broiler farms check on the chicks repeatedly the first 24-48 hours so that necessary changes can be made quickly to ensure the chicks are more comfortable and less stressed out. After assessing the data and checking the status of the data eggs daily, we believe these are some of the best steps that can be taken to counteract the negative side effects of poor temperature control.

The purpose of these two experiments was to identify deficiencies in New Horizon's chick development process and provide solutions that would allow the company to successfully achieve their mission of both making a profit and helping the local community fight the issue of food insecurity. What both experiments showed was that a majority of the issues centered around procedural deficiencies. Whether it be one of the four stressors in the first experiment or lack of temperature control in the second experiment, we believe successfully addressing these issues would result in positive outcome for New Horizons, their out growers, and the local community. While we were not able to distinctively advocate for a certain feed as we wanted too, we still strongly believe that both experiments, and the project as a whole, allowed us to provide company management with attainable goals that will result in positive outcomes. Investment in temperature-controlled transportation and the establishment of a list of standard operating procedures, prior to chick arrival, are what we believe to be the two most important factors that New Horizons must address. If these are addressed adequately, then we believe an even more successful experiment of the same focus could be conducted in the future.

IV. Evaluation

Looking at the poultry project as a whole, both experiments consisted of difficulties that made data collection and accuracy harder to come by. Both experiments contained unique sets of challenges, but common themes were easy to identify. When working in a developing community, such as this one, being able to make adjustments quickly to unforeseen circumstances is critical to ensuring that an experiment can still be conducted successfully. I believe our group did a great job in identifying the issues and addressing them in a timely manner. Overall, I believe both experiments, and the project as a whole, were successful in addressing the issues we came to address but with detailed reflection of the problems we saw and more time in preparation, future projects of this kind could have a chance to be even more successful.

Beginning with the feed experiment, some of the biggest difficulties we experienced in running the tests were the lack of understanding and lack of continuity/consistency among farm employees and the team. Often, there would be farm employees who were supposed to help us with set up and some of the details of the project but being able to consistently communicate effectively could be challenging. Sometimes this was due to the language barrier and sometimes it was caused by inadequate knowledge of poultry science techniques. While these difficulties did not result in the failure of the project overall, it did create challenges such as not always having consistent living conditions for the chicks between the two pens. Some of these

challenges included inconsistent water pressure, varying temperatures between pens, and differences in chick density/size. While not detrimental to the project as a whole, it made accurate data collection more difficult at times.

In an attempt to counter the challenges presented in the experiment, we focused on ensuring that communication between parties was sufficient. Due to issues caused by the language barrier, we began trying to largely communicate with single members of the farm team who could then pass along our information more adequately to other employees who might have been struggling to understand. This allowed for the experiment to become slightly more controlled and helped provide results that we believe successfully benefitted the community. What we learned from the challenges presented by this experiment is that communication of details is critical for data to be gathered accurately and should be the focal point when developing an experiment. As touched on, while there were noticeable challenges presented by this experiment, we do believe we were able to successfully accomplish our goals of assisting in community development. The results from this feed experiment allowed us to provide New Horizons with concrete data regarding the effects of different feed and temperature on chicks. Along with this, there were multiple opportunities where we were able to provide practical advice to out-growers and in-growers on raising healthier chickens.

The second experiment we conducted with regards to the data collecting eggs also proved to have some difficulties of its own. Once again, the biggest problem encountered while conducting this research had to do with the language barrier and being able to adequately express our needs to the farm employees. Presenting the experiment and our plan to the farm management was no problem, as they spoke fluent English, but rather the issue came with speaking to the regular employees who were not bilingual. These issues resulted in challenges such as the data eggs being moved from their designated locations when they were not supposed to and a general uncertainty about the eggs' location. When the eggs were not in the right location, it made getting the correct data very hard to come by.

In order to combat this issue, we once again expressed to importance to farm management about effectively communicating our needs to farm employees as well as having multiple data eggs to get results from. I believe these actions that were taken were successful in addressing the problems because once the general employees fully understood what we wanted, the data began to look more accurate. Also, having six eggs allowed for comparison of data to create the most accurate findings. Overall, while this experiment faced multiple challenges, I do believe that the project successfully assisted in community development. Teaching the company, as well as out-growers, about the importance of temperature for chicks will allow them to grow bigger chicks and thus, make more money. After presenting our project, we had some of the translators come up to us and specifically ask how to help their out-grower friends with temperature. Them asking, as well as us giving them tips, helped assure us that our work was helping the local community develop and become more efficient.

After evaluating each experiment by itself, there were some common challenges that were seen across the project as a whole. The biggest issue faced was obviously the language barrier and everything that comes with it. Whether it be miscommunication about how to set up feed pens or inconsistencies with placement of the data eggs, being able to successfully communicate was critical to the project. We also learned that with a project like this, being able to constantly check in on the chicks and eggs allowed for better control over the details and

better results. Daily check-ins allowed for mistakes in data collection to be fixed quickly before they would start negatively skewing the data. In looking back on how the project was conducted, the major thing that we would want to do differently was establishing all the details thoroughly among the team and farm employees, even if it would have meant starting data collection a few days later. This could have prevented some fixable mistakes in the set-up of experiments allowing for even more data than what we were able to find. Even though there were issues and things we would have liked to do differently, we were satisfied overall in what we were able to learn and how we were able to address the problem we came to address. Our results from the first experiment allowed us to give recommendations for feed as well as directions for how to set-up a chick pen to facilitate better growth. From the second experiment we were able to provide multiple data points and suggestions about how to better handle eggs and temperature control. Overall, I think most of the barriers we encountered were due to the systemic issues in Mozambique such as poor education and communication problems. Future projects in this community would likely face some of the same issues but some of the issues, communication mainly, could be addressed with more time beforehand in establishing the project with farm management.

V. Next Steps

After conducting all the research and taking a step back from the project, we believe the logical next step would be to conduct the same experiments but only after accounting for the issues just discussed in the evaluation section. While our research did provide lots of results and concrete data, with slight changes to the details it could produce even stronger findings. For the first experiment, our desired next step would be to make a detailed list of the standard operating procedures for how to set up and run the broiler houses. During our initial tests, we noticed employees had a hard time understanding and following what exactly we were wanting in terms of how to set up the broiler farms because it was different than how they usually did it and the language barrier was strong. After expressing to the head of the farm what we were wanting to do, he passed the request down to the employees and we had no issues after. We believe that if these desires can be successfully expressed before the chicks arrive at the farms, or even better, before the next group is in country, then the set-up and running of the experiment will be go more smoothly. Along with this, we believe that if the feed project could have been run for longer than nine days the results would have been even more detailed than they already were. If expressing logistical needs and creating a list of SOPs prior to entering the country could be accomplished, we believe running the same feed experiment again would be the next logical step as it would only provide more data for New Horizons to use.

Following the same line of thinking from the first experiment, we believe the next logical step for the temperature experiment would be to run it again with more focus on preparation. One of the biggest issues we saw with this experiment, as mentioned, was employees not knowing what the data-collecting eggs were for and moving them without being asked. In order to combat this, one employee would be put in charge of the eggs from start to finish and focus on ensuring that the eggs are not altered with. By doing this, the next group would be able to get a more accurate reading of how exactly the eggs are being placed and treated. The second alteration to the project for the future would be to run the eggs all the way through the cycle more than once. While time constraints prevented us from doing this, being able to collect data more than once is always a good thing.

While both experiments consisted of challenges that made data collection difficult, we believe addressing the issues and running the same experiments again would be the most logical next step because of the interest and feedback we received at the farm. After presenting our results to the company management on the last day, my group and I were swarmed by both faulty staff and some of the local out growers asking questions. Hearing people who had been doing this stuff for most of their lives ask us, undergraduate students who had only been researching this for a few months, questions about how to improve their livelihood hit me hard and made it all seem worth it. As mentioned, both our projects had areas we felt could be improved but we were still able to provide the local community with many useful ideas and recommendations. It excites me thinking about all the extra good we could have done if our projects ran how we wanted them too, and that is why I think running these experiments again, with the necessary improvements, would be the most logical next step.

VI. Personal Evaluation

Taking a step back and looking at everything I experienced through the development of this thesis project, I noticed growth in myself both personally and professionally. Working in a developing country is one of the hardest, but easily most rewarding, things I have ever done and every moment I had there will not be taken for granted. Professionally speaking, what I learned most was the importance of strong communication and flexibility. As mentioned, communication was one of the biggest challenges we faced with both of the experiments so being able to develop a consistent and reliable line of communication early on is critical. Establishing strong communication also goes farther than just language barriers as consistently talking with my fellow group members and professors helped keep us all on the same page with what the plan was and what our intended goals were. By doing this, it helped prevent issues that could have been detrimental to the data findings we recovered at the end. Along with communication, this thesis also taught me the importance of flexibility in the professional world. Nothing ever goes as planned with these types of projects, especially in developing countries, so being able to adapt to new changes quickly and seamlessly can allow for smoother transitions and less frustration among colleagues. The whole process of developing and running this thesis project has resulted in my learning of key lessons that I will take with me into the business professional world someday.

Along with what I learned professionally, this thesis and working in a developing country has taught me a lot about myself personally. I never thought working internationally was something I would want to do, but after this experience my professional goals have completely changed. After working with New Horizons and the community members in Nampula, I took a step back and realized that helping people was a major passion of mine. Doing work that I know will make someone else better in the long run gave me a sense of purpose that I was lacking. Working in a developing country like Mozambique creates challenges unlike anything I have ever had to deal with in the United States, but it showed me how important discipline and controlling emotions is to being successful. A lot of the time, especially at the beginning of the project, things did not go our way at all, and we had to come up with creative problem-solving strategies on the fly almost every day it seemed like. Before this trip, these unexpected changes would have caused me lots of stress and probably created negative emotions, but our group staying calm and disciplined played a major role in allowing us to still be successful in the end. Since returning, I have tried to consistently to take a step back, control my emotions, and remain disciplined when things seem to be going all the wrong ways and I credit that to my time in

Mozambique conducting this research. Overall, working on a project like this in a developing country such as Mozambique provided me with so many life lessons, both professionally and personally, that I plan to take with me for as long as I live.

VII. Conclusion

Food insecurity throughout the world, and Mozambique, continues to be a problem but after completing research and analysis on our two experiments at New Horizons, we believe we have been successful in showing the positive role poultry can play on the issue. Our first experiment demonstrated the necessity for a list of standard operating procedures in broiler houses before and after chick arrival while also highlighting the importance of choosing the right feed. Our second experiment showed how essential temperature control can be, especially to eggs, and how keeping temperatures within the recommended levels provided by Cobb can result in an increased profit. Both projects consisted of difficulties that we believe can easily be addressed and changed for future research of this kind. Working in Nampula, Mozambique had a profound impact on me for the better and I hope with this thesis I can do the same for the people there.

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