Mobile Chicken Tractor at LaFarm

A Soil Revitalization Feasibility Study

EGRS 451: Capstone Seminar on Engineering & Society

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Introduction

LaFarm History

LaFarm is a sustainability initiative at Lafayette College whose mission is to integrate curriculum practice in sustainable food and agriculture for the campus community. LaFarm grows produce for the dining halls, recycles nutrients from composted food back to the soil, and serves as a laboratory for student-faculty education and research.

Located at the Metzgar Field Athletic Complex LaFarm, is about three miles from the main campus. It is a two-acre working farm and community garden. The institutionalization of LaFarm started with student Jenn Bell, who in 2009 with the help of Professor Kney received a grant from the Clinton Global Initiative University Conference which funded the initial purchase and construction of LaFarm. Jenn was in charge of the farm until 2012 when the project received additional grants that allowed LaFarm to hire the current Garden Manager, Sarah Edmonds. Today, the current members of the Lafarm Board are Professor Cohen, Professor Brandes, Professor Lawrence, and Professor Germanowski.

Lafarm grows a multitude of fruits and vegetables and has since expanded participation to members of the Lafayette community and the local community. As part of Lafayette's Sustainable Food Loop (SFL), LaFarm provides produce to Bon Appetit Dining Services and receives organic waste to be used as compost in return. Remaining space at LaFarm is used as a garden for members of the local community in Easton and Forks Township.

Looking Forward

LaFarm plans on expanding and has already begun to make adjustments for the expansion. Previously, Lafayette leased this proposed expansion space to a commercial farmer who used the land to cultivate corn and soy. A farm's soil is very important to its operations. The amount of organic matter in the soil indicates the kinds of biological micronutrients available for plants, which influences how various plants will grow in that soil. Likewise, soil quality dictates which cultivation methods are most effective (e.g. more clay soils are harder to till by hand, drip irrigation is difficult in sandy soils, etc.) LaFarm has a rocky, clay-based soil with about 2% organic matter. Prior to being in organic production, the soil was mostly inert as it was under conventional GMO corn and soy cultivation. This type of land use, over time, has depleted the soil of its nutrients. As LaFarm expands, a system is necessary to effectively and sustainably fertilize the land.

As proposed in the ESVT 2016 Capstone, the introduction of a chicken flock would allow for the expansion area to be sustainably fertilized. Currently, LaFarm does not have any animals or livestock. By adding chickens, not only do we fertilize the land, but the identity of the farm expands to a sustainable produce and poultry farm; it also changes the duties of Sarah Edmonds, the LaFarm volunteers, and Lafayette College. In our Political Analysis and Social Analysis, we discuss the anticipated change that chickens will have on LaFarm and in the Technical and Economic analyses, we look at how to actually implement the chicken tractor efficiently and effectively.

Goal

As proposed in the ESVT 2016 Capstone, the introduction of a chicken flock would allow for the expansion area to be sustainably fertilized. Our group's goal is to develop a plan for an effective chicken tractor system to be installed, and for it to fertilize LaFarm's nutrient-depleted land. Similar to a feasibility report, we aim to provide all of the necessary information for the introduction of chickens at LaFarm. Through our technical, political, social, and economic analysis we believe our plan will provide Lafarm with an effective and sustainable fertilization solution. After our study, we hope to provide the background information for another group to build upon, both metaphorically and physically, in an effort to implement the chicken tractor at LaFarm.

Challenges

Most of the challenges associated with implementing a solar powered chicken tractor are technical and economic; Sarah believes that implementing this system would not experience much social or political/policy backlash. Nonetheless, it is important for our team to consider all aspects of this sociotechnical system.

There are many designs available for mobile chicken coops, with each one having its own pros and cons. Additionally, there are several technical problems that need to be accounted for in the design, including protection of chickens and a reasonable level of automation so that Edmonds does not spend a lot of time on the chickens every day.

Economically, it is unclear who will pay for the tractor. Along with the varying designs, there are varying costs for each design too. It could be difficult to determine who the costs will change based on the scope that the next group decides to implement.

While Edmonds believes the day-to-day operations could be handled easily, volunteers would be needed weekly, perhaps daily during the peak growing season. Some of our suggestions to increase volunteer involvement and community connection to LaFarm include a LaFarm Living Learning Community, chicken “sponsorships,” and restaurant partnerships.

The introduction of livestock to Lafarm opens up many more regulatory standards which need to be met. Beyond regulations of simply owning livestock, if the eggs produced are to be used by members in the community, the members of Lafarm will need to properly clean, package, store, and distribute them. These standards are monitored strictly by governmental departments such as the Department of Agriculture and the US Food and Drug Administration. Additionally, one standard requires the weekly cleaning of the coup which is a difficult problem to address. Typically volunteers go to the farm in the fall and spring, but nobody goes in the winter as there are no crops to plant or harvest. This would require members of the community (Lafarm, Lafayette College, or Easton) to journey out to the farm and clean/tend for the chickens in the cold.

Section Overview

Social Context: The Social Context section explores the main social aspects of the project that help shape it; they also, in part, explain why this problem is a problem, and why our solution fits within the Lafayette community. The local food movement, alternative agriculture movement, and campus farm initiatives all have a role in shaping societal perceptions of the LaFarm initiative.

Political Context: The Political Context section reviews existing regulations the implementation of livestock into a farm, all the way through to the packaging and distribution of eggs. Additionally, this section reviews potential grants and credentials Lafarm could obtain to increase the prestige. The goal of this section is to make known the political limitations in the chicken tractors system and how to design around it, while also searching for awards to boost the farms standing and reward it some extra funds.

Technical Context: In this section, we go over our three recommended coop designs, as well as the features that should go in every coop. Importantly, every feature that requires electricity will likely be able to be solar powered. We also look at the technical side of fertilization, as the benefits of chickens and their natural interactions with the soil may not be obvious.

Economic Context: The Economic Context section breaks down the cost of our technical recommendation in great detail, as well as providing a macro-enabled spreadsheet tool for future groups to utilize when they are deciding how to move forward with this project.

Social Context

LaFarm's identity and place at Lafayette College has been influenced by the alternative agriculture movement, local food movement, and other campus farm initiatives. Our project, therefore, must be shaped by these contexts as well since it will be integrated within the LaFarm system and become part of its identity. We have determined several ways to connect the faculty, administration, students, and greater Easton community to this project and LaFarm as a whole through these formative contexts.

The main goal of raising chickens on LaFarm is to utilize their natural, soil enriching behaviors to revitalize a section of the field that is depleted from several years of traditional farming practice. LaFarm's mission statement is on the Lafayette College website:

> LaFarm is a sustainability initiative at the College and the cornerstone of the Lafayette College Sustainable Food Loop. Our mission is to integrate curriculum and practice in sustainable food and agriculture for the campus community. We grow produce for the dining halls, recycle nutrients from composted food back to the soil, and serve as a laboratory for collaborative student-faculty education and research (LaFarm, n.d.).

Traditional farming methods and chemical fertilizers, therefore, would not fit in with the mission and values of LaFarm and an alternative method must be found. One possible solution that does fit in within the context that LaFarm has established is solar powered mobile chicken coop. According to Alternative Agriculture (Committee on the Role of Alternative Farming Methods in Modern Production Agriculture, National Research Council [NRC], 1989), "The hallmark of an alternative farming approach is not the conventional practices it rejects, but the innovative practice it includes." Though it is important that LaFarm would be rejecting traditional methods, it is even more crucial that there is innovation. While there is a natural compost process that serves as a fertilizer for much of the current LaFarm area, the innovation of using a solar-powered chicken tractor on a college farm, to fertilize a field that will be used to provide food to dining halls and the surrounding community would be an unprecedented achievement. The chicken tractor is a classic case of alternative systems, which "deliberately integrate and take advantage of naturally occurring beneficial interactions (NRC, 1989)." Lafayette College consistently demonstrates a commitment to constantly improve its stature amongst peers as well as its public image through sustainability (Our Values, n.d.). A chicken tractor could be a staple of the LaFarm and the College's commitment to sustainability, particularly if it is solar powered. By naturally fertilizing and revitalizing a nutrient-depleted field, the college is not only rejecting conventional chemical fertilizers and embracing alternative energy, but creating an innovative, alternative agricultural solution that could potentially be implemented at other college farm initiatives.

Local food movements attempt to connect food producers and consumers who live and work in the same area (Starr, 2010); LaFarm is a classic example of this movement within our campus community. LaFarm provides vegetables and greens to the dining halls, and though it does not provide one hundred percent of the produce that is consumed (LaFarm, n.d.), it does force students to become a part of the local food movement (whether they know it or not). Local food is an alternative to the normative global food model, which typically utilizes industrial agriculture techniques and modern transportation systems so food can long distances to reach the consumer. By supporting local food movements, consumers and farmers are coming together to promote sustainability and food security within their respective communities (Dunne, Chambers, Giombolini, and Schlegel, 2010). According to the USDA, 7.8 percent of U.S. farms were participating in the local food movement to some degree as of 2012. From 2002 to 2007, the number of farms with direct to consumer (DTC) sales increased 17 percent, and from 2007 to 2012 it increased another 5.5 percent. Additionally, local food sales accounted for an estimated $6.1 billion in 2012; these statistics demonstrate that interest in local food, as well as its productivity, is continuing to rise (Low et al., 2015). Researchers have found that the local food movement is partially characterized by "its use of pleasure (Starr, 2010)." Most participants go out of their way (with their time and money) to contribute to local food, and they do so happily. Many farmers recognize the significant satisfaction they gain from the "sensual material embodiment of ecology and craft" while consumers are able to have a more personal experience through interaction with the farmer (Starr, 2010). Harnessing the joy and satisfaction one can experience through participation in the local food movement will be a key factor in the long term success of not only the chicken tractor project, but LaFarm as a whole.

Student farm initiatives on college campuses are not new innovations; the first student farms were established in the early 1900s. With the advent of the counterculture movement in the 1960s and '70s, college farms became more widespread. Recently, interest in sustainability, local food, and preventing climate change has caused a steep upward trend as more institutions begin their own farm initiatives (Hyslop, 2015). While there is not a singular set of rules or defining factors for successful initiatives, college farms generally share several common characteristics including their interdisciplinary nature and educational opportunities. They help to teach students about their environment, sustainability, and often alternative agricultural methods as well (Hyslop, 2015). LaFarm (Lafayette College Community Garden and Working Farm) was initially conceptualized after a "Corn on the Quad" garden project in 2008; students read and analyzed Michael Pollan's "Omnivore's Dilemma," which sparked conversations about the role of food in our lives and at Lafayette (Edmonds, 2015). The farm began to really take shape in 2009 through the efforts of Jenn Bell ('11), who eventually became the first Farm Manager in 2012. Through initial funding from the Clinton Foundation and partnerships with the Society of Environmental Engineers and Scientists (SEES) and the Lafayette Environmental Awareness and Protection (LEAP) organizations, Bell set the foundation for what LaFarm has grown into today (LaFarm Archives, n.d.). In 2015, LaFarm was 37,000 square feet (about .85 acres), produced over three thousand pounds of produce, averages three EXCEL scholars, and had over ten part-time student staff annually (Edmonds, 2015). Lafayette College owns the farmland surrounding LaFarm, and is currently looking at several expansion options; this process birthed the idea of using chickens to revitalize the soil in order to make expansion fit within the ideals and goals of LaFarm and Lafayette's sustainability commitment. The proposed areas of expansion range from one to one and a half acres, pictured below. Through the use of the chicken tractor, LaFarm could increase the amount of production significantly and thus increase the visibility and productivity of the Sustainable Food Loop as a whole.

Currently, there are no livestock or poultry on LaFarm. In fact, "of the 27 colleges to which Lafayette compares itself, 2 have chickens on their farm (Hogan, Ratsimbazafy, and Ungarini, 2016)." Pomona College started a small flock in 2008 for their Animal Husbandry program and Macalester College started a four chicken flock of exotic breeds in 2011 for educational purposes as well (Hogan et al., 2016). At Pomona, the chickens are the responsibility of the Environmental Analysis department and are subject to strict animal welfare standards which are regulated by a national accreditation agency. Student coordinators and volunteers are responsible for the day to day care of the chickens as well; additionally, their farm holds a "Backyard Chicken Basics Workshop" to educate students about how to raise chickens in their own backyards (Pomona College, n.d.). Macalester College, as mentioned above, use their small flock to educate students about sustainable urban landscapes and foodsheds. The chickens are cared for by members of the garden club and the eggs are distributed amongst themselves (MULCH Chickens, n.d.). In addition to revitalizing the field next to Newlin's Farmhouse, our chickens could serve a secondary educational purpose as well if the College models programs after those at Pomona and Macalester.

Adding chickens into LaFarm would not just change its identity, but would also impact the Sustainable Food Loop as a whole. Lafayette College's Sustainable Food Loop (SFL) is "the central organizing principle for activity at Lafayette College aimed at pursuing sustainable food and farming practices." In addition to the produce that LaFarm provides to Bon Appetit Dining Services, Bon Appetit provides LaFarm with organic waste to be used in conjunction with the composting facilities at LaFarm, thus creating the loop (Food & Farm, n.d.). Despite being provided with organic waste, the compost at LaFarm is not enough to re-nourish the soil in the proposed area of expansion, further emphasizing the need for alternative, sustainable methods of revitalization (Edmonds).

Integrating chickens into LaFarm will require more maintenance, oversight, and general labor. At the scale we are proposing, the chickens would require only minutes of care per day in order to feed, water, and collect eggs (Raising Chickens, 2013). However, there are several periodic duties that will require more effort, such as constructing and maintaining the coop if something breaks, as well as cleaning out the coop periodically. Sarah Edmonds, whose official title is “Metzgar Environmental Projects Coordinator and LaFarm Community Garden and Working Farm Manager” lives and works on the farm on a daily basis, and has experience working with chickens in the past. Edmonds does not believe a chicken tractor of the scope that we propose would be a considerable additional burden on her; however, Edmonds will need volunteers to help with all aspects of the chickens when she is unavailable (especially cleaning and maintenance) (Edmonds). This requires significant investment and involvement from students, ideally the commitment would be shared amongst a core group of consistent volunteers. One idea supported by Edmonds and members of the previous chicken study is the possibility of a a LaFarm Living Learning Community (LLC) group, which would be mutually beneficial for the students and Edmonds.(Hogan et al., 2016). A Living Learning Community is a three-person house that is “themed;” residents are expected to create their own learning opportunities and actively participate in the creation of programming centered around their theme. There are several LLCs, but there is a high potential for a group of students to come together and form one related to LaFarm. Currently, there is a “Foodie” themed house, and in the past, there has been a “Botany” house, a “Civic Engagement” house, and a “Social Justice” house; all three relate to themes that surround LaFarm and demonstrate that students are at least interested in the issues that LaFarm attempts to address (Living Learning Community Program, n.d.). These LLCs, in conjunction with the EXCEL scholars, the various volunteer organizations discussed below, and the part-time students that have worked with LaFarm in the past, suggest that finding three students to occupy a LaFarm LLC may not be as far-fetched as we initially believed.

A LaFarm LLC is purely speculative at this time, however there are several volunteer organizations that currently exist and work to help with the operations of LaFarm, as well as general sustainability initiatives around campus. Lafayette Environmental Awareness and Protection (L.E.A.P.) has worked directly with LaFarm in the past, but they are oriented towards promoting awareness of environmental issues through educational public displays (LEAP, n.d.).While L.E.A.P. may not help directly in the chicken tractor operation, they could potentially advertise and promote events relating to the chicken tractor. Delta Upsilon sends volunteers every other Saturday or as needed, and could be an excellent resource for Edmonds to utilize when the coop needs cleaning and maintenance. The Lafayette Food and Farm Cooperative (LaFFCo) works closely with Sarah Edmonds to operate LaFarm; they often volunteer their time to do odd jobs and handiwork around LaFarm and is problem the most central organization to the continued operation of LaFarm. Through communication with Jen Giovanniello, the student contact for LaFFCo, we found that her organization would actually be able to contribute several facets of the chicken tractor. In addition to potentially contributing towards the costs and expressing interest in having LaFFCo help set up the chicken tractor, Giovanniello believes that they could incorporate care into their preexisting volunteer events. Additionally, she mentioned that though she was unsure about interest in a LLC or designated person, the 2017 Environmental Studies Capstone mentioned an EcoRep position that would serve as a student - to - farm liaison, and that perhaps this person could include the chickens in their responsibilities (Giovanniello, 2017). These organizations, especially LaFFCo, would be those that could supply volunteers if the LLC or work-study plan does not work out. These organizations are heavily involved and invested in the LaFarm initiative, and many members could be reinvigorated and excited by the possibility of raising chickens. For the initial construction work, it could be done as part of the engineering curriculum or by a set of volunteers. The Society of Environmental Engineers and Scientists (S.E.E.S.) also works closely with LaFarm and has been heavily involved with the design and implementation of technical systems in the past, especially the composting system (Lafayette College Society, n.d.). S.E.E.S. would be an ideal organization to oversee and perform the construction of the chicken tractor if the College and faculty decide against including the process as a part of the curriculum. The aforementioned volunteer organizations will be crucial in integrating a solar powered chicken tractor socially; the success of the project depends on the willingness of the student body to keep it up and running. The good news is that since we are proposing an initial flock of 25 chickens, Sarah will be able to take care of the chickens daily and there should be more than enough volunteers to help with periodic tasks amongst the previously listed organizations.

Raising chickens at LaFarm could generate more interest, willingness to learn, and volunteers. One way to incentivize faculty, students, and others to be more emotionally invested to the chicken project would be to have chicken "sponsors." These sponsors could name a chicken, and get periodic updates on their health and activities. Sponsors would be more likely to care about the chickens then the average person, and more predisposed to volunteering at LaFarm. A partnership with a locally owned restaurant or coffee shop, which could advertise "Locally sourced organic eggs from Lafayette's LaFarm" would create a deeper community connection, in addition to the obvious economic benefits, and is a perfect example of the local food movement coming alive at Lafayette. Admittedly, there are several potential issues with both of these ideas. Chickens are quite prone to predators, and death in general; it is a natural and common occurrence (Edmonds). Chicken sponsors may be excited to sponsor and become involved at first, and then become dismayed when "their" chicken passes away. This could be countered through proper education about chicken farming and perhaps some sort of guarantee (i.e. if your chicken is killed by a predator, you get to name another one for free). Additionally, there are more stringent regulations when using poultry products commercially which could provide a barrier to the restaurant partnership (Edmonds); these will be discussed further in the Policy Context Analysis.

A flock of chickens, raised in a solar powered chicken tractor for their eggs and fertilizer as part of a sustainability initiative, would undoubtedly change the social identity of LaFarm, the Sustainable Food Loop, and Lafayette College by having wide ranging impacts throughout the arenas of the local farm movement, alternative agriculture movement, and college farm initiatives.

Political Context

Introduction

Although there might not seem to be any legal or policy problems with raising chickens on an already-existing farm, it is important to understand the various laws, regulations, and political actors in order to make the project successful. In addition to a couple Lafayette policies that make the chicken tractor seem viable in relation to the school, there are local, state, and federal regulations that pertain to LaFarm and the proposed chicken tractor. While they may not affect the project at the initial, planned scope, it is important to understand them in case a future group decides to expand the capacity of the chicken tractor project.

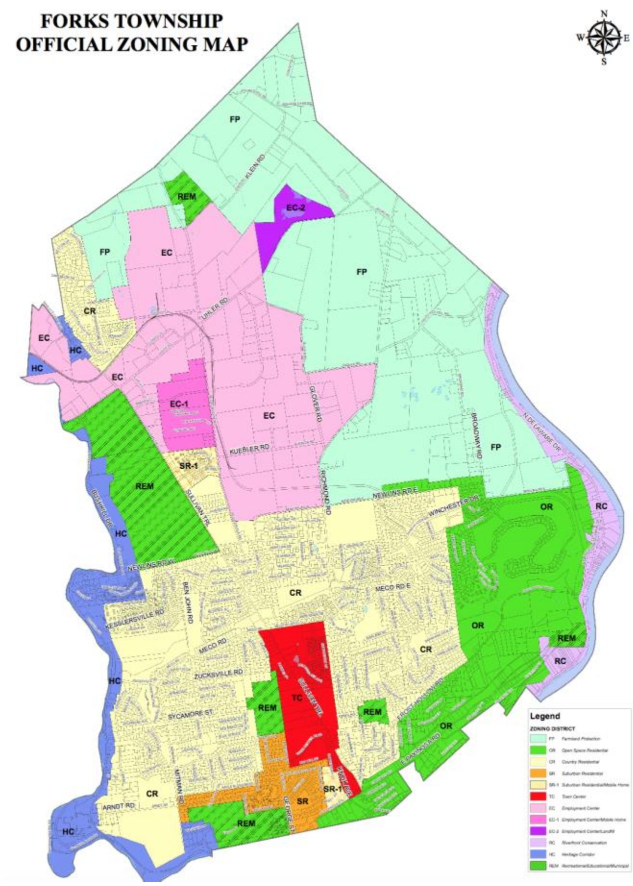
Lafayette College

In 2008, Lafayette College signed the American College & University Presidents' Climate Commitment (ACUPCC), which "is a 'high-visibility effort' to address global warming by creating a network of colleges and universities that have committed to neutralize their greenhouse gas emissions and accelerate the research and educational efforts of higher education to equip society to re-stabilize the earth's climate (Mission, n.d.)". Traditionally, these greenhouse gas emissions are cut through a decrease in energy consumption and investing in alternative energies. When using those two criteria to determine a new solution, a chicken tractor could provide exactly that for LaFarm. The chickens fertilize the field while eating the pests and reduce the need for fossil fuel intensive fertilizers.The Lafayette College Energy Policy states that, "energy efficient products shall be purchased whenever possible"(Energy Policy, n.d.). Additionally, the policy states that the college's "focus has been enhanced to include, beyond all of our conservation measures, the goal of operating our campus with the least effect on our environment." Traditional inorganic fertilizers have been proven to have wide-ranging negative effects on the environment, both through their production and their use (Carpenter et al., 1998). Traditional organic poultry fertilizer has been proven to reduce pollution while improving soil quality to the same degree as inorganic fertilizer (Evanylo et al., 2008). Organic fertilization techniques, therefore, are consistent with both the energy policy of the college and the misison of LaFarm as detailed in the Social Context section. These policies elevate the feasibility of the chicken tractor as well as the potential benefits the school can obtain.

Lafayette College does not appear to have a policy on animals beyond prohibiting pets (Housing Policies, n.d.) and allowing assistance/service animals with proper approval (Assistance/Comfort

Animal Policy, n.d.). An official policy may need to be developed, such as a commitment to the ethical treatment of animals in order to assuage concerns that may arise.

Forks Township



LaFarm is located three miles from campus at the Metzgar Fields Athletic Campus, and is under the jurisdiction of Forks Township. Therefore, LaFarm must adhere to the regulations which the local (Forks Township), state (Pennsylvania), and federal (United States) governments impose on agricultural practices. The regulations regarding zoning are important to be noted. FORKS TOWNSHIP, Article VI, discusses Environmental Performance Standards (Ordinance 331 Code 200, 2014). While Lafayette owns the property and may do with it as it pleases, alterations still must be made notice to Fork's Township and there are requirements for all uses. LaFarm should be exempt from the several forms and regulations as it fits the criteria listed in provisions in this article: steep slopes of less than 3,000 square feet land area, previously and substantially developed lots, and the portion of the land directly affected by location of a through-road or other community facility as determined necessary by the Board of Supervisors (Article VI, 2016). As the EVST 2016 Capstone researchers discovered after contacting Tim Weis with Forks Township, permitting would only be necessary if the eggs were to be sold to the general public (Hogan et al., 2016). Sarah Edmonds stated that the quantity of eggs produced by the amount of chickens LaFarm would have would not be enough to warrant selling them (Edmonds). The purpose of the chickens would be largely educational and any produce would likely stay within the Lafayette community, with produce being distributed at no profit. Additionally, the area of land allotted to LaFarm is listed under the official zoning map for recreational and educational purposes, so it may have some leeway when it comes to regulatory standards. In short, according to Edmonds and prior research there should be no permitting or legal issues due to LaFarm's proper zoning, educational purpose, and low poultry output.

LaFarm

Animal Feeding Operations (AFOs) are agricultural facilities where animals are raised in confined situations, which LaFarm would be technically considered with the addition of chickens (National Resources Conservation Service, n.d.). However, due to the small scale of the proposed chicken project, and because the waste is being used as fertilizer instead of being discharged into a ditch, stream, or other waterway, LaFarm would not be in danger of committing illegal acts.

Students, administrators, and consumers may be concerned about the Food and Drug Administration's egg regulations (and salmonella contamination in general), which require producers to develop methods to prevent salmonella from contaminating eggs. Despite concerns about salmonella, however, producers with fewer than 3,000 laying hens and those that sell all of their eggs directly to consumers are exempt from these regulations (Center for Food Safety, 2017). In fact, Pennsylvania has specific regulations for "Small Flock Producers," which are defined as producers who have "less than 3,000 hens, sells eggs within five days from the date of lay ,and sells eggs within a 100 mile radius from their production or processing facility (EGG, FRUIT AND VEGETABLE INSPECTION, n.d.)." If LaFarm would choose to sell their eggs, they would be subject to these regulations, which are fairly simple and outlined in detail here. Though LaFarm does not sell eggs, if a partnership with a local restaurant were to occur, the eggs would need to adhere to the regulated standard. The requirements are as follows: When storing and transporting eggs, all eggs must be kept at 45 degrees fahrenheit or less, a thermometer must be available in the cooler to verify the temperature; dirty or broken eggs must be removed; the eggs must be properly packaged and labeled, with the name and address, the date of lay, "Keep Refrigerated", and handling instructions; small producers that do not weigh and/or grade their eggs to US Standards must label them as "unclassified;" the Retail Food Code requires that eggs must meet US Consumer Grade B or better standards to be able to be used in

Retail Food Facilities. If LaFarm were to meet all of these requirements, the eggs may be sold and purchased locally.

If consumers are found to be concerned with salmonella contamination despite LaFarm's compliance with the minimum regulations, LaFarm could aim to meet the requirements of the Pennsylvania Egg Quality Assurance Program, which would add a level of certification ot their eggs. PEQAP's goal is to reduce the risk of salmonella spreading, and achieves this by holding producers to a slightly higher standard. Through better monitoring techniques and stricter regulation, the PEQAP certified producer's output higher quality eggs; the program requirements can be found here.

Being zoned for agriculture, there should be no issue constructing a chicken coop, as there were no issues raised with the construction of two sheds and a pavilion and no issues discovered while researching the possibility of constructing a greenhouse (Edmonds).

Federal and Non-Federal Programs and Grants

Recognition amongst the local community is not the only accreditation the school can receive from such a project, though. Beyond Lafayette College lies the potential to be awarded a variety of potential grants, which all seek to find sustainable solutions within the field of agriculture. Sustainable Agriculture Research and Education Grant is a program supported by the US Department of Agriculture and gives grants for research and education for farming projects (Sustainable Agriculture Grants, n.d.). The Organic Transitions Program provides academic institutions funding for research that addresses the issues with transitioning to organic farming and environmental impacts of organic systems (USDA Funding Available, 2016). The Organic Research and Extension Initiative provides funding for addressing critical challenges faced by organic farmers (National Institute of Food and Agriculture [NIFA], 2016). The Agriculture and Food Research Initiative provides grants to academic, private, and nonprofit institutions to conduct agricultural research, education, and extension on issues facing the food and agricultural system including plant and animal health, food safety, climate change, food systems, and rural communities (NIFA, n.d.). If LaFarm were to make use of the chickens for producing organic products, or for educational/research purposes,then it would qualify for either the Organic Research and Extension Initiative or the Organic Transitions Program. Lastly, the use of a solar PV system to power certain electrical elements as noted in the Technical Context section, this chicken tractor would qualify for the Rural Energy for America Program which enables farmers to purchase renewable energy systems and make energy efficiency improvements (Rural Energy For America, n.d.).

Good Agricultural Practices (GAP)

Good Agricultural Practices (GAP) and Good Handling Practices (GHP) are voluntary audits that ensure produce is produced, packaged, handled, and stored safely. Since LaFarm will not be selling eggs at the initial stage, most of these practices do not necessarily apply. The care of the animals is also considered in depth. Most importantly, caretakers should respect animal well-being, avoid non-therapeutic surgeries, minimize the use of antibiotics and hormones, and avoid using animal matter as feed (Animal Health and Welfare, 2007). A more extensive list for animal welfare can be found here and the regulations that would apply to the eggs should LaFarm choose to sell them can be found here.

Food Safety Modernization Act (FSMA)

The Food Safety Modernization Act (FSMA) has a section specifically on biological soil amendments (essentially, raw and stabilized manure). Since the chickens will be applying their raw manure directly to the soil, this section may be applicable to LaFarm. Subject to change, the FDA is currently satisfied with the USDA’s National Organic Program standards. These standards call for a 120 day interval between application of raw manure for crops in contact with soil and a 90 day interval for crops not in contact with soil. Additionally, raw manure must be applied in a manner that does not contact covered produce and minimizes potential for contact with covered produce after application (Food Safety Modernization Act (FSMA), 2017). Nonetheless, it is unlikely anything will be planted on this land until the soil has been revitalized and thus these regulations are not relevant to the project at this time.

Other Political Actors

The LaFarm Advisory Board (LaFAB) and the other organizations involved in the operation of LaFarm are political actors in addition to their role as social actors. Currently, Sarah Edmonds has most organizations volunteer their time on certain weekends and holds several larger, broad volunteering events that are open to the whole community (such as Earth Day). Out of all student organizations, LaFFCo has the largest political presence on LaFarm. They have done a lot of work with the LaFarm informational blog in the past, and they have used their funds to buy a small hoop house for Edmonds to utilize as well. If they would contribute towards the cost of the chickens, as student contact Jennifer Giovanniello has suggested, they would have a greater stake in the chicken project and would be entitled to have a say in all future related endeavors.

Conclusion

LaFarm cannot function without all three parties (the College, the city of Easton, and LaFarm) working together, but to do so the farm must meet all regulations to operate successfully. Once these regulations are met, to make LaFarm stand out to its counterparts it will need to achieve goals that make it stand out from the rest. Though additional certifications, grants, and titles, LaFarm has lots of potential to feasibly enact a chicken tractor. Acting as a creative alternative farming practice, it can grab people's attention and bring more society members and students into LaFarm’s community.

Technical Context

Technological Problem

At first glance, there is a straightforward technical problem: to fertilize The ~1.5 acres behind the Newlins Farmhouse in part of the proposed LaFarm expansion area (LaFarm 2015). In order to convert this land from conventional soy and corn farmland, we need to infuse it with nutrients. Technologically speaking, there are many different methods that can be implemented to meet this basic goal of re-fertilizing the LaFarm expansion area. However, as Engineering Studies Students we aim to develop a plan that meets the goal technologically while keeping with the ideals of LaFarm.

Beginning with conventional and moving to alternative methods, we will start by looking at fertilization methods. Although the conventional practices do not fit within the ideals of LaFarm it is still important for us to look at the technical benefits, if any, these offer. After analyzing the technical aspects of conventional methods we have built upon the research done by the 2016 EVST Capstone, on chickens being used as an alternative fertilization method. Following the fertilization method analysis we will analyze the technological aspect associated with the chicken tractor. Using research done by Worcester Polytechnic Institute and information from Sarah Edmonds, the LaFam manager, we go into detail about the different coop possibilities for LaFarm. We also touch upon the additional technology that can be implemented to improve the life of the chickens and lessen the labor burden on Sarah Edmonds. Finally, we have developed a Chicken Tractor Design Program for future groups to use to best determine a coop that will be suitable for LaFarm to implement. This program takes into account all technical factors associated with the coop and also provides the group with an economic analysis based on the select technology.

Conventional Fertilization

One solution for LaFarm’s nutrient deficient soil is to buy and add fertilizers from an outside source to the soil. LaFarm is nitrogen deficient due to the nature of the previous farming of corn and soy. Nutrient deficient soil isn’t a problem that is unique to LaFarm, many farmers deal with similar issues every year. In order to regain the nitrogen levels in the soil, nitrogen rich fertilizers must be introduced. Conventional fertilization methods require the spreading of nutrient rich materials to enhance the soil. The Haber-Bosch is the method used to produce this type of fertilizer. This process is energy intensive and relies on the use of fossil fuels.

We are confident that conventional fertilizers will be able to fertilize the LaFarm Expansion. However, conventional fertilization methods are not consistent with the ideals of LaFarm.

Alternative Fertilization Method

In an attempt to uphold the values of LaFarm and to continue to expand upon the work done be the EVST 400 Capstone, we are proposing the introduction of a chicken tractor to act as a natural and sustainable fertilization method as LaFarm expands.

Chicken manure is the most nutrient rich manure of all farm animals, making this an optimal choice for LaFarm's fertilization needs. Chicken manure in particular is very high in nitrogen, phosphorus and potassium. Nitrogen is an essential element for photosynthesis and other plant functions. Using manure compost for chickens can cut daily operating costs by replacing organic fertilizers.

A study conducted by Dikinya and Mufwanzala in 2010 found that chicken fertilize had the ability to increase soil fertility and productivity. Adding chicken manure to soil increased nitrogen levels by 50% and phosphorus levels by up to 80%. The chicken manure also increased the yield of spinach that was being grown in the study, proving its fertilizing capabilities (Dikinya & Mufwanzala, 2010). On average, one hen will produce 1 cubic foot of manure every 6 months, providing more than enough manure with 25+ chickens (Dikinya & Mufwanzala, 2010).

Chicken waste can help keep LaFarm sustainable and affordable while assisting an ecologically sound expansion into the Nutrient Enhancement Area.

We propose a Nutrient Center concept where the chicken coop and operations will reside behind the Newlins Farmhouse. According to the most recent plans, the new compost facility will be to the south (left on picture) of the Newlins Farmhouse.

The Tractor

Originally we had planned to design a solar-powered chicken tractor, however, Sarah Edmonds, suggested it may not be necessary to have a solar-powered engine pull the tractor. Nonetheless, solar energy may be better utilized in powering the peripheral energy needs of the chicken tractor (such as a heating pad, an automatic door, or an automated feeding system). In this section, we do not want to establish a set ready to build design, Rather we aim to explore various types of designs and amenities; the ultimate selection will depend on interest from LaFarm volunteers and the College itself. In keeping with the study done in 2016 by members of the EVST 400 class, we are looking at options for a flock that is made up of around twenty five chickens.

Through our research, we have identified three designs for mobile chicken coops that will best suit the needs of LaFarm, each with their own benefits and drawbacks.

The first type is called a hoop coop as seen below in Figure 1. It consists of a wooden bases and aluminum poles to make the arched roof (i.e., the hoop). The specific design that we found is for a 10’ x 6’ x 4.5’ mobile coop with six 1’ x 1’ x 16” egg boxes, two retractable plastic wheels, a handle for maneuvering the coop, three roosts, and two doors. The benefits include the height of the coop (which is more comfortable for the chickens, the retractable wheels (allowing the coop to lay flush to the ground), and the scalability of the design. However, the height could make it difficult to maneuver and the weight could cause too much stress on the two wheels and cause mobility problems.

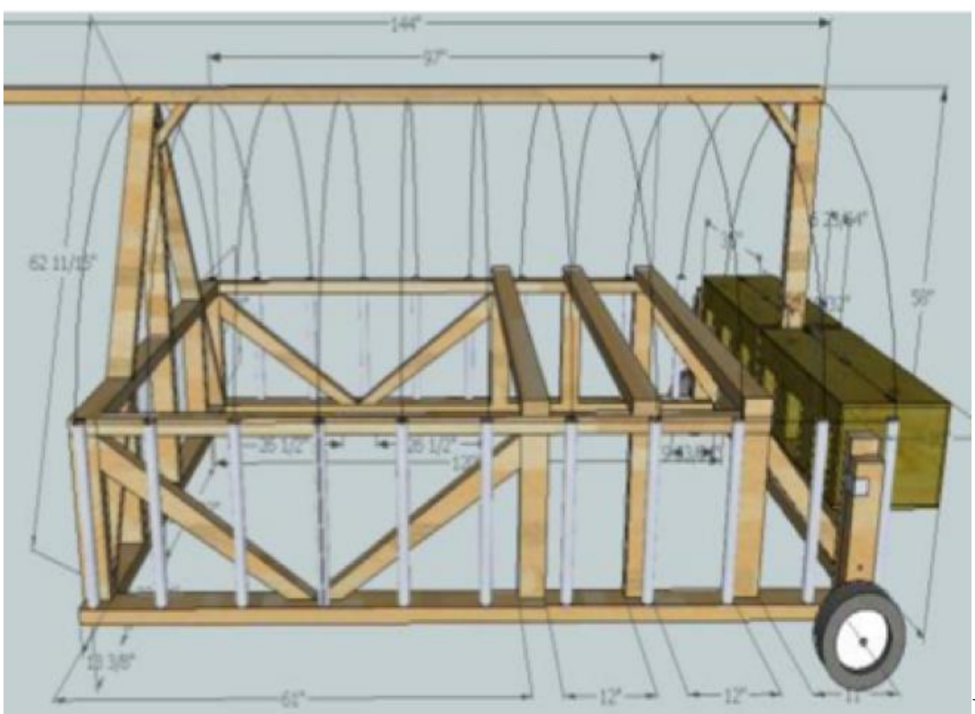


Figure 1: Hoop Coop

The second type of mobile chicken coop that has been identified is the Salatin-hoop hybrid. This design offers the benefits of a hoop coop with the added stability and structure of a standard coop. It is 12’ x 6’ x 5’ with four 1’6” x 1’6” x 2’ egg boxes. It also feature retractable wheels, a front handle, three roosts, one door, and and a hoop, as seen below in figure 2,. The benefits of this design are its staggered roosts, one fully enclosed side (which protects from strong wind gusts), and the retractable wheels. The drawbacks are the open hoop design (a tarp would have to be utilized in case of rain, if not covered the chickens could drown), the small door, and the added weight of the fully enclosed side.

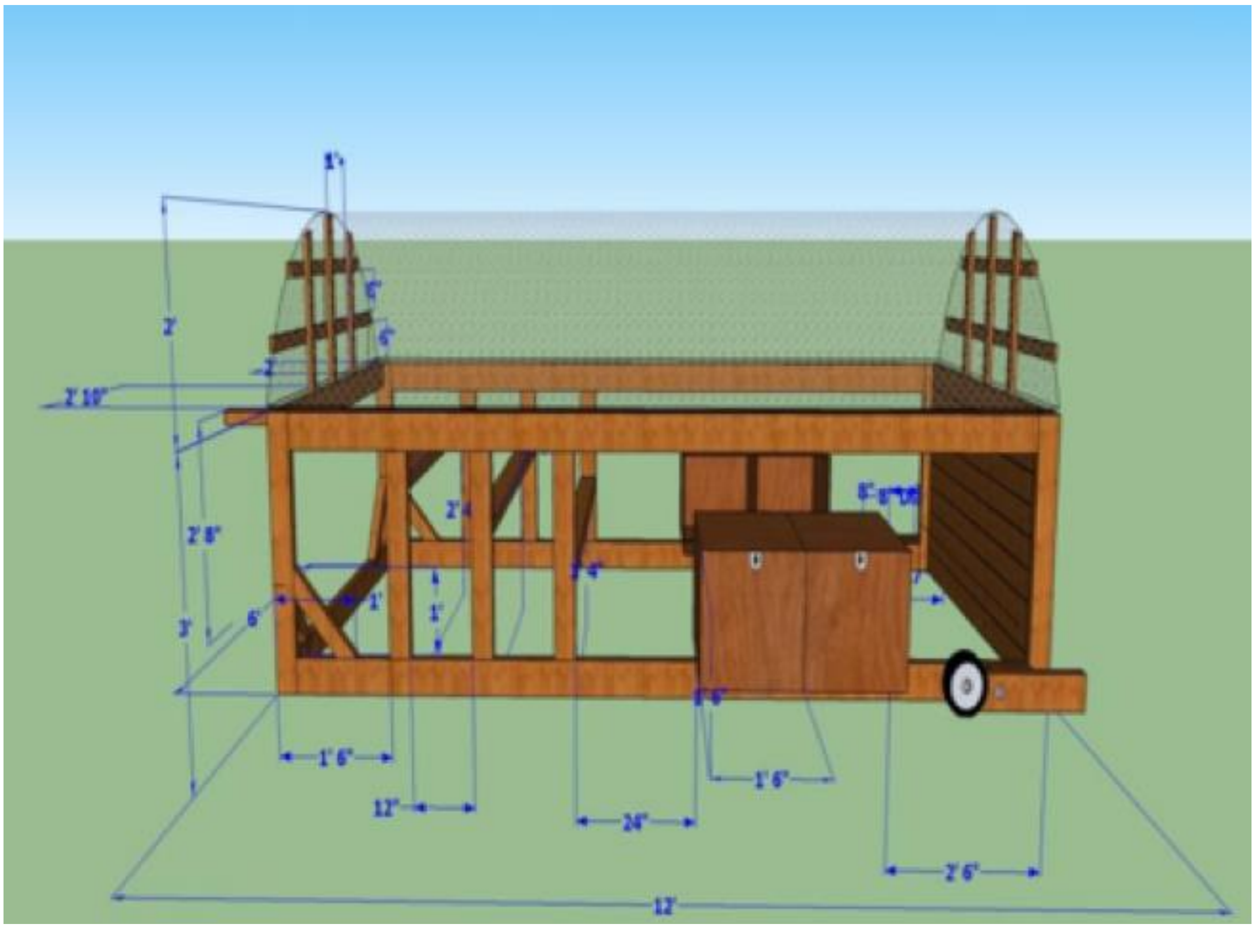


Figure 2: Hybrid Coop

The third design is a fully enclosed coop that is designed to be contained within a second movable pen. As seen below in figure 3, the pen protects the chickens during the day, and the enclosed coop (12’ x 8’ x 4’ with five 1’ x 1’ x 15” egg boxes)protects them during the night. Benefits include the solid flooring of the coop, as well as a smaller size requirement due to the wide range of the outer pen. Drawbacks include the weight and cost of the solid flooring and the increased oversight (chicken owners need to be available to close the doors at night). Sarah Edmonds has worked with a similar design before, and experienced an issue with a predator who pulled the chickens' heads through the outer pen. This was solved by adding another layer of outer fencing which prevents the chickens from exposing their heads to the world outside of their pen.

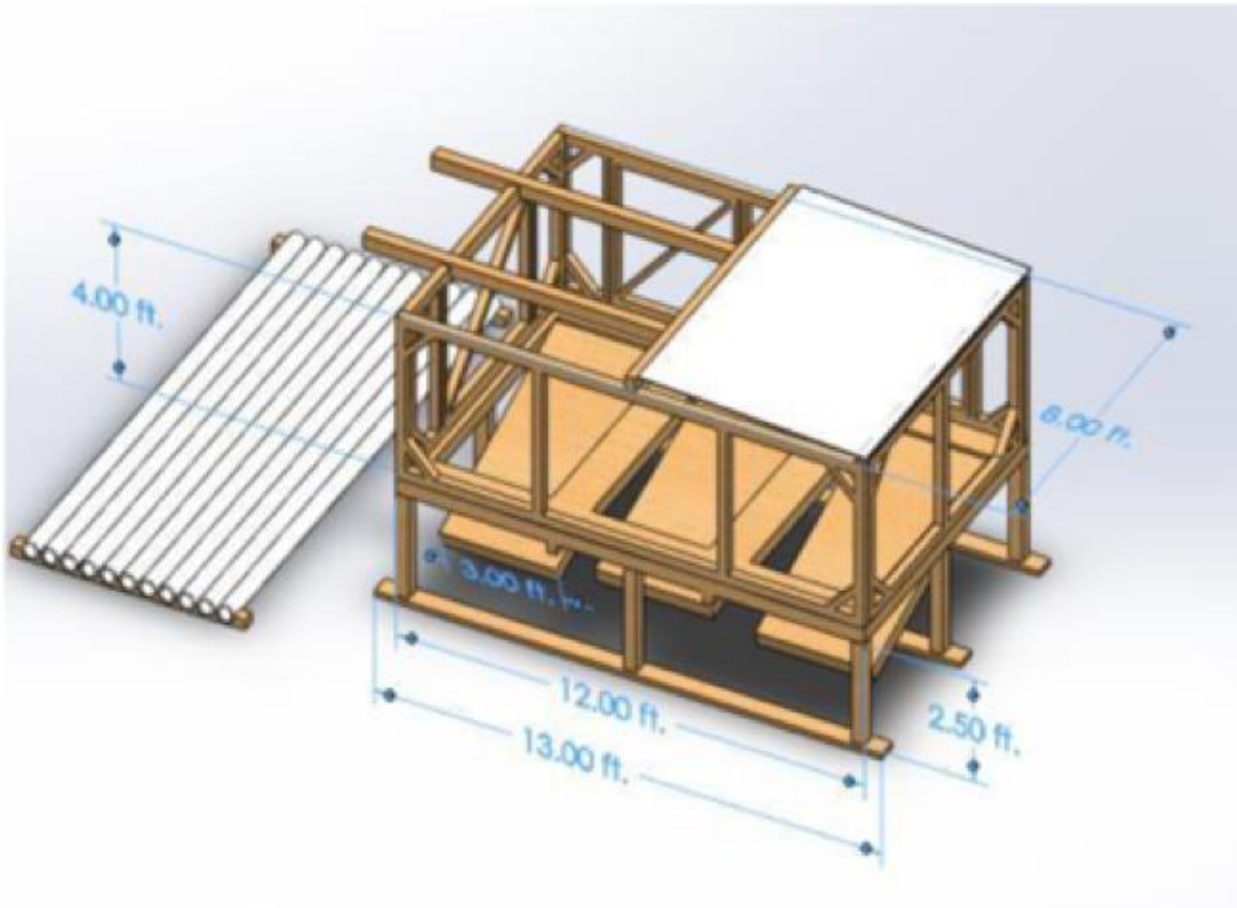


Figure 3: Fully Enclosed Coop

Lastly, we also looked into a premade coop. This off-the-shelf model, meets much of the criteria technically. It is safe, has a solid floor, and chicken tested and approved. However, this method is harder to customize with some of our proposed additional technologies. It also does not entirely stick to the ideals of LaFarm. It is still important for the next group to consider this option because of the ease of installation, but be cognizant of the LaFarm ideals.

Figure 4: Premade Coop

Additional Technology

While these designs do not include considerations for solar power, they are good starting points for future groups. Based off of several factors, we believe the third design may be the most feasible for LaFarm. Sarah Edmonds has experience with this design, and the extra layer of protection will help to keep chickens (some of whom may be named by "sponsors," see Social Context section) safe. The need for a larger amount of oversight than the other options can be rectified through the installation of an automatic door; one brand that manufactures these doors is Poultry Butler (which Edmonds also has experience using). Chickens naturally move into the coop at night; the Poultry Butler operates on a light sensor and provides a timer as well. The website also provides basic instructions on installing a five-watt solar panel, which they claim is sufficient to power the door. Alternatively, an automatic chicken door could be an excellent mechanical engineering project; realistically, however, the purchase and installation of a Poultry Butler (Figure 5) and solar panel array (Figure 6) is the best choice to have the tractor ready in a timely manner.

Figure 5: Poultry Butler Figure 6: Solar Array

Initially, there were strong concerns about the safety of the chickens; Sarah Edmonds assured us that losing a few chickens is just part of the experience, and while important, should not be the main focus of the project. Nonetheless, the chickens should be kept as safe as possible. One of the suggestions that Edmonds offered, in addition to the Poultry Butler, is the option of having a LaFarm dog. This dog could live at LaFarm and would require a fairly low amount of oversight, and could potentially become a sort of mascot. However, if the outer pen/enclosed coop option is the final choice, the dog may not be necessary to protecting the chickens.

Chickens also lay based on daylight; a well-designed chicken tractor should have a light installed inside the coop to account for short winter days. There are many solar powered hanging lamps on the market for rather low prices and they would be quite easy to install in any coop.

There are additional technical elements that must be taken under consideration if LaFarm raises chick, however we recommend foregoing chicks and buying pullets (adolescent chickens) to avoid the unnecessary hassle of raising baby chickens.

Chicken Tractor Design Program

To compile all of our technical factors for the next group, we used an Excel sheet loaded with macros to allow maximum customization of the users preferred tractor system. This program allows the user to choose from any of the four coop designs and add whichever features they believe to be necessary. Additionally, when the user finishes their design, it will produce an image of the tractor which was designed in AutoCad, and will populate the tractor with the chosen features. The AutoCad drawings in figures 1, 2, and 3 were designed to scale, using the dimensions from the dissertation (Cole, DeLuca, and Zielinski, 2014) and the website from which the pre-made coop can be ordered from (Houzz.com). Additionally, the materials needed to construct each of the coops are listed on a separate materials page on the Excel file.

Conclusion

The technical analysis looked into the fertilization potential of both conventional and alternative methods. After confirming chickens as a viable solution, we analyzed different coops for their many different benefits and some of the drawbacks. After assessing each of the coop models, we moved on and analyzed some of the potential additional technologies available. Looking back to the identity and needs of LaFarm, we are recommending that the next group implement, at the minimum, the poultry butler powered by the solar array to alleviate some of the burden on both Farmer Sarah and any of the LaFarm volunteers. Finally, we have provided a method for the next group to design and build the best chicken tractor for LaFarm to install. Using our Chicken Tractor Designer Program, the next group will be able to see all of the necessary economic costs, materials, and dimensions in order to fully implement the chicken tractor at LaFarm.

Economic Context

Challenge:

Due to the nature and the bylaws of LaFarm, it can be difficult to classify the return on investment of adding chickens. There will be many different costs and benefits associated with the addition of chickens to Lafarm. Our economic analysis aims to provide the necessary information to make a recommendation for the financial plan related to the chickens.

Introduction:

Implementing a chicken tractor system is not as simple as buying a few chickens and putting them in a moveable coop. The breed of chicken must be chosen in regard to the problem that is to be solved, and the tractor must be able to properly house this breed. Additionally, the system needs to be structured to match the goals and objectives that Lafarm wishes to promote. When all of this is considered, even if every criterion for the perfect system is met, it still can only happen if the system is economically feasible. An in depth economic analysis provides an array of possible solutions, so that the best solution can be tailored to the particular user.

Initial Costs:

Four structural designs for the chicken tractor were considered for this system. The first design is a premade coop which requires no assembly at a base cost of $484.99 (houzz, 2017). The only modifications which would need to be made to make this a mobile coop are the addition of two retractable tractor wheels and a handle for which to pull it. With these additions, the cost totals at $515.12 (Home Depot, 2017). The remaining three designs were developed as a project at Worcester Polytechnic Institute. The first design, the *Hoop Coop,* was estimated to cost about $240 by the project team, but after analyzing their cost breakdown there was much ambiguity amongst the quantities of materials (Cole, DeLuca, Zielinski, 2015). After reviewing and reassessing the costs, our team estimated the actual cost to be $390.05 (Home Depot, 2017). The second design, the *Hybrid Hoop Coop*, replaces the larger chicken wire fence with an increased amount of lumber. Though the cost was estimated to be higher than the *Hoop Coop*, by manually cutting larger pieces of wood the cost decreases to a total of $324.66 (Home Depot, 2017). The last coop design, the *Fully Enclosed Coop* offered the greatest protection out of the four, and was also estimated to cost above $400 (Cole, DeLuca, Zielinski, 2015). After pricing out the necessary materials, the estimated cost came to a total of $326.24, less than two dollars more than the *Hybrid Hoop Coop* (Home Depot, 2017). All three systems were estimated using the costs of materials from homedepot.com. These costs can potentially be further decreased by purchasing the lumber in a bulk order of one size and then cut to the necessary dimensions.

Hoop Coop			
Material	Quantity	Price	Souce of Price
Hardware Cloth	N/A	79.63	https://www.hom
Carriage Bolt (1/4-20" x 4")	4	2.92	https://www.hom
Carriage Bolt (1/2" x 4")	2	2.32	https://www.hom
Lock Washer (1/2")	8	2	https://www.hom
DBL Wide Zinc Corner Brace (2.5")	2	3.97	https://www.hom
Plastic Wheel (6" x 1.5")	2	11.96	https://www.hom
Aluminum or PVC Piping (1.5" x 12")	10	7.47	https://www.hom
Small Hinges	16	31.52	https://www.hom
Latches	8	3.97	https://www.hom
Drywall Screws (2")	N/A	11.94	https://www.hom
Untreated Wood (2" x 2")	N/A	103.8	https://www.hom
Untreated Wood (2" x 4")	N/A	27.12	https://www.hom
Untreated Wood (2" x 8")	N/A	52.68	https://www.hom
Untreated Plywood Sheet	N/A	48.75	https://www.hom
Total Cost		**$390.05**	

Hybrid Coop Coop			
Material	Quantity	Price	Souce of Price
Lumber			
2in x 4in x 12ft	4	29.48	https://www.ho
2in x 4in x 6ft	11	$39.82	https://www.ho
2in x 4in x 2ft	6	7.37	https://www.ho
2in x 4in x 5ft 8in	3	10.86	https://www.ho
2in x 4in x 1ft 5 in	4	3.62	https://www.ho
2in x 4in x 14ft	1	10.17	https://www.ho
2in x 4in x 2ft	2	3.39	https://www.ho
1in x 2in x 3ft 6in	2	3.39	https://www.ho
1in x 2in x 5ft 6in	2	10.17	https://www.ho
1in x 2in x 1ft 10in	4	3.39	https://www.ho
1in x 2in x 2ft	2	3.39	https://www.ho
4in x 4in x 8in	2	18.34	https://www.ho
Nest Boxes (1ft 6in x 1ft 6in x 2ft)	4	39.96	https://www.tra
Cattle Panel	N/A	26.98	https://www.ho
Hardware Cloth	N/A	79.63	https://www.ho
Tractor Wheels (8", 2.5" thick)	2	22.76	https://www.ho
Drywall Screws (2")	N/A	11.94	https://www.ho
Total Cost		**$324.66**	

Fully Enclosed Coop			
Material	Quantity	Price	Souce of Price
For Frame:			
Untreated Plywood			
2" X 4" X 12'	4	29.48	https://www.ho
2" X 4" X 8'	6	21.72	https://www.ho
2" X 4" X 4'	12	29.48	https://www.ho
2" X 4" X 20'	1	10.17	https://www.ho
4" X 4" X 20'	4	81.36	https://www.ho
1/8" X 4" X 12'	2	8.54	https://www.ho
For Front Door:			
Untreated Plywood			
2" X 2" X 4'	4	4.72	https://www.ho
2" X 2" X 6'	1	8.65	https://www.ho
1/8" X 4" X 6'	1	7.12	https://www.ho
Hinges	2	3.94	https://www.ho
Slide Latch Bolt	1	4.97	https://www.ho
Picture Frame Attachments	3	2.31	https://www.ho
For Two Side Doors			
Untreated Plywood			
2" X 2" X 4'	8	9.44	https://www.ho
2" X 2" X 8'	1	3.57	https://www.ho
Hinges	4	7.88	https://www.ho
Slide Latch Bolts	2	9.94	https://www.ho
For Floor			
Untreated Plywood			
1/8" X 4" X 8'	1	4.27	https://www.ho
2" X 4" X 1'	1	3.62	https://www.ho
Hinges	6	11.82	https://www.ho
Latches	6	29.82	https://www.ho
Chicken Wire	1	21.48	https://www.ho
Drywall Screws (2")	N/A	11.94	https://www.ho
Total Cost		**$326.24**	

The aforementioned costs are solely for the structure of the chicken tractor, there are many other features necessary for the system to operate successfully. To keep predators from entering the mobile coop, a *Poultry Butler* door is to be installed, which will open and close based on a light sensor, at the cost of $179.99 (Poultry Butler, 2017). Additionally, to the predators, the chickens are also at risk to the harsh winter climate. While the chickens are able to survive in temperatures as cold as -10 degrees Fahrenheit, the water dispenser within the coop will freeze. To prevent this from happening a water dispenser with a built-in heater will be installed to assure constant water availability costing $57 (Strombergs, 2017). Having these features in place can give the community some peace of mind that the chickens will live comfortably, but if there are any doubt community members can view the chicken cam to check in on the coop. By installing a wireless *Reolink* camera, at a cost of $129.99, anyone can pull up a webpage and view the stream of the coop (Reolink, 2017). All of these features will require a power source, and to parallel the ideas of Lafarm, a five-watt solar panel will power the door, water heater, and whichever other features are chosen to be installed costing only $57 (BatteryStuff.com, 2017). The one feature which will not be reliant on the five-watt panel is the solar powered light which will be inside the coop, as this has its own panel to power itself, costing only $23.43 (Walmart, 2017).

The 2017 EVST Capstone researched into a few particular breeds of chickens which could be introduced to Lafarm when conducting their analysis, and also determined the appropriate quantity of chickens to implement a coop would be 25. The three breeds were chosen due to their low-cost replacement, widespread availability, and egg production. The Pearl White Leghorn costs $4.45 per chick, being the best white egg layer out of the three, and 25 totals to a cost of $111 (Strombergs, 2017). The Barred Rock, being able to produce brown eggs, costs $4.70 per chick and would total to $118 (Strombergs, 2017). The Blue Andalusian costs $4.70 per chick, being the most expensive of the three options, and totals to $118 (Strombergs, 2017). The cost difference between all three chicks is minimal, so implementing any of these with the tractor system would be feasible. It is important to note that the chicks are cheaper than their adult counterparts. To raise a chick requires them to be kept inside for a few weeks (inside being a barn, shed, or inside a house). The cost of raising the chick is factored into the price of an adult chicken, but given the design of our potential tractor system, it is feasible to house the chicks as the coop will have the proper insulation.

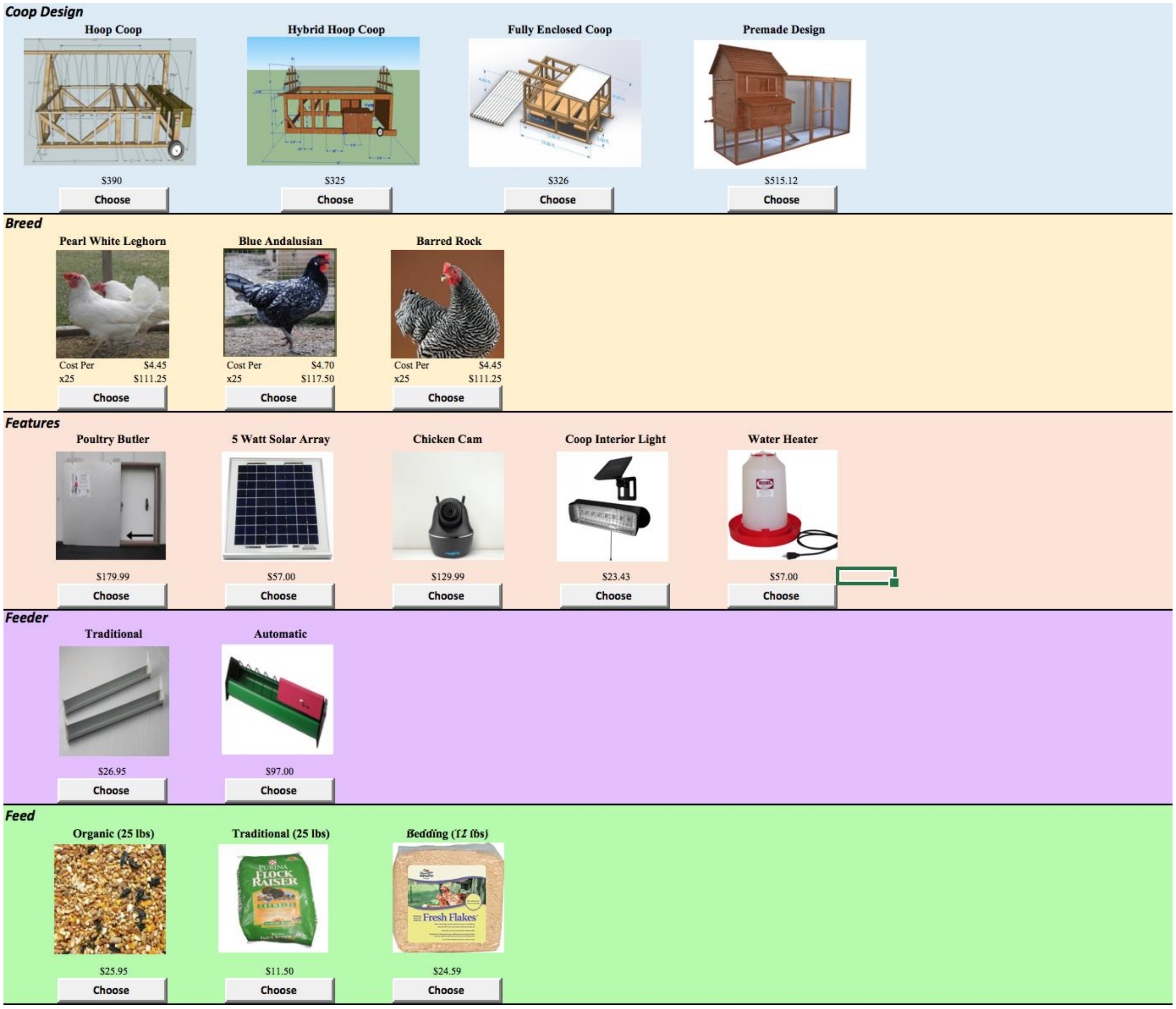
Pearl White Leghorn		Blue Andalusian		Barred Rock	
Quantity	**Price**	**Quantity**	**Price**	**Quantity**	**Price**
1	$4.45	1	$4.70	1	$4.45
25	$111.25	25	$117.50	25	$111.25
50	$222.50	50	$235.00	50	$222.50

Once installed and fully operational, the chicken tractor will continue to have alternative monthly costs. Bedding and feed will be the two main recurring costs, however these materials, if stored correctly, can be bought in bulk in order to cut costs. In addition to its daily grazing consumption, a chicken on average requires 1/4 pound of feed per day (Hoskins). Assuming an initial flock size of 25 chickens, and a price of $11.50 per 25 pounds for traditional and $25.95 per 25 pounds for organic feed we can predict an average yearly cost of $1050 or $2368, respectively (Amazon, 2017). Along with food, chickens require new bedding. Bedding serves many different purposes; drying the chicken manure as well as keeping the chickens occupied. Holding the same assumptions, and a cost of $24.59 we predict an average yearly cost of $295 per year for the coop bedding.

Non-Monetary Costs and Benefits:

Although it is important to identify all the monetary costs in the system, there are other costs and benefits. Deciding to choose chicks over adult chickens saves money, but at the same time will require more hours of labor to monitor and care for them. Resources from other Lafarm activities will have to be transferred to the chickens until they are at an appropriate age. Even though this will require resources to be reallocated, Lafarm now expands to a whole new level of production with the addition of livestock. The chickens being used to self-fertilize the soil also shows the progressiveness of the farm, and bolsters Lafayette College's green initiative. There is also the potential for a greater connection between the community and the chickens when they are bought as chicks. Through raising an animal into its adult age, students may become more connected with the chickens and consequently more devoted to Lafarm.

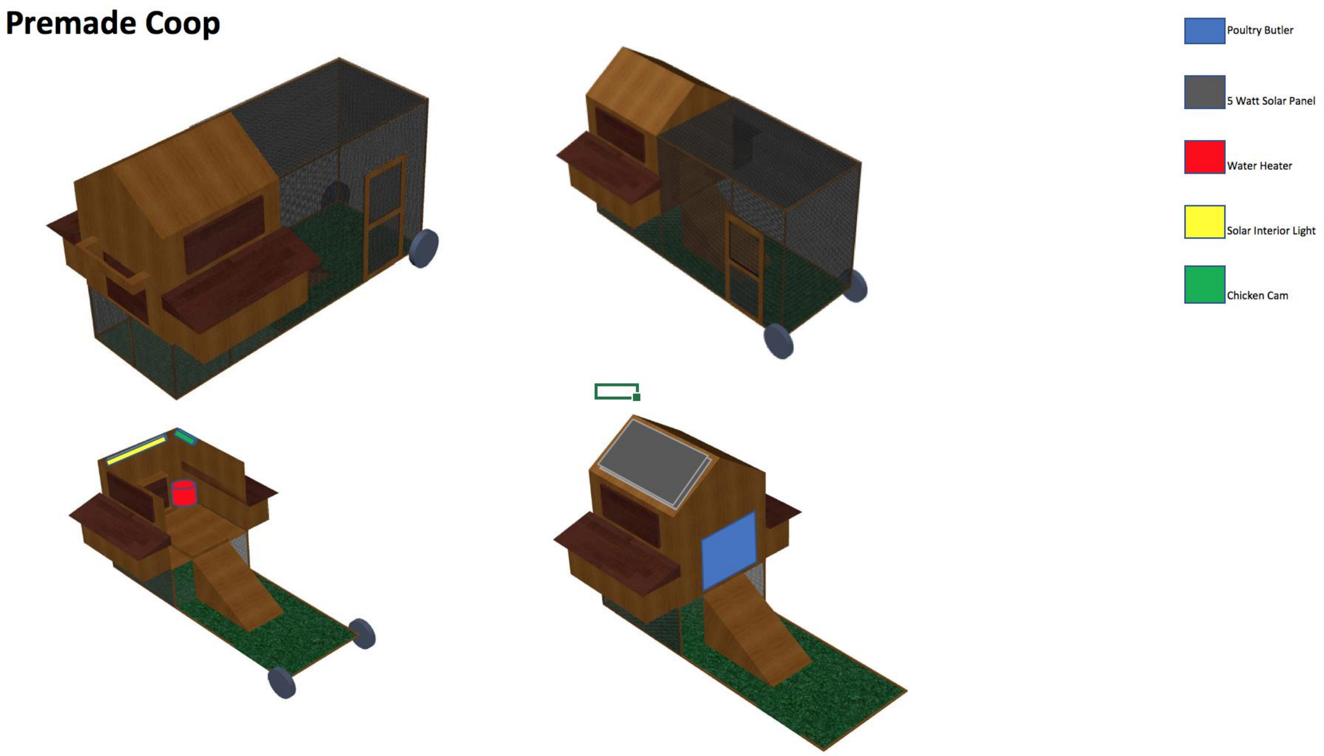
When looking at the chicken tractor system as a timeline, the first step after the feasibility report would be the design and construction of a coop with only the necessary factors. These factors would include the coop itself, along with the poultry butler door and the five-watt solar panel. By implementing only the necessary factors, the price can be minimized while still being operational to the maximum level of efficiency. The materials for each system are accessible, but will require construction to compile. Mechanical Engineers or Engineering Studies majors, or even both together, can take part in constructing the coop and implementing it into Lafarm. A course could be offered for the design and construction of the system, where the students go pick up the materials from Home Depot and assemble the tractor on site at Lafarm. Once the specific design is chosen, the construction could be completed in a matter of days.



Conclusion

Going forward, our team wanted to be sure that the next group to continue this project had all the resources for this economic analysis readily available. To compile all of the data for this section into one place, an excel spreadsheet was created which stores all economic data and the sources containing the prices and location which they can be ordered. To not force the hand of the next group on which direction the chicken tractor system should go, each part of the system can be chosen from a variety of options, to allow a customizable experience. The three varying coop designs, the three breeds of chickens, each feature, feeder, and feed, can all be decided to allow the user to design the tractor to meet whichever goals they prioritize. Additionally, the cost breakdown of the tractors can be found in this document, where each material and the necessary quantity is listed alongside the hyperlink for purchasing. The costs will include a an initial cost, a recurring cost, and salvage value; all of this will also be annualized along the predicted lifetime of the system. We believe having these calculations programmed through excel macros will provide future groups with predetermined and justified initial and annualized costs, which may accelerate the schedule for implementation on Lafarm.

Sample System Design:



Sample Cost Breakdown:

Cost Breakdown

Initial Cost: $1,193.23

Monthly Recurring Cost: $86.25

Annual Costs $1,035.00

Reset Calculation | Reset

Salvage Value: $534.86

Lifetime Costs:	-$1,195.70	**per year**
Lifespan:	10	**years**
Interest Rate:	8.00%	

Change Interest Rate

To View Chicken Tractor Economics Calculator:

[Chicken Tractor System Designer]

Conclusion

Summary

We believe that using chickens as an alternative fertilization method will build upon LaFarm's founding principles along with sticking to its identity. Ultimately, chickens will change the identity of LaFarm from strictly a produce farm to a produce farm with poultry. This change, however, is warranted by the fact that there is a purpose to the poultry; an alternative fertilizer source. Along with impacting LaFarm, the chickens will require input from the Lafayette Community. Funding and support from LaFFCo, a possible LaFarm LLC, educational programs, and student volunteers are all aspects that will allow for chickens at LaFarm.

Politically, LaFarm will be able to add chickens in order to fertilize the expansion area without legal ramifications. By working with the city of Easton, Lafayette College, and LaFarm, we believe that the addition of chickens will be well received. Acting as a creative alternative farming practice, it can grab people's attention and bring more community members and students to LaFarm.

The economic analysis allows the next group to see what different costs may be incurred depending on the design of the coop, number of chickens, breed of chickens, and any additional technologies. By combining the economics with the technical breakdown of each coop and technology in our Chicken Tractor Design Program, we are allowing the next group to choose the exact design that they believe will best serve LaFarm. Although the next group will have the final say on the design of the coop, we are recommending that they install the poultry butler powered by the solar array in the coop.

Our Chicken Tractor Design Program is the culmination of our analysis and is a product of this project. We believe that by analyzing the social and political context and then developing this program, we have set up the next group up to design, build and install a working chicken tractor that will be able to solve the fertilization problem that LaFarm currently faces.

Challenges Moving Forward

Looking ahead, there does not appear to be many obstacles standing in the way of completing this project. However, it could easily run into the same roadblocks as a similar LaFarm proposal (the greenhouse) has for last few years. It seems as though no one has stepped up and really taken the initiative to pay for and install the proposed greenhouse, despite years of capstone projects and proposals. Nonetheless, the chicken tractor has several points in its favor. For one, it is significantly cheaper than the greenhouse; the 2017 EGRS Greenhouse Capstone group (report located on this site as well) found the the cost of building a greenhouse will be around twenty thousand dollars. The proposed chicken tractor will only cost about two thousand dollars in its first year, and about one thousand dollars per year afterward, making it a significantly smaller financial hurdle than the one experienced by the greenhouse. With further expansion by a future group upon our work, we do not foresee any issues in physically starting this project.

Work for Future Groups

Using the groundwork that we have laid, a future group should be able to select, purchase, and/or build one of the coop designs after doing more research to figure out what will be best for Sarah Edmonds, LaFarm, and the other stakeholders. They should be able to receive further approval for this project and actually have the ability to purchase chickens and begin the revitalization process. Further projects could focus on building the coop as opposed to buying a premade one, wiring various components of the coop to a solar array, creating a solar powered tractor to move the chicken coop automatically, and creating the infrastructure necessary for selling the eggs that the chickens produce.

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