Repurposing Retired Navy Bunkers in Vieques, Puerto Rico

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para la Naturaleza

Repurposing Retired Navy Bunkers in Vieques, Puerto Rico

An Interactive Qualifying Project
Submitted to the faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science

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Date:
16 December 2015

Report Submitted to:

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Abstract

Vieques, Puerto Rico suffers from poverty and a high rate of unemployment. Our goal was to assess the feasibility of a mushroom farm that would provide employment to the people of Vieques by recommending a plan for the facility. Based on our objectives which focused around three areas of concentration: engineering, economy and community support, we established methods that included detailed research on renewable energy, rainwater collection, costs for equipment, as well as conducting surveys which gave us information about community support. The data lead to a detailed plan for further research and an initial determination for the likelihood of a mushroom farm being successful enough to employ 10 people.

Acknowledgements

The outcome of our project was influenced by several people over the course of its development. We would like to thank all of the people and groups whose contributions helped us along the way and without whom this project would not have been possible.

We would like to thank our preparatory instructor, Professor Anna Jaysane-Darr for guiding us through our initial stages of the proposal. We would also like to extend thanks to our two project advisors, Professor Karla Mendoza-Abarca for her input in the business aspect of our project and Professor Fred Hart for his help in the engineering requirements and designs for the farm.

We would also like to thank our sponsor liaison and a few other people from Para la Naturaleza. First, thanks to Elizabeth Padilla, Educational Projects Advisor, for overseeing our progress and planning our trips to Vieques. Next, we would like to thank the Auxiliary Supervisor Julian Garcia for taking us to visit the bunkers and distributing the surveys to the inhabitants of Vieques. Our deepest gratitude goes to the Supervisor of the Eastern Region for Para la Naturaleza, Carlos Morales, for giving us his input in the early stages of the project.

Lastly, we would like to thank the Secretary of the Municipality of Vieques, Fabian Martinez, who participated in an interview which enlightened us in the procedures and benefits of a mushroom farm on the island.

Executive Summary:

Video:
The picture below provides a link to a video that gives an overview to our project.

Introduction:

Vieques is a small island off the coast of Puerto Rico and, like Puerto Rico, is in the midst of an economic crisis. Unemployment and poverty rates are extremely high. The economic situation on Vieques has remained the same for decades. Prior to the 1940's Vieques had a booming economy primarily based in the sugar trade. In the early 1940's the United States Navy purchased two-thirds of the island forcing the economy to change; the people no longer had enough land for agriculture. However, the Navy's presence opened up jobs in construction and in restaurants and bars. This sustained the economy for a few years, but when the focus of World War II moved out of the Caribbean theater, construction stopped and there were not enough sailors stationed on the island to support the local businesses. This left the island with no source of income or jobs. The Navy maintained ownership of the land until 2003 when they left after

years of protests by the Viequenses. Today the land is owned by US Fish and Wildlife and the people still cannot return to their agriculture roots.

Our sponsor Para la Naturaleza came up with the idea of converting bunkers left by the Navy into an agricultural facility to create more jobs on the island. The goal of our project was to determine if this farm could be a self-sustainable business that provides employment opportunities in Vieques. We designed a schematic for the bunkers which included a floor plan, a renewable energy and water collection system, analyzed the economic cost of the investment and operation of the facility, and assessed the needs and interests of the community.

Methods:

We broke our project up into three objectives, engineering, economics and community support. Then the feasibility of each was assessed separately by:

1. Evaluating the engineering aspect of such a facility by estimating water usage, determining electrical consumption, and creating a process to grow mushrooms
2. Assessing the economic feasibility of a mushroom facility and computing the amount of jobs that could be provided
3. Weighing the social impact of the facility by gauging community attitude, support from the community and government.

Engineering

We began by looking at the engineering aspect of a mushroom farm. To start, the bunkers have no electricity or running water. We did research on renewable energy sources and solar energy seemed the most plausible given the extensive sunlight in the area. To see if it could supply a sufficient amount of energy to power the farm, we calculated the amount of energy that could be generated by covering the roof of the bunkers with solar panels. Then, we looked at water and designed a water collection system. To determine how much water could be collected during a year, we made calculations using the size of the bunker and graphs of the rainfall in the area. We also researched which months the most rainfall could be collected and how much precipitation would need to be stored to sustain the farm through dryer months. Our team used mushroom growing research to calculate the amount of water needed. We used these numbers in determining the feasibility of the farm.

Next, the outline for the farm was devised. From the mushroom research, we determined the appropriate method for growing the mushrooms desired. From there we designed a floor plan that shows how the mushroom farm could be laid out. Using the floor plan, we determined the square footage of growing area and how much growing medium would be needed. We also computed the average time to complete a full mushroom growing cycle and how many cycles could be completed a year. This lead to our estimation for how many pounds of mushrooms could be produced per year. This information would be used later in calculating the operating costs of the farm and the revenue it could generate.

Economics

Once an arrangement for the farm was solidified, the cost to convert the bunkers into a mushroom production facility was computed. We made a list of all the expenses and each cost was categorized as investment or operational. From this, we discovered a numerical value for all of the costs. The team located vendors that sold the materials required for the farm and either found prices or communicated with the vendors to receive quotes. Some of the costs required more calculations and for these we found the value of a similar expense and scaled it up to our project. For example, the price of installing solar panels on a house compared to the number of square feet of solar panels put down was found and set as a ratio for a unit price per square foot. Then, that information was compared with the square footage of the bunker and the price was adjusted accordingly.

After researching what the farm would cost to create, we looked at the revenue it could generate. We found a range of market prices per pound of mushrooms and multiplied it by how many pounds of mushrooms the farm could theoretically produce. For simplicity, we assumed that all the mushrooms would be sold and just looked at the bunkers production capacity.

Social

Since the goal of the project is to be community-operated, the third area we assessed was community interest. To discover how the general public felt about the project, we distributed surveys to members of the communities in Vieques. The surveys asked a range of questions designed to give clear, quantitative data about support of the farm, both in terms of potential employment and desire for agriculture. There was a portion of the survey that allowed for comments for people to share their opinions and ideas.

We conducted an interview with a member of the government of Vieques in order to gauge their support and to learn about the laws that need to be considered when creating the farm. Our team talked to the Secretary of the Municipality who shared the history of bringing jobs to the island that we need to consider when advertising the farm to people. He also shared what the problems that the farm would hopefully eradicate, specifically issues of self-sustainability and exportation of produce from Vieques.

Results:

The information gathered from research was used to determine of the likelihood of this farm being able to successfully generate employment and be a sustainable business. Each section of the findings can support whether the farm would be practicable in the respective category. From those individual analyses, the entire achievability of a mushroom farm being instigated in the bunker was set. Through research, the team found that the mushroom farm has the potential to be a plausible idea, with a few challenges. In order for this project to be successful, more research must be done in the form of a market study and a pilot study. We also advise that more data be collected on community support through surveys.

Engineering

The engineering aspect of the project holds one of the biggest challenges: shipment of materials, and disposal of them. According to our research, the growing medium would need to be changed out every month and a half. That is 177 cubic yards of material per growing cycle that needs to be shipped to a small island using only one ferry. Additionally, this material needs to be disposed of. The compost is still a viable medium for other crops however it can no longer be used to grow mushrooms. We suggest that Para la Naturaleza talk to local gardening stores and horse farms to gather manure and compost before mixing the compost themselves.

We found many unknowns in our research regarding solar panels and water collection. Solar panels could gather 102,401 kWh of energy per year and the water collection system could collect 161,393 gallons of water per year. The rough estimate for the amount of water needed was little less than can be collected, but Puerto Rico has been experiencing drought the past few years, which causes concern. We were unable to calculate the amount of energy required, however, the solar panels would need to generate enough power to significantly cool the bunker. There was also the issue of storing energy in a battery for 24-hour cooling which is required by mushrooms.

Due to the uncertainties we to recommend, a pilot study be completed in the bunker. A small area would be closed off and a scaled down version of the potential operation would be carried out for an extended period of time. During the study, measurements of water and electricity usage as well as quantity of mushrooms produce would be taken to provide an accurate prediction as to the requirements of the facility. From this information, the plausibility of the farm could be determined.

Economics

The team researched all of the costs associated with converting the bunker into a mushroom farm. We then put the numbers we found into a spreadsheet with two main parts: investment setback, operational costs, and revenue.

The investment cost for converting the bunker was relatively high given that the solar panels themselves cost somewhere between $250,000 and $350,000. On the other hand, the operating costs were relatively low due to not having to pay utilities. This would allow the farm to employ a fair amount of people and still produce a profit. The total investment cost we calculated was about $371,000 and the operating cost, assuming 5 full-time and 5 part-time employees working for 15 dollars an hour, was around $307,000. It is however important to note that these findings are preliminary and exclude the costs of employee insurance and other benefits. These can be costly and need to be considered in continued research of the economic feasibility of the farm.

The farm can produce anywhere between 25 and 48 pounds of mushrooms per square foot per year and can be sold from anywhere between 3 to 6 dollars per pound at a retail price. As long as the mushrooms are sold at a wholesale price of at least 2 dollars a pound, the farm should be profitable. The revenue that the farm could generate was between $432,000 and

$1,659,000 based on retail prices we found. The spreadsheet we used made calculations based on the variables we input. This allowed us to run different scenarios easily.

With the conservative numbers for production of $4.00 per pound of mushrooms, 5,760 square feet of growing area and the workforce mentioned above, we estimated that the farm would need to produce 148,000 pounds of mushrooms to pay off the initial investment. This many mushrooms could be grown in under one year. We believe this is a reasonable amount of time and the project would be a good investment. These calculations were done under the assumption that all of the mushrooms produced would be sold. We recommend a market study be conducted to determine the demand for mushrooms and find a more accurate price per pound.

Social

The community appreciated the idea to have a farm created in the bunkers to increase employment on their island and to advance the agriculture sustainability, thereby decreasing the dependency on importation. Many responses from the surveys agreed that there would be interest in locally grown agriculture sold at the markets. Similarly, our surveys showed that the community would be willing to volunteer on the farm or even seek employment there. An interview with a representative of the municipality's government aided in our understanding the community's attitude. A major social issue in Vieques is employers coming to the island to establish businesses and hiring their companions from the Puerto Rican mainland to work rather than providing jobs for the people of Vieques. Since the mushroom farm aims to provide employment primarily for the people on this small island, there would be a high level of support for this project, according to the Secretary of the Municipality.

The data collected suggests there would be sufficient community support to deem this project socially beneficial. However, we do suggest continued surveying of the public. Many of the people who filled out the surveys were already employed full time, and therefore had no desire for a full-time job on the farm. We believe that if more data was gathered there would be a more accurate representation of the willingness among community members to be employed at the facility.

Conclusion:

After assessing all aspects of the farm separately, a more realistic conclusion was formed about the plausibility of this facility being built to benefit the community. The engineering sector raised challenges since there are no easy ways for adequate water and electricity to be provided to the bunkers; however we designed a system to accommodate for that. It also posed a challenge in transportation and disposal of materials. For this we recommended Para la Naturaleza work with businesses on the island to acquire these materials.

We determined the farm to be economically feasible with a break-even analysis with the implication that our assumptions are correct. The analysis lead to the number of mushrooms needed to be sold to pay back the cost of the farm in approximately one year after which it begins to profit. The facility will also generate enough to employ a fair amount of people, thereby fulfilling its purpose. We assumed all the mushrooms would be sold within a range of

prices. Since there are wide ranges, we recommend a market study. The information gathered will tell PLN how many pounds of mushrooms they can sell and for what price. This will allow for a more accurate break-even analysis.

From the surveys and interviews we conducted, we found that the community would be interested in the project and that people would be willing to volunteer there. Many of the surveys indicated that few people would be interested in working full-time, however most of the people who were surveyed already had full-time jobs. Because of this we recommend that PLN continue surveying the locals and aim for a wider demographic.

In the event that information from one of the studies suggested proves the mushroom farm infeasible, we would advise trying other crops. A few of the other surveys indicated they would also like to see other crops grown in the bunkers. In addition, they may not require as much water, and although it would be necessary to install grow lights they may not require the same temperature control and overall energy. These factors may make the bunker farm project more plausible.

Overall, there are many hindrances that keep us from stating whether or not the farm is ultimately feasible. We believe that there may be a fair amount of profit to be made through this farm however we advise that further research be conducted for each objective.

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1.0 Introduction

Vieques is a small island off the eastern shore of Puerto Rico. Until 2003, most of the island was controlled by the US Navy. Now it belongs to Puerto Rico, although most of the land is under the control of US Fish and Wildlife Services. Eighty years ago, Vieques had an agricultural economy. In 1941, the US Navy set up a military installation on Vieques to practice military exercises on the island until they left in 2003. Today Vieques, along with Puerto Rico, is in a state of economic crisis. Unemployment on Puerto Rico is at an alarming 11.8%, and 41.4% of the population lives in poverty (Rivera, 2015). In addition, the island imports 80% of their food, making it more expensive and sometimes difficult to access (Allen & Penaloza, 2015).

To help improve the situation, Para la Naturaleza (PLN), an environmentally focused nonprofit based in Puerto Rico, is trying to help Puerto Ricans return to their roots with a sustainable agriculture project that will lower unemployment on Vieques. There is a movement to make Puerto Rico self-sufficient and rebuild the island's agricultural industry which presents the ideal stage for sustainable community-operated farms in retired Navy bunkers (Allen & Penaloza, 2015).

Current studies and projects focused on community-supported agriculture around the world are included to show the plausibility of turning the bunkers into farms. Mushroom farms in developed countries prove that there is strength in community cooperation increases the efficiency for mushroom growth. Jobs in these agricultural facilities require minimal training and the diversity of jobs allow for all members of the community to participate.

The history of agriculture in Vieques and the presence of the Navy established the purpose for our project in the retired bunkers. Vieques is home to twenty-two empty decommissioned bunkers located on the western side of the island, which were once used to house ammunition and bombs. They sit on preserved land in the El Buey barrio of the island. There is room for development within these facilities, specifically in transforming them into a space for growing mushrooms because of the low-lit, humid environment that is optimal for mushroom production. Additionally, there is little training required for cultivating mushrooms. This would create several entry-level jobs for the island community.

The goal of this project was to help members of the Vieques community gain employment by creating a plan for a self-sustaining facility that has a practical use on the island. PLN has tasked us with devising a plan by December 17, 2015 that benefits the economy and environment of Vieques. We plan to do this by developing a growth plan for a community-operated commercial mushroom farm in these abandoned bunkers, analyzing the economic cost of the initial operation and maintenance of the facility, and assessing the needs and interests of the community in the project to generate employment opportunities. We hoped that in addition to job creation, implementation of this project would also promote the attitude of sustainable farming on an island with such high importation rates.

2.0 Background

Puerto Rico is aiming to shift their economic focus from being a society based on industry to agriculture and has the ideal environment to expand this movement of farming to generate employment opportunities (Allen & Penaloza, 2015). Para la Naturaleza, a nonprofit organization based in San Juan that strives for a sustainable future for Puerto Rico, has given us the opportunity to create a plan for a community-based farm in Vieques. In this chapter, we will first discuss the history of Vieques. This is critical for understanding the current state of this municipality. Next, an explanation of the current economy is outlined to show the potential areas where farming would make the most impact. Research on community-based agriculture is examined to determine what would be the best design for the proposed farm to be implemented in Vieques. We next propose and describe mushroom cultivation as an ideal agricultural product for the space. We explain the necessary steps and equipment needed for the farm in order to create a budget and production plan. Lastly, the current issues with water and energy on the island are analyzed to illustrate the immense problems with the feasibility of bringing these necessary aspects to the bunkers for a successful farm.

2.1 Vieques and its History with the US Navy

During World War II, the US Navy acquired approximately two-thirds of the island of Vieques causing a major shift in the economy from agriculture to construction and services. In 1943, when the focus of WWII shifted away from the Caribbean, construction was halted; the number of stationed soldiers was reduced and many of the people on the island found themselves without work (Ayala, 2001). The island remained in this state for sixty years, until 1999 when a Vieques civilian working for the Navy who was stationed at a military observation point was killed when two bombs in a training exercise missed their target by about a mile and a half.

Soon after, Puerto Ricans from all over started protesting. The main form of protest was to camp out on the bombing ranges and prevent any military exercises from taking place, resulting in hundreds of people being sent to jail. That same year Governor of Puerto Rico Pedro Rossello negotiated with the U.S. about the island and in 2001, a treaty was signed that the Navy would vacate Vieques by 2003 (Brief History, 2015).

When the Navy left in 2003, instead of returning the land to the people of Vieques, they handed the land over to the US Department of Interior who converted it into a wildlife refuge. The land was then put under the control of US Fish and Wildlife services. This restricted the access the locals had to the land and mitigated the amount of cleanup that should have been done as lands that are dedicated for wildlife preserves are not held to the same standard as those that are designated to be inhabited by people (McCaffery, 2009).

2.1.1 Impact of the Navy

The people of Vieques despise the restrictions placed on their land. The US will not clean up the island and they are preventing the inhabitants from doing it themselves. In addition, the locals cannot harvest anything from the land and they cannot fish in the waters because they are "protected". The result of this is a lot of tension between the residents of the islands and the US Department of Fish and Wildlife. Local Viequense Pito Delarme speaks on the issue, "Now you can't collect coconuts and crabs, you can't fish, you can't collect anything! When the Navy was here, where were these laws? The Navy destroyed the coral, they killed the turtles, the fish, the crabs, contaminated the land—all of this destruction and [Fish and Wildlife] never stopped them for 68 years. And now we want to develop this part of Vieques well, and we're not permitted" (McCaffery, 2009). This outlines the tension present between residents of Vieques and the United States Navy.

There is also much speculation as to whether or not the inhabitants of the island have been and continue to be poisoned by contaminants. The cancer rate is significantly higher in Vieques than on the mainland of Puerto Rico. Some believe this is linked to heavy metal contamination in the food which is grown on the island (McCaffery, 2009). Another study released by the Agency for Toxic Substances and Disease Registry (ATSDR) claimed that there was no contamination at all from the unexploded ordnance and munitions left on the island. However, this agency has been known for minimizing or completely denying the existence of health risks before (McCaffery, 2009).

This helps us understand the socio economic situation in Vieques and how our project will be received. In case people have concerns about the safety of their food, it is important to understand the history of soil and food contamination in Vieques. By understanding the locals' concerns about contamination, we will be able to empathize with the Viequenses while we work to turn this negative piece of history into a positive facility for the community.

2.2 Economy of Vieques

Before the first of the Navy's expropriations (starting in 1942-1943), the island's economy was primarily based upon the sugar trade. They had a plantation system in which one person or company owned a large estate where families would live and work. In some cases, estates like these would be home to as many as sixty families. After the Navy's purchase of the land, many people were forced to move. Also, during this time the economy shifted from agriculture to services; in other words, the main source of jobs was providing for the Navy. One hundred and twenty-nine farms disappeared and the amount of land used for farming decreased by 72%. There was plenty of work, however, in construction as well as jobs in bars, hotels, and restaurants. However in the mid 1940's WWII shifted away from the Caribbean theater and with it most of the Navy. The construction was halted and the bars and restaurants closed, many islanders found themselves without work. Because of this, the island's economy plummeted and unemployment rose. The high unemployment rate and poverty levels remain today (Ayala, 2001).

While Puerto Rico is currently defined as a high income economy by the World Bank with a gross national income per capita of $19,310 in 2013, it has recently amassed quite a large debt of $68 billion (67% of the $102 billion GDP) and has been in an economic depression since 2006 (Knowledge@Wharton, 2015). This is largely due to the expiration of a law that established tax exemption for US corporations settling subsidiaries in Puerto Rico that would send earnings back to the corporation headquarters without paying a federal corporate income tax (Knowledge@Wharton, 2015).

The main sector of the Puerto Rican economy is the manufacturing sector consisting primarily of pharmaceuticals, textiles, electronics, and petrochemicals. The other significant industry is the service industry, consisting of real estate, tourism, finance, and insurance. Agriculture accounts for a mere 0.8% of Puerto Rico's gross domestic product. Puerto Rico currently imports the majority of its food and despite the fact that most of Puerto Rico's land is fertile, only 5% is being used as cropland (Young & Minchenkov, 2014). This makes it difficult for Puerto Rico to be agriculturally self-sufficient.

While there are some jobs on the island such as management positions (22% of all jobs), service occupations (28%), sales and office occupations (16%), construction and maintenance (18%), and a few jobs in farming and fishing (2%), these jobs do not employ very many people. In fact, 11.8% of the Puerto Rican population is currently unemployed (Rivera, 2015), compared to the United States' 5.5% (Databases, Tables & Calculators, 2015). Due to this, many people try and work on the Puerto Rican mainland, however doing so relies on an unreliable ferry system, keeping yet more Viequenses from work.

Unfortunate circumstances due to the Navy's involvement on the island and the collapse of the Puerto Rican economy have led to a high unemployment rate and poverty rate. The goal of this project is to create a source of employment on the island and promote sustainable living, two key parts of helping the island's economy and the inhabitant's quality of life. We believe the economic situation in Vieques will cause the Viequenses to be open to the project and even welcome it.

2.3 Mushroom Farms

Agriculture allows for a range of jobs for any member of the community. Mushroom farms are ideal for communities that are new to agriculture because the process of cultivation requires little training. In one case study, a region of South Korea relies on mushroom production as the main source of income. A healthy byproduct of this is the relationships that were formed which allowed for more collaboration between farmers and more production of mushrooms for the entire neighborhood (Van Gevelt, 2014). In another case study, a mushroom farm in Africa was able to expand largely over a short period of time because of the ease of mushroom production. As the farm grew, so did the need for more employees (Muhanji, 2010). Both of these examples support the ideal community involvement and employment situations for the potential mushroom farm in Vieques.

2.3.1 Community Involvement to Cultivate Mushrooms

Communities around the world have relied on agriculture as a main source of income. As the shift away from industry becomes more popular, so does the negative stigmatisms about the social status of farmers being uneducated and poor. In Cheongyang-Gun, South Korea, nearly everyone in the rural community is heavily involved in oak mushroom cultivation. People use log beds which they either cut down from forest trees on their property or they purchase from a neighbor who sells timber. Others purchase bags of oak sawdust from China to grow their mushrooms. Individual farms are protected by the Forest Law of 1961 and the Forest Co-operative Act of 1980, both of which provide financial and technical aid to ensure households can grow an appropriate amount of mushrooms. Additional support comes from the Mushroom Growers Club: a group made up of mushroom cultivators that provide marketing and load services separate from the technical support from the government. Location of selling the mushrooms greatly impacts the cost of the mushrooms. Those being sold closer to the place of production cost less because they do not need to be dried, transported to cities and stored in markets (Youn, 2004). This example provides useful information about how a community-run mushroom farm not only provides a large source of income but connects neighbors to one another over a worthy cause.

There have been issues where laborers interested in agriculture are growing older and not enough young people are willing to take on their roles since many high paying jobs cannot be found in rural areas. In Korea, oversea producers of mushrooms are cutting into the competition for selling across Asia and to the US. Even though the quality of the mushrooms from Cheonyang-Gun is better, the mass produced mushrooms from China are cheaper to export and come in larger quantities (Youn, 2004). These challenges are critical to recognize when creating a plan for a farm on an island where the unemployment rate is up and exporting produce is expensive. The rate of employment in agriculture for males and females in Vieques is below 3% (World Bank Group, 2015) which provides room for jobs in farming. When it comes time for crops to be sold, consideration of the distance between the production site and the consumer will need to be analyzed for the cost and feasibility of getting the food to the customers.

The economic importance of agriculture in Puerto Rico is not as developed of a motive to household farming as it is in Korea. However, using the example of an established community farm such as the ones in Korea will be beneficial in explaining the impacts the bunker farm will have on the economy if people choose to participate. An initiation of an agriculture club would be helpful to the support of a community-developed farm in the abandoned bunkers. When developing a plan for the farm, location is important to consider since produce will be cheapest when the cost of transportation and packaging will be low.

Considering the climate of Vieques and the properties of the bunkers, mushrooms are the easiest and most cost effective crop for the facility. Mushrooms are good for air filtration and composting, easy to maintain, and easy to teach to the inhabitants to grow. Bunkers will need to be modified for mushroom production while still keeping the cost of construction and equipment as low as possible. Mushroom farms do not require direct sunlight and do require cement floors, sloped roofs, proper insulation and a good ventilation unit.

2.3.2 Employment on Mushroom Farms

In Africa, farmer Emmanuel Munisi expanded his crops to include oyster mushrooms which turned out to be a successful project and is still implemented to this day. Munisi worked along with Horticultural Research Institute (HORTI) - Tengeru to grow the mushrooms on his farm. HORTI supplied the funds needed to start the project and Munisi allowed his farm to be used. In turn, the farm produced about 50 kilograms per week on average, and 20 kilograms per week in the dry seasons with a fair amount of revenue from each crop. Once the mushrooms are initially planted, harvesting each season is less labor intensive which leads to expansions and the need for more employees. Mushrooms are not at the highest of demands in Africa but those who are in the business of trading them have realized the low cost of production and the high return from each crop (Muhanji, 2010).

The knowledge of successful mushroom farms will be influential to the structure of the farm in Vieques and gauging the amount of produce that can come from the establishment. Since we possess the capability of finding the amount of mushrooms harvested per employee like the farm in Africa, our team can determine what the appropriate amount of employees the facility will need.

2.4 Issues Regarding Acquiring Energy and Water

One of the greatest challenges facing this project is water and energy use. Currently the bunkers on Vieques have no running water or electricity, both of which are required for an agricultural facility. The team will be looking into several methods of water collection as well as into solar energy for the bunkers. Concerns regarding the water collection include potential contamination of groundwater due to ordnance left behind by the Navy and the recent droughts Puerto Rico has experienced. Research on the solar energy side proves to be more optimistic; we found records of a successful photovoltaic system being used to generate electricity for some of the island.

2.4.1 Water Contamination

The fear of contamination due to the excessive bombing on Vieques became prevalent in the 1970s when the Agency for Toxic Substances and Disease Registry (ATSDR) investigated the possibility of remnants penetrating the water system. The main sources of drinking water at the time were groundwater and rainwater collections. When threats to public health surfaced because of water with explosive-contamination, a majority of wells were deemed unusable without any tests of cleanliness. In 1977, an underwater pipeline from Puerto Rico to Vieques was built to bring clean drinking water to the island. The water was stored in aboveground facilities before being dispersed. In case water cannot be supplied from the pipe, there are still a few wells that can provide adequate water to the public.

In 2001, the U.S. Department of Health and Human Services published a report that reevaluated the safety of the water systems in Vieques. Only one private well was found to be

toxic because of high levels of nitrate from agricultural pollution. All other wells on the island have been cleared to use for drinking. There have been no reports filed by the ATSDR about the safety of drinking water from rainwater collection (U.S. Department of Health and Human Services, 2001). For our project, the understanding of the quality of the water as well as the accessibility to the water on the island is important. Water is scarce and getting it to the bunkers will be difficult. We also will need to ensure that the quality of the water is proper for agriculture since contaminated water would produce toxic food.

2.4.2 Drought

A recent crisis for the island of Puerto Rico has been the lack of rainfall. From June-August of 2015, 36% the regular rainfall was not received. Water rations were implemented by the government and an estimated 2 million people were affected by mid-August of 2015 (Janssen, 2015). The magnitude of the drought during the dry seasons opens up a variety of concerns when thinking about creating a farm in the area. Rainwater catch systems are viable ways to collect and store water for the farms. While the method may be easier than pumping from wells or importing the water, the feasibility may be low given the weather history of the islands.

2.4.3 Energy

The Fish and Wildlife Service in Vieques has been developing plans to use solar panels as a new source of energy for the island. In 2014, a photovoltaic system saved $18,522.81 in electricity bills and produced 59.751 kilowatts of light. This award winning plant is the only in Puerto Rico that is not connected to the Puerto Rico Electric Power Authority (PREPA). However, the Electronic Security Association (ESA) still provides electricity for the plant to operate (El Nuevo Dia, 2014). This example is important for our potential farm in the reserved areas of Vieques. Para la Naturaleza would be able to bring solar panels to the area and turn the energy collected into electricity used solely for the bunkers without dependence on the major electricity companies.

2.5 Summary

Due to the Navy's use of the land and subsequent failure to clean up after they left, the inhabitants of Vieques have suffered greatly. The island is poor and many of its inhabitants are unemployed. However, we are conducting research that could potentially begin to change all that, starting with a community-based farm. The hope for this project is that if the farm is a success, then it will be possible for other farms to come about. Community-based farms create jobs and supply healthy food to locals for a low cost. By placing the farm in an old military bunker we are turning a formerly unused, potentially harmful plot of land into something that could benefit the whole island.

3.0 Methodology

Our goal with this project was to create jobs in a town that is struggling even more than the territory of which it is a part. In order to achieve our goal, we have developed three research objectives pertaining to the transformation of a bunker into a mushroom farm by:

1. Evaluating the engineering aspect of such a facility by estimating water usage, determining electrical consumption, and creating a process to grow mushrooms
2. Assessing the feasibility of a mushroom facility in this bunker given economic constraints
3. Weighing the social impact of the facility by gauging community attitude, support from the community and government, and computing the amount of jobs that the facility can provide.

3.1 Engineering

In order to create a plan of how to create our facility we needed to research about several different topics including layout and infrastructure of the farm, water and electrical requirements, and a method for growing mushrooms. To create our plan, we conducted online research, contacted various vendors, and traveled to the bunkers to take measurements.

3.1.1 Water and Electricity

Creating an efficient system for harvesting water and electricity is crucial to the success of this farm. A mushroom farm requires a lot of resources to function and yield crop; given the relative isolation and aridity of the bunkers' location, we must take special care in calculating these needs and understanding how we can meet them. A major challenge concerning water and electricity is the bunker's lack of connectivity to the island's electrical grid and water system. Due to this issue, we looked into the bunker supplying its own resources. More specifically, we conducted research on getting our resources in a renewable way while making estimates on the upper and lower demands of the farm.

Electricity is needed to power an air conditioning unit (which in particular requires a lot of resources), lights, a dehumidifier, and fans. Proper temperature and humidity are not only essential to maximizing the efficiency of growing mushrooms, but also they are needed to be able to grow any mushrooms at all given the delicate nature of the fungus.

To calculate the amount of electricity we could obtain for the farm at low cost, we looked into solar panels. Despite the high investment cost of solar panels, they have a quick buy-back cost and pay for themselves after only a few years. They require low maintenance and have a very low carbon footprint. We used a PVWatts calculator online to calculate how many kilowatt hours solar panels could generate if they were to cover the roof the bunker.

An issue with the use of solar panels is that they require constant sunlight to maximize efficiency. Vieques is usually partly cloudy, meaning direct sunlight is not always available. The

amount of electricity used by the farm is also not consistent. While the internal temperature of the bunker must always be cool (around low 70's Fahrenheit), during some stages of the mushroom growing process the internal temperature does need to plummet down to between 62 and 65 degrees Fahrenheit. This cooling process requires a lot of power to manage the plunge in temperature. It's

An abundant amount of water is required for growing mushrooms. Water is required at all stages of the growing process from moistening the initial compost to re-watering compost after mushrooms have been picked to replace the water contained in the mushroom. Having an efficient water-collection system is important to the success of this farm.

We researched small mushroom operations run by farmers as a side business and read reports and articles that they wrote. We looked at the amount of water required during each step and scaled it to a farm of our size. These side operations are run by farmers and these farmers have access to an overabundant supply of water and given this, the farmers did not include much information about the amount of water used in volume. They instead used adjectives describing the amount of water to use in terms of how the soil looks. For example, when watering peat moss during casing, water is supposed to be applied enough so that the dirt is wet, but not so much so that the dirt seals. This is a very vague description in terms of calculating a volume for water so we turned to recipes from mushroom growing kits instead.

While scaling up recipes is not a great way to estimate the amount of water required to run a farm, it was the best option we had immediately available to us. We created a plan to run a pilot study that has the aim to estimate water usage. We can expect such a study to produce more precise results and data on the amount of water mushrooms require during the various stages of their growth.

After estimating how much water a mushroom farm requires, we calculated the amount of water that could be gathered from a rainwater collection system and compared the number of gallons per year to what we would need for a successful farm. We did this by calculating the square footage of the bunker's roof and the average yearly rainfall and multiplying the two numbers to achieve a number in gallons of water. The issue with this calculation is that it implies that all rainwater is collected and there are no drips left on the roof. While this may seem minor, this amount of leftover water can add up. An even bigger factor in this calculation is the assumption that the average yearly rainfall is the actual rainfall each year. Puerto Rico and Vieques in particular have had dry seasons recently and the island has reported very low annual rainfall in the past few years.

3.1.2 Layout and Infrastructure

After assessing the bunker condition, we realized the biggest problem for the farm would be getting water and electricity to it. Therefore, our team brainstormed and drafted ideas for a rainwater collection system along with a map of where solar panels could be placed. The most feasible idea is to first lay down a hard, non-permeable surface over the soil that resides on the roof of the bunker on which water can run down to the lower elevation of the slanted roof. At the end of the sloped surface will be a gutter that will have pipes dug into the ground. The pipes will

be dug about 1-foot-deep and connect to another pipe that connects the storage tanks in the bunker. Water would be stored in tanks and would be used for spraying mushrooms and for composting.

The first step for designing the solar panel farm was to find the maximum amount of area we could use. To do this, we measured the area of the available flat surface on top of the bunker. For our plan, the solar panels would rest on top of the non-permeable surface so water could run off the solar panels for the catch system. Next, an analysis of energy that could be generated from the solar panels was done on a PVWatts calculator from the National Renewable Energy Laboratory which was referred to us by a consultant[1]. Lastly, a map for the solar panels location was drawn.

3.1.3 Mushroom Research

Once we had an idea for how we were going to bring water and electricity to the bunker, we began researching the infrastructure associated with growing mushrooms. We looked at different growing mediums determining which ones would be better for the type of mushroom. Then we looked at the containers the mushrooms would be grown out of (trays, bales of hay, or bags), and what kind of system worked best in the bunker for maximum mushroom production. Using this information we created a floor plan and determined the total mushroom growing area we had.

3.2 Economic Feasibility

Once we had a plausible idea for a system we needed to figure out how much it will cost to build, maintain and operate the facility and how much revenue the farm could generate. We accomplished this with online research and calculations. After gathering the data and making the calculations, we determined the number of jobs the center can produce and whether or not the facility can do what it was meant to.

3.2.1 Cost Research

The first thing we assessed was the cost of turning the bunker into a mushroom farm. We made a list of costs and all of the variables that go into converting the mushroom farm and plugged the numbers into a spreadsheet. The spreadsheet was designed so that should one variable be changed, all of the calculations were redone allowing for different scenarios. The costs were broken up into two sections. The first was investment costs; they are paid once up front and need to be paid back over time. The second section involved the operating costs. These are all the costs that will need to be paid on a regular basis, such as wages and growing materials.

[1] Carina Hart, P.E.

Most of the costs were found using online queries; the team searched for the various materials, found vendors, and used the average prices. Some of the prices required a few more calculations, for example solar panels. For those, we researched the price of putting solar panels on a house. We found the average square feet of solar panels required and how much they cost. Then we found the ratio between the square footage on a house and the square footage on the top of the bunker and scaled the price up accordingly. Once we found all the costs, we then calculated the revenue the farm could generate.

3.2.2 Revenue

To calculate our revenue, we first looked at the average pounds of Portobello mushrooms a square foot of growing area can produce. We then did research into the retail price of Portobello mushrooms. After finding these two number ranges, we determined how many pounds of mushrooms our facility can grow each year by looking at the floor plan that we created and calculated the square footage of the combined growing area. All of these variables were added to the spread sheet in the operating costs section. This allowed us to see if the farm would cost money or generate a profit.

3.2.3 Breakeven Analysis

The third section of the spreadsheet was the breakeven analysis. The breakeven analysis pulls together all the pieces of the spreadsheet. It uses the operational cost and number of mushrooms produced to determine the cost per pound of mushrooms. It then takes the total investment costs and divides it by the market price per pound of mushrooms minus the cost per pound of mushrooms. This analysis tells us how many pounds of mushrooms need to be sold before the investment costs are paid back and the farm will start generating profit.

3.3 Social

The overarching objective of our plan is to produce opportunities for local people to have jobs on the farm. To understand the plausibility of generating jobs, we need to know whether or not the farm would be supported by multiple sectors of the community. The interest of the Viequenses who would potentially be cultivating, boxing, cleaning, and exporting the mushrooms is the most important to know because without the community running the production, the farm will fail to operate. Gaining government support is also key because the government oversees the employment and agriculture projects on Vieques.

3.3.1 Community Attitude and Support for Project

To start gauging the reaction of the inhabitants, we spoke with the Para la Naturaleza contact Julian Garcia who knows the island of Vieques and estimated the desires of the people who would be affected. We asked what his thoughts were on how the farm can benefit the community.

In addition to asking about the community, we created surveys to hear what the people thought of farming, mushrooms, and potential employment opportunities. When designing the surveys, we looked at past IQPs to see what worked best. Mostly, we used questions that were either multiple choice or on a scale (strongly disagree, disagree, etc.). This provides numerical data that could be easily analyzed. We also left an open space for them to express their opinions and tell us what they thought about the project and any ideas they had. We also had the surveys in Spanish and English to make them available to a wider range of people on the island. The demographics of those who answered the questions were asked in the last section of the surveys to know the different sectors of the community that gave input which affects our assessments[2] (Granger, T., Newell, K., Wesley, K., Westlake, P.,2013). Julian Garcia volunteered to distribute these surveys for us because traveling to Vieques for our team is difficult.

A phone interview was conducted with the Superintendent of the Eastern Region, Carlos Morales, who would be in charge of overseeing the project on Vieques. Our team asked him about the original vision Para la Naturaleza had for the bunker farm and any ideas that we could keep in mind when assessing the plan. Given Carlos' experience with projects, we also wanted to know what the biggest hindrances for constructing this plan would be, as well as the largest obstacles that could decrease the feasibility of the farm developing. Lastly, we discussed the social implications that this farm would have for the island of Vieques.

3.3.2 Government Support

An interview with a member of the government was administered to understand the necessary procedures to starting a farm in a wildlife preserve in Vieques. Our team interviewed the Secretary of Municipality, Fabian Martinez, who explained the process needed in order for the land to be used as an agricultural facility.

In addition to the land regulations, Fabian helped us grasp the social desire for agriculture to come back to Vieques after many years of being dependent on industry and jobs off the island. Puerto Rico's struggling economy prevents any grants to be provided to this farm. However, the governor of Puerto Rico is a large advocate for agriculture and supports projects that would advance the agriculture shift on the islands.

3.4 Summary

We collected data in many ways in order to properly construct a plan for the farm and then chose whether the farm would be possible or not. The engineering aspect of the methods consisted of two integral parts:

1. Discover the amount of solar energy that could be generated and compare that to rough estimates of energy that will be used for the farm to function
2. Calculate the amount of water that will be needed for optimal mushroom production and determine whether or not that amount of water can be collected from the rainwater catch system.

[2] Survey Questions can be found in Appendix A

The cost-benefit analysis was constructed to allow our team to determine if this farm would be economically feasible for Para la Naturaleza to make. Lastly, the inhabitants of the island who will be impacted the most needed to give their input in order for us to know whether the farm would be adequately supported by the members of society. When looking at the three portions of the plan separately, a proper assessment for the overall feasibility of the farm can be made.

4.0 Findings

We found that we are unable to definitively state whether or not this farm would be feasible. There were many indicators in our research that supported the success of the farm. Along with that we discovered many challenges the farm must overcome in order to be plausible. The data we collected lead us to suggest that more research be conducted in each area for a more accurate assessment of the farm's practicality.

4.1 Engineering

After examining the engineering aspect of the farm, we encountered a lot of challenges. There was not enough evidence that would support saying whether or not the farm water collection system could acquire the necessary amount of moisture for mushroom production at the large scale. Similarly, there were no ways to know the amount of water needed for each mushroom cycle. We encountered a similar issue with solar energy. We were able to calculated the amount of energy the farm could generate, but we could not estimate the amount of electricity the farm would use. We suggest a pilot study be done in a portion of the bunker to give a better estimate for amount of resources required per cycle of mushrooms.

4.1.1 Water Collection

The water collection system that was brainstormed by our group was the cheapest and easiest to maintain and it has the potential to collect enough water for the bunker farm to be operational if we assume 100% efficiency of the system. We based the system off of a water collection system we saw at Hacienda la Esperanza, one of Para la Naturaleza's historical preservation sites. Our plan would involve laying down plexiglass on top of the bunkers under the solar panels; this provides a smooth non-permeable surface for the water to run down. Around the perimeter of the bunker trenches would be dug and gutters placed in the ground for the water to run into. The gutters would lead to a downspout that would pass through the wall of the bunker and into cisterns on the inside. The cisterns would be place on a shelf up high and a hose would be attached that could reach the floor. This way the entire system works using gravity and no pumps are required. Figure 1 shows a basic illustration of how the system would work.

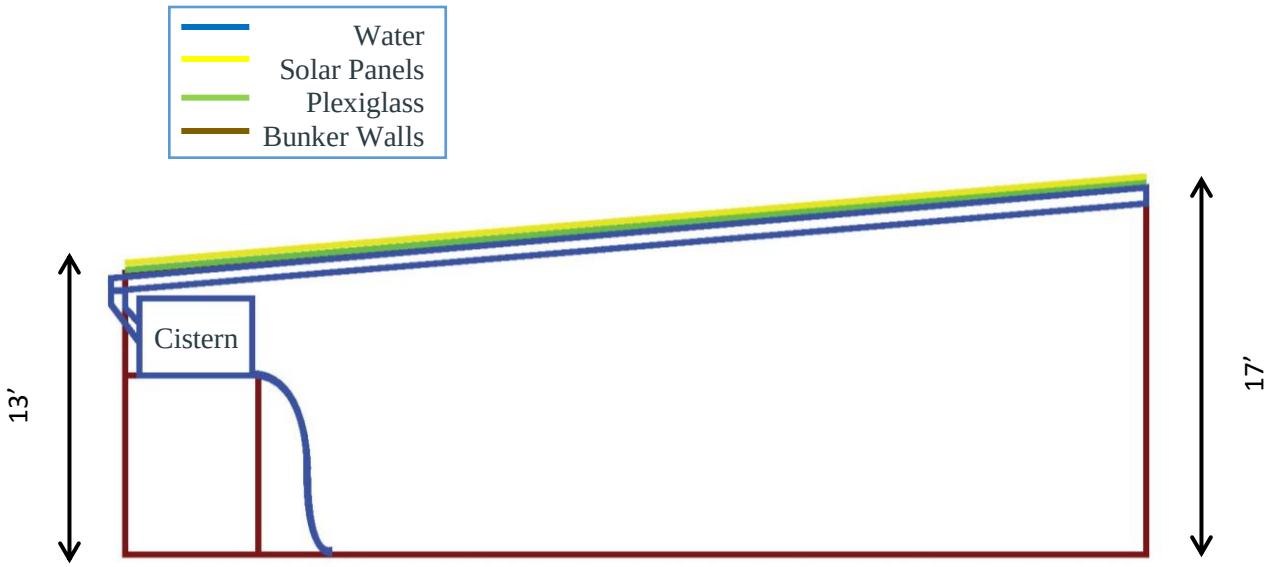


Figure 1: Water Collection System Diagram

The minimum amount of water needed for optimal mushroom production is 158,000 gallons per year; however, this is a rough estimate[3]. The rainwater that can be collected from the area of one bunker roof would be 161,667 gallons per year[4]. We used the average rainfall per month to create the graph in Figure 2 that shows how much rain can be collected in each month. This will allow PLN to determine what months they will receive adequate water and how much water they will need to store to get through the dryer months.

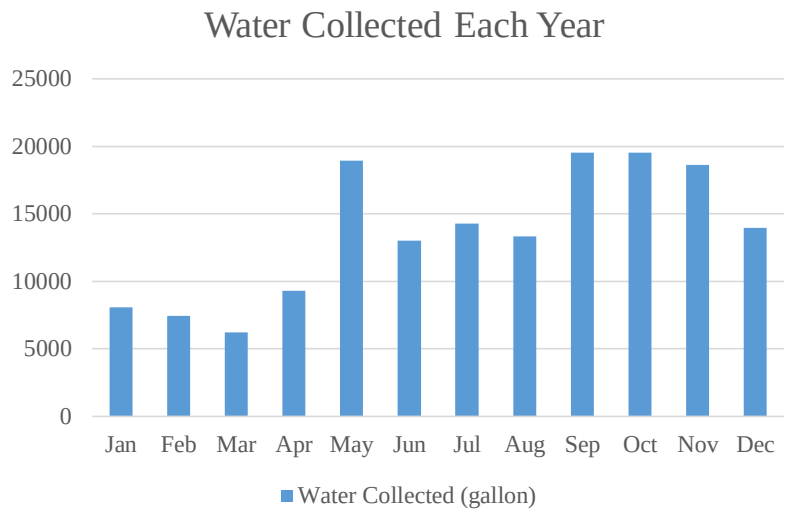


Figure 2: Water Collection Graph

[3] Full calculations done in Appendix B1
[4] Calculations in Appendix B2

The numbers shown above assume that there is an adequate rainfall every year. Considering the drought Puerto Rico has been experiencing, the group was concerned that the bunker may not be able to collect enough water to sustain the farm. In addition, the method we used for calculating the amount of water needed involved scaling up from a square foot mushroom kit to a 5,760 square foot bunker; it gives a rough idea but it may not be incredibly accurate. We recommend as part of the pilot study water usage be closely monitored to find a more accurate number for the amount of water required to grow mushrooms.

4.1.2 Solar Energy

For the plan to work, the solar energy collected from the panels would need to produce enough electricity for the equipment on the farm. The equipment required for the farm does not need to be industrial quality because of the size of the bunker which would lead us to believe that the solar panels could convert enough energy. However, we are unable to calculate the energy usage in kilowatt-hours of fans, air conditioning unit, lights and dehumidifier that such a facility would require each year since there are simply too many factors going into this calculation. Some unknowns we have in calculating this value are how long the AC would need to run to cool the whole bunker, at which power level the AC would need to run on, and the energy required in keeping a stable humidity. We can, however, calculate the maximum power we have access to and according to the PVWatts calculator we found with the help of a consultant[5], the amount of energy that could be generated from a year of solar radiation would be 102,401 kilowatt-hours[6].

However, this is not taking into consideration the need for 24-hour cooling. Some of the equipment like the air conditioners would need to run overnight when there is no sun and a battery would need to be installed as a backup source for energy. Overall, we were unable to determine the feasibility of the bunker just by looking at the electrical conditions and requirements alone. We would suggest using the pilot study mentioned above to measure the amount of electricity needed as well. We also suggest looking at a way to store excess energy generated during the day to be used at night.

4.1.3 Mushroom Infrastructure

Lastly, the bunkers are anticipated to produce a large amount of usable mushrooms which influences the chances of the farm being successful. This requires the maximum amount of space being utilized in the bunkers for cultivating the spores. We decided there would be 2 52”x52”x10” trays per each shelf and the area of the bunkers would allow for 120 trays to be laid out on the floor. Shelves could be stacked on industrial shelving units which would allow for a maximum of three rows high. Therefore, a total of 120 shelves (360 trays) could be used in the

[5] Carina Hart, P.E.
[6] Raw solar energy data available in Appendix C

bunkers. We created a floor plan that was to scale that shows a potential way the bunker could be laid out.

In the layout shown in Figure 3, the brown rectangles represent mushroom trays. The blue cisterns are where the water would be stored. In addition to elevating the cisterns to use gravity to draw water, the space underneath could be used as a closet for storage of tools or a place for employees to leave their personal belongings. The small black squares represent the one and a half square foot cement support columns, and the grey squares represent the vents in the ceiling. Blue lines on the border indicate windows and the green lines indicate the two doors. We believe this layout gives the farm the best chance to produce enough mushrooms that could support the plausibility of the farm.

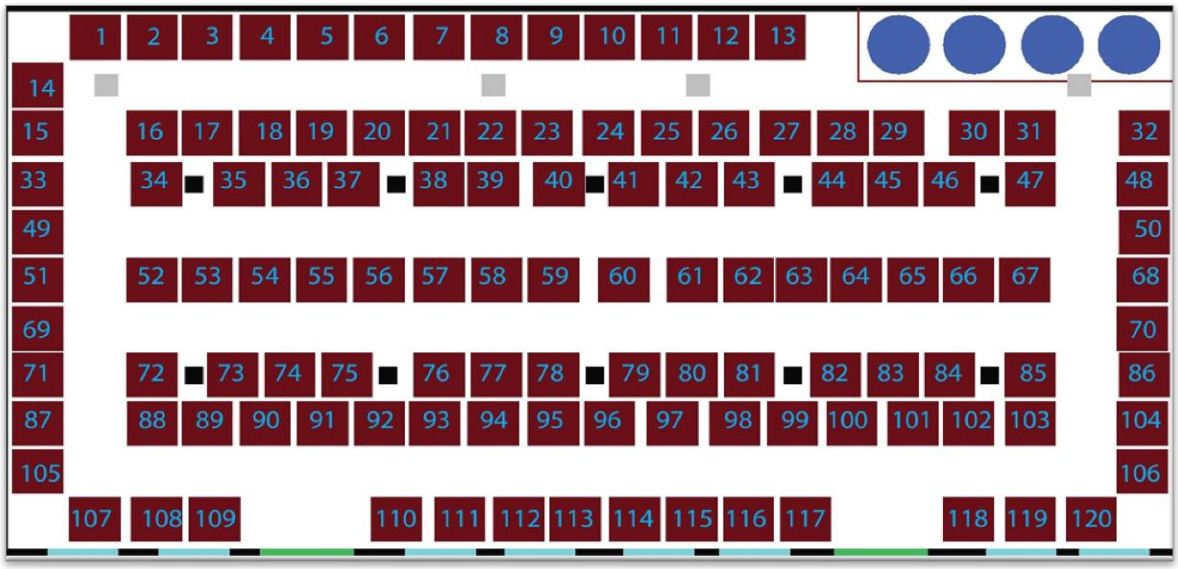


Figure 3: Floor Plan for Bunker

4.1.4 Pilot Study

This section explains the pilot study mentioned in the previous sections. The pilot study would be sectioned off into a 15’6” square in the back right corner of the bunker; this is the section of space between both walls and the pillar in that corner, therefore, little additional construction would be required to create an environment that would mimic the actual bunker. There would be more insulation in this area of the bunker because it is entirely built into the hill whereas the areas closer to the doors get less insulation and more air flow. To gate off the area for the study, there would be two plastic tarp walls. This allows for light to get into the space which would reduce the amount of artificial light needed for workers to farm mushrooms. Two isles of three shelves (18 total 52”x52”x10” trays) would be able to fit in this space.

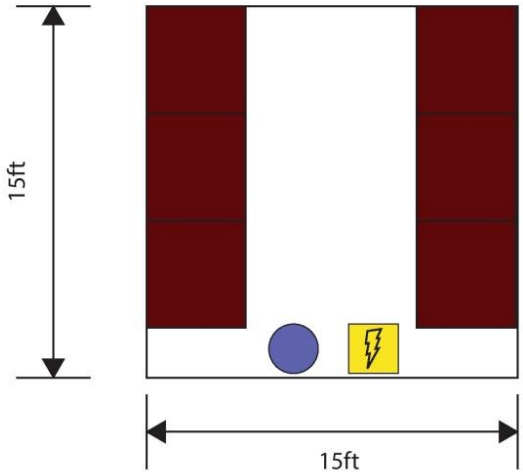


Figure 4: Floor Plan for Pilot Study

Water would be transported to the bunkers from an external source. The amount water used in the pilot study would be monitored by the amount of jugs transported in. Similarly, a small gas-powered generator would be set up in the bunker to provide energy for a dehumidifier, 1-2 lights, a fan and an AC unit. By putting meters between appliances and the generator, we can know the amount of energy used. It is important to note that not all of these appliances will be running simultaneously. In the farm, lights would only need to be on when employees are working with the produce and the air conditioning unit would only need to be running when the temperature needs to be lowered. The energy simulation in the pilot study will allow Para la Naturaleza to determine what power is needed to run the entire bunker and if solar energy can produce the required amount. The pilot study we designed is roughly 1/20 the size and capacity of the full bunker.

4.2 Economic Feasibility

All the information we found was plugged into a spreadsheet[7] that was used to calculate the information we needed. The spreadsheet incorporates all the variables involved in the farm including prices per unit and number of units. The spreadsheet was designed so that if a variable was changed the entire spreadsheet would recalculate the total costs and revenue. This allowed for different scenarios to be calculated quickly, to determine how likely the farm is to produce a profit, what the minimum requirements were, and how long it would take to pay back investment costs. It also allowed us to test wages to find a fair wage for employees of the farm. The spreadsheet was divided up into three sections: investment costs, operating costs and revenue, and a breakeven analysis.

[7] Screenshots of complete spreadsheet with and without formulas in Appendix D

4.2.1 Investment costs

The primary section of the spreadsheet was the investment costs. The first sheet shows a simple list of the categories of costs and the total deficit from investments. The second sheet shows the calculations; it breaks down all of the costs into their components and variables so if any of them should change the rest of the costs would be recalculated. This will allow easy changes if the information changes. The total comes to approximately $371,000.00, most of which comes from the solar panels. Table 1 shows a breakdown of the investment costs.

Table 1: Investment Costs

Investment Costs	
Bunker Prep	
Cleaning	276.00
Painting	1065.07
Energy and Water	
Solar Panels	297000.00
Wiring	9700.00
Water Collection System	19165.59
Mushroom Growing Infrastructure	39480.00
Ventilation System	1800.00
Climate Control	2894.08
Total	371380.74

4.2.2 Operating Costs and Revenue

The second part of the spreadsheet covers operating costs and benefits. It is set up the same way as the first, allowing easy changes to allow for different scenarios. In this case many of the variables could change frequently, such as, pounds of mushrooms per square foot, price the mushrooms could be sold for and number of trays. The numbers we found for pounds per square feet ranged from 25 to 48 pounds per square foot per year, and the retail prices we found ranged from $3-6 dollars. This allows for a huge range in revenue calculations anywhere from $432,000 to a little over $1.65 million. In the example found in Table 2, we input the median values of 35 pounds per square foot, a market value of 4 dollars per pound, and 360 trays. There were many challenges that arose from the wide range of values. We strongly suggest that more research be conducted in a market study. This has the potential to provide a more accurate wholesale price of mushrooms.

Table 2: Operating Costs and Revenue

Operating Costs	Year 1	Year 2	Year 3
Fixed			
Tools	642.70	642.70	642.70
Wages	234000.00	234000.00	234000.00
Variable			
Growing Medium	44031.96	44031.96	44031.96
Spores	28108.80	28108.80	28108.80
Fungicide and Insecticide	371.00	371.00	371.00
Total	307154.46	307154.46	307154.46
Revenue	806400.00	806400.00	806400.00
Total Cost or Benefit	499245.54	499245.54	499245.54

For simplicity, we operated under the assumption that all the mushrooms produced would be sold but there was not enough evidence to support this claim. We recommend an investigation, along with the pilot study before a final decision is made on the project. These studies can give Para la Naturaleza more accurate numbers for pounds of mushrooms per square foot of growing space, wholesale price, and amount of mushrooms that can be sold. We suggest that PLN talk to several local restaurants and markets to see if they will buy the mushrooms and what kind of demand exists. In addition, during our interview with Secretary of the Municipality of Vieques, he suggested we look into exporting to small nearby islands in the area, like Saint Croix. Ability to sell the mushrooms produced is a huge factor in determining the farm's success.

4.2.3 Break Even Analysis

The final part of the spreadsheet7 was the break-even analysis. This analysis tells us how many pounds of mushrooms need to be sold to pay back the investment costs, and about how long it would take, and therefore, how feasible the farm would be. The first step in the break-even analysis was finding the investment costs, which we did in the first part of the spreadsheet. It is critical to know what the mushrooms cost per pound to produce. This was done by taking the operational costs and dividing them by the number of products. The breakeven analysis works by taking the investment cost and dividing it by the market price per product minus the cost per pound of mushrooms, as shown in Table 3.

The example in Table 3 used the same parameters as the revenue calculations. Under those conditions, the cost per pound of mushrooms was approximately $1.52. With the price per

pound being $4.00, it would take around 150,000 pounds to break even. This would take the farm about three quarters of a year to pay off the investment costs.

Table 3: Break Even Analysis

Investment:	366781.66
Materials and Wages:	307154.46
Pounds of mushrooms produced:	201600
Cost per pound	1.523583611
Price per pound of mushrooms	4
Breakeven point	148109.8512
Years to payback investment profit:	0.734671881

4.2.4 Jobs Created

Included in the assumptions made in the spreadsheet were the numbers for employees and wages. The values we used were 10 workers, five part-time and five full-time being paid 15 dollars an hour. We assumed that a full-time employee works 40 hours a week and a part-time employees work 20 hours. The total wages cost the farm $234,000. We then compared the income that could potentially be offered to current income on the island. The part-time workers would make $15,600 and the full-time employees would earn $31,200 a year. The median household income on Vieques is $17,355, so the jobs generated offer decent wages and could have an impact on the people of the island. This neglects insurance, worker's compensation, and other employee benefits which could drastically add to the costs. Para la Naturaleza will need to take these into consideration. These challenges prevent our team from accurately stating whether or not this farm would be viable in an economic sense.

4.3 Social

As we have studied the reactions from the interviews, we have determined there will need to be more research done in order to determine if there is support from the community. The government and Para la Naturaleza are excited to see this plan grow into an actual farm that will bring employment to Vieques. PLN even thinks this farm will go beyond the employment and greatly impact the issue of self-sustainability on the island, as we have found from the interviews.

A clearer understanding about the protocols for constructing a farm and the social impacts this project could have on Vieques was gathered from the interviews with Para la Naturaleza. Carlos Morales, the Superintendent for the Eastern Region of Puerto Rico from PLN, explained the ideas the organization originally had for the project: provide employment for the Viequenses by repurposing these bunkers. He confirmed that the biggest challenge for the farm will be getting water to the bunkers. Water is limited to Vieques since it strictly regulated through a pipe from the main island of Puerto Rico. Since the land that houses the bunkers are owned by Para la Naturaleza and not by the municipal government, zoning and permits are not required to begin creating the farm. However, there is the concern that the influence the municipal government would have if digging wells became necessary for supplying the bunkers with water. Assuming this is an accurate representation of the attitudes of Para la Naturaleza, there is reason to believe there is support from the sponsor.

Fabian Martinez from the office of the municipality's government explained that a major social issue currently on Vieques is how industries and businesses are coming from off the island and bringing labor with them, leaving no available jobs for the Viequenses. There is high hope from Martinez that a community-operated mushroom farm will be strongly supported by the community and be able to expand to other bunkers.

The Auxiliary Supervisor of Vieques from Para la Naturaleza, Julian Garcia, believes that many sectors of the community will be positively affected by this project. The community will be greatly impacted by the educational opportunities the bunker will provide. Para la Naturaleza believes this farm will provide the knowledge for how to grow mushrooms and that knowledge can be taken back to homes so families will be able to have a smaller-scale farm of their own. Garcia also commented on the togetherness that will come from having a farm run by the population.

4.3.1 Surveys

The responses collected from the surveys allowed for the feasibility of community support could be assessed. The first section of the survey yielded results of support for the potential mushroom farm. 82% of the polled population claimed they strongly agree that they would prefer to buy locally grown food, where only 14% admitted they would merely agree and 5% were neutral. This bodes well when considering 73% strongly agreed that the mushrooms should be sold in local markets, while the remaining 27% agreed with the statement. There was strong support for converting the bunkers into a mushroom farm given that there were no responses that were in disagreement with the statement. Similarly, there was a majority of support for buying locally grown food. There was adequate agreement with the statement about knowing more about mushroom farming. From this, we can suggest having an educational aspect to the farm that would allow people to learn about the process of growing mushrooms. Although there were only 22 people who filled out the first portion of the survey, there is still a strong support from the locals to build the farm. However, this data is not entirely representative of the whole population of Vieques.

From the second section of the survey, we learned the demand from mushrooms on Vieques as well as additional support from the community on growing mushrooms. Although there is a relatively low demand for mushrooms from the individuals who participated in the survey, there is a desire to have them sold in markets if they were locally grown. For example, 12 of 23 people said they strongly agreed to purchasing mushrooms from a bunker than from a market if they knew the mushrooms were grown locally. Figure 5 provides a visual of all the responses from Section 1 of the surveys that pertain to locally grown agriculture and mushroom farming. As shown, there is major support in each respective category. To support that, 57% agreed they would use mushrooms more if they were grown locally even though the survey revealed only 8% of people surveyed cook with mushrooms more than once a week[8].

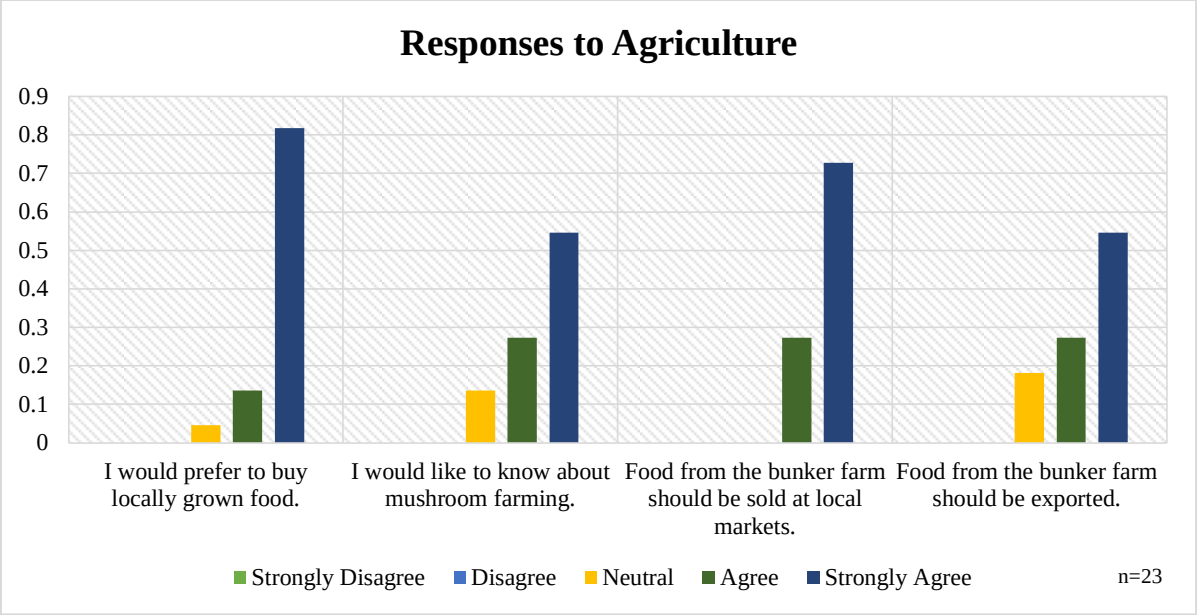


Figure 5: Survey Responses to Questions about Agriculture

It is critical to note that not all surveys were properly filled out which affects the determinations made by the group. There were multiple "no responses" pertaining to the gender, desire for commuting, and income of each year. Conversely, there were multiple answers given for a question, which also skews the accuracy of the results for the demographic. The sections where these errors occurred were in the years lived on Vieques, the highest level of education, and how often people cook with mushrooms. In future studies, the instructions for how to answer the questions should be stated more clearly to allow more accurate data on community support to be collected.

[8] Appendix E contains more detailed numbers for the responses given

4.3.1.1 Community Interest in Locally Grown Agriculture

A range of questions were asked regarding locally grown agriculture in the primary and secondary portion of the survey to gauge the demand for mushrooms compared to other produce. From the answers given by the Viequenses, there is evidence that the community believes they would benefit from the farm other than the employment opportunities it aims to generate. 77% of responses strongly agreed with seeing the bunkers being converted into an agricultural facility with the remaining 23% agreeing with the statement. Similarly, 91% strongly agreed or agreed with converting it into a mushroom growing facility and 9% did say they felt neutral about mushrooms. When comparing the locations where the community members think the food should be sold, 100% agreed it should be sold locally while 82% agreed it should be exported. A majority (82% strongly agreeing, 14% agreeing, 5% neutral) would prefer to buy locally grown food. There is a decent representation (82% in favor) of the community who also wanted to know more about mushroom farming. If this data is an accurate reflection of the entire community in Vieques, we believe there would be adequate demand for the produce of the farm to operate as a successful business.

4.3.1.2 Jobs

The results from the first and second sections of the surveys revealed there was not as strong willingness to work on the farm as there was for support of the farm itself. 36% of responses stated they were neutral to working part time on the farm and 41% were neutral to working full-time, both being the majority in their respective statements. Many people strongly agreed (59%) and agreed (32%) to volunteering on the farm which gives us sufficient evidence that the community would be behind the implementation of the farm but would not seek employment primarily from the farm, assuming that the people surveyed are an accurate representation of the attitude of the entire community. Para la Naturaleza might find different results if they continued passing out surveys and got more responses from people who are employed part-time or are unemployed. Volunteering would be beneficial to the feasibility of the farm because volunteers are not paid. However, that neglects our highest objective of increasing employment opportunities.

For those who desired to work or volunteer in the bunkers, the most popular job was picking mushrooms with the runner up being packaging mushrooms, as found in the second section of the surveys. A chart for showing the popularity of each job is found in Figure 6. Fortunately, interest was shown in every kind of job offered. There were 4 responses for coordinating with local businesses. This will be helpful in the future if there is a market study conducted. Interest in maintenance, cleanup, and construction will be helpful for the early stages of the project when the infrastructure will be converted into the farm. Sufficient support was found in these different areas9. If this is an accurate representation of how the community would be willing to participate, the farm would be possibly feasible. For these responses, though, it is important to note that people filling it out were merely expressing their opinions. Further

investigation will need to be conducted asking if people would participate in the jobs offered in order to have a better assessment of the feasibility of the farm.

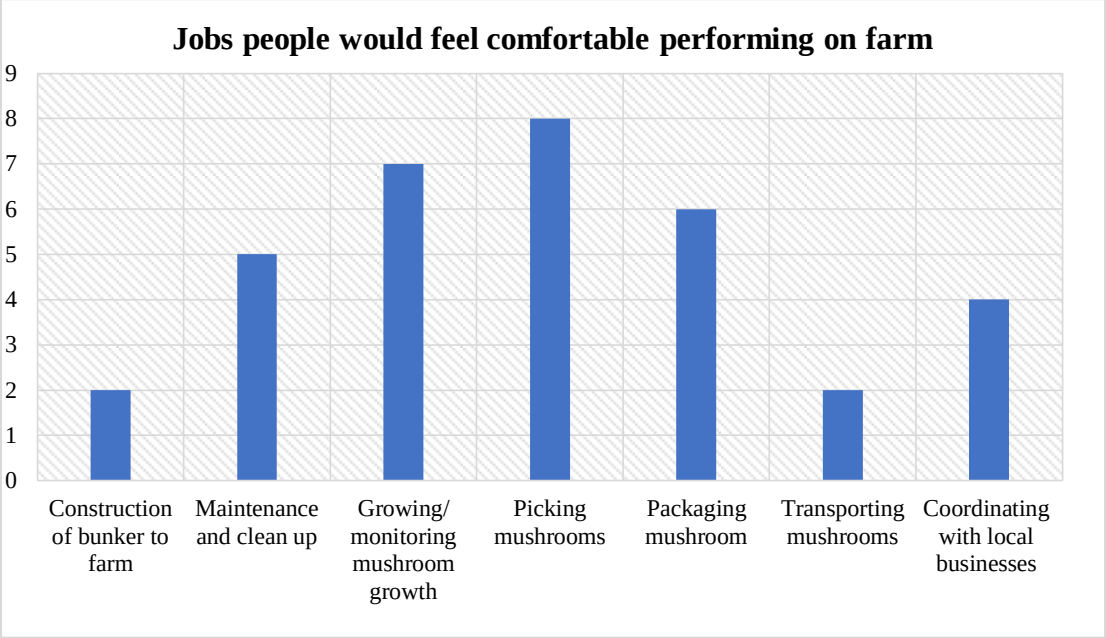


Figure 6: Results to Survey Question about jobs people would be willing to perform

4.3.1.3 Demographics

The last portion of the surveys gathered information about the demographics of people completing the questionnaires. This is important to ensure we are getting an accurate representation of the population. All who were surveyed live on the island and speak Spanish as their first language. There were a large number of people who worked full-time which contradicts the current employment rate in Vieques. We do not want to target those who are employed or unemployed but this information may be skewed because of the high rate of employed people we asked about the farm. A majority of people answered neutral to interest in part-time and full-time employment on the farm and there is reason to believe that the answer for this comes from the biased demographic. For accurate data to be collected, more surveys will need to be handed out and in different areas of the island to increase the chances of having an accurate representation of members of society that will be impacted by this farm.

4.3.1.4 Expressed opinions

We offered an optional section for people to write down any comments about our project. From the responses we received, we can confirm that there is a major portion of the people who are in high support for the bunker farm and are hopeful to see the project bring more

employment to the island. For example, one response stated, “It seems a good idea, the development of a farm in Vieques and mushroom cultivation. Vieques has to return to its roots, to cultivate the land as it did before, for the benefit of our island” Of the 23 surveys, 13 had free-responses and were supportive of the farm by blatantly saying they thought it was a good idea or by suggesting ways the improve the farm in the future. Other responses focused on more locally grown agriculture which lead to the suggestion of producing a diversity of crops in other bunkers if the mushroom farm has the expected production. These responses encourage the social feasibility of the possible mushroom farm in the bunker.

4.3.2 Interviews

Our team interviewed people who would be influential in the construction of this farm. We asked them about the potential risks and rewards they foresee which gave us a clear understanding of the entire community's support. Interviews with a member of the government gave insight into the issues with the current employment status of Viequenses. Talking to Para la Naturaleza members aided in the solidification of the organization's ideas so our team would incorporate them into the plan.

4.3.2.1 Government[9]

The Secretary of the Municipality gave an overview for the ways he thinks this agriculture project would benefit the community and gave his concerns with the engineering aspects that could inhibit the plausibility of the farm. Fabian Martinez believed a mushroom farm will have unbounded interest and support from the community if it stays within the control of Vieques. In years past, companies have started on the small island and workers are brought from other countries or the main island of Puerto Rico, taking away local employment for those residing in Vieques. We took this into consideration and made sure that it is clearly stated that the jobs from this farm are intended to bring employment for the Viequenses and operated by members of the community. This aided in determining the social feasibility of the project.

4.3.2.2 Para la Naturaleza

An interview with Auxiliary Superintendent Julian Garcia[10] aided in the understanding of the visions Para la Naturaleza had for this bunker. Garcia outlined three main areas where he sees this project affecting the community: the economy, the use of the products, and in education for tourists. There could be an influx in the economy of Vieques from this project with employment opportunities and products that would be sold. Garcia also added the idea that there would be increased tourism onto the island from this project. This would not only allow for more centers for environmental education but would also increase the revenue for the entire island. The repurposing of these bunkers would also shift the public's opinion about the facility; this was

[9] Transcription of Interview in Appendix F1
[10] Transcription of Interview in Appendix F2 and F3

once a negative area and can become something positive by showing they can be cleaned out, the structure is still in good condition and there is no risk of contamination, which has been an underlying fear in the community.

There was also a phone interview conducted with the Superintendent of the Eastern Region for Para la Naturaleza, Carlos Morales. He explained concerns regarding the feasibility of Para la Naturaleza being able to put the proposed plan into action. We had to keep in mind the historical sanctity of the bunkers and altering them would inhibit the likelihood of the farm. Morales confirmed the objective of the organization aligning with our highest objective: to generate employment opportunities for the people of the surrounding area with the hopes of also increasing self-sustainability on the island. Most importantly, he informed us of the biggest concern was getting water and electricity to the bunkers. The concerns and visions were taken carefully into consideration as the team conducted further research and then assessed the feasibility of this farm.

5.0 Conclusion

In this chapter, we present a summary of the goals, procedures, and products of the methodology that we created in order to investigate the repurposing of retired Navy bunkers in El Buey into a mushroom farm. We also evaluated the effectiveness of our methods used to determine the feasibility of the facility. Additionally, our team developed recommendations to help future researchers make decisions in working with this facility.

5.1 Summary

The goal of this project was to help members of the Vieques community gain employment by creating a plan for a self-sustaining facility that has a practical use on the island. We devised a plan that benefits the economy of Vieques by developing a growth plan for a community-operated commercial mushroom farm in the abandoned bunkers, analyzing the economic cost of the initial operation and maintenance of the facility, and assessing the needs and interests of the community in the project to generate employment opportunities. We hoped that in addition to job creation, implementation of this project would also promote the attitude of sustainable farming on an island with such high importation rates.

We designed our methodology to analyze three main objectives: engineering feasibility, economic feasibility, and community support of the project. We researched the parameters of a mushroom farm to determine engineering requirements. Our biggest limitations were the electrical needs and water consumption of the farm. We also looked into the economic costs of the facility. Given that the estimation for costs are massively scaled up from small plots, there is uncertainty for variables in the economic feasibility. The support found in the community, both

from organizations and individual members, was sufficient to make an assessment but more focused research will need to be done.

5.1.1 Engineering

After much research, we have determined that this farm is likely to be feasible from an engineering standpoint. However, this determination was based off of assumptions in rainwater collection and consumption, as well as electrical supply and demand. The limitations with our assumptions are that we were only able to arrive at our conclusion after scaling up the results of water usage by a factor of over 6,000. This is not the most accurate method to find this information. It is worth investigating this facility more carefully to better assess feasibility with a pilot study where information on resource consumption can be carefully recorded.

The water collection system that we brainstormed was the easiest and cheapest way to get large amounts of water into the facility. An important limitation to note when collecting rainwater is that during a drought or period of low rainfall, the farm will be deprived of water. To combat these dry periods, water from the wet season will need to be stored for usage. There should also be some plan for getting water transported to the bunker in the event of a complete of lack of water.

As with water, it is possible for the farm to run low on electricity. There are many appliances in the bunker that need to be running 24 hours a day and solar panels do not generate electricity at night. We suggest looking into a way to store excess energy generated during the daytime to be used at night. Ultimately, we are unable to disprove the feasibility of the bunker through electrical supply and demand alone and we suggest a pilot study be conducted to accurately assess the amount of electricity needed to run the farm.

5.1.2 Economic Feasibility

The research into the economic aspect of the indicated the farm could be profitable and beneficial to the island and its inhabitants. The conversion of the bunker to a farm has a high investment cost, the bulk of which comes from installing solar panels. However, high investment cost lowers the operating costs because the solar panels and water collection system keep the farm from having to pay utilities. The most expensive operational cost are the wages paid to the employees.

The spreadsheet we used allowed us to run many different scenarios easily. This was necessary because throughout our research we found numbers that range widely. For example, the numbers for how many mushrooms produced per square foot of growing area range from 25-48 pounds, or the price of mushrooms ranging from $3-6. We ran pessimistic, conservative and optimistic numbers to determine what the minimum revenue that still would allow the farm to be operational

The team also completed a break even analysis to tell us how many mushrooms would need to be sold to pay back the investment cost and the time it would take. We found that the farm would need to sell about 148,000 pounds of mushrooms to pay the expenses back and would take less than a year. After this point, all mushrooms sold would be generating profit. We believe this is an acceptable amount of time to break even, and that the farm would be a good investment. It should be mentioned that all of these calculations were computed with the assumption that every pound of mushrooms produced would be sold. A market study needs to be conducted to discover if the farm can actually sell all the mushrooms it produces and where they would be sold. We suggest talking to local businesses on Vieques to see if they will buy from the farm and look into potentially exporting to nearby island like St. Croix. .

The primary function of the farm was to create jobs and so we looked at the ability of the farm to employ people. Using the employment assumption of 5 full-time employees, 5 part-time employees and an hourly wage of $15/hour, the cost to the farm would be about $234,000 per year. We then compared the jobs that would be created by the farm to the incomes on the island. For part-time workers, we assumed they would be working 20 hours a week, so if they worked for all 52 weeks of the year then they would make $15,600. A full-time employee working 40 hours a week all 52 weeks would have an annual income of $31,200. The average income on the island is approximately $17,355 (Rivera, 2015). The jobs provided by this mushroom farm would be able to supply comfortable living on the island of Vieques if compared to the current income status.

5.1.3 Social

At first glance, the island of Vieques would benefit from the fruition of this project because of the jobs that will advance the economy and for the underlying self-sustainability that will come from an agricultural facility. Many of the reactions pertaining to the farm were positive because of the farming initiative it takes, connecting them back to an era where agriculture was the way of life. People agreed that having job opportunities would be helpful for the entire island. However, those who were interviewed did not have a personal draw to be employed, likely due to the fact that they had a full-time job. Therefore, in order for Para la Naturaleza to have more precise statistics about support and interest, further investigation will need to be done. This can either be through more surveys of the local community or a job search on the island. It would also benefit the sponsor to have more precise questions and clearer instructions for answering in the surveys.

It is important to hear the concerns and opinions from different sectors of society which is why we interviewed members of the government. The government was helpful for steering the focus to jobs based on the current issue with the way outside businesses are establishing themselves in Vieques; they bring their own employees which leaves the Viequenses still without work. Fabian Martinez also referred us to a member of the Department of Agriculture who will be able to aid in permits required for cultivating and selling of the mushrooms. Along with that, this organization can help with ensuring the necessary health codes for farming in Vieques are abided to.

The Superintendent of the Eastern Region for Para la Naturaleza, Carlos Morales, communicated the hopes for the farm. Along with increased employment, there is the desire for there to be an increase in self-sustainability given that the island is highly dependent on imported food. Using the food will not only increase food production but it also has a strong social justice tie. From Morales, there is a negative view of the bunkers because of the impact the Navy had within the last 25 years. By turning these structures into something that the community wants, it will ideally give the people of the island hope that there is the ability to flourish despite their history.

5.2 Recommendations for Future Study

Water is scarce on the island of Vieques currently because of the recent drought and the difficulty to get water from the main pipeline in Puerto Rico to the smaller island. To add to these issues, the bunkers have no access to running water because of their location in a Natural Wildlife Reserve. The wells that once were used in this area are either dried up, inaccessible or contain contaminants from previous agricultural experiments in the area. Therefore, the easiest way for this farm to get sufficient water for optimal mushroom cultivation is to use the roof of the bunker, gutters and a cistern as a rainwater catch system. This would allow for water to be readily available for the needed moistening of mushrooms and compost. Similarly, while we were able to calculate an amount of electricity that could be generated for the farm each year, we were unable to determine if this amount of energy would be sufficient.

These uncertainties have led us to recommend that a pilot study be completed in the bunker. A small area would be closed off and a scaled down version of the potential operation would be carried out for an extended period of time. During the study, measurements of how much water and electricity would be taken to provide an accurate prediction as to the requirements of the facility. More precise data on amount of water and energy required could be collected, set as a variable, and then compared to the size of the bunker to better assess the engineering feasibility of the mushroom farm. These studies can give PLN more accurate number for pounds of mushrooms per square foot of growing space, resources required to grow mushrooms, and amount of mushrooms that can be sold.

References:

Aguirre, H. (2015). An Atlanta Hydroponic Farm Flourishes. Great American Country.

Ayala, C. J. (2015). From sugar plantations to military bases: the U.S. navy's expropriations in vieques, Puerto Rico, 1940-45. Centro Journal, XIII(1), 23-43.

Bank, T. W. (2015). Employment in agriculture, male (% of male employment) | Data | Graph. Retrieved from http://data.worldbank.org/indicator/SL.AGR.EMPL.MA.ZS/countries/1W-PR?display=graph

Bermudez, W. (1998). Wanda BermÃºdez, History of Vieques Island, Puerto Rico. Retrieved from http://www.hartford-hwp.com/archives/43/281.html

Bickis, I. (2015, August 31, 2015). Community agriculture goes corporate with new agrihood housing developments. The Globe and Mail. Retrieved from http://www.theglobeandmail.com/news/national/community-agriculture-goes-corporate-with-new-agrihood-housing-developments/article26162136/

Edible of the Month: Two Simple, Beginner Mushrooms. (2015). Retrieved December 9, 2015, from https://www.garden.org/ediblelandscaping/?page=201111-edible

Holmes, B. (2015). Finding Sustainability on Spring Break: Breakfast at Puerto Ricoâs First Food Hub â Synergies. Retrieved from http://synergies.cofc.edu/article/finding-sustainability-on-spring-break-breakfast-at-puerto-ricos-first-food-hub/

Janssen, H. (2015). Puerto Rico Residents Face Water Rationing That Lasts up to 48 Hours Amid Historic Drought. Retrieved from http://www.accuweather.com/en/weather-news/puerto-rico-drought-el-nino-tourism-local-water-restrictions/51647356

McCaffrey, K. T. (2009). Fish, Wildlife, and Bombs: The Struggle to Clean Up Vieques. NACLA Report on the Americas, 42(5), 35.

Minchenkov, K. Y. a. A. (2015). USDA Releases 2012 Puerto Rico Census of Agriculture. Retrieved from http://www.agcensus.usda.gov/Newsroom/2014/06_27_2014.php

Muhanji, G. (2010). Mushrooms boost farm incomes - ProQuest. ProQuest.

Murray, A. (2004). Prepa launches US$8.2mn, 6MW back-up plant for Vieques - BNamericas. Business Insight in Latin America.

Penaloza, G. A. a. M. (2015). Puerto Rico Is Sowing A New Generation Of Small Farmers.

Refugio de Vieques genera su propia electricidad. (2014). Elnuevodia. Retrieved from http://www.elnuevodia.com/noticias/locales/nota/refugiodeviequesgenerasupropiaelectricidad-1848885/

Rico, C. o. P. (2015). Government Development Bank for Puerto Rico. bgfpr.com: Government Development Bank for Puerto Rico Retrieved from http://www.bgfpr.com/.

Rivera, M. (2015). Puerto Rico Economy. Retrieved from http://www.topuertorico.org/economy.shtml

Sickler, L. (2015). Puerto Rico Takes 'Fresh' Look at Food Production. Borgen Magazine. http://www.borgenmagazine.com/puerto-rico-takes-fresh-look-food-production/

Van Gevelt, T. (2014). Community-based management of Tricholoma matsutake (S. Ito and S. Imai) Singer: A case study of South Korean mountain villages. International Journal of the Commons, 8(1).

Wharton, K. (2012). Can Puerto Rico Reinvent Itself as a Global Competitor? - Knowledge@Wharton. Retrieved from http://knowledge.wharton.upenn.edu/article/can-puerto-rico-reinvent-itself-as-a-global-competitor/

Worley-Lopez, F. (2013, 2013-10-23). Vieques, Puerto Rico, Murder Rate Highest in the World. Retrieved from http://blog.panampost.com/frank-worley-lopez/2013/10/23/vieques-puerto-rico-murder-rate-highest-in-the-world/

Wright, J. (2014). Puerto Rico's First Lady Promotes Community Gardening Starting with Her Backyard.

Youn, Y.-C. (2015). Forest Products, Livelihoods and Conservation: case studies of non-timber forest product systems. volume 1 - Asia (B. B. Koen Kusters Ed.)

Appendices:

Appendix A: Survey Questions

Appendix A1: English Survey

Developing a plan for a new, community-operated farm in Vieques

Sponsor: Para la Naturaleza, the operational division of The Conservation Trust of Puerto Rico

Para la Naturaleza, a unit of the Conservation Trust of Puerto Rico, works to preserve sensitive locations of ecological and historical significance throughout the island. This often involves developing these locations for uses that are consistent with the organization's mission of protecting 33% of the lands in Puerto Rico by 2033.

Project description: At the Área Natural Protegida Cerro El Buey, Para la Naturaleza seeks to convert a disused military bunker into a commercial facility for growing crops. The ultimate goal is for development of the Área Natural Protegida Cerro El Buey. We are researching some techniques for growing various crops that can provide economic benefit for the local community while still maintaining the environmental protection of the area.We would appreciate your help and input in our efforts.

Survey Questions

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I would like to see the bunkers converted into an agricultural facility.					
Converting bunkers into a mushroom farm is a good idea.					
I would prefer to buy locally grown food.					
I would like to know about mushroom farming.					
I would like to know about locally grown food.					
I would like to volunteer time to working on the farm.					
I would like to work on the farm part-time.					
I would like to work on the farm full-time.					
Food from the bunker farm should be sold at local markets.					
Food from the bunker farm should be exported.					

Do you have car? Yes No (circle one)

What is the maximum time you are willing to spend commuting to work?

a.) 10 min
b.) 15 min
c.) 20 min
d.) 30 min
e.) 40 min

Section 2: Mushroom farm

1. I would be more inclined to purchase mushrooms from a bunker than from a market if I knew the mushrooms were grown locally.
    a. Strongly Disagree
    b. Disagree
    c. Neutral
    d. Agree
    e. Strongly Agree

2. I would use mushrooms more if they were grown locally.

3. Strongly Disagree
a. Disagree
b. Neutral
c. Agree
d. Strongly Agree

4 How frequently do you cook with mushrooms?
a. Every day
b. 1-3 times a week
c. 1-3 times a month
d. 1-3 times each year
e. Never

5 If you would be willing to either work or volunteer on the farm, which jobs would you feel comfortable performing on the farm? (circle all that apply)
a. Construction of bunker to farm
b. Maintenance and clean up
c. Growing/ monitoring mushroom growth
d. Picking mushrooms
e. Packaging mushroom
f. Transporting mushrooms
g. Coordinating with local businesses

Section 3: Demographics

1. Are you Male or Female? (circle one)

2. How old are you?
a. 18-24
b. 25-39
c. 40-59
d. 60+
3. Employment Status:
. Unemployed
a. Part-time
b. Full time

4. What is your current household income in U.S. dollars?
a. Under $10,000
b. $10,000-$19,999
c. $20,000-$29,999
d. $30,000-$39,999
e. $40,000-$49,999
f. $50,000-$74,999
g. $75,000-$99,999
h. Over $100,000
i. Would rather not say

5. What is your primary language?
a. Spanish

b. English
c. Other: _____

6. What is the highest level of education you have completed?
a. Grammar school
b. High school or equivalent
c. Vocational / technical school (2 year)
d. Some college
e. Bachelor's degree
f. Master's degree
g. Doctoral degree
h. Professional degree (MD, JD, etc.)
i. Other: _____

7. How would you classify yourself?
a. Arab
b. Asian / Pacific Islander
c. Black
d. Caucasian / White
e. Hispanic
f. Indigenous
g. Latino
h. Multiracial
i. Would rather not say
j. Other

8. How long have you lived in Vieques?
a. Less than 10 years
b. 10-19 years
c. 20-29 years
d. 30-39 years
e. More than 40 years
f. All my life

Please leave any comments here:

_____

_____

_____

_____

_____

_____

_____

You are welcomed to contact me about the farm at the following address:

Name:_____

Address: _____

City/Town: _____

Barrio:_____

Zip Code: _____

Email: _____

Appendix A2: Spanish Survey

Desarrollo de un Plan para una Nueva Granja Operada por la Comunidad en Vieques

Patrocinador: Para La Naturaleza, la división operativa del Fideicomiso de Conservación de Puerto Rico.

Para la Naturaleza, una unidad del Fideicomiso de Conservación de Puerto Rico, trabaja para preservar lugares sensibles de importancia ecológica e histórica en toda la isla. A menudo, esto implica el desarrollo de estos lugares para usos que sean compatibles con la misión de la organización de proteger 33% de la tierra en Puerto Rico para 2.033.

Descripcion del proyecto: En el Área Natural Protegida Cerro El Buey, Para la Naturaleza busca convertir un búnker militar en desuso en un centro comercial para los cultivos. El objetivo final es el desarrollo del Área Natural Protegida Cerro El Buey. Investigamos algunas técnicas para el cultivo de diversos productos que pueden proporcionar beneficios económicos para la comunidad local mientras mantenemos la protección ambiental de la área. Agradeceríamos su ayuda en nuestros esfuerzos.

Preguntas

	Muy en Desacuerdo	Desacuerdo	Neutral	Acuerdo	Muy de Acuerdo
Me gustaría ver a los búnkeres convertidos en una instalación agrícola.					
La conversión de los búnkers en una granja de hongos es una major idea que convertirlos en una granja que crece productos nativos.					
Preferiría comprar alimentos cultivados localmente.					
Me gustaría saber sobre el cultivo de hongos.					
Me gustaría saber sobre los alimentos cultivados localmente.					
Me gustaría trabajar medio tiempo en la granja.					
Me gustaría trabajar de tiempo complete en la granja.					
La comida de la granja debería ser vendida en mercados locales.					
La comida de la granja debería ser exportada.					

¿Es dueño de un coche? Si o No (Circule uno)

¿Cuál es el tiempo máximo que está dispuesto a viajar para ir al trabajo?
a.) 10 minutos
b.) 15 minutos
c.) 20 minutos
d.) 30 minutos
e.) 40 minutos

Sección 2: Granja de de hongos

1. Yo estaría más inclinado a comprar hongos de un búnker que de un mercado si supiera que los hongos se cultivan localmente.
a. Muy en Desacuerdo
b. Desacuerdo
c. Neutral
d. De Acuerdo
e. Muy de Acuerdo

2. Yo usaría más hongos si se cultivan localmente.
a. Muy en Desacuerdo
b. Desacuerdo
c. Neutral
d. Acuerdo
e. Muy de Acuerdo

3. ¿Con qué frecuencia cocina con hongos?
a. Todos los dias
b. 1-3 veces por semana
c. 1-3 veces por mes
d. 1-3 veces por año
e. Nunca

4. Si usted estaría dispuesto a trabajar o ofrecerse como voluntario en la granja, ¿Qué tipo de trabajos se sentiría mas cómodo de realizando? (marque todo lo que corresponda)
a. Construcción de bunker en granja
b. Mantenimiento y limpieza
c. Crecimiento / vigilancia del crecimiento de hongos
d. Coger hongos
e. Empaquetar los hongos
f. Transportar los hongos
g. Coordinar con las empresas locales

Sección 3: Datos demográficos

1. ¿Es usted hombre o mujer? (Circular uno)

2. ¿Cuántos años tiene?
a. 18-24

b. 25-39
c. 40-59
d. 60+

3. Estado de Empleo:
a. Desempleados
b. Medio tiempo
c. Tiempo completo

4. ¿Cuál es su ingreso familiar en dólares estadounidenses?
a. Menos de $10,000
b. $10,000-$19,999
c. $20,000-$29,999
d. $30,000-$39,999
e. $40,000-$49,999
f. $50,000-$74,999
g. $75,000-$99,999
h. Más que $100,000
i. Prefiero no decir.

5. Cual es su idioma nativo?
a. Español
b. Inglés
c. Otro: _____

6. ¿Cuál es el nivel más alto de educación que ha completado?
a. Escuela primaria
b. Educación Secundaria o equivalente
c. Vocacional / escuela técnica
d. Alguna educación superior
e. Licenciatura
f. Maestría
g. Doctorado
h. Título profesional
i. Otro: _____

7. ¿Cómo se clasificaría usted mismo?
a. Árabe
b. Asiático / Islas del Pacífico
c. Negro
d. Caucásico / Blanco
e. Hispano
f. Autóctono
g. Latino
h. Multirracial
i. Prefiero no decir

j. Otros

8. ¿Cuánto tiempo ha vivido en Vieques?
a. Menos de 10 años
b. 10-19 años
c. 20-29 años
d. 30-39 años
e. Más de 40 años
f. Toda mi vida

Por favor, deje cualquier comentario aquí:
_____
_____
_____
_____
_____

Por favor, deje su información de contacto si desea escuchar acerca de las oportunidades de empleo en la granja.
Nombre:_____
Dirección:_____
_____
Ciudad/Pueblo:_____
_____
Barrio:_____
Código postal: _____
Email:
_____

Appendix B: Water Calculations

Appendix B1: Water Collected Calculations

100' x 49.5'=4950 ft^2
4950 ft^2* 144 in^2/ 1 ft^2=721,800 in^2
721,800 in^2 * Rainfall per month (in)= Volume captured (in^3)
Volume (in^3)*1 ft^3/1,728in^3*7.481 gallons/1 ft^3= number of gallons per month

Appendix B2: Water Collection Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (in)	2.6	2.4	2	3	6.1	4.2	4.6	4.3	6.3	6.3	6	4.5
Volume captured in cistern (in^3)	1853280	1710720	1425600	2138400	4348080	2993760	3278880	3065040	4490640	4490640	4276800	3207600
Conversion in^3 to ft^3	1073	990	825	1238	2516	1733	1898	1774	2599	2599	2475	1856
ft^3 to gallons	8023	7406	6172	9258	18824	12961	14195	13269	19441	19441	18515	13887
Gallons	8023.37	7406.19	6171.83	9257.74	18824.07	12960.83	14195.20	13269.42	19441.25	19441.25	18515.48	13886.61

Total 161,393.22 gallons

Appendix B3: Water Required Calculations

12’ wide x 10’ long x 8’ deep
5 cups to set up casing / compost
1 cup spraying for applying casing
Daily (10-12 or 17-21 days):
- Moderate spray mist or sprinkling of water on casing once a day
- Keep surface moist at all times without overwatering
- 80% moisture in peat layer

½ cup water to replenish water after picking
5760 sqft dirt
6 cups / sqft --------- -------- 34,560 cups ---------- 2160 gallons
1.2 cups / sqft ---------- 6,912 cups ---------- 432 gallons
1.2 cups / sqft x 20 days ---- 138,240 cups ---------- 8,640 gallons
.6 cups / sqft ---------- 3,456 cups ---------- 216 gallons
16 cups of gallon
2160 gallons for set-up
8640 for maintenance of a 20 casing
11,232 gallons of water for set-up and first run
Plus 4320 per additional flight (usually up to 2 additional flights)
11,232 + 8640 = 19,872 gallons per 1.5 months x 8 = 158,976 gal/year

Appendix C: Raw Solar Energy Data

Appendix C1: Monthly PV Performance Data

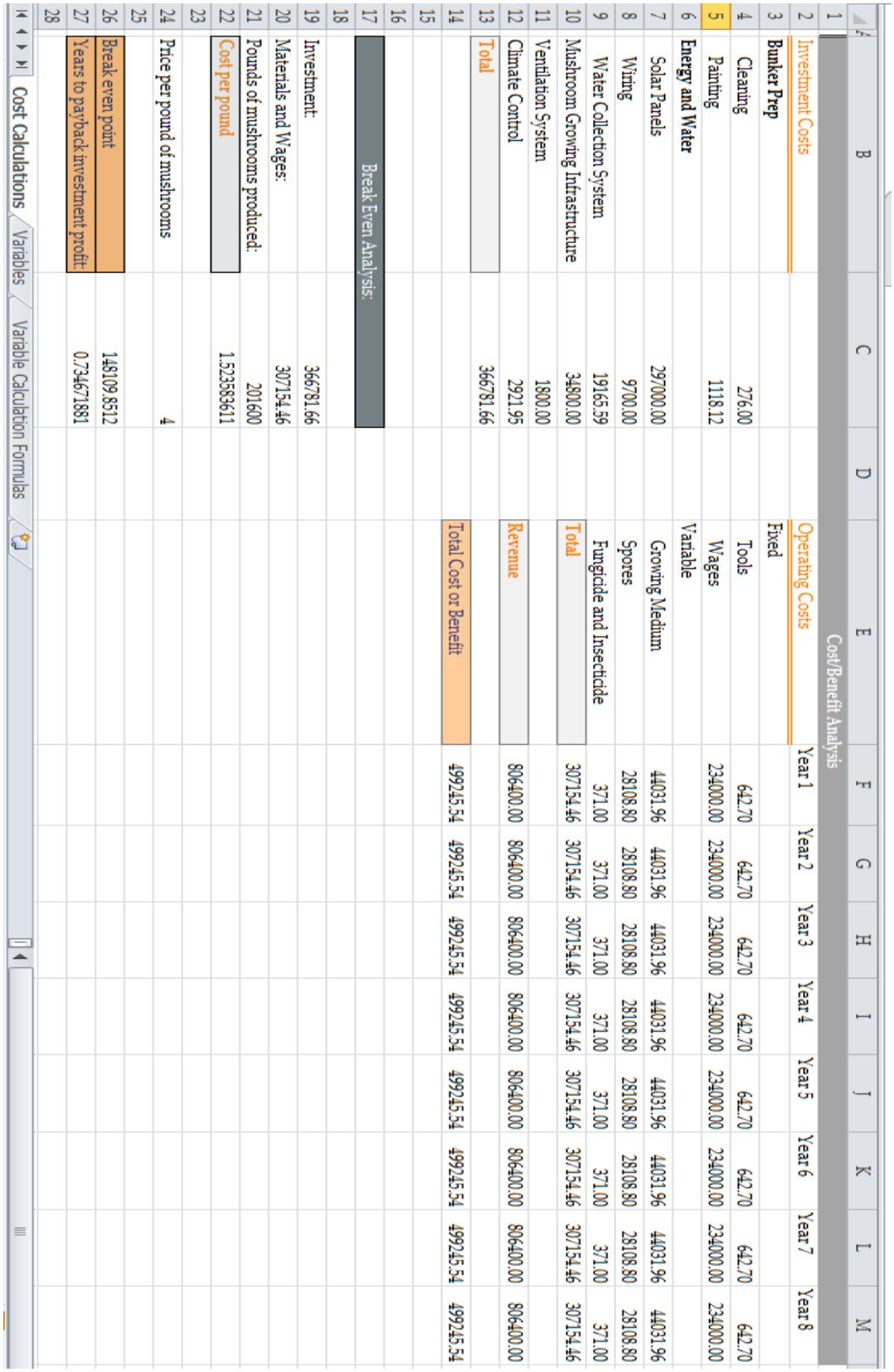
PVWatts: Monthly PV Performance Data	
Requested Location:	Vieques
Location:	ROOSEVELT ROADS, FL
Lat (deg N):	18.25
Long (deg W):	65.63
Elev (m):	12
DC System Size (kW):	69.2
Module Type:	Standard
Array Type:	Fixed (open rack)
Array Tilt (deg):	20
Array Azimuth (deg):	180
System Losses:	14
Invert Efficiency:	96
DC to AC Size Ratio:	1.1
Average Cost of Electricity Purchased from Utility ($/kWh):	No utility data available
Initial Cost	2.6
Cost of Electricity Generated by System ($/kWh):	not determined

Appendix C2: Monthly Energy Output

Month	AC System Output (kWh)	Solar Radiation (kWh/m^2/day)	Plane of Array Irradiance (W/m^2)	DC array Output (kWh)
Jan	8548.33	5.26	163.06	8919.67
Feb	7571.66	5.13	143.76	7907.75
Mar	9363.20	5.84	181.05	9782.97
Apr	9210.71	5.93	177.76	9619.60
May	8483.59	5.29	164.11	8870.01
Jun	8233.04	5.30	158.91	8605.37
Jul	8845.74	5.51	170.74	9241.55
Aug	8920.76	5.54	171.76	9322.88
Sep	8659.83	5.54	166.22	9047.34
Oct	7172.61	4.47	138.72	7510.23
Nov	5600.61	3.58	107.46	5884.66
Dec	7354.60	4.54	140.77	7689.48
Total	97964.68	61.94	1884.31	102401.49

Appendix D: Cost Benefit Spreadsheet (With and Without Formulas Shown)

Appendix D1: Sheet 1 – Without Formulas



	B	C	D	E	F	G	H	I	J	K	L	M
1	Cost/Benefit Analysis											
2	Investment Costs			Operating Costs	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
3	**Bunker Prep**			Fixed								
4	Cleaning	276.00		Tools	642.70	642.70	642.70	642.70	642.70	642.70	642.70	642.70
5	Painting	1118.12		Wages	234000.00	234000.00	234000.00	234000.00	234000.00	234000.00	234000.00	234000.00
6	**Energy and Water**			Variable								
7	Solar Panels	297000.00		Growing Medium	44031.96	44031.96	44031.96	44031.96	44031.96	44031.96	44031.96	44031.96
8	Wiring	9700.00		Spores	28108.80	28108.80	28108.80	28108.80	28108.80	28108.80	28108.80	28108.80
9	Water Collection System	19165.59		Fungicide and Insecticide	371.00	371.00	371.00	371.00	371.00	371.00	371.00	371.00
10	Mushroom Growing Infrastructure	34800.00		Total	307154.46	307154.46	307154.46	307154.46	307154.46	307154.46	307154.46	307154.46
11	Ventilation System	1800.00										
12	Climate Control	2921.95		Revenue	806400.00	806400.00	806400.00	806400.00	806400.00	806400.00	806400.00	806400.00
13	Total	366781.66										
14				Total Cost or Benefit	499245.54	499245.54	499245.54	499245.54	499245.54	499245.54	499245.54	499245.54
15												
16												
17	Break Even Analysis:											
18												
19	Investment:	366781.66										
20	Materials and Wages:	307154.46										
21	Pounds of mushrooms produced:	201600										
22	Cost per pound	1.523583611										
23												
24	Price per pound of mushrooms	4										
25												
26	Break even point	148109.8512										
27	Years to payback investment profit:	0.734671881										
28												

Appendix D2: First Sheet with Formulas

	A	B	C	D	E	F	G	H	I	J
1							Cost/Benefit Analysis			
2		Investment Costs			Operating Costs	Year 1	Year 2	Year 3	Year 4	Year 5
3		**Bunker Prep**			Fixed					
4		Cleaning	=Variables!D4		Tools	=Variables!I4	=Variables!I4	=Variables!I4	=Variables!I4	=Variables!I4
5		Painting	=Variables!D5		Wages	=Variables!G10	=Variables!G10	=Variables!G10	=Variables!G10	=Variables!G10
6		**Energy and Water**			Variable					
7		Solar Panels	=Variables!D11		Growing Medium	=Variables!I15	=Variables!I15	=Variables!I15	=Variables!I15	=Variables!I15
8		Wiring	9700		Spores	=Variables!I21:I21	=Variables!I21:I21	=Variables!I21:I21	=Variables!I21:I21	=Variables!I21:I
9		Water Collection System	=Variables!D13		Fungicide and Insecticide	=Variables!I22+Variables	=159+212	=159+212	=159+212	=159+212
10		Mushroom Growing Infrastructure	=Variables!D28		Total	=SUM(F3:F9)	=SUM(G3:G9)	=SUM(H3:H9)	=SUM(I3:I9)	=SUM(J3:J9)
11		Ventilation System	=Variables!D32							
12		Climate Control	=Variables!D35		Revenue	=Variables!G25	=Variables!G25	=Variables!G25	=Variables!G25	=Variables!G25
13		Total	=SUM(C3:C12)							
14					Total Cost or Benefit	=F12-F10	=G12-G10	=H12-H10	=I12-I10	=J12-J10
15										
16										
17		Break Even Analysis:								
18										
19		Investment:	=C13							
20		Materials and Wages:	=F10							
21		Pounds of mushrooms produced:	=16*Variables!G26*Variables!G27*Variables!G28							
22		Cost per pound	=C20/C21							
23										
24		Price per pound of mushrooms	=Variables!G29							
25										
26		Break even point	=C19/(C24-C22)							
27		Years to payback investment profit:	=C26/C21							
28										

Cost Calculations | Variables | Variable Calculation Formulas

Appendix D3: Second Sheet without Formulas

Row	A	B	C	D
2	***Investment Costs***			
3		unit price	number	total cost
4	**Cleaning**	276	1	**276**
5	**Painting**			**1065.1**
6	paint[1]	127	8	1016
7	cost of roller[2]	4.48	3	13.44
8	roller covers[3]	9.59	3	28.77
9	trays[4]	3.43	2	6.86
10	**Solar Panels**[5]			
11	area covered	60	4950	**297000**
12	**Electrician**		9700	
13	**Water collection**			**19166**
14	area of system		4950	
15	perimeter of system		183	
16	plexiglass cover[6]	63.95	275	17586.3
17	gutter[7]	5.54	18.3	101.382
18	joiners[8]	4.97	18.3	90.951
19	corners[9]	7.56	2	15.12
20	end caps[10]	7.59	2	15.18
21	hangers[11]	2.58	0	0
22	drop outlet[12]	10.27	1	10.27
23	45 degree outlet[13]	2.75	1	2.75
24	downspout	3.69	1	3.69
25	400 gallon cistern	244	0	0
26	600 gallon cistern	335	4	1340
27	hoses			
28	**Growing Infrastructure**[14,15]			**39480**
29	beds[16] per layer	70	120	25200
30	layers		3	
31	racks[17]	238	60	14280
32	**Ventillation System**			**1800**
33	upright fans[18]	149	8	1192
34	floor fans[19]	38	16	608
35	**Climate Control System**			**2894.1**
36	air conditioner[20]	437	1	437
37	dehumidifier[21]	2271	1	2271
38	strip doors[22]	186.08	1	186.08

Row	F	G	H	I
2	***Operating Costs***			
3	**Fixed**	unit price	number	total cost
4	**Tools**			**460.85**
5	trowels[23]	4.47	10	44.7
6	pitch forks[24]	45.31	5	226.55
7	spray bottles[25]	1.81	10	18.1
8	gloves[26]	4.18	10	41.8
9	collection baskets[27]	12.97	10	129.7
10	**Workers Wages**		**234000**	
11	Full time		5	
12	Part time		5	
13	Wages		15	
14	**Variable**			
15	**Growing medium**			**44032**
16	compost[28]	28.95	142.222	4117.33
17	number of boxes		120	
18	number of layers		3	
19	peat moss[29]	39	35.5555	1386.67
20	changes per year		8	
21	**Spores**[30]	3513.6	8	**28109**
22	**Fungicide**[31]	159	1	**159**
23	**Insecticide**[32]	212	1	**212**
25	***Revenue***		**806400**	
26	number of beds in a layer		120	
27	number of layers		3	
28	pounds per square foot/year		35	
29	price per pound		4	

Row	L	M	N	O	P	Q
2	Spore Calculations					
3	sq feet per pound	unit (lb)	area (ft)	price	area we have	total price
4	9.090909091	22	200	122	5760	3513.6

Sources and Assumptions:

1.) Home Depot website: http://www.homedepot.com/p/Seal-Krete-Epoxy-Seal-Armor-Gray-921-5-gal-Concrete-and-Garage-Floor-Paint-92100
2)http://www.homedepot.com/p/Unbranded-9-in-Heavy-Duty-Roller-Frame-RF-211-9/100001737
3) http://www.homedepot.com/p/Performance-Select-9-in-x-3-8-in-Polyester-Roller-Covers-3-Pack-3955077/202282589
4) http://www.homedepot.com/p/Wooster-Pro-11-in-Deluxe-Tray-Liner-Clear-3-Pack-0HR3320110/203584675
5) Solar panels: http://solarpowerauthority.com/how-much-does-it-cost-to-install-solar-on-an-average-us-house/
6) http://www.homedepot.com/p/OPTIX-36-in-x-72-in-x-093-in-Acrylic-Sheet-MC-10/202038046
7) http://www.homedepot.com/p/Amerimax-Home-Products-10-ft-White-Traditional-Vinyl-Gutter-M0573/100079740
8) http://www.homedepot.com/p/Amerimax-Home-Products-White-Vinyl-K-Style-Joiner-M0608/100087674
9)http://www.homedepot.com/p/Amerimax-Home-Products-White-Vinyl-K-Style-Outside-Corner-M0503/100047778
10) http://www.homedepot.com/p/Amerimax-Home-Products-White-Vinyl-K-Style-End-Cap-Set-M0611/100055796
11) http://www.homedepot.com/p/Amerimax-Home-Products-White-Vinyl-Hidden-Hanger-M0622B/100018310
12) http://www.homedepot.com/p/Amerimax-Home-Products-White-Vinyl-K-Style-Drop-Outlet-M0506/100063571
13) http://www.homedepot.com/p/Amerimax-Home-Products-2-in-x-3-in-White-Vinyl-A-Elbow-M0627/100093114
14) http://www.homedepot.com/p/Vassallo-400-Gal-Industrias-Water-Tank-VRM-WT400/100184132
15) http://www.homedepot.com/p/Vassallo-600-Gallon-Water-Tank-VRM-WT600/100133754
16) http://www.homedepot.com/p/Greenes-Fence-4-ft-x-4-ft-x-10-5-in-Dovetail-Cedar-Raised-Garden-Bed-RC4T12B/203477967
17)http://www.warehouserack.com/bulk-storage-shelving-c-29_251/
18) http://www.homedepot.com/p/MaxxAir-14-in-3-Speed-Floor-Fan-H1014UPS/206161424
19) http://www.homedepot.com/p/Ventamatic-22-in-Heavy-Duty-3-Speed-Oscillating-Pedestal-Fan-HVPF22UPS/202924290
20) emailed vendor; received quote
21) http://www.sylvane.com/hi-e-dry-dehumidifiers.html
22) http://www.homedepot.com/p/Aleco-12-in-x-10-ft-Replacement-Strips-7-Per-Roll-177012/203927993
23) http://www.homedepot.com/p/Ames-Hand-Trowel-with-Wood-Handle-1994100/205186018
24) http://www.homedepot.com/p/Truper-Tool-Pro-Manure-5-Tine-Fork-30323/202104475
25) http://www.homedepot.com/p/HDX-32-oz-All-Purpose-Wide-Mouth-Sprayer-FG32HD3-21/205050147
26) http://www.homedepot.com/p/Firm-Grip-Latex-Coated-Cotton-Large-Work-Gloves-5083-48/100123073
27) http://www.homedepot.com/p/Houseworks-Crates-and-Pallet-18-in-x-12-5-in-x-9-5-in-Large-Wood-Crate-94565/203153338
28) https://cedar-grove.com/store
29) http://www.indianamulch.com/ProductDetails/tabid/252/ProductID/157/Default.aspxm
30) http://mushroombox.co.uk/index.php?main_page=product_info&cPath=12&products_id=90
31) http://www.domyownpestcontrol.com/fungicides-c-59_389.html
32) http://www.domyownpestcontrol.com/fungicides-c-59_389.html

Cost Calculations | Variables | Variable Calculation Formulas

Appendix D4: Second Sheet with Formulas

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
2	***Investment Costs***					***Operating Costs***						Spore Calculations					
3		unit price	number	total cost		**Fixed**	unit price	number	total cost			sq feet per pound	unit (lb)	area (ft)	price	area we have	total price
4	**Cleaning**	276	1	**=B4*C4**		**Tools[1]**			**=SUM(I5:I9)**			=50/5.5	22	=M4*L4	122	=G17*G18*16	=(P4/N4)*O4
5	**Painting[1]**			**=SUM(D6:D9)**		trowels	8.5	10	=H5*G5								
6	paint	127	8	=B6*C6		pitch forks	45	5	=H6*G6								
7	cost of roller	14.27	3	=C7*B7		spray bottles	14.7	10	=H7*G7								
8	roller covers	5.73	9	=C8*B8		gloves	5.6	10	=H8*G8								
9	trays	3.87	2	=C9*B9		collection baskets	12.97	10	=H9*G9								
10	**Solar Panels[2]**					**Workers Wages**	**=((G11*40*G13)+(G12*20*G13))*52**										
11	area covered	60	4900	**=C11*B11**		Full time	5										
12	**Electrician[3]**					Part time	5										
13	**Water collection[1]**			**=SUM(D16:D26)**		Wages	15										
14	area of system	4950				**Variable**											
15	perimeter of system	183				**Growing medium**			**=(I16+I19)*G:**								
16	plexiglass cover	63.95	=B14/18	=C16*B16		compost[7]	28.95	=(4*4*(8/12)*	=(G16*H16)								
17	gutter	5.54	=B15/10	=C17*B17		number of boxes	120										
18	joiners	4.97	=B15/10	=C18*B18		number of layers	3										
19	corners	7.56	2	=C19*B19		peat moss[8]	39	=(4*4*(2/12)*	=H19*G19								
20	end caps	7.59	2	=C20*B20		changes per year	8										
21	hangers	2.58	0	=C21*B21		**Spores[9]**	=Q4	8	**=H21*G21**								
22	drop outlet	10.27	1	=C22*B22		**Fungicide[10]**	159	1	**=G22*H22**								
23	45 degree outlet	2.75	1	=C23*B23		**Insecticide [11]**	212	1	**=H23*G23**								
24	downspout	3.69	1	=C24*B24													
25	400 gallon cistern	244	0	=C25*B25		***Revenue***	=16*G26*G27*G28*G29										
26	600 gallon cistern	335	4	=C26*B26		number of beds in a layer	120										
27	hoses					number of layers	3										
28	**Growing Infrastructure[1,4]**			**=D29+D31**		pounds per square foot/year	30										
29	beds[1] per layer	57	120	=C29*B29*C30		price per pound	4										
30	layers		3														
31	racks[1]	238	=C29/2	=C31*B31													
32	**Ventillation System[1]**			**=D33+D34**													
33	upright fans	149	8	=C33*B33													
34	floor fans	38	16	=C34*B34													
35	**Climate Control System**			**=SUM(D36:D38)**													
36	air conditioner[5]	437	1	=C36*B36													
37	dehumidifier[6]	2271	1	=C37*B37													
38	strip doors[1]	213.95	1	=C38*B38													

Cost Calculations / Variables / Variable Calculation Formulas

Appendix E: Survey Responses

Appendix E1: Responses from Section 1 (numbers)

Total Surveys: 23

*the percentages are out of 22 surveys because one person did not fill out the first portion.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I would like to see the bunkers converted into an agricultural facility.				5	17
Converting bunkers into a mushroom farm is a good idea.			2	3	17
I would prefer to buy locally grown food.			1	3	18
I would like to know about mushroom farming.		1	3	6	12
I would like to volunteer time to working on the farm.			2	7	13
I would like to work on the farm part-time.	2	1	8	5	5
I would like to work on the farm full-time.	3	3	9	1	6
Food from the bunker farm should be sold at local markets.				6	16
Food from the bunker farm should be exported.			4	6	12

Appendix E2: Responses from Section 1 (percentages)

*the percentages are out of 22 surveys because one person did not fill out the first portion.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I would like to see the bunkers converted into an agricultural facility.				23%	77%
Converting bunkers into a mushroom farm is a good idea.			9%	14%	77%
I would prefer to buy locally grown food.			5%	14%	82%

I would like to know about mushroom farming.		5%	14%	27%	55%
I would like to volunteer time to working on the farm.			9%	32%	59%
I would like to work on the farm part-time.	9%	5%	36%	23%	23%
I would like to work on the farm full-time.	14%	14%	41%	5%	27%
Food from the bunker farm should be sold at local markets.				27%	73%
Food from the bunker farm should be exported.			18%	27%	55%

Appendix E3: Responses to Questions about Transportation

Have an automobile: 16 si 3 no 4 no response
Maximum time to commute to work:
10 minutes: 1
15 minutes: 1
20 minutes: 7
30 minutes: 3
40 minutes: 1
No response: 10

Appendix E4: Mushroom Farm Responses

Section 2: Mushroom farm

1. **I would be more inclined to purchase mushrooms from a bunker than from a market if I knew the mushrooms were grown locally.**	
Strongly Disagree	0
Disagree	2
Neutral	3
Agree	6
Strongly Agree	12
Total Responses	23

2. I would use mushrooms more if they were grown locally.	
Strongly Disagree	0
Disagree	2
Neutral	4
Agree	4
Strongly Agree	13
Total Responses	23
3. How frequently do you cook with mushrooms?	
Every day	1
1-3 times a week	2
1-3 times a month	8
1-3 times each year	7
Never	7
Total Responses	25
4. If you would be willing to either work or volunteer on the farm, which jobs would you feel comfortable performing on the farm? (circle all that apply)	
Construction of bunker to farm	2
Maintenance and clean up	5
Growing/ monitoring mushroom growth	7
Picking mushrooms	8
Packaging mushroom	6
Transporting mushrooms	2
Coordinating with local businesses	4
Total Responses	34

Appendix E5: Demographics

1. Are you Male or Female? (circle one)	Total	Percent
male	13	54%
female	8	33%
no answer	3	13%
Total Responses	24	
How old are you?		
18-24	0	0%
25-39	10	42%
40-59	10	42%
60+	4	17%
Total Responses	24	
Employment Status:		
Unemployed	4	17%
Part-time	2	8%
Full time	18	75%
No answer	0	0%
Total Responses	24	
What is your current household income in U.S. dollars?		
Under $10,000	4	18%
$10,000-$19,999	9	41%
$20,000-$29,999	3	14%
$30,000-$39,999	0	0%
$40,000-$49,999	0	0%

$50,000-$74,999	0	0%
$75,000-$99,999	0	0%
Over $100,000	0	0%
Would rather not say	6	27%
Total Responses	22	
What is your primary language?		
Spanish	24	100%
English	0	0%
Other: _____	0	0%
Total Responses	24	
What is the highest level of education you have completed?		
Grammar school	0	0%
High school or equivalent	5	20%
Vocational / technical school (2 year)	2	8%
Some college	2	8%
Bachelor's degree	4	16%
Master's degree	1	4%
Doctoral degree	0	0%
Professional degree (MD, JD, etc.)	3	12%
Other: _____	8	32%
Total Responses	25	
How would you classify yourself?		
Arab	0	0%
Asian / Pacific Islander	0	0%
Black	2	8%

Caucasian / White	3	12%
Hispanic	8	31%
Indigenous	0	0%
Latino	12	46%
Multiracial	0	0%
Would rather not say	0	0%
Other	1	4%
Total Responses	26	
How long have you lived in Vieques?		
Less than 10 years	1	4%
10-19 years	4	16%
20-29 years	1	4%
30-39 years	3	12%
More than 40 years	5	20%
All my life	11	44%
Total Responses	25	

Appendix E6: Free Responses (Spanish)

Please leave any comments here:

1. Estoy deacuerdo con el Proyecto.
2. Apoyo el Proyecto.
3. Muy buena vision para nuestra pequeno isla. Trabajemo con ganas.
4. Me parece muy buena idea, el desarollo de una finca en Vieques y el cultivo de hongos. Vieques tiene que volver a sus raices, a cultivar la tierra como se hacian antes, para beneficio de nuesta isla.
5. Estoy deacuerdo con la idea.
6. Encuenta que proyectos como estos es lo que necesita Vieques que progresar.
7. Me gustaria saber mas sobres beneficias de las cultivos de hongos.
8. Mi comentario esto seria muy estupendo porque se abre una puerta para el desarrollo y trabajo.

9. Bueno. Me parece magnifica idea. Es lo que pueblo nesecita. Aparte que tambien tengo esperiencia con los hongos.
10. Seria bien interesante que siga el desarrollo en Vieques para crear mas empleo y haiga mas desarrollo agricula en Vieques.
11. Todo lo relacionado al progreso de mi isla y que sea de beneficio para nuestra gente cuenta con mi apoyo.
12. No gustaria colaborar entre organizacion es un 501 © (3). Fideicomiso de conservacion el historia de Vieques de VIEQUES.VCHT.org.
13. Esto programas deberia implementas mas product como mas plantas ajies, recao, pimiento verde, lechuga y otros. Respaldamos 100%.

Appendix E7: Free Responses (English)

Please leave any comments here:

1. I agree with this project.
2. I support the project.
3. This is a very good vision for our small island.
4. I think this is a very good idea, the development of a farm in Vieques and mushroom cultivation. Vieques has to return to his roots, to cultivate the land as it did before, for the benefit of our island.
5. I agree with this idea.
6. Projects like these is what Vieques need to progress.
7. I would like to know more about the benefits of mushrooms.
8. This would be very great because it opens the door for development and work.
9. Good! I think it is a wonderful idea. It is what people need. Besides that, I have experience with mushrooms.
10. I would be interested in following the development in Vieques that will create more employment and the agricultural developments in Vieques.
11. Everything related to the progress of my island and the benefits to our people has my support.
12. Do not like to collaborate between organization 501 © (3). The history of Vieques Conservation Fideicomiso. VCHT.org.
13. This program should implement more products such as peppers, cilantro, green pepper, lettuce and other plants. I support it 100%.

Appendix F: Transcription of Interviews

Appendix F1: Fabian Martinez, Secretary of the Municipality

Fabian: There's no water in that area. There is the main pipe that comes from Puerto Rico, it goes through Vieques and goes to Culebra but that's the main pipe-it's a big pipe. And the water company will not allow anyone to connect into this main pipe. So there...they've included in their plans for infrastructure development to put a big tank in on one of the hills and then from there. But this is a process, you know. It's something that takes...takes some time. So those are probably your biggest problems there. It's just the water. The electricity i guess you can solve with the panels-the solar panels and a contract with the municipal government. Each..uh..each proposal is reviewed and analyzed and we have a group of people that make decisions on that. We recommend to the mayor and the mayor makes a final decision. But for something like that, I really see no problem at all.

Serena: How do you think the people of Vieques feel about a project like this happening in the bunkers?

Fabian: I really not...I haven't actually gone out and asked something like that. I think the biggest thing that the people of Vieques want to look at is participation. You know, if we bring people from the outside, and to make projects and these projects don't create jobs or opportunities for the people of Vieques, then they would be more resistant. But in the...in the...to the degree to which you will include the people of Vieques in your project, then the acceptance would be greater. You know...but that's the big issue. We have a lot of people coming to Vieques from the outside, you know, placing their businesses here and they're not hiring a lot of the people from Vieques. They bring their own employee to here and people resent that very much. As they would in any other place, you know.

Sarah: So, this farm would be a community-based project.

Fabian: Yes, so you would need some local support...to do something like that.

Sarah: We're planning on surveying local people and asking them if they would mind, like, if they would work there or if they would buy the mushrooms grown in the farm. We're gonna try to include everyone as much as possible.

Fabian: There's not a lot of volume, you know, sales volume in Vieques. You know, we have like nine-thousand people and a lot of the people, they get on the ferry boat. They take their cars and they buy in all the grocery stores and the supermarkets in Puerto Rico and they bring them here so there's not a lot of his volume. Now, if you're going to export, then your biggest problem would be getting space on the ferry-the cargo ferry to take it from Vieques. Vieques is not an international port so it you're going to ship it anywhere it has to go to an international port like San Juan...uh...uh...and from there you can...you can ship directly from Vieques to any place. Except by air. Planes are too expensive.

Matt: We wanted to know if there were any grants or anything that are like farming related or agriculturally related that might be able to help out the farm.

Fabian: Well, Puerto Rico is going through a very difficult stage financially. SO we're...we're having a hard time paying our bills. So, there have been in the past, you know, grants and incentives for farms. The governor is..is very big on farming so there are some incentives but as far as grants, I'm not sure. you would have to check with the Department of Agriculture. But there's not a whole lot of money in Puerto Rico these days.

Matt: We were wondering if there's any tax breaks or anything for businesses that use renewable energy or renewable water sources like…

Fabian: Well, as far as the municipality - the bunkers and the municipal government, we, as an incentive can..uh..depending on numbers of jobs you create in one of the bunkers, you can get rent free for anywhere up to two years. And basically do that because those first two years are the difficult ones and that's where a lot of the money needs to be put into the business so you can get a break on the rent from the municipality related on the number of jobs you produce. And the length of the lease for the building you are going to…

Serena: So you talked about how um the people would be expecting the jobs being created from this project. Do you foresee any other like things that the government or the people would want to see more of from this project besides just employment?

Fabian: Well, Puerto Rico doesn't produce all the food that it consumes so it's a high priority in the government. And I expect that will continue to be. Right now in Puerto Rico there's enough food for about two weeks, should something happen. In Vieques, we're talking about days, okay? Uh, if you go to the supermarket- they come, I think, on Tuesdays and Thursdays- if you go Wednesday, there's nothing left. You go on Friday, there's almost nothing left. So, uh, you know. With the problems in transporting things here, that makes it more difficult, you know. The

shelves are not always well-stocked in our stores here. So, yes, you know, agriculture, anything. We have a lot of people growing. I-I'm a farmer myself, you know, in my free time. When I get out of here, I work on my farm. I make hot sauce and some other people sell vegetables, fruits and things like that. But there's no concerted effort, you know. I'll give you an example, I have about 15 different varieties of mangos on my farm and I don't sell them because there's no, you know, outlet for them. So if an organization like yours, for example, were to...be able to gather all of these fruits and vegetables to produce and manage to export it you would have that here and that would create money and work and income for our people so...

Sarah: So you mean exporting to the mainland of Puerto Rico?

Fabian: Well, there's the mainland of Puerto Rico, there's the-the volume here is very low. But to the St. Croix, St. Thomas, all the minor Antillas, they import everything from, basically from Puerto Rico and other parts of the US mainly. So, so you have a market there it's just a matter of doing your market study and your promotion, your marketing strategy.

Appendix F2: Julian Garcia, Auxiliary Superintendent of Vieques for Para la Naturaleza, Spanish

Julián: El beneficio que podemos tener en términos de la idea del proyecto de siembra usando los bunkers, los interiores, me parece que puede ser un beneficio bien positivo en dos direcciones: El proyecto puede ser beneficioso en la parte económica; generar un poquito de economía en la comunidad. Y además el producto que manejemos que podemos producir en estos bunkers podemos también integrarlo, ser utilizado, vendido dentro de la misma comunidad. Me parece que esas son las proyecciones además del turismo; que pueden ser centros para educación ambiental y siembra en términos generales. Así que tenemos tres fases: la economía, el uso del producto, y en términos educativos. Así que esas son las tres posibilidades que veo positivas para nuestra comunidad.

Julián: …como se siente la comunidad una vez que la marina abandona estas estructuras, que debe haber sido una inversión grande en cada una de ellas. Me parece que de momento pues impactó en términos de que la reacción fue negativa porque tu no sabes que vas a hacer con lo que te han dejado. Pero me parece que según vayámoslo manejando, utilizándolo y haciendo posiblemente estos proyectos o poniendo en marcha estas ideas que están surgiendo ya la idea cambia, en términos de que ya se le esta dando un uso, y al darle un uso ya tenemos la justificación y hay una producción envuelta. Así que de esa manera, la visión puede cambiar a

algo positivo definitivamente. Pero puede haber sido que la reacción al principio fue negativa porque había una preocupación al principio, si estaban limpios, si se podían usar o no se podían usar. esa fue una preocupación que siempre la comunidad tuvo. Siempre pensaban y decían que no eso se puede entrar ahí, que está contaminado, que eso no sirve para nada, que es una estructura, y que vamos a hacer con esto ahora. Pero si les vamos dando este cambio, esta visión, estoy seguro que va a ser un cambio rotundo a esa emoción que teníamos al principio.

Elizabeth: …crees que puede haber un tipo de resentimiento por no dejar quizás un plan para… (couldn't hear the whole question)

Julián: Exacto, creo que si. Exacto, como no hubo un plan, simplemente te entrego eso ahí y ya; y que vas a hacer te corresponde a ti. Pero si se hubiese tenido planificado, la visión seria distinta definitivamente, si.

Elizabeth: …tenga interés en venir a trabajar en el proyecto? (couldn't hear the beginning of the question).

Julián: Me parece que dentro de este proyecto definitivamente. Creo que la comunidad lo va a ver positivo y si se le invita a participar, lo van a tomar muy bien y van a querer hacerlo, y yo creo que la impresión va a ser bien positiva en cuanto a participación, querer ser parte del proyecto, claro que si. Y lo veo así por la experiencia que he tenido con las personas que converso en la comunidad. Así que yo creo que va a ser una buena idea hacerles esa invitación a ser participe. Así que podemos formar un gran equipo, creo que podemos ser un buen equipo en esta gran idea.

Appendix F3: Julian Garcia, Auxiliary Superintendent of Vieques for Para la Naturaleza, English

Julián: The benefit we have in terms of the idea of the project seeding the bunkers, interiors, it seems to me that it can be a positive benefit in two directions: The project can be beneficial in the economic part; to generate a bit of economy in the community. And in addition the product we handle that we can produce in these bunkers we can also integrate, use, sold within the same community. It seems to me that these are the projections in addition to tourism; that can be centers for environmental education and planting in general terms. So we have three phases: the economy, the use of the product, and in educational terms. So these are the three possibilities that I see positive for our community.

Julian: …how did the community feel once the Navy abandoned these structures that must have been a large investment in each one of them? It seems to me that at the moment because

impacted in terms that the reaction was negative because you do not know that you are going to do with what you have left. But it seems to me that according to driving by it, using it and possibly making these projects or putting in place these ideas that are emerging as the idea changes, in terms of it was this giving a use, and to give it a use we already have the justification and there is a production wrapped. So in that way, vision may change to something positive definitively. But it may have been that the reaction to the principle was negative because there was a concern to the principle, if were clean, if you could use or could not be used. That was a concern that the community had always. Always thought and said that you cannot enter the bunkers, that they're contaminated, that they serve no purpose, which is a structure, and that we are going to do with this now. But if we are going to give this change, this vision, I am sure that is going to be a drastic change to this emotion that we had at the beginning.

Elizabeth: …you think you may have a type of resentment by not leaving perhaps a plan for… (couldn't hear the whole question)

Julian: Exactly, I think so. Accurate, as there wasn't a plan, simply I give you that there and you; and you are going to make you corresponds to it. But if you had planned, the vision would be different definitely, yes.

Elizabeth: …have interest in coming to work in the project? (couldn't hear the beginning of the question).

Julian: It seems to me that within this project, definitely. I believe that the community is going to see it in positive way and if they are invited to participate. They are going to take it very well and are going to want to do it, and I believe that the impression is going to be very positive in terms of participation, wanting to be part of the project, if that is made clear. And I see it like this because of the experience that I had with the people who I have talked to in the community. So I believe it is going to be a good idea to make this an invitation for participation to the community. So this can make a great team, I think that this can be a good team in this great idea.