BUILDING RESILIENCY AT THE CUBUY COMMUNITY CENTER

A HANDOFF REPORT

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Overview of the Cubuy Community Services and Development Center

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INTRODUCTION

This report aims to document the first developments in the relationship between WPI and ID Shaliah, the Karma Honey Project, and the Cubuy Community Center. The Cubuy Community Center is located in Cubuy, Puerto Rico, and is an abandoned school building that has been retrofitted into a community center. Here, residents of Cubuy can take self-defense classes, get free meals at a soup kitchen, learn about beekeeping, and so much more. Community members can also seek refuge here in times of emergency and find food, water, and power. Our goal was to assist the Cubuy Community Center in implementing a sustainable, reliable power and potable water source. Within this document is a description of our work during the seven weeks in Puerto Rico. Detailed specifically are our findings regarding reliable power, water usage analysis, expanding our network, and funding opportunities. We describe the status of these topics before we came to the site, how we advanced them, and what we recommend future groups do at the site to progress our work. This document aims to show our findings in a succinct, understandable, and visually appealing manner. We want to ensure that future IQP groups, our sponsors, and anyone interested in this project can understand the value and meaning of our work by using this document. We envision this document being edited and improved as more IQP groups continue to complete projects in Cubuy. We are extremely proud of what we have accomplished in this period and feel honored to have been the start of a meaningful connection between WPI and the community of Cubuy.

This document is one of three main deliverables of this project, which can be found at our Puerto Rico Project Center website or by request at the Cubuy Center website.

Deliverables:

- “Building Resiliency at the Cubuy Community Center” handoff guide
- Revit model and renderings of the site illustrating PV panel placement
- Contact list containing all contacts with their information and relevant notes on the conversations had

ACKNOWLEDGEMENTS

This work would not have been possible without the support of Scott Jiusto and Gbeton Somasse, our amazing advisors who helped us navigate our project work in both Worcester and Cubuy and worked tirelessly to get us to Puerto Rico; J.M Davis, the PRPC director who made it possible to do our project in Cubuy; Javier Valedon and Johnny Williams, our sponsors who trusted us to help them improve the community center and gave us creative freedom while also guiding us along the way; and the volunteers at ID Shaliah who kept us well-fed and became our family in Puerto Rico. We thank you all for your support and guidance!

The “Roofers” with members of the ID Shaliah volunteer team at the Community Center

PHOTOVOLTAIC SYSTEM

What Existed Previously:

After beginning work on this project, we learned that there was no prior use of a photovoltaic (PV) system at the community center. Some buildings on the site were not connected to the utility grid due to damage to the wiring system. During our time on-site, none of the buildings had power. Our sponsors wanted to save money by not turning on the power until it was absolutely needed. A generator was used as a temporary power source. A PV system seemed like the optimal solution for the community center since the area lost power for months after Hurricane Maria and because there are often blackouts in Cubuy that lasting days. The site showed great potential for a large PV system given all the available roof space exposed to the sun and given Puerto Rico's optimal geographical location for insolation.

Advancements We Made:

Once we got to Puerto Rico, our sponsor Johnny informed us that he had already established a connection with a local solar energy company. The company, ProSolar, had agreed to donate a PV system to the community center but they had yet to figure out the details. From this point, we took over as the point of contact with the company. A representative from ProSolar had previously been to the site but only got on one of the roofs. They needed more information on every roof at the community center to determine the possible size of the system to donate. They asked us to provide measurements of each roof along with pictures of obstructions and surrounding infrastructure. With the gathered roof edge measurements, we developed a two-dimensional layout of the site in AutoCAD. This model included the length of edges for each roof to the nearest inch along with the total area of each roof. The spacing in between the buildings at the community center was initially modeled from satellite imagery and then confirmed on site visits. We also created a document for the pictures of each roof, numbered for easy referencing that lists the obstructions, materials, and areas. These files were then sent to our contact at ProSolar, Greg Jones, which he passed along to their engineering team to determine the number of panels that could fit on the roofs. An engineer from ProSolar then developed an AutoCAD drawing with the maximum number of panels that would fit on the roofs considering the obstructions and sent it back to us. The drawing they created also included the locations of the PREPA meters on site. Once they figured out system sizing, they were ready to have a meeting to share the specifications of the proposed system.

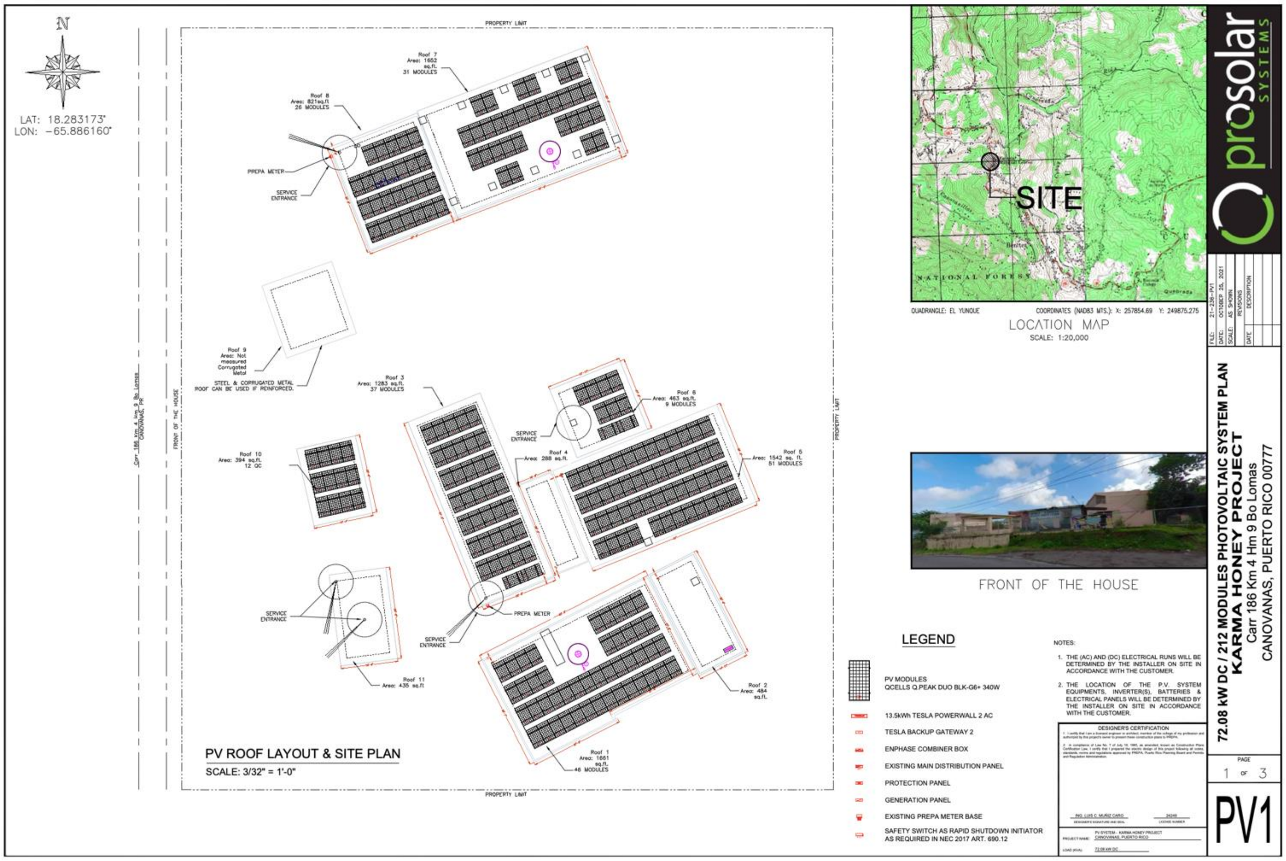
We learned many key details about what they planned to donate listed below:

- The site has a maximum potential for 221 solar modules
- The system will be connected to PREPA, a utility company
- The system will include Tesla batteries for excess electricity storage
- The panels will be anchored with proprietary clips to minimize damage from storms
- Racking is made from stainless steel to eliminate rust possibility
- Silicon solar cells are coated for anti-reflectivity
- The system will likely use 400-Watt modules
- The optimal tilt for panels in PR is 18 degrees, ProSolar does 10 to ensure panel security
- It would be safe to harvest rainwater on roofs with panels installed
- The system will produce single phase power

They informed us of their installment plan when Greg and the CTO, Brad Spernak made an onsite visit. Initially they plan to install the Tesla batteries, the solar racking required on all roofs, and a small number of panels altogether valued at about $66,000. After that, they agreed to donate another solar panel for each sale they made. This will eventually fill the available roof space with panels and provide a significant amount of electricity to the community center. While on site they also informed us that there are two separate connections to the electricity utility which is not ideal.

Recommendations:

- Focus on creating content to spread the word about ProSolar and how they are donating a panel per sale
- Find who can work on the electrical at the site to combine the two separate connections into one
- Research what could be useful at the community center that would utilize any excess electricity production
- Determine if PREPA will purchase or give credit for any electricity given to them



Roof layout detailing the locations of solar panels and PREPA meters on the roofs of the site from ProSolar

Rendering of solar panel placement modeled by IQP team

WATER USAGE ANALYSIS

What Existed Previously:

The site currently relies on municipal water supplied by the Puerto Rico Aqueduct and Sewer Authority (PRASA) for normal operations. This system is proficient in supplying water to all buildings at the community center and providing water to the septic system. Most of Cubuy relies on municipal water as well.

Advancements We Made:

While on site, we were able to perform a water usage analysis and broke down water use at the community center into three distinct categories: normal operation, emergencies, and alternative use. Normal operation is the daily water use at the community center, supplied by PRASA as mentioned before. However, municipal water has a great chance of being cut off during storms, such as when Hurricane Maria struck in 2017. Emergency use applies to water used for consumption and personal hygiene (domestic water) when normal operations are interrupted. Alternative use applies to non-essential, non-potable uses of water, such as watering gardens or washing clothes. This alternative use of water should supplement the other sources of water at the community center. As previously stated, a system was in place for normal operations, but we needed to explore systems for emergency and alternative use.

We initially explored utilizing a rainwater harvesting (RWH) system for emergency use due to the amount of annual rainfall in the area. The ecosystem of Cubuy provides a significant amount of rainfall annually which serves as a free and sustainable source of water. For emergencies, we prioritized domestic water because after interviewing residents of Cubuy, we truly understood how necessary water was during the aftermath of Maria. They described having to wash clothes, bathe, and drink from river water and we wanted to ensure they did not experience this again. We were curious as to how much rainwater each roof could collect, and how many people could be supplied with domestic water based on that amount. To start, we researched water needs in emergencies, and discovered that people need 1.98 to 3.98 gallons of water per day for domestic use (World Health Organization, 2013). We then gathered ten years' worth of daily rainfall data from a weather station in Palma Sola and calculated the average rainfall for each month. Roofs collect approximately 0.6 gallons of water per square feet for every inch of rainfall (GrowNYC, n.d). Finally, to determine how much rainwater each roof could collect, the following formula was used:

Gallons Collected = area of roof (sq. ft) x 0.6 gallons/inch x monthly rainfall (in) x collection efficiency

We gathered measurements on the square footage of each roof since we did not obtain the original construction documents with that information. The collection efficiency relates to the amount of water that is lost due to runoff/absorption/etc. and varies by material. Most roofs on the site are made of built-up asphalt material, a few are exposed concrete, and one is terracotta tile. Once the gallons of water collected from the roof were calculated, we were able to determine how many people this could serve. Since the value of domestic water needed for survival was given to us in a range, we calculated the amount of people served for the low end (1.98 gallons/person/day) and the high end of the range (3.98 gallons/person/day). We called this minimum and higher domestic use respectively. We multiplied these two values by the number of days in each month to determine how many gallons of domestic water a person would need for survival per month. These values were then divided by the gallons of rainwater collected on the roof in a month to determine how many people could be served domestic water. Overall, we determined that Roof 5 (The Refugee Building) would be able to harvest the most rainwater, at approximately 80,000 gallons a year. On average, this would support 112 people for minimum domestic use and 55 people for maximum domestic use per month. These calculations were done for every roof except for Roof 7 (The Workshops) and Roof 9 (The Storage Building). We concluded that Roof 7 was not in suitable condition to collect rainwater. Aged and blistered asphalt remained in standing water every time it rains which could leak toxins into the water supply. We were unable to access and measure the metal roof, Roof 9, due to safety concerns.

Location Labeled	Name of Location	Rooftop Area (sq.ft.)
1	Cafe and Multipurpose Building	1661
2	Beekeeping Room	484
3	Medical Clinic Building	1283
4	Classroom	288
5	Refugee Building	1542
6	Bathrooms	463
7	Workshops	1652
8	Technology and Learning Building	821
9	Storage Building	
10	Pavilion	394
11	Office	435
------	Property Line	

Map of Cubuy Community Center and Rooftop Areas

Adapted from Google Maps (2021)

After completing our calculations, we were eager to learn more about RWH systems. We met with Kendall Lang of Fusion Farms, an aquaponics company in Puerto Rico. Through this conversation, we learned just how in-depth it is to implement a RWH system. He gave us many points to think about when implementing a RWH system such as:

- To maximize the use of gravity and therefore minimize the need for pumps in a RWH system
- To prioritize the acquisition of as-built structural documents for the building
- To note how much water needs to be stored on a daily, weekly, and monthly basis based on the number of people served, number of bathrooms, kitchen facility, etc.
- To note if there was a sewer or septic system on site.

Very importantly, we learned that water collected from a RWH is challenging to use as drinking water. The collected water needs thorough and extensive filtration and treatment to attempt to make it drinkable.

We were also able to initiate connections with several other companies and organizations that deal with RWH systems. We contacted the following organizations:

- Cary Company
- DG Authority
- HydroLogic
- ProTank
- Pure Aqua Inc.
- Universal Equipment

We inquired about supplies for a RWH system from these companies such as tanks, piping, filters, and pumps. Universal Equipment provided us with a list of local tank suppliers, as they do not have tanks. ProTank informed us that they have 5,000 and 20,000-gallon tanks available. These water storage tanks were estimated to be $5,886 and $47,106 respectively. Reuben Gonzalez of DG Authority emailed us back very quickly and was enthusiastic about the project. He donated three bee boxes to the community center. We feel like this is a start to a great relationship with this company, and hope that others can continue it after we are gone. Even though we did not hear back from the other companies, they are key contacts for future project groups in addition to Johnny and Javier.

Overall, we determined a RWH system would be best utilized for alternative use rather than emergency use. The fact that rainwater cannot be used for drinking was a major factor in this decision. Additionally, we would not want the community center to be completely dependent on the ecosystem to provide water in an emergency. A RWH is a cheaper system—only the infrastructure must be paid for. The water collected from a RWH needs less treatment because its intended utilization is for non-potable uses such as flushing toilets, watering gardens, or washing clothes. Most of a RWH system's infrastructure is above ground, which makes it less resistant to storms. However, the community center could still operate if this water system is cut off. Another driving factor in this decision was seeing that at maximum, a RWH system can provide domestic water for 55-112 people monthly. This does not align with our sponsor's vision of providing water to the greater community of Cubuy. While a solution for alternative use was found, a system for emergency use was still needed.

Month	Average Monthly Rainfall (in)	Estimated supply to collection tank (gal)	People Supported for Minimum Domestic Use	People Supported for Maximum Domestic Use
January	6.08	5,060	82	41
February	5.40	4,495	81	41
March	7.92	6,591	107	54
April	5.37	4,472	75	38
May	8.38	6,977	114	57
June	4.50	3,748	63	32
July	10.53	8,771	143	71
August	12.26	10,212	166	83
September	9.05	7,536	127	63
October	7.51	6,257	102	51
November	10.30	8,578	144	72
December	8.79	7,321	140	60
Average	8.01	6,668	112	55
Annual	96.10	80,019	1345	662

Table showing estimated water collection and people supported for domestic use of water monthly for Roof 5

A well was explored as a potential system to utilize during emergencies. Drilling a well was analyzed due to its large potential to provide an abundance of clean water to the community center. This system was an attractive option, but we still had outstanding questions about the logistics of drilling a well. We set up an interview with Adamaris Quiñones and Excel Colón, two water engineers from Black & Veatch Engineering, where we raised a few questions. We learned valuable information about the well-drilling process, such as:

- Wells supply clean water; however, it needs to be treated chemically to ensure it is safe for drinking. The best method to treat this water is through chlorination. Chlorine eliminates most bacteria and viruses in well water. The residual chlorine protects the water from recontamination during storage tank.
- A private well needs to be separated from PRASA systems, meaning the well could not be connected to any existing plumbing
- Any well that is drilled at the site would need to comply with the regulations of the Environmental Protection Agency (EPA) and the Department of Health (DoH)
- Test wells tend to cost around $10,000 to $15,000
- The power supplied from the PV system could easily power the well pump, approximately 10HP
- There is a limited record of drilled wells in Cubuy
- A contamination test must be performed to see to detect potential hazards within a mile radius of the well
- A yield test must be performed to see if drilling a well would affect the groundwater table

One engineer provided contact information for multiple reliable well drilling companies that could give quotes on a test well. They also shared information from PRASA about test wells to see if drilling one in the area is feasible and what the potential local flow rate is.

To help determine the feasibility of drilling a well at the site, we contacted companies that would be able to give us a quote for drilling a well. We contacted:

- Brewster Well Drilling
- Complete Well
- Jaca & Sierra Engineering

We received a quote for a test well from one of the companies we contacted. They broke the quote down into three stages. The first stage consists of installing the casing of the first 80 feet of the well. A 12-inch superficial casing is applied in the upper 10 feet, and then a perforated 8-inch casing is applied up to 8 feet. The second stage consists of drilling an open hole, if possible, from 80 to 300 feet. The second stage consists of drilling a test open hole from 300 feet to 500 feet. Stage 1 would cost $35,415.43. Stage 2 would cost $13,728. Stage 3 would Cost $10,400, for a grand total of $59,273. This is very expensive for a test well and costs more than we imagined. Since they were the only ones that responded to us despite sending many emails to companies, this was the only quote we were able to secure.

We believe that the idea of drilling a well at the site for emergency purposes should be further researched and expanded on. If feasible, this is the best long-term option for providing potable water for domestic use in emergencies. Wells have great potential to provide an abundance of clean water that does not need much treatment to make it drinkable. They are also resistant to storms, considering most of their infrastructure is located underground. Wells are seen as an investment, where a large initial payment allows people to reap the benefits for years to come. Drilling a well aligns seamlessly with our sponsor's vision for serving the greater community of Cubuy. Connecting a well to a storage tank would allow for our sponsor's vision of a drive-through water station for the community to become reality. Since drilled wells are not common in Cubuy, and the feasibility of drilling one in the area is not widely known, there is a great need for expansion on this aspect of the project.

Recommendations:

- Continue to research a RWH system for non-potable water use alongside a separate potable water source
- Further explore the placement of a RWH system
- Keep reaching out to the companies mentioned by using the contact sheet to continue a relationship with them and secure donations for the community center
- Research installing a drainage system and gutters on potential roofs for a RWH system
- Expand research on the feasibility and optimal location of a well at the community center
- Perform contamination and yield tests at the site
- Develop an estimate of water usage at the community center
- Contact PRASA to find out the previous water usage at the center before it closed
- Obtain more quotes from other well drilling companies

EXPANDING OUR NETWORK

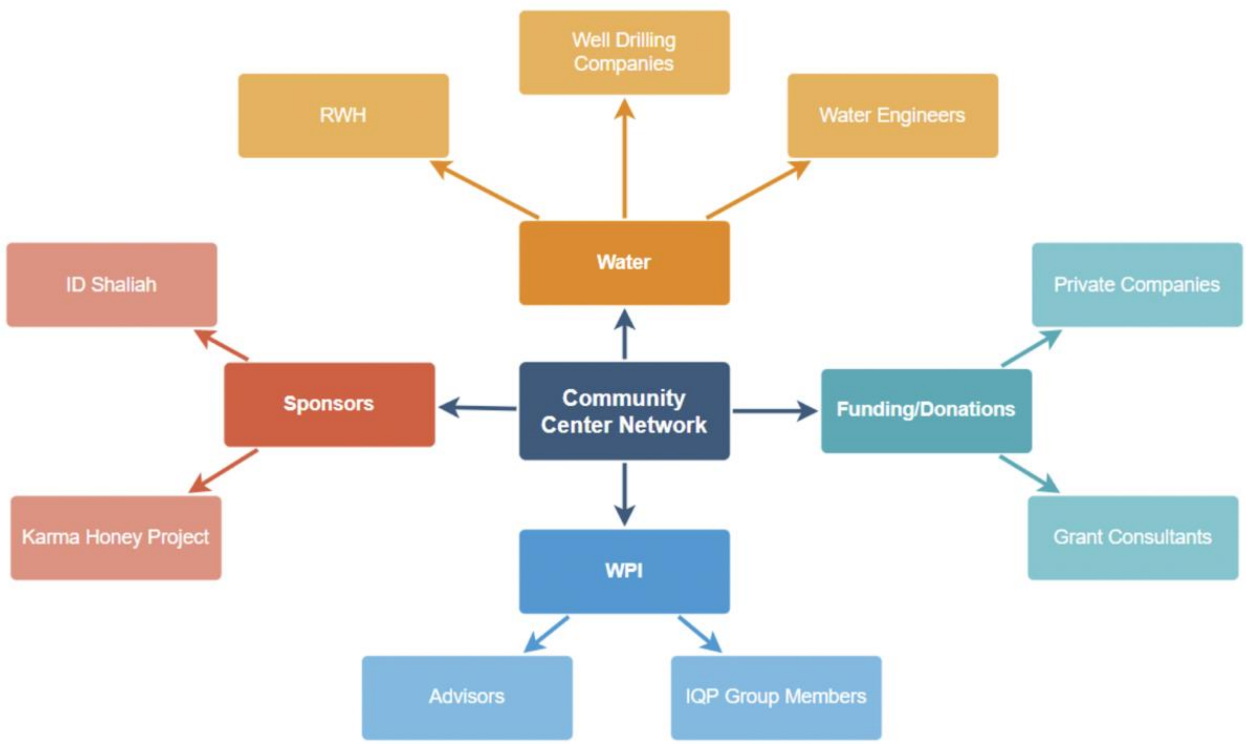
What Existed Previously:

Prior to our arrival on-site, Johnny and Javier initiated two important connections that would help us throughout the project. We were informed that Greg Jones from ProSolar and Kendall Lang from Fusion Farms visited the site and had knowledge about both PV and RWH systems. Another important relationship already established was with the mayor of the Canóvanas region. She promised a donation of approximately $7,000 to fix the electrical system at the community center. Johnny and Javier are great at networking, which proved to be advantageous to our project.

Advancements We Made:

We used our sponsor's contacts to our favor to advance the project work. We contacted and spoke to Greg to obtain information about the PV system ProSolar planned to donate. We also emailed and had a meeting with Kendall about installing a RWH system. These conversations are outlined in the sections detailing PV systems and water usage calculations. Outside of our sponsor's contacts, we reached out to dozens of other organizations that could be useful in any way. We emailed lots of companies involved in well drilling, RWH systems, and other organizations like ID Shaliah to seek guidance from them. We were able to establish a large, extensive network with some very useful contacts. Documentation of all the contacts we reached out to can be found here. The link is connected to a Google sheet containing a list of every contact we reached out to in any way throughout the course of our project. It includes a list of all names, emails, phone numbers, websites, why each contact could be useful, and notes including the extent of what our communication was with each contact.

We attempted to form meaningful relationships with ResilientSEE, Tidal Basin, and Black & Veatch Engineering. Our contact with ResilientSEE, Yanel de Angel, has completed several projects like ours before and has contacts all over the island that could be extremely useful. Unfortunately, she was unable to get us in touch with anyone since she has work for other jobs, and simply did not have the time to help us in such a short timeframe. Tidal Basin seemed extremely excited about the idea of our project and wanted us to follow up with them. However, upon following up, we lost contact with them. They would still be a great resource to investigate for any future groups doing research on grants, and what grants could be especially useful for the community center. Black & Veatch was a connection established late into our project after weeks of attempting to get in contact with them, however they provided us with lots of useful information, outlined in the water usage analysis section. They know all about wells and the process that goes into digging and implementing one. If Johnny and Javier are serious about having a potable water supply for the community of Cubuy, Black & Veatch will be a particularly valuable resource that can help them make this a reality. All interview notes with these companies can be found hyperlinked to the same contact sheet that is in the paragraph above.



Web diagram detailing the connections established while completing project work

Recommendations:

- Reach out to companies early and often – Networking in Puerto Rico can be difficult, and it can often take days if not weeks to get a response or set up a meeting
- Be persistent and send multiple follow up emails to obtain the information you are looking for
- Continue to reach out to new people and organizations, as well as ones that might have not responded before
- Follow up with people and organizations such as Black & Veatch Engineering, DG Authority, Fusion Farms, ProSolar, ResilientSEE and Tidal Basin. These are all people that were very helpful to us and already have knowledge about the project and can help in various ways (check the spreadsheet to see specifics of communications)

FUNDING OPPORTUNITIES

What Existed Previously:

Due to the foundation of non-profits and grass root initiatives, finances can be a major challenge for these organizations. ID Shaliah and The Karma Honey Project are both growing non-profit organizations that were founded in 2020 and 2018 respectively. Often, small and rural developments turn towards grants and outside sourcing to provide resources that they cannot obtain by themselves. When we spoke with Javier and Johnny there was a great interest in applying for grants because they can provide a significant amount of funding. Grants can provide valuable resources for organizations to carry out projects that they would not be able to complete otherwise. However, there were some concerns expressed about the unfamiliarity of formal grant writing as well as the unique documents required when applying.

Advancements We Made:

We researched various grant opportunities that are related to community development, energy, and water and waste disposal from organizations such as FEMA, USDA, and EPA. When approaching the search for funding, we targeted grants that had been awarded to projects in Puerto Rico with similar initiatives to ours. We have also researched, interviewed, and selected several agencies and organizations that could assist in the application process. After an interview with Yanel de Angel from ResilientSEE, she informed us that the Ponce Community Project that they worked on secured a $8.5M FEMA Mitigation grant for Community Safe Room. We also found that the Municipality of Dorado received an investment of $769,498 through the USDA Rural Development Community Facilities Grant Program. To aid in the longevity of the project, we compiled a list of grant opportunities that the Cubuy Community Center project aligns with in terms of eligibility and application window.

We concluded a list of grants the community center is potentially eligible for:

- USDA - Community Facilities Direct Loan & Grant Program
- USDA - Rural Water and Waste Disposal Program
- USDA - Emergency Community Water Assistance
- FEMA – Building Infrastructure and Communities (BRIC)
- EPA - WIIN Grant: Small, Underserved, and Disadvantaged Communities Grant Program

Recommendations:

- Focus on organizing the finance structure and budget of the Cubuy Community Center, including both of our sponsors non-profits
- Create a Volunteer Management System (VMS) as an organization tool
- Compile all necessary documents into a formal project proposal
- Work with contacts that can assist with professional grant writing

The application process would aim to enhance transparency, accountability, and mitigate financial risks. Grants can help build the visibility and credibility of ID Shaliah and the Karma Honey Project. Once grant makers see that notable organizations have contributed to the project's case, they are more likely and inclined to award additional funding.

Each grant application process is different, and the first step is contacting the appropriate representative responsible for Puerto Rico. For more information regarding the best contact for the USDA, FEMA, EPA, and EDA refer to the contact list or online at Grants.Gov.

Resources:

- **FEMA Preparedness Grants Manual:** https://www.fema.gov/sites/default/files/documents/FEMA_2021-Preparedness-Grants-Manual_02-19-2021.pdf
- **USDA Rural Water Factsheet:** https://www.rd.usda.gov/sites/default/files/fact-sheet/508_RD__FS_RUS_WEPDirect.pdf
- **USDA Community Facilities Factsheet:** https://www.rd.usda.gov/sites/default/files/fact-sheet/508_RD_FS_RHS_CFDirect.pdf

SOURCES

GROWNYC. GROWNNYC. (N.D.). RETRIEVED OCTOBER 3, 2021, FROM HTTPS://WWW.GROWNYC.ORG/FILES/OSG/RAINWATERMANUAL_2018_FINAL_HIGHRES.PDF

WORLD HEALTH ORGANIZATION. (2013, JULY). TECHNICAL NOTES ON DRINKING-WATER, SANITATION, AND HYGIENE IN EMERGENCIES. RETRIEVED FROM WORLD HEALTH ORGANIZATION: HTTPS://WWW.WHO.INT/WATER_SANITATION_HEALTH/PUBLICATIONS/2011/WHO_TN_09_HOW_MUCH_WATER_IS_NEEDED.PDF