Hydroponic Gardening in Gandul, San Juan:

Growing A Solution for Food Insecurity

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Interactive Qualifying Project

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Abstract

The urban neighborhood of Gandul in San Juan struggles with food insecurity due to limited local bodegas and high grocery costs. Project sponsors Gandul Community Center and Corporación La Fondita de Jesús engaged us to develop a model hydroponic garden to provide a sustainable source of fresh produce, addressing this issue. The garden will produce food, enhance community health and hydroponics education, and community self-sufficiency. Our project analyzed food availability at local grocery stores and created the hydroponic system, an operating manual, and an educational pamphlet. The new partnership with project sponsor staff enriched our lives and underpinned project outcomes, while paving the way for future collaborations between WPI and the Gandul community.

Executive Summary

For decades, the Puerto Rican economy has relied on the import of foreign goods, mainly from the United States, to supply the island's daily needs. This excessive import-oriented system increases the island's vulnerability to economic crisis and reduces its economic autonomy. Data from the American Society for Nutrition (2014) reveals that Puerto Rico only produces 18% of consumed goods, importing 82% of its food, increasing prices and making food insecurity a dilemma across the island. Combined with the effects of disinvestment and economic inequality, "food insecurity" or "food deserts" describe conditions in which an area is deprived of nutritious food whether through economic barriers, unavailability of food, lack of proper resources to access food or other injustices. Natural disasters, like Hurricane Maria, emphasize the need for more self-sufficient practices, such as investing in Puerto Rican agriculture, rather than sourcing food from elsewhere.

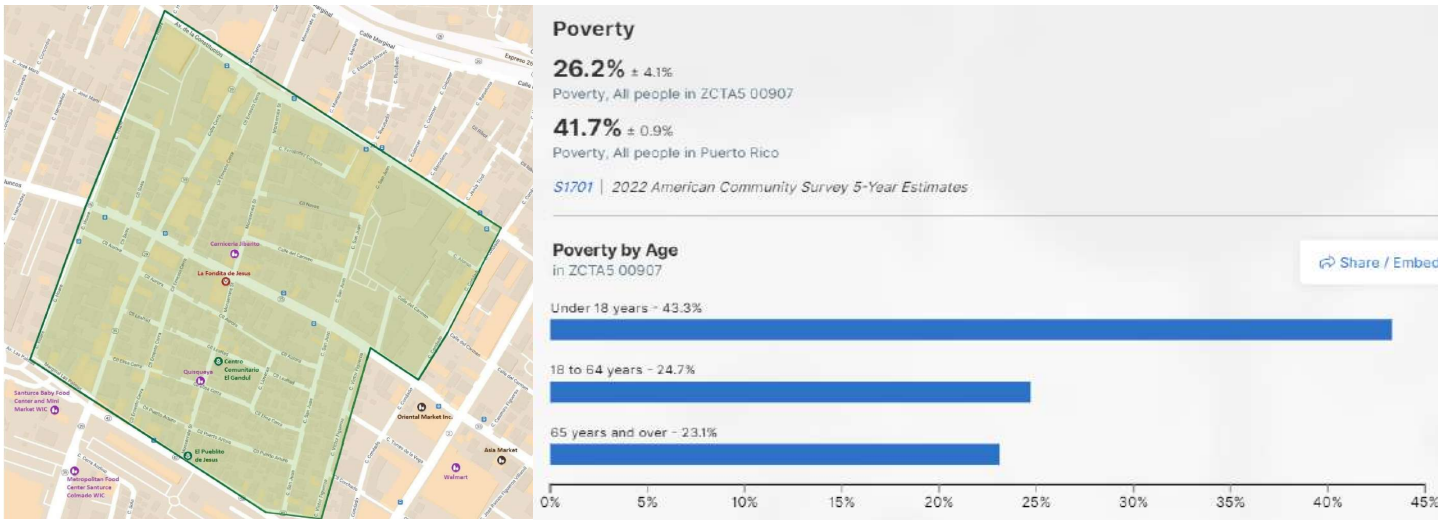

Figure 1: *Map of Gandul area generated by student team and partners on Google MyMaps (Left). Poverty rates in the Gandul zip code area (00907) according to the 2022 U.S. Census Bureau (Right).*

Poverty, closely correlated with food insecurity, especially plagues the municipality of San Juan, where 26.2% of residents struggle to live at the minimum standard of living. According to anecdotal evidence from the team's partnering organizations, Gandul struggles with poverty and food insecurity. Organizations like La Fondita de Jesus and the Gandul Community Center combat these issues by providing essential medical and educational services, distributing cooked meals and food items, and organizing programs to promote community engagement and self-sufficient lifestyle habits. To target local food insecurity, the Gandul Community Center, with support from La Fondita de Jesus, teamed with Worcester Polytechnic Institute (WPI) to create a model hydroponic garden to grow fresh crops like cilantro and lettuce.

Hydroponic gardening is a promising tool to combat food insecurity in urban areas like Gandul (Cole et al., 2023, Gumisiriza et al., 2022), and involves growing crops in nutrient-

infused water rather than soil. Case studies suggest that the development of this soilless agricultural practice not only supplies healthy foods, but also encourages social capital and connectivity in the local community as residents work together to become familiar with hydroponics and to maintain the needs of the system. However, since this form of gardening is not common in Puerto Rico (Solis-Toapanta et al., 2020, Caputo et al., 2020), the team also developed hydroponic-education material to reinforce the important concepts about this modern agricultural tool. To qualitatively understand food insecurity in Gandul, the team also mapped the neighborhood for local food sources and generated a grocery brochure illustrating several aspects and insights of each store.

The goal of this project was to construct a hydroponic garden with the Gandul community to introduce a source of fresh food to El Gandul, establishing a novel partnership between Worcester Polytechnic Institute and the Gandul Community Center. Additionally, the team mapped food sources to visualize food insecurity and designed educational material to increase the community's familiarity with hydroponic gardening.

To achieve this three-part goal, the team fulfilled the following objectives:

1. Establish Hydroponic Garden:
    - Create a sustainable hydroponic gardening system that could be moved if necessary, maintained and recreated by the local community.
2. Educate and Empower:
    - Provide educational resources to the community by designing a hydroponics manual and supplemental activity booklet to enhance traditional learning with interactive learning strategies.
3. Foster Community Engagement and Partnership:
    - Engage with the community through continuous interaction and participatory design to ensure the project meets the community's needs.
4. Gain Insight on Food Insecurity:
    - Locate and document details on local grocery stores to measure food insecurity in Gandul. Produce a map to visualize food sources and food insecurity.

Once on site, the team regularly met with the leaders of El Gandul Community Center and La Fondita de Jesus to strategize and construct the garden. Considering user requirements, the team deduced that a double-sided A-frame hydroponic structure following deep flow technique (DFT) was most suitable (Vega et al., 2023) because:

- Ideal shape to reduce taken space.
- High yield potential and simplicity.
- Unique setup.
- Ease of collapsing for storage.
- Replicability.

Hydroponic Garden:

The team gathered materials from local hardware and hydroponic stores with funding from the WPI 2024 Puerto Rico Project Center (PRPC). Alongside Gandul community members, the garden site was cleaned, the hydroponic frame was constructed, and the system was built and tested to ensure proper function.

In collaboration with the Gandul Community Center and Corporación La Fondita de Jesús, the team developed a functioning hydroponic system using DFT with an A-frame structure that fits up to 90 plants. The deep flow technique ensured efficient water usage and faster plant growth. T-connectors and hooks allowed for easy storage during natural disasters. The hydroponic is also sheltered by a plastic tarp, secured by a metal pop-up tent frame. All materials and tools were sourced locally to ensure future replicability and accessible maintenance. In the final weeks on site, cilantro seeds were seeded, germinated, and eventually transferred to the hydroponic frame. This is the start of an ongoing supply of produce from the frame.

The hydroponic garden provides sustainable agricultural services, allows members to learn new gardening techniques, fosters connectivity between different various generations and demographics, and serves as an outlet to improve mental health and relieve stress.

Figure 2: *Collaborating with mothers of the Gandul community about the design of the hydroponic garden.*

Grocery Brochure:

Concurrently, the team visited several grocery stores in the Gandul neighborhood, documenting prices of common food items, food availability, and food variety. These findings were synthesized into a grocery brochure which featured a grocery map generated from Google MyMaps and Microsoft Paint. The creation of the grocery brochure was also driven by community feedback through semi-structured interviews and a focus group meeting on April 3rd, 2024 with the Gandul community. Through these interventions and participatory approach, the team gathered valuable perspectives on hydroponic gardening, food availability, dietary habits

and shopping priorities. The team individually met with social workers and hydroponic gardeners at La Fondita de Jesus.

Secondly, the team developed brochures in English and Spanish to distribute to the Gandul community, listing grocery information within the local neighborhood. Food and shopping analysis tables and a grocery location map aimed to increase knowledge on accessible food availability, providing comparative information on shopping factors valued by the community. The brochures inform and promote local, cost-effective shopping, redirecting business to local stores rather than larger corporations.

The grocery brochure highlighted local grocery stores in the Gandul community and provided information about shopping factors to encourage local shopping. Mapping created from the local perspective of shopping priorities and neighborhood borders allowed for more accurate, relevant information which can inform and encourage locals to affordably shop in Gandul.

Educational Resources:

Lastly, a hydroponic educational and activity manual was developed using selected information from existing manuals, anecdotal experiences from workshops, and insights from experienced hydroponic gardeners. This document was created to familiarize the community with hydroponic knowledge, providing the resources for future models. Its creation supports that the hydroponic system created at the El Gandul Community Center will be successfully maintained by the community, under the leadership of José Ramírez, the community center manager.

The final deliverable was a comprehensive hydroponics manual and activities manual for the Gandul community, aimed for both adults and youth. The combination of information and interactive activities was produced to increase familiarity with hydroponics in an engaging, hands-on way. The manual covers hydroponic construction, maintenance, health and safety, budgeting, alternative designs, and future considerations. The activities include demonstrations of hydroponic stages, recipes, and DIY hydroponic projects. With his extensive hydroponic experience and leadership at the Gandul community center, José is the perfect educator to facilitate these activities with community members. These pieces facilitate the adoption of sustainable practices and ensure that the hydroponic garden will function for many years to come.

Shopping Factors	Grocery Stores in Gandul				
	Metropolitan Food Center Santurce Colmado WIC	Santurce Baby Food Center and Mini Market WIC	Quisqueya	Carnicería Jibarito	Walmart
General Price Point ($,$$, or $$$)	$	$$$	$$	$$	$
Distance from Gandul Community Center	0.2 miles	0.2 miles	150 feet	500 feet	0.4 miles
Relative Availability of Fresh Vegetables	Moderate	Low	Low	Low	High
Relative Availability of Fresh Fruit	Low	Moderate	Low	Moderate	High
Ownership	Public	Public	Family-Owned	Family-Owned	Public

Figure 3: *Cover of the hydroponic manual (Left) and a sample shopping data table from the Gandul grocery brochure (Right).*

Reflections:

Close connections with members of the community, including our sponsors, and open communication through active listening and sharing ideas shaped the design of the hydroponic system and the map of Gandul. Information and excitement about the hydroponic system spread quickest through word-of-mouth, as volunteer-builders and interviewees from this project informed their families and friends. These positive experiences from workshops encouraged many residents to work on the hydroponics systems, and gave our team a deeper understanding of hydroponic systems, the impacts of food insecurity, and the connections between residents which make Gandul a community.

As aspiring engineers and scientists, this project has allowed us to experience the process and impact of engineering beyond the classroom. From clients to colleagues, this experience has equipped the team with the skills to make fruitful change for the world outside of WPI, and enriched our lives as our memories and hearts stay with Gandul. The project team believes that the growth within the hydroponic garden symbolizes the growth of the Gandul community, along with WPI's growth of new connections with global communities such as Gandul.

Acknowledgements

For aiding this team in crucial ways above and beyond for the entirety of this project, we would like to thank a number of people who helped us along the way.

First and foremost, we would like to thank our main project sponsors, José Ramírez, Glory Rodriguez, and Carola Visalden, for all of their time, support, and commitment to our project. Their constant care and expertise helped enrich our project and contributed greatly to our work.

We would also like to thank all related sponsor partners who helped us along the way. Thank you to Mark Wilson and Rocío Nájeraurriola for leading workshops and providing us with valuable advice for the hydroponic garden. Thank you to Darving Irizarry for your time and support as a translator during our focus group and community meetings. Thank you to Anthony G. Calzada Rivera for your assistance during our hydroponic construction and lending us your tools.

Thank you to the Gandul community for your constant support and willingness to share your time with us. We are so lucky to have been able to connect and learn from you all, and thank you for making us feel so welcome.

We would also like to thank Charles Luster, the founder and executive director of the 2Gether We Eat organization, who took the time to meet with us and provide insight on hydroponics and education.

We would like to thank Worcester Polytechnic Institute as well for providing us with such an enriching experience.

Finally, thank you to our Worcester Polytechnic Institute advisors, Dr. Grant Burrier and Dr. Scott Jiusto. Your unending support and guidance are greatly appreciated and your dedication to us and our project helped make this work possible.

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Introduction

Brightly painted square houses, and enthusiastic “Buenas” from locals taking a moment to pause their afternoon chats, welcome the four American newcomers to the quaint neighborhood of Gandul. Vibrant murals adorn the walls of alleyways and restaurants on the walk to lunch, mirroring Gandul’s flavorful tastes, bold Borinquen coffee, and embrace of heritage which simmer in the luscious stew of Puerto Rican culture.

Arriving at the community-favorite lunch spot with our sponsor, Las Palmas greets us with dishes of soft white rice, tender nuggets of fried pork, candy-sweet plantains, all with a side of the pleasant remark– “¡Buen provecho!”. From warm, traditional tripleta sandwiches, to foreign-inspired matcha lattes, the streets of Gandul are speckled with an array of cuisines. However, while these restaurants, bars, and cafes construct the perception of a food utopia, they mask the ominous reality that Gandul is rather a food dessert, lacking the proper fresh foods for a healthy, nourishing diet.

Ongoing struggles in Puerto Rico like unemployment and poverty have historically contributed to food insecurity issues across the island. U.S. colonialism and other factors have been drivers, leading to a situation where 85% of food on the island is imported (Gunzburg et al., 2022). Taxation on imported goods coupled with logistical costs means food is expensive. Along with government focus on promoting agricultural exports, Puerto Rico does not sustain itself with locally-produced food. The Jones Act exacerbated the island’s state of insecurity (Princeton University et al., 2022). The act, enforced since 1920, states that Puerto Rican shipments can only be transported through US ships and crews, which raises the cost. In turn, the island is highly dependent on outsiders for food supply, and prices continue to rise with inflation on the mainland while salaries stagnate on the island. With this economic strain, the area could benefit from a change of lifestyle that does not rely so heavily on exterior partners and outlets for something as vital as food. Recurring natural disasters like Hurricane Maria in 2017 demonstrate the severity of the island’s vulnerability (Gunzburg et al., 2022). Without attention and action, the food insecurity struggles of Puerto Rico will only worsen from more natural disasters and increased food prices.

In Puerto Rico, and particularly the San Juan area, accessibility and affordability of healthy food is a constant struggle. Especially in Gandul, not every family lives in close proximity or has the physical ability to reach healthy food, and even those within distance often find it economically unaffordable (Gunzburg et al., 2022). Moreover, around one third of Puerto Ricans report feeling food insecurity (Princeton University et al., 2022). To combat this, increasing self-sufficiency is one of the more reliable practices to implement. Considering San Juan’s low soil fertility and city landscape, standard soil gardens generally require extensive investments of time, effort, space, and money. One potential solution in urban settings is hydroponic gardening. Hydroponics are soilless gardening techniques that employ nutrient-infused water to sustain plant roots. The ability to directly control the system allows for quick growth and increased crop yields in small spaces and environments that have poor soil quality. With proper design, hydroponic gardens are significantly more energy efficient and even require less water and space than traditional soil methods (Cole et al, 2023).

Our team collaborated with two non-profit sponsors from El Gandul in San Juan: Corporación La Fondita de Jesús (La Fondita) and the (El) Gandul Community Center. We built a hydroponic garden for the Gandul community and collected data to visualize food insecurity in the community.

The "A-shaped", deep floor technique hydroponic garden will provide harvests of 90 plants, primarily cilantro and lettuce, for the community. Additionally, the garden can also serve as a form of social and community building which promotes community engagement, while also teaching valuable skills and lessons. The garden has the potential to strengthen community knowledge and investment in agriculture which aligns with the mission statement of El Gandul Community Center. Not to mention, it will provide fresh produce and hands-on educational activity for the marginalized community members including the elderly, youth, and homeless–which aligns with the mission of Corporación La Fondita de Jesús.

Several mapping strategies were also used to document food accessibility and availability in Gandul. The team visited various food outlets in the Gandul community and used quantitative measurements and qualitative analysis to document the availability, variety, freshness, price, and locations of nutritious local food. This data was consolidated into a grocery brochure distributed to the community. Therefore, locals will be able to compare various grocery stores and choose to shop at the store which best suits their needs and priorities.

The hydroponic garden and mapped sources of local, nutritional food provide relief for the Gandul community. The project also accomplished the important tasks of raising awareness of food insecurity to Gandul residents, providing fresh food to this food desert, improving community self-sufficiency, and establishing a novel partnership between Worcester Polytechnic Institute (WPI) and the Gandul Community Center.

Sponsor Background

Our sponsors and partners for our project are Corporación La Fondita de Jesús and Comunidad El Gandul (El Gandul Community Center). Founded in 1984 by a group of friends working to bridge the gap between vulnerable populations and the community, Corporación La Fondita de Jesús is a 501(c)(3) nonprofit organization founded in San Juan, with several sites across the capital city, and outreach across all of Puerto Rico, such as Culebras, Luquillo, Guaynabo, Caguas, Salinas, and Utuado. Members provide aid and transform the lives of homeless people and those in vulnerable areas. They particularly focus on relationships working towards commitment, respect, and a determination to understand and validate the realities and experiences of the people who put their trust in the organization.

The group initially began by delivering food to different parts of Santurce in their cars, a lively neighborhood in San Juan. By 1985 the group was integrated into the State Department, and later that year renovated a building to advance their efforts. The facilities offered a plethora of services and supplies for the homeless from regular meals to even barber services. Their efforts do not go unnoticed as the locals appreciate their work alongside the mayor who visits annually. Corporación La Fondita de Jesús is known to be the first private non-profit organization to offer such services in San Juan. The group continues to expand in size and in their work, forming new partnerships often, Worcester Polytechnic Institute being one of them. La Fondita consists of social workers who are new to the organization but are filled with the desire to help the community. Their services include a computer lab for public use, a thrift store managed by volunteers and social workers, and a central hub on Calle Monserrate within Gandul. This hub provides a large space for community events, daily meals, and a kitchen serving under-resourced elderly members. Additional on-site facilities include offices for health and social workers, a donation center, transitional housing apartments, and public amenities like lockers, showers, laundry, and bathrooms utilized by the homeless. Through mobile health clinics, educational programs with schools, and other community services La Fondita expands their impact throughout the entire island of Puerto Rico. La Fonita de Jesus also supervises other offshoot programs, such as La Percha, which is a local thrift store in Gandul and Vivero Siembra Verde which produces fresh cilantro and lettuce using a rooftop hydroponic garden in a building also on Calle Monserrate. These vegetables are either sold to the community or used for La Fondita’s community kitchen for meals.

Figure 4*: La Fondita de Jesus social worker, Glory Rodriguez, recording the needs of vulnerable adults facing homelessness in Toa Baja.*

Figure 5*: La Fondita de Jesus social worker, Carola Visalden, working with children from the Abraham Lincoln School in Old San Juan on a reading-writing program. Although La Fondita de Jesus is based in Gandul, their work extends to various Puerto Rican neighborhoods. April 19, 2024.*

Source Note: Corporación La Fondita de Jesús Instagram

Source URL: https://www.instagram.com/p/C59SxAnyWCp/?img_index=2

These efforts contribute to the overarching goal of the group, which is to equip and prepare the community to reach a high level of self-management and ensure they have a strong support network alongside them. Naturally the organization's goal of improving community sustainability is reflected in this hydroponic garden proposal as well. Different learning opportunities and support systems allow for this mission to transpire, such as workshops, education opportunities, and programs. Considering La Fondita's ability over the years to raise awareness and create change, this organization is considered "an instrument of communication with government agencies and the legislature" (Corporación La Fondita de Jesus et al., 2022).

Corporación La Fondita de Jesús is built on the work of various social workers, dedicated to impacting different aspects of the community. Gabby Gonzalez, a social worker who works in the Family Services department, began working at this organization because she prioritizes family as a primary personal value. She has a tight-knit family and hopes to replicate this with the community within and around El Gandul. She and many other social workers find it to be very humbling work that keeps them grounded day by day. Glory Rodriguez, another social worker, says she chose to work for La Fondita to fight for people's rights, and because the organization prioritizes community events to build a sense of unity. She believes unity will allow for the Gandul area to progress and form long lasting relationships that will ultimately help others in the future. Social worker, Carola Visalden, chose to work for La Fondita because they provide important services for free, which is significant since poverty is a large issue on the island, and especially in Gandul. She also believes in La Fondita's goal to help families receive housing and security, continuing to assist community members even after they get on their own feet.

The El Gandul Community Center has similar goals for bettering the community through both educational and enrichment activities and workshops. The center functions as a place for youth from ages 5 to 21, to partake in after school activities involving games, art, music, and work, which are important for fostering well-rounded future citizens. The center is not only limited to youth and also hosts bi-weekly community meetings, has a kitchen for event catering, and now features a hydroponic garden in the adjacent alleyway as a result of the team's work over the past several weeks. All are welcome to partake in the opportunities and projects which promote individual wellbeing and social networking, strengthening the community of Gandul.

Figure 6: *Community members gather to repaint the El Gandul Community Center. March 25, 2023.*

Source Note: Comunidad El Gandul Instagram

Source URL: https://www.instagram.com/p/CqO8bvdLD1C/?img_index=8

The El Gandul Community Center has two main workers that we have collaborated with. The first being Eudalia Santana Peralta (Berkys), who owns the community center and sets up community meetings every other week. The second is José Ramírez, the center's manager and an expert in hydroponics and the Gandul community. In 2020, he began running activities at the community center as he wanted to give back to the place where he lived for 42 years. José also wanted to create a safe and fun environment for children as he believes youth are one of the most important parts of society and the future of Puerto Rico. For that reason, the community center is filled with games, arts and crafts supplies, music, and snacks. The El Gandul Community Center uplifts kids and allows them to express their creativity while having fun.

Figure 7: *One of our main sponsors, José Ramírez, who actively works at Gandul Community Center.*

This was Worcester Polytechnic Institute's first time partnering with El Gandul Community Center, alongside Corporación La Fondita de Jesús. Collaborating with both organizations sprouted strong potential for community growth and partnership. During this partnership we have furthered the mission of both organizations: to empower Gandul through service, youth learning, and workshops.

Understanding the Gandul Area

The members of the Gandul community are very passionate about maintaining a safe, clean neighborhood for their families. Our sponsor José Ramírez, along with many parents from the community picked up hundreds of needles from the grounds of the Gandul park and basketball court about 5 years ago. This spring, our team played at that same court while a little boy scrambled up the playground in the neighboring park. Both areas were clean, vibrant, and safe for children. Strangers to Gandul who would smoke or loiter in the parks are confronted by José and any nearby parents. Vigilance is the reason why the parks remain a haven within the community, as many drug abusers and homeless persons wander the surrounding area.

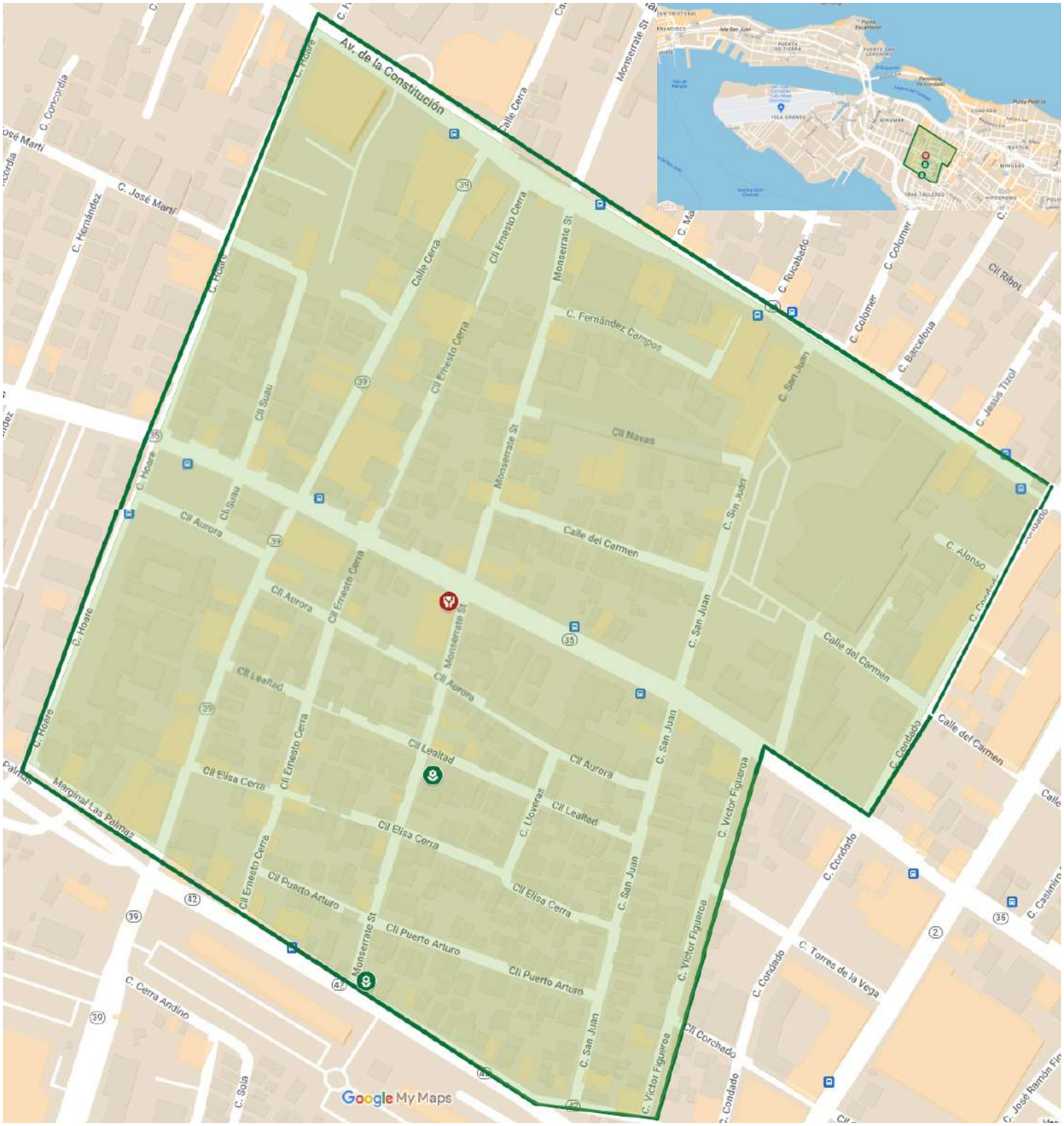

Figure 8: *A custom designed map showing the Gandul community in San Juan highlighted in green. The Gandul community center is the green circle in the center of the page, the red circle is the main building of Corporación La Fondita de Jesús, and the red dot near the bottom of the page is where La Fondita's rooftop hydroponics are located.*

Often seen in crowds in front of Corporación La Fondita de Jesús on Calle Monserrate, or heard as sudden yelps and loud talking from the middle of Calle Aurora, drug users and homeless people can be found in Gandul night and day. Locked gates and rusted metal bars guard every house and local business because community members know the community's history with crime and drug abuse, the latter peaked between 1991 and the early 2000s. La Fondita provides housing, food, informative health consultations, and rehabilitative activities including workshops, movies, household practices like laundry which have successfully decreased homelessness and drug abuse in Gandul. Community residents have also become more dedicated to educating the youth about the risks and realities of drug abuse to decrease the future presence of drugs in the community.

Many people struggling with drug addiction in Gandul also struggle to find work which makes them more susceptible to homelessness and food insecurity. Dozens of people in need can be seen outside of La Fondita's building every day of the week, and more arrive for the aforementioned meals and activities hosted by La Fondita. This phenomenon highlights the difficulty to afford food and housing for locals.

All residents of Gandul attest to increases in rent, prices of groceries, and Airbnbs over the past several years, which contribute to homelessness. The influx of tourism to this well-kept residential area of San Juan, namely the popular destination: Calle Cerra, has increased economic pressure and displacement of locals. Expensive restaurants and bars provide high-quality sources of food and consume precious property spaces which were once homes. Few locals are interested in being employed at these clubs and bars for various reasons, late night shifts being one of them. Thus residents of Gandul work outside of the neighborhood and shop outside of the neighborhood.

Most Gandul residents make a 7 minute (2 mile) drive to Sam's Club for their groceries on a weekly basis. Carpools are organized for neighbors without cars because it is not accessible by foot due to highways or buses due to routes. Many rely on coupons and brand deals at Sam's Club to buy a variety of items in bulk for their families on an efficient budget. These external companies are better known to the community than the few local food stores in Gandul which do not offer the same freshness or variety of foods. The freshest produce offered in Gandul is from the hydroponic gardens of La Fondita, which sell small bags of lettuce and cilantro that are sold out within a day at $2 per bag. This finding demonstrates that residents would pay for fresh, healthy food closer to their homes, and also inspired the purpose of this project to produce more quality food and hydroponic gardening for Gandul.

Literature Review

Food Insecurity in Gandul

Gandul is a community within the city of San Juan, Puerto Rico facing food insecurity and poverty. Food insecurity is the condition of not having access to sufficient and/or nutritious foods, which often is coupled to poverty. While little micro-data is accessible for the neighborhood of Gandul, census data from its larger zip code area: 00907, indicates that 26.2% of the population lives in poverty, 43.3% for inhabitants under the age of 18, meaning that children are at the highest risk of food insecurity. School enrollment rates are shockingly low, 53.1% for children up to the 12th grade, and adult unemployment is relatively high at 50.5% (United States Census Bureau). These economic statistics are likely even lower for the neighborhood of Gandul specifically, since the area of northern Condado near the shoreline is more affluent from tourism and commerce, thereby inflating the zip code's statistics. The urban setting inherently limits available space for vendors to sell food while increasing the cost of transportation and living for inhabitants and businesses. Disadvantaged urban neighborhoods throughout San Juan also experience high rates of crime, drug abuse, homelessness, and poverty (Hernández, 2017, Tavárez & Fuentes-Ramírez, 2023, Lindner, 2024), which contribute to the local struggle to access healthy foods (Wight et al., 2014, Strike et al., 2012). These factors cause residents to shop outside of their neighborhoods in search of the best deals and sufficient groceries. The struggle to afford and access nutritious food marks Gandul as a food desert.

In addition to archival evidence from published articles, our team has direct evidence of food insecurity in Gandul through the accounts of our partner organizations: Corporación La Fondita de Jesús and El Gandul Community Center. Hydroponic gardening is a promising tool to combat food insecurity in urban areas (Cole et al., 2023, Gumisiriza et al., 2022), which involves growing crops in nutrient-infused water in structures without using soil. Typically holes are made in wood, PVC, or plastic trays for each plant to be grown. This system includes a light source and water flowing at the tips of plant roots in artificial channels (Resh, 2022, Miller et al., 2021). This form of gardening is relatively unknown to locals in Puerto Rico (Solis-Toapanta et al., 2020, Caputo et al., 2020). Therefore, this project also develops hydroponic-education material to reinforce the importance of practicing local agriculture which can sustain the community nutritionally and socially.

Hydroponics as an Agricultural Solution to Food Insecurity

A water-based hydroponic garden for El Gandul addresses the larger scale topic of agricultural solutions needed in Puerto Rico since hydroponics can produce high yields of healthier food using little space and less water than a traditional garden (Cole et al, 2023, Ayambire et al., 2019, Gumisiriza et al., 2022). This type of gardening is particularly suited to urban environments where space constraints limit traditional farming methods. Although the material costs to build a hydroponic garden, such as steel pipes and PVC, pose a challenge, (*See "Methodology; Hydroponic Garden Construction"*) a community garden will ultimately empower El Gandul to sustain themselves.

Many communities in Puerto Rico, such as Gandul, have experienced difficulty obtaining locally sourced food. The root of this food insecurity traces back to the early 1500s when the Spanish colonizers in Puerto Rico enforced the production of sugar, tobacco, and coffee on most farmland in Puerto Rico in order to export these cash crops in Europe (Flores et al., 2009, Nagovitch, 2020, Charles, 2017). The island was fed through the importation of food and other resources from Spain, which financially benefited the colonizer (Spain) at the expense of the colony (Puerto Rico). In 1898, when the United States obtained Puerto Rico as a territory after the Spanish-American War, the federal government continued and encouraged the industrialization of monoculture farming through the 1960s and 1970s in order to generate valuable trade crops like bananas for export to the mainland rather than proposing diverse agricultural production that focused on local consumption.

To this day, Puerto Rico has few large-scale farms growing diverse crops and relies on imported food to feed its population. This practice is unsustainable financially for Puerto Rico, and renders the island vulnerable to food shortages and extreme market inflation (including a greater sales tax on food than any other U.S. state) due to delayed shipments during natural disasters and insufficient internal revenue to afford such importation (Villanueva, 2021, Suárez, 2018, Flores et al., 2009). Hurricanes have always been destructive challenges in Puerto Rico (Abrania et al., 2022, Trossi-Torres et al., 2024), yet food insecurity on the island coincides with importation and a decrease in domestic food production. Several studies have determined that most Puerto Rican municipalities did not have access to fruits and vegetables after hurricane Maria in 2017 (Colón-Ramos et al., 2019, García et al., 2023). Care packages sent from the U.S. mainland were insufficient and primarily contained preserved snacks instead of nutritious foods. Revitalizing local gardening practices, whether in soil or hydroponic, can achieve greater local food autonomy and rejuvenate the agricultural industry in Puerto Rico.

Figure 9: *"Meal. Ready to Eat." taken at the Museo de Arte Contemporáneo de Puerto Rico depicts an image of a food ration package delivered by the United States. The practice of distributing Meal*

Ready to Eat or MRE boxes became a standard in 1986 for military purposes. In Puerto Rico, MRE boxes are recognizable by local communities for their use in natural disaster relief. This image was taken in the year after Hurricane Maria and underscores Puerto Rico's dependence on American-imported foods, especially in times of disaster.
Meal, Ready-To-Eat (MRE) 2018. Museo de Arte Contemporáneo de Puerto Rico.

Cole et al. (2023) as well as several other agricultural reviews describe the positive effects of local agricultural practice on healthy diet choices, food availability, physical exercise, local business, and the learned abilities from local gardening which we discuss later (Cole et al., 2023, Massey, 2015, Chalmin-Pui et al., 2021). Other literature such as the qualitative interviews performed by Marrero et al. (2022) and the primary research article from Vega et al. (2023) suggest that enabling the community to be more self-sustaining is a reliable way to protect the lives and futures of citizens in vulnerable communities such as Gandul. The future of the entire island could also be protected given that 85% of food in Puerto Rico is imported, which undermines domestic agriculture and the island's economy (Ginzburg, 2022). Agriculture can generate long-term revenue and jobs for Puerto Ricans (Gould et al., 2017, Gould et al., 2015). However, vocational competition with tourism and market competition with large-scale commercial businesses from the U.S. are current economic barriers (Marrero et al., 2022, Ginzburg, 2022).

The tourism industry has made a dramatic impact on the employment market in San Juan, especially as the island recovered from hurricane Maria in 2017 (Casado-Claro, 2021, Figueroa Miranda, 2023, *PRNewswire*, 2023). The massive influx of tourists to the city is made possible by the construction and staffing of luxury hotels, Airbnbs, restaurants, and night clubs founded by external companies and private investors. Tourism provides stable pay and plentiful job opportunities to Puerto Rico, which has enticed the youth to find work in facets of tourism or leave the island altogether (U.S. Census Bureau, 2022, *PRNewswire*, 2023, Aponte-Parés, 2019). The U.S. Census Bureau found in 2022 that most employed inhabitants work in administrative business, retail, health care, or entertainment services. As Puerto Rico's population of farmers continues to dwindle and age without replenishment, agricultural knowledge and the key to self-sufficiency is lost (McCune et al., 2019). Although tourism does generate revenue and bolster the economy, the practices of businesses should become more considerate of Puerto Rican heritage (MacDonald, 2023, Aponte-Parés, 2019), and the importance of agriculture needs to be revitalized for the youth.

Local businesses which are more connected to their communities and better exhibit the traditions and culture of Puerto Rico struggle to compete with the variety and lower prices of large-scale multinational corporations. Brand name companies such as McDonalds and Walmart have the means to construct many buildings in Puerto Rico, becoming very prevalent and accessible. However, they also prioritize processed foods that are cheaper than healthy, largely imported, groceries. Many Puerto Ricans then find themselves eating fast food often and buying from these brand name companies out of economic necessity, inadvertently diminishing local businesses and farms (Ginzburg, 2022, Marrero et al., 2021). Tax cut provisions allow external businesses to pay fewer taxes in Puerto Rico than on the mainland, and some businesses evade taxes altogether

(Quiñones-Pérez & Seda-Irizarry, 2016), which further siphons money from circulation in Puerto Rico. The local production of healthy foods in hydroponic gardens could therefore relieve some of this economic pressure, and offer forms of emotional relief for the community.

Hydroponics, Mental Health, and Social Capital

Community gardens, such as the hydroponic garden for El Gandul, generally increase social connectivity and mental wellbeing for participants. Such benefits were demonstrated in the Seeding Plan program in Shanghai China, two community gardens in the Kuchyňka and Vidimova districts of Prague, Czechia, and an organipónico, an organic, urban cooperative farm in Cuba. Findings in all these case studies highlighted the benefits that community gardens provide, from individual-focused mental health improvement to community-wide connectivity.

Gardening studies from Shanghai, China and Prague, Czechia found similar positive benefits within their respective participants which tended to soil gardens (Kou et al., 2021, Dubova & Machac, 2019). Through questionnaire surveys, interviews, and comparative analyses, the researchers observed the impact of community gardening on the mental health of local residents and the organization of public safety in the context of the coronavirus pandemic. Participants in Shanghai included those who were actively in the Seeding Plan program (group A), non-participants living in the communities where the Seeding Plan was implemented (Group B), and those in outside districts (Group C). The data indicated that Group A displayed the highest scores for mental health, with Group B also achieving positive scores above Group C. Overall, the researchers deduced that community gardens allow for convenient access to nature, facilitate social interactions that "soothe people's psychological stress during a major public health emergency", and with simple implementation and dissemination, results in improved mental health for the community in a "bottom-up process" (Huaiyun et al., 2021). In Prague, Dubova and Machac found that community gardens have a crucial role in promoting social interaction and recreation, but also contribute to "benefits for the whole society" (Dubova & Machac, 2019). A notable feature from both studies were the widespread impact community gardens yielded: from an individual improvement in one's quality of life to acting as beacons for the upward communication of community needs.

Personal statements from local participants in Cuban organipónicos also reported similar positive impacts on personal well-being as well as community belonging and cooperation (Duffy et al., 2017). Applying input from Cuba is efficacious, as the country is analogous to the territory of Puerto Rico; both being developing Caribbean islands, highly prone to natural disasters, and drawing from similar cultural roots. Moreover, semi-structured interviews were conducted in a qualitative study in order to assess urban gardening impacts on mental health, social capital, and economic capital from the Cubans directly working on the farm. In terms of social-capital, one respondent reported "...a sense of belonging and reciprocity with the farm and developing close relationships on the farm (Informants 1, 3, and 4)." Friendly and rewarding interactions achieved through farming together enriched the lives of the participants. Although workers on the farm were paid, the article reports a very low turnover rate of employees due to the fulfilling work and positive connections made on the farm. Several other studies exhibit similar findings in terms of social capital benefits,

with one report combining over 30 different garden studies and evaluating their input. This article reviews how community garden participation impacts a community in terms of social interactions and dietary benefits. The majority of the studies reported a stronger sense of connection across the community, especially between different backgrounds, races, and more. Words like belonging, support, respect, and collaboration were all heavily expressed in participants' reports after partaking in a community garden.

Another major social-capital outcome is community sharing, where produce from the garden can be shared amongst the community including crops, knowledge, culture, and gardening tools. Sharing of the wealth and donations from the gardens in the mixed study report were generally divided among members that partook in the garden as well as external groups like soup kitchens and other community members, proving that the garden also encourages outreach and benefits more than just those directly involved with it (Burt et al. 2021). In fact, participation in community gardens has been surging recently, and even "between 2008 and 2013 there was a 200% increase in the number of households participating in a community garden" (Burt et al., 2021). Clearly, gardens often facilitate social connections both in and out of the direct groups themselves. Many of the gardeners in Burt's report noted increased socialization in the community even outside of the garden itself after participation.

Considering the context of El Gandul in San Juan, facing food insecurity and external influence from the U.S. mainland, a community garden will serve as an impactful resource in improving mental wellbeing during a time of emergency and struggle, while also promoting strong connectivity within the community.

Developing Hydroponic Educational Materials

The key to sustaining the newly constructed hydroponic garden is the implementation of an effective education intervention catered for the Gandul community. Through educational materials, locals from Gandul will be equipped with the necessary skills to maintain the hydroponic system for generations to come. This pedagogical component aims to increase self-sufficiency in growing fresh foods, facilitate direct access to produce, encourage the adaptation of more nutritious eating habits, and demonstrate the value of local, community gardens.

Hydroponics are scarce, poorly-known gardening systems despite their relevance in providing good-quality foods (Gumisiriza et al., 2021). The Gandul hydroponic education materials will promote the adoption of healthy eating habits and the importance of access to freshly-grown food in combating food insecurity. Our team reviewed past studies centered on hydroponics as an educational tool to develop our educational activities.

In an article from the U.S. Department of Education, high school students actively engaged in the set-up and maintenance of hydroponic systems as an intervention to promote healthy eating. The authors noted the importance of incorporating "multi-component interventions", such as education focused on specific produce, rather than general nutrition, hands-on activities, special training of educators, active involvement of parents, and community involvement (Anderson and Swafford, 2011). During the study, participants collected plant yield data and tracked produce

shipments as a means of melding together academics and hands-on hydroponic gardening. Discussions from student focus groups later revealed that all students consumed the recommended vegetable and fruit serving according to healthy dietary standards after participating in the study. This case study also incorporated parent and community participation by providing recipe information that these demographics could benefit from. While this study utilized hydroponics in healthy eating education, the next case used hydroponics to promote climate change awareness.

Researchers in New York City investigated the impact of hydroponics on environmental sustainability education. The New York Sun Works (NYSW) Greenhouse Project Initiative combined climate and sustainability curriculums with hydroponic food labs to encourage project-based learning in students kindergarten to twelfth grade. Classroom spaces were converted into hydroponic science labs which utilized hands-on activities about urban farming. The table below illustrates the various approaches, listed to the left, and how they are achieved in the program, listed to the right. From the table, hydroponics was utilized to fulfill experiential learning and was a vital practical application.

Table 3. Operationalization of evidence-based components within the NYSW program.

Evidenced-based educational component	NYSW program application
Pedagogical approaches	
Active learning	Students are expected to create projects that explore real-world problems
Experiential learning	Student led experiments related to hydroponics, aquaponics, composting, rain catchment, and pest management
Inquiry-based learning	In each lesson students explore the answer to a focusing question (constructivism)
Practical applications	
Technology applications	Computer based simulations, programing, and activities aimed to engage students with the human impact on climate change
Hydroponics	Hands-on hydroponic and aquaponic science labs using Nutrient Film Technique and fish farming among other components

Figure 10: *Table from NYSW Greenhouse Project Initiative. Educational components and their correlating NYSW program applications*

Source: Kate G. Burt, Marissa Burgermaster, Dina D'Alessandro, Rachel Paul & Marina Stopler (2020)

Results revealed that students in the NYSW program achieved higher science scores, which could have been due to the relevance of the subject that was studied: climate change. Students were likely exposed to climate-related discourse in their daily lives, thus they were personally connected to the educational material. Personal relevance is an essential factor in a student's enjoyment and interest in a subject matter, fueling motivation and curiosity in understanding a topic (Burt et al., 2020). While hydroponics might be an unfamiliar topic to the community, food insecurity is a relevant, well-known issue. Activities regarding food production will capture the attention of Gandul residents.

Drawing from the educational components described in the case studies above, the Gandul hydroponic education program will incorporate hands-on components in order to make the

educational experience informative, engaging, and thought-provoking for a wide range of age groups. Studies by Lombardi et al. (2014), Thuneberg et al. (2018), and Yannier et al. (2021) found that hands-on activities stimulate interest and attention while learning a new subject for many different age groups from 12 years old to college students. Content was better retained in post-tests by individuals who had physical activities and some autonomy integrated into a lesson. Interactive workshops or games are already well-liked within the Gandul community since community meetings often involve ice-breaker games and open discussion to share community information about new mural commissions peppered with gossip between neighbors.

Supplementing these case studies, the team also interviewed Charles Luster, the founder and executive director of 2Gether We Eat, a non-profit organization based in Worcester, Massachusetts promoting hydroponic education for all generations. Initially inspired by cannabis cultivation, Luster realized hydroponic gardening's potential for combating food insecurity in the Worcester community. Utilizing a combination of hands-on gardening exercises and informational content, Luster described his work in educating both elementary youth and elderly communities through hydroponics. Luster noted the importance of reading the audience and suiting the educational program to their interests. As a former sports coach, he also underscored the need to make activities engaging and to encourage participants who might be apprehensive about hydroponics. Luster specifically mentioned an activity called "Light, Camera, Action", where children go up to the front of the classroom in groups and talk about what they learned after a hydroponics lesson. This activity empowers children to speak publicly, aids in knowledge retention, and incorporates a level of friendly competition between youth. Apart from knowledge-based exercises, Luster welcomes participants to tend to the hydroponics where they plant seeds, monitor water levels, and harvest freshly grown vegetables, all in their special lab coats. Through a positive and welcoming environment, Luster uses hydroponic education to "grow people and plants". Developing this atmosphere comes from simple activities, such as creating special handshakes when greeting children and distributing t-shirts to build a uniformed community. Interviewing Charles Luster provided insight on how to create a successful educational program for Gandul, following the same motives and values that 2Gether We Eat fosters. He also invited us to visit him in Worcester at 2Gether We Eat when we return from our project to collaborate with us, share experiences, and see our report findings.

After considering the available literature, and the opinion of our partners Corporación La Fondita de Jesús and El Gandul Community Center, the project team believes that the production of locally available, healthy food and community hydroponic education will empower Gandul. Locals will be encouraged to vary their diet, practice sustainable agriculture, and strengthen healthy social connections.

Methodology

This Interactive Qualifying Project project assisted Corporación La Fondita de Jesús and El Gandul Community Center in San Juan, Puerto Rico to reduce food insecurity and strengthen community infrastructure by constructing an efficient hydroponic garden and employing community mapping techniques to increase awareness. The following objectives were completed:

- The build site was cleaned of debris and the hydroponic system was designed and built in collaboration with José from the Gandul Community Center as well as the help of our sponsors from La Fondita and volunteers living in Gandul.
- A hydroponic manual and separate activities manual were created to enable the community to care for the hydroponic garden, familiarize themselves with general hydroponics and the specific design process of this garden, and advance their use of hydroponics in the future.
- Interviews were conducted with our sponsors and adult volunteers living in Gandul to inform the design of our hydroponic garden, deliverables of this project, and food availability in Gandul.
- Personal ethnographies of the community were recorded to document food availability and community infrastructure.

With the exception of some quantitative data described in the hydroponic manual for plant care, mainly qualitative research techniques were used. While quantitative research is reproducible, objective, and often yields numerical data that can be calculated and statistically analyzed, it cannot discern the subjective opinions and social implications of human interactions within a community. These are strengths of qualitative research, making the two forms complementary and holistic when used together (Berg & Lune, 2017).

The methods used in this project were best for discerning subjective social problems such as food insecurity, mental health, and developing engaging yet universal hydroponic activities. The exact data collected from each method and considerations for the benefits and disadvantages therein are discussed below in dedicated sections. Data was collected in various forms including published papers, direct opinions from adults between the ages of 21-80 living in El Gandul, interviews with our sponsors from La Fondita and the Community Center, and personal first-hand observations while working in Gandul. Overall, a multimethod approach was used to triangulate data from each method and achieve each of the aforementioned objectives (Berg & Lune, 2017).

Below, each exact method utilized during this project is explored through the triangulation of peer-reviewed sources as well as our personal experience through them. Each method section discusses the purpose, process, and precise utilization in terms of our project in Gandul.

Archival Research

Archival research is the process of learning information about a topic from previous documents such as peer-reviewed papers and public media. This includes newspaper articles, files from earlier projects in Puerto Rico, and/or social media videos from Youtube. This method did not involve respondents directly since information was obtained and interpreted by the student team privately for reflection. Drawing information from existing sources provided a solid background of the history and culture of Puerto Rico in relation to our goals and the probable impacts of implementing a hydroponic garden for the Gandul community (Berg & Lune, 2017). This basic but thorough understanding of our goals and the motivation which created them prepared us for the project design and allowed for a more efficient creation of a garden that met the needs of the community. Though our design changed while working on site, the knowledge gained from extensive, topic-driven research was necessary since the members of this student team did not have any previous expertise in hydroponics or the social state of Puerto Rico.

The wide array of available information found during archival research enriched our understanding of hydroponic gardening and food insecurity in Puerto Rico prior to and during our project. Important topics included: how to build hydroponic gardens, causes of food insecurity in Puerto Rico, community mapping methods, impacts of gardening on mental health and social capital, and the deficit of sufficient food vendors in Gandul. Nearly all of our objectives were researched through online sources to prepare for this project.

However, we have recognized that there was potential for selection bias during our research, therefore we consulted multiple sources to triangulate conclusions, assessed the credibility of our sources and author backgrounds, and cited overlapping information related to both our topic and time period from multiple sources (Berg & Lune, 2017). The triangulation approach was recommended by Berg & Lune (2017) in their novel which analyzes many research methods including the archival research method. By synthesizing conclusions from multiple sources, our student team encountered different perspectives which bolstered information about our topics, such as sources of food insecurity in Puerto Rico. The triangulation of sources also revealed possible areas of uncertainty through thesis contradictions. We reviewed authors' experience and expertise on our relevant topics which yielded more genuine and accurate conclusions during background research.

No respondents or outside participants were required for archival research. Thus the ethical questions of this method were largely based on the credibility of information. In order to produce credible information for our hydroponics project in El Gandul, our team cited many peer-reviewed authors converging on similar topics with ample experience in the subject area to support our project design and understand our objectives.

Semi-Structured Interviews

The team conducted interviews in a semi-structured fashion with willing participants who have direct experience and knowledge on a subject. Semi-structured interviews involved a relaxed

interview with curated questions to guide conversation. For the purposes of this student-team's project, the interviewees consisted of willing members over the age of 18 who are residents or are employed in the neighborhood of Gandul, San Juan. While these criteria do not constitute the entirety of useful first-hand accounts, it does provide an appropriate sample size and general opportunity for adults to share their anecdotal experiences.

Persons of varying ethnicities and demographics were offered the opportunity to share their answers to questions. These questions touched upon food insecurity within the community as well as opinions and current knowledge of hydroponic gardening. These key perspectives assisted the team in mapping vulnerable areas of the community that need support in the forms of food availability, price, and freshness. Opinions from locals also assisted the team design a hydroponics education program best suited to the abilities and interest of the general public, which will encourage more members of the community to participate in the program.

Our student team implemented several useful techniques for conducting genuine, informative interviews. This includes showing warmth and support to interviewees in the forms of:

- Smiling
- Friendly small talk
- Respectful tone and word choice
- Active listening (Berg & Lune, 2017)

Active listening entails somewhat frequent eye contact, nodding, and responding to the participant with key words from their end of the conversation. The questions were curated to make the participant share their opinions and experiences on specific topics such as their experience with food insecurity, what kind of topics or advertisement would encourage them to practice hydroponic gardening, and other such questions related to our objectives. The questions were open-ended to encourage thoughtful responses from interviewees. For example, all interviewed subjects were asked, "What do you wish would change or improve about grocery stores in this neighborhood?". Gentle probing questions such as "Could you tell me more about…?" and "I would like to know how you feel about…?" were also utilized in order to gain as much direct information from the participants as possible without introducing interviewer bias (Berg & Lune, 2017). Exercising these practices encouraged a more comfortable, conversational-style interview, rather than an intimidating exchange of direct questions and responses.

The team generated a list of questions, organized by theme (i.e. food insecurity, hydroponic gardening) to guide the conversation and address gaps in the team's knowledge of the community. Depending on the interviewee's level of comprehension and knowledge on the topic, questions were modified in wording or structure. Structural modifications and slight phrase changes were utilized when appropriate to allow for interviews to have a more colloquial, relaxed feel, encouraging the interviewee to provide honest feedback. Some interviews were also conducted in Spanish to adjust to the interviewee's preferred speaking language.

The team recognized the possibility for biased interviewee responses depending on personal experiences, and limitations of sample size since the entire Gandul community was not interviewed.

There were no documented responses from children due to consent limitations. Interviews were also conducted with willing participants mainly from the area surrounding the El Gandul Community Center and Corporación La Fondita de Jesús office building, which was not necessarily representative of all persons living in El Gandul. To mitigate these limitations the team interviewed as many consenting individuals as possible from all backgrounds, to increase the sample size (Berg & Lune, 2017).

The primary semi-structured interviews were with staff members from La Fondita, including social workers, gardeners, and coordinators. All interviews were conducted with at least two student team members, with one member actively engaged in the conversation, and another acting as a scribe to record responses.

Into the fifth week of the project, the team conducted one interview with a non-local credible individual who is well versed in hydroponic gardening and education. We Zoom interviewed the founder and executive director of 2GetherWeEat, a Worcester-based non-profit organization determined to combat food insecurity through hydroponics. Through this conversational interview, the team gained insightful information on structuring hydroponics education and hydroponic gardening, improving the quality of the team's project through the director's opinions.

In another instance, a local Gandul resident was spontaneously interviewed in a small grocery mart. After recognizing the team in the mart, a man in a striped shirt and round, black glasses initiated a conversation in English, introducing himself and asking about the project. Naturally, the team began to ask the man about his thoughts on food availability in Gandul, his personal background, and his views on starting a hydroponic garden at the Gandul Community Center. After the conversation, the local consented to having his responses be considered in the team's report anonymously.

Focus Groups

On April 3, 2024, a focus group interview (Berg & Lune, 2017) was conducted at the Gandul Community Center with local residents in which two facilitators led a discussion about local food availability and current understanding of food insecurity. Community insight gained regarding where Gandul residents shop for food, prioritized factors of grocery shopping including price, variety, and freshness, and their current understanding of what food insecurity is in Gandul. Additional questions covered familiarity with hydroponic gardening and any suggestions, requests, or questions about the hydroponic system as we were in the construction process. The responses were used to inform and tailor the hydroponic garden, workshop activities, and Grocery Brochure to the Gandul community (*See Appendix D: Focus Group Questions and Responses*).

The focus group was performed as a walk-and-talk gallery, in which topic questions were printed in large writing on poster paper and dispersed around the walls inside the community center. This technique was recommended by our sponsors at La Fondita based on their experience with holding community meetings. Walking and holding a standing group discussion for about 5 minutes at 6 different questions successfully captured the attention of individuals whether they were speaking or listening to others and generated smaller, focused discussions for each topic.

The participants consisted of 11 adults, 3 males and 8 females, between the ages of 30-65 living in Gandul. No specific qualifications were required to participate in an attempt to assemble a demographically diverse group. Consent to document responses was asked and received from all participants.

Figure 11: *Glory Rodriguez (Corporación La Fondita de Jesús) and Jocelyn Hinchcliffe (WPI) facilitating Gandul focus group, 04/03/24.*

Glory Rodriguez from Corporación La Fondita de Jesús and Jocelyn Hinchcliffe from the WPI team co-facilitated the focus group in Spanish. Community familiarity, great public speaking skills, and fluency in Spanish from Glory helped initiate discussion while objective and question insight and conversational Spanish speaking skills from Jocelyn helped break-down topics and focus the discussions. All facilitators and collaborators were well prepared for each topic due to prior structured planning of the focus group in a 2-hour meeting between Glory, Carola, and the student team earlier that day. Facilitators tried to give all participants opportunities to speak (Berg & Lune, 2017), however some participants naturally had stronger voices than others whose opinions dominated conversation. A translator employed from La Fondita, Darwing Irizarry, was positioned alongside the focus group, and relayed community responses from quieter participants for our team to scribe in English.

Figure 12: *Community discussion regarding food insecurity and preferences from Gandul community members, April 3, 2024.*

All of the collected information regarding food and local stores was considered when creating the Grocery Brochure (*See "Deliverables: Grocery Brochure"*) and reassures the implementation of hydroponics in Gandul. In addition to food awareness, we also learned that Gandul residents and their children are eager to participate in the garden but require guidance or instructions. This information was directly applied to the Hydroponic Manual the student team crafted to provide the proper resources for those working with the garden in the future.

Hydroponic Garden Construction

The physical construction of the hydroponic garden was carried out in collaboration with José Ramírez and the assistance of La Fondita. In the first week, the team restored and cleaned the garden site in the alley with the help of local community members. This included debris cleanup, powerwashing, and cleaning out unnecessary supplies. Considering the following requirements, the team deduced that implementing a deep flow hydroponic technique to create a double-side A-frame structure was the most suitable design for the garden. This design was selected according to the following factors:

- Slim shape, which utilized more vertical space and reduced used floor space. This was ideal for the narrow alleyway of the garden's location.
- High yield potential and simplicity
- Unique setup compared to the typical table design
- Ease in collapsing for indoor storage
- Ease in replicating for community members

After the design was determined, a sample design sketch and 3D model were constructed out of wooden sticks by utilizing scaled measurements and calculations. Measurements that were utilized in the scaled model considered the space offered in the alleyway in order to make a design that had efficient space constraints.

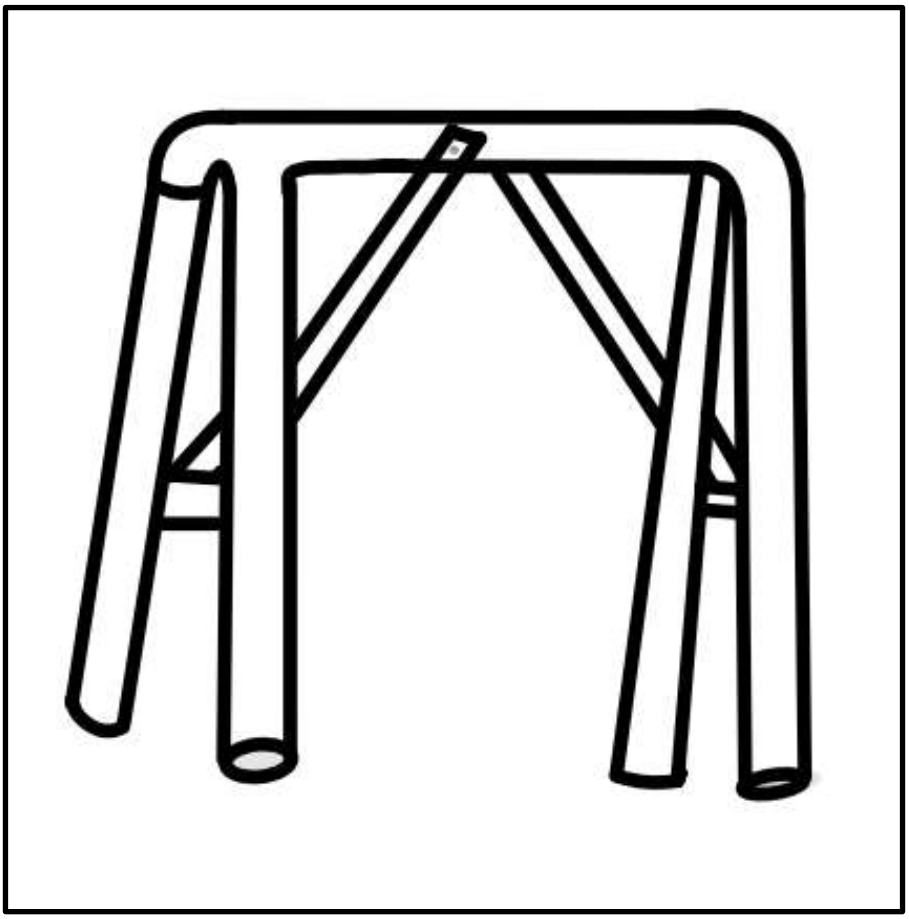

Figure 13: *Digital mockup of hydroponic frame. Image is not to scale.*

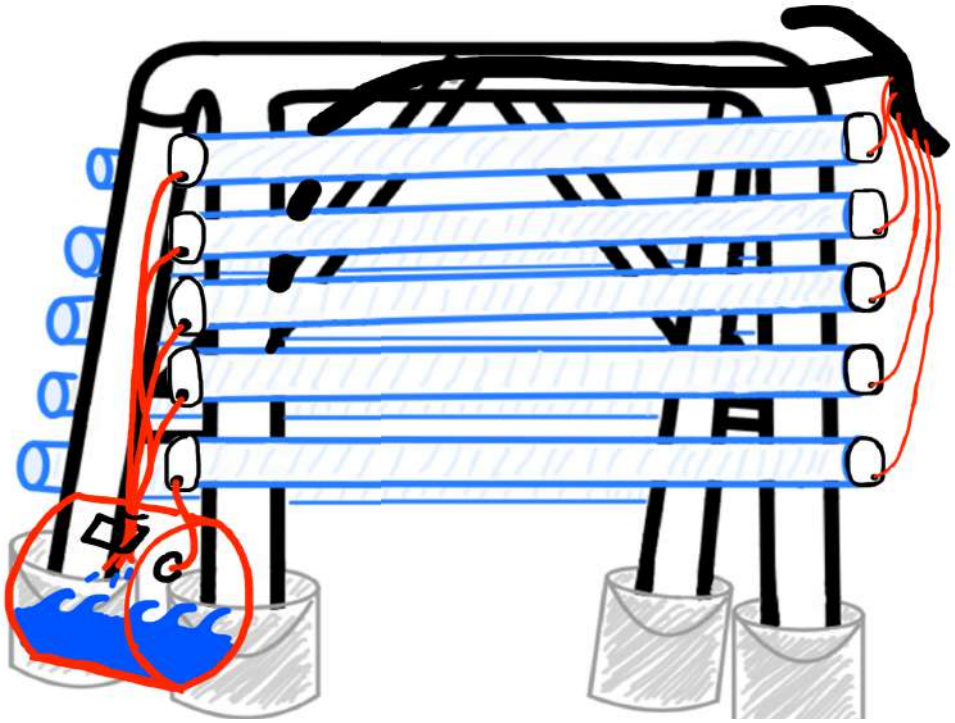

Figure 14: *Digital mockup of the student team's hydroponic garden. This design excludes rubber tubing, a water tank, and a water pump. Image is not to scale.*

The proper materials for construction were purchased from Home Depot, a local corner store: Ferretería Comercial Caraballo, Ferretería Maderas 3C, Walmart, and Hydro Warehouse. These materials included but are not limited to: PVC pipes as troughs and framework, PVC caps and elbows, black spaghetti tubes, black rubber tubing, an adjustable EcoPlus 793 GPH submersible water pump, cilantro seeds, and NPK 11-11-40 fertilizer powder. Exact details regarding the materials and building process are described in the supplemental Hydroponic Manual.

A deep flow technique (DFT) hydroponic design was implemented utilizing the electric water pump. The main frame was made of 2" PVC cut by a handsaw and connected at the center pole by a removable PVC T-connecter. 2" PVC plant troughs fit into plastic J-hooks on the sides of the frame, allowing the structure to be disassembled if necessary. Nine 2" holes were drilled into each PVC trough at 5" apart to accommodate plant growth. With 10 troughs, this totalled to 90 holes capable of growing 90 plants. The troughs had a 0.5 inch decline in order for laminar flow of water as it naturally traveled through the system. Half-inch thick rubber tubing carried water from the pump to the top PVC pipe frame, through a small T-connecter, and into rubber tubing with five, ¼" holes drilled under each tube where spaghetti tubes channel the water down into the PVC troughs holding the plants. Removable PVC caps were attached to the ends of plant troughs to prevent water evaporation and convenience for trough cleaning and inspection.

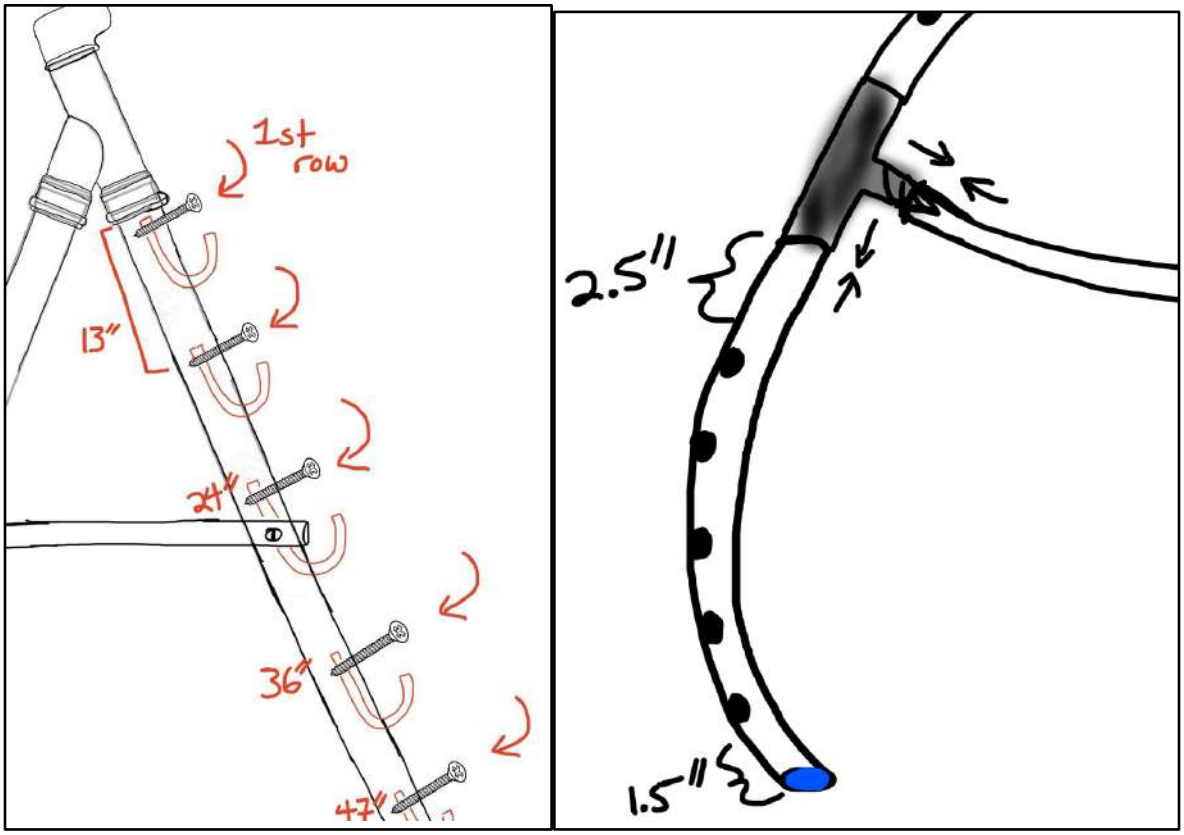

Figure 15: *Digital mockup of spacing and placement for J-shaped hooks that will hold the water troughs. Image is not to scale (Left). And a digital sketch of T-connector and rubber tubing with five ¼" holes for spaghetti tubes to deliver water to each PVC pipe. Image is not to scale (Right).*

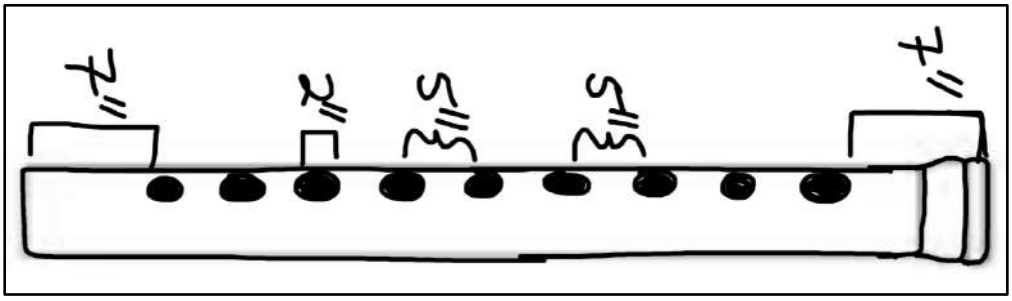

Figure 16: *Digital mockup of spacing for water troughs that will hold hydroponic plants. Image is not to scale.*

In order to stabilize the hydroponic frame, each leg of the hydroponic frame was placed in cement buckets and filled with gravel. Gravel was used to avoid potential weed growth or pest attraction.

To protect plants in the frame from rain water and wind, a pop-up tent frame was utilized with a plastic tarp covering the frame. The plastic tarp is transparent to allow light in and drapes along the sides of the frame to protect from strong winds and rain.

Verbal consent from participating adults was obtained in order to properly inform the Gandul community and protect every individual's privacy. Children were not permitted use of any construction tools or transport of heavy objects to ensure safety for all. Children were also supervised and engaged during construction by José Ramírez for their safety and inclusion during the project.

Developing a Hydroponics Manual and Educational Activities

To promote confidence in hydroponics and awareness on food insecurity, the team designed educational material for the Gandul community. In collaboration with the leaders of our two sponsors Corporación La Fondita de Jesús (Vivero Siembra Verde) and El Gandul Community Center, a manual on hydroponics was created, containing standard guidelines to caring for the hydroponic garden and detailed instructions revealing the process of building a hydroponic garden from the team's experiences. The structure of the manual was inspired from the 2009 Thailand IQP team's manual, along with recommendations from the 2GetherWeEat executive director. Furthermore, the content of the manual was derived from the Vivero Siembra Verde hydroponic gardening manual, practices done by José and Mark, along with the team's research and anecdotal experiences. For example, information taught by Rocío Nájeraurriola and Mark Wilson in their workshop with the team were incorporated.

Figure 17: *The student team partaking in a hydroponic workshop led by Fondita members Mark Wilson and Rocío Nájeraurriola at the Vivero Siembra Verde site.*

The team used semi-structured interviews, focus groups, and personal outreach with the community in order to encourage locals to learn about hydroponic gardening. In one instance, the team organized a community meeting focus group on April 3, 2024 to discuss hydroponics and food insecurity through a gallery activity with roughly 15 community members (*See Methodology: Focus Groups*). Five questions related to these two topics were written on posters and hung on the walls of the community center space. As a group, participants walked up to a poster, read the labeled question, engaged in insightful discussion, and listed answers to that question. Through this exercise, members gained more information on hydroponics in a relaxed and interactive method.

To supplement the instructional hydroponic manual, a booklet with engaging activities involving hydroponics was also created. While the hydroponic manual was designed for adults, the activities were targeted towards a wide age range to engage all members of the community in

hydroponics. The activities section included a brief review of basic information relating to hydroponics, review questions to demonstrate inquiry-based learning, coloring sheets since many children enjoy art-related activities at the community center, recipes to engage parents, and instructions to a "do-it-yourself" hydroponic system using recyclable household materials. The combination of written information paired with interactive, and even engineering-styled, activities yield the most fruitful learning experiences.

Ethnographies

Ethnographies are a qualitative form of data collection that describes a culture, or experiences observed in the place of study. Ultimately, this strategy aims to depict a culture or experience from a "native point of view" (Berg & Lune, 2017). Written accounts of ground observations and a familiarity with the location are a crucial aspect of this field research. Parts of the observations derive from descriptions using the 5 senses from personal interaction and experiences. This is an effective strategy since it is important to do more than just observe the Gandul neighborhood, but to consider the dynamics of it as well and go beyond a surface level of interaction. In the context of food insecurity, we considered more than the physical location of food outlets, and also took into account the accessibility and affordability of these food sources to get a less biased or vague perception of the locals' realities. Observer bias often leads to a skewed perception of the actual situation. Therefore, the team perceived surroundings with an open mind without expectations, to avoid observing what we hoped or intended to find.

Figure 18: *Rayna Jacob playing a xylophone during the team's visit to a Gandul resident's backyard. The community lovingly calls this place the"Tree House" because of the frequent visitors and overgrown state of his yard.*

Ethnographies were recorded by each team member on their personal cell phones as written observations or captured as images or videos. These descriptions were pooled into a shared Google Doc where team members could add and review various ethnographic notes. While exploring the Gandul neighborhood, the team always made sure to capture vibrant mural artwork, note the various dynamics and interactions between residents, and taste various types of cuisines from local restaurants. Experiencing Gandul through the 5 senses allowed for an immersive experience to produce realistic ethnographic accounts.

Mapping

Local grocery stores were located via Google Maps search or direct mention from our sponsors at La Fondita and the Gandul Community Center. José accompanied the team as we visited all nearby stores to document basic details for each store such as store location, variety of foods sold, hours of operation, and a short description of each store with consent from privately owned store

owners. Data collection categories were based on responses from the Gandul community from a past focus group meeting and factors that were deemed essential by the team to measure food accessibility in Gandul. Examples of these categories included price point of store items, distance from the Gandul Community Center, store ownership and relative availability of fresh produce. Prices of specific food items across all stores were also documented for comparative data analysis. Each store was visited once over the course of this project, usually in the afternoon on a weekday.

After data collection, information was compiled to develop a booklet-styled, grocery brochure to allow residents of Gandul to optimize their grocery shopping. Information was displayed in the form of two tables. The first table, titled " Food Analysis Table", compared the prices of some commonly found foods across all stores. The second table, "Shopping Analysis Table", compared shopping data across all stores (*See pages 5 and 6 of "A Guide to Food Availability and Accessibility in Gandul"*). Following these pages was a section dedicated to individual store details, which included store names, hours, addresses, images and a brief paragraph describing each store. Finally, a comprehensive, color-coded map, located in the first few pages of the booklet, was created using Google My Maps and Microsoft Paint. The map was generated to visualize the entire Gandul community with labels on all streets and pinpoints on grocery stores, our sponsor locations, and current hydroponic gardens in the community. A legend for the map was also included to define color-coded pinpoints for each pinned location.

Figure 19: *Map of Gandul Community and its layout. Streets included in the Gandul boundaries were confirmed by sponsors and local residents.*

Limitations:

A few overarching limitations central to the Gandul community must be acknowledged. To start, it was important to acknowledge that Spanish is the official language in Puerto Rico, thus a significant language barrier challenge existed. When teammates worked with Spanish-speakers, either a student on the team with sufficient Spanish speaking ability or a community member who

was capable of English-Spanish translation was consulted to help facilitate efficient communication between both parties. This was mostly done at the community meetings and the semi-structured interviews. It is important to note that English is also a primary language in Puerto Rico, so the team was able to communicate with local community members to an extent. However, the team members did not assume that every individual in Gandul spoke English or was comfortable speaking in English, while some locals felt sufficient communication in both English and Spanish.

Another limitation was the time constraint of the project. Operating on a 7-week schedule, the team had limited room for delays or task extensions. Thus, the proposed Gantt chart (*see Appendix G*.) was used to track the team's objectives and tasks for each week. The Gantt chart was an accurate representation of what was completed once the project started. The team was also aware that unexpected changes might require modifications to the original schedule, such as delayed IRB approval, inclement weather, and other emergencies. Locating and purchasing materials was its own challenge due to the need for transportation, funding, and research into hardware stores stocked in San Juan. The team reviewed and monitored progress at least once per week and discussed the need for any changes accordingly. With only 7 weeks, the team was under an aggressive schedule to get to the final goal of the project: successful yield of hydroponic crops.

Finally, being from Worcester, MA, the IQP team was unfamiliar with daily life in Gandul and the team's knowledge on the area was quite limited. To overcome this limitation the team immersed themselves into the Gandul community by interacting with locals and making observations with an open mind. By embracing the opportunity to explore and connect with this new community, the team was able to learn and come to understand Gandul's culture and values, despite our limited background. While conducting the data collection methods listed above, it was essential for the team to be mindful of these general limitations to work around them.

Location and Time:

From March 11th through May 1st, the team built the garden and collected data in the community of El Gandul in San Juan, Puerto Rico with Corporación La Fondita de Jesús and El Gandul Community Center. We collected data while working on-site for the hydroponic garden and in the form of informal interviews, focus groups, and observational community mapping. Both of our sponsors lead regularly occurring community meetings to discuss plans and hear local thoughts and needs concerning the community. During our stay, we were fortunate enough to take part in these meetings to share our project and hear about their thoughts and goals for us. We prioritized attending these community meetings that occurred every other Wednesday at 5:00 pm since we are working for these two liaisons who specialize in helping the community. Here we heard from several local members in the form of casual conversations, discussions, and interactive activities. Additionally, we scheduled meetings during the weeks we worked with each main sponsor of ours and additional members of the organizations. Times and locations were collaboratively decided prior to the meetings and consequently varied for each sponsor, all taking place during work hours at either El Gandul Community Center or La Fondita. Talking and collaborating with multiple community members and our sponsors only strengthened our ability to provide efficient aid to the

community through the hydroponics project while allowing different voices and perspectives to be heard.

Ethical Considerations

Ethical standards had to be met when conducting research involving live participants. This was to ensure the safety, comfort, and rights of every human being throughout our research. This student team met the ethical standards of:

- ➔ Informing participants of their participation in this project and the use of their responses to help further this project.
- ➔ Informing participants of the goals/objectives of this project.
- ➔ Obtaining verbal or written consent from all participants in our interviews to (1) participate and (2) share their responses in our project report.
- ➔ Prioritizing the comfortability of the participants both physically and mentally as they answered questions. If any pain or discomfort occurred, the participants were free to leave the study, with no consequences.

With all of these ethical concerns relating to privacy, harm, consent, and confidentiality met, our team was in compliance with ethical research requirements (Berg & Lune, 2017). We also highly valued the happiness of the locals of El Gandul and our partner corporations: La Fondita and El Gandul Community Center, and wanted to make a positive impact on these groups using moral practices.

It was essential that the El Gandul team prioritized ethics when collecting data and interacting with local Puerto Ricans. Correct ethical practices were underscored when conducting semi-structured interviews and focus groups, where human participation was essential. Guidelines listed in the Federal Regulation 45 CFR 46 “Protection of Human Subjects”, specifically subpart A (“2018 Common Rule”) and subpart D (“Additional protections for research with children”) were carefully followed to mitigate the risk of any ethical dilemmas, especially since youth participation was expected in this project. This guideline rests on the three ethical principles of respect for people, beneficence, and justice. These principles ensured that individuals should be treated with autonomy and have access to proper protection; the project must be done with good intention; all individuals would be treated equally and equitably.

To ensure that the team followed other standard ethical protocol, an application to the Institutional Review Board (IRB) was submitted. Once approved, the team started participant data collection, mostly done in the El Gandul Community Center. After approval and prior to data collection, a copy of the “Informed Consent Agreement for Participation in a Research Study” document was sent to the prospective participant which outlined the purpose of the study, the procedure, risks and benefits of their participation, record keeping and confidentiality details, alternative procedures, compensation in the event of injury, subject compensation and any other essential information. After an adult participant gave their verbal consent, following the template in

Appendix C: Verbal Consent Script, and was well-informed on the study, data collection in the shapes of semi-structured interviews commenced. Verbal consent, rather than a written signature, was used since the project was done in a community where consent documentation agreement was not a typical activity as speaking was the preferred method, and written consent may unintentionally spark intimidation and alarm. Since the nature of this project involved minimal risk, written consent could be waived by the IRB.

Community center member José Ramírez was an experienced expert in hydroponics and had worked with youth in the Gandul community for numerous years. He directed the team's gardening plans, ensuring that all tasks were done safely and effectively. José would perform the more experience-demanding tasks to ensure safety for group members and children. Mr. Ramírez was a trusted source and helped maintain all participant safety, but most especially, minor safety throughout the project. While the team engaged with kids who came to the Gandul Community Center for afterschool and community programs, these children were not considered research subjects in this project, thus formal parental consent was not necessary for the team to casually interact with them.

Utilizing informed consent was a priority when collaborating with Puerto Ricans, especially since a history of incorrect ethical research practices between American researchers and Puerto Rican individuals had existed on the island. Most notably, in the 1950s, American researchers coerced Puerto Rican women into forced sterilization and subjected them to experimental birth control pills without proper, informed consent. These deplorable mistakes of the past reminded this team and researchers everywhere how imperative it is that informed consent is a priority.

Privacy of Data

Participant information and private data were stored in an encrypted folder in which only the 4 team members and 2 advisors had access. This folder stored any visual data, information from interviews and focus groups, and any audio recordings. Each individual file was also encrypted to ensure maximum security. Data was only accessed or retrieved in private settings, such as the Corporación La Fondita de Jesús computer lab that had a secure internet connection. Audio or visual recordings or photographs were initially stored on a team member's personal device (i.e., cell phone), but were imported to the shared encrypted folder and removed from the personal device within 24 hours. This procedure ensured that all research data was solely located on a secure platform accessible to only a few trusted individuals.

Results and Analysis: Our Findings at Gandul

In collaboration with our partners at the Gandul Community Center and Corporación La Fondita de Jesús, our team constructed an A-frame hydroponic garden for the community of Gandul with space for up to 90 plants, wrote a stepwise maintenance manual for the hydroponic system, provided hydroponic workshop activities along with the manual, and mapped food availability about Gandul. Outreach to the community through word-of-mouth interviews, flyers, community meetings, and walking through the neighborhood to immerse ourselves in the community enabled us to better understand Gandul and create products that best serve the community.

The designs and characteristics of each deliverable were crafted based on the voices heard from El Gandul and our own observations as we gained familiarity with the community. Close connections with members of the community, including our sponsors, were formed through active listening and sharing ideas during construction and mapping. Information and excitement about the hydroponic system spread quickest through word-of-mouth, as volunteer-builders and interviewees from this project informed their families and friends. These positive experiences from workshops encouraged many locals to work on the hydroponics system, which can lead to greater use of hydroponics in homes and the community. While our own experiences in Gandul led to a deeper understanding of the inner workings of hydroponic systems, the impacts of food insecurity, and the connections between residents which make Gandul a community.

Deliverables

Hydroponic Garden

We designed and constructed an A-frame hydroponic system with aid from our sponsors at Gandul Community Center and Corporación La Fondita de Jesús. The deep flow technique was used for this system since it requires less water and growth time than traditional techniques while still producing large yields. The frame and model itself were constructed using several T-connectors and hooks, so in the case of natural disasters the system can be easily disassembled and stored. With the accompanying plastic tarp roof and walls, the system will also be protected from direct sunlight, rain, and most pests.

All materials were purchased within the surrounding area and tools were locally borrowed, ensuring replicability and accessibility of materials for future maintenance and replication. Considering the materials used, where they were purchased, and the construction process, the design was crafted to be readily maintained and replicated for potential future systems in the area.

Figure 20: *Completed hydroponic garden system, featuring PVC A-frame structure, plastic roofing, rubber tubing, 55-gallon tank, and cement bucket stabilizers.*

Hydroponic Manual and Educational Materials

Supplementing the hydroponic garden, the team created a hydroponics manual, including interactive activities, and designed educational materials for the Gandul community. The manual serves as an instructional booklet on the construction and upkeep of a hydroponic system, specifically the system at the Gandul Community Center.

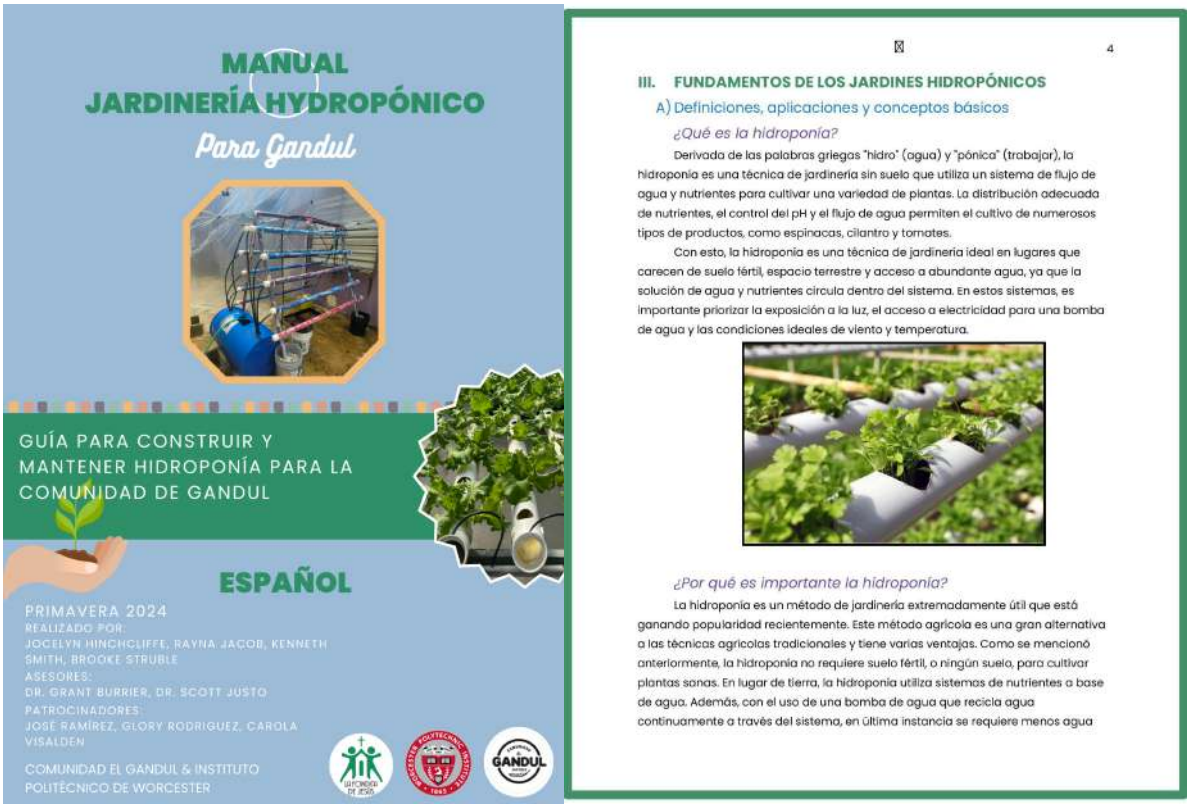

Figure 21: *Image of the cover of the hydroponic manual in spanish (Left) and a page within the student team's "Hydroponic Garden Manual for Gandul" (Right). This page covers the beginning of the "Fundamentals of Hydroponic Gardens" section.*

The manual is divided into two sections: textbook-style information and a list of hydroponics activities. While the informational section is intended for adults and older family members, the activities aim to involve youth participation and are designed to engage younger audiences. The purpose of the hydroponic manual is to encourage local families to learn basic science about hydroponics, the maintenance of the Gandul Community Center hydroponic system, and how to create a personal hydroponic system in their own homes, increasing accessibility to fresh produce and empowering self-sustainable dietary habits. To fulfill these intentions, the manual content is divided into the following main sections:

- Basics Of Hydroponic Gardens
- Gandul Community Center Hydroponic Garden
- Educational Material and Activities

These sections cover topics such as construction instructions, hydroponic maintenance, notes on health and safety, limitations, an estimated budget, alternative designs and future considerations.

Figure 22: *Cover page (Left) and coloring activity (Right) included in the student team's "Hydroponic Garden Activities and Education Material". This pamphlet is a supplemental piece of the Hydroponic Garden Manual.*

The purpose of the educational activities is to engage the community with interactive activities focused on hydroponics and basic plant science. Rather than a lecture-based pedagogical system, activities invite the entire community to participate in hands-on learning. These activities include demonstrations on hydroponic steps, answering questions on hydroponic knowledge, and "do-it-yourself" hydroponic systems using plastic water bottles.

A vital aspect of the educational resources are the educators leading this entertaining intervention. From the case studies mentioned earlier and the team's interview with Charles Luster, a common thread of finding a teacher who is both knowledgeable and amicable is underscored. José is a perfect fit for this role since he has worked with hydroponics for decades and will be equipped with the needed skills to teach community members and train future hydroponic educators. Furthermore, the case study from the U.S. Department of Education mentioned the incorporation of community members and parents for successful education interventions. These individuals already

participate in Gandul community center activities and will likely be interested in engaging in educational activities.

Grocery Brochure

Figure 23: *Cover and back page of final Grocery Brochure (Title in English: "A Guide to Food Availability and Accessibility in Gandul").*

Alongside the hydroponic garden and manual, the project team made a brochure for residents in the Gandul community to find cheaper grocery stores in the area to combat big market corporations. There are both an English and Spanish version to accommodate people that speak either language. Not many supermarkets resided within the community, and exact cost differences between local stores and commercial ones were not well known. This brochure contained concrete data comparing price, quantity, quality, and other shopping factors important to the Gandul community. It also provided images and addresses of the stores so readers would know where to get different essentials at a cheaper price. Parents, elderly, and vulnerable adults living in Gandul can obtain these brochures from La Fondita or the Gandul community center to inform and increase their local grocery shopping.

Análisis de alimentos

	Supermercados en Gandul				
Comidas	Centro de Alimentación Metropolitano Santurce Colmado WIC	Centro de alimentación infantil y mini mercado Santurce WIC	Quisqueya	Carnicería Jibarito	Walmart
Naranjas	3 por ($5.00)	3 por ($7.00)	N/A	N/A	1 libra ($1.86)
Plátanos	N/A	N/A	$1.59 cada uno	$1.25 cada uno	1 libra ($0.98)
Huevos (1 docena)	$3.99	$5.99	$4.75	$4.39	$3.28
Papas	N/A	5 libras ($7.00)	1 libra ($1.50)	1 libra ($1.00)	1 libra ($1.28)
Pan Barra	$3.29	$2.89	N/A	$4.19	$2.94
Carne	12 onzas Carne de res en conserva ($5) [$0.42 por onza]	12 onzas Carne de res en conserva ($ 6.79) [$0.57 por onza]	1 libra de jamón fresco ($10.50) [$0.66 por onza]	12 onzas Carne de res en conserva ($4.89) [$0.41 por onza]	12 ozas Carne de res en conserva ($4.44) [$0.37 por onza]
Arroz (3 libras)	$2.69	$2.79	$2.50	$2.99	$1.74
Agua	24 botellas (16,9 onzas cada uno) ($3.00)	24 botellas (16,9 onzas cada uno) ($5.00)	Botella de 1 galón ($1.50)	24 botellas (16,9 onzas cada uno) ($4.99)	24 botellas (16,9 onzas cada uno) ($3.57)
Frijoles Negros Enlatados	$1.99	$1.32	$1.29	$1.25	$1.58
Queso	12 onzas de queso cheddar en rodajas ($3.00)	16 oz de queso cheddar en rodajas ($5.79)	N/A	N/A	12 onzas de queso mozzarella en rodajas ($3.28)
"Canasta Básica" (Total gastado para los mismos artículos)	$16.67	$21.89	$20.54	$18.51	$14.61

*LAS SELECCIONES DE FRUTAS, VERDURAS Y CARNE VARIARON EN TODAS LAS TIENDAS
*LOS PRECIOS NO INCLUYEN IMPUESTOS SOBRE LAS VENTAS.
*LOS PRECIOS REFLEJAN EL PRECIO DE MERCADO DURANTE MARZO/ABRIL DE 2024.

5

Figure 24: *"Supermarkets in Gandul" Table included in the student team's Grocery Manual. This table discusses prices of different food items at different local grocery locations.*

Figure 25: *"Map of Gandul" map included in the student team's Grocery Manual.*

The grocery brochure was key to our project as the project team was looking for ways to help the community get essential nutrients that might not be able to be produced in the hydroponic garden. Big commercial corporations offer cheaper prices for essential foods, but are farther away from Gandul and siphon business away from the area. The brochure is meant to encourage cost-effective, local shopping for particular groceries. It also compared the prices directly in a table of

foods considered nutritious and common by residents of Gandul during the focus group. The "Canasta Básica" is a social term for the essential groceries recommended in a healthy diet, so the final row shows the total grocery cost for the essential foods that were in stock across all stores. This row is a great comparison for the same hypothetical basket of food, and was inspired by a local community member we met at Corporación La Fondita de Jesús who explained the term "Canasta Básica".

Key Conceptual Findings

Growing New Partnerships

Our team organized a community meeting the very first week we arrived in order to introduce ourselves and share our project purpose and goals to as many community members as possible. When we finished our introductions and had passed out the flier describing hydroponic gardening and our contact information, Glory and Carola showed us our seats at a large table which was surrounded by many chairs. A dozen mothers and children, a few men, and our sponsors from Corporación La Fondita de Jesús and the community center had seats which circled our table, allowing all to see and talk to us. Conversations and laughs were held between neighbors and shouted across the room filling the center with a constant hum of voices. Getting someone's attention usually took shouting their name three times. Surprise plates of pork, rice, and brown beans were served to our group as the entire room insisted we eat first as guests at Gandul. It was extremely kind and special to be welcomed by the community in such a way that felt like a family reunion. In José's words that is what our group became during our time in Gandul; "...you guys are a part of this community now."

The partnership between our team and our sponsors developed from a vague familiarity of the organizations to a strong understanding of the missions and motivations of each member we worked with. Our professional relationship with our partners at La Fondita grew as we met with Glory and Carola to plan community meetings and sanded PVC pipe for the hydroponic garden together. José and others also provided professional help as we crowded notebook pages with hydroponic sketches, drilled holes into PVC, and traveled to local hardware stores that he introduced us to.

Figure 26: *WPI Student team and local partners drilling holes into the PVC water troughs for the Hydroponic Garden*

Beyond professional compatibility, we felt a personal connection with our sponsors and with members of the community that visited the community center. Many local volunteers demonstrated the value they had for this hydroponics project and their value of our team through service. Local mothers and an elderly friend of José's helped us cut vegetation and clean the alleyway before construction began. Weeks later, their children visited the community center after school and spray-painted the hydroponic garden with José. One man even offered his car and drove us to Home Depot to buy materials. These members of the community and our sponsors were also our lenses for understanding food insecurity in the community and general characteristics of Gandul. Their insight helped our team map the area and highlight resources important to the residents.

Figure 27: *Coloring plants and foods with children who attended the focus group community meeting with their parents.*

Professionalism grew into trust and genuine friendship as we learned about our partners as individuals and they learned about us. José complemented the team's nerves and urgency regarding project success with hopefulness and reassurance. Our team shared interests and conversations about mangoes with José, beaches with Glory, and the Netflix show: "Avatar: the Last Airbender" with Carola, which enabled us to become friends with our coworkers. The most powerful commonality which connected our team and all of our partners was a love for the Gandul community. These relationships established with members of Corporación La Fondita de Jesús, the Gandul Community Center, and several members of the community were vital for completing this project, enriched the experiences and lives of this student team, and paved the way for future collaborations between WPI and the Gandul community.

Building Gandul's Custom Hydroponic Garden

While hydroponics has been around for decades, it has only recently begun seriously taking root in urban areas of Puerto Rico in the past few years. Particularly in Gandul, familiarity with hydroponics varies; locals are aware of its presence, but seem to lack a full understanding of the maintenance and logistics of it. With a generally older demographic, there appears to be favor leaning towards traditional gardening techniques with soil and pots. However, being one of many sub-barrios of San Juan, Gandul residencies generally lack the green space that rural inland towns

tend to have in Puerto Rico. Local residents and sponsors mention growing individual house plants themselves, but it is difficult to self-cultivate produce with only a balcony as outdoor space. With this, the alternative of soil-less agriculture has proven to be an extremely useful alternative.

Our sponsor, Corporación La Fondita de Jesús, is one of the few to take this farming option and put it into action in Gandul through their Vivero Siembra Verde program. Upon arrival, our team was given the opportunity to learn from two of Fondita's members who helped develop and currently operate their hydroponic gardens, our partners and friends, Mark Wilson and Rocío Nájeraurriola. Our other sponsor, José, also helped develop the early stages of these hydroponic gardens which currently provide lettuce and cilantro for public sale and supply the La Fondita community kitchen.

Mark and Rocío led a workshop for us demonstrating a wide array of knowledge to guide our personal hydroponic process. This ranged from the specifics of how to read and adjust nutrients to their own personal tips and cautionary pitfalls which they have encountered over the past five years. For instance, one important note they mentioned was that magnesium needs to be added to the tank separately from the other nutrients since it can react violently otherwise. Through their stories and participatory demonstrations of planting and harvesting, our team gained necessary insight for our own garden design, materials, and plant nutrients. Not to mention, the workshop shined light on the importance of familiarizing ourselves and local participants with the vast realm of hydroponics.

Figure 28: *Learning and practicing transplanting sprouts of lettuce into the hydroponic table systems at La Fondita. The workshop was led by Fondita members Mark and Rocío.*

Out of all of the knowledge that serves to encourage participation and interest in hydroponics, the benefits of its use appear to be the most effective. Hydroponic agriculture is known to require less harvest time, less water, and less maintenance to produce equally healthy and green produce. Moreover, since the input of fertilizer and nutrients is directly measured and placed into water tanks, it proves to be much easier to pinpoint problems as they arise. With this, the blatant advantages hydroponics has over traditional gardens should stir interest in communities like Gandul, that otherwise cannot cultivate harvests of produce. Not to mention, at community meetings with our sponsors and local residents, as time went on we recognized an increase in interest for participation.

As our project and garden developed and we took steps forward with community members, their trust and investment in hydroponics only grew. To combat any remaining unfamiliarity, we have also created and promoted a community hydroponic manual with complementary activity and workshop suggestions (See *Developing a Hydroponics Manual and Educational Program*). Without a doubt, uncertainty and unfamiliarity could be a factor holding back the expansion of hydroponics in Puerto Rico. With people like our partners at La Fondita and Gandul, however, we hope that our partnership with them only increases the growth and push for hydroponics and self-sufficiency in urban areas.

The team has designed an optimal hydroponic garden system to serve the community best by collaborating with the hydroponics expert, José Ramírez, members of La Fondita de Jesús, and local community members. The design process was initially informed by the availability of space at the build site, the needs of the community, and any material or financial limitations. With this, our group has created an A-frame hydroponic model to account for the limited space in the construction site, which is in the alleyway beside the community center. The PVC pipes holding the plants are constructed at a 0.5 inch decline in order for the water to naturally flow through the system and out the receiving end back to the pump in the original bin of water. This allows for a continuous flow of water through the system that is controlled by a standard timer that is on and off on 15 minute intervals. See *Appendix A: Figures* for the proposed design, which includes an image of the garden's location and a draft sketch of the hydroponic system.

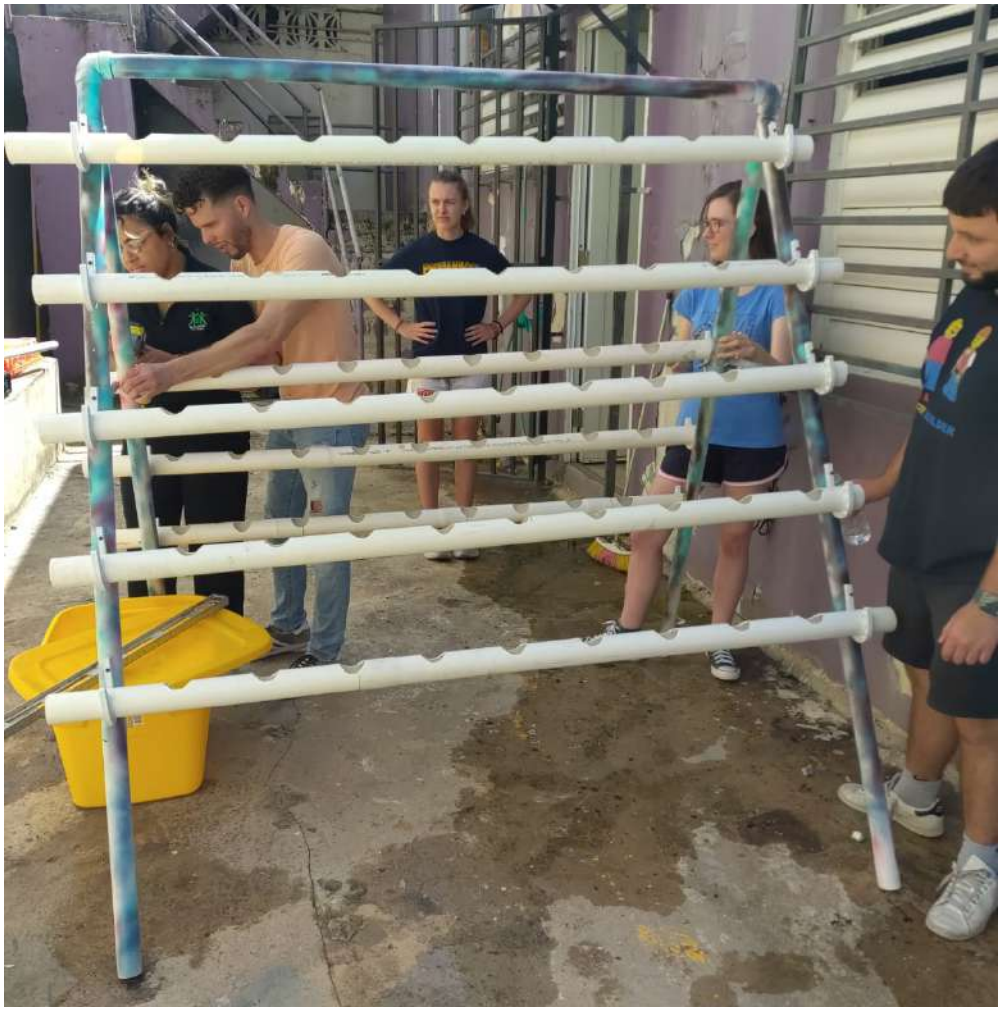

Figure 29*: The team working with Glory and Anthony G. Calzada Rivera to assemble the PVC A-frame. Screws were drilled into PVC pieces to attach J-hooks and strengthen the frame.*

During the design and construction process, our team considered suggestions from several sources in addition to our own findings. To begin, our sponsor José had a major guiding hand in the design. We strongly valued and considered the opinions and participation of local members from the Gandul community and La Fondita during the construction process. Ultimately, a lot of our proposal design drew from the existing hydroponic gardens run by Mark Wilson at La Fondita. Consenting locals were invited to participate in the hydroponic building and maintenance, including drilling holes, cutting PVC, and sanding the PVC troughs.

Figure 30*: Glory Rodriguez, Rayna Jacob, and Brooke Struble sanding the holes in PVC pipes meant to hold plants in the hydroponic garden.*

Our current A-frame hydroponic model cost roughly $600 to build ($650 if no tools had been available to us), and was funded in majority by the WPI PRPC 2024. Additionally, we have received funding and materials from the Hispanic Federation and local donations for future models thanks to the help of José. While costs and upkeep of building materials is a common challenge of hydroponics, our project center and sponsors have fortunately helped meet this. This team's archival research on community-based hydroponic systems implemented in other vulnerable areas of the world also provided useful guidance in the construction process as well as the education manual.

Figure 31: *Jocelyn Hinchcliffe and José Ramírez connecting and testing the tubes for water outflow from the hydroponic system.*

Ideally, with enough resources, budgeting, and time an organization such as the Gandul Community Center could build a resilient greenhouse to protect a hydroponic system from harsh winds and rain year-round. However, the necessary funding and materials were delayed for the first three weeks of March due to funding requests and organizational backups within the Hispanic Federation. In addition to the loss of time and the high cost of implementing a complete greenhouse or roof in the alleyway next to the Gandul Community Center, a walled greenhouse poses a risk of overheating the plants. The greenhouse would trap humidity and induce evaporation, which could be reduced by introducing closeable vents on the walls to allow hot air to escape at the top of the wall and cooler air to enter at the bottom. These vents could be closed during hurricane conditions, however a sturdy greenhouse requires more expensive materials such as steel or aluminum framing and polycarbonate sheets (*Greenhouse Buildings | Greenhouse Facilities | Sprung*, *These Hurricane-Resistant Greenhouses Are Making Island Nations More Self-Sufficient | AGRITECTURE*), anything less is not as likely to endure a hurricane.

The sponsor plans on creating more community hydroponic systems in this alleyway in the future, meaning the ideal greenhouse should span the entire alleyway to be most efficient with cost and materials. A project of this magnitude could be realized in a future IQP collaborating with the Gandul community through additional greenhouse planning, purchasing proper materials, or collaborating with a company such as Sprung Structures to construct a hurricane-resistant greenhouse to incorporate many hydroponic systems.

As a temporary solution in place of a greenhouse, our team elected to build a removable tarp cover for the hydroponic system. Our sponsors' main concern was protecting the plants from rainwater which could alter the pH of the hydroponic system, and they approved of our adjusted plan to use the metal frame of a generic foldable canopy with semi-transparent plastic tarp to cover the top and sides of the hydroponic system. This option successfully shields the system from rainwater and is cost effective since the materials for the canopy were already in storage at the Community Center while plastic tarp is cheap and easy to obtain. Most notably, however, the deconstructible nature of our roof allows for the most protective measure for possible natural disasters: storage inside a building. The plastic tarp is securely fastened to the metal canopy using zip ties and tape. Should a hurricane occur, the cover, hydroponic frame, and plant growth tubes can all be disassembled and stored safely indoors. This design is optimal for Gandul since, hypothetically, a structure that could withstand the intense winds and rain of a hurricane would require thorough investment of a permanent, large structure to protect the patio next to the Community Center.

Figure 32: *The whole student team setting up the clear, plastic canopy to cover the hydroponic system from rain.*

For the purposes of this project and in consideration of budgeting, time, and materials the hydroponic garden will be best protected within the walls of a standard building like the Gandul Community Center. This method of ensuring long-term protection of the hydroponic system was also recommended and affirmed to our group by an employee from Hydro Warehouse PR, a specialty gardening and hydroponics store roughly 15 minutes outside of Gandul. Their garden expert employees all recount the destruction caused by hurricane Maria vividly. Thus at any time our sponsor could disassemble and store the hydroponic garden, while also utilizing easily replaceable, affordable materials.

Discovering the Gandul Diet

The very name of Gandul, which translates to “pigeon pea”, juxtaposes its availability of nutritious foods. Shopping options are limited in Gandul, thus influencing the local diet. Despite its distance from Gandul, Walmart is the most popular grocery destination because of its affordable prices and wide variety of items, catering to the dietary needs of the community. The lack of variety in more accessible locations forces residents to rely on Walmart for a complete shopping experience. While local stores exist within Gandul, they are typically limited in stock and only offer basic essentials such as canned foods, grains, and beverages. These shops often fall short in providing a wider variety of fresh produce, which influences the dietary habits of residents and highlights the significant gap in Gandul’s dietary landscape.

Figure 33: *José Ramírez collects real gandules (pigeon peas) that grow in the community as small trees.*

The limited availability of fresh produce in these local stores contrasts sharply with the extensive array of fruits and vegetables found at Walmart. This discrepancy underscores a broader issue within the community: access to diverse and nutritious food options is not just a matter of preference but of logistics and economic feasibility. Consequently, residents who prioritize a diet rich in fresh produce must make the trip to the farther, inaccessible Walmart.

Figure 34: *Kenneth Smith showing a picture of the aisles in one of the local bodegas in Gandul.*

Ethnographic observations of dietary patterns in Gandul revealed distinct preferences and priorities between men and women. Older women in the community, for example, prioritize purchasing fruits and vegetables, emphasizing the importance of a balanced and nutrient-rich diet. In contrast, men tend to gravitate towards meats and carbohydrate-rich foods. This division not only highlights dietary preferences, but also points to a broader cultural division of nutritional roles and awareness within the community.

Amongst all demographics, foods favored by the entire community include chicken, pork, rice, beans, plantains, and salads. These items form the backbone of local cuisine and are cherished

across generations. The popularity of these foods reflects a deep cultural heritage and a preference for hearty, flavorful meals. The community's culinary practices are not only a reflection of their cultural identity but also a response to the limited shopping options and the economic realities of living in Gandul. This interplay between culture, economy, and food availability paints a complex picture of daily life and dietary habits in the Gandul community.

Figure 35: *Various foods the team ate which were made in restaurants in Gandul and by several local mothers for community meeting dinners. Top two images are sandwiches of ham, pork, pickles, and mustard. Bottom two dinners are brown rice, black beans, pork chops, chicken thighs, and small side salads.*

Gathered opinions from the April 3rd community meeting indicated that Gandul residents eat in accordance with health and hunger, prioritizing vegetables, grains, and meats. However, when purchasing food, the consideration of price trumps preference. Limited availability of fresh foods in local stores inform dietary decisions as well. Thus, shopping for what is currently available and affordable tend to be the deciding factors. With this, price and freshness of food are the two only factors residents would prefer to change about local food stores.

Reduced grocery sources significantly influence Gandul's dietary habits and access to diverse foods. With local stores only offering basic essentials, residents must work with what is cheapest and closest nearby. Overall, the relationship with food in Gandul is crucial, as it reflects the community's identity, health, and sense of unity.

Gandul: The Peapod of San Juan

Just like the peas of a *gandule* [pigeon pea], the Gandul community embodies a close-knit pod, where each member grows in unity amongst a diverse family of dependable, committed members. From the seeds of fruitful young toddlers to the long withstanding trees of resilient elders, Gandul is a comforting home for a variety of families and individuals. Tasked as the only individual responsible for the uptake of the Gandul Community Center, José Ramírez ("Papo") serves as an amicable, lighthearted grandfather figure for all community members. This can be especially illustrated in his relationship with Meibeline Humphrey, a 21-year-old college student and part-time restaurant employee, who has been deeply involved with the community center. At first glance, many locals assume José and Meibeline are relatives, from their father-daughter chemistry. Whether it is their sarcastic bickering or José's incessant encouragement for Meibeline to pursue professional basketball, there is a sense of mutual respect and compassion.

José's presence as a respectable figure is also observed when walking along the streets of Gandul. Everywhere José wanders, a friendly holler is sure to be heard- "Que pasó, José?". His joyful energy radiates wherever he steps, brightening the faces of the destitute, making them feel appreciated and seen as he warmly greets them at the Corporación La Fondita de Jesús entrance.

Figure 36: *Playing an ice-breaker game ("The High-Five Challenge") with the Gandul community before beginning a community meeting.*

This appreciation is also visible in other community members, especially at large community gatherings. Once every few weeks, locals meet in the Gandul Community Center to partake in a community program, often followed by a provided dinner. The open space is filled with various noises, illuminating the room with life: the soft sound of pleasant chatter, the squeals of a mischievous 3-year-old girl, the laughter of teenagers escaping from their enclosed corner. A contagious energy especially radiates from the young girl as she affectionately embraces the local mothers and frivolously prances around the room, peeping adorable animal noises. Everyone is enraptured by her innocence and cares for her, like their own daughter or younger sister. Community meetings typically feature interactive, icebreaker activities generally enjoyed by the participants since they encourage individuals to learn new information lightheartedly. Therefore, the hydroponic educational workshop was designed to feature engaging activities known to be liked by the community.

Once it is time for dinner, everyone finds a seat and anticipates the delicious meal. Rather than everyone serving themself, buffet-style, the Gandul women make their way to each person gently laying plates of savory, Puerto Rican dishes. There is a sense of humility and respect in this kind of gesture. Gathered, the Gandul community joyfully communes like a family at the dinner table.

It is clear that the people of Gandul not only live as residents of their cherished town, but also as relatives of each other. This camaraderie translates into a passion for serving the community and improving its conditions. While the presence of homelessness, drug abuse, violence and crime taint Gandul's image, the community carries a determined sense of responsibility to revitalize its home. Directly across the Gandul community center is a children's park surrounded by a sapphire-blue gate and vibrant murals. However, this community space was once an area where the homeless would gather, polluted with used needles and debris. The community was committed to reclaiming this space and worked to clean the park, adding new playsets, painting the cement walls with creative artwork, and fastening a secure gate around the enclosure. Motivated to make an area for children to safely gather, the community members' united efforts illustrate their relentless perseverance to create a better future for Gandul.

Figure 37: *Gandul Community Park (Lealtad Park) that sits directly across the street from the Community Center.*

Conclusion

The team delivered a hydroponic garden to the Gandul community which provides sustainable agricultural services, allows members to learn new gardening techniques, fosters connectivity between different various generations and demographics, and serves as an outlet to improve mental health and relieve stress. Supplementing the garden was the creation of two educational deliverables, encouraging community knowledge and familiarity with hydroponics. These pieces facilitate the adoption of sustainable practices and will help the hydroponic garden function well for many years to come.

Additionally, the team created a comprehensive map of the Gandul community in a grocery brochure. The map highlighted local grocery stores in the Gandul community and provided information about shopping factors to encourage local shopping. Mapping created from the local perspective of shopping priorities and neighborhood borders allowed for more accurate, relevant information which can inform and encourage locals to affordably shop in Gandul.

This project also marked the establishment of a new partnership between Worcester Polytechnic Institute and the Gandul area, facilitated through the El Gandul Community Center. The project team believes that the growth within the hydroponic garden symbolizes the growth of the Gandul community, along with WPI's growth of new connections with global communities such as Gandul. This project was also a stepping-stone to redeeming the United States' relationship with Puerto Rico as the two nations have historically had unpleasant accounts with each other.

As aspiring engineers and scientists, this project has allowed the team to experience the process and impact of engineering beyond the classroom. Through participatory design, extensive background research, and numerous accounts of trial and error, the team utilized problem-solving strategies to fulfill a need in the community. Lessons on effective collaboration, engineering principles, and successful implementation can be synthesized from this 7-week experience. Furthermore, this hands-on project exposes the project team to work beyond the typical work found within each teammate's major.

This Interactive Qualifying Project not only inspired connection between WPI and the Gandul community, but also amongst the four unique students of this team, sprouting collaboration from different disciplines of study. These insights are valuable for each teammate's future as we encounter various individuals in our professional lives. From clients to colleagues, this experience has equipped us with necessary skills to make fruitful change for the world outside of WPI, and enriched our lives as our memories and hearts stay with Gandul.

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Annex

Appendix A: Figures

Relative Poverty from the U.S. Census Bureau by State/Territory

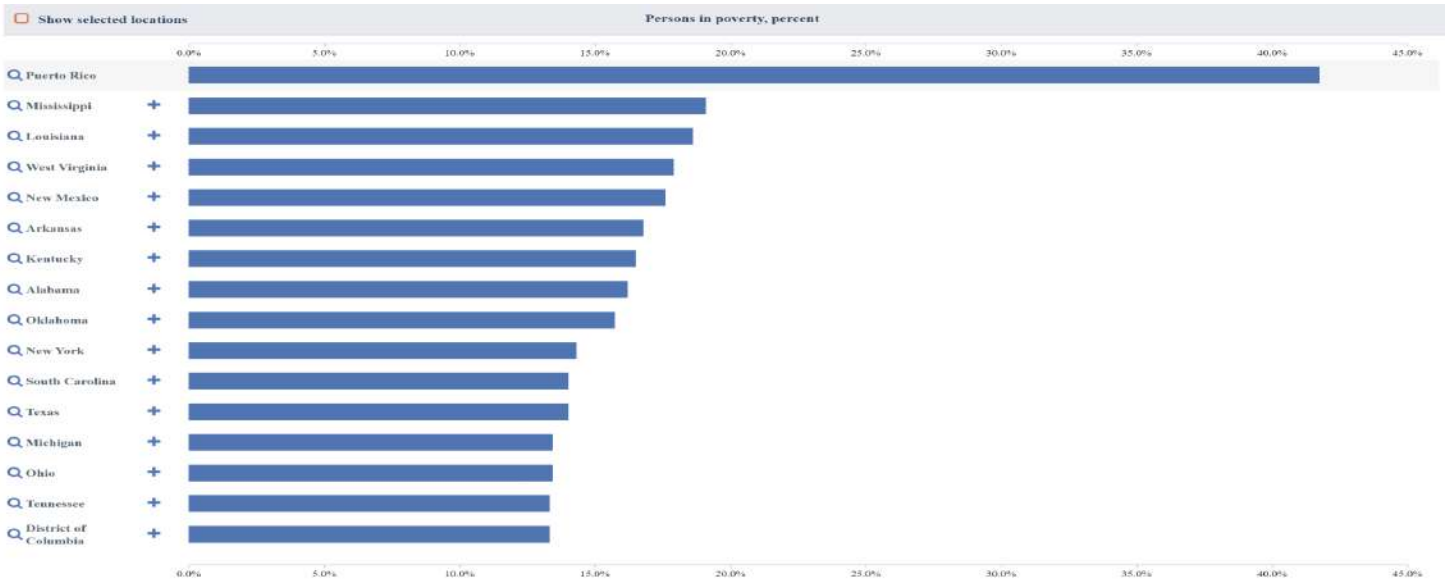


Figure 1: Puerto Rican average poverty population by percentage compared to mainland U.S. states

U. S. Census bureau quickfacts: Puerto rico. (n.d.). Retrieved February 28, 2024, from

https://www.census.gov/quickfacts/geo/chart/PR/IPE120222

Potential Hydroponic Garden Design

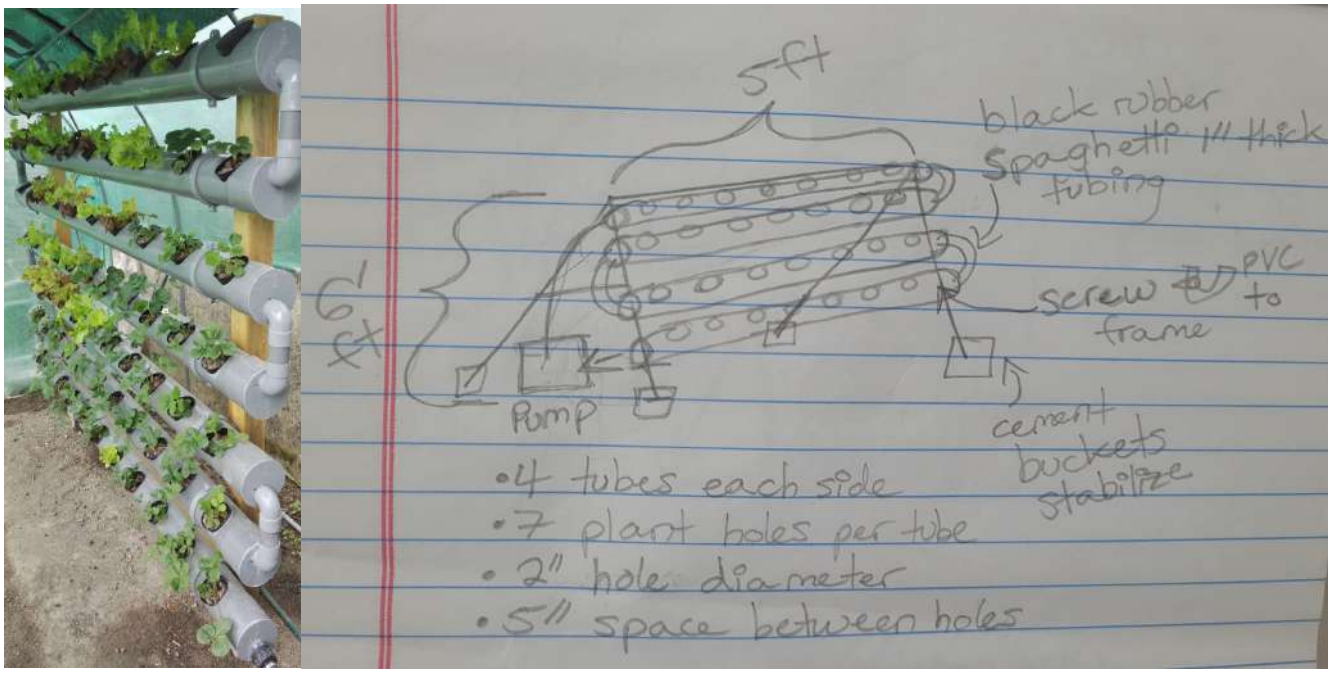


Figure 2: Hydroponic system flow design inspiration before arriving on site in Gandul (Left).

Hydroponic frame design during the second week on site (Right).

(20+ Best Hydroponic Gardening Design Ideas For Beginners | Hydroponic gardening, Hydroponic farming, Hydroponics diy. (n.d.). Pinterest. Retrieved February 18, 2024, from https://www.pinterest.com/pin/722405596464576240/)

Appendix B: Interview Questions for Gandul Community

Questions:

Section A: Hydroponic Gardening

1. What is your experience with gardening? Feel free to share your experiences from any point in your life.
2. Are you familiar with hydroponic gardening?
3. We (the student team) are working together with El Gandul Community Center and La Fondita de Jesus to build a hydroponic garden for the community to use and gain fresh

produce from. Are there specific foods you would like to have grown in the hydroponic garden?

4. Do you think the community will take care of the hydroponic system in the future? How can we encourage residents to visit and tend to the garden?
5. Do you have any suggestions for the system design, location, or information you want to know from us?

Section B: Food Insecurity

1. What inspired you to work with or visit Corporación La Fondita de Jesús or the Gandul Community Center?
2. Where do you purchase your food? Is there any particular reason you shop there?
3. If you could change one thing about local food stores in Gandul what would it be and why?
4. Have you ever had any concerns about having enough food?
5. If given access to a local community garden, would you consider partaking in its maintenance and share its produce?

Appendix C: Focus Group Responses (Spanish)

Gandul Community Center Focus Group
Date: April 3, 2024 Community Meeting
Participants: Project Team and Gandul Community Members

Activity 1) Dinámica caminata del privilegio

Aseveraciones:

- **Tengo más de 10 años viviendo en el Gandul**
    - **Número de personas: 7/12**

- **Compras regularmente en los supermercados de la comunidad, por ejemplo, Quisqueya**
    - **Número de personas: 3/12**
- **Tengo un espacio para cosechar alimentos en mi hogar**
    - **Número de personas: 0/12**
- **Nunca me he acostado sin comer**
    - **Número de personas: 2/12**
- **Conoces a alguna persona o has experimentado el no tener alimentos para alimentarte a ti o tu familia**
    - **Número de personas: 12/12**
- **Tienes la posibilidad de comer frutas y vegetales al menos una vez al día**
    - **Número de personas: 8/12**
- **Cuentan con alimentos saludables y nutritivos en su hogar**
    - **Número de personas: 11/12**

Activity 2) Breve descripción de seguridad alimenticia. ¿Por qué están trabajando en el proyecto de hidroponía?

- **¿Sabes qué es seguridad alimenticia?**
- **¿Sabes qué es inseguridad alimentaria?**

Activity 3) Comida galería El Gandul

Preguntas escribido en espanol Sección A: Jardinería hidropónica - En español

1) **¿Cuáles son tus prioridades cuando vas a comprar comida? ¿Precios, comida, cantidad, cualidad, alimentos frescos, sabor, comida local o importada?**

1. Precios: No tienen suficiente dinero para comprar alimentos que sean saludables o buenos para ellos. Necesitan distribuir el dinero y gastarlo según corresponda.

2. Por gustos o preferencia

3. Buscando la economía

4. Prioridades, lo que necesito al momentos

5. Compran alimentos perecederos para que dure más la compra. O normalmente compran productos no perecederos.

2) **Sí puedes cambiar una cosa sobre las tiendas de alimentos locales qué sería y por qué?**

1. Los precios, ya que usualmente los venden al doble que las cadenas de supermercados

2. Que sea comida fresca porque a veces están vencidas. Las tiendas no deberían vender alimentos echados a perder.

3) **¿Qué tipo de alimentos come con frecuencia? ¿por qué?**

1. Vegetales, granos, carnes, Pan, tostadas integrales, avena, café, huevo hervido, leche, arroz, habichuelas, sopa de huevo hervido, chuletas, pollo, viandas, guineo verde, aguacate

2. La razón por la que comen estos alimentos es por salud, hambre y porque es lo que tienen disponible.

3. Algunas personas afirmaron que comerán cualquier cosa.

4) **¿Alguna vez has tenido alguna preocupación sobre tener comida suficiente para alimentarte a ti o a tu familia?**

1. Si, hay que rendir el dinero y la comida.

2. Sí, me preocupo cuando los precios suben o mi comida caduca.

5) **¿Si se le da acceso a un hidropónico comunitario, consideraría participar en su mantenimiento y compartir sus productos?**

1. Están interesados en el mantenimiento de la hidropónica. Tiempo. Aprender, adquirir, conocimiento. Están dispuestos y ansiosos por ayudar, pero quieren saber más sobre cómo funciona la hidroponía y cómo pueden ayudar.

2. Los próximos pasos son cultivar productos como cebollas, ajos y otras cosas que crecen rápidamente y duran mucho tiempo.

Appendix D: Focus Group Responses (English)

Gandul Community Center Focus Group
Date: April 3, 2024 Community Meeting
Participants: Project Team and Gandul Community Members

Activity 1) Dynamic walk of privilege

Assertions:

- **I have been living in El Gandul for more than 10 years.**
    - **Number of people: 7/12**
- **You shop regularly at community supermarkets. e.g. Quisqueya**
    - **Number of people: 3/12**
- **I have a space to harvest food in my home.**
    - **Number of people: 0/12**
- **I have never gone to bed without eating.**
    - **Number of people: 2/12**
- **Do you know someone or have experienced not having food to feed yourself or your family?**
    - **Number of people: 12/12**
- **You have the possibility of eating fruits and vegetables at least once a day**

- **Number of people: 8/12**

- **They have healthy and nutritious foods in their home**
  - **Number of people: 11/12**

<u>Activity 2) Brief description of food safety. Why are you working on the hydroponics project?</u>

- **Do you know what food safety is?**
- **Do you know what food insecurity is?**

<u>Activity 3) Food gallery of El Gandul</u>

Questions written in Spanish Section A: Hydroponic Gardening

6) **What are your priorities when you go shopping for food? Prices, food, quantity, quality, fresh food, flavor, local or imported food?**

   1. Prices: They don't have enough money to buy food that is healthy or good for them. They need to spread out the money and spend it accordingly.

   2. By taste or preference

   3. Looking for the economy

   4. Priorities are whatever I need at the moment. When I go to the store for a food I am craving or how much money I have saved that week.

   5. They buy perishable foods to make the purchase last longer. Or they usually buy non-perishable products.

7) **If you could change one thing about local food stores what would it be and why?**

   1. The prices, since they usually sell them at double that of supermarket chains

   2. Let it be fresh food because sometimes they are expired. Stores shouldn't sell spoiled food.

8) **What type of foods do you eat frequently? because?**

1. Vegetables, grains, meats, bread, whole grain toast, oats, coffee, boiled eggs, milk, rice, beans, boiled egg soup, pork chops, chicken, tubers, green banana, avocado.

2. The reason they eat these foods is for health, hunger, and because it's what they have available.

3. Some people claimed that they will eat anything.

9) **Have you ever had any worries about having enough food to feed yourself or your family?**

1. Yes, you have to give up money and food sometimes.

2. Yes, I worry when prices go up or my food expires.

10) **If given access to a community hydroponic, would you consider participating in its maintenance and sharing your products?**

1. They are interested in hydroponic maintenance. Time. Learning, acquiring, knowledge. They are willing and eager to help, but they want to know more about how hydroponics work and how they can help.

2. The next steps are to cultivate products like onions, garlic, and other things that grow quickly and last long.

Appendix E: Verbal Consent Script

Verbal Consent Script (Adult Participants):

1) **Adult Participation: Derived from University of Oxford "Template Oral Consent Script"**

Introduction: Hello [x], my name is [x]. I'm currently doing my undergraduate degree at Worcester Polytechnic Institute and am working on my Interactive Qualifying Project, or IQP.

Project details and aims: In my project, I want to learn about the presence of food insecurity and the significance of community engagement in Gandul, San Juan. With the Gandul Community Center, our team will be building a hydroponic garden to reduce food insecurity and provide an outlet for the community to learn and develop. To get a sense of how food insecurity is experienced and how the garden can be tailored to fit the needs of Gandul, I will be conducting interviews with locals. If you choose to be a part of this interview here is what will happen:

Interviews/ surveys/ tasks description: I will have a conversation with you for about 10-15 minutes where I will ask a range of questions about your experiences with food insecurity and your opinions on a hydroponic community garden.

Data sharing/ access/ confidentiality: The responses you give will form the basis of my IQP project publication and final presentation.

The IQP team and advisors will have access to personal data that you may provide, such as where you reside, when you were born, your age etc. Your personal information will be confidential and will be stored safely in an encrypted, digital folder. The data will be kept in the folder for 2 years after publication.

I would like to be able to use your de-identified data in future studies, and to share this data for future IQP projects.

Audio/ video recording/ photos/ notes: With your permission, I would like to take an audio recording of our discussion to make sure I'm getting an accurate record of the interview. Instead of recording you, I can take notes in my notebook. Which would you prefer?

Keeping contact details: I would also like your permission to keep your contact details so that I can re-contact you to clarify information you gave me in your interview.

Risks: The following risks are involved in taking part in this interview: discussion on struggle to find food, which can be a sensitive topic, and the chance that the interview might exceed 15 minutes, which could seem time-consuming to you. You might find aspects of this interview difficult as I'll be asking for your opinions about hunger, lack of access to proper food, and struggle. In order to reduce any potential risks, I will let you know beforehand if the question involves a sensitive topic. You may also choose to not answer any questions if you do not want to. You can also request to take a break during the interview or stop the interview altogether if you feel uncomfortable.

Rights: You can choose to not participate in the interview. You can ask me any questions you want before or throughout the interview. You can also withdraw at any stage of the interview without giving a reason. After the interview you can withdraw your information until April 29, 2024.

Publication plans: The project will be published in an online archive of past WPI projects.

Complaints/ concerns procedure: If you have any complaints or concerns please feel free to contact me. My phone number is [mobile number]. You can also reach me at [WPI email address].

Ethics review details: This project has been reviewed and approved by a Worcester Polytechnic Institute ethics committee, the WPI IRB. The ethics reference is [Rxxxxx]. If, after contacting me with any concern, you're still unhappy and wish to make a formal complaint, please contact the ethics committee. Their email address is irb@wpi.edu.

Data Protection statement: Worcester Polytechnic Institute is responsible overall for ensuring the safe and proper use of any personal information you provide, solely for project purposes. Further information about your rights to information you provide is available from the university's data protection website: https://www.wpi.edu/about/policies/privacy-notice

Do you have any questions?

Do you give your permission for me to interview you and audio record you?

Do you give permission for me to re-contact you to clarify information?

Do you give me permission to quote you directly? It is up to you on whether you would prefer me to use your real name or quote you without personal identification.

Are you happy for me to collect sensitive personal data as specified earlier in our conversation?

Are you happy to take part in this project?

Ok, thank you, let's start.

Appendix F: Interview Consent Form (Spanish)

Introducción: Hola [x], mi nombre es [x]. Actualmente estoy haciendo mis estudios universitarios en el Instituto Politécnico de Worcester y estoy trabajando en mi Proyecto de Calificación Interactivo, o IQP.

Detalles y objetivos del proyecto: En mi proyecto, quiero aprender sobre la presencia de inseguridad alimentaria y la importancia de la participación comunitaria en Gandul, San Juan. Con el Centro Comunitario Gandul, nuestro equipo construirá un jardín hidropónico para reducir la inseguridad alimentaria y brindar una salida para que la comunidad aprenda y se desarrolle. Para tener una idea de cómo se vive la inseguridad alimentaria y cómo se puede adaptar el huerto a las necesidades de Gandul, realizaré entrevistas con los lugareños. Si elige ser parte de esta entrevista, esto es lo que sucederá:

Entrevistas/encuestas/descripción de tareas: Tendré una conversación con usted durante unos 10 a 15 minutos donde le haré una variedad de preguntas sobre sus experiencias con la inseguridad alimentaria y sus opiniones sobre un jardín comunitario hidropónico.

Intercambio de datos/acceso/confidencialidad: Las respuestas que usted proporcione formarán la base de la publicación y presentación final de mi proyecto IQP.

El equipo y los asesores de IQP tendrán acceso a los datos personales que usted pueda proporcionar, como dónde reside, cuándo nació, su edad, etc. Su información personal será confidencial y se almacenará de forma segura en una carpeta digital cifrada. Los datos se conservarán en la carpeta durante 2 años después de su publicación.

Me gustaría poder utilizar sus datos no identificados en estudios futuros y compartir estos datos para futuros proyectos de IQP.

Grabación de audio/vídeo/fotos/notas: Con su permiso, me gustaría realizar una grabación de audio de nuestra conversación para asegurarme de obtener un registro preciso de la entrevista. En lugar de grabarte, puedo tomar notas en mi cuaderno. ¿Cual preferirías?

Conservar los datos de contacto: También me gustaría su permiso para conservar sus datos de contacto para poder volver a comunicarme con usted para aclarar la información que me proporcionó en su entrevista.

Riesgos: Los siguientes riesgos están involucrados al participar en esta entrevista: discusión sobre la lucha por encontrar comida, que puede ser un tema delicado, y la posibilidad de que la entrevista exceda los 15 minutos, lo que podría parecerle lento. Es posible que algunos aspectos de esta entrevista le resulten difíciles, ya que le pediré su opinión sobre el hambre, la falta de acceso a una alimentación adecuada y la lucha. Para reducir cualquier riesgo potencial, le avisaré de antemano si la pregunta involucra un tema delicado. También puede optar por no responder ninguna pregunta si no lo desea. También puede solicitar un descanso durante la entrevista o detenerla por completo si se siente incómodo.

Derechos: Puede optar por no participar en la entrevista. Puedes hacerme las preguntas que quieras antes o durante la entrevista. También podrá retirarse en cualquier momento de la entrevista sin dar motivo. Luego de la entrevista podrás retirar tu información hasta el 29 de abril de 2024.

Planes de publicación: el proyecto se publicará en un archivo en línea de proyectos anteriores de WPI.

Procedimiento de quejas/preocupaciones: Si tiene alguna queja o inquietud, no dude en ponerse en contacto conmigo. Mi número de teléfono es [número de móvil]. También puede comunicarse conmigo en [dirección de correo electrónico de WPI].

Detalles de la revisión de ética: este proyecto ha sido revisado y aprobado por un comité de ética del Instituto Politécnico de Worcester, el WPI IRB. La referencia ética es [Rxxxxx]. Si, después de contactarme con alguna inquietud, aún no está satisfecho y desea presentar una queja formal, comuníquese con el comité de ética. Su dirección de correo electrónico es irb@wpi.edu.

Declaración de protección de datos: Worcester Polytechnic Institute es responsable en general de garantizar el uso seguro y adecuado de cualquier información personal que usted proporcione, únicamente para fines del proyecto. Más información sobre sus derechos sobre la información que proporciona está disponible en el sitio web de protección de datos de la universidad: https://www.wpi.edu/about/policies/privacy-notice.

¿Tiene usted alguna pregunta?

¿Me das permiso para entrevistarte y grabarte en audio?

¿Me das permiso para volver a contactarte para aclarar información?

¿Me das permiso para cotizarte directamente? Depende de usted si prefiere que use su nombre real o lo cite sin identificación personal.

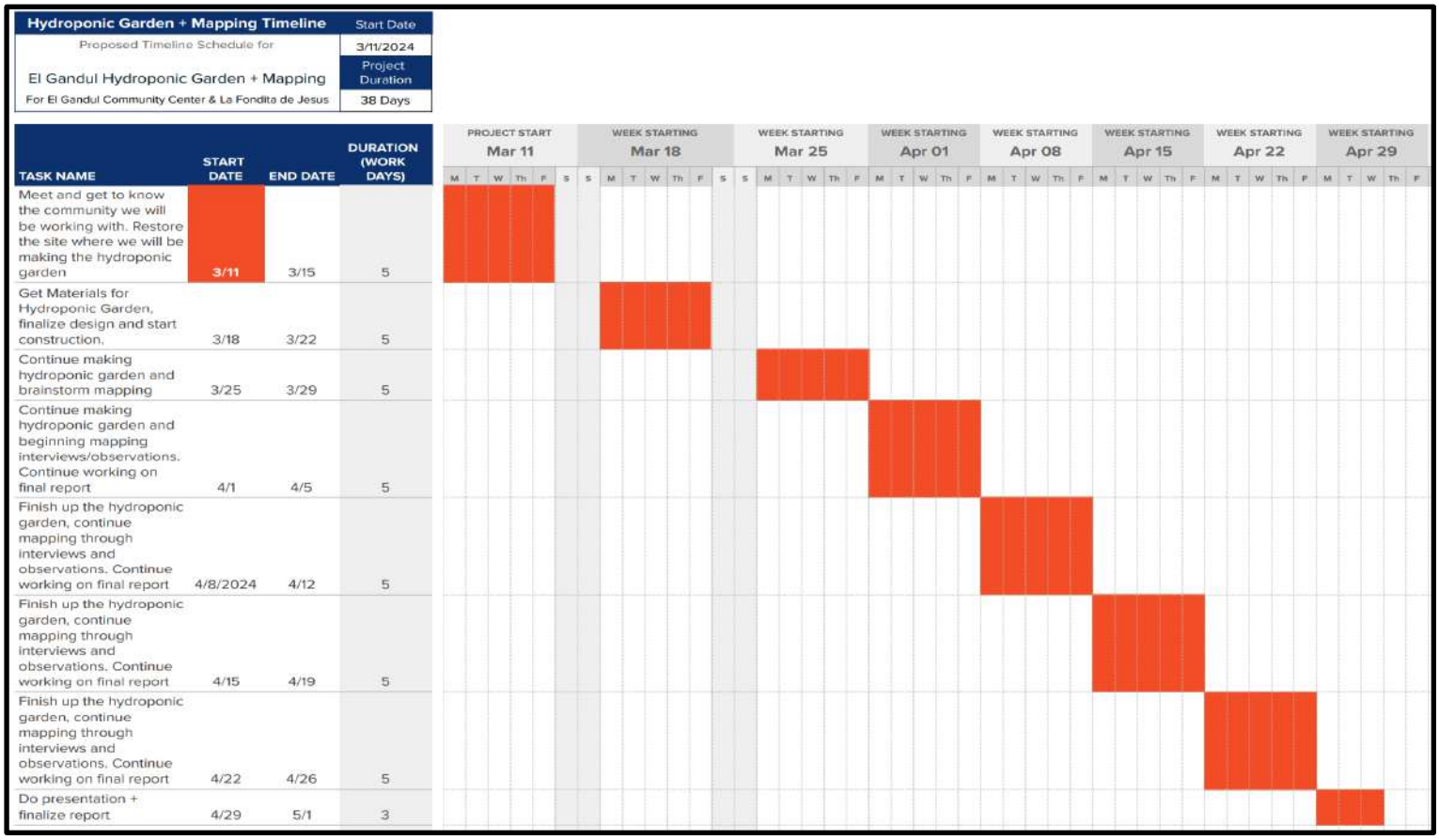
¿Está contento de que recopile datos personales confidenciales como se especificó anteriormente en nuestra conversación?

¿Estás feliz de participar en este proyecto?

Ok, gracias, comencemos.

Appendix G: Gantt Chart

Project Outline Gantt Chart



Hydroponic Garden + Mapping Timeline	Start Date
Proposed Timeline Schedule for	3/11/2024
El Gandul Hydroponic Garden + Mapping	Project Duration
For El Gandul Community Center & La Fondita de Jesus	38 Days

TASK NAME	START DATE	END DATE	DURATION (WORK DAYS)
Meet and get to know the community we will be working with. Restore the site where we will be making the hydroponic garden	3/11	3/15	5
Get Materials for Hydroponic Garden, finalize design and start construction.	3/18	3/22	5
Continue making hydroponic garden and brainstorm mapping	3/25	3/29	5
Continue making hydroponic garden and beginning mapping interviews/observations. Continue working on final report	4/1	4/5	5
Finish up the hydroponic garden, continue mapping through interviews and observations. Continue working on final report	4/8/2024	4/12	5
Finish up the hydroponic garden, continue mapping through interviews and observations. Continue working on final report	4/15	4/19	5
Finish up the hydroponic garden, continue mapping through interviews and observations. Continue working on final report	4/22	4/26	5
Do presentation + finalize report	4/29	5/1	3

Figure 4: Gantt Chart for 7-Week Time Period

Team tasks are divided into the weekly sprints where one task under "Task Name" is the focus for each specific week. This Gantt chart serves as a template for the projected progression of this project. It may be modified throughout the project to adjust for any timeline deviations.