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## Developing Permaculture Systems Through Community Based Programs in Carpio, Costa Rica

An Interactive Qualifying Project (IQP) Submitted to the Faculty of  
WORCESTER POLYTECHNIC INSTITUTE



In partial fulfillment of the Requirements for the Degree of  
Bachelor of Science

Submitted by:

Leila Chow (ECE)  
Isabella Garver (BIO)  
Cole Jeznach (MA)  
Marisa Sposato (CHE)  
Jaime Stephen (ME)

Submitted to:

Professor Fabienne Miller, Worcester Polytechnic Institute,  
Ph. D  
Professor Seth Tuler, Worcester Polytechnic Institute, Ph. D



# WPI

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Sponsoring Agent:

Sistema Integral de Formación Artística  
para la Inclusión Social (SIFAIS)



Costa Rica Project Center

Worcester Polytechnic Institute

This report represents the work of 5 WPI undergraduate students submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on its website without editorial or peer review. For more information about the projects program at WPI, please see

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## Abstract

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Carpio, Costa Rica is a poor urban community that struggles with pollution, social exclusion, and stress. The goal of our project was to develop a permaculture program with our sponsor SIFAIS to create green space while maintaining and improving community involvement. To achieve this goal we observed the community and determined its constraints, investigated best gardening practices, and tested and analyzed the practices. We worked with children at SIFAIS to create community gardens at their site and with seven families to create individual gardens for their homes. To promote involvement among residents we created informative materials to start a garden, recommended ways to share gardening practices, and proposed ways for community members to obtain fertilizer and more plants.

## Executive Summary

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### The Problem, Goal, and Objectives

Currently, one quarter of the people living in poverty, which is defined as living on less than \$2 per day, reside in an urban setting (Baker, 2008). Urban poor face a variety of social disadvantages that result in a lower quality of life (Katzman, 2001) including pollution (Molpeceres-Abella & Garca-Lapresta, 2016), social exclusion (Hanna & Oh, 2000), and stress (Weller, 2015). These conditions make it difficult for the urban poor to go beyond the struggles of daily life to develop important relationships (Baker, 2008).

Carpio, Costa Rica, a community located 10 kilometers north-west of San Jose, struggles with the social disadvantages linked to urban poverty (Schneider, 2008). Organizations in the community, such as our sponsor El Sistema Integral de Formación Artística para la Inclusión Social (SIFAIS), have been using a bottom-up approach to engage community members and address problems associated with urban poverty in Carpio (Fundación SIFAIS, 2015). For example, SIFAIS offers judo, music, and sewing classes to empower community members by teaching them new skills, and is looking for new programs that have a similar mission. Permaculture programs, or permanent agriculture, offer a complement to existing SIFAIS programs and provide additional benefits, such as educating people about environmental concerns, enhancing a neighborhood by creating a sense of community, and helping to reduce mental stress (Kuo, Sullivan, Coley, & Brunson, 1998; Saldivar-Tanaka & Krasny, 2004).

**The goal of the project was to develop a permaculture program in Carpio to create green space while maintaining and improving community involvement.** To achieve this goal we:

1. Determined the constraints and opportunities of the Carpio community as they pertain to gardening and composting.
2. Investigated best gardening, composting, and community involvement practices in Carpio.
3. Applied best practices to create gardens in Carpio.
4. Assessed the response of the Carpio community and the status of gardens.

### Methodology

To guide our approach on creating green spaces, we determined the constraints and opportunities in the Carpio community by observing the materials, water, soil, and motivation of community members. We used this information to narrow potential garden designs for the community. To deepen our knowledge of gardening, composting, and how to involve the community, we interviewed nine experts to help us develop permaculture designs and implementation methods for Carpio.

We provided community members the opportunity to learn how to build and take care of a garden by working hand-in-hand to make community gardens at SIFAIS and individual gardens for their homes. The community gardens included four different styles of gardens as seen in the photos below: tire gardens, hanging can gardens, ground gardens, and fence gardens.



Planter types at SIFAIS: a) tire garden (top left) , b) hanging can garden (top right), c) ground garden (bottom left), d) fence garden (bottom right).

We created the community gardens by using repurposed materials found at SIFAIS and by obtaining plants and soil from a nursery in San Jose. We involved children throughout the building process both to encourage motivation and get people excited about the gardens. We made seven colorful tire gardens, ten hanging can gardens, two ground gardens, and a fence garden with four window boxes. After construction, we checked on the plants semiweekly and made adjustments to the garden designs and types of plants in each garden in response to plant status.

We also helped seven families create individual gardens for their homes. First, we interviewed interested families to learn about their plant preferences and past experiences with gardening. Second, we conducted a workshop with each family to assist them in building their own individual gardens using a window frame, plastic cardboard, chicken wire, and plastic bottles as seen in the photos below.



A hanging garden being constructed and installed in Carpio home

Finally, to assess the workshop, we conducted post-workshop interviews to see what the families thought of the building process. One week after the workshop, we conducted follow-up interviews to check on the status of their plants and assess how well garden had assimilated into the families' lifestyles.

## **Findings**

1. Materials for construction, space, soil, and motivation are constraints for gardening and composting.

### *Community gardens at SIFAIS*

After constructing the community gardens at SIFAIS and monitoring the status of the plants and people's interactions with the garden, we developed three key findings that relate to the motivation of community members to use the community gardens and three key findings that relate to the logistics of the constructing and maintaining the community gardens.

#### **Motivation of community members to use the community gardens**

2. Community gardens at SIFAIS were sustained by children and art.
3. Garden design encouraged behaviors that can undermine the garden or encourage inappropriate behaviors.
4. Maintaining the interest of community members to take care of the community gardens was difficult.

#### **Logistics of constructing and maintaining the community gardens**

5. Simple irrigation systems were a solution for dry soil conditions in the community gardens at SIFAIS.
6. Using repurposed materials helped to overcome the problem of limited resources.
7. Location has a large impact on the health of plants because of variations in sunlight, and wind.

### *Individual gardens in homes*

After working with the the seven families to constructing individual, vertical gardens for seven different members of the Carpio community and interviewing those that were involved, we developed five findings that relate to the motivation of community members to garden individually and four related to the logistics of constructing and maintaining the individual gardens.

#### **Motivation of community members to garden individually**

8. Following up, being responsive, and forming relationships with gardening participants was important for maintaining motivation and participation.
9. Community members of Carpio learn well through hands-on instruction and demonstrations.
10. Gardens that fulfill a person's purpose lead to increased motivation.
11. Residents enjoyed using repurposed, accessible materials to construct individual gardens.
12. Visually appealing gardens motivate more community members to participate.

#### **Logistics of constructing and maintaining the individual gardens**

13. Bartering helped community members overcome resource constraints.
14. Vertical gardens are an effective use of limited space in homes.
15. Gardeners repaired their gardens successfully and with little assistance.
16. There is a demand for usable soil and fertilizer in Carpio.

## Recommendations

The recommendations we presented to SIFAIS are organized into five main categories:

- Maintaining the community gardens at SIFAIS
- Improving the community gardens at SIFAIS
- Maintaining individual gardens for homes in Carpio
- Improving individual gardens for homes in Carpio
- Composting for the community

Additionally, we present recommendations for future SIFAIS volunteers or IQP teams.

### Maintaining the community gardens at SIFAIS

**We recommend that SIFAIS staff utilize the plant guides for the community gardens.**

The purpose of this recommendation is to ensure that the plants in the community gardens have the best chance of thriving. In Finding 7 we learned that different plants require different amounts of water, space, and sunlight to survive. Also, in Finding 9 we learned that community members who we worked with in Carpio learn well with hands on demonstrations. These plant guides allow SIFAIS to easily demonstrate the process of watering the specific plants.

**We recommend that SIFAIS staff water the community gardens once a day with one or two children from the Montessori school.** The purpose of this recommendation is to encourage children to become involved in the community gardens. In Finding 5 we mentioned that the SIFAIS staff are busy during certain times of the year, so involving children can be beneficial to maintaining the gardens. We also learned from Finding 2 that children bring a lot of energy to garden maintenance. We have only been worked in Carpio working on gardening during the dry season, so different protocols for the amount of water might have to be used during the wet season.

**We recommend using a slow drip irrigation system to minimize the frequency of watering.** The purpose of this recommendation is to improve the irrigation system installed in the community gardens. The team noticed in Finding 5 that the watering responsibility was given to SIFAIS staff who were already busy setting up classes for the start of the year. The watering was sometimes skipped and the garden suffered. In Finding 5 we also learned that the simple drip irrigation systems we introduced with water bottles and a siphon bucket were successful in reducing the amount of watering needed for the plants.

### Improving the Community Gardens at SIFAIS

**We recommend SIFAIS consult gardening professionals.** The purpose of this recommendation is to encourage SIFAIS to improve their understanding of plants and expand their garden. When we presented the constraints, we found from Finding 1 to the professionals, we were able to gain information on which gardening practices were appropriate for Carpio.

**We recommend that SIFAIS staff seek donations for gardening supplies (plants and soil).** The purpose of this recommendation is to ensure that the community gardens receive new plants and soil as needed. We learned in Finding 16 that the soil in Carpio isn't suited for growing plants. We also learned in Finding 6 that SIFAIS regularly asks for supply donations and stores these in their warehouse. Establishing a source for donations will help to avoid going outside of Carpio to find suitable plant or hardware supply stores.

**We recommend planting more herbs, succulents, vegetables, and vines in the community garden.** The purpose of this recommendation is to ensure that the community gardens contain plants that thrive at the SIFAIS site. We learned in Finding 7 that herbs, succulents,



vegetables, and vines grow well in the dry season in Carpio. We recommend that SIFAIS plant more of these or add similar plants as they make additions to these gardens.

**We recommend relocating the Lantana and Torenia flowers from the tire garden to the fence garden.** The purpose of this recommendation is to maximize the chances of flowers flourishing at SIFAIS. We learned in Finding 7 that flowers, such as the Lantanas, did not do well in the garden space between the main and office buildings because the wind caused some of the flowers stems to break and the area received inadequate sunlight.

**We recommend that SIFAIS staff continue to use art in the garden.** The purpose of this recommendation is to encourage interest and motivation towards gardening. We learned in Finding 2 that including art with the gardens increased the participation of children helping with the garden. Additionally, Nehemias, an expert gardener, recommended to involve art in gardening to capture the attention of children (Rivera, 2017). Therefore, to continue to engage children, SIFAIS should encourage artistic activities alongside gardening, such as painting plant containers and choosing colorful and interesting plants.

### **Maintaining the Individual Gardens in Homes**

**We recommend to use smaller plants that are best suited for growing in the water bottle design that don't have large water requirements.** The purpose of this recommendation is to ensure that the plants have adequate root space. We learned in Finding 14 that the vertical garden design is ideal for homes in Carpio, and thus the types of plants used in this design must be chosen carefully. These plants must not require a lot of space, as they are planted in small plastic bottles, and must not require a lot of water, as the plastic bottles do not hold a lot of water. We therefore recommend growing plants like succulents, thyme, and oregano in the plastic bottle containers. These have previously been shown to be successful with past participants based on their size and amount of water needed.

### **Improving the Individual Gardens in Homes**

**We recommend that community members use repurposed materials to build the vertical garden.** The purpose of this recommendation is to utilize resources that are available rather than those that are hard to find. We learned in Finding 11 that some of the materials we used to construct the vertical gardens were difficult to find, such as the window or wire, but can be substituted for other materials community members may have access to. For example, a wooden pallet could be substituted for the window frame as long as it has a sturdy structure and isn't too heavy to be hung on a wall.

**We recommend that community members use cuttings from plants in the community gardens to populate their home gardens.** The purpose of this recommendation is to provide another source for people to obtain new plants. From Finding 10, we learned that people wanted more of the same plants that they received. Aesthetically pleasing plants are hard to find in Carpio, so using cuttings from pre-existing plants could be a way for community members to start their own garden without having to leave Carpio or spend a lot of money. As seen in Finding 13, we were able to successfully grow a new succulent from a cutting we made off the plants hanging at SIFAIS, further developing the feasibility of this method.

**We recommend creating a support network of all of the gardening families to give each other suggestions based on their gardening experience.** The purpose of this recommendation is to initiate a forum about gardening to strengthen the sense of community in Carpio. We have created a sign-up list to collect contact information of gardeners. The contact list

will remain at the SIFAIS building where participants of the individual garden workshop can voluntarily place their name and phone number.

### **Composting**

**We recommend SIFAIS incorporate a vermicomposting system at their site.** The purpose of this recommendation is to provide the SIFAIS gardens and community members a resource to obtain fertile soil to help their plants grow. As noted in Finding 16, there is a desire for useable soil in Carpio, and composting could help provide fertilizer. However, we do not recommend a traditional compost system, as discussed in the background chapter, because its requirements are too specific and are not feasible for the SIFAIS site. We instead recommend a vermicomposting system that uses a small bin with Red Wiggler worms to break down the organic material and can be placed inside (Erez, 2017).

**We recommend that SIFAIS recruit one or two people who built vertical gardens to be in charge of the construction of the vermicomposting system as well as its daily maintenance.** The purpose of this recommendation is to ensure that the vermicomposting bin is built and properly maintained. In Finding 4 we noted that it was difficult to maintain interest in the community gardens. While working with one community member, we found that she thought that it would be a good idea to introduce a compost system at the SIFAIS building, and would be willing to work with SIFAIS to exchange labor (such as maintaining the SIFAIS garden) for soil and more plants for her own garden.

**We recommend that SIFAIS staff involve children in composting to educate them about the natural processes of recycling.** The purpose of this recommendation is to sustain motivation and interest in the compost system. As noted in Finding 2, children were both willing and excited in helping us construct the community gardens. We found that much of their interest in the gardens was because they enjoyed the things they saw, such as painted tires or plants. Hence, children may be as equally interested in vermicomposting as other community members, which would be a good way to teach them concepts of recycling organic materials and the life cycle of different organisms.

### **Future SIFAIS Volunteers or IQP Teams**

We understand that a two month time frame is not enough time to ensure that a gardening project is sustained over a long period of time. Our project therefore has room for future SIFAIS volunteers or IQP teams to develop our project by and analyzing the community's response to the community gardens at SIFAIS and individual gardens in homes.

**We recommend future SIFAIS volunteers or IQP teams to analyze the impact of the gardens on the community after one year.** The purpose of this recommendation is to measure how successful the gardens have been since they were first established. Since, the goal of the project was to develop a sustainable program, it is important to check how sustainable it really is. We learned in Finding 8 that maintaining relationships with community members is a key component of motivation. Yet, with the loss in motivation from a previous gardening program in Carpio (Nystrom, 2017), a long term analysis may be beneficial to develop more clear-cut reasons for loss of motivation in the Carpio community.

**We recommend future SIFAIS volunteers or IQP teams to analyze the status of the garden's plants and look into who has maintained them.** The purpose of this recommendation is to revisit how the plants are doing and how they got to that state. We encountered difficulties in keeping the plants alive in both the community and individual gardens. After one year it would be

valuable to know if the plants survived, if SIFAIS expanded the garden, and if SIFAIS shifted the responsibility of maintaining the gardens to the community or to other staff members.

### **Conclusion**

We built four different styles of community gardens at the SIFAIS site. There were over a dozen children who were excited and eager to get involved with building and taking care of the gardens. Involving children may provide a sustainable approach to a gardening program. We also helped seven community members construct vertical gardens for their homes. The garden program will further decrease pollution by repurposing materials, reduce social exclusion by increasing community involvement, and relieving stress by adding beautiful green spaces.

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## Authorship Page

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Section Title	Written By	Edited By
Abstract	team	team
Executive Summary	team	team
Introduction	Izzy, Cole, Jaime	Marisa, Leila
Background 1	Jaime	Izzy, Cole, Marisa, Leila
Background 1.1	Jaime	Izzy, Cole, Marisa, Leila
Background 2	Jaime	Jaime, Cole, Izzy, Marisa
Background 2.1	Izzy, Marisa	Jaime, Cole, Leila
Background 2.2	Izzy, Marisa	Jaime, Cole, Leila
Background 3.1	Cole	Jaime, Marisa, Izzy, Leila
Background 3.2	Cole	Jaime, Marisa, Izzy, Leila
Background 3.3	Izzy, Cole	Jaime, Marisa, Leila
Background 4.	Marisa	Jaime, Cole, Izzy, Leila
Methodology	Marisa	Leila, Cole, Izzy, Jaime
Results Intro	Izzy	Marisa, Cole, Jaime, Leila
Results Community Gardens	Jaime	Marisa, Cole, Izzy, Leila
Results Individual Garden	Cole	Marisa, Jaime, Izzy, Leila
Recommendations 1.	Marisa	Izzy, Jaime, Cole, Leila
Recommendations 2.	Leila	Izzy, Jaime, Cole, Marisa
Recommendations 3.	Izzy	Jaime, Cole, Marisa, Leila
Recommendations 4.	Cole	Izzy, Leila, Jaime, Marisa
Conclusion	Marisa	Jaime, Izzy, Cole, Leila
Conducting Interviews	Cole, Jaime	
Deliverables excluding compost	Jaime	
Vermicompost Guide	Izzy	
Formatting Final Paper	Jaime	



## Chapter 1. Introduction

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Currently, one quarter of the people living in poverty, which is defined as living on less than \$2 per day, reside in an urban setting (Baker, 2008). People living in these areas face a variety of disadvantages that result in a lower quality of life than people of higher social status (Kaztman, 2001) including pollution (Molpeceres-Abella & Garca-Lapresta, 2016), social exclusion (Hanna & Oh, 2000), and stress (Weller, 2015). In recent years, social scientists have developed the concept of social capital to describe the importance of having dense social networks and strong community ties inside the community itself to address the quality of life of distressed areas. However, conditions associated with urban poverty, such as limited infrastructure, space, and resources, undermine dense social networks and strong community ties, described as social capital (Hanna & Oh, 2000). These conditions make it difficult for the urban poor to go beyond the struggles of daily life to develop important relationships (Baker, 2008).

Carpio, Costa Rica, a community located 10 kilometers north-west of San Jose, struggles with similar disadvantages listed above (Schneider, 2008). Much of the community, which is composed of Nicaraguan refugees, lives on government-owned land, has a high unemployment rate, and has a poor relationship with the surrounding neighborhoods and the government (Miller, 2015). Local media describe Carpio as one of the poorest and most dangerous places in Costa Rica (Miller, 2015). Additionally, nearby communities deposit nearly 700 tons of trash daily in the landfill just outside Carpio, polluting the local rivers and adding to street pollution (Nystrom, 2017).

Private organizations and government agencies around the globe have attempted to resolve problems associated with urban poverty. Many organization have attempted to use a top-down approach, by promoting particular solutions without community participation. Some have done this by “throwing money at poverty” to provide relief, but failed to have a lasting impact on the community (O'Brien, 2010). Conversely, other organizations, such as Outreach International and Dig In, have used a bottom-up approach. A bottom-up method involves a community-based approach for engaging individuals to improve their quality of life and sense of community (‘Yotti’ Kingsley & Townsend, 2006). Research suggests a good bottom-up approach is introducing permaculture programs, or permanent agriculture, because green space can promote education about environmental concerns, enhance a neighborhood with a sense of community, and help to reduce stress (Kuo et al., 1998; Saldivar-Tanaka & Krasny, 2004). Providing green spaces and launching healthy habits for those who are accustomed to living in a poor urban setting, such as the residents of Carpio, may bolster a higher quality of life.

In Carpio, the Costa Rican Humanitarian Foundation has promoted the increase of green space in the community, but has struggled to maintain motivation for doing so (Nystrom, 2017). Another organization in Carpio, el Sistema Integral de Formación Artística para la Inclusión Social (SIFAIS), focuses on empowering community members by teaching them new skills and is interested in continuing the effort to expand permaculture programs in the community. With previous fallout, due to low motivation, in a bottle garden program conducted by another organization in Carpio, the team focused on creating a sustainable permaculture program that community members were excited about.

The goal of the project was to develop a permaculture program in Carpio to create green spaces while maintaining and increasing community involvement. To achieve this goal, we:

1. Determined the constraints and opportunities of the Carpio community as they pertain to gardening and composting through observations.
2. Investigated best gardening, composting, and community involvement practices in Carpio through interviews.
3. Applied best practices to create gardens in Carpio.
4. Assessed the response of the Carpio community and the status of gardens.

Our overall intention throughout these steps was to improve the quality of life of the residents in Carpio by connecting them to other members of the community through nature and the creation of green spaces in their home and community. We constructed community gardens at the SIFAIS building and individual gardens for seven community members in Carpio. We learned that although initial interest and excitement for both types of gardens was high, maintaining interest in caring for the the community gardens was difficult. The community gardens serve as a space for all to learn and see good gardening practices, and the individual gardens are an opportunity for community members to bring that knowledge home.

## Chapter 2. Background

In this chapter, we begin with a brief overview of the general problem of urban poverty and how it affects quality of life in Carpio. Next, we examine different ways to address urban poverty, and further examine specific community outreach programs in Nicaragua and Africa. However, there are ways to deal with poverty other than those two programs did, such as implementing permaculture systems, which have been introduced elsewhere in Australia, Chicago, and Costa Rica. With an emphasis on gardening and composting, we explore the benefits and problems that arise by introducing permaculture meant to alleviate problems associated with poor, urban areas. We conclude by explaining that successful green space programs have previously devised methods to keep community members engaged, and we plan on adopting these same strategies for Carpio.

### 2.1 The Impacts of Urban Poverty on the Quality of Life

According to the 2008 World Bank Development census, 3 billion people worldwide are considered to be in poverty, living on \$2 or less per day (Baker, 2008; Shah, 2013). Additionally, the number of people in urban poverty has steadily risen from the 1990s to the 2000s by 2.2% annually (UN-Habitat, 2010), and the World Bank projects that the majority of people in poverty will live in urban settings by 2080 (Baker, 2008).

Urban poverty manifests itself in many countries, including Costa Rica. Out of the 1,300,000 households surveyed in a 2011 census, 318,810 households in Costa Rica lived in poverty (Costa Rican News, 2011). Of these households, 17% of them were located in urban neighborhoods in the Province of San Jose. Carpio, located 10 kilometers north-west of San Jose, is a community where 40,000 residents live on 62 hectares of mostly government-owned land (outlined in red in Figure 1), and over half of the population is considered impoverished (Shah, 2013).



Figure 1. Map of Carpio outlined in red, with its landfill highlighted by a star, (Google, 2016)

The majority of the population is unemployed, and those who are employed, typically through lawn or home care, find it difficult to maintain a steady income (Miller, 2015). However, the residents of Carpio are by no means lazy and are always looking for work (Miller, 2015).

Living in an urban setting can significantly decrease the quality of life for those living in poverty, with increased pollution, social exclusion, and stress levels.

Pollution is often higher in urban low-income areas than rural areas due to increased traffic and industry (Wolch, Byrne, & Newell, 2014). This type of pollution has led to negative health

effects including cancer and chronic bronchitis (Lee, 2015). Carpio is an area that struggles significantly with pollution, affecting the daily lives of its residents. Many of the streets are littered with plastic bottles and other debris, thus contaminating and clogging public drainage systems (J. Stephen, personal communication, January 19, 2017). In addition, San Jose and surrounding areas deposit 700 tons of trash daily to a landfill right outside of Carpio (EBI Parque Tecnológico La Carpio), indicated by a star in the upper left hand corner of Figure 1. The trash sometimes contributes to the pollution of the surrounding rivers, eliminating them as a potential water source (Vindas, 2005); J. Stephen, personal communication, January 19, 2017).

Beyond pollution, lacking social relations in poor urban areas can lead to social exclusion, powerlessness, and insecurity in one's own status or community (Hossian & Hossian Khan, 2012). Carpio lacks a constructive relationship between the media and the government of Costa Rica. The local media has previously titled Carpio as the worst slum in Costa Rica and gives Carpio the label "precario", referring to how unstable and precarious the community is perceived to be (Miller, 2015; Waddell, 2009). Some researchers, such as Lynn Schneider (2008), argue that the media may inflate the severity of crime and violence that is prevalent in Carpio. She argues that this treatment of reporting on Carpio worsens the perception that outsiders have about the neighborhood, as well as the ability for the community to voice its opinions without being labelled as violent or unruly. The community experiences a negative relationship with the government, summed up by the outcome of the "La Carpio Environmental Technological Park" Project. The government agreed to pave all of the streets, create a community trust fund, and title the lands on which the Carpio residents had built their houses in exchange for allowing surrounding communities to dump garbage nearby (Vindas, 2005). However, over time roads stopped being paved (Nystrom, 2017), and the agreed-upon quota of USD \$0.15 per ton of garbage that was to be put into the community trust fund was not given to them (Vindas, 2005).

Studies also show that people living in poverty are seven times more likely to experience serious distress than those living above the poverty line (Weller, 2015). Nicaraguan migrants in Costa Rica tend to have higher stress levels than the rest of Costa Rica due to lower social status (Marquette, 2006). As an impoverished region including 36,000 Nicaraguan refugees (Evans, 2012), Carpio may experience high stress levels.

## 2.2 Social Empowerment Groups and the Community

There is a complex landscape of methods on how to address urban poverty. Two main strategies are top-down and bottom-up approaches. Top-down approaches tend to have the organization in power making decisions that are impacting a community. On the other hand, bottom-up approaches let the community have the power in deciding what needs to be done and how to accomplish their goals (Nisbet & Weiss, 2010). Determining which method best suits a particular area based on the root causes is the difficulty (Nisbet & Weiss, 2010).

Bottom-up approaches that emphasize social empowerment have been particularly successful. Social empowerment groups have shown that programs that encourage social revitalization internally with community members have higher success rates than groups that don't interact with community members to gain their input (Drucker, 2004). For example, Outreach International worked in El Tunel, Nicaragua and was able to provide a central location for residents to gather together, decide to fix their road, and put forth 90% of the effort and expenses required to pave the road (Balshe, 2016). Social empowerment groups have also been successful especially when the community's ideas were taken into consideration and relationships were built to achieve a common goal (Combaz & Mcloughlin, 2014). Arvai and Post were able to accomplish this in poor

rural areas of Africa by allowing community members to test different water purification treatments and select the design they liked best rather than imposing a design on the community (Arvai & Post, 2012).

### 2.2.1 Social Empowerment in Carpio, Costa Rica

Currently, there are two major NGOs working with the community of Carpio: The Costa Rican Humanitarian Organization and SIFAIS. While the former emphasizes formal institutions, such as day-care centers and health clinics to aid the symptoms of poverty (Nystrom, 2012), the latter offers extracurricular activities (music, art, and judo classes) to reduce social exclusion by forming connections between participants and helping them become more socially involved (Fundación SIFAIS, 2015). Both NGOs work directly with the community to alleviate the effects of poverty, and both have been successful in their own manner. The Costa Rica Foundation was able to close one of their health clinics after six years partly because they were able to teach the community better sanitation practices and stabilize a large portion of the population's health (Nystrom, 2012), and the number of programs that SIFAIS offers has grown from one class to 60 in just five years (Fundación SIFAIS, 2015).

The programs of SIFAIS have directly affected the community by not only teaching hobbies through programs, but also by relieving stress through art and music. The programs promote spending time with other community members, which leads to positive attitudes in the community. A parent who sends their children to SIFAIS even claims that the programs have changed the social atmosphere of Carpio (Bingley, 2015). SIFAIS has tried to continue improving the social atmosphere by seeking assistance to increase green space through permaculture.

## 2.3 Permaculture as a Building Block for Social Empowerment

Other researchers and organizations have attempted permaculture programs to empower and revitalize distressed urban areas (Ohmer, Meadowcroft, Freed, & Lewis, 2009). The term permaculture, short for permanent agriculture, encompasses any method or system that encourages ecological development, protection of the nature, or green sustainability (What's "permaculture"?, 2002). It can include gardening, composting, irrigation, water filtration, and other waste management systems (Permaculture, 2011). Permaculture can educate people living in urban areas about the importance of being environmentally friendly, a criterion that the American Psychological Association identifies as essential for those who wish to empower a community (Hoffman, Doody, Veldey, & Downs, 2016). A recurring example of permaculture that has had positive social and environmental implications in urban areas is the implementation of community gardens (Ohmer et al., 2009).

### 2.3.1 Benefits and Challenges of Community Gardening

Community gardens offer many socially inclusive and educational benefits for a community, but can also run into several challenges. The benefits and challenges of community gardening are summarized below in Table 1.

Table 1. Benefits and challenges of community gardening

Benefits	Challenges
<ul style="list-style-type: none"> <li>● Creating deep connections between gardeners where they feel comfortable talking about their terminal illnesses, raising children, and professional networking<sup>1</sup></li> <li>● Becoming more socially involved, having more visitors, and feeling a greater sense of community<sup>2</sup></li> <li>● Learning agricultural practices and the consequences of one's actions on the environment<sup>3</sup></li> <li>● Enjoying time spent with plants and fellow gardeners<sup>4</sup></li> <li>● Connecting children with nature<sup>5</sup></li> </ul>	<ul style="list-style-type: none"> <li>● Difficulty in finding a proper location for the garden<sup>6</sup></li> <li>● Maintaining a proper water supply for gardens in areas with dry seasons<sup>7</sup></li> <li>● Educating people about the risks of gardening methods<sup>8</sup></li> <li>● Disconnect in communication between the social empowerment group and actual participants<sup>1</sup></li> <li>● Difficulty maintaining motivation<sup>9</sup></li> </ul>

The benefits presented in Table 1 reinforce the general discussion of social empowerment approaches in Carpio, Costa Rica in section 2.2.1. It is important to note that one of the challenges presented in the table is difficulty maintaining motivation. We learned that a gardening program previously existed in Carpio but died out because of low motivation to participate by community members (Nystrom, 2017) that gardens can suffer from seasonal aridness. Carpio experiences a wet season from May to mid-November and a dry season from mid-November to April that is particularly arid. Introducing irrigation systems, such as simple drip systems (Ngozi Rita & M. O. Edoga, 2006), can overcome seasonal aridness (Molden & Gates, 1990).

<sup>1</sup> 'Yotti' Kingsley, J., & Townsend, M. (2006). 'Dig in' to social capital: Community gardens as mechanisms for growing urban social connectedness. *Urban Policy and Research*, 24(4), 525-537. doi:10.1080/08111140601035200

<sup>2</sup> Kuo, F. E., Sullivan, W. C., Coley, R. L., & Brunson, L. (1998). Fertile ground for community: Inner-city neighborhood common spaces. *American Journal of Community Psychology*, 26(6), 823-851. doi:1022294028903

<sup>3</sup> Saldivar-Tanaka, L., & Krasny, M. E. (2004). Culturing community development, neighborhood open space, and civic agriculture: The case of latino community gardens in new york city. *Agriculture and Human Values*, 21(4), 399-412. doi:AHUM.0000047207.57128.a5

<sup>4</sup> (River, 2017)

<sup>5</sup> Starbuck, S., Olthof, M., & Midden, K. (2014). *Gardening with young children*. Saint Paul, US: Redleaf Press.

<sup>6</sup> Saldivar-Tanaka, L., & Krasny, M. E. (2004). *Culturing community development, neighborhood open space, and civic agriculture: The case of latino community gardens in new york city* doi:AHUM.0000047207.57128.a5

<sup>7</sup> Molden, D. J., & Gates, T. K. (1990). Performance measures for evaluation of irrigation-water-delivery systems. *Journal of Irrigation and Drainage Engineering*, 116(6), 804-823.

<sup>8</sup> Gallaher, C. M., Mwaniki, D., Njenga, M., Karanja, N. K., & WinklerPrins, Antoinette M G A. (2013). Real or perceived: The environmental health risks of urban sack gardening in kibera slums of nairobi, kenya. *EcoHealth*, 10(1), 9-20.

<sup>9</sup> Nystrom, G. (2017). In Marisa Sposato (Ed.), *Interview with gail nystrom*

### 2.3.2 Vertical Gardens as a Response to Limited Space

Since ground space can be limited in urban areas, such as in Carpio, vertical gardening can be a solution. This style of gardening puts an emphasis on minimizing the land required to grow fruits, vegetables, herbs, flora, and other plants. The idea of creating vertical gardens has been tested and implemented in many urban communities (Specht et al., 2014). Some of these areas were impoverished communities that were seeking to increase community involvement, similar to the situation in Carpio, while others were wealthier cities looking for ways to continue gardening in limited space. Even though these are two different contexts, the basic design and approach of each vertical garden have the same key benefits and challenges. The benefits and challenges are shown below in Table 2.

Table 2. Benefits and challenges of vertical gardening

Benefits	Challenges
<ul style="list-style-type: none"> <li>● Require less soil and compost material<sup>10</sup></li> <li>● Require less arduous maintenance<sup>10</sup></li> <li>● Produce fewer weeds<sup>10</sup></li> <li>● Easier to irrigate (water from one plant drips down to those below it and waters them)<sup>10</sup></li> <li>● Uses recycled materials (plastic cups, plastic bottles, etc.)<sup>11</sup></li> </ul>	<ul style="list-style-type: none"> <li>● Fewer plants must be used because they are unable to hold large amounts of weight<sup>12</sup></li> <li>● Moisture and leakage problems can arise if the garden is not properly installed<sup>13</sup></li> <li>● Installation is difficult because many are unfamiliar with this style of garden<sup>14</sup></li> </ul>

Even though challenges for vertical gardens exists, the advantages highlighted in Table 2 make the garden feasible for many as they reduce the amount of time and costs needed to maintain them. Examples of vertical gardens that are made from recycled materials and take up little land space can be seen below in Figure 2.

<sup>10</sup> Fell, D. (2011). *Vertical gardening : Grow up, not out, for more vegetables and flowers in much less space*. Pennsylvania: Rodale. Retrieved from <http://replace-me/ebraryid=11267542>

<sup>11</sup> Anita B Stone. (2015). *Vertical gardening grows skyward*. Waterloo: Countryside Publications, Ltd. Retrieved from <http://search.proquest.com/docview/1652771026>

<sup>12</sup> Eden Now. (2014). 10 things to consider before choosing a vertical garden or greenwall system. Retrieved from <http://www.verticalgardensedenow.com.au/vertical-garden-blog/10-things-to-consider-before-choosing-a-vertical-garden-or-greenwall-system>

<sup>13</sup> Tomeo, T. (2013). Vertical gardening has a place, but some just aren't right. Retrieved from <http://www.mercurynews.com/2013/05/02/vertical-gardening-has-a-place-but-some-places-just-arent-right/>

<sup>14</sup> Specht, K., Siebert, R., Hartmann, I., Freisinger, U. B., Sawicka, M., Werner, A., . . . Dierich, A. (2014). Urban agriculture of the future: An overview of sustainability aspects of food production in and on buildings. *Agriculture and Human Values*, 31(1), 33-51.



Figure 2. Example vertical gardens 2a) Hanging garden of recycled bottles (2il Org, 2014) and 2b) standing vertical garden made from flower pots (AIDG, 2007)

### 2.3.3 Composting

Gardens need nutritious soil to keep growing and remain sustainable, and one way to obtain rich soil is through composting. Composting is a decomposition process that breaks down organic waste and creates a nutrient rich substance known as humus (Stechmann, Herchenroder, Guinn, & Bourgault, 2005). Although not always necessary, composting is often a counterpart to gardening as it can be used as a fertilizer to improve the quality of plants and help reduce organic waste. Similar to gardening, it poses its own benefits and challenges, which are different for two different methods of composting: compost piles and vermicomposting. These benefits and challenges are summarized in Table 3.

Table 3. Benefits and challenges of traditional composting and vermicomposting

Composting Type	Benefits	Challenges
Traditional Compost Pile	<ul style="list-style-type: none"> <li>● produces humus, which enriches soil<sup>15</sup></li> <li>● recycles organic materials<sup>16</sup></li> </ul>	<ul style="list-style-type: none"> <li>● requires large space<sup>17</sup></li> <li>● can potentially be dangerous<sup>18</sup></li> <li>● requires a long period of time<sup>3</sup></li> <li>● requires frequent turning and watering<sup>3</sup></li> </ul>
Vermicomposting	<ul style="list-style-type: none"> <li>● produces worm castings, which enriches soil<sup>2, 5</sup></li> <li>● recycles organic materials<sup>2, 5</sup></li> <li>● requires little space<sup>5</sup></li> <li>● can engage children with worm<sup>19</sup></li> <li>● produces little odor<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>● requires specific worms<sup>3</sup></li> <li>● requires a long period of time<sup>5</sup></li> <li>● requires frequent watering<sup>5</sup></li> </ul>

<sup>15</sup> Stechmann, D. P., Herchenroder, K., Guinn, W., & Bourgault, A. (2005). *Composting for sustainable waste management*. Worcester, MA: Worcester Polytechnic Institute.

<sup>16</sup> Singh, R. P., Singh, P., Araujo, A. S., Ibrahim, M. H., & Sulaiman, O. (2011). Management of urban solid waste: Vermicomposting a sustainable option. *Resources, Conservation and Recycling*, 55(7), 719-729.

<sup>17</sup> Erez, B. (2017). In Garver I. (Ed.), *Interview with benny erez*

<sup>18</sup> Asomani-Boateng, R. (2007). Closing the loop community-based organic solid waste recycling, urban gardening, and land use planning in ghana, west africa. *Journal of Planning Education and Research*, 27(2), 132-145.

<sup>19</sup> Goldberg, B. (2017). In Garver I. (Ed.), *Emails with Ben Goldberg*



Table 3 shows that both composting and vermicomposting produce a material for enriching soil. However, vermicomposting may better suit urban areas like Carpio because it requires less space and, as previously stated, space is very limited in Carpio. Vermicomposting produces less odor than traditional composting which would attract fewer rodents. For more information on composting see Appendix A.

## 2.4 Summary

The major takeaways from literature on gardening and composting are that these methods of permaculture have the potential to be used in a bottom-up approach to reduce waste, decrease social exclusion, and alleviate stress in a distressed, urban community such as Carpio. Each of these permaculture designs and solutions have varying success depending on how they are implemented in the particular setting. It was up to us to determine which permaculture designs work well in Carpio and how to implement them.

## Chapter 3. Methodology

The goal of the project was to develop a permaculture program in Carpio to create green spaces while maintaining and increasing community involvement. Permaculture systems, as they pertain to our project, refer to both gardening and composting practices. To achieve our goal, we:

1. Determined the constraints and opportunities of the Carpio community as they pertain to gardening and composting.
2. Investigated best gardening, composting, and community involvement practices in Carpio.
3. Applied best practices to create gardens in Carpio.
4. Assessed the response of the Carpio community and the status of gardens.

### 3.1 Objective 1: Determine the constraints and opportunities of the Carpio community as they pertain to gardening and composting.

The purpose of this objective was to determine the constraints and opportunities in the Carpio community by observing the town and residents to guide our thinking on how to create green space. First, we made visual observations of the Carpio community which we documented using photographs and written notes. These observations were made by walking around the neighborhoods of Carpio, inside the homes of residents, and through the SIFAIS site. This investigation allowed us to verify and expand upon background information and narrow potential garden designs for the community. We further refined the designs by taking into consideration which were feasible within the limitations as defined in Table 4. We completed a majority of our observations during our first visit to Carpio, but we continued to seek answers to these research questions throughout the duration of our project to deepen our understanding of the community.

Table 4. Team observations and research questions

Research Question	Location of Finding
What types of materials are in excess and can be used to create permaculture systems?	Street sides
What supplies are available at SIFAIS to work with?	SIFAIS property
What type of space do we have to work with?	Personal homes, SIFAIS property
What water resources are available? Is tap water clean, reliable, and able to be used to water plants?	Homes of residents, SIFAIS property
Is the soil of good consistency and nutritious enough to support plant growth? Does it drain well?	Homes of residents, SIFAIS property, Humanitarian Foundation Daycare Center
What types of gardens or plants currently exist in Carpio?	Homes of residents, Humanitarian Foundation Day Care Center
Are residents and SIFAIS members very busy during the day? Do they have time to take care of a garden?	Neighborhoods, homes, SIFAIS property
How do community members interact?	Neighborhoods surrounding SIFAIS property

### 3.2 Objective 2: Investigate best gardening, composting, and community involvement practices by in Carpio.

The purpose of this objective was to gather input from other individuals experienced in the gardening, composting, and community involvement fields. We interviewed nine people to help us develop feasible and practical permaculture designs and implementation methods for Carpio. Table 5 shows the purpose for each interviewee. Specific interview questions can be found in Appendix B. We coded all of the interviews using nonhierarchical coding because the questions we asked were tailored to the experience of each interviewee and the topics covered varied slightly (Coding of qualitative data, 2017).

Table 5. Interview purposes and interviewees

Purpose	Interviewee	Organization	Job Title
Gardening	Gail Nystrom	Costa Rican Humanitarian Foundation	Founder and Director
	Francis	Costa Rican Humanitarian Foundation	Day Care Teacher
	Nehemias Rivera	Comunicaciones Nazarenas Latinoamericanas	Experience in forming community gardens
	Employee	Vivero Joan's Garden	Gardening Employee
	Mariel Casadena	Costa Rican Garden Club	Member
Composting	Benny Erez	ECO City Farms	Senior Technical Advisor
	Ben Goldberg	Rich Earth Institute	Director
	Gail Nystrom	Costa Rican Humanitarian Foundation	Founder and Director
Involvement	Gail Nystrom	Costa Rican Humanitarian Foundation	Founder and Director
	Nehemias Rivera	Comunicaciones Nazarenas Latinoamericanas	Experience in forming community gardens
	Magdalena Lopez	SIFAIS	Community Liaison Director

### 3.3 Objective 3: Apply best practices to create gardens in Carpio.

The purpose of this objective was to give community members the opportunity to learn how to build and take care of a garden. We learned that the bottom-up approach used by social

empowerment groups often is more successful in an urban poverty setting like Carpio (Drucker, 2004). Hence in our application of best practices, we worked directly with the community to take into consideration their thoughts and preferences when constructing gardens. To increase community involvement, we pursued two initiatives: creating community gardens at SIFAIS and creating individual gardens for the homes of community members. From there we took into consideration the information gathered in objectives 1 and 2 to devise proper garden designs for each initiative as follows.

### 3.3.1 Community Gardens

To build community gardens at SIFAIS, we first took inventory of what resources were available for us to use at the SIFAIS site. Keeping these resources in mind, along with the information gathered in objectives 1 and 2, we revisited the designs we had researched, such as those in Figure 2, as well as new design ideas we found in Costa Rica, as seen in Figure 3 below.



Figure 3. Example gardens found in Costa Rica 3a) A bottle garden design and 3b) Tire garden design

From there we were able to narrow down our design ideas accordingly. After presenting these ideas to our sponsor and eliciting feedback, we chose several designs and plants that we and our sponsor agreed could be a good fit for the community gardens. Appendix C shows details on the process of construction and materials used in the four garden designs. See Appendix D for potential garden space at the SIFAIS site. Additionally, we planned for the majority of our construction to take place on a Saturday, the day that SIFAIS schedules the majority of their programs and thus when the greatest number of people are on the property. This allowed us to actively encourage the children and volunteers of SIFAIS to join in the building process.

### 3.3.2 Individual Gardens for Homes in Carpio

In seeing the strong interest from community members, SIFAIS wanted to create gardens for individual homes. We designed an individual garden appropriate for the constraints by using materials found in the SIFAIS warehouse to create a modular window garden design.

We conducted semi-structured interviews with four families introduced to us by our sponsor. During these initial interviews, we asked each family about what experiences and preferences they had for gardening in their homes. These initial interview questions can be found in Appendix B. The purpose of these interviews was to determine specific constraints and opportunities for each family regarding the addition of a garden to their home. We voice-recorded these interviews and took notes during each conversation. We then coded the information using hierarchical coding and categorized the data using an excel spreadsheet to effectively compare responses (Coding of qualitative data, 2017).

We worked hand-in-hand with each family to build their individual garden during a workshop at the SIFAIS building. Detailed instructions on how to build this type of garden can be found in Appendix E.

### 3.4 Objective 4: Assess the response of the community and the status of gardens.

The purpose of this objective was to evaluate the success of the gardens created in Carpio based on the responses of community members to the program and the status of the plants. The assessments helped us make recommendations for SIFAIS and community members to enhance their permaculture programs.

#### 3.4.1 Community Gardens

We monitored the community gardens at the SIFAIS property twice a week by taking photos of the plants and documenting their progress. If necessary, we moved the plants around from one location to another around the SIFAIS property based on whether they needed more or less sunlight or space.

#### 3.4.2 Individual Gardens

To assess how the building workshop went, we asked the families five questions after we finished building the individual garden together. These post-workshop questions can be found in Appendix B. The purpose of these questions was to get their immediate feedback on the organization and structure of the workshop. Five to ten days after the families' gardens had been built, we interviewed them again to see how their plants were doing and how they had adapted the new garden design to fit their home. These follow-up interview questions can be found in Appendix B. We later coded both of these interviews with axial non-hierarchical coding to generate common positive and negative reactions from the participants as they pertain to their gardens.

## Chapter 4. Results

We start this chapter with our findings for constraints and opportunities developed as part of our work to complete objective 1. We organized the remainder of the chapter according to the two initiatives outlined in the methods: community gardens at SIFAIS and individual gardens for homes. Each section is then grouped into motivation and logistics themes to highlight the importance of community involvement for the project (motivation) from our other findings (logistics).

### **Finding 1: Materials for construction, space, soil, and motivation are constraints for gardening and composting.**

Through observations, we identified four important constraints. With each constraint, we developed potential opportunities for both the community and individuals to overcome them. Because the constraints for the community gardens at SIFAIS and individual gardens for community members were sometimes different, we separated the opportunities for these two types of gardens in Table 6. Details about how the constraints and opportunities were developed are presented in Appendix F.

Table 6: Opportunities and constraints of particular Individual and community gardening systems

Constraints	Community Opportunities	Individual Opportunities
Materials for construction	Recycled materials, SIFAIS inventory, Donations	Recycled materials, SIFAIS inventory, Bartering
Space	Vertical spaces, horizontal spaces,	Vertical spaces
Soil	Vermicomposting, Donations	Vermicomposting
Motivation	Children, Community, Art, Aesthetic appeal	Children, Family, Art, Aesthetic appeal

The majority of the opportunities to overcome gardening and composting constraints for community gardens versus the individual gardens are the same with a few exceptions. One difference is that SIFAIS has the opportunity to use horizontal spaces in addition to the vertical spaces while the majority of individual homes can only utilize vertical space due to their overcrowded living conditions.

### 4.1 Community Gardens

With the help of children and volunteers, we built the community gardens together at SIFAIS. Using materials from SIFAIS's warehouse, we constructed four main types of gardens:

**7 tire gardens:** built with children by laying out painted tires and placing rocks for drainage at the bottoms, potting soil, and then the plants as seen in Figure 4.



Figure 4. Tire gardens 4a) placement and 4b) construction with children.

**10 hanging can gardens:** Built with children by using a can opener to open large donation tin cans, and placing rocks, soil, and then the plants in. Finally, we attached them with wire and hung them around SIFAIS as seen in Figure 5.



Figure 5. Hanging can gardens 5a) placement and 5b) construction with children

**2 ground gardens:** Built by encompassing 2 flower beds with available rocks, placing topsoil, planting vines, and inserting a wire fence for the vines to grow up as seen in Figure 6.

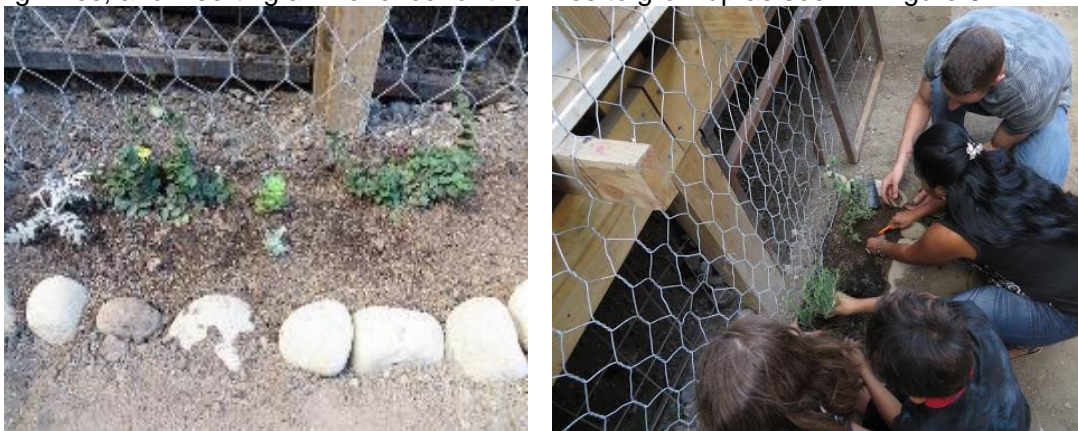


Figure 6. Ground gardens 6a) placement and 6b) construction with children

**1 fence garden:** Built by attaching 4 flower boxes with wire to a fence in an open play area for children. They were placed at the entrance of the Montessori school so that they may plant them in the future as seen in Figure 7.



Figure 7. Fence garden 7a) placement and 7b) construction with children

We modified and adjusted the gardens through an iterative process each week based on their growth. For example, we originally placed the Dusty Miller ferns in the hanging can gardens, but we later swapped them out for the *Sedum makinoi tornados*, which produced a better hanging effect. A more detailed version of construction is described in Appendix C.

#### 4.1.1 Motivation of Community Members to Use the Community Gardens

##### **Finding 2: Community gardens at SIFAIS were sustained by children and art.**

Our sponsor identified the Montessori school children as good participants to water the community garden. The children attended school at the SIFAIS property weekdays from 7am to 1pm. Children brought an energy to the construction of the community gardens that was not only infectious, but also powerful at motivating us and other children to complete the garden. Nehemias Rivera, one of the professional gardeners the team interviewed, said his successful gardening programs channel the children's enthusiasm to keep the programs running (Rivera, 2017). Additionally, our sponsor mentioned how the children wanted to participate in every part of the building process and would much rather be involved in the activities where they were doing something, rather than being taught in a classroom (Lopez, 2017). This hands-on approach taught children indirectly about basics of gardening and simple techniques to care for the plants.

Nehemias also suggested that using art in garden projects would be an easy way to not only make the area look nice but keep the attention of the children in regards to gardening (Rivera, 2017). Just as Nehemias described it to us, we found that to be true: the community garden designs that incorporated art, particularly the tire gardens, were popular with the children.

##### **Finding 3: Garden design encouraged behaviors that can undermine the garden or encourage inappropriate behaviors.**

We found that occasionally garden designs were not adequately explained to the children at SIFAIS. As a result, the gardens were not appropriately handled.

First, after the implementation of the irrigation systems, we noticed that a couple of plastic bottles were scattered in the garden. We hypothesized that the people passing by saw the plastic bottle systems and left their bottles in the garden because they thought that that was where they were supposed to be placed. Another hypothesis was that the people saw the plastic bottles being



used for irrigation systems and left them behind for us to use. Either way, non-intuitive garden design led to misunderstandings of how to properly use the irrigation systems.

Second, the bottle gardens originally set up for the potential gardening activity with Montessori students, depicted in Figure 8a below, encouraged poor behavior.



Figure 8. Garden for Montessori children to plant 8a) plastic bottles (left), 8b) flower boxes (right)

The garden was purposefully put in the north open child play area, as depicted in the SIFAIS site map in Appendix D, for a future activity for children to plant flowers with Montessori teachers. Unfortunately, some children stuck their feet through the bottom sections of the fence and thought it would be fun to kick some of the bottles out of place, thus destroying the garden. Additionally, some of the wire was exposed and posed a hazard to people walking by the fence. As a result, we modified the design by hanging flower boxes on the top part of the fence and securing them with wire. To avoid the hazard of wires sticking out again, we wrapped the wire around the fence and inserted it back into the flower box container pointing downwards so that when the plants were placed inside the ends of the wiring would no longer be exposed, as seen in Figure 8b. So far, there haven't been any reports of misbehaviors or accidents since using plastic flower boxes on the hand railing.

**Finding 4: Maintaining the interest of community members to take care of the community gardens was difficult.**

From observing the health of the community gardens, we noticed that the plants were not being watered sufficiently. One challenge was that SIFAIS staff were very busy with other program work. We discussed with our sponsor proper watering procedures for the SIFAIS staff and developed a watering schedule to hang up in the building as a reminder, shown in Appendix G. The purpose of this schedule was to confirm that someone checked the plants in the garden at different times throughout the day. Unfortunately, the calendar was never presented to the SIFAIS staff, resulting in sporadic watering resulting in wilted, dry plants.

#### 4.1.2 Logistics of Constructing and Maintaining the Community Gardens

**Finding 5: Simple irrigation systems were a solution for dry soil conditions in the community gardens at SIFAIS.**

We created two types of irrigation systems using repurposed materials for the community gardens in between the SIFAIS buildings, which helped reduce the frequency the plants needed to be watered.

First, we created a slow-drip system using plastic water bottles with holes in the caps. We placed these bottles upside down in the soil, which allowed the water to slowly drip out when the soil was dry. The system helped to increase the moisture level in the soil for each plant, especially the celery that reacted very well, as shown in Figure 9 below.



Figure 9. Celery plant 9a) before (left) and 9b) after water bottle drip irrigation was installed (right).

We noticed that individuals at SIFAIS easily could repeat the process of the bottle irrigation system. One person (who remains unknown) used a water bottle to irrigate a plant that was dying in the front of the building, as shown in Figure 10. The simple nature of the design may have helped make the irrigation system repeatable.



Figure 10. Participant initiated irrigation system

Second, we implemented a simple drip-irrigation system in the ground, lining the back side of the SIFAIS activity building, to help with watering. We made holes in the hose near the plants' roots and inserted it into a bucket full of water. Since the hose was put at an elevation lower than the bucket, the water leaving the tapped holes would force water up the tube in a siphon-like manner, thus slowly draining the bucket. Images of the construction of this system are shown below in Figure 11.



Figure 11. Installation of simple drip irrigation system for ground plants

Slow-drip irrigation techniques demonstrated effectiveness in keeping plants sufficiently watered. SIFAIS's tap water was the easiest water source for the community gardens because of its location within the SIFAIS property, as highlighted in Appendix D.

**Finding 6: Using repurposed materials helped to overcome the problem of limited resources.**

We learned through interviews with the NGO leaders in Carpio that materials in Carpio are limited, including those that could potentially be used to build a garden. SIFAIS's warehouse, as shown in Appendix D, houses its donations as well as with excess building materials. We had access to the majority of these items for our project. We used tires, tin cans, cinderblocks, and chicken wire from the warehouse to construct the community gardens at the SIFAIS site.

**Finding 7: Location has a large impact on the health of plants because of variations in sunlight, and wind.**

The environmental conditions of the space between the buildings provided some unexpected complications. Strong wind between the two SIFAIS buildings blew off most of the petals from the flowers. Moreover, when a new shelf was built above the garden, as shown below in Figure 12, it blocked the morning sunlight that the plants originally received. Because the shelf was built toward the end of our project, further analysis of the effects of reduced sunlight may need to be done to determine whether the flowers need to be moved to another location.



Figure 12. Shelving added above the garden area blocked sunlight from the tire gardens

Table 7 summarizes what we learned from a post-observational study of the plants in the community gardens and the possible needs of each after one week.

Table 7. State of plants one week after being planted at SIFAIS

Plant	Did well?	Appearance	Possible Needs
Lantanas	No	Dry, broken, no petals, minimal leaves	Water Sun Less wind
Toreneas	No	Dry, sagging, still has petals	Water Sun
Dusty Millers	No	Sagging	Water Sun
Succulents (inside and outside)	Yes	Unchanged	none
Ficus Ivy	Yes	Unchanged	none
Celery	No	Sagging	Water
Rosemary	Yes	Unchanged	none
Mint	No	Dry, minimal leaves left	Water

## 4.2 Individual Gardens

We worked alongside seven families in Carpio to help them introduce or expand gardens in their homes. With initial interviews of the first five families, we learned (as in Finding 1) that space was a significant constraint for many of them. Consequently, we developed a vertical garden design that takes up little space, as shown below in Figure 13. After constructing the gardens with the seven families, we conducted interviews with the families and categorized our findings into two themes: motivation and logistics.



Figure 13. Hanging garden installed in Carpio home

#### 4.2.1 Motivation of Community Members to Garden Individually

##### **Finding 8: Following up, being responsive, and forming relationships with gardening participants was important for maintaining motivation and participation.**

While working with the community members to build their own gardens, we found that the members we developed close relationships with were more receptive to the program. For example, one community member appeared more willing to work with us as we spent more and more time with her. During our first interview, she was rather straight forward with her responses and seemed in a rush. The same was true during the construction of the individual garden. However, after we visited her home to check on her plants and conduct the follow-up interview, we developed a much closer relationship with her by helping her with common gardening tasks and asking her about her past gardening experiences. We began to form a bond, and she quickly became more responsive to our conversations and was quite pleased to be more involved in the garden program. She was also interested in helping other Carpio community members with their gardens by offering plant advice and assisting during a workshop. She even told us that “If [you] need anything, knock on my door. I will help with much pleasure,” (translated from Spanish).

##### **Finding 9: Community members of Carpio learn well through hands-on instruction and demonstrations.**

While speaking with our sponsor and observing the classes at SIFAIS, we learned that the students at the Montessori school and the children who take classes at SIFAIS learn best from hands-on activities and experiences.

Our workshop was hands-on so the community members learned the construction process by doing. We explained the building process by completing small steps with them, as seen in Figure 14 below. Six out of seven participants of the individual garden workshop responded that the process was easy, with all agreeing that they were able to rebuild the garden despite our limited ability to communicate in Spanish.



Figure 14. Teaching a family how to build an individual garden

**Finding 10: Gardens that fulfill a person’s purpose lead to increased motivation.**

When first interviewing families about what types of plants they wanted to have in their garden, the two main preferences were aesthetically pleasing plants (such as flowers) and plants for cooking (such as vegetables and herbs). These responses of the families interviewed are shown in Table 8 below.

Table 8. Initial interview responses<sup>20</sup>

Community Member	Desired Garden Type	Plants Desired	Intended Use of Plants
1	Inside, Hanging, Ground	Cilantro, Mint, Chayote, Coriander, Shallots, Herbs for Soup, Lettuce, Potatoes, Carrots, and Yucca	Cooking
2	Hanging/ Ground	Larger plants to expand her garden, Roses	Aesthetic
3	Hanging	Not important	Indifferent
4	Outside, Hanging	Herbs, Pink Flowers	Cooking, Aesthetic
8	Inside, Hanging	Roses, Basil, Oregano, Mint	Cooking, Aesthetic

<sup>20</sup> We did not conduct initial interviews with all eight of the community members with whom we worked to build individual gardens. Community Members 5, 6, and 7 showed interested in the last week of the project in Carpio and only had time to answer the post-workshop interviews but not the initial interview questions.

While working with the seven families to construct their own gardens, we ensured that the plants we gave them were what they wanted. We found that by growing plants that people could use helped maintain interest in gardening (Nystrom, 2017). For example, one participant stated that she liked her garden specifically, “because [she] liked the plants” she had received. In fact, the one thing that she suggested to us, in a friendly manner, was to “give her more plants!” (translated from Spanish).

**Finding 11: Residents enjoyed using repurposed, accessible materials to construct individual gardens.**

Since resources are limited in Carpio, we designed and built individual gardens using the leftover materials accessible to us in the SIFAIS warehouse. Other items we used, such as plastic bottles, are abundant in Carpio, as seen in Figure 15, and can be repurposed and used in our vertical garden design.



Figure 15: Plastic bottles on the side of a street

Families found water bottles to be an easy resource to find. One woman said the design was “creative” because of the materials it involved, and that she enjoyed constructing the garden because she “likes the idea of recycling” (translated from Spanish), as shown with the individual garden design in Figure 13.

Although water bottles were easy to acquire, other materials are not as easy to find, as shown in Table 9 below.

Table 9. Post-workshop survey responses

Community Member	Difficulty Level of Building	Ability to Find Materials Again	Aesthetic Quality of Design	Able to Rebuild	Responses to Workshop (translated from Spanish)
1	Easy	Bottles- Easy Window- Difficult Wire- Difficult	Beautiful	Yes	Thank you for helping, hug, likes plant, likes recycling
2	Average, Wire was tricky	Bottles- Easy Window- Difficult Wire- Difficult	Beautiful	Yes	Thank you for helping, likes recycling
3	Easy	Bottles- Easy Window- Easy Wire- Easy	Good	Yes	Everything is good. I like the plants
4	Easy	Bottles- Easy Window- Easy Wire- Easy	Good, plants are nice	Yes	I like the plants
5	Easy	Bottles- Easy Window- Easy Wire- Easy	Good	Yes	I liked the construction process because I like to build things
6	Easy	Bottles- Easy Window- Easy Wire- Difficult	No response	Yes	I like the construction because I like plants
7	Easy	Bottles- Easy Window- Easy Wire- Easy	No Response	Yes	Very pretty to present

Six of the seven participants said the process of constructing of the garden was easy. One participant, however, found the process to be of average difficulty, explaining that the difficulties stemmed from having to manipulate the wires. Despite this setback, she was still able to complete this step with the help of her son.

**Finding 12: Visually appealing gardens motivate more community members to participate.**

Participants of the individual garden workshop, in general, responded that they enjoyed the construction and the implementation of the individual gardens. The main reason they liked the gardens was that the design itself was “beautiful”.



Two people interested in the individual gardens approached us after having seen them on display at SIFAIS. During the workshop, a community member, who had been walking around the building, stopped by after seeing that the items we were repurposing were being used to hold plants. She spent several minutes observing the process and asking us questions. Similarly, the other community member walked by the SIFAIS building to tell us that she wanted a garden after seeing that her neighbor owned one.

We learned during follow-up interviews that relatives of participants were interested in having their own gardens. For example, Community Member 4 said that “[her] children like it a lot, they take care of it.” She also told us that after showing the individual garden to her mother-in-law, “My mother-in-law asked me, ‘Give me, give me your garden!’ but I told her, ‘It’s mine! Make your own,’” (translated from Spanish).

#### 4.2.2 Logistics of Constructing and Maintaining the Individual Gardens

##### **Finding 13: Bartering helped community members overcome resource constraints.**

Since supplies in general are limited in the community, bartering is a common practice as a means to obtain supplies. This is practiced at the SIFAIS building as they employ local families and community members to perform tasks at the building, such as mopping or organizing. We expect this system to be used for community members to obtain the current materials found at SIFAIS.

Another way for community members to obtain plants, without having to purchase them, is to take cuttings from the plants currently at SIFAIS. Cutting off a portion of an existing plant and placing it in soil in a new location allows this cutting to grow into an entirely new plant. We tested this method at SIFAIS with a *sedum makinoi* tornado succulent, as seen below in Figure 16.



Figure 16: *Sedum makinoi* tornado cutting growing at SIFAIS

##### **Finding 14: Vertical gardens are an effective use of limited space in homes.**

The community members found the vertical garden we designed to be suitable for the space they had available in their homes. From our initial interviews with the community members, as seen in Table 8, we found that four out of five wanted a garden that was either hanging or small enough to be placed indoors. Furthermore, two families had space for only indoor or hanging gardens. Thus, we designed the individual gardens to be slim and capable of resting or hanging on a wall. We presented this design to two participants before constructing it at their homes, and they agreed it would be a good design for the space they had available. When we conducted the follow up interviews, we found that the community members had properly placed the gardens where there was enough space, as seen in Figure 13.

**Finding 15: Gardeners repaired their gardens successfully and with little assistance.**

In subsequent visits, we found that the community members were well-prepared to deal with minor issues with their garden on their own. For example, one woman told us, “one of the plants is drying... the mint. But they told me that it’s because it needs a bigger growing environment,” (translated from Spanish). She was able to obtain this recommendation from other volunteers at SIFAIS and proceeded to move it to a larger pot. Another participant accidentally dropped her individual garden, causing two of her plants and the soil to spill out. She quickly repotted the two plants in other flower pots she had available until she was able to get more soil from SIFAIS.

**Finding 16: There is a demand for usable soil and fertilizer in Carpio.**

While making observations in Carpio, we noted that there was little open space and thus little soil available. In the little open spaces we did find, the soil was dust-like. The ground in these locations was very dry and compacted, even cracking in some places. Additionally, one resident told us that the “soil in Carpio doesn’t function well to grow plants” (translated from Spanish). She further explained that instead of using the soil in her yard, she waits until she finds moderately useable soil, brings it to her house, and fertilizes it using organic waste, such as rice, water, and potato skins. Two other community members told us that they wanted fertilizer for their plants.

### 4.3 Summary

Through interviews and observations of the community and individual gardens, we found several challenges in building and maintaining the gardens. Perhaps most important, we found that although children and art may provide energy and enthusiasm to gardening, it is sometimes difficult to maintain interest in caring for a garden when no one is designated to be in charge. Additionally, we found that encouraging people to grow the plants that they want and developing close relationships with these people helped sustain motivation for individual gardens for the seven weeks we were there. Lastly, we observed that despite the constraints of gardening in Carpio, such as little space and poor soil, the community members we worked with were willing to garden and seek better methods to obtain plants and soil.

## Chapter 5. Recommendations

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The recommendations we present for SIFAIS are organized first by community gardens and individual gardens. Within each of these categories we talk about how to maintain and improve that particular type of garden based on our findings. We organized it this way to allow SIFAIS to determine the necessary recommendations to implement if they seek to maintain their gardening program at its current stage or opt to improve it. SIFAIS is therefore the key stakeholder that decides what is best for their gardening program and community. Next, we provide recommendations for a composting program at SIFAIS. Finally, we present recommendations for future volunteers and WPI IQP teams to expand on this project.

### 5.1 Community Gardens at SIFAIS

We proposed recommendations about the maintenance and expansion of the community gardens. These recommendations will increase the likelihood of the gardens thriving and suggest ways for community members to come together and support each other's gardening efforts.

#### 5.1.1 Maintaining the Gardens

**We recommend that SIFAIS staff utilize the plant guides for the community garden.**

The purpose of this recommendation is to ensure that the plants in the community gardens have the best chance of thriving. In Finding 7 we learned that different plants require different amounts of water, space, and sunlight to survive. Appendix H shows plant signs that can be cut out and hole punched, illustrating how much water, space, and sunlight a particular plant needs. One hole indicates a small amount is needed, two holes indicates moderate amounts, and three holes indicates the most amount of that particular resource is needed for the plant. Also, in Finding 9 we learned that the Carpio residents learn well with hands-on demonstrations. These plant guides allow SIFAIS to easily demonstrate the process of taking care of the specific plants.

**We recommend that SIFAIS staff water the community gardens once a day with one or two children from the Montessori school.** The purpose of this recommendation is to make sure the plants get watered and to encourage children to be involved in the community garden. In Finding 5 we mentioned that the SIFAIS staff are busy during certain times of the year, so involving children may be a beneficial way to maintaining the gardens. We also learned from Finding 2 that children bring a lot of energy to garden maintenance. This would be a way to involve children at the Montessori school and teach them about gardening and recycling, through the process of watering the plants and refilling repurposed water bottles as part of the irrigation system. We recommend SIFAIS to utilize the watering calendar in Appendix G to ensure that the plants are being checked on every day. It is important to note that we have only been in Carpio during the dry season, so different protocols for the amount of water each plant needs might change during the wet season.

**We recommend using a slow drip irrigation system to minimize the frequency of watering.** The purpose of this recommendation is to improve the irrigation system we installed for the community gardens at SIFAIS. The plants improved when the slow-drip irrigation bottles and siphon bucket were installed, as seen in Finding 5. To create a more self-sufficient system and avoid frequently refilling the siphon bucket, it may be possible for SIFAIS to use a water source that is located near the bucket or garden hoses to fill the bucket more easily.

### 5.1.2 Improving the Community Gardens

**We recommend SIFAIS consult gardening professionals.** The purpose of this recommendation is to encourage SIFAIS to improve their understanding of plants and expand their garden. We found that gardening and composting experts were a valuable source of information because they were able to pass on knowledge that helped inform our garden and compost decisions. When we presented the constraints we found from Finding 1 to the professionals, we were able to gain information on which gardening practices were appropriate for Carpio. The gardeners presented the type of plants that worked well under the constraints and opportunities shown in a frequency chart in Appendix I.

We therefore encourage SIFAIS to also ask people with gardening and composting experience for information as they have years of experience to share. A more in-depth and advanced conversation with professionals may help SIFAIS and community members to eliminate a trial-and-error period when starting their garden.

**We recommend that SIFAIS staff seek donations for gardening supplies (plants and soil).** The purpose of this recommendation is to ensure that the community gardens receive new plants and soil as needed. We learned in Finding 16 that the soil in Carpio isn't suited for growing plants. We also learned in Finding 6 that SIFAIS regularly asks for supply donations and stores these in their warehouse. Establishing a source for donations will help to avoid going outside of Carpio to find suitable plant or hardware supply stores and bring supplies back to SIFAIS themselves. Additionally, asking for donations can establish a relationship between SIFAIS and the supplier to help provide a long term source of plants and soil for SIFAIS.

**We recommend planting more herbs, succulents, vegetables, and vines in the community garden.** The purpose of this recommendation is to ensure that the community gardens contain plants that thrive at the SIFAIS site. We learned in Finding 7 that herbs, succulents, vegetables, and vines grow well in the dry season in Carpio. We recommend that SIFAIS plant more of these types or seek plants similar to these types as they make additions to these gardens. For culinary purposes, we recommend SIFAIS plants more edible plants, like Celery and Rosemary, for community members to take home and enjoy. For aesthetic appeal, we recommend SIFAIS plant more succulents. We also recommend to add more vines along the chicken wire fence to increase vertical green space along the back wall of the SIFAIS main building. In preparation for the wet season, we recommend that SIFAIS relocate/replant plants that do well with more water, one of our main constraints. For example, Celery and Mint grow well in wet conditions and may not need to be relocated for the wet season.

**We recommend relocating the Lantana and Torenia flowers from the tire garden to the fence garden.** The purpose of this recommendation is to maximize the chances of flowers flourishing at SIFAIS. We learned in Finding 7 that flowers, such as the Lantanas, did not do well in the garden space between the main and office buildings because the wind caused some of the flower stems to break. Gardening experts stated that the flowers require six to eight hours of sunlight to survive (Lantana, 2016). Since the garden space receives inconsistent sunlight and wind, the flowers struggled to survive.

**We recommend that SIFAIS staff continue to use art in the garden.** The purpose of this recommendation is to encourage interest and motivation towards gardening. We learned in Finding 2 that including art with the gardens increased the participation of children helping with the garden. During our build of the garden on a Saturday, where children were readily helping, we found that many of them enjoyed the garden because of the way it looked: the tires were colorful and the plants looked interesting. Additionally, Nehemias, an expert gardener, recommended to involve art in

gardening to capture the attention of children. Therefore, to continue to engage children, SIFAIS should encourage artistic activities alongside gardening, such as painting plant containers and choosing colorful, interesting plants.

## 5.2 Individual Gardens for Homes in Carpio

For the individual gardens, we present recommendations about maintaining and improving the gardens. Following these recommendations will help increase the number of individuals gardening throughout Carpio, help the plant and designs last longer, and improve the quality of the plants.

### 5.2.1 Maintaining the Gardens

**We recommend to use smaller plants that are best suited for growing in the water bottle design that don't have large water requirements.** The purpose of this recommendation is to ensure that the plants have adequate root space. We learned in Finding 14 that the vertical garden design is a good use of vertical space for homes in Carpio, and thus the types of plants used in this design must be chosen carefully. These plants must not require a lot of space, as they are planted in small plastic bottles, and must not require a lot of water, as the plastic bottles do not hold a lot of water.

In terms of plants, we recommend growing plants like succulents, thyme, and oregano in the plastic bottle containers. These have previously been shown to be successful with past participants based on their size and amount of water needed. We do not recommend growing mint, or similar plants that require a large amount of moisture, because the water bottles are too small to sustain enough water over long periods of time. To overcome this issue, bigger water bottles may work better if they are secured differently to the window frame design. To help new community members start a garden and consider these ideas before picking out plants, we have created a poster with five questions they should consider, as seen in Appendix J.

### 5.2.2 Improving the Gardens

**We recommend that community members use repurposed materials to build the vertical garden.** The purpose of this recommendation is to utilize resources that are available rather than those that are hard to find. We learned in Finding 11 that some of the materials we used to construct the individual gardens were difficult to find, such as the window or wire, but can be substituted for other materials community members may have access to. For example, a wooden pallet could be substituted for the window frame as long as it has a sturdy structure that can hold the weight of the plants and isn't too heavy to be hung on a wall. A piece of wood the size of the frame or pallet can be used instead of the plastic cardboard as a backing. Twine can also be used instead of the thin wire to secure the components together.

**We recommend that community members use cuttings from plants in the community gardens to populate their home gardens.** The purpose of this recommendation is to provide another source for people to obtain new plants. From Finding 10, we learned that people wanted more of the same plants that they received. Aesthetically pleasing plants are hard to find in Carpio, so using cuttings from pre-existing plants could be a way for community members to start their own garden without having to leave Carpio or spend a lot of money. As seen in Finding 13, we were able to successfully grow a new succulent from a cutting we made off the plants hanging at SIFAIS, further developing the feasibility of this method. Cuttings should be done on plants that are healthy and fully grown so that the cutting does not damage the plant or stunt its growth.

**We recommend creating a support network of all of the gardening families to give each other suggestions based on their gardening experience.** The purpose of this recommendation is to initiate a forum about gardening to strengthen the sense of community in Carpio. We recognize that organized interaction with neighbors is not routine in Carpio, but we want to incorporate interaction among community members to maintain motivation for gardening. The forum provides a system by which individuals can share their gardening experiences and learn techniques that work and don't work for individual gardens. We have created a sign-up list to collect contact information of gardeners. The contact list will remain at the SIFAIS building where participants of the individual garden workshop can voluntarily place their name and phone number. The sign-up list can be seen in Appendix K. This list should be easily accessible so it can be used as resource for someone who has a question regarding plants to garden. It is preferable that the families we built the individual gardens with offer to be a resource to community members who want to build their own gardens, as they felt confident in rebuilding the garden design based off their experience at our workshop.

### 5.3 Composting for the Community

We learned in Finding 16 there was interest in wanting fertilizer for plants in the individual gardens. Therefore, we present recommendations of how to successfully incorporate a composting system at SIFAIS.

**We recommend SIFAIS incorporate a vermicomposting system at their site.** The purpose of this recommendation is to provide the SIFAIS garden and community members a resource to obtain fertile soil to help their plants grow. As noted in Finding 16, there is a desire for usable soil in Carpio, and composting could help provide fertilizer. However, we do not recommend a traditional compost system because its requirements are too specific and are not feasible for the SIFAIS site. We instead recommend a vermicomposting system because it uses a small bin with Red Wiggler worms to break down the organic material and can be placed inside (Erez, 2017). SIFAIS could begin this program by using the organic waste from snacks and lunches at the Montessori school. We have provided instructions for constructing and maintaining a vermicompost bin, the resources to purchase a kit, and contacts to purchase worms, as seen in Appendix L.

**We recommend that SIFAIS recruit one or two people who built vertical gardens to be in charge of the construction of the vermicomposting system as well as its daily maintenance.** The purpose of this recommendation is to ensure that the vermicomposting bin is built and properly maintained. In Finding 4 we noted that it was difficult to maintain interest in the community gardens. Thus we recommend that SIFAIS starts with a relatively small bin to address any problems when they arise such as leakage or rodents. Any composting system requires a lot of maintenance (such as daily watering), and we found it difficult to sustain interest in the community gardens at SIFAIS as a new program. While speaking with our sponsor, we determined that it would be realistic to place one or two reliable people in charge of composting so that the care is completed regularly and the contents of the bin do not rot (Fernandez, 2017). While working with one community member, we found that she thought that it would be a good idea to introduce a compost system at the SIFAIS building, and would be willing to work with SIFAIS to exchange labor (such as maintaining the SIFAIS garden) for soil and more plants for her own garden. We recommend SIFAIS involve someone like this community member in the composting program and include them as one of the main caretakers.

**We recommend that SIFAIS staff involve children in composting to educate them about the natural processes of recycling.** The purpose of this recommendation is to sustain

motivation and interest in the compost system. As noted in Finding 2, children were both willing and excited in helping us construct the community gardens. We found that much of their interest in the gardens was because they enjoyed the things they saw, such as painted tires or plants. Hence, children may be as equally interested in vermicomposting as other community members, which would be a good way to teach them concepts of recycling organic materials and the life cycle of different organisms.

#### 5.4 Recommendations for Future SIFAIS Volunteers or IQP Teams

We understand that a two-month time frame is not enough time to ensure that a gardening project is sustained over a long period of time. Our project therefore has room for future SIFAIS volunteers or IQP teams to develop our project by and analyzing the community's response to the community gardens at SIFAIS and individual gardens in homes.

**We recommend future SIFAIS volunteers or IQP teams to analyze the impact of the gardens on the community after one year.** The purpose of this recommendation is to measure how successful the gardens have been since they were first established. Since, the goal of the project was to develop a permaculture program in Carpio that is sustainable, it is important to check how sustainable it really is. We learned in Finding 8 that maintaining relationships with community members is a key component of motivation. Yet, with the loss in motivation from a previous gardening program in Carpio (Nystrom, 2017), a long-term analysis may be beneficial to develop more clear-cut reasons for loss of motivation in the Carpio Community.

**We recommend future SIFAIS volunteers or IQP teams to analyze the status of the garden's plants and look into who has maintained them.** The purpose of this recommendation is to revisit how the plants are doing and how they got to that state. We encountered difficulties in keeping the plants alive in both the community and individual gardens. After one year, it would be valuable to know if the plants survived and if SIFAIS expanded the garden or added more plants. It would also be valuable to know if SIFAIS shifted the responsibility of maintaining the gardening to the community or to other SIFAIS staff members. Also analyzing if the wet season had a particular effect on the gardens would be an important factor to consider.

## Chapter 6. Conclusion

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Urban poverty has been shown to decrease the quality of life of impoverished populations. The quality of life is often impacted by three main factors: pollution (Wolch, Byrne, & Newell, 2014), social exclusion (Hossian & Hossian Khan, 2012), and stress (Weller, 2015). Carpio residents face trash and pollution difficulties from its poor disposal infrastructure, increased levels of stress from its urban poverty setting (Weller, 2015), and social exclusion from the Costa Rica government (Nystrom, 2017) and the media (Schneider, 2008). We tried to improve the quality of life by developing a permaculture program in Carpio, because permaculture has been shown to address problems stemming from a low quality of life in urban neighborhoods. We laid out four objectives to provide more relevant details for the project, develop the permaculture program, and begin to analyze its effects.

Despite the constraints of materials for construction, water, soil, and motivation of community members, we built four different styles of community gardens at the SIFAIS site while involving over a dozen children who were excited and eager to help us construct. We also constructed seven individual gardens with thirteen workshop participants. The individual gardens help to bring appreciation to green spaces by beautifying the homes and providing something for them to appreciate and learn how to take care of. The garden program will be present in Carpio for years to come, further decreasing pollution by repurposing materials, reduce social exclusion by increasing community involvement, and relieve stress by creating green space.



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## Appendix A: Information about composting

### Parameters for normal composting versus parameters for vermicomposting

(Singh et al., 2011)

<u>Parameter</u>	<u>Composting</u>	<u>Vermicomposting</u>
Waste Characteristic	Municipal Solid Waste, preferably same decomposition rate	Any organic waste that is not oily, spicy, salty, or hard
Particle Size	Between 25-75 mm	Between 25-50 mm
Carbon/Nitrogen Ratio	20-50	30:1
Moisture Content	55%	40-55%
pH	Not required	5-9
Process Involved	Thermophilic stage must be attained	No thermophilic stage requirement
Time Duration	Decomposed by microorganisms so it takes longer	Matures relatively faster than compost
Texture	Coarser	Finer
Fate of Heavy Metal and Pathogen	Risk of heavy metals in compost, may have chance of pathogens	Heavy metals removed and worms make it pathogen free

### Seven various types of composting structures

(Altieri et al., 1999)

<u>Structure</u>	<u>Basic Overview</u>
Indore	Dig a pit in the ground and fill with alternating layers of green (fresh) and brown (dry) compostables. Usually kept moist to encourage organic activity and turned over whenever temperature drops in the pit
Bellsuille Pile	Composting partially drained aqueous waste
Pile	Creating piles of layered green and brown compostables and kitchen refuse up to 1 meter in height
Bin	Layering green and brown compostables and kitchen refuse in a perforated bin. Requires turning the compost periodically to allow oxygen
Corral	For larger composting system. Metal corral/fence that is 2 meters in diameter. Green and brown compostables and kitchen refuse layered in corral
Biodigesters	Underground sealed case that mixes water with organic waste for anaerobic fermentation. Produces methane gas used for cooking or producing electricity
Vermicompost	Uses <i>Eisenia foetida</i> earthworms to facilitate in decomposition. Earthworms layered in bed of compost to create humus rich in texture, nutrients, and enzymes.

## Appendix B: Interview Questions

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### Initial Interview Questions for Families

#### General Remarks about interview:

We will conduct semi-structured interviews to ensure that the citizens of Carpio feel comfortable with talking to us. We will be asking about their gardening experience and preferences to learn about how we may construct gardens in their homes in the future. These interviews will be conducted in Spanish. Because translation may be an issue, every member of our team will take handwritten notes and we will (with permission if granted) record each of the interviews with the cellphones to later code and then discuss the results we found.

#### Introduction:

- General introduction of names
- We are students from the United States working with Magdalena from SIFAIS to help introduce gardening into the Carpio community in two ways
  - workshops at SIFAIS
  - helping build gardens in people's homes
- I apologize if my Spanish isn't good, because all of us are still learning the language!
  - I would appreciate if you could talk slowly so that I can better understand
  - Additionally, if it is okay with you, I'd like to record our interview on my phone so that I don't miss any information in translation from Spanish to English. Is that okay?
- The idea here is to gather as much information from you as possible that may help us to build a garden for you or for other people in La Carpio, so any information you give us could be helpful. Does that make sense?

#### Interview Questions

- 1.) What is your name?
- 2.) Do you have any kids?
  - a.) If they do:
    - i.) How many children do you have?
    - ii.) How old are your children?
    - iii.) Do they attend any SIFAIS programs?
- 3.) Have you ever had/do you currently have a garden?

Has a garden	Did not have a garden
<ul style="list-style-type: none"> <li>• Why did you start to garden? What do you enjoy about gardening?</li> <li>• Can you describe your garden, please?</li> <li>• How do you water your plants?</li> <li>• Do you grow food, herbs, or flowers?</li> </ul>	<ul style="list-style-type: none"> <li>• Would you like to have a garden for your house? Why?</li> </ul>

- 4.) What types of plants would you like to grown in a garden? Why?
- 5.) Would you want us to help construct a garden with you? What time works best?
- 6.) Would you or others in your family be able to dedicate time to taking care of a garden?
- 7.) What would you like to see in a garden for your house?
  - a.) For example: something big, small, pretty, useful, requires little maintenance, etc.
  - b.) If none provided, ask about the criteria below

- i.) Ease of Build, general maintenance, amount of water, accessibility of materials, space, aesthetic/professional looking, durability

#### Closing Remarks

- Do you have any questions for us?
- If you'd be willing, it would be helpful to have some way to contact you (a phone number if possible)
- Thank you for your time, it was nice to meet you, and we will be in contact by Saturday, 1/28/17

## Expert Interview Questions: Gail Nystrom, Founder of the Costa Rican Humanitarian Foundation

### General Overview of the Interview

Interview took place January 25, 2016. Used a similar introduction as previously stated, focused on how and why she started the Costa Rican Humanitarian Foundation, what she found successful in programs → specifically her program with bottle gardens and what worked and didn't work. Interview in Gail's office at the Costa Rican Humanitarian Foundation. Four of us participated with one person trying to write down everything said, 2 people taking notes, and one person mainly asking the questions. The interview was conducted in English.

### Interview Questions

1. What inspired you to found the Costa Rican Humanitarian Foundation in 1997?
2. Do you work mostly with adults or children?
3. What types of programs work best for engaging the community?
4. What is your favorite program that the Costa Rican Humanitarian Foundation has executed?
5. Have you ever run a gardening program?
  - a. If yes:
    - i. What style of gardens did you decide to use?
      1. Vertical / horizontal
      2. Large (for the community) / small (for a household)
    - ii. What types of materials did you use? How did you gather these materials?
    - iii. What types of plants were grown? Did they grow well?
    - iv. Where did you get the plants?
  - b. If no: have you ever considered it? Do you think it would be successful?
6. Have you ever worked with SIFAIS before?
  - a. If yes: doing what/on what project or event?
  - b. If no:
    - i. \*describe what SIFAIS does
    - ii. Have you ever heard of them?
    - iii. Would you be willing to collaborate with them to help create gardens in the community?
7. Have you ever done composting? What worked and what didn't work?

## Expert Interview Questions: Gardening Experts

a) Mariel Castadena, Costa Rican Garden Club

### General Overview of the Interview

We contacted veggelution through email with the same introduction sending both a spanish and english version. We plan on communicating over email and possibly skype. If we use skype, the conversation will most likely be recorded with 2 or 3 of us taking notes and others asking questions. For a skype interview, we plan on having a semi-structured with room for them to elaborate on additional points and topics.

### Interview Questions

1. How long have you worked with the Costa Rican Garden Club organization?
2. What is your position/role within the organization?
3. Where is your garden?
4. What style of gardening is practiced at your location? (vertical/horizontal)
5. What types of vegetables have grown best in your gardens?
6. What types of plants would you recommend for a dry environment?
7. Do you usually start planting from seeds?
8. What type of soil do you use? Where do you get your soil?
  - a. If they get it from a store:
    - i. Where is the store located?
  - b. If they bring up composting:
    - i. Do you find that soil to be nutritious and helpful in growing the plants?
    - ii. Would you recommend it?
    - iii. Where is your composting location located?
9. What struggles have you encountered while gardening? How have you gone about solving them?

b) Nehemias Rivera, San Jose Community Gardener

### General Overview of the Interview:

We plan on interviewing Nehemias in a semi-structured interview via email in Spanish to learn about his experience with urban gardening San Jose, Costa Rica.

### Interview Questions:

1. We read in an article on Tico Times: "Learn how to grow an urban garden in Costa Rica", that highlights you going about gardening in a different way. Can you elaborate on your process?
2. We understand you started a garden at Alma Mater. How did you go about helping the students to create a garden?
3. Was the garden there successful? Why?
4. What successful methods have you used to engage communities and students in gardening?
5. In what gardens have you worked? How have they been different?

## Post-workshop interview questions for families

1. Did you think it was easy or difficult to make? Why?
2. Do you think this is something you would be able to make on your own, or teach someone else how to do?
3. Do you think that you may be able to find like materials to make more in the future?
4. Did you like doing this or no? Why?

5. Do you have any suggestions or comments for us?

### Follow-up interview questions for families

1. How has your experience been gardening so far? good or bad? why?
  - a. How are your plants doing?
2. Is there anything in particular that you think has helped or hurt your garden?
3. Is there anything that you wish you had known before starting a garden? Why?
4. Do you think that the teaching of the gardening was sufficient? Was the process of making the garden clear, and is there anything we could have done better? Please explain.
5. How do you think we, or someone else could best help you to continue with your garden? Do you think that you are okay with caring for it now? Would you like someone to periodically check in? OR something along these lines?
6. Do you have any questions for us?



## Appendix C: Community Gardens Guide

To build community gardens at the SIFAIS building, we first gathered inventory of what resources were available for us to use at SIFAIS's location. These resources were found in the SIFAIS office, warehouse, and activities building. We found numerous tires and large tin cans and



decided to utilize these as a material for our design. The images below show the four different garden designs we implemented at SIFAIS.

Planter types at SIFAIS: a) tire garden (top left), d) fence garden (top right)  
c) ground garden (bottom left), b) hanging can garden (bottom right).

a) Using tires leftover in the SIFAIS warehouse, we planted Lantanas, Torenia, Celery, Rosemary, and Mint in the ground space between the SIFAIS buildings. The tires were filled halfway with rocks and topped soil followed by each plant. The tires were used in this location because they take up more space laterally and are able to hold larger plants. This is ideal because this is the largest amount of lateral space we had to work with in all of Carpio. The sides of the tires were already painted when we found them, which made this design a nice addition of color to the space and thus more aesthetically pleasing.

b) The fence garden contains four medium sized flower boxes attached to the fence outside of the office building. This garden location was recommended to us by Kayla, a community member and SIFAIS volunteer, to create a green space closer to the Montessori school. The boxes were secured to the fence by poking two holes in the back of the flower box and weaving a wire through each and around the fence. This wire was twisted and secured on the inside of the box pointing down. We did not place any rocks, soil, or plants or seeds in these flower boxes as Kayla and Magdalena plan to work with the children at the Montessori school to begin this garden in the near future.

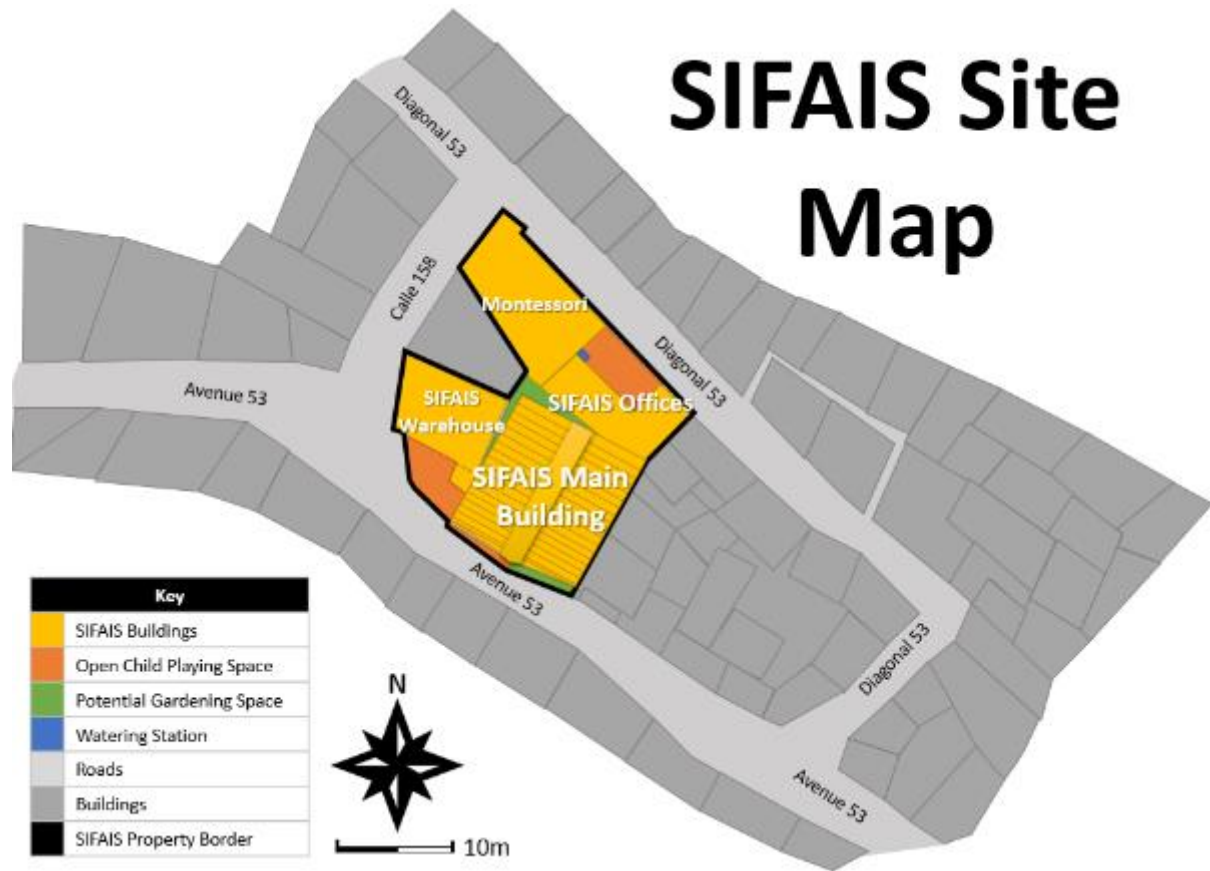
c) This garden in the ground contains Ficus Ivy, Dusty Millers (ferns), and small succulents planted at the base of the back wall of the activity building. We placed better soil on top of the existing soil at this location; this region was closed in by large, smooth rocks to zone off the space and make it aesthetically pleasing. We also placed chicken wire behind this zone for the Ficus Ivy to

climb us as it grows. The idea here is that it extends itself upwards to create a vertical aspect to the garden below.

d) We created the hanging can gardens by filling large tin cans with *Sedum makinoi tornado* succulents and hanged them inside the SIFAIS activity building. We took the tops off of the cans using a can opener and then poked six holes in the can: three holes on the bottom of the can for excess water to drain out, and another three holes evenly spaced around the rim of the can to hang wires from. Three wires were twisted around the rim at these locations and then brought together and twisted around a carabiner. We tied wire around each of the ten beams on the inside of the SIFAIS building, and hooked these planters onto the wire to hang throughout the building.

## Appendix D: SIFAIS Site Map

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## Appendix E: Vertical Garden Guide

a) Guide on how to construct a modular vertical garden: English (left)


b) Guide on how to construct a modular vertical garden: Spanish (right)

**Sifáis WPI**



### Construcción de Jardines Verticales Modulares en SIFAIS

Pida a Magdalena o Maris que construyan su propio jardín vertical



**Paso 1**

- Quitar el vidrio

**Paso 2**

- Corte el cartón plástico apropiadamente
- Conéctelo a la ventana con alambre

**Paso 3**

- Cortar malla de alambre para cubrir la ventana

**Paso 4**

- Hacer agujeros en la lamina de plástico apropiadamente
- Doblar la malla de alambre alrededor la ventana y palo a través de los agujeros


**Paso 5**

- Cortar botellas de plástico de 1,0 litros en un ángulo
- No corte demasiado la botella

**Paso 6**

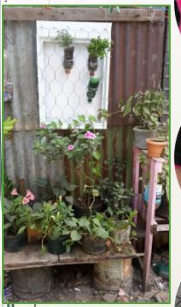
- Añadir algunas rocas y tierra en botellas
- Inserte la planta apropiadamente

**Sifáis WPI**



### Construcción de Jardines Verticales Modulares en SIFAIS

Pida a Magdalena o Maris que construyan su propio jardín vertical



**Step 1**

- Remove glass

**Step 2**

- Cut the plastic cardboard appropriately
- Attach with wire

**Step 3**

- Cut wire fencing appropriately

**Step 4**



- Make holes in the plastic cardboard
- Wrap wire fencing around window

**Step 5**

- Cut 1L plastic bottles at an angle
- Do not cut too much

**Step 6**

- Insert rocks and dirt into bottle
- Insert plant appropriately

## Appendix F: Team Observations and Research Questions

Constraint	Research Question	Location	Observation	Findings / Opportunities
Materials	What types of materials are in excess and can potentially be used to create permaculture systems?	Street sides, SIFAIS warehouse	Plastic bottles, tires, chicken wire, rocks, cinder blocks, large tin cans	Use SIFAIS Inventory  Use recycled materials  Seek donations
Water	What water resources are available? Is tap water clean and reliable and able to be used to water plants?	Homes of residents, SIFAIS buildings	Tap water from sink or spigot is clear: suitable for drinking, fine for plants	tap water  Bottles water  Rain during wet-season
Soil	Is the soil of good consistency and nutritious enough to support plant growth? Does it drain well?	Homes of residents, open space at SIFAIS, Humanitarian Foundation Daycare Center	Dry and dust-like, land is hard, crackling in some places; ground does not look like it can absorb a lot of water	Proper drainage systems and composting methods will be needed to produce usable soil for gardens.
Motivation	Are residents very busy during the day? Would they have enough free time to take care of a garden?	Street activity, scheduled appointments, SIFAIS program calendar, Neighborhoods surrounding SIFAIS	Children wander the streets in pairs or small groups (this was their summer break).  Mothers remain in their homes, especially in the morning (when our group was there). Fathers were not present; we did not meet any fathers.  SIFAIS programs happen on Saturdays; this is when the building is the most occupied with families (mothers, fathers, and children).	A heavy focus must be placed on how to involve the community in helping with the gardens.

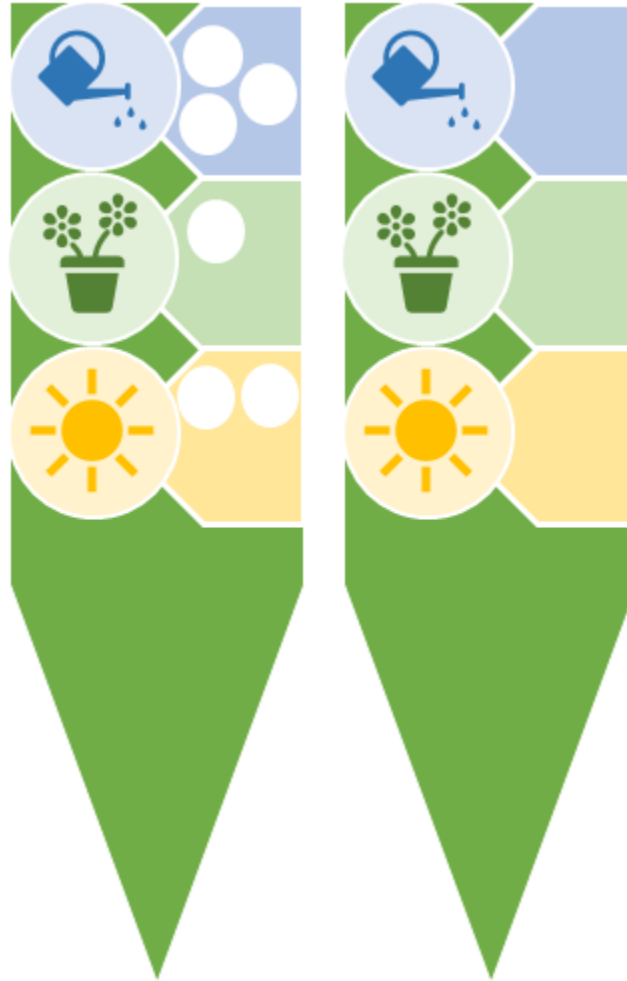
## Appendix G: SIF AIS watering schedule, drafted by project team

2017			January				
SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	
01 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	02 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	03 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	04 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	05 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	06 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	07 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	
08 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	09 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	10 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	11 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	12 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	13 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	14 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	
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05 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	06 9am 12pm 3pm <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Notas:					

## Appendix H: Plant Signs

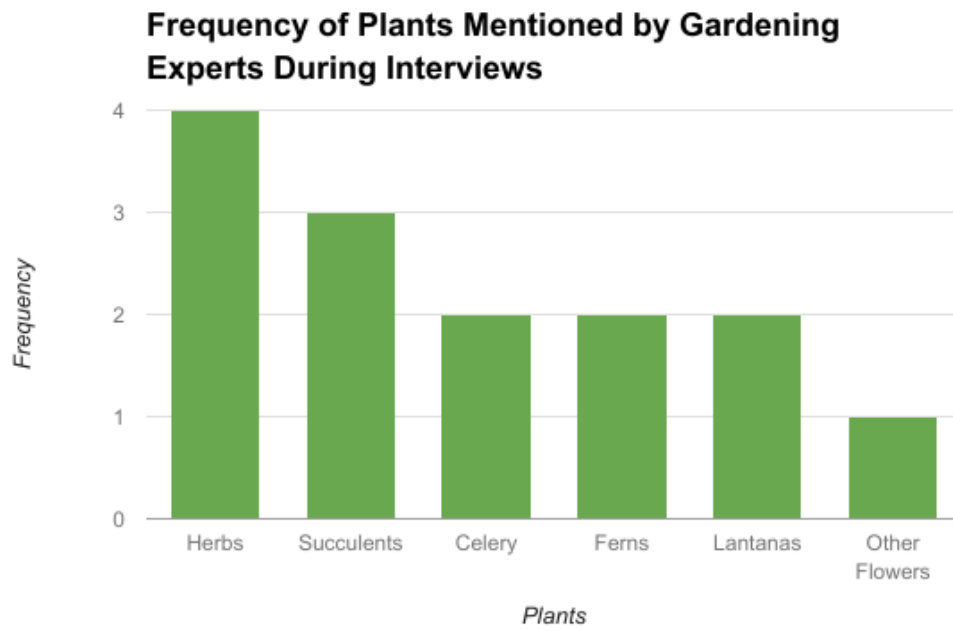
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These plant signs are meant to be inserted in the soil next to the plant after being hole punched according to how much water, space, and sun that particular plant needs.




## Appendix I: Frequency of Plants Mentioned

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## Appendix J: 5 Questions of higher level thinking poster


**Sifais**  **WPI**

# Preguntas para pensar



 ¿Por qué quiere un jardín?

 ¿Cuáles son las condiciones climáticas en el lugar de donde quiere un jardín?

 ¿Cómo está la tierra?

 ¿Hay espacio suficiente?

 ¿Tiene tiempo para cuidar a un jardín?





## Appendix L: Composting Recommendations

### Vermicomposting Guide

**Compostaje con Gusanos**

MUY FACIL Y DIVERTIDO!

1. UTILIZAR GUSANOS
2. PONER LOS RESTOS DE COMIDA EN EL COMPARTAMIENTO
3. RECIBIR LA TIERRA
4. USAR SUELO PARA CULTIVAR LAS PLANTAS

**Que puede usar a compostaje?**

LAS FRUTAS  
LOS VEGETALES  
EL CEPED  
LAS HOJAS  
LAS RAMAS

**Donde puede obtener los gusanos?**

RIGOBERTO PÉREZ, 506-8652-6856  
ENTREGA A SAN JOSE LOS FINES DE SEMANA  
2 KILOGRAMS DEL GUSANOS PARA 8.000 COLONES  
INCLUYE COMIDA PARA LOS GUSANOS

**Donde puede obtener el compartimiento?**

DOS COMPARTIMIENTO EN AMAZON.COM  
WORM FACTORY D53BT 3-TRAY WORM COMPOSTER PARA 44.860 COLONES  
O  
WORM FACTORY 360 WF360B WORM COMPOSTER PARA 61.121 COLONES

LOS GUSANOS ESPECIFICAMENTE PARA EL COMPOSTAJE SE LLAMAN LOMBRIZ ROJA

EL COMPOSTAJE TIENE 70-80% HUMEDAD

PARA COMENZAR, COLOCAR LOS GUSANOS ENCIMA DEL COMPOST

NO USA CARNE

6 EL ABONO ES LISTO EN SEIS MESES

SE COMBINAN CON LA TIERRA PARA CULTIVAR PLANTAS

### Constructing and maintaining a vermicompost bin

We have found free resources for proper methods of construction and maintenance of vermicomposting as a beginner which was consistent with our background research and our interviews with experienced composters:

<http://www.asociaciongrama.org/documentacion/manuales/Manual%20de%20Vermicompostaje%20GRAMA.pdf>

### Composting expert contacts

Lastly, we have been in contact with several people of composting expertise that stated they would be willing to answer any basic questions that SIFAIS has about vermicomposting. Their names and contact information are found below:

- 1.) Ben Goldberg, Director at Rich Earth Institute, [plunkatune@gmail.com](mailto:plunkatune@gmail.com)
- 2.) Fabian Pacheco, [bloqueverde@gmail.com](mailto:bloqueverde@gmail.com)