

# **Recycling and Sustainability Education in Ciudad del Saber**

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# Acronyms

CdS:	Ciudad del saber or City of Knowledge
CAM:	Centro de Acopio y Manejo de Desechos Sólidos or the Recycling Center in CdS
FAS:	Fundación de Acción Social por Panamá
FCdS:	Fundación Ciudad del Saber
FMEA:	Failure Mode and Effects Analysis
IWC:	Informal Waste Collector
TSOS:	Time Study Observation Sheet
WPI:	Worcester Polytechnic Institute

# 1. Introduction

In the modern world, due to rapidly developing economic status, waste management has become one of the main issues for many of the countries in the world. Poorly managed waste leads to many other problems including the contamination of the world's ocean, the transmission of diseases, and the decrease in air quality. For developing countries, the matter is even more urgent due to the high rate of waste generation accompanying this fast economic growth (Kaza et al., 2018, p. 1). Indeed, Panama falls within this category.

Panama is one of the fastest growing economies in the world, second fastest in the Latin America and the Caribbean region. Inherently, one side-effect of economic growth is increased amounts of waste generated. In 2010, Panama generated 1.22kg of waste per inhabitant per day (Pan American Health Organization, 2010, p. 104), 95% of which inhabitants incinerated or placed in a landfill. This is equivalent to only 5 percent of waste being recycled (Ciudad del Saber, 2020). In comparison, the United States recycles or composts 35.2 percent of waste (U.S. Environmental Protection Agency, n.d.). Similar to many countries, it is vital for Panama's recycling programs to become more eminent and efficient in order to combat its rapid generation of waste.

Recycling is the process of converting waste into something new and reusable. This process prevents materials from being sent to landfills and incinerators (U.S. Environmental Protection Agency, 2016). Incinerators release carbon dioxide. As items in landfills decompose, they release methane and carbon dioxide into the atmosphere (U.S. Environmental Protection Agency, n.d.). Both gases are greenhouse gases meaning they trap heat in the Earth's atmosphere and take 300 to 1000 years to break down (Buis, 2019). These gases act like insulation around the Earth and prevent heat energy from escaping the atmosphere (Union of Concerned Scientists 2009). This heat energy is causing the lower atmosphere to heat up and create negative effects such as climate change that impacts human life.

One strategy for improving the waste management situation is to advance the existing recycling system in Panama. This project focuses on the operations of a recycling center at Ciudad del Saber (CdS) which is near Panama City. CdS, also referred to as the City of Knowledge, is a community of students, scientists, artists, and leaders who work alongside community and

government leaders, non-profit organizations, and businesses committed to sparking societal change (Ciudad del Saber, n.d.).

Previous WPI teams have done work for CdS related to sustainability. In 2015, a WPI team investigated the possibility of a composting program in CdS in order to limit the amount of organic waste being sent to landfills. In 2018, another group produced a report on the carbon-emissions of the community to assess CdS's carbon footprint. Furthermore, this group suggested community strategies to improve its carbon emissions in the future. One of the suggestions was to improve their recycling center (Milsark, Mittleman, & Van Tronk, 2018, p. viii).

The goal of our project is to improve the recycling process currently in place at Ciudad del Saber, and to educate the public about the importance and correct practices of recycling. In order to assist CdS to gain insight on implementing improvements to their current recycling center processes, our team identified four main objectives:

- 1) Understand the current waste management process at Ciudad del Saber.
- 2) Recommend improvements to the current waste management process at Ciudad del Saber.
- 3) Determine the current level of understanding about recycling.
- 4) Propose new signage and education programs.

## 2. Background

### 2.1. Recycling

Recycling is the process by which used materials previously thought to be waste are converted into something that can be reused rather than thrown out. Potential recyclable materials include paper, cardboard, glass, metal, certain types of plastics, and more. Different countries have a variety of methods for collecting recyclable materials such as curbside pick-up as well as centers where people can drop off their recyclables themselves. Recycling centers are places where people drop off their recyclables rather than throwing these items in the trash. Workers in these centers organize and sell the recyclables to an outside party. Depending on the recycling center, machines sometimes exist to process materials on site. Eventually, these processed materials get reused as raw materials (U.S. Environmental Protection Agency, n.d.). Generally, there are two standard methods of sorting the recyclable materials into groups based on their material.

The two methods of sorting recyclable material are single stream and source separation. The single stream method allows for one single bin at the drop off point. Recycling center workers sort this bin after collection. In contrast, source separation entails multiple bins at the source, and consumers place the items into bins based on material type. Therefore, source separation reduces the need for recycling center workers to sort recyclables. Citizens view single stream recycling as favorable because it is more convenient to place all the recyclables in one bin rather than sorting them. In this case, the citizen may be more likely to recycle. However, single stream separation does have its costs (see **Figure 1**). Single stream separation often results in contamination of certain materials due to the mixing of various other materials (Rogoff, 2014). Due to the severity of this issue, in 2018, China enacted the National Sword policy, banning the importation of most plastics and other materials to its recycling processing plants. The policy caused a global crisis as China had previously been handling nearly half of the world's recyclable waste (Katz, 2019). On the other hand, stream separation reduces contamination, as well as maximizes revenue by organizing scrap material and limiting the cost for sorting at the facility. CdS uses both single stream and source stream separation, which we will discuss in greater detail in section 2.5 (Rogoff, 2014).

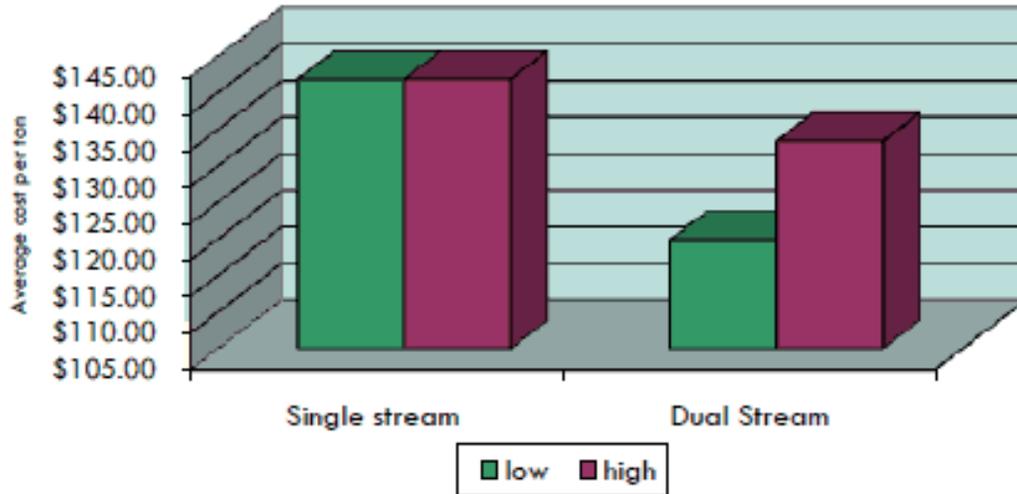


Figure 1: Average Net Cost Estimates of Single Stream versus Dual Stream Recycling (Container Recycling Institute, 2008)

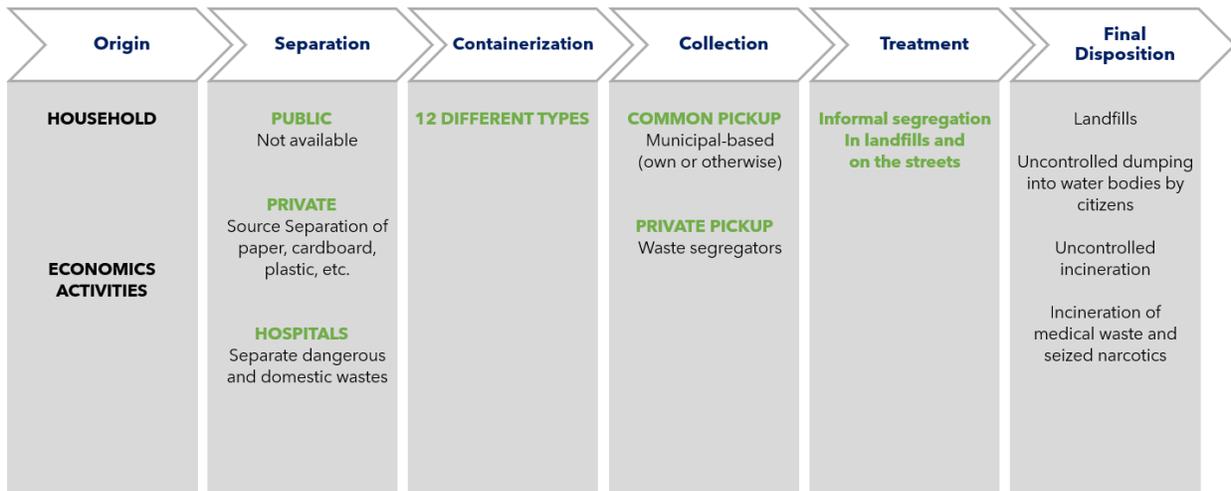
People often describe recycling as a circular economy model (see **Figure 2**): a good is manufactured, used, reused, collected, recycled, and processed into raw material for remanufacturing. Analyzing the model, every stage is crucial for the flow of goods around the loop. However, recycling in many countries, including Panama, is not an efficient process, due to the existence of bottlenecks. In the case of Panama, the issue lies mainly in the underdeveloped collection process.



Figure 2: Circular Economy of Recycling (Smith, 2019)

## 2.2. Waste Management and Recycling in Panama

As a consequence of the increased economic activities and population, Panama generates a huge amount of waste. Panama City alone generated more than 36,000 metric tons of waste in January 2019 (Ineco, 2017). With the exception of medical waste, generally there are no public or government organizations in Panama's capital of nearly four million residents separating the generated waste. However, several private businesses separate their waste and sell the recycled materials to reduce collection fees and to minimize environmental impact. These private businesses utilize various techniques to store their waste, such as in carnatas or industrial-sized trash bins. Municipalities then collect the waste, using either their own means or private contractors. In many regions of Panama, waste treatment and recovery are not available post-collection. Nevertheless, recently, both the government and private organizations have made efforts to treat collected waste before the final deposition, especially in the region of Panama City. The process ends with burial at landfills or incineration.



*Figure 3: Flowchart of the current Waste Management Model in Panama (Ineco, 2017)*

Overall, the waste management system in Panama (see **Figure 3**) is lacking in many aspects, especially in the area of separation and treatment, which are part of the collection stage in the circular economy model. Realizing these shortcomings, local authorities have taken actions towards a green Panama, such as the launch of Zero Waste Program and the publication of the National Plan for Integrated Waste Management (Ineco, 2017). However, due to the unequal

distribution of wealth, the intensity of actions taken is uneven throughout the nation with most of the efforts concentrated in large cities, such as Panama City and Colón.

Nevertheless, these efforts are helping the country achieve its goals of becoming a greener nation. For Panama City, authorities have been collecting data to optimize waste collection routes. The authorities have been installing more waste containers, including containers for recyclables (see **Figure 4**).



*Figure 4: Recycling Station as part of the Zero Waste Program in Panama City (Basura Cero, 2019)*

With the current measures implemented by the authorities, the citizens of Panama City have been exposed to the idea of recycling. However, to effectively tackle the waste issue, public education on recycling is a crucial step to cultivate a more proactive mindset and engender cultural change.

## 2.3. Environmental Education

As mentioned above, investment in infrastructure supporting recycling is one component of the solution to improving waste management. Educating everyone on the importance and processes of recycling has the effect of increasing participation in current recycling practices and improving the quality of recycling activities. It is pointless for a country or region to have great facilities and materials to recycle if no one is actually doing their part and recycling. Through education and a raise in the awareness of the problem, significant growth in participation of recycling will start to happen in Panama.

There are a couple of approaches and settings that could be effective in raising awareness on the recycling issue in Panama. The first would be educating young children on the topic. Sadly, according to the “Global Competitiveness Report” Panama is ranked 129th in the world for Primary Education (Mattson & Teran 2011). However, it may be possible to educate Panamanian children on recycling despite the poor education rankings. In fact, there are many tested strategies that have worked in other countries. There are a couple of approaches to incorporating recycling into the school curriculum. The first is by downloading previously created recycling plans from online. There are many lesson plans that generous people have made free of charge for any teacher to use for their classroom. This eliminates the teacher actually having to make the plan themselves and instead ensures that someone with prior knowledge is teaching the material. Another technique is to play a recycling bingo game. Children love to play games, so it can be very effective to play a recycling-themed bingo game in which the teacher would take time to educate the children on recycling between rounds of the game (Tornio 2020).

There are also other opportunities for children to learn and practice recycling outside of the classroom. One way is by parents taking their children to a park or beach. With animals walking and flying around, parents can educate their kids on how the trash left on the ground affects the wildlife. Another nice and simple scheme is to read bedtime stories to children. An example would be the Lorax by Doctor Seuss. There are also many other children's books on recycling that parents and teachers can use to educate kids in a fun way (Shapley 2019).

Outside of educating just children, awareness campaigns are great for all age groups. One successful campaign, the “Deal with the Consequences” campaign in Brazil (see **Figure 5**),

shows the public the damaging effects of not recycling and not taking care of the environment (2020). The campaign uses facts to support its claims which is effective when aiming at adults. Simply scaring adults into recycling will not work however. There has to be a balance between using facts and statistics to show potential negative outcomes and words of encouragement. If this balance is reached, then there is the highest chance of success.



*Figure 5: An Advertisement as part of the 'Deal with the Consequences' Campaign (van Gurp, 2011)*

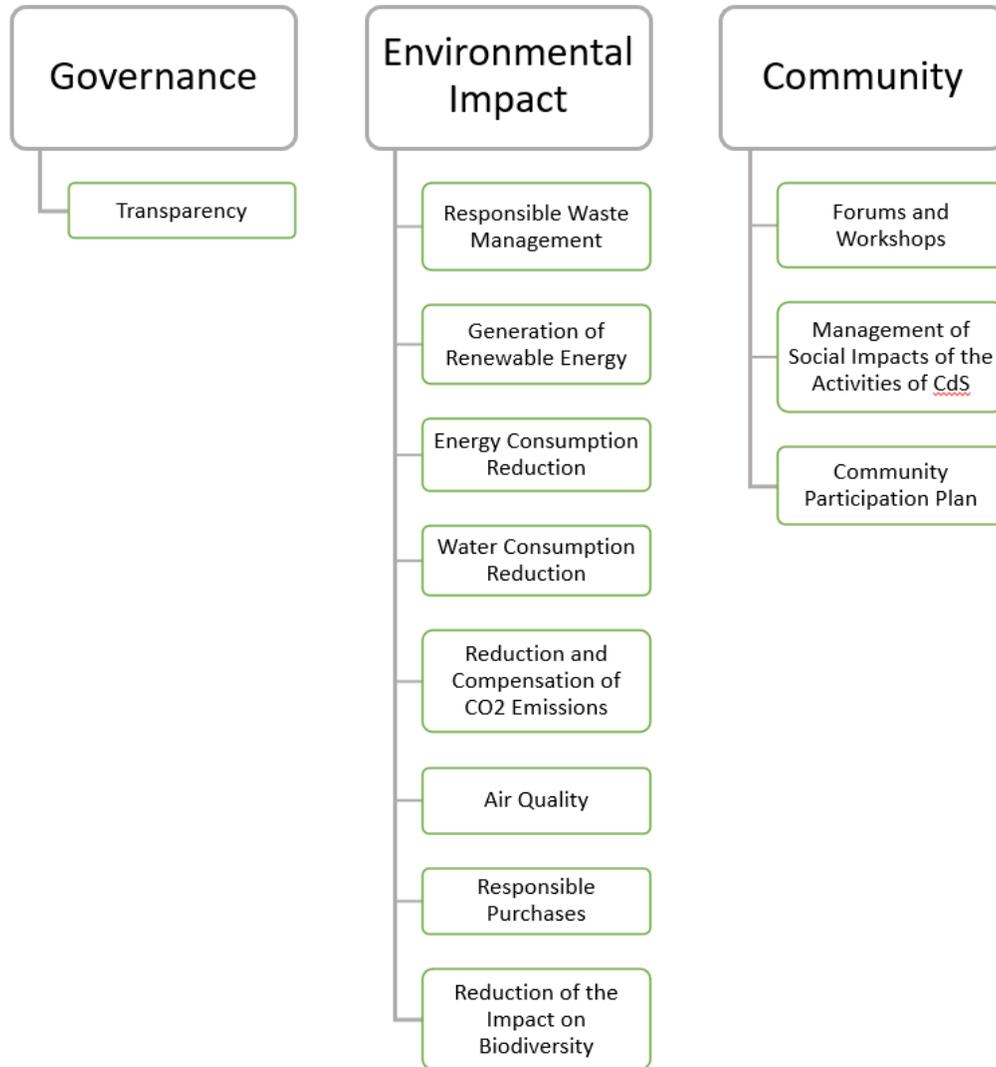
## **2.4. Workforce in Recycling**

As part of an economy, available labor is an important factor to consider for the success of any initiative. Similar to many countries, due to lack of government intervention Panama faces the issue of lacking a formal workforce in recycling.

In some under-developed countries, including Panama, there exists a group of Informal Waste Collectors (or IWCs) who scavenge and salvage recyclable materials and sell them directly to sorting or recycling facilities. In these cases, the government does not tax their proceeds. On the other hand, private companies employ Formal Waste Collectors to collect their waste. When both of these groups co-exist, the number of IWCs is usually small as they earn very little income. In Oshakati, Namibia, an IWC makes US\$0.08 per hour of labor (Bennett, Chretien, Gomarlo & Hurly, 2017). Though there are no statistics available on the income of an IWC in Panama, one can assume the figure is a small number. Since their income is very low, only people who do not have employable skills often become IWCs. Furthermore, IWCs in Panama have to face other issues such as the ban on scavenging and the lack of access to open-air landfills in Panama (Ariel Montenegro, 2017). Hence, unless the government intervenes, the Panamanian workforce in recycling will remain an issue.

Upon closer speculation, one reason for the low income is that contamination causes the majority of the recycling cost to focus on cleaning and sorting materials (Gentle, 2020). In other words, intermediate buyers of recyclables cannot afford to pay much to the sellers. The current solution for the middle-man centers is to recruit volunteers and seek 'free' labor. In Panama, EcoSólidos embarked on a project through partnering with a local penitentiary center and the International Committee of the Red Cross to fuse "the activity of recycling, re-socialization and the reinsertion of inmates" (Ciudad del Saber, 2019). In the case of the recycling center in Ciudad del Saber, since there are only five full-time employees working at the center, volunteers come to the facility once a month to help sort through the collected recyclables.





*Figure 7: CdS's Pillars of Sustainability (Milsark et al., 2018, p. 5)*

The first pillar, Governance, aims to achieve transparency in its sustainability actions on campus. In other words, employees, residents, stakeholders, and visitors of CdS must be aware of CdS' sustainability strategies and policies, which they communicate using a variety of methods including their website. The second pillar, Environmental Impact, focuses on researching and implementing measures to reduce waste and improve environmental qualities. The last pillar, Community, concentrates on increasing community involvement in sustainable activities. Workshops about waste reduction, or education on recycling are effective at achieving this pillar.

As an effort to translate the pillars into visible action, the CdS community has a Waste Management and Collection Center (CAM). The center has a drop-off location where citizens

can bring their recyclables. Currently, the center accepts paper, cardboard, plastic containers, glass, aluminum, and clean Tetra-Pak containers, as well as electronic scraps, batteries, and oil. One Saturday a month volunteers come to the center to sort the collected recyclables and place them into separate areas. As a part of their education effort, CdS educates volunteers on which materials are recyclable or salvageable and how to handle each material. An example of CdS informing volunteers is the bulletin board in **Figure 9** which displays effective ways to handle each material. Such effort is evident through the notice boards and bins that classify different kinds of recyclable materials, such as those shown in **Figure 8**.



*Figure 8: Different Bins for Recyclable Sorting at CAM (Li, 2019)*



*Figure 9: Recyclable Materials Information Board at CAM (León, 2019)*

The CdS recycling center is open for business and staffed by Fundación de Acción Social–Panamá (FAS) workers from 7 am to 3 pm Monday through Friday. The recycling center operates only on weekdays as it is expensive to staff the center. CdS pays FAS to manage the recycling center. The recycling center is one of the only reputable recycling centers around Panama City, leading people from all over and around Panama City to bring their recyclables to the center. CdS asks people to clean and sort their recyclables before arriving at the center. FAS workers have to throw out uncleaned recyclables and food waste. Once at the center, people place their recyclables into bins based on their materials. However, this is commonly not the case. People tend to hand their recyclables to the FAS workers rather than paying attention to

source separation as many people view the separation process as time consuming and disgusting. Rather than forcing people to organize their recyclables, FAS workers will sort these materials themselves, wasting time and effort.

FAS is in charge of finding the best buyers of the recyclable materials. The center has a plastic and cardboard compactor. Compacting material increases the value of these materials because denser material is easier to transport.

Separate recycling and waste bins exist on campus in order to collect the recycling and waste that FCdS employees, tenants, residents and visitors produce on campus. Currently, many people on campus throw their waste into both bins without caring if it is the recycling or trash bin. FAS employees collect these bins and return them back to the recycling center. CdS currently faces a problem because these recycling bins are heavily contaminated with trash. Every time FAS collects the recycling bins, they must then throw out rather than recycle the majority of the bins.

## 2.6. Stakeholders

Before we begin planning the research approaches, our team identified several groups of stakeholders who are directly or indirectly involved with recycling in CdS. The various groups that have different influences on the recycling process in CdS are:

1. **FCdS Employee:** A person who works for Fundación Ciudad del Saber. Since FCdS manages the CdS campus, an FCdS employee can help with recycling through means of administration.
2. **CdS Resident:** A person who resides in a Ciudad del Saber residential facility for at least one night. The residents are responsible for the quality and quantity of the recyclable waste generated that is later collected by FAS workers
3. **CdS Tenant:** A person who operates or works for a business that leases out space on the CdS campus from FCdS. Though recycling programs are not obligatory for the tenants, those who have such programs have their recyclable materials sent to the recycling center.
4. **CAM/FAS Employee/Volunteer:** A person who works at the recycling center. These are the people who directly process the collected materials.
5. **Visitor to CAM:** A person who drops their waste off at the recycling center. These are individuals that contribute to the quality and quantity of the recyclable materials received.
6. **Visitor to CdS:** A person who comes to the CdS campus but does not fit into any of the previous categories. People who fit into this category may generate waste during their visit to the campus. Thus, understanding their perspective can help with determining the solution to the recycling issues

As we work towards our goal, these are the stakeholders that we will consider in our objectives in order to help CdS improve their current recycling processes.

### 3. Methodology

Our project's main goal is to provide Ciudad del Saber recommendations on how to improve their current recycling center as well as on campus participation in recycling. Our team identified four main objectives in order to help CdS improve their current recycling processes:

- 1) **Understand the current waste management process at CdS.** Identifying the existing problems and successes in the system will allow us to propose solutions that are relevant and effective. We will look into the waste classification process, pick-up and drop-off points, and campus participation and communication about recycling.
- 2) **Recommend improvements to the current waste management process at CdS.** Our team will provide CdS with feedback on the efficiency of current operations, as well as offer suggestions on how to operate CAM more efficiently. If time permits, we will begin implementing our proposed solutions and begin to evaluate their degrees of success and potential setbacks for long-term implementation.
- 3) **Determine the current level of understanding about recycling.** This objective will provide our team with a foundation for building an education program, as we will uncover gaps in knowledge of the CdS community.
- 4) **Propose new signage and education programs.** With Fundación Ciudad del Saber (FCdS), we will design and suggest educational materials to raise awareness on the importance and the process of recycling. If we have time, our final step will work towards implementing and evaluating this educational material.

The Gantt chart in **Figure 10** shows how we plan to organize our tasks during our seven weeks in Panama. The lighter color boxes represent less activity on a certain task. Our team will start at the recycling center (CAM) and interview FAS workers to gain general knowledge about processes that occur in the recycling center. Once these interviews are near completion, we will begin an in-depth observation and analysis of these processes. During this time, our team will hand out surveys to CAM workers and visitors, as well as observing the activities at the recycling center for data collection. Once done observing the waste management process at

CAM, we will produce visual graphics based on the data collected and begin analysis of our survey data. Another stage of the project will be to distribute more surveys to the people on the CdS general campus, such as tenants, FCdS employees, residents, and visitors. We will analyze these results as they come in, and work to research and propose recommendations to FCdS regarding the waste management process on campus as well as education programs that may help increase correct participation in recycling. The final stage of this investigation will be compiling all of our findings into a final report and presentation. The remainder of this chapter covers all these activities in more detail.



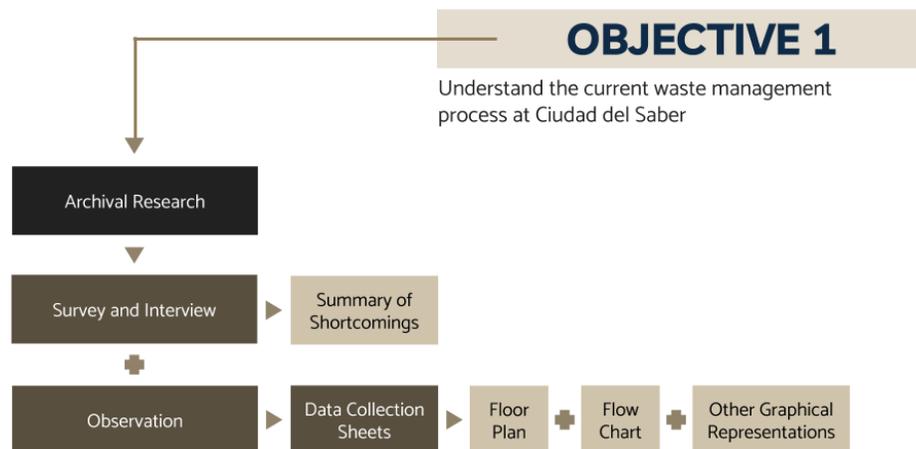
*Figure 10: Gantt Chart of our Project's Methodology*

### 3.1. Objective 1: Understand the current waste management process at CdS

Ciudad del Saber (CdS) recognizes that their recycling center could be more efficient. Specifically, they want us to focus on pick-up and drop-off points as well as campus participation and communication regarding recycling. By identifying the positive and negative processes and attributes of the current recycling center and comparing these characteristics with our current knowledge on recycling centers, we may be able to determine future solutions to implement in order to improve recycling on the CdS campus and surrounding community.

**Figure 11** depicts the flow of the steps the project team will take to develop these solutions. To guide our investigation, we have compiled a list of four overarching questions to gain knowledge on the recycling process and the participants:

1. What are the current sources for the majority of recyclables?
2. What is the current process at the recycling center?
3. What motivates people to recycle?
4. How convenient is it for people to recycle on campus and when dropping off recyclables at the recycling center?



*Figure 11: Overview of Objective 1 Methodology*

With these questions in mind, the first stage is to conduct archival research. We will analyze past financial and operational reports generated by FAS in order to collect data on who is currently involved with the recycling processes at the center, the amount of recyclable materials collected, and the general budget of the recycling center. After reviewing the reports, we will have a better idea of the further information we will need to acquire. To collect the necessary data, our investigation will use two different approaches: Interviews and Surveys, and Observation.

### **3.1.1. Approach 1: Interviews and Surveys**

Based on the findings of the past reports, the team will create interview questions for the FAS employees (see Appendix A provides a preliminary list of questions). The goal of the interviews is to refine our understanding of who is recycling and what they are recycling. Interviews are efficient methods of gaining background information about the recycling center because FAS employees know first-hand the day to day processes currently in place at CAM. Moreover, by completing the interviews during our first couple of weeks in Panama, the responses will provide an opportunity to adapt our surveys and observation approaches.

The last two questions of our first objective require understanding how the consumer feels towards the recycling center. Our team has created an online survey (see Appendix B) to send out to random groupings of people on campus. The first part of the survey is the General Information Questions for all participants to answer. Examples of questions asked in this section are: “Do you currently recycle?” or “What are your motivations for recycling?” After the general questions, there will be an additional two to four questions based on the survey-taker’s category of stakeholder, as defined in section 2.6. These questions can be further refined once we gain further insight from our initial interviews and informal discussions. All survey questions will need to be rather simple, and in English and Spanish, in order to overcome the language barrier on both ends.

### **3.1.2. Approach 2: Observation**

As the interview questions are open-ended, it will be challenging to gain quantitative data on the processes at the recycling center. Hence, our team will conduct naturalistic observational research by observing the activities of the CAM/FAS workers/volunteers and CAM visitors in

natural surroundings. We have decided to use this method of research to minimize the effect of our presence on the activities of the workers and volunteers. Moreover, the observation should yield insight on overlooked matters, and avoid potential problems with self-reported data.

Appendices C to I provide a copy of the Data Collection Sheets.

A limitation to this method is the inability to control different variables to confidently establish the cause-and-effect relationship between the observations. Hence, we cannot repeat the research and expect the same data collected.

### **Approach 2.1: Flow Chart**

Using the information gathered from the data collection sheets (see Appendices C-I), our team will create a set of flowcharts to facilitate understanding of the recycling processes. Some specific types of flowchart we envision are a swimlane chart, and a value-stream map. A swimlane chart has several 'lanes', each assigned to a specific individual or group. This chart will help us understand the relationship between the tasks in a process. A value-stream map serves a similar function of displaying the current state of the process. However, a value-stream map also displays quantitative data such as cycle time (the time taken for each task to be completed), lead time (the time taken for the whole process to be completed), and the amount of resources needed (Russell & Taylor, 2011). To complete these charts, we will need the following data:

1. The tasks involved in the whole process
2. The personnel responsible for completing a specific task
3. The dependency of the tasks on each other
4. The time taken to complete each task
5. The time taken in between tasks.

To collect this data, the team will use the Time Study Observation Sheet (TSOS) (see Appendix C) . We will use a stopwatch to time the workers on their activities for ten repetitions to find an average time ( $\bar{t}$ ) for each activity. The next step is to find the normal time (Nt) by multiplying the

average time ( $\bar{t}$ ) by a performance rating factor (RF), which ranges from about 0.8 to 1.2 (Russell & Taylor, 2011). We will calculate the standard time by adding in an allowance factor.

To summarize the collected data, the team will use a Table Process Flowchart (see Appendix D). The time column will consist of values calculated in the TSOS. One team member will need to measure the shortest distance between the locations where the workers usually move between to complete an action. We will calculate the sum of the total time taken, as well as the sum of the total distance traveled at the end of this table. These numbers are the quantitative data that we will compare with those of our proposed improvements.

In addition, the team will use the Current Process Table (see Appendix E) to record other information on the current process, including the personnel responsible for a task, the tools needed for said task, and any uncategorized observations. We will add a column to this table to measure the amount of recyclable materials being processed during and between each task if we are able to collect such data based on our time and resources. The next task is to categorize the staff based on their role at the plant and how this role fits into the whole process. We will use these categories in the swimlane chart.

The Gantt chart in **Figure 10** depicts the detailed data collection schedule to complete the mentioned sheets/tables. Once we have completed the sheets/tables, the next two steps involve creating the swimlane flowchart and the value-stream map.

For the swimlane flowchart, we will divide a blank paper into the same number of rows as the number of role categories obtained above plus one row for the customer (CAM visitors). In each lane, we will write the tasks responsible by the categorized staff in sequence, connected by arrows to show the order of those tasks. A rectangle activity in the chart shows an action that does not require making a decision. A rhombus denotes a decision making activity with at least two possible outcome activities.

The value-stream map uses the same collected data as shown above. However, the format is different, using a standardized set of process icons and data boxes. Each data box shows the name of the task, the cycle time, the changeover time, and the resources needed to complete the task. In between these boxes are usually yellow triangles showing the existence of inventory - or

the status of materials waiting to be processed during the next task. A timeline is also included at the bottom of the map to show the duration of each task, and the waiting time, if any, of the recyclable materials.

### **Approach 2.2: Floor Plan**

One common problem that many facilities and businesses run into is that their floor plan is inefficient. For instance, tasks that workers should complete at tables next to each other may in reality require a worker to walk across the building. Since CdS does not have an in-depth floor plan, our team will create a block diagram of the current layout of the recycling center on top of the floor plan that CdS provided (see Appendix J). Arrows will be drawn to represent the path a worker takes in completing their day to day activity. The team will later analyze this floor plan as part of our second objective in order to suggest a more efficient floor plan for the facility.

The specific data needed for making the floor plan include:

1. The sizes and locations of the workstations
2. The distances between the workstations
3. Repeated movements between workstations
4. The amount of material moving between workstations
5. The relationship between the workstations.

With the collected data, our team will create a block diagram and/or a relationship diagram. We will use both diagrams in order to understand the movements of employees and materials, and the connectivity of the workstations.

### **Approach 2.3: Other Data Collection and Graphical Representation**

Since CdS currently pays the FAS workers to operate the recycling center from 7 am to 3 pm Monday through Friday, it is possible that CdS is currently paying FAS to operate during hours that it is not economically viable to stay open. While observing the recycling center, one team member will count the number of people that visit the center per hour as the day goes on for each

day of the week that the center currently stays open. We will use the Visitor Tally Table (see Appendix F) to collect this data. Our group will analyze the results of the table to see how the traffic of people dropping off items at the center changes during different hours of the day using a histogram showing the number of visitors versus the time.

Another issue that the recycling center faces involves the waste received by the center not being fully cleaned before it arrives. Using the Rejected Recyclable Table (see Appendix G), our group will collect qualitative and quantitative data on the common contaminants to the recyclables and their frequency of occurrence, and organize this data into a chart that shows what and how items are commonly left uncleaned. The column “Type of Recyclable” shows the material category of that item (for example, plastics or aluminum). A team member will record the reason for rejection in the next column with an acronym denoting the reason for rejection. We will create a table with standard reasons for rejections and their respective shorthand acronyms after we interview the FAS workers. For example, ‘contaminated with food waste’ will be shortened to CFW.

To accompany the surveys and interviews, our team will also observe any current shortcomings using the Fishbone Diagram (see Appendix H) (Russell & Taylor, 2011). We will categorize the shortcomings into one of six groups of causes: Measurement, Personnel, Machines, Environment, Materials, and Methods. We will title the box on the right Current Shortcomings of the Process.

### 3.2. Objective 2: Recommend improvements to the current waste management process at CdS

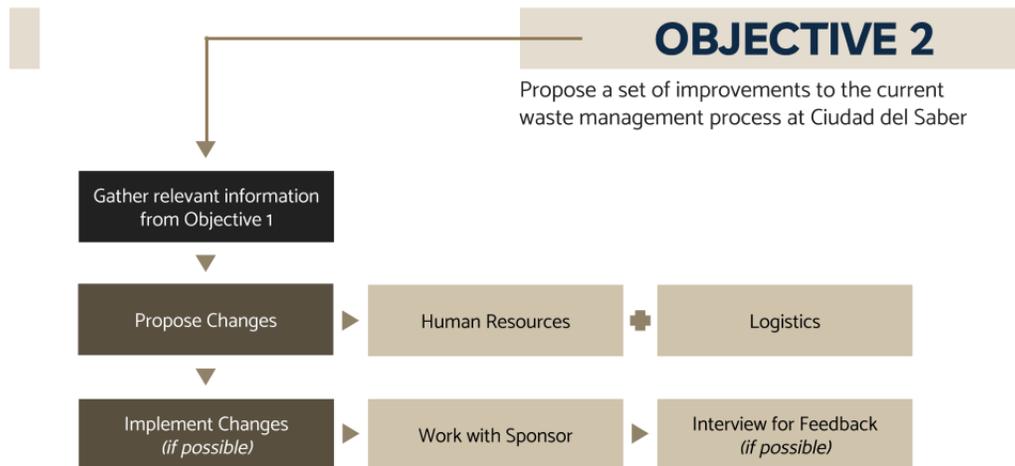


Figure 12: Overview of Objective 2 Methodology

After collecting data on the state of recycling in CdS, we will be ready to propose several changes. The collected information from Objective 1 will determine the starting point for our recommendations to reduce the cycle time of the process. To shorten the cycle time, we will look into seven sources of waste, defined as “anything other than the minimum amount of equipment, materials, parts, space, and time which are absolutely essential to add value to the product” (Russell & Taylor, 2011), to differentiate from the term “waste” in “waste management”:

1. Overproduction: this is because the work-in-progress and inventory does not generate income for the center.
2. Waiting: due to the different rates of work of the tasks, some tasks may have to wait on the materials processed by the previous task.
3. Transporting: This source of waste is the need to transport materials from one station to another.
4. Processing: This source of waste arises from processing steps that do not add value to the final product.

5. Inventory: This waste refers to the need to store and conduct inventory checks on materials.
6. Movement: This source of waste refers to the movements of the workers to look for tools or approval.
7. Defects: Defects can cause a waste of time and resources as they may have to be reworked or discarded.

With these types of waste in mind and the data collected, we will use the flowcharts, the floor plans, and other graphical representations made above to suggest improvements.

### **3.2.1. Approach 1: Surveys and Interviews**

As mentioned earlier, our team will have collected responses of the surveys and interviewed the FAS employees. We will first look at the survey responses according to the question clusters. Questions 2.7 and 2.8 provide us an insight to the stakeholders' motivations regarding recycling. If several responses indicate that 'The recycling bins are full' or 'There are no recycling bins available' are the reasons that prevent the stakeholders from recycling, we would include a suggestion to install more recycling bins in common areas. To accompany this suggestion, question 3.11 would provide information on the effectiveness of the current source-separation recycling bins on campus, and whether they should be widely installed. Questions 2.11 and 2.14 ask the stakeholders if any of the listed incentives would motivate them to clean and separate recyclable materials. The answers to these questions will inform a suggested incentive program to FAS and FCdS to reduce the amount of contaminated recyclable materials and consequently reduce the amount of time wasted by the employees separating the collected materials while increasing the volume of clean materials that the CAM can sell to earn revenue. Questions 3.12 and 3.13 ask the CAM visitors which day(s) of the week they frequently come to the center, and if they would prefer the center to open on a particular day. The replies to these two questions could lead to suggestions for the center to modify its operation hours in order to get more visitors.

Using the interviews of FAS employees (see Appendix A), we can identify qualitatively any current successes and shortcomings of the process at the center. This analysis could provide

suggested improvements to the process, from both human resource and logistics perspectives. The employees may share their discomforts while working in CAM. This could point to suggested methods to boost the employees' morale and improve the working condition. Another possible outcome is a list of items to pass along to FAS Panama and FCdS that the employees think will help them in their work.

Moreover, if the surveys and interviews indicate that FAS workers and volunteers have difficulty locating any tools or materials, we can suggest the use of visual control. We can suggest the recycling center to build shadow boards at each workstation with the tools needed for that workstation. These boards will reduce the Movement waste mentioned above. We can also suggest taping out the work area of each workstation with colored tape on the floor so that the workers can avoid clustering the walking space between each workstation. We also want to suggest the creation of 'In' and 'Out' areas within each work area. The 'In' area will be used to store materials to be processed at that workstation, while the 'Out' area will contain materials that have been processed at that workstation. These two areas will inform the workers at the previous and next workstations whether they should continue producing at the same rate or change the rate. We hope these two areas will reduce waste from Overproduction and Waiting.

### **3.2.2. Approach 2: Observation**

As a result of Objective 1, our team will have a collection of data sheets and visual tools to analyze the current process. Knowing the average time taken to complete a task, our team wants to establish a standard time for the workers to complete the task. The sum of the average times provides us the cycle time for the whole process. We can then use this sum as a baseline to measure the extent of improvement of our proposal.

#### **Approach 2.1: Flow Chart**

The team can use the swimlane chart from Objective 1 to determine if waste sources 2, 5, and 7 exist and suggest strategies such as the reallocation of manpower to tasks that take longer and add value to the final product. We can also suggest the size reduction of storage space and use those spaces for value-added steps, such as purchasing machines that process recyclables into

sellable products. Using the value-stream map, we will identify the current non-value added tasks, or a task of waste source 4.

With the identified sources of waste, we will draft a new swimlane chart proposing a new set of tasks. This new chart will indicate potential and/or current challenges of each task using poka-yoke, a technique in ‘mistake-proofing’ (Russell & Taylor, 2011). For each challenge, we want to identify the causes, the possible solutions, and the potential outcomes of each solution. We will then present the new flowchart with our proposed new process to the sponsor.

If the sponsor decides to implement our proposed process modification in the future, they can display the swimlane chart at the recycling center so the employees can look at the suggested solution for any pre-diagnosed problem. If the sponsor is not in favor of implementing our suggested modification, we will still suggest the display of the current swimlane chart with the poka-yokes to help the employees solve any common problems of the current process.

### **Approach 2.2: Floor Plan**

As mentioned in Objective 1, our team will have created a block diagram and/or a relationship diagram. We will then use these tools to create a new floor plan showing our recommendation of an improved layout. The principle behind the reorganization is to minimize waste of movement and transporting. In other words, the CAM should place workstations that are the most dependent on each other should be closest to each other, while those that do not interact should be further away. We will then propose this new layout to the sponsor, explaining how the new layout would help improve the recycling process. Additionally, our report will suggest displaying the current floor plan, annotated with the work stations’ locations so that new staff, volunteers, and visitors can easily locate where each task occurs.

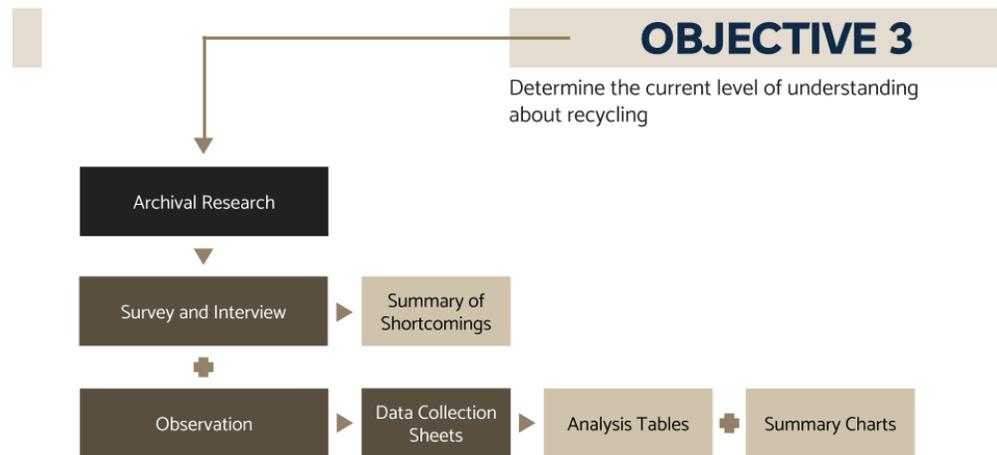
### **Approach 2.3: Other Graphical Representation**

With the visitor tally collected in Objective 1 (see Appendix F), the histogram showing the visitor traffic, and the responses to question 3.12 and 3.13, this investigation can identify which day(s) of the week and which time of the day the center can expect high traffic of visitors and recommend a daily work schedule that takes this traffic behavior into consideration. For example, when there are many visitors to the center dropping of the recyclable materials, the

staff can focus on receiving and sorting the waste so that the collected materials do not have to wait to be processed. On the other hand, during low traffic hours, we can recommend the workers to work on processing the materials collected. Moreover, we want to use the information to suggest if the current operation hours would be the most beneficial. If the traffic to the center is low during the middle of the day, we can recommend closing the center during that time period and keep the center open till a later time in the day.

With the Rejected Recyclable data collected (see Appendix G), our team will create a pie chart to summarize the common reasons for rejection which will guide our suggestions on updated methods for processing the recyclable materials. Then, for instance, we can suggest the implementation of a cleaning station to potentially increase the quality of and the revenue from the materials sold, since CAM does not currently have one.

### 3.3. Objective 3: Determine the current level of understanding about recycling



*Figure 13: Overview of Objective 3 Methodology*

As an integral part of CdS is to educate its community and inspire others to be better (Ciudad del Saber, 2020), Objective 3 is the necessary stepping stone in proposing a better education program in Objective 4. Similar to Objective 1, this phase of our research begins by browsing through a collection of old educational materials to understand past efforts made by Ciudad del Saber and FAS Panamá. This research includes focusing on where the materials are displayed to evaluate accessibility. The point is to understand the focus of CAM's past recycling education activities. In addition, the team will learn which medium FCdS and FAS have used to educate the public. Once we have gathered information on the past efforts, the next step is to determine the current level of understanding on recycling of key stakeholders. We ultimately want to know what stakeholders currently answer to the following questions:

1. What is the impact of recycling?
2. What materials are recyclable?
3. What materials are accepted at CAM?
4. What is the correct recycling practice?
5. What are some common mistakes about recycling?

To get a grasp of what current stakeholders are thinking about these questions we will send out surveys and interview FAS workers.

### **3.3.1. Approach 1: Surveys and Interviews**

The strategy is to use the surveys mentioned in Objective 1 (see Appendix B) to investigate the stakeholders' knowledge on recycling practices and misconceptions. The General Information Question section contains survey questions that we will ask all stakeholders. In this section of the survey:

- Questions 2.4 to 2.8 aim to get an overview about the state of recycling from the stakeholders' perspective.
- Questions 2.7 to 2.14 ask the stakeholder if and why they clean/separate recyclable materials.
- Questions 2.15 to 2.17 test their understanding on correct recycling practices and potentially identify any misconceptions.
- Questions 2.18 to 2.22 gauge the interest in participating in recycling education and explore potential solutions from their point of view.

The project team has tailored the Specific Questions section of that survey, to each stakeholder. The responses from the FCdS employees and the CdS residents, to question 3.7 should provide us a window into why they think recycling is important to the foundation and potentially identify aspects of the FCdS missions and goals that we should serve as the focus for proposing new education materials. For the CdS Tenants, our questions ask if there are any recycling programs in place at their offices, and if FCdS could provide any resources to help them recycle. For the FAS employees and volunteers, the question 'How did you hear about FAS/CAM?' should provide information about how visitors find out new information about recycling.

We will also use the same interview responses from objective 1 with the FAS employees to understand the current practices of the visitors that cause issues at the recycling center. Without

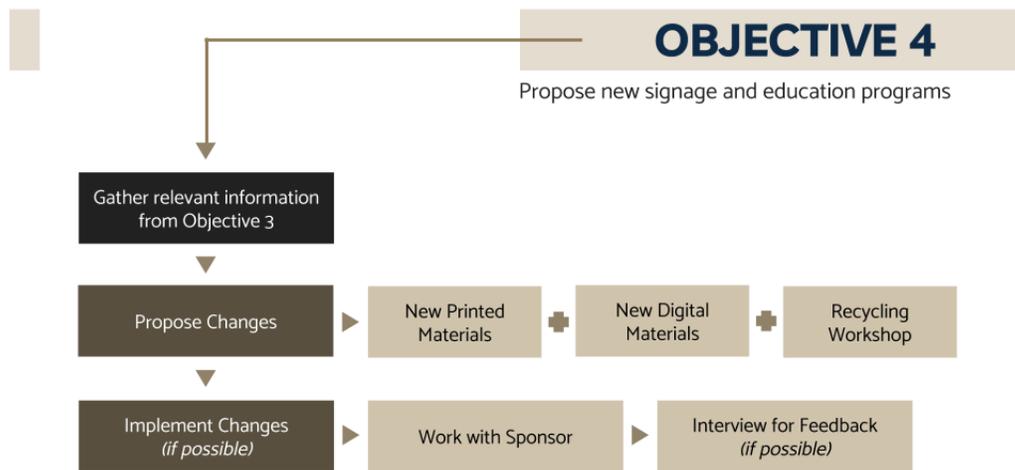
understanding the motivation and knowledge of these CAM visitors, our proposed signages and programs may be ineffective.

### **3.3.2. Approach 2: Observation**

The same Rejected Recyclable Materials Sheet mentioned in Objective 1, Approach 2.3 (see Appendix G), as well as the new Failure Mode and Effects Analysis table (FMEA) (see Appendix I). Should produce information on the common sources of contamination and possible causes for those contamination sources (e.g., an unclean soda bottle will be noted in the table, with the possible cause of ‘Visitors do not clean the materials before depositing’). The team will conduct qualitative analysis of this information for the purpose of yielding both the effects of the error and potential useful solutions to fill into the FMEA table.

Using another Fishbone Diagram (see Appendix H). The team will fill in this diagram with the right-hand side box annotated as ‘Ineffective Education Efforts’.

### 3.4. Objective 4: Propose new signage and education programs



*Figure 14: Overview of Objective 4 Methodology*

To accomplish this objective, we will create educational materials that contain information on correct recycling practices. The results from objective 3 about where the current knowledge gap exists will determine the customization of our educational material. The answers to the question on mean of communication in objective 3 will guide our choice of the publicity platform to use to distribute the materials. For example, if the majority of the replies indicates that social media platforms are the most popular media, the team will investigate initiating an awareness campaign on those platforms, using photographs, videos, and manufactured content such as posters. At the same time, the result of that question can yield a recommendation to FAS Panamá to improve their public presence using the appropriate media.

Furthermore, we want to use the survey responses as an indication to propose several recycling workshops targeted at various stakeholders. For the CdS Tenants, we may propose onsite recycling training based on the response to survey question 3.5. For the general public, we have created targeted survey questions aimed at evaluating interest in a Recycling Fair. The answers to question 2.21 would give our team an indication of whether a Recycling Fair would be well-received by the public. Using the responses to the suggested incentives in the survey (questions 2.11 and 2.14), we can also implement some of these incentives during the fair.

Our search will select the content of the new materials based on the responses to question 2.20, where survey respondents indicate their learning preferences on recycling. If our analysis establishes a correlation between the categories of the stakeholders and their learning topic preferences, we can use this correlation to tailor educational materials for different audience groups.

If there is time remaining during our research in Panama to implement any signage, we would like to evaluate the impact of signage on stakeholders' participation using another survey or conducting informal interviews.

Through our surveys, interviews, observations and research, our team hopes to propose and potentially implement many impactful changes to current recycling operations on the CdS campus. Our work has the potential to not only speed up numerous processes in the recycling center, but also educate people on the CdS campus about the importance of recycling.

# Bibliography

- Ariel Montenegro, E. (2017, October 10). Autoridades Inician Negociaciones con Recicladores en La Chorrera. *Panama America*. Retrieved April 25, 2020, from <https://www.panamaamerica.com.pa/provincias/autoridades-inician-negociaciones-con-recicladores-en-la-chorrera-1085785>
- Basura Cero. (2019, March 25). *Estación para Reciclaje #26*. Alcaldía de Panamá. Retrieved April 20, 2020 from <https://basuracero.mupa.gob.pa/estacion-para-reciclaje-26/>
- Biddle, D. (1993). Recycling for Profit: The New Green Business Frontier. *Harvard Business Review*, 71(6), 145.
- Buis, A. (2019, October 09). *The Atmosphere: Getting a Handle on Carbon Dioxide*. NASA. Global Climate Change. Retrieved May 1, 2020, from <https://climate.nasa.gov/news/2915/the-atmosphere-getting-a-handle-on-carbon-dioxide/>
- Ciudad del Saber. (n.d.). *Nuestra Mision*. Ciudad del Saber. Retrieved May 7, 2020, from <https://ciudadelsaber.org/nuestra-mision/>
- Ciudad del Saber. (2019, August 21). *Recycling, Resocialization and Reinsertion: How a Penitentiary is Giving New Meaning to the 3Rs*. Retrieved March 28, 2020, from <https://ciudadelsaber.org/en/2019/08/21/recycling-resocialization-and-reinsertion-how-a-penitentiary-is-giving-new-meaning-to-the-3rs/>
- Ciudad del Saber. (2020, January 31). *Sustainability*. Retrieved March 28, 2020, from <https://ciudadelsaber.org/en/sustainability>
- Ciudad del Saber. (2020, March 25). *What is the City of Knowledge?* Retrieved March 28, 2020, from <https://ciudadelsaber.org/en/what-is-the-city-of-knowledge/>
- Container Recycling Institute. (2009). *Average Net Cost Estimates - Single Stream vs Dual Stream 2007* [Bar Graph]. Retrieved April 18, 2020, from <http://www.container-recycling.org/assets/pdfs/reports/2009-SingleStream.pdf>

- deOliveira Hyme, B., Monk, D., & Tremblay, C. (n.d.). Recycling stories: Lessons from community arts-based process and exhibition in Brazil. *Journal of Adult and Continuing Education*, 22(2), 216–232.
- Gentle, Carrie. (2020, March 13). *Cleaning and Sorting Adding to Cost of Recycling*. The Falmouth Enterprise. Retrieved April 23, 2020, from [https://www.capenews.net/falmouth/news/cleaning-and-sorting-adding-to-cost-of-recycling/article\\_8bbe97fe-de55-5e30-a5fb-8636ec027217.html](https://www.capenews.net/falmouth/news/cleaning-and-sorting-adding-to-cost-of-recycling/article_8bbe97fe-de55-5e30-a5fb-8636ec027217.html)
- Ineco. (2017). Plan Nacional de Gestión Integral de Residuos 2017-2027, Illustration 16, pp 92, Autoridad de Aseo, Retrieved May 5, 2020, from <http://aaud.gob.pa/plangestion/Docs/PNGIR.pdf>
- Katz, C. (2019, March 07). *Piling Up: How China's Ban on Importing Waste Has Stalled Global Recycling*. Yale Environment 360. Retrieved May 08, 2020, from <https://e360.yale.edu/features/piling-up-how-chinas-ban-on-importing-waste-has-stalled-global-recycling>
- Kaza, Silpa, et al. (2018). *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. Washington DC: World Bank.
- Li, Pa (2019). [4 Black Trash Bins] [Photograph]. Retrieved May 1, 2020, from <https://goo.gl/maps/J6sphLdo8dfMXLYr8>
- León, Alex De (2019). [Recyclable Information Board at CAM] [Photograph]. Retrieved May 1, 2020, from <https://goo.gl/maps/wt5UCLrHuHSQUgyN8>
- Pan American Health Organization. (2010). *Regional Evaluation on Urban Solid Waste Management in Latin America and the Caribbean*. Retrieved May 10, 2020, from <https://publications.iadb.org/publications/english/document/Regional-Evaluation-on-Urban-Solid-Waste-Management-in-Latin-America-and-the-Caribbean-2010--Report.pdf>.
- Mattson, S., Teran, A. (2011, September 6). *Education Trap Threatens Panama's Economic Boom*. Reuters. Retrieved April 28, 2020, from <https://www.reuters.com/article/us-panama-education/education-trap-threatens-panamas-economic-boom-idUSTRE7857D420110906>

- Milsark, M., Mittleman, A., & Van Tronk, J. (2018, October). *Ciudad del Saber: Carbon Footprinting*. [Interactive Qualifying Project, Worcester Polytechnic Institute]. WPI Electronic Project Collections.
- Paglia III, J. (2019, May). The Importance of Community Outreach and Public Education. *Waste Advantage Magazine*, 10(5), 20.
- Rogoff, M. (2014). *Solid Waste Recycling and Processing : Planning of Solid Waste Recycling Facilities and Programs* (2nd ed.). Waltham, MA: William Andrew Publishing.
- Russell, R. S., & Taylor, B. W. (2011). *Operations Management: Creating Value Along the Supply Chain* (7th ed.). Hoboken, NJ: John Wiley & Sons.
- Shapley, Haley. (2019, September 10). *Teaching Kids to Recycle*. Retrieved May 7, 2020, from <https://earth911.com/home-garden/teaching-kids-to-recycle/>
- Smith, R. (2019, October 17). *Is the Circular Economy Inconvenient?*. Sourceable. Retrieved April 24, 2020, from <https://sourceable.net/is-the-circular-economy-inconvenient/>
- This is ECO (n.d.). *5 Advertising Campaigns That Make You Want to Recycle*. Retrieved May 7, 2020, from [https://www.thisiseco.co.uk/news\\_and\\_blog/5\\_Advertising\\_Campaigns\\_that\\_make\\_you\\_want\\_to\\_recycle.html](https://www.thisiseco.co.uk/news_and_blog/5_Advertising_Campaigns_that_make_you_want_to_recycle.html)
- Tornio, S. (2018, November 21). *29 Ideas Big and Small to Bring Recycling into the Classroom*. We Are Teachers. Retrieved May 7, 2020, from <https://www.weareteachers.com/21-ideas-big-and-small-to-bring-recycling-into-the-classroom/>
- Union of Concerned Scientists (2009, June 6). “Why Does CO2 get Most of the Attention When There are so Many Other Heat-Trapping Gases?” Retrieved May 7, 2020, from <https://www.ucsusa.org/resources/why-does-co2-get-more-attention-other-gases>
- U.S. Environmental Protection Agency. (2016). *Advancing Sustainable Materials Management: 2016 Recycling Economic Information (REI) Report*. Retrieved May 2, 2020, from [https://www.epa.gov/sites/production/files/2017-05/documents/final\\_2016\\_rei\\_report.pdf](https://www.epa.gov/sites/production/files/2017-05/documents/final_2016_rei_report.pdf)

U.S. Environmental Protection Agency. (n.d.). “Basic Information about Landfill Gas.” Retrieved May 7, 2020, from <https://www.epa.gov/lmop/basic-information-about-landfill-gas>

U.S. Environmental Protection Agency. (n.d.). “National Overview: Facts and Figures on Materials, Wastes and Recycling.” Retrieved May 10, 2020, from <https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials>

van Gorp, M. (2011, April 25). *Pollution: Deal with the Consequences*. Osocio. Retrieved May 7, 2020, from <https://osocio.org/message/pollution-deal-with-the-consequences/>

William Bennett, Emily Chretien, Sophia Gomarlo, Peter Hurly (2017, March 3). *A Proposed Recycling Facility for the Informal Waste Collectors of Oshakati*. [Interactive Qualifying Project, Worcester Polytechnic Institute]. WPI Electronic Project Collections.

Williams, Hannah. (2011). *Examining the Effects of Recycling Education on the Knowledge, Attitudes, and Behaviors of Elementary School Students*. [Outstanding Senior Seminar Paper, Illinois Wesleyan University]. IWU Digital Commons.

# Appendices

## Appendix A: Interview Protocol for FAS Employees

Name(s) of Interviewer(s): \_\_\_\_\_

Date of Interview: \_\_\_\_\_ Time of Interview: \_\_\_\_\_

Hello! We are a team of students from Worcester Polytechnic Institute, USA. We are conducting a research to understand the recycling processes in Ciudad del Saber as well as in Panama in general. As part of our investigation, you have been asked to participate in an interview. This interview will be recorded due to language comprehension issues. The recording will be deleted once we have gathered the information for our questions. This interview involves no risk to you. As an incentive to attend, each person will receive ... which will be given directly following the interview. This investigation will result in a proposal to Fundación Ciudad del Saber of suggested improvements to the recycling strategies on campus. Although the results of this study may be published, no information that could identify you will be included. Questions about this research may be addressed to [gr-cofk-a20@wpi.edu](mailto:gr-cofk-a20@wpi.edu). Complaints about the research may be presented to .... Questions about research subject's rights or research-related injury may be presented to .... Your consent is being given voluntarily. You may refuse to participate in the interview. If you decide to participate in the interview, you are free to withdraw at any time without any negative effect on your relations with Fundación Ciudad del Saber or with any other participating institutions or agencies. Thank you for your participation! Do you have any questions for us before we begin?

Do you give your consent to participate in this interview? *(Receive verbal confirmation/denial)*

Do you give your consent to us recording this interview? *(Receive verbal confirmation/denial)*

Our main goal with this interview is to gain knowledge on where processes at the recycling center can be made more efficient. We believe recycling is vital in order to lead a sustainable future. Let's get started with the questions!

*Note: the interviewer will use phrases such as “Tell me more”, “Could you give me an example?”, “Could you explain that?” as prompts to solicit more detailed information when needed.*

1. To get started, let’s introduce ourselves. In your introduction, please tell us who you are, and your job at the recycling center.
2. Which parts of the current process at the center do you think are functioning well?
3. Which parts of the current process at the center do you think can be improved?
4. What are some of the challenges you face in this job?
5. What tools or processes do you think could be provided or improved in order to make your job easier?
6. Which aspect of your job do you think could be improved?
7. What are some sources of contamination you notice while accepting recyclable materials?
  - a. Are there any sources of contamination that are very common?
8. What are your expectations for the people who bring recyclables to the recycling center?

## **Appendix B: Master Survey**

### **Recycling at Ciudad del Saber (Aug 2020)**

#### **Q1.1 Recycling at Ciudad del Saber Survey**

Responsible Investigators: Xavier Curney, Hoang (John) Do, Ethan Graham, and Katherine Pawlak

- We are a team of four college students from Worcester Polytechnic Institute, USA. You have been asked to participate in our research study that aims at investigating i) the recycling process and ii) the understanding on recycling in Ciudad del Saber.
- You are asked to take the following survey.
- Completing the survey involves no risk to you.
- This investigation will result in a proposal to Fundación Ciudad del Saber of suggested improvements to the recycling strategies on campus.
- Although the results of this study may be published, no information that could identify you will be included.
- Questions about this research may be addressed to [gr-cofk-a20@wpi.edu](mailto:gr-cofk-a20@wpi.edu). Complaints about the research may be presented to .... Questions about research subject's rights or research-related injury may be presented to ....
- Your consent is being given voluntarily. You may refuse to participate in the survey. If you decide to participate in the survey, you are free to withdraw at any time without any negative effect on your relations with Fundación Ciudad del Saber or with any other participating institutions or agencies.

Thank you for participating in this survey.

#### **Q1.2 Do you give consent to participate in this investigation?**

- Yes (1)
- No (2)

#### **Q1.3 There are two sections to this survey:**

- General Information Questions: All participants are asked to respond to the same list of questions.
- Specific Questions: Each participant will respond to a specific list of questions based on their category.

All multiple choice questions are required. There is an option if you do not wish to respond for most questions.

All open-ended questions are optional.

Abbreviations:

CAM: Centro de Acopio y Manejo de desechos sólidos

CdS: Ciudad del Saber

FAS: Fundación de Acción Social por Panamá

FCdS: Fundación Ciudad del Saber

## **Q2.1 Section 1 - General Information Questions**

Please answer the following questions.

### **Q2.2 Which range describes your age?**

- Under 20 years old (1)
- 20-29 years old (2)
- 30-39 years old (3)
- 40-49 years old (4)
- 50-59 years old (5)
- 60 years or older (6)
- I do not wish to respond (7)

### **Q2.3 Which of these categories describe you? (choose all that apply)**

- FCdS Employee - A person who works for Fundación Ciudad del Saber (1)
- CdS Resident - A person who resides in a Ciudad del Saber residential facility for at least one night (2)
- CdS Tenant - A person who operates or works for a business that leases out space on the CdS campus from FCdS (3)
- CAM/FAS Employee/Volunteer - A person who works at the recycling center (4)
- Visitor to CAM - A person who drops their waste off at the recycling center (5)
- Visitor to CdS - A person who comes to the CdS campus but does not fit into any of the previous categories (6)

### **Q2.4 Do you recycle?**

- Yes (1)
- No (2)

### **Q2.5 Who is (are) the most frequent recycler in your household?**

- Adult female(s) (1)
- Adult male(s) (2)
- Child(ren) (3)
- Everyone recycles (4)
- No one recycles (5)

### **Q2.6 Do you think recycling is important?**

- Extremely important (1)
- Very important (2)
- Moderately important (3)
- Slightly important (4)
- Not at all important (5)
- I do not wish to respond (6)

**Q2.7 Why do you not recycle? (choose all that apply)**

- Recycling is time-consuming (1)
- Recycling is unnecessary (2)
- Recycling is expensive (3)
- Recycling is inconvenient (4)
- There are no recycling bins available (5)
- The recycling bins are full (6)
- I do not have enough recyclable materials (7)
- Someone else will separate the recyclable materials from my trash (8)
- I do not know how to recycle (9)
- Other (please specify) (10)
- I do not wish to respond (11)

**Q2.8 What are your motivations for recycling? (choose all that apply)**

- Recycling is good for the environment (1)
- I feel good when I recycle (2)
- I receive compensation when I recycle (3)
- I am told/made to recycle (4)
- By recycling, I feel that I am donating to Ciudad del Saber (5)
- Other (please specify) (6)
- I do not wish to respond (7)

**Q2.9 Do you clean recyclable materials before depositing them?**

- Yes (1)
- Sometimes (2)
- No (3)
- I do not wish to respond (4)

**Q2.10 What do you find inconvenient to cleaning recyclable materials before depositing them? (choose all that apply)**

- The task is dirty (1)
- The task is time-consuming (2)
- The task does not make a big difference (3)
- Other (please specify) (4)
- The task is NOT inconvenient (5)
- I do not wish to respond (6)

**Q2.11 Which of these incentives would make you want to clean recyclable materials before depositing them? (choose all that apply)**

- Receiving money for your clean recyclable materials (1)
- Receiving a certificate for your clean recyclable materials (2)
- Receiving community service hours for your clean recyclable materials (3)
- Being invited to events about recycling (4)
- Learning about recycling (5)

- Other (please specify) (6)
- I do not need an incentive to clean recyclable materials (7)
- I do not want to clean recyclable materials before depositing them (8)
- I do not wish to respond (9)

**Q2.12 Do you separate recyclable materials into different categories before depositing them?**

- Yes (1)
- Sometimes (2)
- No (3)
- I do not wish to respond (4)

**Q2.13 What do you find inconvenient to separating recyclable materials before depositing them? (choose all that apply)**

- The task is dirty (1)
- The task is time-consuming (2)
- The task takes up space (3)
- I do not know how to separate them correctly (4)
- The task does not make a big difference (5)
- Other (please specify) (6)
- The task is NOT inconvenient (7)
- I do not wish to respond (8)

**Q2.14 Which of these incentives would make you want to separate recyclable materials before depositing them? (choose all that apply)**

- Receiving money for your clean recyclable materials (1)
- Receiving a certificate for your clean recyclable materials (2)
- Receiving community service hours for your clean recyclable materials (3)
- Being invited to events about recycling (4)
- Having more recycling bins (5)
- Learning about recycling (6)
- Other (please specify) (7)
- I do not need an incentive to separate recyclable materials (8)
- I do not want to separate recyclable materials before depositing them (9)
- I do not wish to respond (10)

**Q2.15 Which of these items are or are not accepted at CAM?**

	Accepted at CAM (1)	Not Accepted at CAM (2)	I do not know (4)	I do not wish to respond (3)
Paper (1)				
Cardboard (2)				
Plastic Containers (3)				
Glass (4)				
Wood (5)				
Aluminum (6)				
Tetra-Pak Containers (7)				
Electronic Scraps (8)				
Batteries (9)				
Oil (10)				
Receipts (14)				
Organic waste (11)				
Fabric (12)				
Tissue/Napkin (13)				
Plastic bags/ wrappings (16)				
Shredded Paper (17)				
Coffee Cups(18)				
Light bulbs (19)				
Styrofoam (20)				

**Q2.16 When you are unsure whether an item is recyclable, what do you usually do?**

- Place item in the trash (1)
- Place the item in the recycling bin (2)
- Ask others where to place the item (3)
- Look up information on the internet where to place the item (4)
- Contact CAM (5)
- Other (please specify) (6)
- I do not wish to respond (7)

**Q2.17 How do you typically dispose of plastic bags?**

- Put them in the trash can (1)
- Put them in the recycling bin (2)
- Reuse them then place in trash can (3)
- Return them to the store (4)
- Other (please specify) (5)
- I do not wish to respond (6)

**Q2.18 Have you seen or heard about recycling programs in Ciudad del Saber?**

- Yes, frequently (1)
- Yes, occasionally (2)
- Yes, rarely (3)
- No, I have not (4)
- I do not wish to respond (5)

**Q2.19 Would you be interested in learning more about recycling?**

- Definitely yes (1)
- Probably yes (2)
- Probably not (3)
- Definitely not (4)
- I do not wish to respond (5)

**Q2.20 What would you specifically want to learn more about? (choose all that apply)**

- Types of recyclable materials (1)
- Recommended recycling practices (2)
- The impact of recycling (3)
- The process of recycling (4)
- The shortcomings of recycling (5)
- Common misconceptions about recycling (6)
- Other (please specify) (7)
- I do not wish to respond (8)

**Q2.21 Would you be interested in participating in a Recycling Fair in Ciudad del Saber?**

- Definitely yes (1)
- Probably yes (2)
- Probably not (3)
- Definitely not (4)
- I do not wish to respond (5)

**Q2.22 How would you want to help with recycling in Ciudad del Saber? (choose all that apply)**

- Clean recyclable materials before depositing them (1)
- Separate recyclable material before depositing them (2)
- Work/Volunteer for CAM/FAS (3)
- Donate money (4)
- Educate the Ciudad del Saber community on recycling (5)
- Participate in online recycling awareness campaigns (6)
- Other (please specify) (7)
- I am not interested in helping with recycling (8)
- I do not wish to respond (9)

**Q3.1 Section 2 - Specific Questions**

The following questions are specific to \${Q2.3/ChoiceGroup/SelectedChoices}.  
Only a few questions left!

**Q3.2 Which category would describe the business you operate/work for in Ciudad del Saber? (choose all that apply)**

- International/Non-Profit/Non-Governmental Organization (1)
- Education (2)
- Research and Development (R&D) (3)
- Other (please specify) (4)
- I do not wish to respond (5)

**Q3.3 Does the business you operate/work for in Ciudad del Saber currently have a recycling program/facility in place?**

- Yes (1)
- No (2)
- I do not wish to respond (3)

**Q3.4 Do you think recycling is important for your business?**

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**Q3.5 How useful would the following be to help your business recycle more?**

	Extremely useful (1)	Very useful (2)	Moderately useful (3)	Slightly useful (4)	Not at all useful (5)	I do not wish to respond (6)
Onsite assistance and training (8)						
Free recycling container (9)						
Free education materials on how to and where to recycle (e.g. pamphlets, magnets, etc.) (10)						

**Q3.6 Why do you work/volunteer for CAM/FAS?**

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**Q3.7 Do you think recycling is important for Ciudad del Saber?**

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**Q3.8 Do you have another job beside the one at CAM/FAS?**

- Yes (1)
- No (2)
- I do not work for CAM/FAS (3)
- I do not wish to respond (4)

**Q3.9 What is the purpose of your visit to Ciudad del Saber?**

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**Q3.10 How did you hear about CAM/FAS? (choose all that apply)**

- AS Website (1)
- CdS Website (2)
- Facebook (3)
- Instagram (4)
- Twitter (5)
- Other online sources (6)
- Newspaper Article/Advertisement (7)
- Radio (8)
- TV (9)
- Passing by (10)
- Word-of-mouth (11)
- Other (12)
- I do not wish to respond (13)

**Q3.11 Do you separate waste based on the different colors of the bins in Ciudad del Saber?**

- Always (1)
- Most of the time (2)
- About half the time (3)
- Sometimes (4)
- Never (5)
- Not Applicable/I do not wish to respond (6)

**Q3.12 Which day(s) of the week do you usually bring recyclable materials to CAM? (choose all that apply)**

- Monday (1)
- Tuesday (2)
- Wednesday (3)
- Thursday (4)
- Friday (5)
- I do not wish to respond (6)

**Q3.13 Which day(s) of the week would be the most convenient for you to bring recyclable materials to CAM? (choose all that apply)**

- Monday (1)
- Tuesday (2)
- Wednesday (3)
- Thursday (4)
- Friday (5)
- Saturday (6)
- Sunday (7)
- I do not wish to respond (8)

# Appendix C: Time Study Observation Sheet

Time Study Observation Sheet																
Operation										Date						
										Observer						
		Cycles										Summary				
		t	1	2	3	4	5	6	7	8	9	10	$\Sigma t$	$\bar{t}$	RF	Nt
1		R														
		t														
2		R														
		t														
3		R														
		t														
4		R														
		t														
5		R														
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		t														
7		R														
		t														
8		R														
		t														
9		R														
		t														
10		R														
		t														

Normal Cycle/Lead Time \_\_\_\_\_ + Allowance \_\_\_\_\_ = Std. Time \_\_\_\_\_

## Appendix D: Process Flowchart Table

Location: _____								
Process: _____								
Step	Operation	Transport	Inspect	Delay	Storage	Description of Process	Time (____)	Distance (____)
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	○	➔	□	D	▽			
	Page ____ of ____					<b>Total</b>		

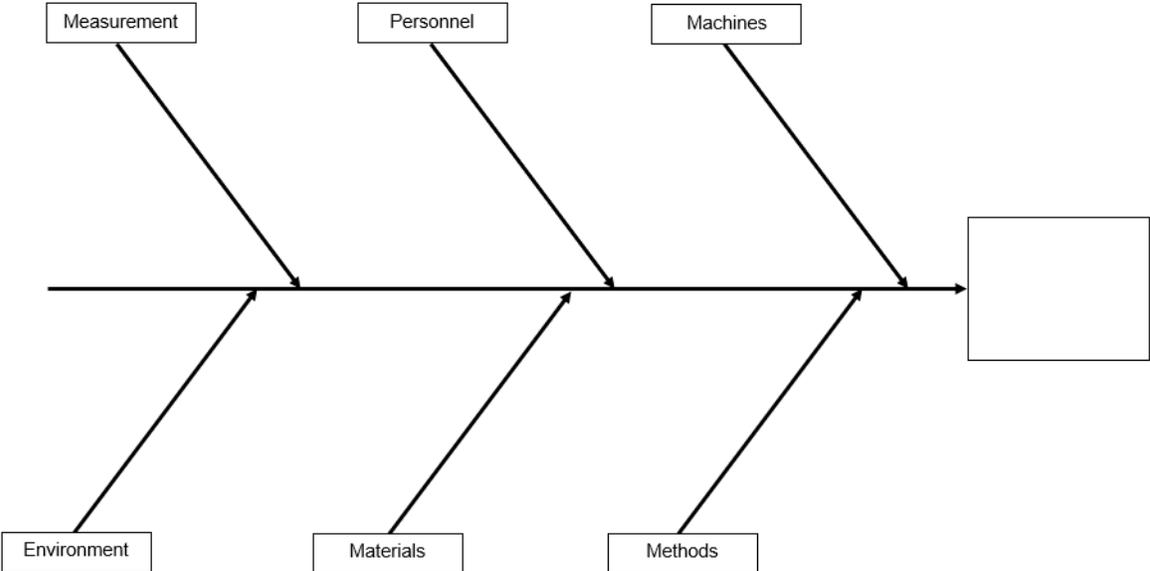


**Appendix F: Visitor Tally Sheet**

Week .....	Mon	Tue	Wed	Thu	Fri
7-8AM					
8-9AM					
9-10AM					
10-11AM					
11AM-12PM					
12-1PM					
1-2PM					
2-3PM					



# Appendix H: Fishbone Diagram



# Appendix I: Failure Mode and Effects Analysis

Failure Mode	Cause of Failure	Effect of Failure	Corrective Action

# Appendix J: CAM's Current Floor Plan

