

# PLASTIC BOTTLE GREENHOUSE: STEP BY STEP UPCYCLING GUIDE FOR COMMUNITIES

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## CHAPTER ONE: INTRODUCTION

### 1.1. *Motivation for this Manual*

#### 1.1.1. *Waste Challenge*

##### 1.1.1.1. **Waste Generation**

- **Global Communities:** (Europe, Africa, Latin America, Asia)  
Municipal solid waste (MSW) sources include *residential* (waste from single, multi-dwelling and apartment houses), *commercial* (stores, hotels, restaurants, markets, offices etc.), *industrial* (light and heavy manufacturing, fabrication, construction sites, power and chemical plants), *construction* (new construction sites, road repair, renovation sites, demolition of buildings) and *institutional* (schools, hospitals i.e. non-medical waste, prisons, government buildings, airports etc.). The rate of municipal solid waste generation differs generally within and between countries and these rates depend on *income levels*, *socio-cultural patterns* and *climatic factors*. (Wilson et al, 2015).

In general, the consumption habits of most communities will continue to increase in years to come and this is an indication that more wastes will continue to be generated. It is important to state that waste generation also occurs at every stage of a typical product's lifecycle, ranging from extraction, processing, manufacturing, packaging, use, and disposal.

Municipal solid waste (MSW) generation globally has been on the rise in recent times as the rate of urbanization and global population increases. It is worthy to note that estimating MSW generation per capita provides data on MSW generation to be standardized and eliminates the effects of changes in population (European Environment Agency, 2013).

About 1.3 billion tonnes of municipal solid waste are currently generated per year globally and this amount will increase to 2.2 billion tonnes by year 2025 (Hoornweg et al, 2012). Furthermore, talking about municipal solid waste generation across regions and continents of the world, the volume and composition differs because of dynamic factors such as population, urbanization, GDP, etc. and this is validated by both (Liu C Wu, 2010, Chiemchaisri et al, 2007) and an understanding of the correlation among these drivers (i.e. volume/composition and populations, urbanization etc.) is important to clearly understand MSW in these regions

The median waste generation rates in high-income countries is six-times greater than in low-income countries which shows a strong positive correlation between a country's GDP and waste generation (Wilson et al, 2015). Another dynamic of municipal solid waste generation also lies in its composition, i.e. organic fractions, which are much higher in middle and low-income countries with an average of 67% than in high-income countries with an average of 28% (Wilson et al, 2012).

- **North America (United States and Colorado)**

Municipal solid waste (MSW) generation in the United States has increased in recent years because of the population growth and high level of urbanization. In 2012, about 251 million tons of municipal solid waste was generated (US EPA, 2012) increasing to about 258 million tons in 2014 (US EPA, 2014). In 2012, out of the municipal solid waste generated, about 87 million tons were recycled and composted which gives a recycling rate of 35 percent (Figure 1). The characterization of the MSW generated in 2012 revealed that organic materials (paper/paperboard, yard trimmings, and food waste) remained the major constituent of MSW (US EPA, 2012) as shown in Figure 2 below:

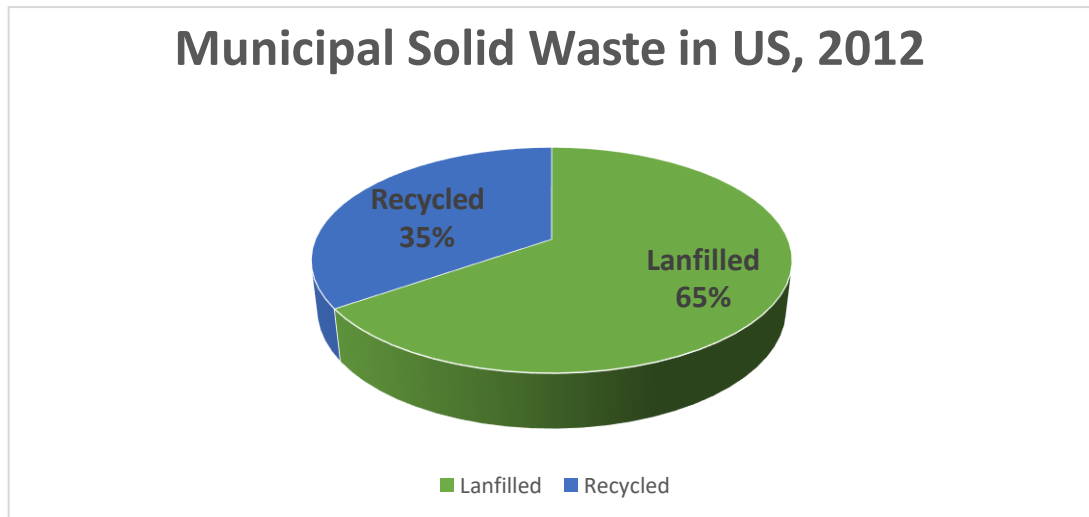


Figure 1-US Municipal Solid Waste 2012

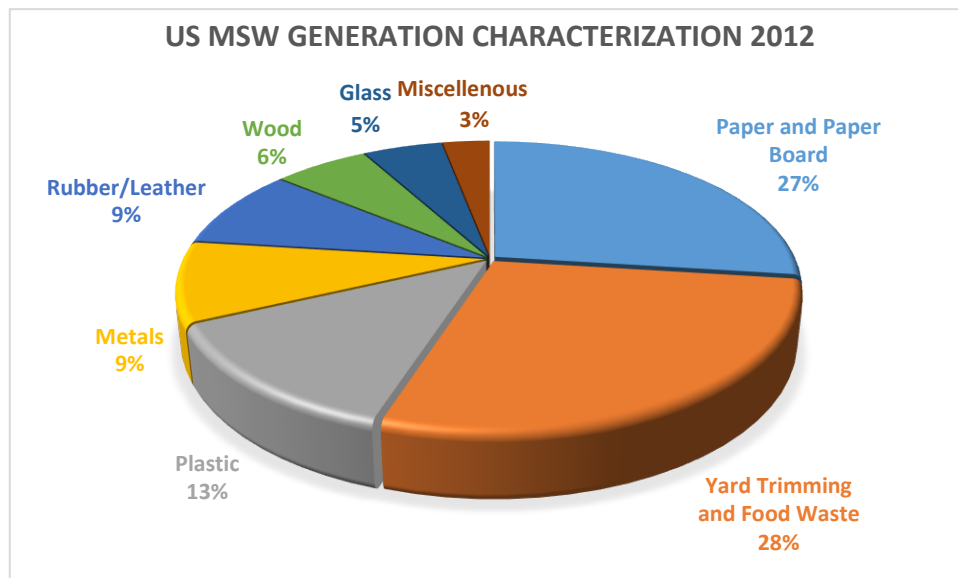


Figure 2-US Municipal Solid Waste 2012 (EPA, 2012)

To put in perspective, it is important to define waste generation and diverted. Waste generation is the amount of waste produced per time at a given location

while waste diverted is the amount of waste generated and are saved from going to the landfill. Therefore, the relationships among waste generation, waste recycled, waste diverted and landfilled is; *waste generation* equals the summation of *waste recycled, diverted and landfilled*.

In the state of Colorado, the Department of Public Health and Environment (CDPHE) in 2014 reported that the total municipal solid waste generated in Colorado was estimated at 8.8 million tons, with a diversion rate of 2.1 million tons (or 23%) while in 2015, 9.3 million tons was generated with a diversion rate of 1.98 million tons (21.4%).

Similarly, at the local level, the community of Boulder, Colorado recently reported that in 2010, municipal solid waste generation totalled 221,000 tons with plastics ranking the 4<sup>th</sup> most generated waste with 29,180 tons (13.2%) (BCRCD Report, 2010).

A municipal solid waste study conducted in five counties (Archuleta, Dolores, La Plata, Montezuma and San Juan Counties) as well as the Southern Ute and Ute Mountain Ute Tribes in Southwest Colorado in 2014 by Southwest Colorado Council of Governments (SWCCOG), revealed that 107,000 tons of waste was generated across the five counties with only 14,000 tons recycled (13%), 2,000 diverted (1%) while 91,000 tons (91%) landfilled (SWCCOG, 2014). Comparing both national and state diversion rates of 23% and 34% respectively to that of the Southwest Colorado region studied (14%) (SWCCOG, 2014), revealed that the region need to do much more to reduce municipal solid waste sent to landfill.

#### **1.1.1.2. Waste Diversion (Recovery) and Landfilling**

##### **○ Global Communities (Europe, Africa, Latin America, Asia)**

Increasing human activities will continue to lead to more municipal solid waste generation and it is therefore imperative that communities, regions and nations around the world begin to think of how waste generated can be reduced at production or diverted from the landfill for a sustainable world. To put in perspective the relationships among waste generation, waste recycled, waste diverted and landfilled; *waste generation* equals the summation of *waste recycled, diverted and landfilled*.

Waste diversion and landfilling is based on the concept of the hierarchy of waste management- reduce, reuse, recycle, recover, incineration and landfilled. One key advantage of waste diversion is that it helps reduce the volume of wastes that ends up in the landfill and promotes the return of materials back into the economy- circular economy. In the United States, the waste diversion according to the US EPA (2012) was estimated to be about 87 million tons with paper and paperboard being the one with the most fraction of over 51 percent, while yard trimmings, food waste, metals and glass accounted for about 22 percent, 2



percent, 9 percent, and 4 percent respectively as shown in **Error! Reference source not found..** Plastic and wood accounted for 3 percent each while other mixed materials also accounted for about 6 percent of waste diversion. Furthermore, in 2012 the US EPA factsheet reported that plastic containers including plastic water bottles and packaging accounted for the most recycled at the rate of 14 percent and 31 percent of polyethylene terephthalate (PET) bottles in that year were recovered.

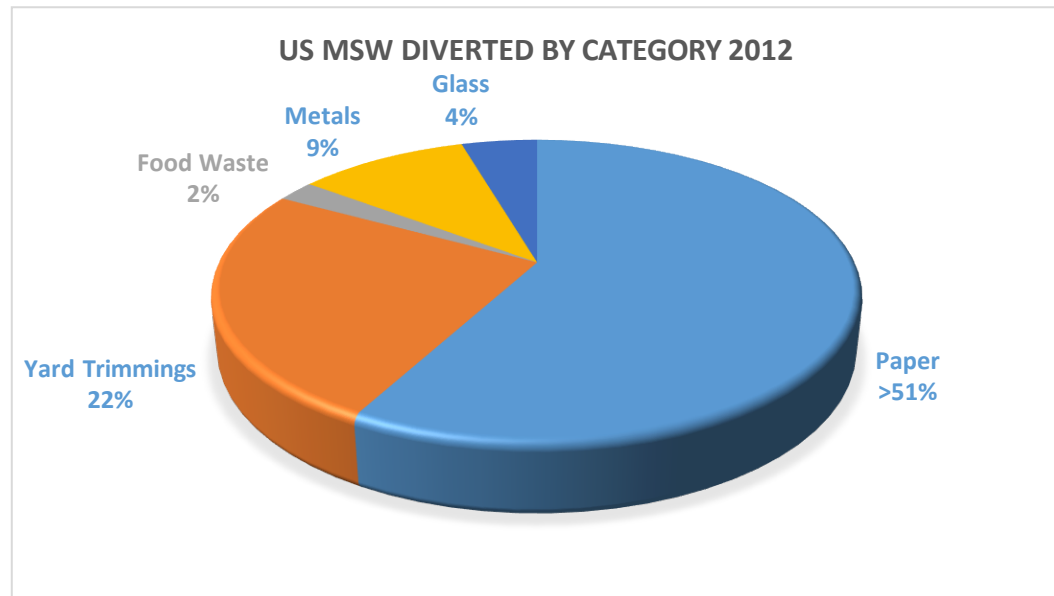


Figure 3- US MSW Diverted by Category 2012

#### ○ **United States & Colorado**

US EPA (2012) reported that the total amount of municipal solid waste (MSW) sent to the landfill in the US were much lower than in 1990 dropping from 145.3 million tons in 1990 to 135 million tons in 2012 because of waste diversion and recovery best practices that were in place. It was further reported that after the recycling, composting, and combustion for energy recovery of wastes, the “net per capita discard rate to landfills was 0.001 tons/cap/day in 2012, lower than the 0.002 tons/cap/day rate in 1990”.

Although US EPA (2012) reported a decrease in total amount of MSW landfilled from 145.3 million tons in 1990 to 135 million in 2012, another finding by America Civil Engineers through the America’s Infrastructure Report Card (2013), which is a comprehensive assessment of the nation’s major infrastructure categories reported that landfilling is the most widely used solid waste disposal method in Colorado, with a total of 186 landfills sites state-wide (ASCE Infrastructure Report, 2013). Supporting this trend, the Colorado Department of Public Health and Environment stated that Colorado landfills had a lifespan of 50 years more as at 2013 meaning that with the rate at which the State’s landfills are being used, there will be a time when there will be no more landfills available to dispose wastes in the State. It is therefore imperative

moving forward that Colorado begin to increase its solid waste diversion and recycling efforts in a bid to reduce its high per capita waste disposal rates. For example, an attempt has been made by Boulder county, Colorado to increase waste diversion. Residents and businesses in Boulder diverted about 35% of waste materials from the landfill and the internal waste diversion program for the county has reached a 71 percent diversion rate (BCS, 2016).

Apart from Boulder, other front range cities in Colorado have improved on their waste diversion. For example, Loveland has a waste diversion rate of 61 % while Louisville and Fort Collins has a 48 % and 32% diversion rate respectively through the provision of a robust recycling and composting programs (Eco-Cycle, 2016).

#### **1.1.1.3. Plastic Waste**

##### **○ Generation**

Today, plastics are found everywhere and have formed part of our modern life in sectors like communication, health, transportation, safety and security etc. According to a report by World Watch Institute in 2015, the global production of plastics in 2013 totalled 299 million tons which represented an increase of 4% from 2012 which comes without its identified destructive environmental impacts. Global Production of Plastics, (2013) reported that production of plastics is quite energy intensive, requiring 62-108 mega joules of energy per kilogram of plastic produced (MJ/kg-plastic). This is equivalent to 31.9kWh of electricity consumed/person/year (17,200 to 31,950 watt-hours) when one kilogram of plastic is produced as well as driving 33.23 miles in an average family car and the energy required to jog 290 Miles (The Footprint of Plastics Report, 2014). EPA's Waste Reduction Model (WARM) 2010 for virgin production of a polyethylene terephthalate (PET) bottle material reported that the Raw Material Acquisition and Manufacturing (RMAM) emission factor is *2.13 mtCO<sub>2e</sub>/short ton*. It is important to state that this figure came from three emission sources namely; *process energy, transportation energy and non-energy processes*.

Hopewell et al, 2009 reported that packaging and disposable consumer items which are single-use disposable products comprised of 50 percent plastics, construction products such as pipes, cable coatings and structural materials also consists between 20-25 percent plastics while the rest comprises of durable consumer products with transitional lifespan like electronic goods, furniture, vehicles. It is therefore evident that most plastic waste generated globally comes from packaging products but as reported by Hopewell et al 2009, products such as waste electronics, electrical equipment (WEEE) as well as end-of-life vehicles (ELV) are becoming important sources of plastic waste.

- **Impacts (Pollution and Threat to Biodiversity etc.)**

The United Nations Environmental Program (UNEP) reported that between 22% - 43% of plastics consumed globally are disposed of in landfills, causing resource loss, among other dangerous impacts to communities (Raynaud et al, 2014). In addition, the increased demand for plastics-based materials such as plastic bottles and containers in recent times has tremendously led to constant accumulation of large volumes of plastic wastes in our environment with impacts both on humans and aquatic organisms. Furthermore, because of the durability of the polymers involved, substantial quantities of discarded end-of-life plastics are accumulating as debris in landfills and in natural habitats worldwide. Chemical additives present in plastic such as fillers, plasticizers, stabilizers, flame retardants and colorings are toxic, bio-accumulative, and persistent in the environment. These substances can leach out of plastic into the environment, affecting the health of wildlife and biodiversity in general (Thompson *et al*, 2009). The potential leaching of bisphenol A (BPA) from plastic containers into human food could also be a source of concern to human health.

The impacts of sending plastic wastes to landfills in various communities could include pollution which results in the contamination of groundwater and aquifers producing toxic liquids known as leachates as well as soil contamination thereby affecting agricultural activities and killing beneficial biodiversity. In addition, landfill gases being released produces toxic pollutants such as solvents, pesticides and other hazardous organic chemicals that can cause health problems to communities with chronic exposures to cancer, asthma etc.

#### **1.1.1.4. Plastic Bottle Wastes**

- **Generation**

Plastic bottles have appeared everywhere in the environment in recent years because of consumers' choices which has influenced its increasing production by manufacturers of these consumer products leading to high volume in landfills today despite recycling initiatives. It has been estimated in the United States that about 60 million plastic water bottles are used daily according to an article from "Ban the Bottle" in 2012 and about 38 billion plastic water bottles sent to the landfill in a year (Fishman, 2007). To meet plastic bottle consumer demands in the United States in a year in terms of its manufacturing, transportation and disposal, it will take approximately 15-17 million barrels of oil which is equivalent to the amount needed to power about 100,000 cars in a year (Catherine, 2016). This was also corroborated by Arnold *et al*, 2007 where it stated that about 1.5 million barrels of oil will be required to produce plastic water bottles, making the environmental impacts a source of worry.

- **Impacts**

There are several impacts associated with plastic bottle and its wastes ranging from human, animal and environmental impacts among others. These impacts are the same and cuts across boundaries and global communities.

For instance, the impacts of plastic bottle wastes on humans/animals occurs most times along the food chain through ingestion where chemicals bio-accumulate and affect the highest ranked organism in the food chain (Science for Environment Policy, 2011). According to the same report, chemicals such as Bisphenol A, phthalates, flame retardants and toxic monomers are mostly often found in plastic materials and it has been confirmed to have harmful effects on human and animal health, primarily affecting the endocrine system and have been heavily linked to cause cancer and reproductive issues. Despite all these identified health threats, research has not fully and clearly established the pathway through which plastic chemicals impacts both humans and animals.

The environmental impacts related to plastic bottle wastes are evident in the marine environment, where there have been reported cases of entanglement and ingestion of plastic bottle wastes by wildlife. Plastic bottle wastes in marine environment has also attracted persistent organic pollutants (POP) because of their hydrophobic nature (repels water). There have also been reported cases of the modification of habitats and the transport of alien species (Science for Environment Policy, 2011).

#### *1.1.2. Need for Plastic Bottle Waste Upcycling in Communities*

##### **1.1.2.1. Globally (Europe, US, Africa, Latin America, Asia)**

Recycling to some extent has provided solutions to the nuisance plastic bottle creates in our environment by diverting them away from landfills and returning them back in to the economy for reuse. Without recycling these plastics, they will end up in the landfill thereby leading to the release of appreciable amount of greenhouse gases. (GHGs). Greenhouses gases are those that traps heat from the atmosphere which include carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and fluorinated gases (US EPA, 2014). The US EPA's Municipal Solid Waste (MSW) Fact Sheet 2012 reported that recycling paper and paperboard to the tune of about 44 million tons led to the decrease of 130 MMT CO<sub>2</sub>e in 2012 which was estimated to eliminate 27 million cars from the road in a year. Producing new products with secondary materials (materials that have been used once and has potentials to be reused again) can save significant energy. Also, Hoornweg et al 2012 reported that the energy required to produce aluminum from recycled aluminum (secondary material) will be 95% less than manufacturing it from virgin materials. Recycling as a matter of fact helps to reduce greenhouse gases (GHGs) as well as provide noteworthy economic and job creation opportunities.

In most low-income, middle-income and developing countries, waste management are predominately operated by informal waste pickers at waste collection and disposal sites to divert discarded or unwanted wastes. Most often, waste management in low and middle income countries are practiced through an open dump system which most of the time leads to environmental issues such as pollution (air, surface and groundwater).

However, having understood the benefits of recycling, we still face numerous waste challenges in our communities due to population explosion and high rate of urbanization. In low and middle income countries, the lack of waste management facilities is the bane of effective waste management in these regions. Like earlier mentioned, the informal waste management operations are fully in operation since technologies involved in waste management with respect to waste collection, recycling/materials recovery, composting/anaerobic digestion, incineration/waste-to-energy/refuse-derived fuel (RDF) and landfilling are not available. These technologies are expensive to run and the cost of waste management in general is also a factor hindering effective management of waste in these countries. On the contrary, high income countries have invested heavily in waste management and it has reflected in the improvement seen so far in these countries.

Specifically, despite the highs, lows and limitations of recycling of plastic bottle wastes, one viable solution to its effective management without impacting the environment in any way is using these materials as novel resources for higher products rather than recycling them (waste upcycling). One among many advantages of this process is that it can be adopted in any region, community where plastic wastes are generated regardless of availability of waste management infrastructure. Another advantage is that it fosters and improves economic and social lives of global communities in terms of job creation and community integration.

### *1.1.3. Need for Plastic Bottle Waste Structures in Communities*

#### **1.1.3.1. Affordable Housing**

The lack of adequate recycling infrastructure, high cost of effective waste management, lack of basic social and housing infrastructure as well as the increasing rate of urbanization in our communities has necessitated the promotion of plastic bottle structures in communities to address these problems.

Plastic bottle structures are now being encouraged as alternatives to address the high cost of conventional housing, housing unit deficits, high cost of greenhouses as well as lowering plastic bottles waste in our environment by serving as raw materials. The utilization of plastic bottles as novel materials for building can be a suitable solution for alternative of conventional materials (Shoubi *et al*, 2013). The study also revealed that plastic bottle has been considered as a waste with



sustainability quality that can be utilized as a building material instead of some conventional material such as brick in building construction. There has been tremendous success with its utilization as a construction material and this could be a potential solution to the housing problems in global communities, especially for people living below the poverty line. For example, houses made from plastic bottles have been built in Nigeria in a village called Yelwa village in Kebbi State where local masons are trained in the plastic bottle building methods. Also, Eco-Tec Environmental Solutions have constructed houses and structures made from plastic bottles in other parts of the world including Honduras, Bolivia, India and Colombia. Prominent and significant among many embarked projects by Eco-Tec includes PET bottle homes built in Haiti after the devastating 7.0 earthquake that affected that country in 2010 where more than 160,000 people were killed and displacing close to 1.5 million persons. Eco-Tec have provided training programs in their own customized sustainable construction techniques which involves the development of a large diversity of structural works such as temporary shelters, warehouses, water storage tanks and permanent housing through the effective management of the post-disaster debris and conversion of non-biodegradable waste like plastic bottles and tires into construction materials.

Plastic bottles used as an alternative to bricks are bind together with strings and cement plaster and this has been a good substitute to bricks made from cement and it can save energy consumption in factories during brick baking as well as help cut carbon emission from the quantity of cement used (Shoubi *et al.*, 2013). Also, these buildings are energy-independent structures and as stated by Shoubi *et al.*, 2013, “the most important benefits of these alternative innovative materials compared to conventional materials such as brick includes: good construction abilities, low cost compared to brick, suitable thermal behaviour, non- brittle characteristics, absorbs abrupt shock loads and are utilized in green construction. Saxena *et al.*, 2013 concluded that by utilizing polyethylene terephthalate (PET) bottles in construction, thermal comfort can be achieved in very low cost housing which is a benefit for people who cannot afford to buy and operate heating and cooling systems.

#### **1.1.3.2. Greenhouses**

Plastic bottles can also be readily used to construct greenhouses, especially in cold climate regions where growing seasons are limited. Due to longer winter season and presence of snow almost all year around in cold climate communities, growing agricultural crops could be difficult and impossible, thereby necessitating greenhouses made from plastic bottles which could potentially assist farmers grow crops all year around regardless of the weather. Some of the advantages of constructing greenhouses with plastic bottles include cost effectiveness, the ability to self-water whenever it rains (tropic communities)

where the rain water infiltrates through the gaps between the bottles, positive temperature differential of up to 10 degrees, cost efficient repairs, structural strength to withstand strong winds (Douse, 2014).

#### ***1.1.3.3. Water Storage Tanks***

Communities facing water scarcity and cannot afford the construction of water storage tanks can use plastic bottles as construction materials for building plastic bottle water storage tanks. Although, it is labor intensive, it is cheaper and uses less materials compared to the conventional water storage tanks. Also, local farmers in arid regions can use plastic bottles to construct water tanks for irrigation purpose.

#### ***1.1.3.4. Schools***

Building classrooms using plastic bottles is a smart and innovative way to get rid of those plastics we generate daily from the environment to provide educational facilities in poor and struggling communities. Providing and enhancing educational infrastructure development in underprivileged communities through plastic bottle schools will help these communities grow out of poverty and build community resiliency towards growth.

Hug it Forward, a grass-root organization in Latin America has been at the forefront of promoting plastic bottle schools in communities. It has carried out education awareness by empowering communities in this region where plastic bottles have been used to build schools. Schools from plastic bottles are schools constructed using “eco-bricks” i.e. plastic bottles packed with inorganic trash. To date, 71 schools have been built by this organization across Latin America. Again, the entire host communities came together to construct more sustainable educational infrastructures for their own future. The key message Hug It Forward brings is the cost-effectiveness in building schools from plastic bottles than the traditional schools, the entire process of helping to clean the environment, educating citizens about environmental sustainability and overall encouraging social interactions among people within the community with a sense of pride and ownership of the bottle schools through their involvements in the construction processes.

#### ***1.1.3.5. Firewood/Bike Sheds/ Storage Units***

Most homes in cold climate struggle for space of where to put their firewood for their heating systems during winter. Others desire space of where to keep their bikes or store their extra personal belongings that cannot fit into the main building and will need extra funds to build these structures but with the availability of plastic bottles all around us, these easy to construct structures can be built at a very cheaper cost while helping to save the environment.

#### **1.1.3.6. *Potential Solutions to Plastic Bottle Waste Problems in Communities***

As earlier mentioned in this manual, plastic bottles have constituted nuisance in our environment and with the rate at which world's population is growing as well as rapid urbanization, there will be more consumption of materials i.e. plastic bottles and hence, solutions must be provided on ways by which these materials can be repurposed for much higher products. Therefore, plastic bottles can serve as potential “eco-bricks” and raw materials for structures in communities thereby decreasing plastic bottle wastes in the environment.

#### **1.1.3.7. *Improve Quality of Life***

- **Generate Employment Opportunities for Vulnerable and Marginalized Populations**

Building plastic bottle structures in marginalized and vulnerable communities will empower, inspire and provide employment opportunities for poor families thereby boasting quality of life. For instance, the construction will provide the opportunity for local masons and building experts within the community to be contracted for jobs and all construction materials procured from local merchants. This will in a way boast economic development within the community through the circular flow of money, thereby causing ripple economic impacts for businesses locally.

Also, it will help create the platform for unskilled or untrained citizens to come together to get trained and work on innovative projects that will make them independent of the system and be self-reliant.

- **Help Raise Economic Awareness of the Best Value for Resources**

Plastic bottle structures will provide opportunities for communities to understand and identify potential economic values and benefits they can derive from under-utilized waste materials like plastic bottles and other waste materials for their own benefits. Before now, no one saw the potentials of using plastic bottle and other waste materials for something of economic benefits but today, it is gaining some popularity especially with the reality of economic recession and the rate of waste generation increasing with population increase.

- **Improve Community Self-Esteem**

Engaging community members in the construction of plastic bottle structures provides an opportunity for them to own the project and become involved. Involvement of every member of the community as a team in the planning, participation, execution and completion of the project promotes self-fulfillment, satisfaction and true ownership of the projects. Communities take responsibilities for these projects from start to end as a sign of self-worth.

- **Build Communities**

Constructing plastic bottle structures in communities are essentially and usually involve community efforts. From little children to elderly ones in the community are all involved in the entire process which gives the unique opportunity for interactions across different age, religious and social groups, thereby fostering social integration and unity towards a common goal. This process helps to build the entire community and can proudly boast of ownership of such structures.

#### ***1.1.3.8. Promote Productive Environmental Education***

Environmental education can be promoted through the construction of plastic bottle structures in communities by teaching kids and other community members about the long-term impacts of waste in our environment and the risk of not taken actions now. This helps to create environmental awareness within the community which will help citizens understand how waste generated by them could be of beneficial use. It will also create environmental consciousness by everyone in the community seeing such structures, thereby leading to respect for the environment.

#### ***1.1.3.9. Advance Green Building Innovations***

Plastic bottle structures are new innovative, sustainable designs in the green building industry that are beginning to gain prominence in poor communities where access to basic amenities are limited. It is a very good alternative to the conventional building where high-embodied carbon materials such as cement, wood and iron rods used are substituted with waste materials for construction.

#### ***1.1.4. Need to Strengthen Social Networks in Communities***

We live in a divided world, and in our communities today, there have been segregation and high level marginalization among various ethnic, religious and social groups and it is therefore imperative to seek ways to bring us all together through a common purpose. This can be achieved through a concept known as “barn raising” which is the gathering together of community members cooperatively where they erect structures (barn) for the benefits of the community, typically followed by a celebration.

Plastic bottle structures can provide unique opportunities to bring world communities together and strengthen social networks and harmony in communities. Although not affected by war, Haiti suffered a devastating 7.0 earthquake in 2010 in which more than 160,000 people were killed and close to 1.5 million displaced (EcoTec Haiti, 2010). Through the adoption of plastic bottle construction techniques, Haiti built resiliency through the development of a large diversity of structural works such as temporary shelters, warehouses, water storage tanks and permanent housing with non-biodegradable waste like plastic bottles and tires as construction materials. This helped Haitians tackle their social problems, thereby strengthening community support networks moving forward.

## **1.2. Bringing it Together (Through a How-To-Manual)**

### *1.2.1. A Community Guide for the Process of Building Bottle Structure (From Conceptual Idea to Finished Structure)*

The purpose of developing this community guide is to:

*1) promote innovative and alternative utilization of waste materials (plastic bottles) in global communities 2) to address key social, environmental and economic gaps through 3) a step by step and easy to understand approach which can be adoptable anywhere around the world.*

This manual is intended to be adopted by two types of communities: 1) those with limited or inadequate basic infrastructure. i.e. housing, schools, greenhouses, water storage tanks etc., and 2) those communities struggling with waste management issues. This manual will educate communities about the innovative and alternative benefits that can be derived from plastic bottles and other waste materials when used as eco-bricks for affordable housing and other structures such as greenhouses.

**Chapter Two** focuses on the step by step methods on how to engage communities to be part of the project.

**Chapter Three** focuses on the step by step approach to raising necessary funds for your project.

**Chapter Four** focuses on workshop program/do-it-yourself (DIY) which will involve project designs and skill training for the community.

**Chapter Five** will focus on the step by step approach/guide on the construction of the structure.



## CHAPTER TWO: COMMUNITY ENGAGEMENT PROCESS

Community Engagement processes requires continued commitment on the part of both the planners and community members for it to be successful. Once correctly conducted and implemented, community projects will be successful.

Community Engagement has been defined as “the process of working collaboratively with groups of people who are affiliated by geographic proximity, special interests, or similar situations with respect to issues affecting their well-being” (CDC, 1997, p 9). Community Engagement provides community members the opportunity to be empowered in making critical decisions that influences their lives and environment. Community Engagement is a form of empowerment which involves “a group-based participatory, developmental approach through which marginalized or oppressed individuals and groups gain greater control over their lives and environment, acquire valued resources and basic rights, and achieve important life goals and reduced societal marginalization” (Maton, 2008).

Community Engagement is key to the successful implementation of any new community project. It is important to understand the community in which you are trying to engage with as well as recognize that every community has its own unique culture and norms.

To frame the various themes of this manual’s community engagement section for best practices (methodology), common themes in all the community engagement frameworks reviewed as adopted in other communities as well as the Community-Based Participatory Research (CBPR) (a peer reviewed process) framework which talked about the principles and characteristics of a community-based participatory research were used to determine this process. These frameworks previously adopted by other communities were in line with the principles and characteristics of CBPR, which has been validated by researchers in the academia as best practices with respect to community engagement. The overarching themes/references considered for framing the community engagement section of the manual as shown in Table 1 include: *Clear Overall Goals, Objectives and Boundaries of Engagement, Inclusiveness, Early Involvement, Access to Decision Making, Coordinated Approach, Transparent and Accountable, Open and Timely Communication, Mutual Trust and Respect and Evaluation and Continuous Improvement.*

**Table 1- Community Engagement Matrix (Guiding Principles for Community Engagement)**

COMMUNITY ENGAGEMENT MATRIX											
BASIC GUIDING PRINCIPLES FOR COMMUNITY ENGAGEMENT											
S/N	CASE STUDIES	Clear Overall Goals, Objectives and Boundaries of Engagement	Inclusive	Early Involvement	Access to Decision Making	Coordinated Approach	Transparent and Accountable	Open and Timely Communication	Mutual Trust and Respect	Evaluation and Continuous Improvement	Links
1	Douglas Shire Council Community Engagement Guide and Tools	X	X	X	X	X	X	X	X	X	<a href="https://douglas.qld.gov.au/download/community_engagement/Community%20Engagement%20Guide%20and%20Tools.pdf">https://douglas.qld.gov.au/download/community_engagement/Community%20Engagement%20Guide%20and%20Tools.pdf</a>
2	Communit Engagement Framework (Sunshine Coast Council)	x	X	X	X	X		X	X	X	<a href="https://d1j8a4bwze3.cloudfront.net/~media/.../Community/commengagefwork.pdf..">https://d1j8a4bwze3.cloudfront.net/~media/.../Community/commengagefwork.pdf..</a>
3	Community Engagement Procedures (PittWater Council)	x	x	x	x	x	x	x	x	x	<a href="http://portal.pittwater.nsw.gov.au/common/Output/DataworksAccess.aspx?id=qYrV8xl%252fuWE%253d&amp;ext=pdf">http://portal.pittwater.nsw.gov.au/common/Output/DataworksAccess.aspx?id=qYrV8xl%252fuWE%253d&amp;ext=pdf</a>
4	Community Engagement Handbook (Model Framework for Leading Practice in Local Govt. in South Australia)	x	x	x	x	x	x	x	x	x	<a href="https://www.lga.sa.gov.au/webdata/resources/files/Community_Engagement_Handbook_March_2008_-_PDF.pdf">https://www.lga.sa.gov.au/webdata/resources/files/Community_Engagement_Handbook_March_2008_-_PDF.pdf</a>
5	Community Engagement Framework 2015 (City of Guelph)	x	x	x	x	x	x	x	x	x	<a href="http://guelph.ca/wp-content/uploads/CEF_Framework.pdf">http://guelph.ca/wp-content/uploads/CEF_Framework.pdf</a>
6	Moorabool Community Engagement Framework	x	x			x	x	x	x	x	<a href="http://haveyoursaymoorabool.com.au/communityengagement/documents/">haveyoursaymoorabool.com.au/communityengagement/documents/</a>
7	Community Engagement Strategy (Mosman Council)		x	x	x	x	x	x	x	x	<a href="http://mosmanroundtable.net/ces/">http://mosmanroundtable.net/ces/</a>
8	Halifax Regional Municipality Community Engagement Strategy	x	x	x	x	x	x	x	x	x	<a href="http://www.halifax.ca/get-involved/documents/communityengagementsstrategy.pdf">http://www.halifax.ca/get-involved/documents/communityengagementsstrategy.pdf</a>
9	Principles of Community Engagement (2nd Edition)	X	X	X	X	X	X	X	X	X	<a href="https://www.atsdr.cdc.gov/communityengagement/pdf/PCE_Report_508_FINAL.pdf">https://www.atsdr.cdc.gov/communityengagement/pdf/PCE_Report_508_FINAL.pdf</a>

Therefore, for this manual, the step by step approach for community engagement include:

## 2.1. Step One: Know and Understand the Project at Hand

### 2.1.1. *State the Scope and Objectives of the Community Engagement*

- ***Be clear and identify outcomes to be achieved with the community engagement.***

Before you kick start any community engagement process, it is important that you understand and determine why you want to engage that community (goals). To better frame these goals/objectives, consider their immediate needs and determine how the project can address it. You should set clear overall goals and objectives as well as clarify what you plan to achieve with the overall engagement process. Objectives set before the commencement of any community engagement process should describe what you want to achieve with your community in the delivery of the said project. Ensure that the set objectives being developed are actions or activities based and/or centered on building relationships with the community or stakeholders.

For example, objectives that are action/activities based could be to determine structures that are needed to be built in this community, to deliver balanced and objective information to the community, to acquire feedbacks on the community's views on the project, to have a clear understanding about the issues, worries and hopes of the community regarding the project, to encourage the community to be part of the scope and decision-making process, to encourage platforms on which the community can offer valuable contributions to the entire process and making them aware how these contributions will be used or implemented in the project etc. One critical thing to keep in mind also when developing the objectives of the project is to make sure the community from the onset feels that the engagement processes will be open and transparent, to ensure full participation from all stakeholders within that community. Relationship-centered objectives examples could be to encourage stakeholders to take ownership of the new project/innovation as well as create mutual understanding with key stakeholders within the community.

As the objectives are being designed, ensure that they are *specific, measurable, achievable, realistic and time bound* (SMART).

- ***Identify Key Current and Historical Issues that May Have an Impact on the Project.***

Having a clear understanding of the community you are working with helps shape the objectives of the community engagement. Before you engage the community, you need to find out what are the historical and current issues that are critical to the success of the project you want to implement? For example, if you plan to build plastic bottle houses in the identified community, you need to find out what are the legal building permit regulations? what approvals needs to be received before such projects can commence? has this type of project been implemented before? and if yes, what were the

obstacles that were faced in implementing it? All this information can be retrieved by consulting with key stakeholders within and around the community where you want to implement the project. Once you can identify these critical information, it will help to frame effectively your objectives and how best you can engage the community and stakeholders for full participation and involvement.

#### *2.1.2. Develop a Short Issue Statement to Explain to all Stakeholders What the Project Involves*

It is very helpful to create a well-thought document or statement to clearly state the problems your proposed project wants to solve, solutions it is going to bring and how they can be part of it with benefits involved before approaching your stakeholders in the community. For instance, approaching a community lacking regular water supply with the proposal of building a plastic bottle water tank will receive full participation and involvement by all stakeholders because it offers solutions to what they need as a community and such will be a success.

So therefore, while developing the scope and objectives of your community engagement, it is important to outline what your project is bringing to the table and how it will solve current issues within that community for the community engagement processes to be successful.

#### *2.1.3. Define What is Open for Discussion/Decision-Making and What is Not*

In some instances, the project planners would have decided what project they want to carry out in a community and will just require them informing the community but there are some that require consultation with the community on their needs before such projects can commence. So, it is therefore important that you are clear about what is open for discussion and what it is not and once this is clearly spelt out, engagement efforts can be channeled towards it for judicious use of time, energy and resources. Usually, open discussions are those decisions that are yet to be made and will require some level of consultation while those that are not open are those in which decisions have been made largely and does not require consultation which has been influenced by funding or the law.

## **2.2. Step Two: Know your Community Inside Out**

### *2.2.1. Ensure Engagement Planning, Designing and Implementation Approaches Recognizes, Respect and Compliment Community Cultural Traditions*

- ***Values & Norms, Economic Conditions, Social Networks, Political & Power Structures, Historic & Demographic Trends, Language, Age, Gender, Race, Personal Interest etc.***

For any community engagement to be successful, planners must ensure that they understand the cultural, demographic and traditional dynamics of the community they are working with. These could include values, norms, economic, social, political and power structures as well as language, race, gender, age and personal interests. In

addition, being knowledgeable about the community's perceptions about the project and the project members will go a long way in making the community engagement processes successful which will facilitate effective planning and program development. A better understanding of the community will also help you identify the community leaders you can work with in assisting you navigate through barriers that you might encounter as well as point you in the right direction in terms of community personnel, assets and institutions that will enhance your work.

- ***Identify and Mobilize Community Assets***

Identifying and understanding key stakeholders in and around the community you want to engage with will go a long in helping to harness resources for effective community engagement. Resources such as skills, interests and experiences of individuals and local organizations will make your job easier and reduce the cost of engagement.

## **2.3. Step Three: Identify Stakeholders to Be Engaged**

### *2.3.1. Identify all Relevant Stakeholders Who Will Be Affected or Have an Interest in the Project/Issue (Internal & External)*

- **Who are the Individuals, Groups/Organizations with Interests in the Outcome of the Project?**

Identifying key stakeholders (internal and external) early enough within and around the community who might have influence on the project is critical. It is vital to know the individuals, organizations who may be interested in the product of your project as well as those that have special influence over its outcome. Be flexible as much as possible, seek out advice from community members and think widely about who could potentially be part of your project in the community.

Examples of relevant stakeholders in the construction of plastic bottle structures in a typical community in general could include; top community members, local government authorities, community leaders, religious leaders, professional bodies in the building industry, educational institutions etc.

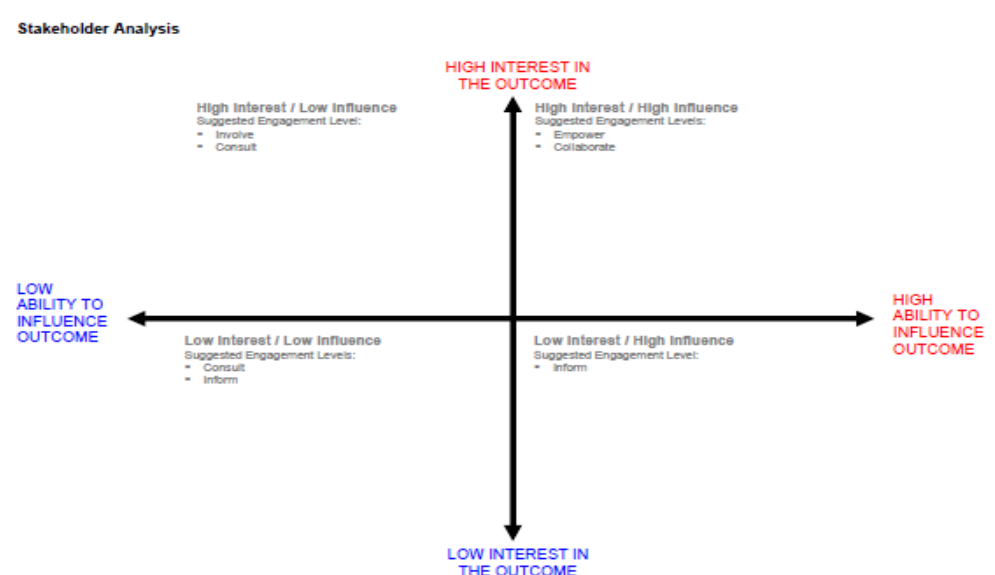
### *2.3.2. Understand Your Stakeholders and Their Needs Within the Community (Analyse your Stakeholders)*

- **Stakeholder Analysis**

It is one thing to Identify your key stakeholders, it is another thing to understand them and their needs. Therefore, it is important to gain some sense of their level of interest as well as how they can influence the project outcomes to better serve their needs and this can be achieved through stakeholder analysis with the use of a stakeholder matrix. This is a great tool in planning any engagement process in any community.

The process of understanding your stakeholders can only occur when you establish good relationships with them. Building good relationships with stakeholders in the community influences trust and enhances involvements and effective participation.





**Figure 4-Stakeholder Analysis (Moorabool Shire Council)**

Source: Moorabool Shire Council

## 2.4. Step Four: Determine the Level of Impact

### 2.4.1. Assess the Level of Impact the Project will Likely Have on the Community

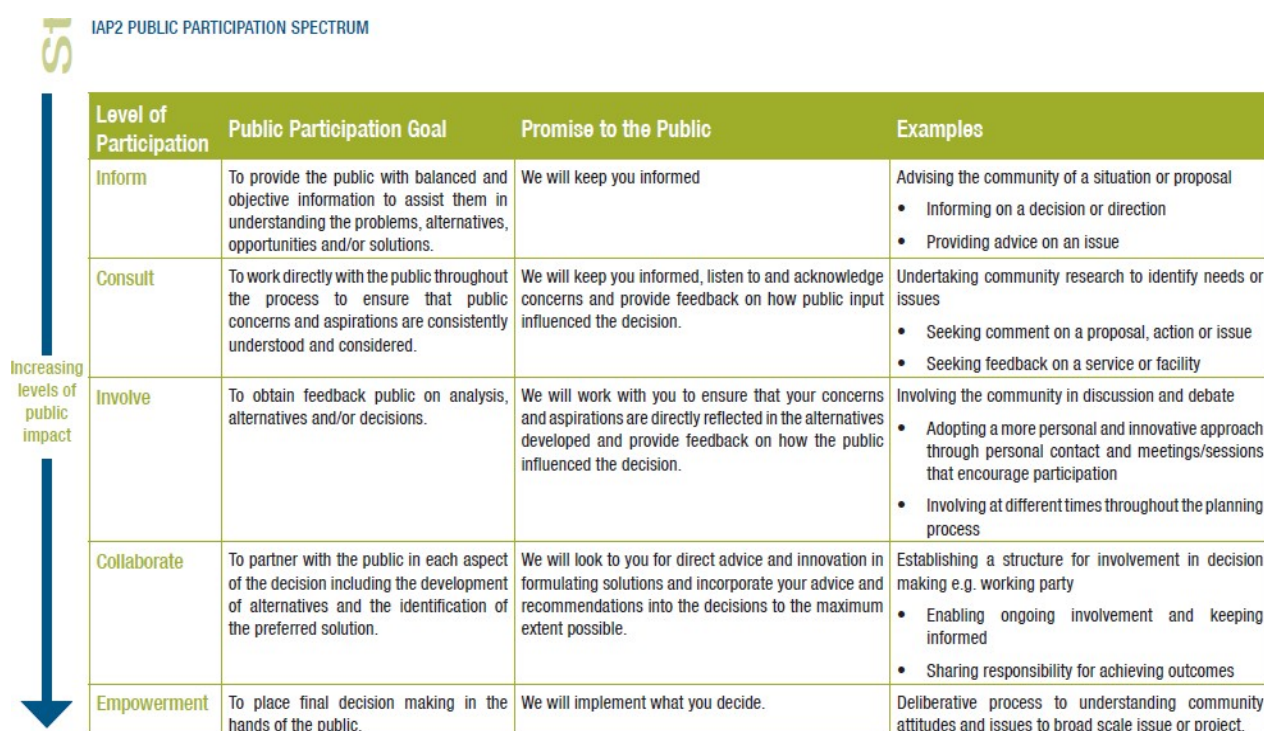
In determining the level of impact of a project in your community, it is important to first identify the key stakeholders that are interested in or impacted by the project's decisions. Project impacts could be high, medium or low and it is of a necessity to determine how the project decision impacts will affect the community and the understanding of this will help influence the level of engagement to be deployed. The higher the level of impact, the greater the level of engagement. According to the *IAP2 Spectrum for Public Participation*, there are five categories of community engagement which include *inform (being the least)*, *consult*, *involve*, *collaborate* and *empower* (being the most vital level of community engagement). It should be noted that although some projects could have high level of impact, it does not mean that the level of engagement requirements for the stakeholders is to empower them but it may only require them to be *informed, consulted or even be involved*.

One critical thing to keep in mind during the project is that the levels of impact may require some degree of review due to better knowledge of the problems and the consequences of the outcomes.

## 2.5. Step Five: Determine the Levels of Stakeholders' Community Engagement/Participation

You need to do an assessment or evaluation of the level of stakeholders' participation immediately after the level of project impacts have been determined. Using the International Public Participation (IAP2) Spectrum, the extent or level to which you will engage or involve your stakeholders in decision-making regarding the project include;

- 2.5.1. **Inform:** This is a one-way communication process that keeps stakeholders informed and provides balanced and objective information to assist a better understanding on the issue at hand or that has happened.
- 2.5.2. **Consult:** This is a two-way communication process planned to seek stakeholders' feedback about ideas on alternatives and feedbacks on how stakeholders' inputs informed decision making.
- 2.5.3. **Involve:** It is more of a participatory process planned to help identify issues and opinions to guarantee that concerns and aspirations are understood and considered in the alternative provided preceding decision making.
- 2.5.4. **Collaborate:** This is the process of partnering with the stakeholders in all aspect of the decision-making process, including the understanding of all issues, development of options, and identifying ideal solutions.
- 2.5.5. **Empower:** This is a critical level in the spectrum in the sense that the stakeholders are empowered to develop solutions and implement them. In other words, the final decisions are handed over to the stakeholders for them to implement.



**Figure 5-IAP2 Public Participation Spectrum (International Public Participation)**

Source : International Public Participation (IAP2) Spectrum

## 2.6. Step Six: Determine Community Engagement Methods

### 2.6.1. Analyse the Level of Stakeholders' Participation/ Community Engagement Levels (Step 5) to Determine the Most Appropriate Methodologies

At this stage, the engagement levels as stated in step 5 will be used in determining the most effective methods to engage the stakeholders. It is important to understand the purpose of engaging a stakeholder and this helps to know how best to achieve it.

Figure 6-Community Engagement Communication Methods

LEVELS OF PARTICIPATION	METHODS
INFORM	<u>Website</u> - Consultation project page, public meetings, documents on public exhibition, online comments. <u>Publications</u> - Flyers, Facts sheets, newsletters, reports. <u>Direct Communication</u> - Phone, Letters, Reports. <u>Media</u> - Press Release, Advertisements. <u>Displays/Exhibits</u> - Customer Service, libraries, Community Notice Boards.
CONSULT	<u>Meetings</u> - Public meetings, Stakeholder meetings. <u>Community Fairs &amp; Events</u> - Submission/Feedback Sheets. <u>Survey</u> - Phone, Online, Paper. <u>Social Media</u> - Blogs, Twitter, Facebook, Instagram etc. <u>Focus Groups</u> - Shopfronts, minority groups.
INVOLVE	Open House, Community Reference Groups, Photovoice, Round Table Workshops.
COLLABORATE	Charrettes, Deliberative Forum, World Cafes, Deliberative Retreats, Summits, Committees etc.
EMPOWER	Citizens Juries, Ballots, Advisory Groups.

Source: Pittwater Council

## 2.7. Step Seven: Develop an Operational Plan

At this stage, it is important to design an operational plan to work with to keep you on track and for an effective community engagement process. This may include deciding which stakeholders you will engage, at what level (inform, consult, involve, collaborate and empower), which communication method will you use, and at what stage of the engagement process.

It is also important you ensure that your operational plan being implemented visibly state the ultimate decision making process during the cause of the engagement and it leads to a familiar and permanent sign-off the decisions made by all stakeholders.

Remember that your operational plan for the community engagement needs to go through review, sign-off and approval by relevant authorities in the community before it can be implemented. In a situation where there are no authorities to seek approval from, it is important that the community engagement process contributors (stakeholders) be reached out to by informing them to let them know how their inputs were adopted in the final decision made. Once approved by the authorities/contributors, the plan should be implemented in the community.

## **2.8. Step Eight: Evaluate the Community Engagement Process**

### *2.8.1. Reflect on the Entire Engagement Process and Identify What Worked and Did Not Work*

It is important at the end of any community engagement process to evaluate the performances and engagement outcomes to decide if the process was successful and all outcomes were achieved.

Performance tracking is also important at the end of any engagement process by asking yourself questions about the community engagement plan used because it provides the opportunity to learn from wrong steps taken during the process and adjust. Questions to asking during performance tracking could be were the objectives of the engagement process achieved? If not, why? To what extent did participants contribute to the process? etc.

### *2.8.2. Tools for Evaluation*

There are several tools which can be used to evaluate community engagement process and these include: attendance sheets at public meetings, collection of demographic data, evaluation forms given to participants/contributors about the engagement process, minutes of meetings etc.

**Figure 7- Step by Step Approach for Community Engagement**





### **Box 1- Community Engagement for the Plastic Bottle Greenhouse in Gunnison Colorado**

Gunnison is one of the coldest cities in the US with a lot of snow which limits amount of food that can be grown locally. Growing seasons are limited only to 63 days in a year with limited affordable greenhouse. Another need peculiar to Gunnison is limited waste management infrastructure in which only plastics #1 and #2 can be recycled with the rest going to the landfill. This limitation accounted for 18,647 tons of municipal solid waste landfilled in 2015 (Chavez, 2017).

The above limitations led to providing solutions to address the waste management issues as well as limited growing season with the construction of a plastic bottle greenhouse by engaging the residents of Gunnison and other key stakeholders. Communication outlets such as the Gunnison Marketplace Facebook page, local dallies (Gunnison Times) etc. as well as group meetings were used to reach to the community to inform and harvest opinions on their perception about the project. Doing this, helped tremendously in getting support (monetary, technical, kind etc.) needed to complete the project.



**Ayodeji, soliciting community members/stakeholders support for the plastic bottle greenhouse project**

## CHAPTER THREE: FUNDRAISING PROCESS

Fundraising is an important aspect of any community project and for it to be successful, it requires the joint efforts of all those associated with the project. The moment the project is tied to a community's need, it is more likely to receive the backing of community members.

Fundraising requires lots of hard work to achieve the desired results. Also for best practices, fundraising strategies and frameworks from peer- and grey-reviewed literature were referenced while framing the fundraising steps discussed in this chapter. The common themes identified in a typical fundraising process as highlighted in Table 2 below include: *mission (case) statement, clear purpose of fundraising, clear fundraising goals/objectives and program budgets, monitoring of all fundraising activities, building good, trusted relationship with donors, transparency and accountability, open and timely communication, trust and respect, defined responsibilities and clear expectations, thanking donors, celebrate and evaluation.*

**Table 2- Fundraising Matrix**

FUNDRAISING MATRIX														
BASIC ELEMENTS FOR FUNDRAISING														
S/N	CASE STUDIES	Mission (case) statement	Clear Purpose of Fundraising	Clear fundraising goals/objectives and program budgets	Monitoring of all fundraising activities	Building good, trusted relationship with donors	Transparency and Accountability	Open and Timely Communication	Trust and Respect	Defined Responsibilities and Clear Expectations	Thanking donors	Celebrate	Evaluation	Links
1	The 5 Keys to Successful Fundraising	X	X	X	X	X	X	X	X	X	X	X	X	<a href="http://www.pachyonychia.org/wp-content/uploads/2016/11/Guide-5KeysFundraising-stepbystepfundraising.pdf">http://www.pachyonychia.org/wp-content/uploads/2016/11/Guide-5KeysFundraising-stepbystepfundraising.pdf</a>
2	A Guide to Fundraising		X	X	X	X	X	X	X	X	X			<a href="https://www.scribd.com/document/175930321/A-Guide-to-Fundraising">https://www.scribd.com/document/175930321/A-Guide-to-Fundraising</a>
3	Fundraising Strategies for Environmental Funds	X	X	X	X	X	X	X	X	X	X			<a href="http://www.aligningvisions.com/resources/Re-dLAC+AV+Fundraising+Strategies+for+Environmental+Funds.pdf">http://www.aligningvisions.com/resources/Re-dLAC+AV+Fundraising+Strategies+for+Environmental+Funds.pdf</a>
4	The 2016 Nonprofit Fundraising Strategic Plan Guide	X	X	X	X	X	X	X	X	X	X			<a href="https://blog.everyaction.com/nonprofit-fundraising-strategic-plan-guide">https://blog.everyaction.com/nonprofit-fundraising-strategic-plan-guide</a>
5	Best Practices for Fundraising Success- Diversifying Giving Channels	X	X	X	X	X	X	X	X	X	X		X	<a href="https://www.blackbaud.com/files/resources/7-12-Desktop_Book_Web.pdf">https://www.blackbaud.com/files/resources/7-12-Desktop_Book_Web.pdf</a>
6	Fundraising for Dummies- 3rd Edition	X	X	X	X	X	X	X	X	X	X	X	X	<a href="http://www.dummies.com/cheatsheet/fundraising">www.dummies.com/cheatsheet/fundraising</a>

Therefore, for the aspect of this manual, the step by step approach (Figure 8- Fundraising Steps) adopted from literatures reviewed for fundraising include:

### 3.1. Step One: Know “WHY” You are Raising Money (Purpose)

As you begin to raise funds for the project, it is important from the onset that the reasons and motivation for raising money should be spelt out clearly to help donors know why they should contribute to the cause. Sharing the purpose of why you are raising funds and how important donors' support is very imperative to the project will go a long way in helping you reach the fundraising targets set as soon as possible because more people will be willing to donate once they have a clearer understanding of the purpose of the fundraising.

#### 3.1.1. State the Goal of the Project in the Community

Most donors will be most interested in knowing what the goal of project is and what it aims to achieve within the chosen community before they commit their funds to it. Therefore, it is important at the beginning of any fundraising to clearly state the goal(s) of that project/effort you want to raise funds for to receive support from donors. This is

one of the most important aspect of any fundraising because it commands positive responses from potential donors and help to achieve the desired results. In stating the goal of the project, ensure that such goal is SMART (*specific, measurable, achievable, realistic, and time*). The goals set for the project will also provide the opportunity to be able to track its outcomes to have clear knowledge about what worked, what can be improved upon and what did not work as a guide to future fundraising project campaigns.

### *3.1.2. Identify What Can Motivate People to Donate Within and Around the Community*

The creativity and benefits around a project influences participation of potential donors. Ensure that your proposed project seeking funding will solve a real problem within and around the community to encourage people to donate to it. Most donors feel motivated to want to contribute to specific projects that addresses specific community needs which in most cases are “out of the box” kind of projects. Be creative and study the community where the project will be located to identify pressing needs associated with that community and tie your project to them.

### *3.1.3. State the Purpose of the Fundraiser*

#### **3.1.3.1. What is the funds going to be used for? i.e. community building structure, schools, outreach etc.**

After stating the goals of the project, it is also important to state the purpose of the fundraising as well. Giving the reasons for fundraising will go a long way in encouraging participation of donors and contributors. Most potential donors would want to know the specific reason (s) why you are raising funds and what it will be used for with proofs before committing their monies to such cause. Again, they might also want to know what other avenues have you explored before fundraising. Potential reasons for raising funds could be for projects such as community building structures, community schools etc.

#### **3.1.3.2. What Motivated the Need for a Fundraiser?**

Before you kick-start your fundraising activities on any project, there is the need to carefully identify the motivation behind it before starting at all. Is it because of the need for new sources of funds to support the project or is it just to create awareness about the project? Is it to get support (formation of team) from community members and key influential individuals/groups within the community or to meet specific community needs? The motivation behind your project’s fundraising will inspire better planning and outcomes in achieving the desired goals.

### *3.1.4. Address Donors Concerns*

#### **3.1.4.1. Community Members, Volunteers, Businesses etc.**

People sometimes could be hesitant in making donations because there are so many causes out there seeking for support and may not be genuine. One among

many set of questions people ask when approached to donate is what does the money go for? Therefore, for you to successfully earn the trust of donors that donations will be judiciously utilized and also meet your fundraising goals, there is the need for effective communication of your project's mission, purpose of the fundraiser and what it will be used for at the beginning of the fundraiser for effective results.

### **3.2. Step Two: Choose the Right Fundraiser**

#### *3.2.1. What/Who is the Most Beneficial Program/Person to your Community?*

##### **3.2.1.1. Community Members/Volunteers etc.**

Every fundraiser has its own uniqueness considering the available resources (material and human). In choosing the right fundraiser for your community project, it must be one that will be most beneficial and meets the immediate demands and cause in the chosen community. You must ensure that all fundraising activities are tailored towards pressing needs within the chosen community for it to attract the right human (volunteers) and material resources needed to support it. This will encourage volunteers and community members to want to commit and dedicate their time, energy and resources to the fundraiser for the success of the project, thereby promoting good community partnerships among members.

##### **3.2.1.2. Types of Fund Raiser to Explore**

###### *3.2.1.2.1. Sales*

One of the ways to raise funds to support any project cause is through sales of products or services rendered and the choice of such products or services is very crucial for its success of fund generation. Think about products and services unique to your community that people will be interested in and should be within reasonable amount that won't scare people away. Ensure that products and services offered for sales are not inferior which could in some ways damage the trust the community might have in the fundraising as well as the project. For ideas on sales of products or services you can do to raise funds for your project, you can check [Fundraising-ideas](#).

###### *3.2.1.2.2 Events*

Another way to raise funds for community projects is by organizing fundraising events. Good fundraising events will help you appeal to the public and community in general, reach your fundraising goals easily as well as give more publicity to your project. Therefore, thinking outside the box with a conducive enabling environment, will help you create a very successful fundraising event suitable for your community.

###### *3.2.1.2.3. Direct Solicitation from Potential Donors*

Direct solicitation is another way of seeking funding for projects especially from potential donors. This process is carried out directly by

those in charge of the fundraising and it requires going to meet all identified potential donors one-on-one to donate to the cause. Other examples of direct solicitation which could be explored to source for funds comprises of grant writing, letter writing, emails etc. For a successful direct solicitation, you must ensure that lists of all potential donors in your community are generated and map out strategies/plans on how to persuade them to donate to your cause. Some fundraiser experts have argued that emails may not be an effective way to solicit for funds but could be used for follow-ups.

#### *3.2.1.2.4. Online Fundraising*

Raising funds online has become prominent, becoming the future in the world of fundraising. What online fundraising technology has done to improve fundraising is that it has created the opportunity and platform for more people to be reached and can access your cause which will enable you raise more money. For example, most online fundraising sites such as GoFundMe, Crowdrise, Giveforward and YouCaring have integrated social media platforms to their websites which is a good one since most people within and around your community use one form of social media or the other (Facebook, Twitter, Instagram etc.). What this does is that it increases the potentials of sharing the cause on these social media platforms, thereby increasing potential donors. Online fundraising also provides the opportunity for you to share stories about your cause and how you plan to use the money raised.

#### *3.2.1.2.5. Peer-to-Peer Fundraiser*

This is an online fundraiser as well but different in the sense that it takes the advantage of using peers (friends, family members etc.) instead. Using peers as fundraisers will give your cause an extended reach by capitalizing on your friends, families and peers' network by helping to share your cause. Because they know you personally, it gives them the opportunity to advocate, promote and solicit for your cause. One advantage among many is that it is cost effective because you don't have to sell anything or rent a place to host your events. You must ensure that there is transparency in the fundraising by giving report of how much is being raised and do not forget to say "thank you" to every donor.

### **3.3. Step Three: Organize your Fund Raising**

#### *3.3.1. Create your Community's Fundraising Goals*

Before you kick-start your community project, it is important to ensure that you clearly spell out the fundraising goals you want to see achieved. This will guide you throughout the fundraising activities for the community project you want to embark on and help you plan effectively towards it. You need to ask yourself, what do we want to achieve with fundraising and what is our target?

### **3.3.1.1. Identify/Know the Budgetary Needs of the Project**

It is important that you carefully identify all financial needs of the proposed community project to help inform what your fundraising goals for the project will be. You must ensure to be detailed about all the costs of the various components of the project. Do not overlook any aspect no matter how little or insignificant it could be.

### *3.3.2. Establish a Proper Cost to Revenue Ratio*

#### **3.3.2.1. Ensure your fundraising costs/expenses are close to Zero**

As you begin the process of raising funds for your project, you might incur some operational costs which is okay but you must ensure that the costs are at the barest minimum so that it would not take the large chunk of your hard-earned funds meant for your project. Incurred costs could be from buying operational materials such as stationaries, paying for internet services etc. and the lesser these costs are, the better for your cause.

### *3.3.3. Determine/Set your Budget*

#### **3.3.3.1. Determine How Much that Can be “Potentially Raised” from the Fundraiser**

In deciding on any project you plan to embark on, the first thing to consider is the budgetary implications. Note that for every successful fundraising project, budgeting has become one of the most important aspect of it. Creating a very detailed budget during the planning stages will help you determine how much you can set and raise for your project. It could be a difficult task to come up with a very good budget, but once that is done, it guides you to how much money you could potentially raise within and around your community for your project. Ensure to conduct some thorough research on the cost of every item included in your budget and always anticipate for some other forms of expenses that might arise.

#### **3.3.3.2. Determine How Much Money, Product/Services will be donated towards the Community Project (Corporate Sponsorship, Technical Skills, Building Materials, Labor etc.)**

As part of your fundraising activities, it is necessary to be able to identify within the community what donations will be given to support the community project. Such donations could be in form of cash, technical skills, building materials etc. This will help you to be able to plan and properly develop your project budget as well as the fundraising goals. Some members of the community may like your project ideas but don't have the money to give and may want to offer their technical skills, building materials which in a great way lower the cost of operations to make this project happen.



### *3.3.4. Donations and Corporate/Community Sponsors*

#### **3.3.4.1. Seek Donations and Corporate/Community Sponsors for the Project**

As part of efforts to reduce costs in implementing your project and having a successful as well as rewarding fundraising, it is worthy to note that reaching out to corporate bodies/organizations as well as community sponsors personally within and around where you plan to execute the project will be a good one in ensuring that you meet your fundraising goals. Identify corporations that their mission statements are in line with the goals of the project you want to execute or might be willing to invest in their host community as well as a way of carrying out their corporate social responsibilities (CSR). Remember, donations could be monetary, space, building materials, manpower etc. The more donations you can receive, the better it is for you to attain your fundraising goals. For example, if you are planning to build plastic bottle schools in a community and you are trying to raise funds for it, seek out companies or community organizations who might have skilled professionals to help you design the said project free of charge.

### *3.3.5. Timelines and Organization of the Fundraiser*

#### **3.3.5.1. Write Down All Major and Minor Task Details to Be Accomplished for Successful Fundraiser**

One critical aspect of fundraising is effective planning and organization. Start with your fundraising goals, study it and map out strategies on how to achieve them. Ensure that these strategies are achievable, realistic and are broken down into categories where specific tasks (major and minor) as well as action steps are assigned to persons responsible for their execution. These action plans should also have attainable timelines assigned to each. To ensure you and your team members are on track with your fundraising plans, it is important that everyone on the fundraising team have and are familiar with the fundraising plans and timelines so that everyone can be reminded and held accountable on their roles moving forward.

#### **3.3.5.2. Set Deadlines for Tasks**

It is not enough to just have specific tasks and people to execute them, but it is more important that deadlines as to when they will be accomplished should be determined at the beginning of the fundraising planning.

## **3.4. Step Four: Focus on Team Work**

### *3.4.1. Helps to Learn from the Experiences of Others*

To achieve an unprecedented fundraising campaign, you need to work effectively as a team and leverage on each team member's experiences to get the job done. Carefully identify the strengths and weaknesses of everyone on the team and assign tasks as appropriate for effectiveness. Every team member has unique experiences they bring to the team which should be used to the advantage of the fundraising campaign.



### *3.4.2. Helps Increase Accountability*

Working as a team ensures that everyone involved in the fundraising campaign is held accountable for every task assigned to them. During the planning stages, the team should agree on tasks and actions to achieve the fundraising goals with definite timelines to execute them which will make everyone carry out their functions effectively and would not want to fall short of this.

### *3.4.3. Helps Inspire and Encourage Team Members*

One of the greatest advantages of working as a team is that it provides the opportunity for members to encourage and inspire one another during the execution of the campaign. It is necessary to keep in mind that there will certainly be sometimes when things would not go the way you planned it and it is at that point that other team members could be of help and offer valuable advices to move on. Never fail to ask for help from your team members whenever you need them.

### *3.4.4. Helps Combines Talents/Resources to Raise More Money*

Team work provides the opportunity to leverage on strengths and talents of individual members and volunteers to help the fundraising campaign in achieving its goals. Keep in mind that you nor any member of your team alone cannot achieve results when working in isolation unless as a team. Fundraising campaigns could be very demanding and working effectively as a team leads to raising more funds for your campaign.

### *3.4.5. Things to Consider During Team Work*

#### **3.4.5.1. Leadership**

In every team or group, there must be someone or group of people leading to give directions and guidance to the team. Therefore, it is important that whoever is leading the team must have what it takes to lead and do that effectively. The reason why good leadership is important in every successful fundraising campaign is that they are provided with the mandate to ensure the team attain the goals and strategies of the campaign.

#### **3.4.5.2. Defined Responsibilities and Clear Expectations**

To avoid confusion and clash of interests among team members, it is of high necessity to define roles and responsibilities of each members of the team as well as the leadership. This will help keep the team focused, highlight clear expectations and boost productivity of the fundraising. This also encourages delegation of roles which makes everyone on the team important and relevant in contributing to the goals of the fundraising campaign. The results of this will result in efficiency and produce the desired results.

#### **3.4.5.3. Communication**

##### *3.4.5.3.1. Means of Communication E.g. Telephones, Meetings, Emails*

As a team, you should unanimously identify the easiest means or platform of communication that will make roles and responsibilities easier to carry

out. Is it regular weekly meetings to check in with each other or exchanging correspondences via emails or text messages, or scheduling telephone/teleconferencing etc.? Please kindly keep in mind that it is better to go for communication platforms that will not put additional costs on your campaign and will also be effective to carry out the tasks.

#### *3.4.5.3.2. Frequency of Communication*

During the planning stages of the fundraising campaign, it is very necessary to agree with team members on how often do you want to communicate with each other. Having this in mind well ahead of time will help everyone on the team in carrying out their tasks effectively. You might have specific time of meeting as a team or as the need may arise.

### **3.5. Step Five: Act on the Fundraising Process**

#### *3.5.1. Volunteer Support*

Forging ahead with your fundraising campaigns and taking proactive actions towards achieving your set goals requires the massive support of volunteers. Most fundraising campaigns have leveraged on the opportunities and support volunteers bring to any fundraising campaign because they present numerous benefits such as helping with planning, executing and spreading the cause to the community. Their support also saves operational costs that the campaign might incur. Since volunteers give support to your campaign because of their trust in the cause you promote, it is important that you appreciate them by thanking them for their efforts always through “thank you” notes and ensure that they feel accepted as team members of the campaign. This gives them more sense of belonging and wanting to commit more to the campaign.

#### *3.5.2. Keep Focus of the Fundraising Process*

Stay closely to your fundraising plans (goals and strategies) and timelines despite obstacles and challenges you might encounter. It is easy to get discouraged when things seem not going well as planned and that might get team members discouraged. Having strong fundraising plans at the beginning regardless of any challenges will keep your team going.

#### *3.5.3. Ensure to Thank Donors e.g. community donors*

##### **3.5.3.1. Letters, Notes, Thank you Cards**

Every donor who contributed to your cause deserves to be appreciated no matter how little they gave. Have comprehensive lists of all donors both online and physical so that you can have all their information handy to be able to send thank you notes or cards to them as a show of gratitude and appreciation for their donations. This will further cement the cordial relationship already established with all donors which may translate into continued funding towards the cause.

### *3.5.4. Community Celebration*

#### **3.5.4.1. Brief the Community How Much Was Raised**

Yes, at the end of your fundraising, it is of essence to give feedbacks or reports to all stakeholders, especially those who donated online as well as those within and around your community on how much your team raised. This will ensure transparency and give your cause more credibility.

#### **3.5.4.2. Ways to Celebrate with the Community**

##### *3.5.4.2.1. Community Celebration Party*

Now that your fundraising campaign has been completed, it is time for the team to celebrate with the community members and donors. This will provide the platform for the team to interact with those donors and socialize.

##### *3.5.4.2.2. Recognition of Community Leadership Efforts*

It is important to note that your fundraising campaign will not be successful without the support of community member volunteers and donors, therefore, it is imperative that your team recognizes such support coming from community leaders and groups who may have volunteered to spread your cause.

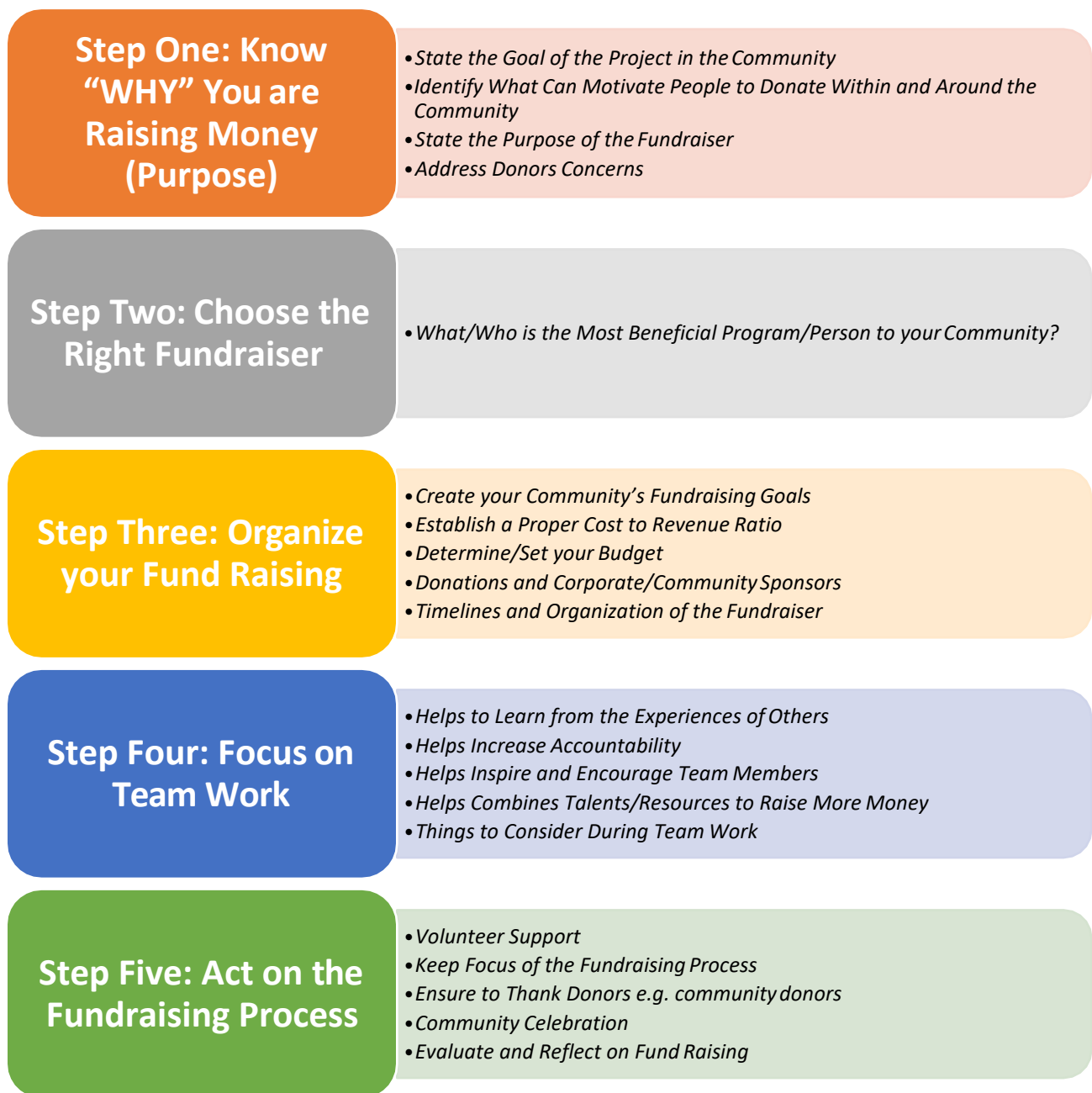
### *3.5.5. Evaluate and Reflect on Fund Raising*

#### **3.5.5.1. Through Survey**

Although you might have possibly met your fundraising goals or you may not have, there is still need for you to evaluate and reflect on the entire process and see where you did well and areas where there are needs for improvement for future campaigns. This can be achieved through written surveys or interviews which will help your team to continue what worked and change what didn't work.

#### **3.5.5.2. Meeting**

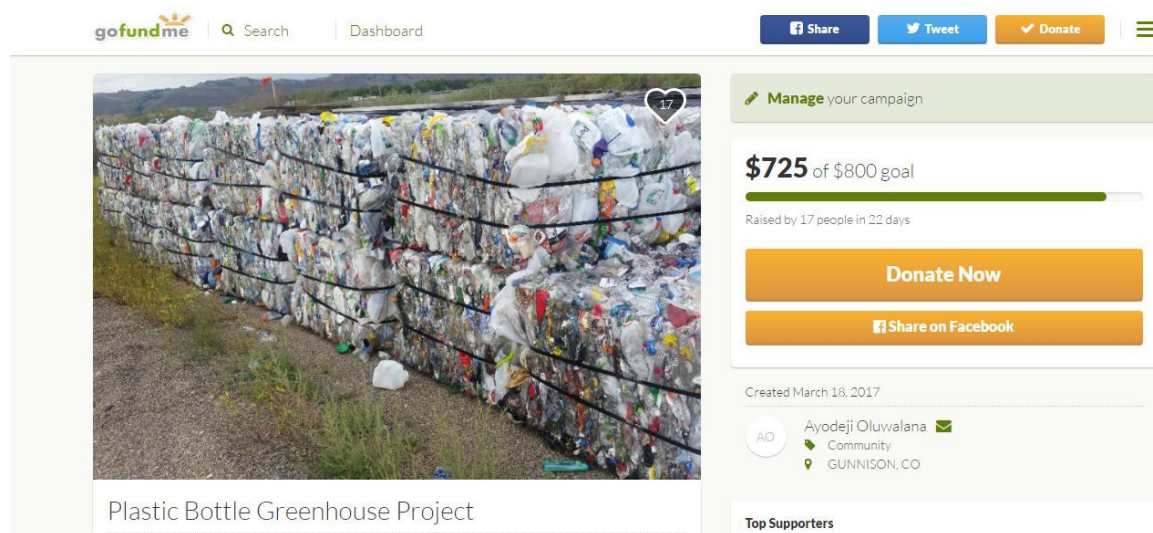
Organizing meetings as a form of getting feedbacks from all team members as well as all stakeholders that participated in the fundraising campaign will be a great form of evaluation of the campaign. If the decision to adopt meetings as a form of evaluation of the campaign was taken at the planning stage, dates of such meetings should be made known to all those involved as early as possible so that they can prepare for such. Evaluation should be done as soon as possible immediately after the completion of the fundraising campaign so that all feedbacks captured are accurate and represents a true reflection of the entire fundraising campaign.



**Figure 8- Fundraising Steps**

### Box 2- Fundraising for the Plastic Bottle Greenhouse in Gunnison Colorado

Most of the funds were raised for this project within the community and how that worked was because we were clear with the goal of our project and that of the fundraising (what the money raised was for) and linking that to the community needs/problems to be solved through the project. In addition, we identified what could motivate people to donate to the project which was local solution to global problems. Working closely with a reputable non-profit organization in Gunnison- Coldharbour Institute was one of the biggest selling point in terms of credibility of the cause. Coldharbour is community-oriented organization that has worked with different stakeholders within the community and beyond. GoFundMe fundraising platform was used to raise funds and the link shared with community members via the Facebook page of the community marketplace, friends and family members. We had a budget goal of \$800 to finance the project and in less than two weeks, we were almost at 100 % of the funds needed.



**GoFundMe page for the Plastic Bottle Greenhouse project in Gunnison, Colorado**

## CHAPTER FOUR: WORKSHOP PROGRAM/TRAINING PROGRAM (HANDS-ON)

### 4.1. Step One: Conduct Workshops

#### 4.1.1. Project Design

To be successful with community projects such as building sustainable structures, for example greenhouses from plastic bottle wastes generated within the community as well as adequately carry the people involved along with the project, it is important that all project team members know and understand the fundamental processes involved in project design and how it will be executed. This is necessary because it provides the fundamental foundation of what the team plan to achieve with the project and the ability to evaluate the impacts of the project within the community. Also, in developing a robust project design and its execution, the team must ensure that the design addresses the reasons why the project is being carried out. Keep in mind also that any community-based project like this must form the core of the needs and choices made by the community you are working with.

Note that project designs occur at the early phase of the project and are usually the beginning of every project cycle, where the entire team in charge of the project analyse the issue at hand, plan and implement strategies to address the issue with evaluation to monitor the progress and success of the project. This is to ensure that an effective approach is adopted to achieve the desired goals and objectives of the project. Conducting basic workshop sessions before the commencement of the project with all parties involved on project design and execution is critical to ensure that everyone is on board, understand the demands of the project and can give their best to the project.

International Labour Organization (ILO) 2010 reported that projects stand the risk of its quality being compromised when enough time is not dedicated to project design when it is to be executed. ILO 2010 further highlighted that project cycle management strategies in general assists in ensuring that projects are related to issues of the targeted community, must be feasible and the solutions provided by such projects are sustainable.

According to ILO 2010 and corroborated by Bartle (2007), project design phase of any project cycle consists of four stages as shown in figure ... which include; **project identification** (analysing the situation), **project formulation** (formulating your strategy and structure), **implementation planning** and **planning of monitoring and evaluation**.

#### 4.1.1.1. Project Identification

This *first stage* involves a participatory process which analyses the current condition and problems that are to be solved. Situation Analysis are usually used to identify projects of this type (ILO, 2010). Project identification is the most crucial step of the project cycle because it enables the organization of the project activities to address the specific needs of the stakeholders.



#### 4.1.1.2. Project Formulation

The *second stage* involves the formulation of the project which include the establishment of firm outcomes i.e. objectives and results to help achieve actions to be taken and resources needed to address the problems. Indicators to monitor each objective of the project should also be established for effectiveness.

#### 4.1.1.3. Implementation Planning

The *third stage* is the establishment of an implementation plan for the project in order to have a robust and result-oriented work plan and a budget.

#### 4.1.1.4. Planning of Monitoring and Evaluation

The *fourth stage*, which is the final stage involves the monitoring & evaluation of the project and must be planned and budgeted for before the start of the project. This stage helps to track what happened in the previous stages of the project design as well as compare what eventually happens at the end of the project to the main plan at the start of the project. According to ILO (2010), monitoring and evaluation consists of four key concepts which include; comparison, measurement, verification and action.

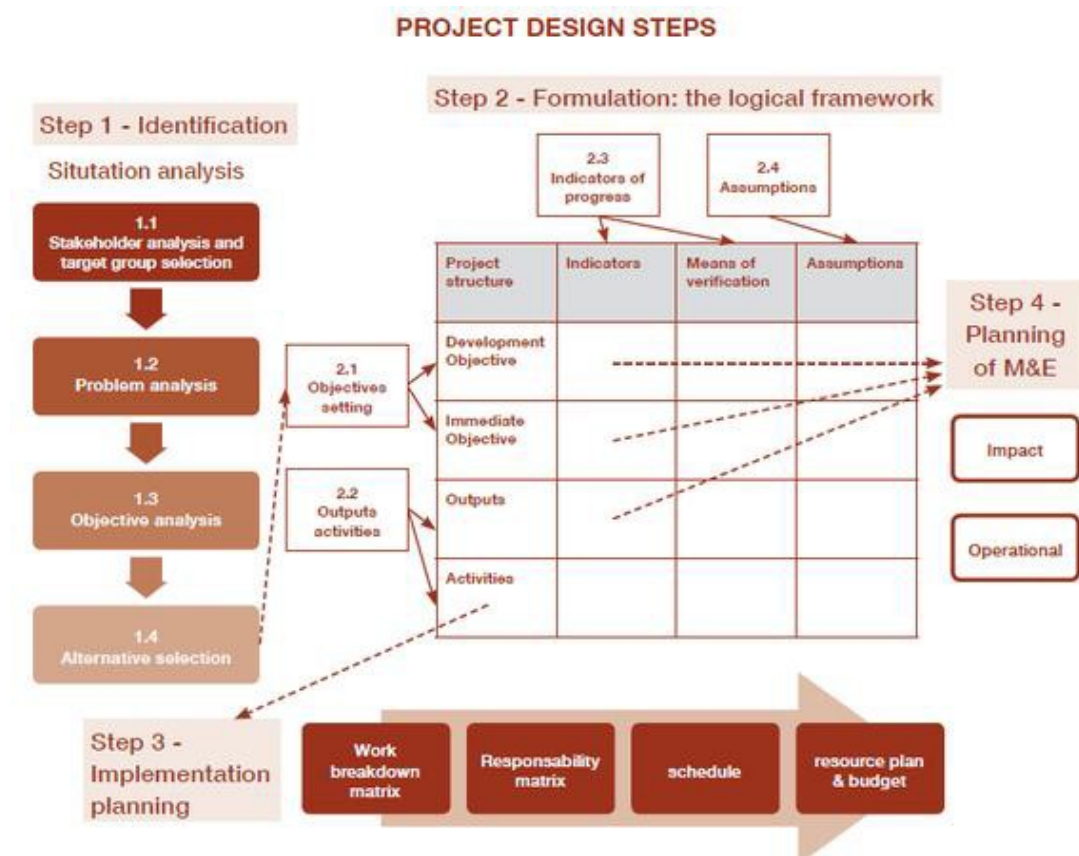


Figure 9-Project Design Steps

Source: International Labor Organization (ILO), 2010. For more detailed information on project design and project planning, see [Project Design Manual-Step by Step Tool](#), [Community Project Design- Guidelines for Leaders](#), [Project Design Template: A 9-Step Approach to Designing a Project](#).



#### 4.1.2. Skill Development

To achieve the goals and objectives of any project, there is the need for all team members to possess the required skills to tackle the problems the project is set to address. Having the required skills to execute projects will provide the opportunity to carry out project designs and plans with success and in good time. In putting together project team members, ensure to look out for the required skills needed and in the situation where the required skills are lacking, there should be planned workshops to address the required skill gaps. Such workshops should be targeted at addressing the core skills (either hard or soft skills) needed to achieve the goals of the project.

Skills can be divided into **hard** and **soft** skills;

- **Hard skills:** These are skills that are task-specific, teachable and can be quantified. They are usually technical in nature and are knowledge based. Example include proficiency in building designs, project management etc. Hard skills usually need the human's left brain which is the logic part of the brain (intelligence quotient- IQ). Hard skills are usually the same and are required by most projects regardless of the goals of such projects (Hard Skills Investopedia, 2017).
- **Soft skills:** These are skills that are personality-based and are not tangible and cannot be quantified. They are skills that describes people's association with others on a team and emphasizes who people are rather than what they know as in the case of hard skills. Example include teamwork, time management, leadership etc. Soft skills are typically developed at the right side or emotional center which are usually referred to as emotional intelligence quotient (EQ). Soft skills usually changes depending on the goals of the project and not teachable unlike hard skills (Soft Skills Investopedia, 2017).

Figure 10- Types of Skills



Source: Padhi, D. (2016). "Soft skills are hard and hard skills are soft"

## CHAPTER FIVE: BUILDING THE STRUCTURE

Structures such as schools, houses, hospitals, community centers etc. have been built with conventional building materials such as cement, iron rods etc. but sustainable innovations have emerged where waste and earth materials such as plastic bottles, glass bottles, straw bales are now being used to build houses and other basic community infrastructure (schools, hospitals etc.).

This manual is specifically focusing on using plastic bottle wastes to construct greenhouses, although they can also be used to build whatever structure especially houses, water storage tanks etc. as the case may be.

This chapter discusses basic steps to consider and follow when constructing greenhouses and other structures with plastic bottles.

### 5.1. Step One: Decide Type of Structure to be Built within the Community

#### 5.1.1. *Greenhouse*

Needs differ by communities and the need of each community determine the structure to be built. If a community is struggling with food security due to extreme weather conditions (i.e. excessive snow season), thereby limiting longer growing season and only encourages imports of food from neighboring communities, then there is need for such community to be innovative and provide lasting solutions to address such problems. Greenhouses built from plastic bottles can be an easy, cheaper way for the community to explore so that local farmers can grow more food within such community and reducing imports of food, thereby ensuring food security for community members.

#### 5.1.2. *Plastic Bottle House*

Most rural communities face housing problems among other basic amenities. Using plastic bottles to provide shelter and housing is a cheaper and easier way for communities to meet their housing needs. This will also help communities with limited or no waste management infrastructure to manage their wastes especially plastic wastes which litters most communities globally today and clean up their community and ensure healthy environment.

#### 5.1.3. *Water Storage Tank*

Global communities are experiencing water scarcity as well as struggling to get clean and safe drinking water. According to UNDP 2006, “about 1.2 billion people live in areas of physical scarcity, and 500 million people are approaching this situation. It further stated that “another 1.6 billion people face economic water shortage in countries where they lack the necessary infrastructure to take water from rivers and aquifers”. This trend is projected to continue in communities in the twenty-first century (FAO, 2007).

Based on all these facts with regards to water scarcity in communities, especially in developing and under-developed nations, there is an urgent need to develop

means of storing water and one of the cheapest and sustainable ways to do this can be by using plastic bottles to build a storage tank. Examples of such water storage tanks built with plastic bottles were the ones in Tegucigalpa, Honduras in 2009 by ECO-TEC Environmental Solutions where twelve plastic bottle water tanks with storage capacities ranging from 1,600 to 24,000 liters were built (ECO-TEC 2010).

**Figure 11- ECO-TEC Water Storage Tank in Tegucigalpa, Honduras**



*Source: ECO-TEC Environmental Solution, 2010*

#### *5.1.4. Schools*

Another potential structure that could be built with plastic bottles are schools, most especially in communities that have dilapidated or no educational infrastructure due to funds or other factors. Usually called “bottle schools” by a 501(c)(3) non-profit organization based in the USA called Hug It Forward, schools built with plastic bottles has provided an efficient solution to tackle the lack of educational infrastructure and cleaned tons of trash littering poor communities with no waste management facilities. Hug It Forward observed that bottle schools also boost environmental education, empower people to learn new skills, boost community leadership and help build resilient communities. Hug It Forward till date has built a total of 91 schools in 83 months and still counting.



Figure 12- A volunteer plastering a bottle school walls in Granados, Guatemala



Source: pbs.org

## 5.2. Step Two: Identify Location for Construction

Before commencing construction, one critical thing to consider is the location where the structure will be built. In considering the location, the following factors should be well-thought of;

### 5.2.1. Clear and Level Land

Regardless if it's a plastic bottle greenhouse or a bottle school, this process is important before commencement of the construction phase.

One thing that should also be considered before starting to build the plastic bottle greenhouse structure is to ensure that there are legal rights/permission to build on that land. If it is a community property, ensure that all stakeholders within the community supports the structure to be built on it to avoid litigation and rancor.

Once you have the permission or rights to build on the land, there is the need to prepare the land for construction activities by clearing all barriers such as vegetation, root stumps, rocks etc. that could impede construction with either hand tools or heavy machines such as tractors if there are access to them as well as making sure that the ground is levelled and does not have any form of gradient, suitable to build your structure on. This is important because it helps you to get a balanced structure and not a tilted one. Usually, most builders use what is known

as “dumpy level” or to ascertain how levelled a land is. A well levelled site will enable construction to be much more easier and help avoid any form of pressure on your structure.

#### *5.2.2. Determine Soil Texture and Composition*

Another factor to consider when planning on constructing a plastic bottle greenhouse is to determine the composition and texture of the soil upon which you will be building the structure. Soil texture and composition differs by location, hence, the need to determine the suitability of the soil for the structure. According to Anderson et al (1990), soil texture can usually be determined by the quantities of various inorganic particle sizes present (sand, silt, clay) and it is a very vital physical property the soil on your land must possess to be suitable for use.

#### *5.2.3. Solar Path*

With a plastic bottle greenhouse structure in mind, your main goal will be to locate and situate your structure in the path where there is enough sunlight (usually south-end of your location, although some prefer the east-end). Depending on what you want to use the greenhouse for in terms of whether it is for growing seedlings, growing to maturity and growing all season, there is the need to ensure that the greenhouse gets at least a minimum of 6 hours a day of direct sun (Greenhouse Basics). Greenhouse Basics highlighted that the sun is usually much lower in the sky during winter than in summer and a location that has full sun access during summer may have quite a bit of shade in winter because of long shadows from nearby structures and potential trees. In addition, it stressed that the entrance of the greenhouse should be much more away from potential prevailing winds in order reduce heat loss because of cold air that may enter each time the door to the greenhouse is opened.

Because greenhouse generally needs enough heat to form that “greenhouse effect” the plants need to grow, there is the need to regulate the heat inside by creating one or two vents in the greenhouse to balance the heat exchange.

#### *5.2.4. Flood/Erosion Plains*

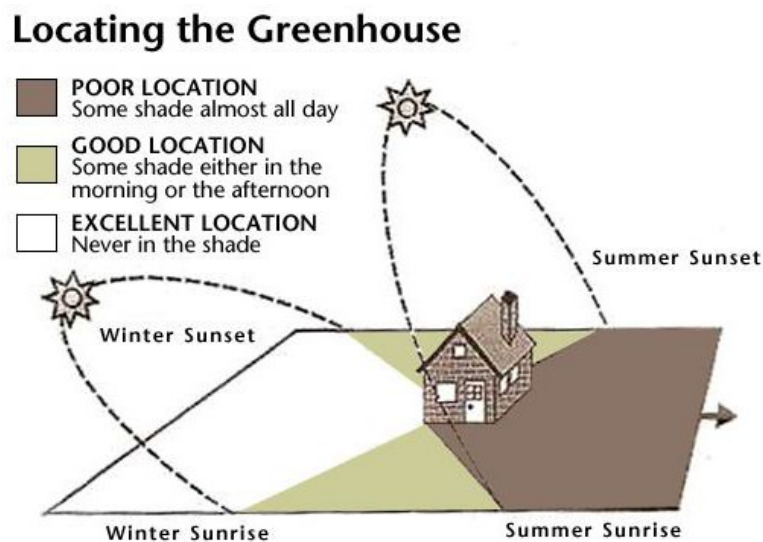
Watch out for flood plains because you don’t want to have your greenhouse structure on a location or spot that is prone to flood. That will ruin the hard work you had put into the construction. Ensure to know and understand the history of the land with respect to the pattern and frequency of flood or erosion to gain the sense of where to position the greenhouse.

#### *5.2.5. Orientation of Building*

One critical thing you want to get right with your greenhouse is its orientation. This determines how your greenhouse faces the direction of the sun. Depending on where you live, situating your greenhouse in the direction of the sun is key and important to make the best out of the greenhouse for your plants. If you live

in the Northern hemisphere (US, Canada, Europe, Middle East, Saharan Africa) you must ensure that you orientate your greenhouse, facing east of south to the sun to adequately take advantage of the early morning sun coming from the east to get heat into the building earlier in the day and if you live in the Southern hemisphere (Antarctica, Australia, South America and some southern islands of Asia), the complete reverse is the case. (Warmke, 2008).

Figure 13- Showing How Best to Locate a Greenhouse



Source: [www.marijuana.com](http://www.marijuana.com)

#### 5.2.6. Local Weather Conditions

Again, depending on where you are located around the world, the dynamics of the weather conditions i.e. wind, visibility, temperature etc. must be clearly understood to be able to build an effective and functional greenhouse. In selecting the location for the greenhouse, it is important to keep in mind that weather could be erratic and are often harsh, so there is need to factor that in when you are selecting your location for your greenhouse. In the case of wind, ensure that your greenhouse structure is strong enough to withstand it by firmly securing it from collapse. Windbreaks could be used if possible to reduce the intensity of the wind as well, depending on the condition.

### 5.3. Step Three: Identify Materials

#### 5.3.1. Waste Materials e.g. plastic bottles, tires, straw bales etc.

Waste materials are being generated every day and they end up in the landfill if not properly managed. There have been unique ways waste materials such as tires, plastic bottles, straw bales are re-used to build structures such as homes, water storage tanks, bike sheds, greenhouses etc. Depending on the structure, there is the need to identify which waste material to use for its construction. For this manual, the focus is plastic bottles and as mentioned earlier in the manual, they are readily available and due to their good insulating properties, there are good building materials for greenhouse, especially in cold climate.

### *5.3.2. Other Materials*

To successfully construct a plastic bottle greenhouse, essential materials needed include the following: lumbers for the framing (quantity depends on the dimensions of the structure), clear Palruf Fiber sheets for roofing, working tools like hack saws, circular saws, drilling machines, drilling bits, sledge hammers, 3" dry wall screws, extension cables, saw horses, tape measure (30'), square, level, wire cable strings etc. Personal protective equipment (PPEs) such as hand gloves, eye goggles are highly recommended during construction for safety reasons.

## **5.4. Step Four: Identify Construction Process**

### *5.4.1. Determine Structure Design and Dimensions*

Decisions on the dimension and design of the structure should be made based on the purpose of the structure. Since, we are talking about a greenhouse, ensure that it has enough space to grow enough food as much as possible. Another thing to think to consider is to determine if it is going to have a foundation (concrete or earthen material) which should be factored into the structure design and material procurement. Structure designs and dimensioning should be done by a seasoned and experienced architect/structural engineer and not just anyone because of the technicalities associated with the building of a plastic bottle greenhouse.

### *5.4.2. Determine Type and Amount of Plastic Bottles Needed*

Building sustainable structures from waste materials (plastic bottles) will increase waste diversion from our landfills and protect the environment. To effectively do this, there is the need to calculate the amount and type of waste materials needed for such structures based on the intended dimensions, hence, materials saved or diverted from landfill.

Once the design and dimensions of the greenhouse have been completed, the type and quantities of plastic bottles needed to build the structure should be determined. Usually, I will recommend a 2-liter clear bottles but any size could be used depending on what is available within the community but ensure that the bottles are well-rounded with no gaps to prevent air from passing through. The quantity of plastic bottles needed depends on the dimension of your proposed structure. For me, I built a 10'x12'x8' plastic bottle greenhouse and collected close to **1500** 2-liter plastic bottles. From experience, you need a lot of helping hands to assist with the bottle collection because it could be very stressful.

To estimate the number of bottles needed to be collected after you determine the dimension of your structure, the first thing is to measure the diameter of the bottle to be used and divide that by both the length (100 inches) and height (96 inches) and multiple. Repeat the same for both the breadth (144 inches) and height (96 inches) and



multiple. Sum up what you get and multiply by two for both sides of the structure to get the total number of bottles you need to collect. If you need to add a door to the greenhouse, then the number of bottles will be less the dimension of the door.

#### *5.4.3. Conduct Plastic Bottle Collections/Gathering/Washing*

To be candid, this is one of the most daunting task and it requires lots of hands to collect and wash the bottles. If you will be building a 10' by 12' structure, you are talking about over 1,000 plastic bottles that needs to be collected and washed, before the construction starts. To easily collect the huge number of bottles needed for your project, it is important to reach out to volunteers within the community (community groups, school children, churches, religious groups etc.). This is a unique way to teach little children and other groups on the dangers of plastic bottles in the landfills for their future.

Apart from collection, the bottles need to be washed and labels removed. Note that some labels come off easily and others don't which could be soaked in soapy water to ease removal. Again, more hands are needed here as well, and you will want to leverage on community members for help.

#### *5.4.4. Determine if Structure Needs Permits or Not*

Depending on location and local building authorities, permits processes varies. Permits are a "type of authorization that must be granted by a government or other regulatory body before the construction of a new or existing building can legally occur" (Investopedia, 2017). Before you start construction at all, ensure to check with your local building authorities to ascertain if your structure needs a permit or not. In some communities around the world, a structure like a greenhouse need no permits but **please**, do not assume or you may regret this later. When in doubt- ASK.

#### *5.4.5. Foundations*

Foundations are key to the strength and durability of your structure because it helps bear the load of your structure. In making foundations, it is necessary to consider the type and properties of the soil on which the structure will be built. The design of the structure also determines the load-bearing capabilities that your foundation must have to consider it strong enough to withstand the pressure.

The foundation of the plastic bottle greenhouse we built was constructed on wooden skids (for mobility), because we live in cold climate with huge amount of snow and that was the best way to overcome the barrier. If this structure is to be built in areas where there is no snow, then holes of up to 3 feet (1 meter) should to dug to erect the frames for the structure. Depending on the purpose of the greenhouse (pre-season or all-year round), the floor of the greenhouse could be concrete, wooden slabs or just bare ground. You should decide what is suitable for your condition in this case.

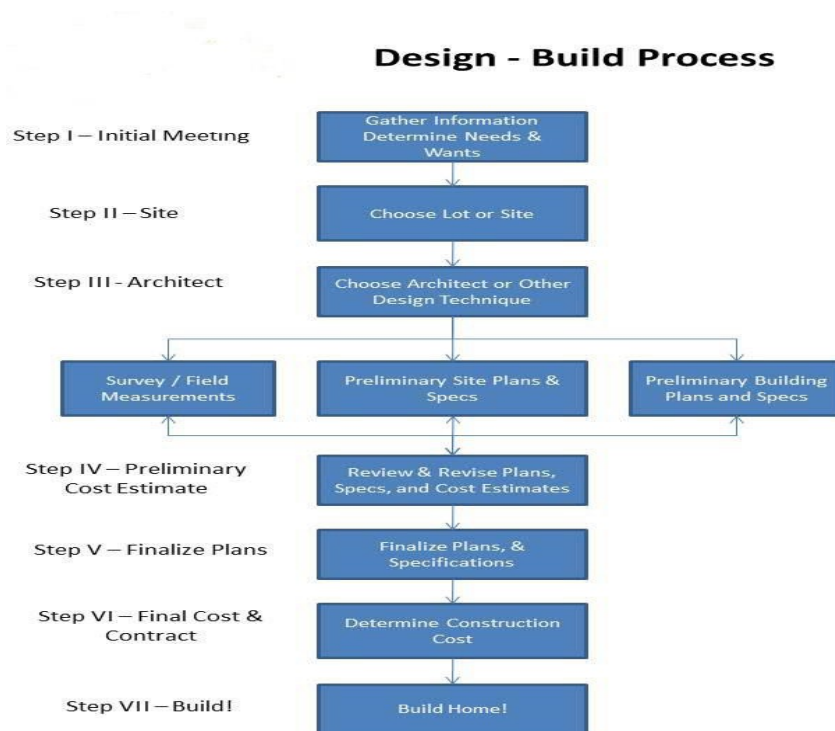
#### 5.4.6. Outline your Structure's Bill of Material (BoM)

Wikipedia defined Bill of Materials (BoM) as “a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture a product”. Before the start of any construction, it is very important to outline and document the structure's bill of materials to ensure that all materials needed for the construction of your structure are readily available.

#### 5.4.7. Develop a *Building Construction Plan Certified by Architects and Structural Engineers*.

Ensure to have a clear and detailed step by step building construction plan before the commencement of your construction which must be approved by both qualified architects and structural engineers on your team.

A typical building construction processes is shown in Figure 14 below;



**Figure 14- Building Construction Processes**

Source- Homoly Construction

#### 5.4.8. Conduct a Budget/Market Analysis

This is an important aspect that should not be ignored. Conducting a market analysis even before the construction of the structure is critical, because it helps to determine if it is economically or operationally feasible to build that type of structure in the first place. Estimate how much all construction materials for the structure will cost, are there technical experts (architects, structural engineers, qualified masons etc.) readily available to help with the construction? and if so, what is the cost of their services?

Based on all these factors, determine if the available budget or funds can cover it before you even start the project at all. You don't want to start a project and mid-way, gets stranded due to some of the factors highlighted above.

#### *5.4.9. Conduct a Comprehensive Cost-Benefit Analysis*

To ascertain the sustainability of the structure you are planning to build, it is vital to first determine the costs and benefits associated with it before going ahead with the construction.

The cost might include how much it will take to complete your structure in terms of land acquisition (if not donated), material procurement, tools, human resources and other logistics etc. associated with the structure. In the analysis, ensure that you document every cost (environmental, social and economic) that might be envisaged to occur before, during and after construction.

The benefits might vary, depending on the type of structure and the problems it will address in the community. Ensure also to document all benefits that will be derived from building the structure based on the community's needs which might include a greenhouse, water storage tanks etc. in the analysis as well and if possible, include all environmental, social and economic benefits that could be derived from the construction of the structure.

With the analysis of both costs and benefits associated with the construction documented, determine if the construction of such structure is viable to embark upon or not. If the costs outweigh the benefits, then discontinue and if otherwise, move on with the construction. Keep in mind that most costs associated with your construction could be paid for through solicited donations (kind, time and cash) by community members.

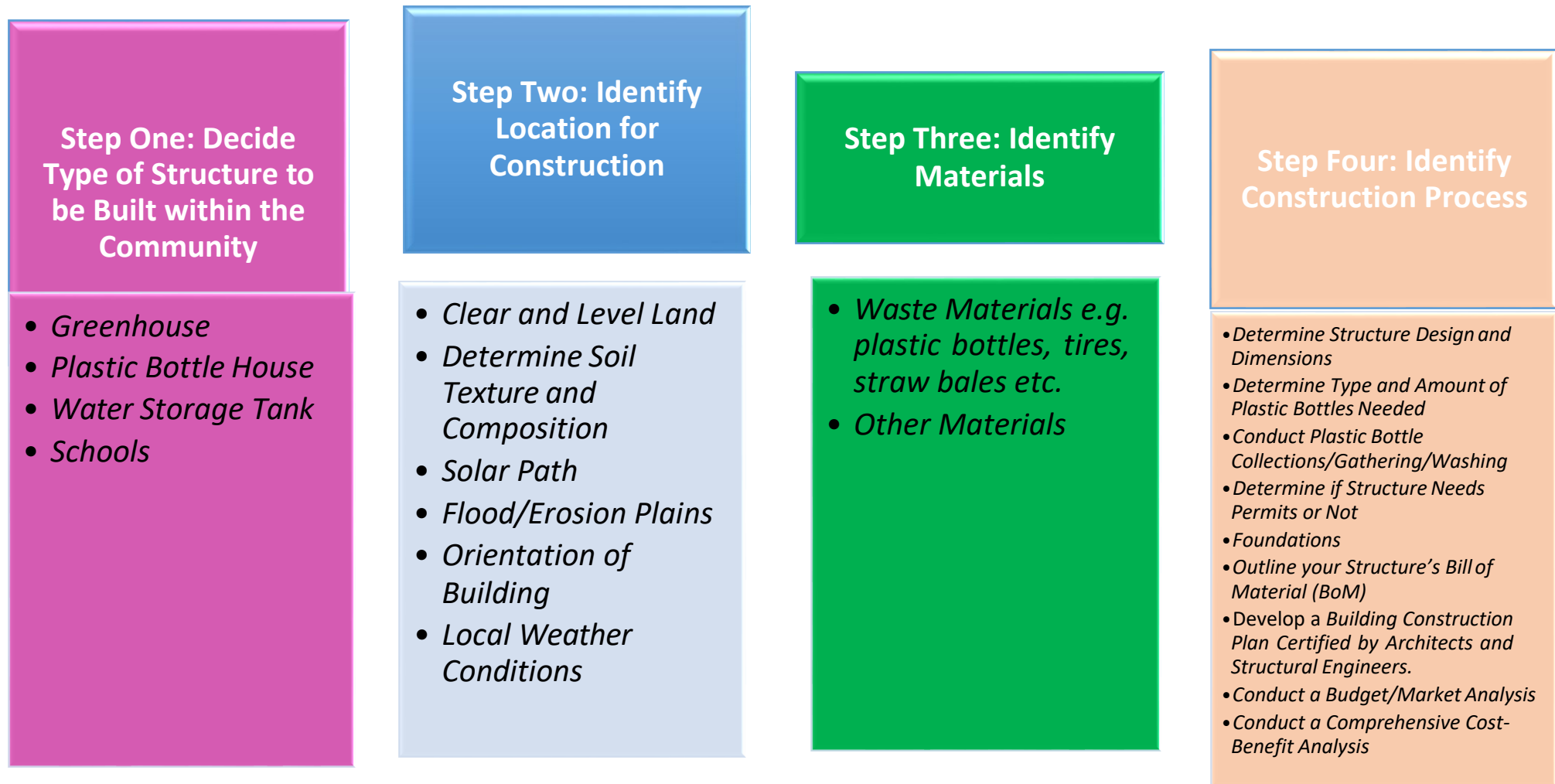


Figure 15- Basic Steps to Consider when Constructing Greenhouses and other Structures with Plastic Bottles

### Box 3- Construction of a Plastic Bottle Greenhouse in Gunnison, Colorado

The construction of the first-ever plastic bottle greenhouse in Gunnison was carried out based on the needs of the community. Gunnison is usually cold for most part of the year with a lot of snow which limits the growing season for local farmers. This idea is basically showing the possibilities of reusing plastic bottle wastes for a higher product. The greenhouse was built on skids on Coldharbour ranch, to serve as demonstration structure to educate the community in promoting reusing plastic bottle waste as well as encouraging local farmers to adopt the innovation to grow more food within the valley. We used a 2-liter clear bottles but any size could be used depending on what is available within the community but ensure that the bottles are well-rounded with no gaps to prevent air from passing through. For us, we built a 10'x12'x8' plastic bottle greenhouse and collected close to **1100** 2-liter plastic bottles. Other materials used for the construction include: 4 (4"x4"x12') lumber posts, 12 (2"x6"x8'), 8(2"x6"x10'), 6(2"x6"x12'), 4(2"x4"x12') wood lumbers, 26" x 12' Clear Palruf Fiber sheets for roofing. The construction tools used include- hack saws, circular saws, drilling machines, drilling bits, sledge hammers, 3" dry wall screws, hand gloves, extension cables, saw horses, tape measure (30'), square, level, wire cable strings.

The plastic bottle greenhouse is being used by Calder Farms (local farmers) and are utilizing it for growing food during the upcoming growing season to test-run its effectiveness.



**South wall of the Plastic Bottle Greenhouse**

## References

- American Society of Civil Engineers (ASCE) (2013). Infrastructure Report Card: Colorado's Infrastructure . Retrieved from <http://www.infrastructurereportcard.org/state-item/colorado/>
- Anderson, J. L., & Halsey, C. F. (1990). Evaluating Soil Texture for a House Site: Housing and Technology : Environment : University of Minnesota Extension. Retrieved April 5, 2017, From <http://www.extension.umn.edu/environment/housing-technology/moisture-management/evaluating-soil-texture-for-a-house-site/index.html#soil>
- Arnold, E., and Janet L. "Bottled Water: Pouring Resources Down the Drain." Earth Policy Institute. 2 Feb. 2006. 28 June 2007.
- Bartle, P. (2007). Community Project Design; Guidelines for Leaders. Retrieved March 10, 2017, from <http://cec.vcn.bc.ca/cmp/modules/pd-pd.htm>
- Boulder County Sustainability (BCS) 2016- Waste. (n.d.). Retrieved September 4, 2016, from <http://bouldercountysustainability.org/waste/>
- BCRCD (2010). Boulder County Resource Conservation Division Waste Composition Study. Boulder County. Retrieved from <http://www.bouldercounty.org/doc/rc/boulder.final.wcs2010.pdf>
- British Plastics Federation 2008. Oil consumption. [http://www.bpf.co.uk/Oil\\_Consumption.aspx](http://www.bpf.co.uk/Oil_Consumption.aspx) (20 October 2008)
- Boulder County Sustainability- Waste (2016). Retrieved September 4, 2016, from <http://bouldercountysustainability.org/waste/>
- Catherine C. (2016): Water Bottle Pollution | National Geographic Kids. (n.d.). Retrieved December 5, 2016, from <http://kids.nationalgeographic.com/kids/stories/spacescience/water-bottle-pollution/>
- CDPHE. (2014). Solid Waste User Fee and Volume Report. Colorado Department of Public Health and Environment. Retrieved from [https://www.colorado.gov/pacific/sites/default/files/HM\\_sw-2014-user-fee-volume.pdf](https://www.colorado.gov/pacific/sites/default/files/HM_sw-2014-user-fee-volume.pdf)
- Centers for Disease Control and Prevention (CDC) *Principles of Community Engagement* (1st ed ) Atlanta (GA): CDC/ATSDR Committee on Community Engagement; 1997
- Chavez, A. (2017). Gunnison County Energy, Materials, and Greenhouse Gas Emissions Inventory: 2015 Baseline & 2030 Forecast
- Coping with Water Scarcity. Challenge of the Twenty-first Century. UN-Water, FAO, 2007
- Danny K, Kate B. (2016)- Recycling A Missed Opportunity to Make Denver More Sustainable. [http://copirg.org/sites/pirg/files/reports/Denver-Report-2016\\_Eco-Cycle\\_print-web.pdf](http://copirg.org/sites/pirg/files/reports/Denver-Report-2016_Eco-Cycle_print-web.pdf)



- Douse, A. (2014). How to Build a Greenhouse Made From Plastic Bottles | Dengarden. Retrieved May 22, 2016, from <http://hubpages.com/living/plasticbottlegreenhouse>
- Eco-Cycle, 2016. Front Range Recycling Rates. Accessed at <http://www.ecocycle.org/take-action/Denver>
- Eco-Tec (2010): Construction with Plastic Bottles and Debris. Retrieved May 20, 2016, from [www.eco-tecnologia.com](http://www.eco-tecnologia.com)
- Eco-Tec Haiti English 2010. (n.d.). Retrieved May 19, 2016, from <https://www.scribd.com/doc/27891288/Ecotec-Haiti-English>
- Environmental Protection Agency. (n.d.). U.S. Municipal Solid Waste Generation from 1960 to 2014 (in million tons). In Statista - The Statistics Portal. Retrieved December 2, 2016, from <https://www.statista.com/statistics/186256/us-municipal-solid-waste-generation-since-1960/>.
- EPA Waste Reduction Model (WARM) to Estimate Streamlined Life-Cycle GHG Emission Factors for Various Plastics. Retrieved September 4, 2016, from <https://www.epa.gov/climatechange/what-you-can-do-about-climate-change>
- Fishman, Charles. "Message in a Bottle." Fast Company Magazine July 2007: 110.
- The Footprint of Plastics (2014). Retrieved September 4, 2016, from <http://www.how-green-is.co.uk/article.asp?Uname=1038>
- Global production of plastics 2013 | Statistics. (n.d.). Retrieved December 12, 2015, from <http://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/>
- Greenhouse Basics: Part 3-Selecting The Best Location For Your Greenhouse - Garden.com. (n.d.). Retrieved April 6, 2017, from <https://www.garden.com/garden-articles/greenhouse-basics-part-3-selecting-the-best-location-for-your-greenhouse/69/>
- Moorabool Shire Council Community Engagement Framework, 2013.
- Municipal Solid Waste (MSW) Fact Sheet 2012 | US EPA Archive Document-2012\_msw\_fs.pdf [https://archive.epa.gov/epawaste/nonhaz/municipal/web/pdf/2012\\_msw\\_fs.pdf](https://archive.epa.gov/epawaste/nonhaz/municipal/web/pdf/2012_msw_fs.pdf)
- Hard Skills Definition | Investopedia. (n.d.). Retrieved March 13, 2017, from <http://www.investopedia.com/terms/h/hard-skills.asp>
- Hoornweg, D., Bhada-Tata P. 2012. What a Waste: A Global Review of Solid Waste Management. March 2012, No. 15. Urban Development Series Knowledge Papers. [http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/What a Waste2012 Final.pdf](http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/What_a_Waste2012_Final.pdf)
- Hoornweg, D., P. Lam, M. Chaudhry. 2005. Waste Management in China: Issues and Recommendations. Urban Development Working Papers No. 9. East Asia Infrastructure Department. World Bank.



- Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics Recycling: Challenges and Opportunities. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1526), 2115–2126. <https://doi.org/10.1098/rstb.2008.0311>
- Hug It Forward | Bottle Schools. (n.d.). Retrieved May 22, 2016, from <http://hugitforward.org/>
- International Public Participation (IAP2) Spectrum
- International Labor Organization, Cooperative Branch, & ILO Country Office for the United Republic of Tanzania, K., Rwanda and Uganda. (2010). *Project design manual: a step-by-step tool to support the development of cooperatives and other forms of self-help organization*. Geneva: ILO. Retrieved from <http://www.ilo.org/public/libdoc/ilo/2010/468723.pdf>
- Investopedia (2017)- Building Permits. Retrieved April 17, 2017, from <http://www.investopedia.com/terms/b/building-permits.asp>
- Maton KI. (2008). Empowering Community Settings: Agents of Individual Development, Community Betterment, and Positive Social Change. *American Journal of Community Psychology* 2008;41(1):4-21
- Padhi, D. (2016, January 27). "Soft skills are hard and hard skills are soft"! That is my view; what is yours? Retrieved March 13, 2017, from <https://www.linkedin.com/pulse/soft-skills-hard-my-view-what-yours-damodar-padhi>
- PAHO. 2005. Report on the Regional Evaluation of Municipal Solid Waste Management Services in Latin America and the Caribbean. Pan American Health Organization. Available at: [http://www.cepis.ops-oms.org/residuos-solidos/evaluacion/i/index.html#Scene\\_1](http://www.cepis.ops-oms.org/residuos-solidos/evaluacion/i/index.html#Scene_1)
- Plastic Water Bottles Impose Health and Environmental Risks | Ban the Bottle. (n.d.). Retrieved from <https://www.banthebottle.net/articles/plastic-water-bottles-impose-health-and-environmental-risks/>
- Raynaud, J., Richens, J., Russell, A., United Nations Environment Programme, Plastic Disclosure Project, & Trucost (Firm). (2014). *Valuing plastic: the business case for measuring, managing and disclosing plastic use in the consumer goods industry*.
- Saxena, S., & Singh, M. (2013). Eco-Architecture: Pet Bottle Houses. *International Journal of Scientific Engineering and Technology Volume*, 2(12), 1243–1246.
- Science for Environment Policy | In-depth Reports | Plastic Waste: Ecological and Human Health Impacts November 2011
- Soft Skills Definition | Investopedia. (n.d.). Retrieved March 13, 2017, from <http://www.investopedia.com/terms/h/soft-skills.asp>

Solid Waste | 2013 Report Card for America's Infrastructure. (n.d.). Retrieved December 4, 2016, from <http://www.infrastructurereportcard.org/colorado/solid-waste/>

Themelis, N. J., Castaldi, M. J., Bhatti, J., & Arsova, L. (2011). Energy and economic value of non-recycled plastics (NRP) and municipal solid wastes (MSW) that are currently landfilled in the fifty states. *New York, NY: Columbia University*. Retrieved from <http://plastics.americanchemistry.com/Education-Resources/Publications/Report-from-Columbia-Universitys-Earth-Engineering-Center.pdf>

UNDP (2006). *Beyond Scarcity: Power, Poverty and the Global Water Crisis*. New York, NY: UNDP. <http://hdr.undp.org/sites/default/files/reports/267/hdr06-complete.pdf>

US EPA, O. (2014). Overview of Greenhouse Gases [Overviews and Factsheets]. Retrieved March 14, 2017, from <https://www.epa.gov/ghgemissions/overview-greenhouse-gases>

Warmke J. (2008): Building a Plastic Bottle Greenhouse: Blue Rock Station Style  
[www.bluerockstation.com](http://www.bluerockstation.com)

Water Bottle Pollution -- National Geographic Kids. (n.d.). Retrieved December 5, 2016, from <http://kids.nationalgeographic.com/kids/stories/spacescience/water-bottle-pollution/>

Wikipedia. [https://en.wikipedia.org/wiki/Bill\\_of\\_materials](https://en.wikipedia.org/wiki/Bill_of_materials)

World Bank Country and Lending Groups – World Bank Data Help Desk. (n.d.). Retrieved December 1, 2016, from <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519>