Rainwater harvesting: the possibilities of an integrated network in urban communities based on people's perceptions, attitudes, and neighborly efforts

by

Shaedon Wedel

A REPORT

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Department of Landscape Architecture and Regional & Community Planning
College of Architecture, Planning and Design

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Approved by:

Major Professor
Dr. Sara Hadavi

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Abstract

Climate change consequences such as drought and flooding and how they affect urban neighborhoods have been pressing issues over the past few decades. Due to historically marginalized communities' lack of resources, there has been concern for how these climate event factors play into the demand for water (Haque et al., 2016). Rainwater harvesting – collecting rainwater runoff from a catchment source and using it for the benefit of humans - is a method to address this issue. (Sivanappan, 2006; Hillel, 2005; Geetha, 2022 p. 102). While rainwater harvesting has been explored, less attention has been paid to the functional use of the water, and the attitudes and perceptions of the users of the systems. This is important due to the lack of water resources available to low-income neighborhoods and how rainwater can be utilized to mitigate water insecurity (Bathke, 2022).

The aim of this study is to explore how the use of collected rainwater and attitudes and perceptions of the users can help with increased implementations of integrated rainwater harvesting systems. This study considers eight neighborhoods of Eastside Kansas City, Missouri as a case to examine how a variety of land-use types in low-income neighborhoods respond to various functional uses of collected rainwater and their attitudes and perceptions of such systems. Observation, mapping, and semi-structured interviews were used to collect data from residents through random sampling of three land-use categories supported by the observation and mapping: 1) Cultural and Educational Institutes, 2) Industrial, Restaurant and Retail, and 3) Residential and Living Centers. Semi-structured interviews were performed with fifteen participants in the study area. The data analysis showed there is an overall concern of local drought and flooding across all categories, with no immediate concerns of water availability. It also showed that approximately one-third of participants had no knowledge about rainwater

harvesting. After learning about the values of rainwater harvesting such as reduced water cost and variety of uses of collected rainwater, participants showed willingness to work with their community to create a set of integrated rainwater harvesting systems within the neighborhoods. . These findings offer insight into how rainwater harvesting systems can be an asset to businesses and residents. It also contributes to the existing body of literature by presenting preferred uses of rainwater collected and the users' attitudes and perceptions towards such systems. Another outcome of this study is a set of recommendations and guidelines on how to approach implementing a series of micro-cores of water collection to support the broader integrated network of rainwater harvesting systems in various land-use categories.

RAINWATER HARVESTING

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Keywords: Rainwater Harvesting, Drought and Flooding, Climate Change, Preferences, Attitudes, Micro-Cores, Integrated Networks

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CHAPTER 1

OPENING

INTRODUCTION & BACKGROUND

Due to the emission of greenhouse gases, there is a steady increase in global atmospheric temperature (Punia et al., 2022, p. 46). This will cause extreme climate events such as drought and increased flood frequency and will leave an impact on the human population, especially in urban areas (Narayan et al., 2003, p. 46). Urban areas will be substantially affected by the drought (Haque et al., 2016). Particularly in urban areas, droughts will amplify issues of water supply availability and affordability, which is an increasing problem across the globe due to climate change, population growth, rapid urbanization, and industrial development (Haque et al., 2016). It is expected by 2030, approximately 5 billion people, or 60%, of the Earth's population will be living within cities, a 2.1 billion increase from the year 2000 (Guneralp et al., 2015, p. 217). Consequences are already affecting urban dwellers, there are currently millions of people in cities across the world that are victims of water shortages, both seasonally and perennially (Punia et al., 2022, p. 46).

RESEARCH FOCUS

One drought or flood mitigation strategy is rainwater harvesting; rainwater harvesting systems collect and store rainwater and runoff from rooftops and other impervious areas for potable and non-potable water use (Alamdari et al., 2018, p. 179). Current research focuses on traditional harvesting systems and does not address the functional or visual preferences within neighborhoods. As urban residents begin to experience the lack of available and affordable water, landscape architects can encourage rainwater harvesting for capture and later use through identifying people's needs and preferences and applying them in the planning and design process.

THE STUDY

This study considers eight neighborhoods in Eastside Kansas City as a case to explore the potential for utilization of rainwater harvesting systems based on people's preferences for functional use of the collected water and their attitudes and perceptions of such systems. This study will focus on the following concepts: to learn more about the possibilities of developing a community-driven, integrated rainwater harvesting system within neighborhoods, as well as how these integrated rainwater harvesting systems can be applied to specific land uses. Semi-structured interviews have been conducted to explore the residents' awareness of rainwater harvesting systems, and their willingness to be engaged in either individual or community-based activities related to water harvesting systems. The expected outcome of this research is intended to be a guide for professionals such as landscape architects, planners, architects, artists, contractors, as well as neighborhood associations and residents. It is expected to serve as an evidence-based guide for integrated rainwater harvesting systems in Kansas City – for the potential to be adopted by other cities – and present the opportunity for rainwater harvesting systems to low-income families and mitigate costly water consumption.

RESEARCH QUESTION

To learn more about functional use of collected rainwater and attitudes and perceptions of rainwater harvesting systems, this study aims to explore the following question:

> *How can integrated rainwater harvesting systems be utilized in residential areas based on residents' functional use of the water and their attitudes and perceptions of the systems?*

Figure 1.1 shows the research process diagram, and how five major steps guided this research project.

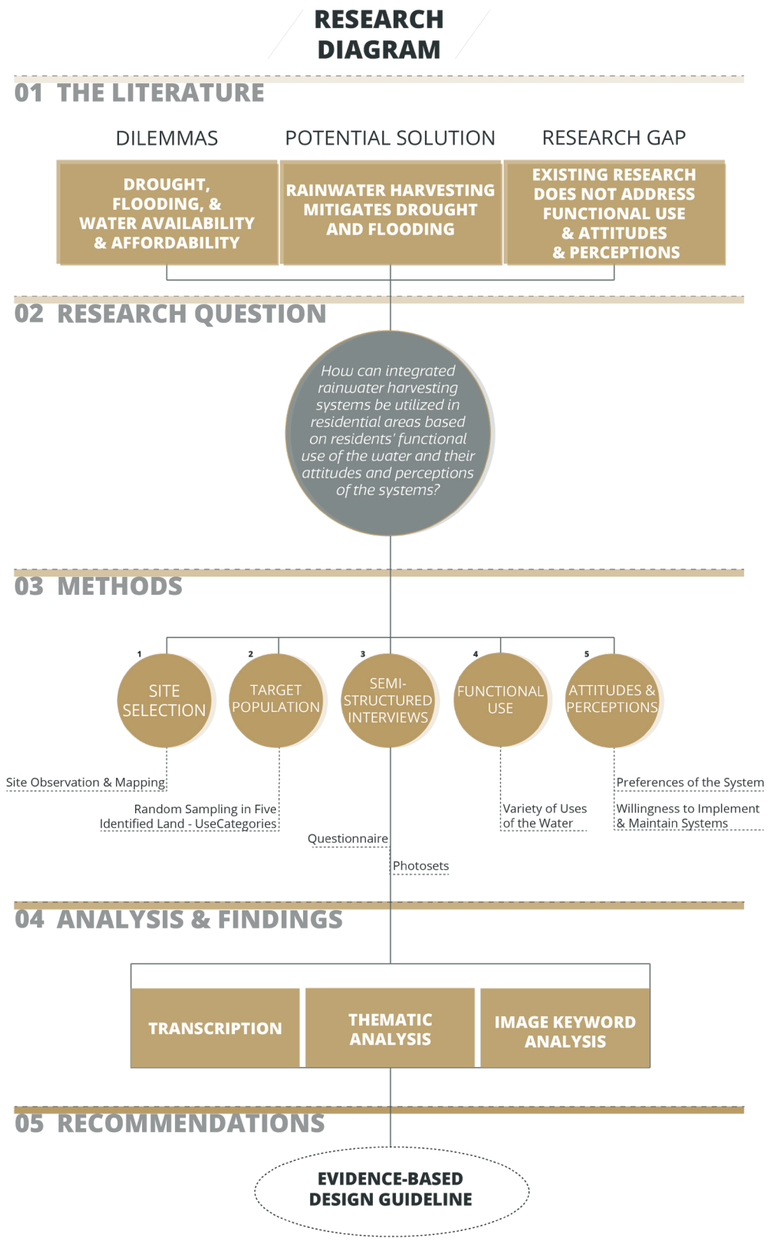

Figure 1.1 The research process.

"I see a lot of value in rainwater collecting. Because it actually puts it to get to good use instead of wasting the water."

– Community Member

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CHAPTER 2

INFORM

LITERATURE REVIEW

By the year 2050, over 52% of the human population will be victims of severe water shortages (Haque et al., 2014; IFPRI, 2012; Wang et al., 2015). Water demand will also increase by 55%, resulting in less water availability for human use and consumption (Haque et al., 2014; IFPRI, 2012; Wang et al., 2015). The increase in climate change-related extreme storms and drought events coupled with an increase in population in urban areas will threaten ecosystems and water services due to increased water insecurity (Barron, 2009, p. 1). The increasing demand for water resources highlights the need for rainwater harvesting as an important method to reduce water insecurity (Barron, 2009, p. 1). This literature review will be addressing three topics: 1) defining the dilemma of water availability for urban residents due to anthropogenic climate change consequences observed since the late 20th century (Diffenbaugh et al., 2008, p. 1; Haque et al., 2016; IPCC, 2007); 2) exploring the history, benefits, and current typologies of rainwater harvesting systems (Geetha, 2022, p. 103); and 3) defining the gap in the existing literature on the functional use of captured rainwater and the attitudes and perceptions of the rainwater harvesting systems by low-income neighborhoods most affected by climate change. The review will look at how the rainwater harvesting systems can be used as a community asset to address the issue of water availability and affordability.

ANTHROPOGENIC CLIMATE CHANGE AND WATER AVAILABILITY

What is Climate Change?

The increase in extreme weather events is a manifestation of climate change (Macpherson, 2014, p. 288). The term weather is referred to as short-term atmospheric changes, whereas climate refers to the long-term variations recorded for a specific region and period – typically over the span of 30 years (Armstrong et al., 2018, p. 7). Therefore, climate change is the result of atmospheric changes and weather studied in a specific area over the span of a specified duration of time. As Armstrong et al., (2018) explains, the increase of a city's average daily temperature over decades provides evidence of climate change. It is important to address climate change due to the severity of consequences. Examples of climate change consequences include severe periods of drought, severe precipitation and flooding, and overall extreme weather (Armstrong et al., 2018, p. 7-8). Because of these consequences, climate change is one of the top risks globally to water availability and affordability (Macpherson, 2014, p. 289).

Climate change is caused by several factors. Greenhouse gases, such as carbon dioxide (CO2), are emitted into the earth's atmosphere when fossil fuels such as coal, natural gas, and oil are burned. Industrial waste, deforestation, expansion of urban areas, the burning of wood, decomposition of waste, and manufacturing cement are all human activities that contribute to greenhouse gas emissions (Armstrong et al., 2018, p. 9; Punia et al., 2022, p. 47). The released gases have caused a major increase in atmospheric temperature (Punia et al., 2022, p. 46).

Supported by long-term observation, experiments, climate modeling, and measurements, scientists and researchers have found that the increases of emitted greenhouse gases by humans are the primary influence on climate change (Armstrong et al., 2018, p. 12). Extreme temperature changes, changing precipitation patterns, sea level rise, and extreme weather all contribute to the evidence suggesting that humans are the leading cause of climate change (Narayan et al., 2003).

Drought and Water Availability

Consequences of climate change can cause immense pressure on the safety, health, and well-being of humans (Armstrong et al., 2018, p. 15). One of the major consequences of climate change is drought – and by extension – water availability. The droughts recorded in the United States are currently the worst in over 800-years (Strzepek et al., 2010, p. 2). To understand the drought consequences, one must understand drought. While drought is defined in several ways, each relates to an affected water supply due to extreme heat events that stress hydrological cycles, resulting in decreased rainfall and decreased soil moisture (Strzepek et al., 2010, p. 2; Triyono et al., 2021, p. 2). Another

contributor to drought is the amount of wind, which can evaporate soil moisture (Hao et al., 2018, p. 108; Mullan et al., 2005). According to Bathke (2022), a drought can also be defined as precipitation deficiency over a period, typically a season, resulting in water shortages. It was measured that approximately 79 global cities have been directly affected by drought within the first 20-years of the 21st century (Zhang et al., 2019, p. 1). Studies have also shown that droughts have been increasing in severity over decades. In the year 2012, the peak drought season revealed 81% of the United States was in abnormally dry conditions (Bathke, 2022). This reveals the severity of urban drought caused by climate change, thus putting intense strain on cities' water systems (Zhang et al., 2019, p.1).

Due to the increased drought conditions, this has begun to pose serious threats to people regarding supply and water cost. Droughts are primarily defined by the lack of water which results in people having limited access for recreational use, household use (e.g., drinking, cooking, watering, playing, etc.), agriculture, transportation, and power. Droughts will also cause bodies of water such as lakes, ponds, and rivers to dry up. This in turn will cause many cities and urban areas to have zero water access, as evidenced by the ongoing water crisis in the American Southwest (EPA, 2021; Geetha, 2022, p. 101; Levy et al., 2015, p. 312). As droughts begin to affect water availability, it can increase water costs, increase the need for rationing, or eliminate self-replenishable water sources such as wells and aquifers (Bathke, 2022). The effects of water availability and affordability will directly impact low-income neighborhoods that feature few resources and funding to support the rising costs of water (Dean, 2022). Moving forward, it will be important for policymakers and landscape architects to consider and accept the planning challenges that droughts will present and how they will raise the demand for water (Strzepek et al., 2010, p. 1). These extreme events will leave an impact on society. There is expected to be a large response to mitigate these insecurities and combat the extreme consequences associated with climate change (Narayan et al., 2003, p. 46).

Flooding and Water Availability

The collection of various data has shown that the frequency of flooding has increased over the past century and specifically in the Midwest, as it is considered a 'high hotspot' of climate change consequences (Diffenbaugh et al., 2008, p. 4; Union, 2018, p. 2). Several studies and resources have suggested that extreme weather, in particular extreme precipitation, is becoming more persistent since the mid-1900s (Union, 2018, p. 2). The persistence in flooding is creating problems for urban dwellers and mitigating climate change consequences. Both flooding and drought contribute to approximately 38% of all natural disaster events; while it affects approximately 84% of people associated with natural disasters (Guneralp et al., 2015, p. 217). One of the primary causes of flooding is extreme precipitation due to extreme weather events, a consequence of climate change (Levy et al., 2015, p. 312; Union, 2018, p. 1). Flooding occurs when the rainwater falls on land or in rivers that are incapable of absorbing and draining the water. A piece of land or river that is incapable of absorbing the abundance of precipitation could be due to the capacity storage of water the soil can withhold, conditions of the land and vegetation, duration of rainfall, and the dryness of the land (Union, 2018, p. 2). Other factors that contribute to flooding include impermeable surfaces, lack of bodies of water, and lack of stormwater management and green infrastructure (Union, 2018, p. 4). Extreme flooding is a trend that is predicted to continue throughout the 21st century (Union, 2018, p. 4).

Future Predictions

Climate change is a rampant anthropogenic phenomenon that continues to affect our earth today and will continue to affect our earth into the future. Due to climate change, the warm seasons (late spring, summer, and early fall) will continue to get hotter. As human-induced climate change increases, there will be significant hardship on the economic, social, and natural systems of the Earth. These affected systems will result in a major decline in water availability and potentially a decrease in affordability (Narayan et al., 2003, p. 47). Millions of people in cities today already face a water shortage seasonally, annually, and perennially (Punia et al., 2022, p. 46). It is expected that by 2050, approximately 993 million people will be confronted with perennial water shortages, and 3.2 billion people will face seasonal water shortages (McDonald et al., 2011). The most affected by water shortages will be those who live in urban areas, and there is

expected to be approximately 2-billion more urban residents by 2030 (Zhang et al., 2019, p. 2). The effect of climate change will disproportionately impact people in urban areas; therefore, low-income, and marginalized communities are more susceptible to be affected by water availability and affordability (ADF, 2003). While climate change consequences – drought and flooding – are extremely prevalent, these are not the only problems causing water shortages. Population growth, per capita water use, and water conservation are other factors that will need to be considered in the future of the Earth's water supply (Jenerette and Larsen, 2006; Punia et al., 2022, p. 46). To have a consistent and sustainable urban future, it is important for local and regional households and governments to transition their existing practices, and guide society to efficient water use (Abdulla et al., 2009, p. 196). As water availability has been a focused interest across the globe, rainwater harvesting is an important method to consider for combating the decrease in water availability and affordability (Abdulla et al., 2009, p. 196).

RAINWATER HARVESTING

One way of addressing drought and flooding caused by climate change is rainwater harvesting. This process allows residents or users of the harvesting systems to store collected rainwater for later use, which can help mitigate the impacts of drought, flooding, and water costs for low-income households. Rainwater harvesting is a resilient action response toward climate change and extreme weather. By understanding the history of extreme weather and how modern societies can adapt to addressing climate change consequences, the reliability of rainwater harvesting system processes is better understood, particularly how they can be a functional asset in collecting rainwater for low-income communities (Narayan et al., 2003, p. 56).

What is Rainwater Harvesting?

Rainwater harvesting is a simple technology of the practice of capturing and storing rainwater for the benefit of later use (Abdulla et al., 2009, p. 196). It can also be defined as collecting rainwater runoff from a catchment source and using it for the benefit of humans, animals, or crops (Geetha, 2022, p. 102; Hillel, 2005). One of the main purposes of rainwater harvesting is to increase retention and be able to store water for a variety of functions and uses (Barron, 2009, p. 2). There are several different ways of collecting and storing water, including soils, dams, underground or above-ground storage tanks, containers, pots, and cisterns. The rainwater collected in these systems can be from a variety of sources such as rooftops and impervious surfaces or a direct catchment system that catches the rainwater out of the air (Abdulla et al., 2009, p. 196; Campisano et al., 2017, p. 196). Post collection, there are several uses and benefits of the water. The water can be supplied to households, animal and human communities, irrigation systems for land, soils, agriculture, toilets, laundry, car washing, swimming pools, heating, cooling, and can improve the quality of life for people to use in potable and non-potable forms (Alamdari et al., 2018, p 178; Campisano et al., 2017, p. 196; Department of Health, 2013; Geetha, 2022, p. 102; Gupta and Agrawal, 2015; Rashid et al., 2021, p. 1). The system(s) is not a "one size fits all" solution and can continuously be developed and altered as needed over time (Abdulla et al., 2009, 196).

Background of Rainwater Harvesting

Rainwater harvesting is an old method of collecting water from rainfall (Campisano et al., 2017, p. 196). Rainwater harvesting has a lasting and rich history that gives rise to present-day standards. Historically, rainwater harvesting has been practiced in regions where it is most necessary due to the climate conditions, or in areas where the water supply is extremely lacking (Terry, 1998, p. 65). The origin of rainwater harvesting derived from India. The Indians have innovatively produced and practiced efficient and sustainable methods of rainwater harvesting for centuries (Bhattacharya, 2015; Geetha, 2022, p. 106). Common harvesting practices by the Indians, which emerged over 1,000-years ago, included ponds, bunds, underground storage containers, irrigation tanks, temple tanks, and wells to name a few (Geetha, 2022, p. 102; Sivanappan, 2006). Table 2.1 depicts a list of the traditional and common rainwater harvesting systems practiced by the Indians. The left column is the name of the system in Hindi language, and the right column explains what the practice entails.

Table 2.1 Traditional and Common Rainwater Harvesting Systems in India*

Hindi Word	*Method of Practice/Meaning*
Ghuls	Water is tapped from hillsides (Western Himalayas).
Ghar & Dara	Channelizing of water for agricultural use (Brahmaputra Valley).
Virdas	Using dry riverbeds, digging shallow holes to collect drinking water (Western India).
Stepwells (No Hindi word)	Water is available at the bottom of a series of steps (Rajasthan & Gujarat).
Talabs	Potable drinking water collected in natural or constructed ponds.
Taanka	An underground cylindrical well that collects water from courtyards and rooftops (Rajasthan).
Ahar Pynes	Manmade lakes locked on three sides. Open side connected to channel (South Bihar).
Johads	Mud dams used for storing rainwater.
Panam keni	A well, built of wood for storing water (Kerala).
Khadins	Similar to bund, a dam constructed on a slope/hillside.
Kund	A circular well with the surface slanted towards the center of the well; used for collecting drinking water.

*Adapted from Geetha 2022, p. 106; Pradhan and Sahoo 2019

There are also supplementary measures that can be practiced aside from the previously mentioned systems and techniques of rainwater harvesting. These may include trenches and/or terraces aimed to enhance soil moisture or a storage container of various sizes with a tap such as a jar, a storage barrel, or large container (Geetha, 2022, p. 106). These other techniques and technologies that are available for harvesting rainwater to provide a valuable source of water for people, plants, animals, and the environment (Martinson et al., 2014, p. 10).

Components and Processes of Conventional Rainwater Harvesting Practices

Components of a rainwater harvesting system differ between each harvesting typology, but the primary components include a collection or catchment piece, the rainfall mode of transportation to the storage container (e.g., pipe, drain, tubing, guttering, etc.), an in-ground or above-ground storage container, and lastly, depending on the functional preference, a way in which the water is applied or used (Geetha, 2022, p. 103; Terry, 1998, p. 65).

Pitched roofs typically collect the water using a pipe and direct the water to the preferred method of storage as previously mentioned (Geetha, 2022, p. 103). A typical rainwater harvesting system begins with the installation of 75 – 100 mm (2.5" – 4") diameter pipes (Geetha, 2022). The pipe dimensions can vary depending on the regional location, prevalence of extreme weather events, as well as the supply of water intending to be captured. Storage tanks, above or in-ground, are typically of sizes from 8,000 gallons to 13,200 gallons in industrial harvesting and anywhere from 50 gallons to 3,000 gallons in residential harvesting (CSE Webnet, n.d.; Geetha, 2022, p. 103; Rainwater Storage, n.d.). The materials of the storage container can vary based on the visual and functional preferences of the user. The materials can include brick, concrete, precast concrete, stone, or metal (Geetha, 2022, p. 103). Depending on the method of rainwater harvesting and the preferences of the functional use of the collected water, the stored water can be directed into different water body typologies such as ponds and reservoirs, soil, above or in-ground tanks, aquifers, or direct consumption to residents' homes (Geetha, 2022, p. 103; Martinson et al., 2014, p. 101; Oweis et al., 2001). Figure 1.2 shows a more advanced rainwater harvesting system at a residential home.

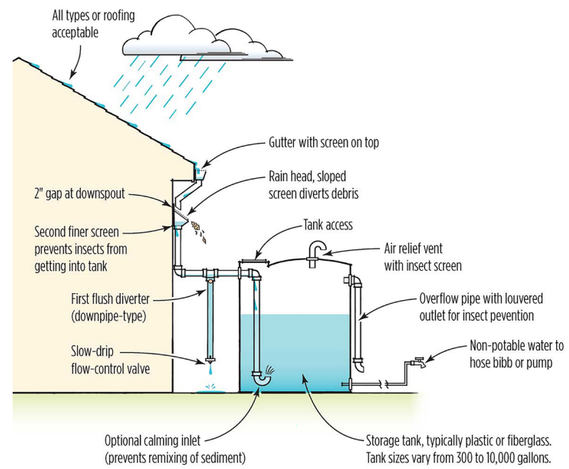


Figure 2.1 Typical residential rainwater harvesting system. The sizing and language may change based on system typology and how it is applied.

The following subheadings elaborate on specific components and methods of modern rainwater harvesting. As previously mentioned, it is important to consider other techniques and practices preferable to the regional location, visual preferences of the collection systems, and preferred functional use of the water collected.

Components

Catchment and Collection

The catchment and/or collection area is where the rainwater is in the process of being harvested. This is the initial process of rainwater landing on a surface such as a rooftop, concrete, asphalt, soil, etc. (Geetha, 2022, p. 103). It is important to know the specific surface being collected from as it can alter the type of collection system and affect the effectiveness of rainwater collection (Rainwater Collection, n.d.).

Collection and Transportation

The collection and transportation of the rainwater is the process of the water being transported to its desired location. This can include drains, channels, rooftops, pipes, or gutters. This is dependent on the implementation preferences and how the water is initially being collected (what the catchment system is: rooftop, concrete, etc.; Geetha, 2022, p. 103; Rainwater Collection, n.d.).

Storage and Collection of Rainwater

There are two primary ways of storing rainwater after collection: closed tank storage and open surface water storage (Geetha, 2022, p. 104). The following two methods are tailored toward storage of water that will be used for later use in potable, non-potable, and watering scenarios.

Closed Tank Storage

The closed tank storage method is a sanitary method that allows the water to be used for consumption. This method typically requires the storage to be relatively close to the area it was collected (Geetha, 2022, p. 104).

Open Surface Water Storage

The open surface water storage method is typically for large industrial and agricultural use where water will be stored in a large amount. The water is filtered through a sand gravel filter, PVC pipe filter, charcoal, or sponge filter (Geetha, 2022, p. 104; Pradhan & Sahoo, 2019). This method is typically not used for water that will be ingested by humans.

Water Storage–Based Practices

Wet System Storage Tanks

Wet system storage tanks are primarily recommended for residential storage use as it is relatively easy and affordable. The water is directly transported to storage, typically through piping. The storage tanks can then be connected to the plumbing system, irrigation, or by other methods based on the user's preference. This method is good in regions with year-round precipitation and constant source of water. The "wet" system primarily allows the water to sit in the collection piping system until it is either used or pushed/drained through the pipe. This is the reason for using such a system in areas with more precipitation. In dry regions, a large tank with a larger quantity of water and longer duration storage capability is more appropriate (Geetha, 2022, p. 104–105; Santos and Taviera Pinto, 2013).

Dry System Storage Tanks

The dry system storage method refers to storage tanks placed a few meters away from the property. This allows the pipes to be configured in a way that allows the water to flow through a filtration tank before going into the recharge well. This method is suitable for wells, areas with shallow water tables, and areas with short periods of annual rainfall (Geetha, 2022, p. 105). With the "dry" system, the piping that transports the water is placed above the tank to allow the water to drain out completely, unlike the wet system, which holds the water in the pipes. The pipes generally direct the water to the storage tank using gravity and is one of the simplest methods in terms of system components and maintenance (Scheidegger, 2018).

Considerations for Rainwater Harvesting

There are several considerations to evaluate when deciding to implement a rainwater harvesting system. The collection systems are typically large; therefore, it is important to consider where the collection tanks will be located and how much water they can hold. On average, a residential roof may generate approximately 30,000 gallons of runoff per year, and a typical rainwater harvesting system would

be large enough to store water for a dry summer (Seattle, 2022). A standard 55-gallon harvesting system will only harvest a small amount of the 30,000 gallons. With that, it is important to consider the size of the roof being collected from. A small residential home with a small roof surface area may not be viable for collection if considered as an individual unit. However, an industrial building would provide ample amounts of water (Rainharvesting, 2017). Most considerations are primarily associated with single-unit rainwater harvesting systems, while there is opportunity to consider rainwater harvesting as an integrated system through identification of various urban land use types. These land uses may include residential, industrial, religious, educational and commercial parcels which have different sizes of impervious surfaces and different groups of users. Identifying these categories in a specific area, provides opportunities for going beyond single-unit rainwater harvesting systems and creating an integrated network of various systems that are implemented through community involvement and community led initiatives.

It is also important to consider where the overflow water will drain to. If there is not enough room in the storage containers, then the water will need to be discharged to an appropriate and environmentally beneficial location (Environmental Services, n.d., p. 2-3). An integrated harvesting system can address this concern. Lastly, it is important to consider the demand of water to be used. Determining the amount of desired water to be used prior to installation will help mitigate a lack of water availability from the collection system, or an overabundance of water being collected and not used (Rainharvesting, 2017). Community involvement is important to consider as the residents and users of the systems will be the primary people benefiting from and utilizing the resource of free water. In an integrated system, the overabundance of water can find its way to the most beneficial point to be used.

Modern Technologies and Opportunities of Rainwater Harvesting

As we are already in an era of new and more intense weather patterns because of climate change, it is becoming more common for new rainwater harvesting technologies and updated practices to be implemented to help mitigate the demand on water and to adapt to climate change (Amos et al., 2016; Campisano et al., 2017 p. 196).

These new technologies are not to be implemented without the inclusion of communities. To begin this implementation of rainwater harvesting systems, it will be important to include social networks to help provide resources and information to individuals that may not be aware of such technologies and strategies (Samaddar et al., 2014, p. 97). The social inclusion and influence on a community will be discussed more in-depth in the following sections; however, it is important to preface the importance of new technologies and how they need to be socially accepted as well.

Some of the rainwater harvesting methods being practiced today, are quite simple and easily adaptable to communities, such as the following:

1. Rain Barrels: Opposed to large storage tanks, rain barrels are approximately 55-gallons and simple systems that collect rainwater form roofs using gravity (Tallarico, 2020). Figure 2.2 shows a typical rain barrel.

Figure 2.2 A set of rain barrel at a residential property. The barrels can either be a multiple set, or singular barrrel (2020).

2. Rainpods: This type of system allows open-air rainwater collection with no water being collected from a runoff source. As it is a large system, it typically stands taller than a human and spreads across a large surface area (Jagyasi, 2020). Figure 2.3 shows a conceptual image of the Rainpod.

Figure 2.3 A contemporary and innovative solution to typical rain barrel aesthetic and function (2008).

3. Rain Chains: A rain chain is not typically effective in collecting water. It more or less directs the water from a gutter, rather than using a traditional downspout, through a visually appealing sculpture (Jagyasi, 2020). Figure 2.4 shows a rain chain in action.

Figure 2.4 A rain chain for visual and auditory aesthetic.

4. Cista: This method is guided towards urban dwellers and structures. The system is attached to a structure and has a plant or plantings that crawl the system. It both collects water, and serves as a plant habitat (Jagyasi, 2020). The water is collected through the gutter system. The Cista is shown in Figure 2.5.

Figure 2.5 A modern rectilinear collection tank attached to the side of a house and gutter system (2009).

5. Watree: This is a rainwater harvesting system that is simply an inverted umbrella-like sculpture. It serves both as a shade structure and a water collection system. It is typically used in playgrounds and parks (Jagyasi, 2020). Figure 2.6 shows the Watree system.

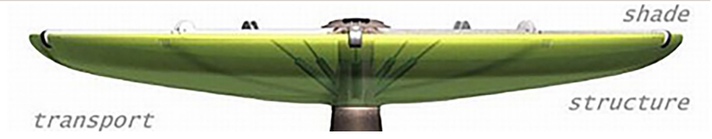


Figure 2.6 A contemporary and innovative solution to typical rain barrel aesthetic and function; inverted umbrella type system.

6. Rainwater Harvesting Systems with Storage Tanks or Cisterns: Rainwater harvesting tanks and cisterns collect runoff from roofs or other impervious surfaces and collect them in tanks, cisterns, or rain barrels. These refer to the systems discussed in the section: Components and Processes of Conventional Rainwater Harvesting Practices.

Figure 2.7 A typical large rain barrel system that stores and holds the water.

The modern technologies and rainwater harvesting systems differ from traditional methods. However, they still effectively serve the purpose of capturing and storing rainwater for use by humans, animals, and plants. It should be acknowledged that there are many supplementary techniques, in addition to the systems listed above, which are innovative, experimental, and trends being practiced globally. Further discussion of other techniques is beyond the scope of this proposal.

Benefits, Possibilities, and Opportunities of Rainwater Harvesting

Historically, water has been one of the most important aspects in supporting the development and culture of human society. For water to continue providing resources for society, practitioners and policymakers need to become the leading advocates for rainwater harvesting systems and educators of their benefits for humans and ecosystems (Barron, 2009, p. 3). Some of these benefits include providing another source of water to reduce the demand on groundwater, reducing stormwater flow to decrease flooding in prone areas, and reducing water bills (Barron, 2009, p. 3; Geetha, 2022, p. 108; Mishra et al., 2013; Rahman et al., 2014). Rainwater harvesting can also provide an accessible source of water alternatives to the city watermains (Rashid et al., 2021 p. 1). Geetha (2022) also provides an overarching basis for the benefits of rainwater harvesting systems:

1. Rainwater is free and a relatively clean source.
2. The methods are primarily inexpensive, including low-cost maintenance.
3. It is a top resource in emergency and municipal water situations.
4. It is the cheapest water use for irrigation and reduces flooding and runoff.
5. It can be installed in new or old development, such as offices, institutions, residential, hospitals, or churches (Geetha, 2022, p. 103; Mishra et al., 2013; Rahman et al., 2014).

Rainwater harvesting has benefits impacting all spectrums. It is often perceived to be a "green practice" because of its ability to collect potable rainwater and mitigate flooding and drought (Rashid et al., 2021, p. 1-2). When analyzing rainwater harvesting systems and pushing beyond the standard use of the rainwater, there is always a water source that could utilize additional support. Martinson et al. (2014) expresses how even in tropical climates or precipitation-heavy regions, there are springs, rivers, or wells due to ease of experiencing drought depending on the type of land use, land cover, over-utilization, and, most importantly, climate change. Martinson et al. (2014) also states how important it is for us to collect rainwater to reduce the risk of water insecurity (Martinson et al., 2014, p. 103). It is, therefore, reasonable to collect the rain where it rains (Narayan et al., 2003, p. 53).

Other benefits that do not revolve around safe drinking water and are commonly studied, include decreasing water insecurity (de Sa Silva et al., 2022, p. 2; Jiang et al., 2013), it being a valuable method of combating and adapting to climate change (de Sa Silva et al., 2022, p. 2; Vargas-Parra et al., 2013), decreasing in the use of resources and chemicals to treat the rainwater for non-potable uses (Abdulla and Al-Shareef, 2009; Correa et al., 2018; de Sa Silva et al., 2022, p. 2; Vargas Parra et al., 2013), mitigating soil erosion (de Sa Silva et al., 2022, p. 2; Jiang et al., 2013), mitigating urban flooding (Campisano and Modica, 2016; de Sa Silva et al., 2022 p. 2; Lopes et al., 2017; Malinowski et al., 2015), reducing the urgency to build new stormwater infrastructure (de Sa Silva et al., 2022, p. 2; Lopes et al., 2017), and reducing stormwater and raw sewage connected collection systems (de Sa Silva et al., 2022 p. 2; Fernandes et al., 2020) as practiced in Kansas City, Missouri.

Costs of Implementation of Optimal Rainwater Harvesting Systems

There are various processes that go into the creation and installation of rainwater harvesting systems. The cost of the system can vary based on the complexity, location, amount of water anticipated to be collected, and material. However, there is an expected range depending on the complexity of the system, shown in Figure 2.8, and Table 2.2. It is important to note that the systems listed are optimal and high-quality systems. There are options to consider with recycled materials and cheaply purchased supplies. These systems can range as low as $12-$15 (CustomMade 2015; Homeadvisor 2022).

The following table includes further installation, material, sizing, and other considerations with the estimated price ranges:

Table 2.2 Average cost of optimal rainwater harvesting systems, labor, material, components, and maintenance. Does not include if user self-installs or utilizes recycled materials.*

ITEM	COST
Average Rainwater Harvesting System Cost	National Average: $2,500
	Average Range: $1,000 – $3,500
	Low-end: $150
	High-end: $15,000
Cost by Project Range	Rain Barrel: $150; (can be as low as $12–$15
	5,000 Gallon Dry System: $2,500
	5,000 Gallon Wet System: $15,000
Average Cost by Method (Includes Labor)	Rooftop Harvesting: $1,000 – $5,000
	Surface Harvesting: $8,000 – $15,000
Average Tank Cost by Material	Polyethylene: $2,000 – $4,000
	Fiberglass: $2,000 – $5,000
	Steel: $3,000 – $6,000
	Concrete: $3,000 – $6,000
Average Labor Costs for Installation	Landscapers: $50 – $100 per hour
	Tank Installation: simple: $250; complex: $1,300;
	Plumber: $75 – $130 per hour
	Excavation: $440 – $760 for 3-hours
	Downspouts replaced/installed: $300 – $600
	Gutters installed: $900 – $5,000
	Piping (Plumber): $75 – $130 per hour
System Components (Materials)	Filtration: $75 – $200
	Conveyance System: $100 – $1,500
	Water Storage: $120 – $6,000
	Collection Area: $500 – $9,000
Optional Components	Gutter Outlet: $5 – $10
	Gutter Mesh: $0.80 – $1.25 per linear foot
	Tank Screen: $10 – $50
	Tank Gauge: $30 – $50
	Downspout Screen: $10 – $50
	First Flush Diverter: $20 – $60
	Pump: $150 – $300
	Top-up System: $100 – $200
Maintenance	Landscapers: $50 – $100 per hour

*Adapted from CustomMade 2015; Homeadvisor 2022; Miguelez 2021

Economic Payback

The following paragraph is an example of the economic payback of a rainwater harvesting system adapted from Hammerstrom and Pushard (n.d.). All figures are for the purpose of the example:

A 1,000-gallon rainwater harvesting system costs approximately $2,500 for installation (national average). The water bill will cost approximately $136 (regional specific) a month, or $1,632 for the year. For this example, the water bill rate will not increase annually, therefore, over the span of 10 years, the household would pay approximately $16,320 to the water supplier. For this example, approximately 50% of the water use will be replaced by the rainwater collected. Therefore, a 1,000-gallon system would pay for itself in three years ($2,500 / $816 = 3 years; Hammerstrom & Pushard, n.d.).

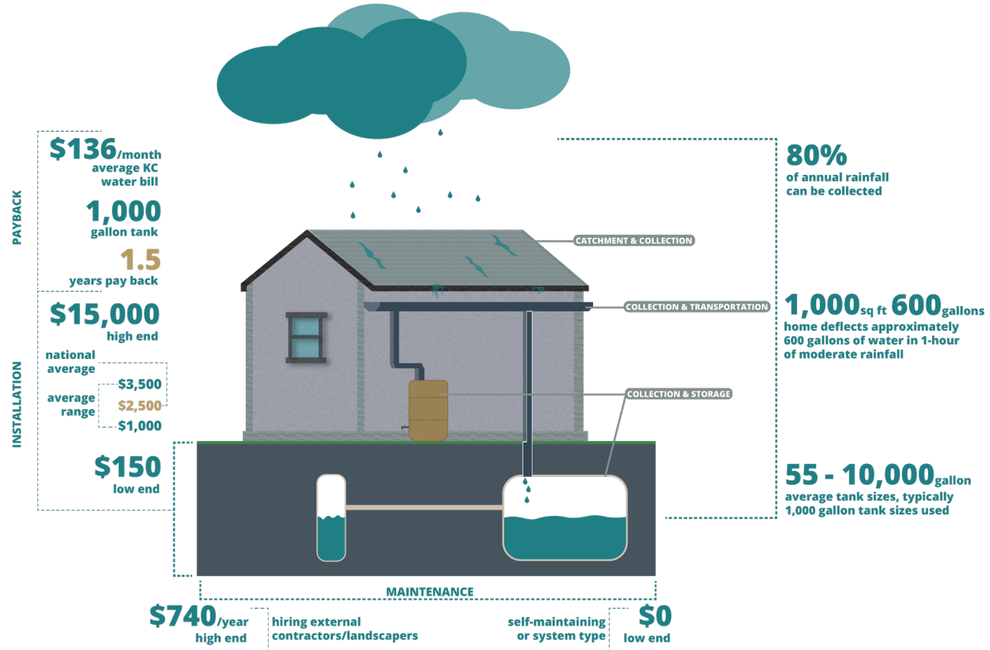


Figure 2.8 Average economic benefits, installation, and maintenance costs for rainwater harvesting systems. Information adapted from: CustomMade 2015; Homeadvisor 2022; Miguellez 2021

Limitation and Weaknesses of Rainwater Harvesting

It is important to consider the potential limitations and weaknesses of rainwater harvesting. While there are an exponential number of benefits to rainwater harvesting and systems, there is also a number of weaknesses that can derive from them. One of which is the unreliability of rainfall. Rainfall can be predicted, but not guaranteed. It is important to consider the sizing of the container if the expected use of the water is to help mitigate water shortages in drought, or overabundance of water in flooding events (Dan 2022; Maxwell-Gaines, 2022; Rinkesh, 2022).

Another limitation could be real estate. Depending on the size of the storage tank, whether above or below ground, the size could occupy a good portion of the area it is being implemented. This would also depend on the size of the property that the tank is being placed on (Maxwell-Gaines, 2022; Rinkesh, 2022). Along with the size of the container and real estate space, there could be property constraints that would restrict the installation of efficient or effective rainwater harvesting systems (Dan, 2022; Maxwell-Gaines, 2022; Rinkesh, 2022). In result, it may require technical skills or experts to install the systems as well. Depending on the complexity of the system, it may be necessary to hire a contractor, plumber, or landscaper to install the system, which automatically increases the cost of installation opposed to self-installation. With this, there is also the possibility of city ordinances limitation – potentially requiring a permit for the installation.

The potential for chemicals or other pollutants to seep into or infiltrate the water is a limitation as well. This can happen through roof or impervious surface runoff. This can be caused by animal droppings, plants, or insects (Rinkesh, 2022).

Lastly, a limitation is the cost for implementation. Depending on the type of rainwater harvesting system, size, material, and how the water plans to be used, these factors will alter the cost, and in some cases, limit the accessibility to certain users (Dan 2022; Maxwell-Gaines, 2022; Rinkesh, 2022).

Social Perceptions, Environmental Awareness, and Rainwater Harvesting

People's perceptions and attitudes are important to consider with rainwater harvesting. For people to have positive perceptions and attitudes towards rainwater harvesting systems, it is important for them to have awareness and clarity of what these systems provide to communities and how they combat climate change consequences. To continue pushing the idea of rainwater harvesting forward, it is important to consider the preferences of the users and those directly involved or impacted by the systems. Those most impacted by climate change consequences are women, children, elderly, people with disabilities, individuals with direct exposure to weather, minority groups, and low-income communities (Levy et al., 2015, p. 312). The users of the rainwater harvesting systems are or will be those affected by environmental climate change and the health consequences associated with it. Those consequences ultimately will affect civil, political, economic, social, and cultural rights, which directly affect people's rights to shelter, security, health, life, culture, and safe food and water – all of which contribute to the social wellbeing of a community (Levy et al., 2015, p. 312). Low-income and historically disinvested communities who live in flood and drought prone areas are the most susceptible to the impacts of climate change (Levy et al., 2015, p. 312). Addressing these problems through the community preferences must be coordinated in a way that protects the rights of humans, advocates social justice, and mitigates the possibility of new or increased existing problems of the vulnerable populations (Levy et al., 2015, p. 312). Existing rainwater harvesting systems typically focus only on the conservation of the rainwater and not the multi-purpose benefits to communities (Campisano et al., 2017, p. 205).

There have been recorded problems to the social acceptance of rainwater harvesting, and these problems were primarily revolving around the quality of the water, the perceptions of the social and health risks, and the financial benefits of the systems (Campisano et al., 2017, p. 204; Fewtrell and Kay, 2007; Ward et al., 2010; Roebuck et al., 2011; Rozin et al., 2015). One of the contributing factors to these problems is that of social capital and how it is dependent on different

neighborhood or community compositions (Curley, 2010 p. 79; Wilson, 1987). Low-income communities have several different social groups and networks that are extremely different than that of a high-income neighborhood or community. Therefore, it is important to consider the social aspects of low-income neighborhoods and how their perceptions are majorly influenced on their social networking and lack of access to proper social capital (Curley, 2010, p. 79).

As previously stated, there has been a need for increased knowledge of rainwater harvesting systems and how to reduce some of those challenges associated with it. However, it is becoming widely known and accepted to use rainwater harvesting for non-potable methods (Campisano et al., 2017, p. 204; Dobrowksy et al., 2014; Egyir et al., 2016; Gwenzi et al., 2015; Mankad and Tapsuwan, 2011). The social benefits to rainwater harvesting have been intended to attract large support from policymakers, businesses, and communities. The studies of the benefits of rainwater harvesting have investigated the effectiveness of the systems and the community participation of the rainwater harvesting systems. This in turn will affect the social influence of a larger integrated system of rainwater harvesting (Campisano et al., 2017, p. 204; Getnet and MacAlister, 2012; Stenekes et al., 2006). It has been generally concluded that rainwater harvesting systems have many social impacts that are positive in nature as well as socially acceptable (de Sa Silva et al., 2022, p. 6; Campisano et al., 2017). As previously stated, many of the community acceptance measures to rainwater harvesting systems revolves around perceptions of their health, quality of water, and the financial stability of the systems (de Sa Silva et al., 2022, p. 6; Campisano et al., 2017).

A study in Yogyakarta, Indonesia, of the social perceptions of rainwater harvesting systems showed people's perceptions primarily are affected by the social environmental conditions (Triyono et al., 2021, p. 1). This specific study revealed that people were not interested in rainwater harvesting, because they were under the impression that rainwater is lower quality water than well water or other available sources (Triyono et al., 2021, p. 1). This directly relates to the need for environmental awareness in communities of how rainwater harvesting can be a clean and sustainable source of water (Triyono et al., 2021, p. 1). This need suggests that there should be a dedication to understanding the components of social perception and how rainwater harvesting community acceptance can be achieved, especially how local governance and socio-political agencies can specifically engage and lead this effort (Campisano et al., 2017, p. 196). However, this presents the obstacle of determining who wants to receive this information. Various social networks provide a platform for people to learn about rainwater harvesting, but they also restrain people from receiving this knowledge based on the behaviors within the social groups and how those behaviors influence people that do want to learn of such systems (Samaddar et al., 2014, p. 97). As Samaddar et al. (2014) suggests, the number of social interactions within social networks have a large influence on the amount of information being distributed. Social groups that have more frequent interactions will have more cohesive members and regular interactions, which increase the amount and type of information distributed throughout a community (Ibarra and Andrews, 1993; Samaddar et al., 2014, p. 98). It is also suggested that individuals within similar geographical proximity will have similar behaviors and knowledge as well as share similar values and emotions (Rogers, 1983; Samaddar et al., 2014, p. 99). The close proximity of people results in a higher rate of interactions to share their knowledge, experiences, and to make similar connections throughout the community. In relation to rainwater harvesting systems, Rogers (1983) and Samaddar et al. (2014) express that these interactions among people in close proximity help community members become informed about innovative methods (such as rainwater harvesting); and this helps reduce the negative perceptions as they are able to first-hand witness and engage with members who may have adopted such systems already (Rogers, 1983; Samaddar et al., 2014, p. 99). This concept of neighborhood membership promotes community members to have influence on one-another through social learning and social influence (Rogers, 1983; Samaddar et al., 2014, p. 99).

Planning, Policy, and Design with Rainwater Harvesting

Water availability and affordability are more than a climate issue, it is a policy and design issue as well. Water systems

are complex because of the interwoven social and ecological systems at the water-user specific scale. To move toward sustainable and resilient practices, there must be a change in the existing systems (Butler et al., 2016, p. 1; De Haan et al., 2014, p. 85; Eppel 2014; Farelly & Brown, 2014, p. 11; Ward & Butler, 2016, p. 1). Local initiatives, support groups, businesses, landscape architects, planners, and governments have the capacity to reveal and express the vulnerability that our current water systems have. They can help improve the resiliency from drought or flooding through education and outreach on how our water system is susceptible to these extreme events (Bathke, 2022). Traditional water systems on a local and regional scale can become more efficient if there is an increase in local knowledge, such as on a water-user specific scale (Narayan et al., 2003, p. 55). The practicing, promoting, educating, and policymaking of water conservation and water efficiency are important in mitigating climate change consequences. Local entities can also express the need for change and push for alternative water sources for human potable and non-potable use (Bathke, 2022). Harmful water practices that cause damage to ecological systems, social systems, and capital systems struggle to reach the benefits that they are capable of offering. There is a need for creative policy-making that would improve these overall water practices and long-established systems, fund technology and human capital, and invest in facilities that monitor and facilitate water consumption (Narayan et al., 2003, p. 55). These initiatives, plans, ideas, and alternative methods can include rainwater harvesting as a method to combat drought and flooding as harvesting rainwater is expected to increase in the coming century (Terry, 1998, p. 101). Currently, it is common that existing water and climate policy does not acknowledge the benefits of rainwater harvesting systems as an asset to combat climate change, particularly in urban areas with no water restrictions (Narayan et al., 2003, p. 57). Other preventative measures that can start on a neighborhood scale and work up to city planning is the implementation of green infrastructure (rainwater harvesting falls in this category) or the utilization of other power sources that do not rely on water, such as solar and wind (Bathke, 2022). Although planning and policy happen at the municipal level, there is also a need for community willingness to influence these decisions. The community needs to be inspired to participate in governmental or municipal activities to express their ability in influencing technologies, such as rainwater harvesting, into communities (Triyono et al., 2021, p. 2).

LOW-INCOME NEIGHBORHOODS

Rainwater harvesting systems can be worthwhile in low-income neighborhoods due to their effectiveness, low maintenance, and the lowering of water costs for residents. Rainwater harvesting reduces water loss, thus increasing the amount of water stored and decreasing city water usage – ultimately reducing water costs. Public outreach and education combined with rainwater harvesting can increase efforts in utilizing these systems in low-income neighborhoods and in regions most vulnerable to climate change (Geetha, 2022, p. 102).

Utilizing Rainwater Harvesting Systems in Low-Income Neighborhoods

Low-income neighborhoods serve as an opportunity to find innovative methods to address climate issues such as drought and flooding. Low-income neighborhoods are disproportionately affected by climate change consequences which directly correlate to the social injustice experienced by communities (Levy et al., 2015, p. 312). Natural resources such as water are extremely important for well-being and survival, particularly for low-income individuals. This suggests that rainwater harvesting systems are a valuable resource to low-income neighborhoods residents that experience water insecurity. The rainwater harvesting systems can serve as an asset to the low-income neighborhoods by improving their livelihoods, well-being, and economics through city water use savings and providing them a free and renewable resource (Barron, 2009, p. 1). Rainwater harvesting can also create connections between ecosystems and humans. Using the collected rainwater towards human benefit and use through water supply in urban areas improves the user's health and wellness, while also decreasing their city water consumption (Barron, 2009, p. 1). Innovative methods, such as rainwater harvesting, can decrease water costs for residents, improve stormwater management, and increase the use of a renewable resource for human benefit and well-being (Barron, 2009, p. 1). Low-income neighborhoods

need local action, investment, and improvement. Rainwater harvesting acts as a local intervention with almost immediate and local benefits to humans through on-site recycling of the water (Barron, 2009, p. 4, Martinson et al., 2014, p. 103).

RESEARCH GAP

There is a need for innovative and efficient methods to mitigate climate change consequences such as drought and flooding. These methods should not undermine the natural ecosystem resources and should provide opportunities for benefits of the users (Barron, 2009., p. 1). As Martinson et al. (2014) explains, there is opportunity for utilizing public buildings and low-income residential homes for rainwater to be harvested, stored, and used on the premises. Due to population growth, people moving into cities at a fast pace, industrial development, and historically marginalized communities lack of resources, there has been concern for the future of water supply availability and affordability and how these factors play into the demand for water (Haque et al., 2016). Current research focuses on traditional harvesting systems and does not fully address people's attitudes, perceptions, and awareness of such systems and how these factors are associated with willingness to get involved in developing such systems based on the functional and visual preferences within neighborhoods. It is also important to consider people's awareness of such systems and what their perceptions are. To get people involved in climate actions, such as rainwater harvesting systems, it is important to make sure they are aware of the problem of climate change. Users who have more knowledge about climate change issues are more likely to participate in interventions and are able to imagine how they could benefit from them. The studies of the benefits of rainwater harvesting have investigated the effectiveness of the systems and the community participation of the rainwater harvesting systems. This in turn will affect the social influence of a larger integrated system of rainwater harvesting (Campisano et al., 2017, p. 204; Getnet and MacAlister, 2012; Stenekes et al., 2006). It has been generally concluded that rainwater harvesting systems have many social impacts that are positive in nature as well as socially acceptable (de Sa Silva et al., 2022, p. 6; Campisano et al., 2017). It is important to understand the preferences of the users of the rainwater harvesting systems such as how they wish to use the water collected, as well as their perceptions and attitudes of such systems.

This project uses eight neighborhoods of Eastside Kansas City, MO as a case to examine how rainwater harvesting systems can be an asset to urban low-income neighborhoods and contribute to the existing body of literature by presenting findings of the neighborhood residents' preferences of the functional use of collected rainwater, their attitudes and perceptions of rainwater harvesting systems, and their individual or community efforts to implement such systems. Further, this project aims to offer a series of evidence-based design recommendations for rainwater harvesting systems in urban low-income neighborhoods. Figure 2.9 shows a literature map of all sources used in this literature review and project.

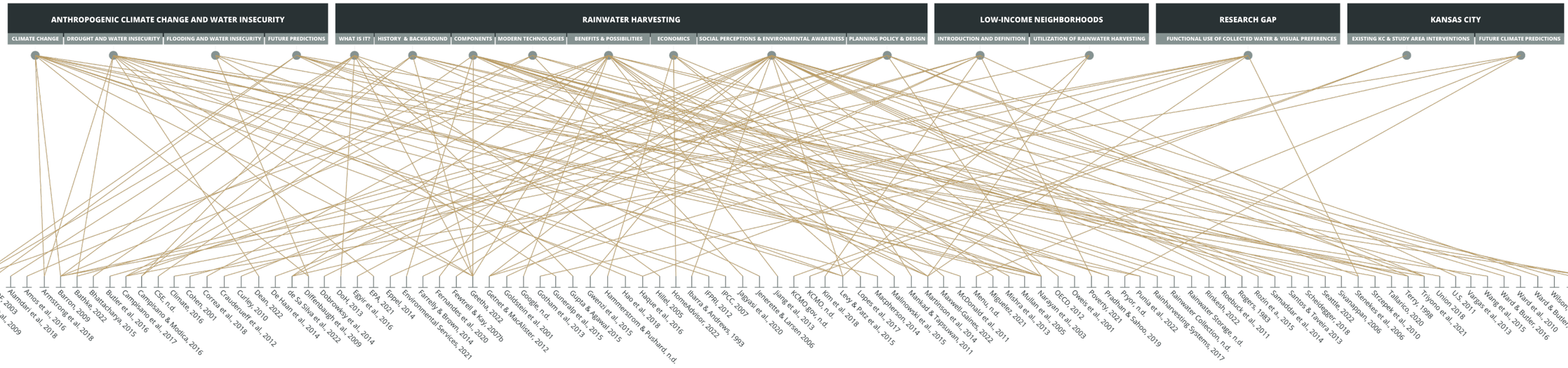
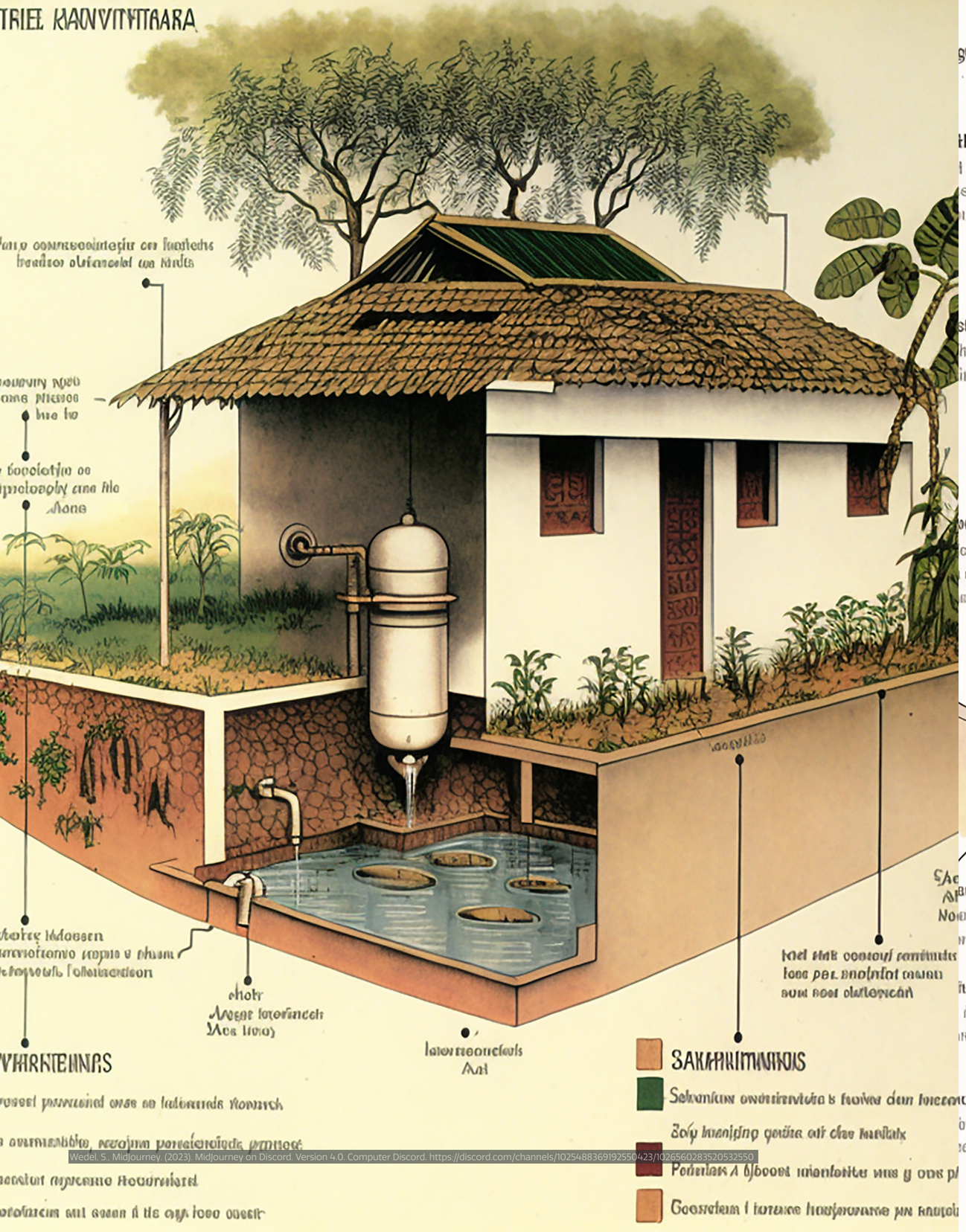
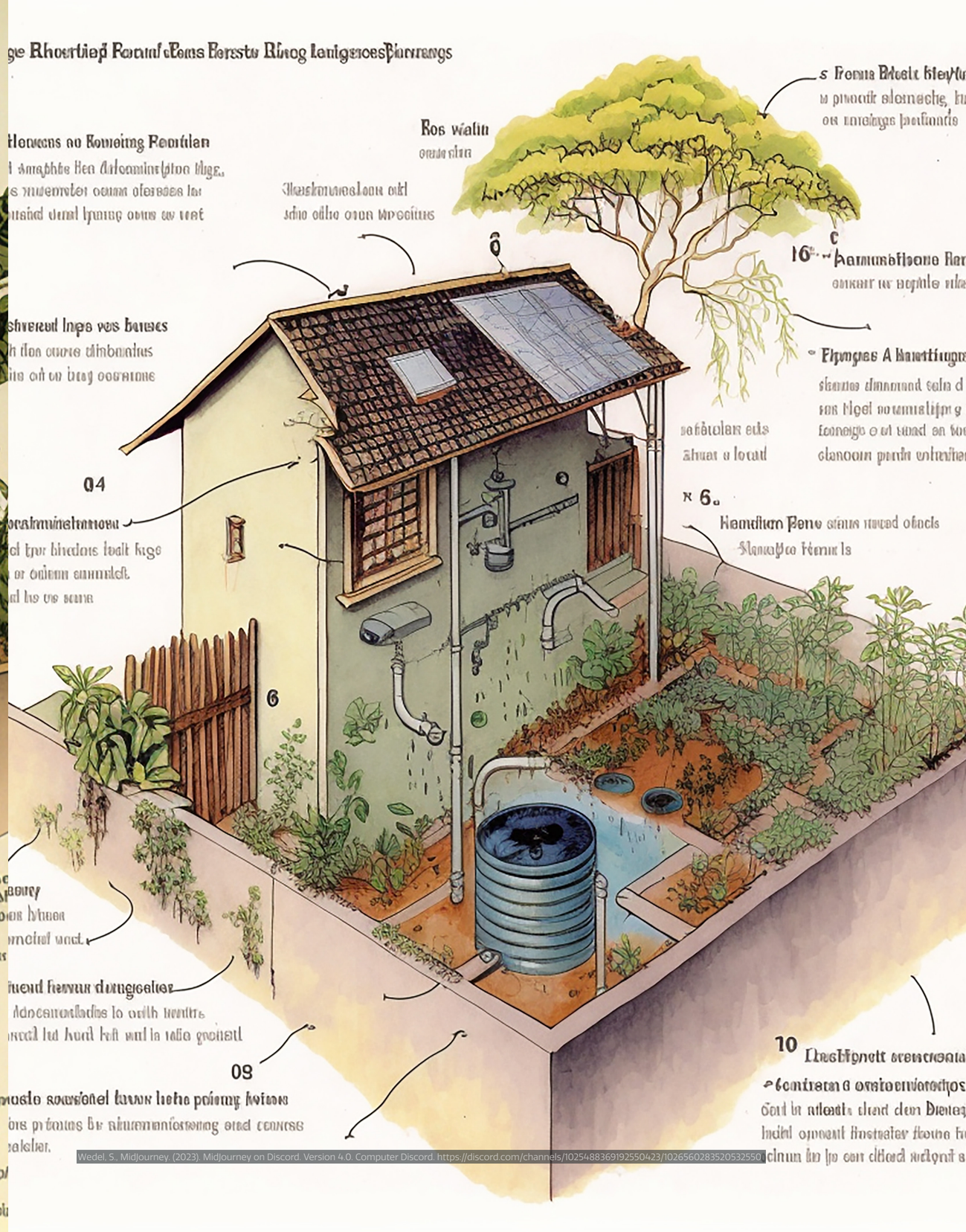


Figure 2.9 The literature map of sources used in this project.





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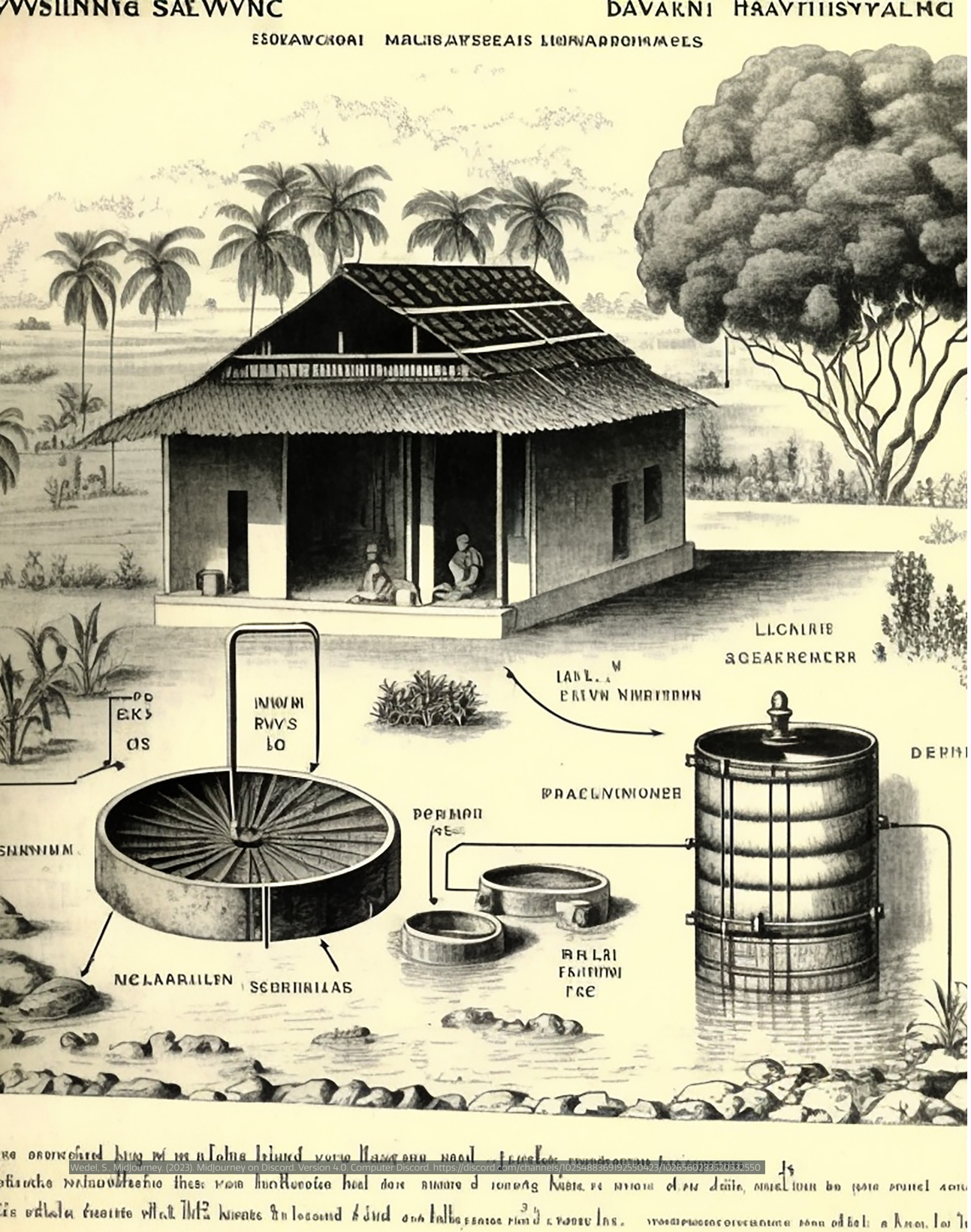

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CHAPTER 3

TECHNIQUE

METHODOLOGY

STUDY SITE OVERVIEW

Eight neighborhoods in East Side Kansas City, Missouri, were selected for study. The eight neighborhoods consist of 18th & Vine, Beacon Hill, Wendell Phillips, Washington Wheatley, Mt. Hope, Key Coalition, Santa Fe, and Ingleside. The study area, as shown in Figure 3.1, is surrounded on three sides by Interstate 70 (North and East sides), and Troost Avenue (West side). The farthest southern portion of the site is bordered by 35th Street. The eight neighborhoods in the study have a population of approximately 11,200 people. Five of the eight neighborhoods are on average below the household poverty line of $26,500 for a household of four (Poverty, 2021), assuming most of the households have on average three-to-four people per household due to most of the zoning being primarily residential.

The neighborhoods were initially selected as the sites because of their vulnerability to climate change consequences and water availability and affordability due to the high rate of low-income households. The eight neighborhoods are also historically segregated and disinvested as they are located east of Troost Avenue – the dividing roadway between the majority-white population west of Troost Avenue and majority-black population east of Troost Avenue. As the eight neighborhoods are of low-income and historically segregated families, they serve as an appropriate study area for the creation of a set of community-driven design recommendations for the implementation of an integrated rainwater harvesting system set to mitigate drought and flooding, increase environmental awareness, and increase the awareness of the benefits that rainwater harvesting provides. It will also provide an asset to the community at minimal cost.

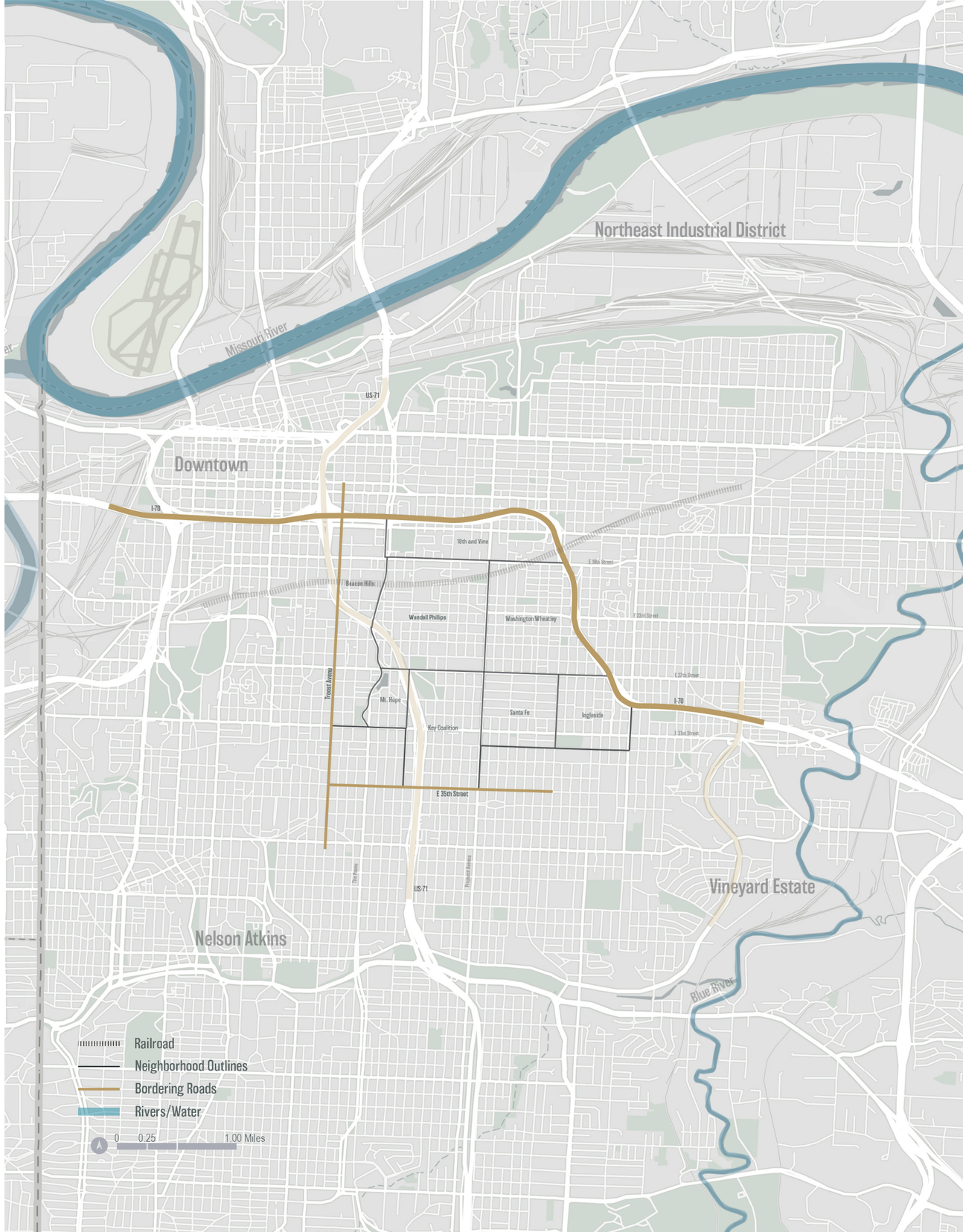


Figure 3.1 Study area map and contextual information of Kansas City, Missouri.

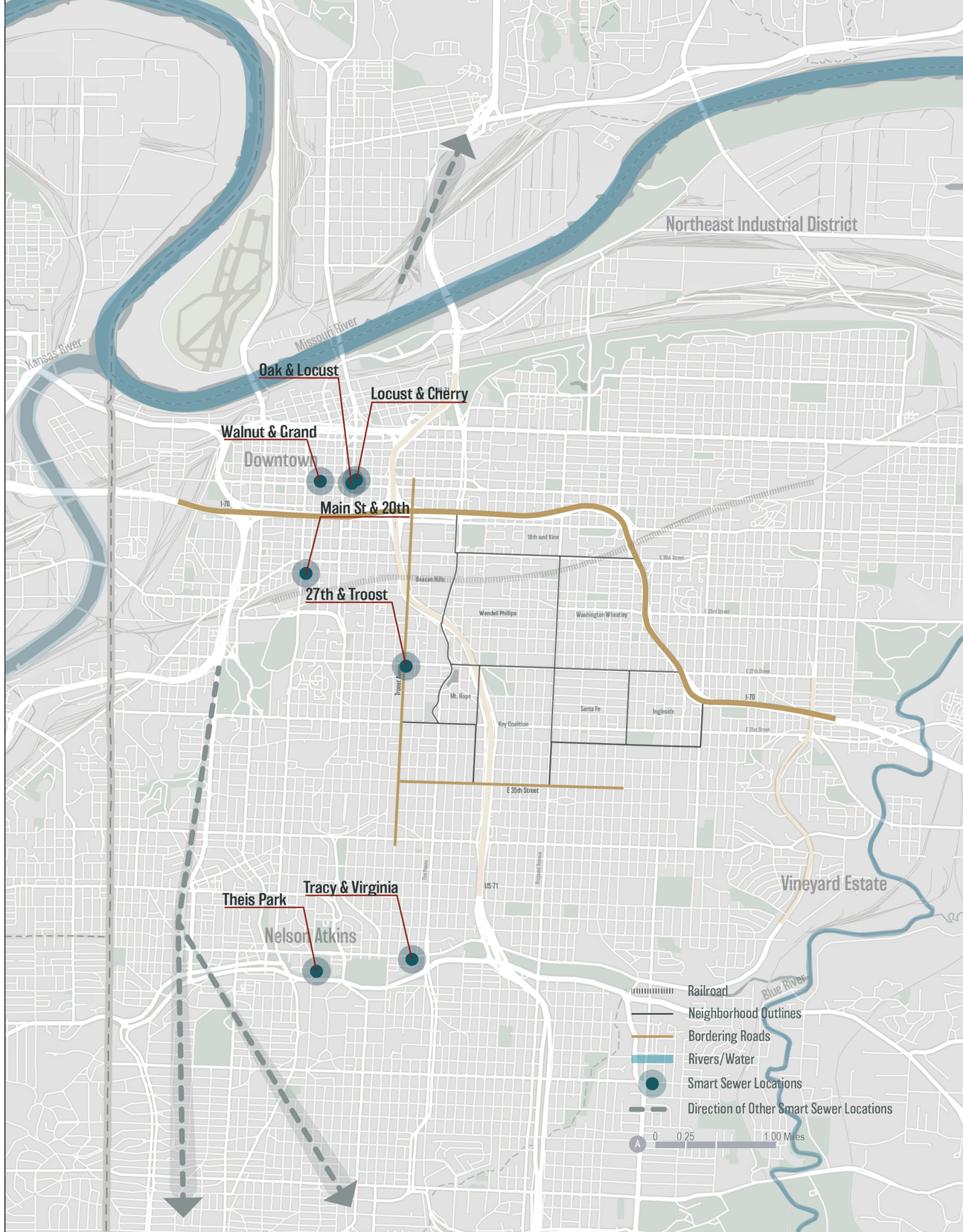
EXISTING KANSAS CITY AND STUDY AREA INTERVENTIONS

There are various instances of rainwater harvesting within the eight-neighborhoods, as well as throughout the city of Kansas City. Not only are there different rainwater harvesting techniques, but Kansas City is also actively implementing a new program called Smart Sewer to inspect and repair their existing stormwater and sewage pipe-ways and connections (KCMO, n.d.).

Stormwater Interventions within Kansas City and Study Area

Kansas City is historically known to have a combined stormwater and raw sewer system. Due to the combined systems, a major stormwater management practice is currently being implemented throughout Kansas City – the Smart Sewer plan. Beginning in 2010, the Smart Sewer is a 30-year plan that is estimated to cost billions of dollars (KCMO, n.d.). The plan is to help mitigate stormwater collected in the sewer system and ultimately prevent overflow during heavy precipitation events (KCMO, n.d.). This will effectively establish a healthier wastewater sewer system and improve the water quality that is released into the local waterways and rivers. Many Kansas City neighborhoods are currently experiencing flooding and water back-ups, such as flooding in their basements (KCMO, n.d.). This new system is expected to help mitigate these backups, which will result in a safer environment for neighborhoods and residents most affected by extreme precipitation events. The Smart Sewer plan is expected to impact all of Kansas City; however, there are no publicly available plans that majorly affect the eight-neighborhood study area.

Figure 3.2 Existing stormwater infrastructure within Kansas City and study area.



Rainwater Harvesting Systems and Green Stormwater Infrastructure within Kansas City and Study Area

Green stormwater infrastructure, such as rainwater harvesting systems, support in the process of capturing and utilizing rainwater that would otherwise runoff into the sewer system (KCMO, n.d.). There are several examples within the eight-neighborhood study area of rainwater harvesting, as well as other green stormwater infrastructure projects. There are currently rainwater harvesting systems at churches and schools that use the collected water for gardens. There are also several gardens, community gardens, and greenhouses that are utilized by the neighborhood residents that have rainwater harvesting systems and rain barrels for irrigation purposes. Lastly, along with the Smart Sewer program, there are several green stormwater infrastructure projects being implemented throughout Kansas City (KCMO, n.d.). One of these intervention projects was implemented on the west border of the study area on Troost Avenue, from 23rd street to 95th street, and was designed using curb-cuts and rain gardens (KCMO.gov, n.d.). This project consisted of 22 rain gardens and 19 stormwater curb cuts to collect and infiltrate the stormwater (KCMO.gove, n.d.). Other mitigation strategies included the creation of three street medians with plantings, and several other tree and vegetation plantings (KCMO.gov, n.d.). While this specific intervention fell within the technical boundary of the study area, there are 17 additional green stormwater infrastructure projects that are not included nor near the eight-neighborhood study area. This provides ample opportunity for supplementary stormwater mitigation practices such as rainwater harvesting for the study area.

FUTURE CLIMATE PREDECTIONS OF KANSAS CITY, MISSOURI

Kansas City is split between two states, Kansas, and Missouri. The eight-neighborhood study area is within the Missouri border and in Jackson County. Due to Kansas City being in both Kansas and Missouri, the city is also split between being considered in the Great Plains Region and the Midwest Region. For this study, the future climate prediction of Kansas City is considered in the Midwest Region. There are major consequences of climate change that will directly affect Kansas City, Missouri such as its impacts on agricultural production, forest compositions, health risks to humans, force to transition to a fossil-fuel dependent energy system, and increased risks to rainfall and flooding and drought (Menu NCA, n.d.).

Increased Risk to Precipitation and Drought

One of the major considerations for the future climate predictions for Kansas City, Missouri is the need to be prepared for significant precipitation events. These extreme precipitation events have increased in the past century and will continue to increase (Pryor, n.d). However, by the latter half of the century, precipitation is expected to increase by 10-20% during the winter and spring months (Pryor, n.d.). Although precipitation is expected to increase, days with no precipitation of any kind are expected to also increase and could potentially cause agricultural drought and affect the cooling of water at power plants (Gotham, 2013; Pryor, n.d.). More precipitation does not result in less drought. The state of Missouri is expected to have an approximately 70% increase of widespread drought by the year 2050 (Climate Central, 2016). With this, Kansas City is currently confronting one of the five worst threats to drought in major U.S. cities (Climate Central, 2016).

In conclusion, precipitation and drought will continue to increase through extreme weather events. There will also be an increase in drought due to the lessening of the number of precipitation days per year. This necessitates strategies for saving rainwater during extreme precipitation events and utilizing it over drought periods.

DATA COLLECTION

The data collection included two primary methods. The first method was observation and mapping. The second method consisted of semi-structured interviews conducted with a random sampling of community members from three different land-use categories developed through the mapping. The interviews included photosets and a short questionnaire for information about the three categories and included various numbers of people from each category based on the frequency of units in each category. The two methods will be explained in-depth in the following sections.

Study Site Selection Through Mapping and Observation

In-depth mapping was conducted to gain knowledge on the existing conditions of the sites' water systems, land cover, and impervious structure typologies. The first set of mappings were water systems and if or how many water sources there are available to the neighborhood residents. This provides a basis for understanding the flooding, drought, and water availability. The second set of mappings were land cover. The land cover of the study area is important to understand to distinguish the pervious from impervious surfaces. The land cover reveals the barren land, roads, and forest and herbaceous plantings. This helps filter out areas that are not accustomed to rainwater harvesting systems. It also reveals the impervious structures of the site. The third set of mappings were impervious surfaces and structures. The impervious surfaces and structures distinguish specific categories for rainwater harvesting opportunities. These categories are the bases for creating an integrated rainwater harvesting system for community involvement and awareness. The specific categories revealed during this mapping included, 1) Cultural and Educational Institutes, 2) Industrial, Restaurants and Retail Services, and 3) Residential and Living Centers.

Category Development and Descriptions

Initial site analysis mapping consisted of a large amount of different land cover classifications. Through consolidation and combining, the land cover was classified into three major categories including 1) impervious buildings, 2) impervious roadways, and 3) forest and herbaceous planting. Overlaying the three categories with land use data in the eight-neighborhood study area, revealed a need for more specific categories including 1) Cultural and Educational Institutes, 2) Industrial, Restaurants and Retail Services, and 3) Residential and Living Centers.

The development of these categories is also tailored towards community involvement and where rainwater harvesting can be an integral part of the neighborhood network and foster community relationships. The rainwater harvesting systems are to be an integrated system that is supported, maintained, and strengthened by the involvement of the community.

The categories are also developed through similar characteristics, similar or different system solutions, and sizing of the units. They are also determined through the similarity of uses and how the water can be used by the different categories.

It should be noted that all categories automatically include existing gardens and community gardens. Existing community gardens are typically organized by an entity or business that falls within one of the three categories.

The details for each category are described on the following pages:

Category 1: Churches & Religious Institutes

Details: Various religious organizations, youth religious organizations, churches of different denomination (Presbyterian, Baptist, Progressive, Episcopal, etc.), Fellowships, Ministries, Elementary Schools, Prep Schools, Middle Schools, Libraries, early learning centers, driving schools, financial education practices, youth organizations, etc.

Units: Approximately 130 Cultural and Education Institutes
- Target population 5%
- 130 X .05 = Approximately 6.5 units

Potential Solutions: One large storage tank, several large storage tanks, various smaller tanks/barrels dedicated to different uses:
- Various group functions such as baptisms, potlucks, festivals, large gatherings for children playing and recreation, watering plants.
- Educational purposes – learning about the environment, rainwater harvesting, planting/watering/maintenance etc.

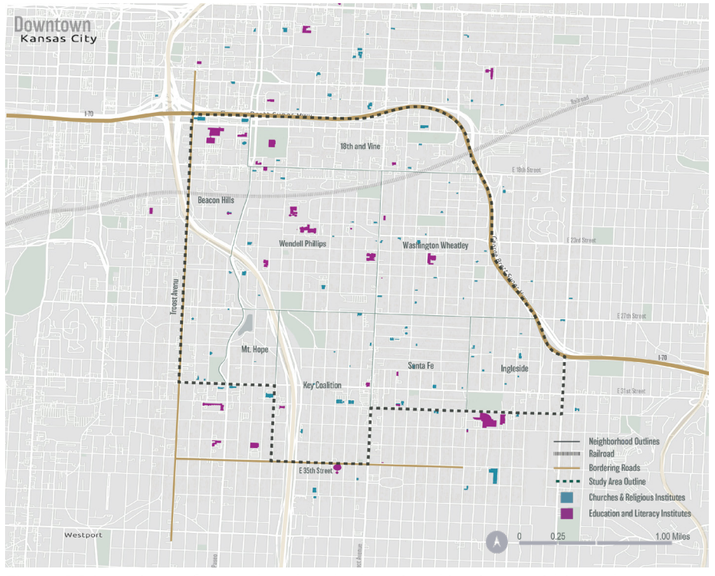


Figure 3.3 Locations of the cultural and educational institues within and around the site. This primarily includes churches, schools, and similar organizations.

Category 2: Industrial, Restaurants & Retail Services and Lots

Details: Manufacturers, tire shops, autobody shops, gas stations, banks, barber shops, clothing stores, fast food chains, local restaurants, grocers, multi-use strip malls, and large impervious lots.

Units: Approximately 359 Industrial, Restaurants & Retail Services and Impervious Lots
- Target population 3% (Differs due to time limitations and large number of units)
- 359 X .05 = Approximately 10.77 Units

Potential Solutions: Several or one large storage tank per unit, or series of smaller tanks for different uses per unit:
- Washing/cleaning for manufacturers, autobody shops, and restaurants
- Water plantings
- Human use if the right filtration system was implemented.
- Rain gardens or bioswales for multi-use strip malls, etc.
- Community gardens and plants ran by these organizations.

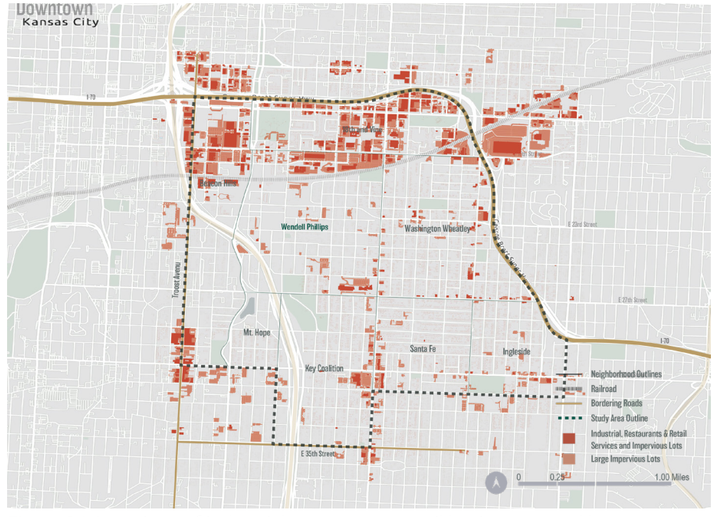


Figure 3.4 Locations of industrial, restaurants, retail businesses, and large impervious lots.

Category 3: Residential & Living Centers
Details: Single family homes and duplexes, multistory apartment buildings, retirement homes and facilities, rehabilitation facilities, daycares, preschools, early learning care, etc.

Units: Approximately 2,178 Residential and Living Centers
- Target population 1% (Differs due to time limitation and large number of units)
- 2,178 X .01 = Approximately 21.78 Units

Potential Solutions: Typically, one storage tank from 55-gallons to 3,500 gallons for different uses, or multiple tanks:
- Washing/cleaning depending on filtration system
- Child play
- Habitats – bird baths, etc.
- Gardens – flowers and edible
- Therapeutic practices such as outdoor/indoor water features (recycling the water)

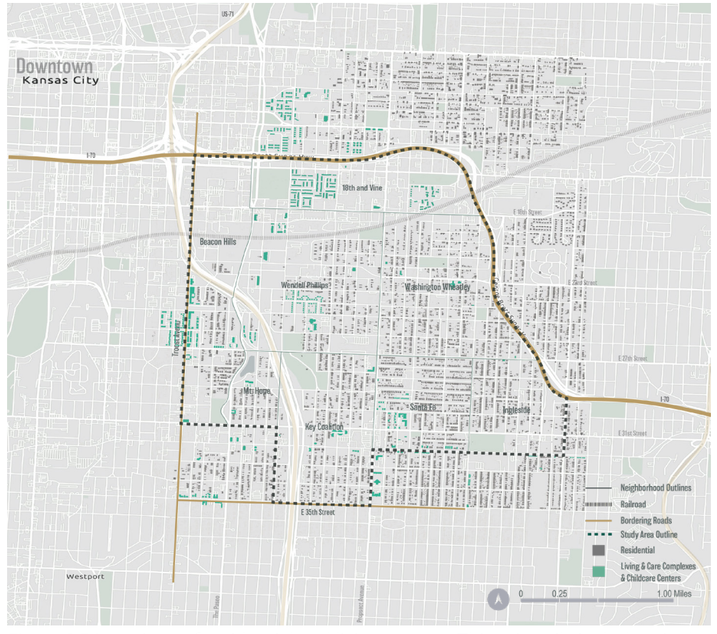


Figure 3.5 Locations of residential and living centers. This primarily includes single family homes, duplexes, apartment buildings, and care facilities.

Through the three sets of mapping and the development of the three categories, rainwater harvesting opportunities are revealed. These opportunities are to increase community interaction and environmental awareness in creating an integrated rainwater harvesting system and network. This network is to consider the attitudes and perceptions of the users and those directly involved or impacted by the rainwater harvesting systems. The specified categories will each have their own curated design guidelines based on the findings of semi-structured interviews.

Table 3.1 shows the benefits of rainwater harvesting systems based on the impervious surface area, amount of water being collected, and the water saving of that specific collection.

Table 3.1 Amount of water able to be collected depending on impervious surface area and average rainfall, amount to be collected, and cost of water*

Impervious Surface Typology & Area (Example surface area; will differ per building/impervious surface are):	Amount of Rainfall Average Per Month (Example amount provided and consistent across all typologies; average of Kansas City in the month of May):	Amount of Rainwater Able to Be Collected (Dependent on surface area and amount of rainfall):	Costly Benefit of Water Collected (Example if half of the amount of water able to be collected was collected and used; based on Average $136.00/month water bill across Kansas City, Missouri based on 5,000 gallon/month consumption):
Cultural & Educational Institutes	5.39 in. / month	16,138 gallons / month	8,000-gallon Storage Tank = approx. $217.60/month, or $2,611.20/year savings
Industrial, Restaurants & Retail and Lots	5.39 in. / month	971,292 gallons / month	Several Large Storage Tanks to equal 500,000-gallons stored = approx. $13,600/month, or $163,200/year savings
Residential & Living Centers	5.39 in. / month	8,730 gallons / month	4,300-gallon Storage Tank = approx. $116.96/month, or $1,403.52/year
Example Calculation: 4,806 sq. ft. X 5.39 in/m = 25904.34 X 0.623 (quantity of water in gallons one inch deep in one square foot of space) = 16,138 gallons/month. Then, $136.00 / 5,000 gallons = $0.0272 average cost per gallon of water X 8,000-gallon storage tank (example if half amount collected) = $217.60 / month OR X 12 = $2,611.20 / year savings *Calculations are for month of may and estimated for yearly benefit based off of the month of May. It is also necessary to consider the cost of installation of units that would differ per category.			

*Water Utilities, n.d.; Google Earth, n.d.

OUTREACH, RECRUITMENT AND PARTICIPATION

The interview participants were recruited through several methods. The first method was contacting specific locations in each of the three categories via email. Approximately 200 emails were sent to various businesses throughout the study area in December 2022. Once permission was granted to conduct interviews of individuals at these facilities, verbal consent and description were provided. Flyers were also posted or handed out at local stores, libraries, community centers, churches, and restaurants. The flyers provided the option to scan a QR code and sign up for a time slot on a specific date to be interviewed. The participants were required to be eligible to participate by being 18 years of age or older, and either using or occupying the facilities or locations being interviewed in. The interviews were advertised as in-person interactions; however, online meeting platforms were also an option and utilized. Due to the time limitations of the study, it was not possible to have a large sample size of each category or interviews. Therefore, the target sample populations were five percent for the first category, three percent for the second category, and one percent for the third due to the large number of units.

The following paragraphs explain the recruitment for each category, as well as a map depicting the recruitment locations corresponding to the specific category.

Participation

1 – Cultural and Educational Institutes
Participant recruitment for category one was solely via email. Emails were sent out to various churches, religious organizations, schools, and educational institutes. The emails consisted of requesting one participant in a leadership position to be interviewed for a student project. The template for the emails sent can be viewed in Appendix D. As much recruitment as possible was done, which resulted in four participants responding and being interviewed for this category. Each interview for this category was conducted in-person at the establishment that the participant worked in.

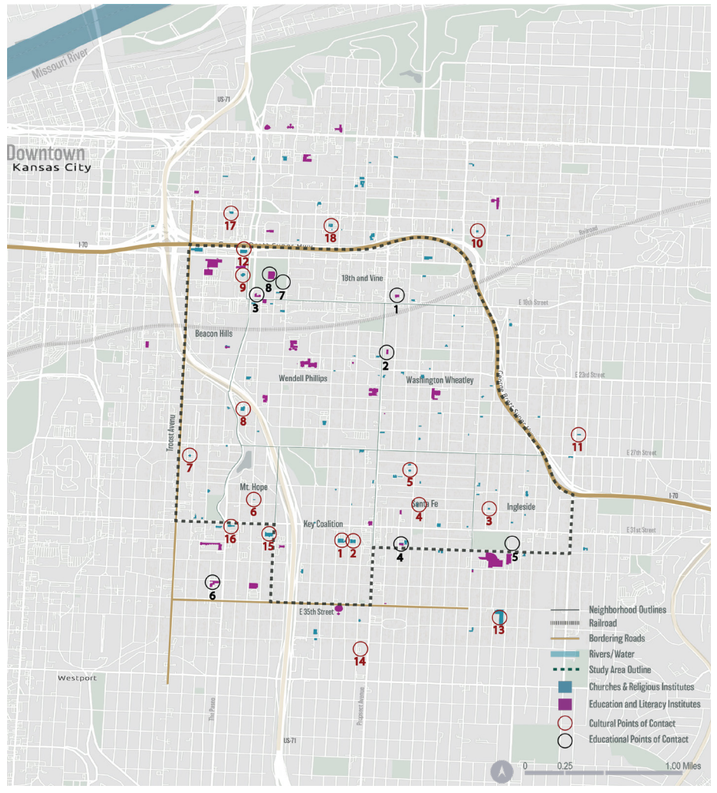


Figure 3.6 Recruitment locations for the cultural and educational institutes.

2 – Industrial, Restaurant, and Retail
Participant recruitment for this category was conducted via email, as well as walking into various business in the neighborhoods and requesting in-person to interview an employee or someone who represented the establishment. This resulted in six participants being interviewed for this category. Five of the participants were recruited via email, and one was invited in-person.

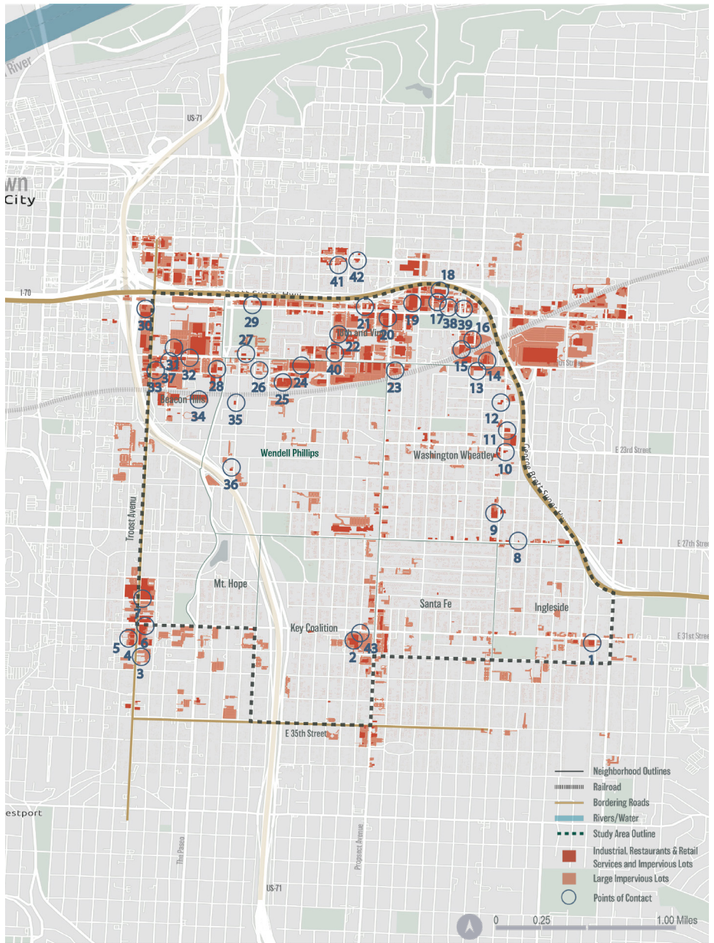


Figure 3.7 Recruitment locations for the industrial, restaurant, and retail.

3 – Residential and Living Centers
Recruitment for this category was conducted differently to that of the other two categories. Flyers as previously described were posted across various businesses within the neighborhoods. The flyers resulted in one participant contacting the researcher, and this interview was conducted via zoom. Another method of recruitment was by setting up an interview station in the local library located within the study area. Three separate days at different times of each day were spent attempting to recruit community members to participate in the study. Three participants were recruited from the library, however, they requested for the interviews to be virtual via Zoom. Lastly, one participant was recruited by walking into various businesses in the neighborhoods and requesting in-person to interview an employee or someone who represents the establishment. Therefore, one person's interview from this category was conducted on-site and in-person. Although this one participant was recruited at a business, the participant requested to be interviewed for the residence category. Six total participants were recruited for this category.

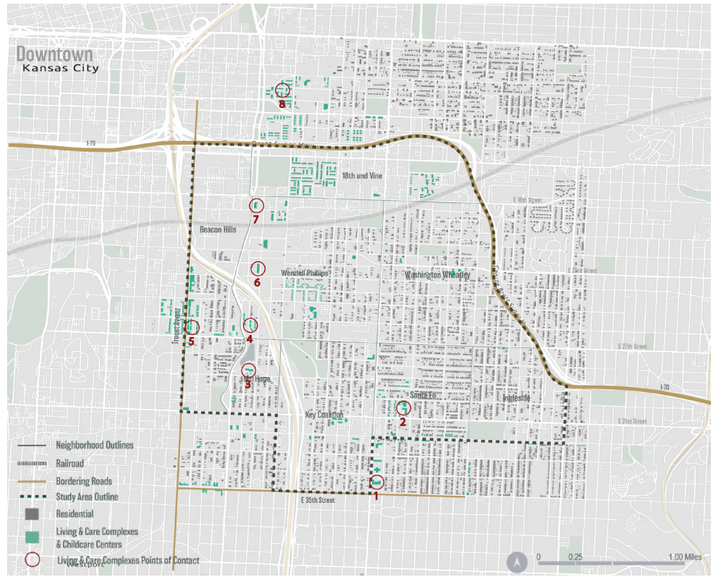


Figure 3.8 Recruitment locations for the residential and living centers.

SEMI-STRUCTURED INTERVIEW TOOL

Photosets containing images, as well as a short questionnaire and interview questions, were constructed to guide the conversation and assist interviewees in thoroughly explaining their thoughts and ideas. The interview questions and photos used in photosets can be viewed in Appendix B.

Photo-Sets

The photosets used in the interview process were separated into three themed categories, Current Rainwater Harvesting Systems, Functional Use Diagrams, and Artistically Designed Systems. Each of these themes had a set of photos under each of the three land-use categories.

The first set of photos showed current rainwater harvesting systems that one would typically experience in that specific category. During the viewing of the first set, participants were asked if they had any further questions or comments about the imagery before proceeding.

The second set of photos showed functional use diagrams for the specific land use category. These showed how the collected rainwater could be used at the specific establishment within the category. Participants were then asked to respond to a set of questions that revealed their perceptions, attitudes, and opinions on the uses of the water, if their establishment would benefit from a system, would they work individually or on a community level, and their potential concerns of implementation.

The third and final set of photos showed artistically designed rainwater harvesting systems. The participants revealed their preferred image, if they could see a system like this be implemented at their establishment, and any potential concerns.

Participants provided their most preferred image in each photoset theme under each category. Supplementary comments were given by the participants that were not directly related to the interview content, however, still proved extremely valuable to the data. The interview responses, preferred photos, and keywords can be viewed in the data analysis spreadsheet in Appendix C.

INSTRUMENTS NEEDED

Tables, chairs, clipboards, pens, and pencils were necessary for comfort and filling out the questionnaire and for the participants to use during the interview. The photosets were used to show images to the participants. Lastly, a recording device was used to record all interviews.

CONDUCTING THE INTERVIEWS

As part of the verbal consent, participants in the interviews were first notified of the researcher's name, purpose of the study, the structure of the interview, and how the interview would be recorded for transcription. The study considered all participants with no bias.

Interview Process

The interview process consisted of five major steps:

1. Asking participants their perceptions and attitudes on environmental awareness (drought, flooding, rain frequency, water conservation), water insecurity (availability and affordability), and rainwater harvesting (knowledge and value).

2. Informing the participants about rainwater harvesting and showing them visuals about current uses and asking them about their perceptions and attitudes of the systems. As well as if they had a general understanding of how the systems work.

3. Showing images about potential uses and asking about their preferred functional uses of collected water, if their establishment would benefit form a system like this, if they would be a part of a process individually or work with their community, and what their concerns about implementation were.

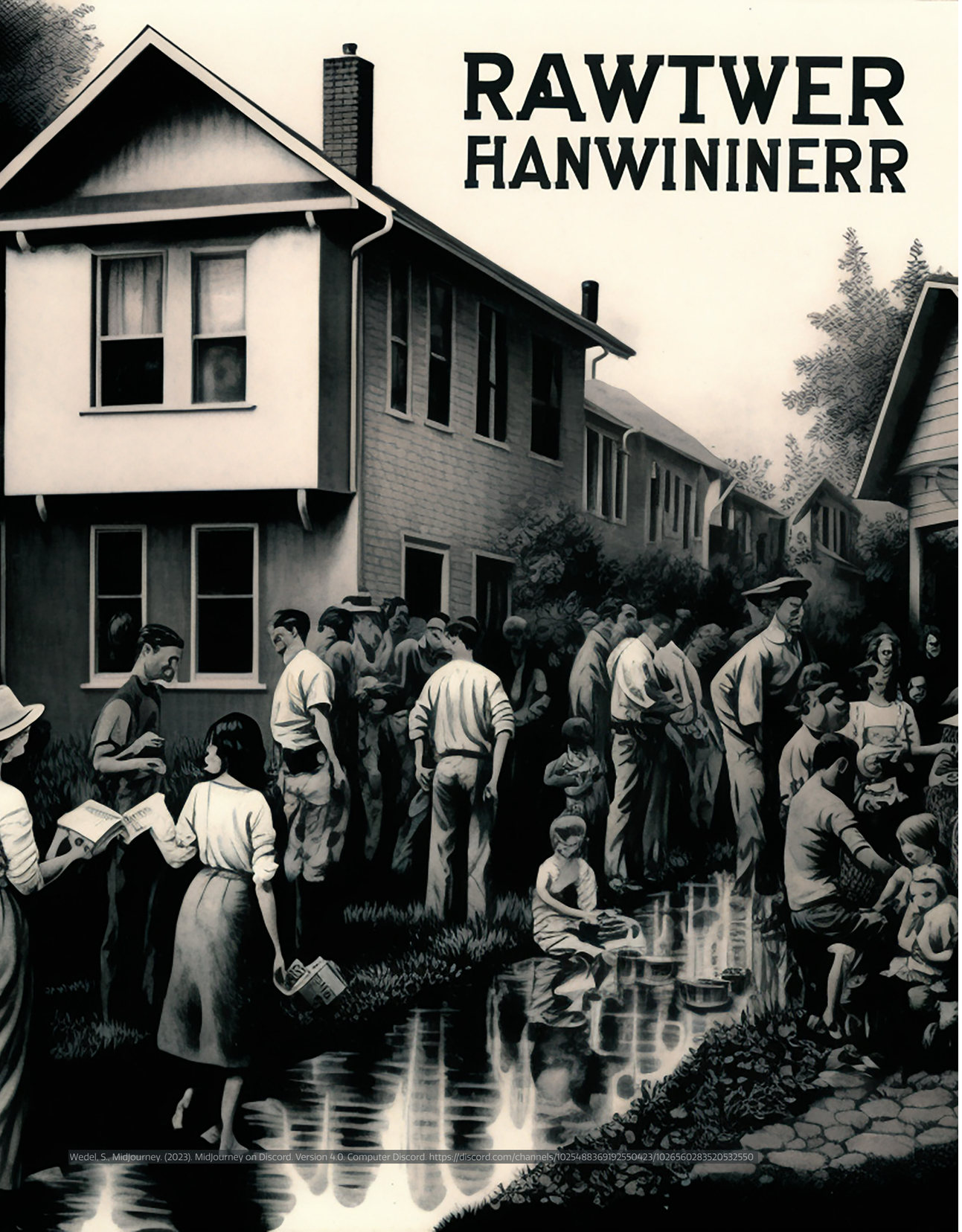
4. Showing artistically designed images to get participants feedback on their visual preference and aethetic perceptions on the harvesting systems.

5. Distributing a demographic questionnaire for the participant to fill out post verbal interview.

"I think that would benefit everyone. It would be free. Coming from the sky and having those [rainwater harvesting] systems in place already will prepare us for the future..."
- Community Member

Wedel, S., MidJourney. (2023). MidJourney on Discord. Version 4.0. Computer Discord. https://discord.com/channels/1025488369192550423/1026560283520532550

Wedel, S., MidJourney. (2023). MidJourney on Discord. Version 4.0. Computer Discord. https://discord.com/channels/1025488369192550423/1026560283520532550



Wedel, S., MidJourney. (2023). MidJourney on Discord. Version 4.0. Computer Discord. https://discord.com/channels/1025488369192550423/1026560283520532550

CHAPTER 4

REVEAL

ANALYSIS & FINDINGS

AUDIO TRANSCRIPTION

After the 15 interviews were conducted, the audio recordings were transcribed through a free trial of an online transcription software called Rev. After transcription was completed, the text was reviewed again to be sure no respondents' answers were incorrectly transcribed due to software audio errors. In the case that the audio transcription program was not accurate, manual transcription was performed to ensure accuracy. Each interviewer has been assigned their own Word document of recorded interviews and transcription. The audio recordings and transcriptions were separated into one of the three respective categories: 1) Cultural and Educational Institutes, 2) Industrial, Restaurant, and Retail, and 3) Residential and Living Centers.

DATA COLLECTION ANALYSIS

Overall Demographics

The interviews consisted of fifteen total participants from the three categories. There were four participants from the Cultural and Educational Institutes category, six from Industrial, Restaurant, and Retail, and five from Residential and Living Centers.

Despite no bias against gender orientation, the sample resulted in being male dominated. Gender population may bring some bias to the findings due to ideas represented primarily being from male participants – which is a limitation of this study. Eleven of the fifteen participants were male, and the remaining four were female. Regarding age of participants, there were six age ranges represented: two participants from 18-25 years of age, three from 26-35, two from 36-45, two from 46-55, four 56-65, and two participants 66+ years of age. A breakdown of the gender and age range can be viewed in Figure 4.1.

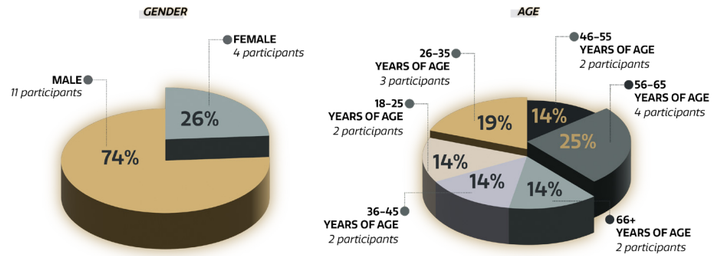


Figure 4.1 The distribution of gender and age among the participants recruited form the three categories.

There were a variety of neighborhoods represented by participants. There was one participant each for the following neighborhoods: Ivanhoe, Beacon Hill, Mt. Hope, Wendell Phillips, and Washington Wheatley. There were also two participants from 18th & Vine, two participants from Key Coalition, four participants from Jackson County, and two participants that did not disclose their location. Since the study area is located within Jackson County, this does not discredit the information provided by the four participants that indicated Jackson County as they were located within the study area at the time of recruitment.

Educational attainment overall consisted of a majority of bachelor's degrees, which were selected by eight participants. One participant had a high school degree as their highest level of education, two participants had some college and no degree, and four participants had a graduate degree. The makeup of the neighborhood location and educational attainment can be viewed in Figure 4.2.

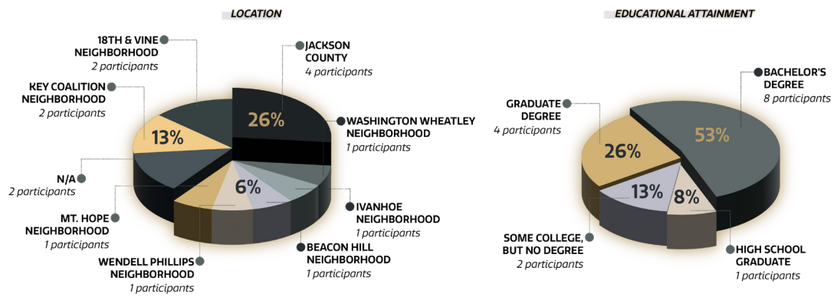


Figure 4.2 The makeup of the location and educational attainment of the recruited participants from the study area.

Two participants had an annual household income of $0 – $30,000, five participants had a household annual income of $31,000 – $60,000, two had $61,000 – $90,000, four had $91,000 – $120,000, and two participants had a household annual income of $120,000 or more. The land use category response breakdown and household income can be viewed in Figure 4.3.

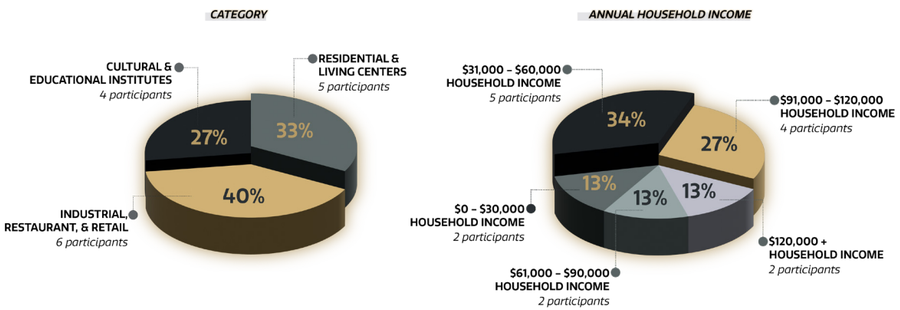


Figure 4.3 The category response breakdown and annual household income values for the participants.

The race of the participants included Black, White, and Asian.

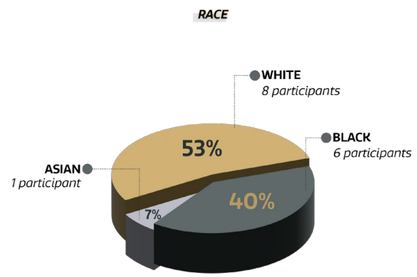


Figure 4.4 The category response breakdown of race among the participants.

Demographics Per Category

Cultural and Educational Institutes

All four participants in this category were males. One participant was 36–45 years of age, one participant was 56–65 years of age, and two were 66+ years of age. The current locations of these participants were Ivanhoe, Beacon Hill, 8th & Vine, and Mt. Hope. For educational attainment, one person was a high school graduate, while the other three had a graduate degree or higher. Lastly, two participants listed their annual household income as $0–$30,000, and the other two circled $91,000–$120,000.

Industrial, Restaurant, and Retail Services

Beginning with gender, all six participants in this category were male. There was one participant in each of the age ranges of 18–25, 36–45, 46–55, and 56–65 and two participants in the age range of 26–36. There was one participant from each of the neighborhoods of Wendell Phillips, Key Coalition, 18th & Vine, and Washington Wheatley, and two participants did not report their neighborhoods. In terms of educational attainment, one person had some college but no degree, while the remaining five participants had a bachelor's degree. Lastly, one participant listed their annual household income as $31,000–$60,000, one participant as $61,000–$90,000, two participants as $91,000–$120,000, and two participants at $120,000 or more for their annual household income.

Residential and Living Centers

The third category of this study, Residential and Living Centers included five participants, four females and one male. One participant listed their age as 18–25 years of age, one participant 26–35, one participant 46–55, and two participants 56–65 years of age. Of the five participants, one revealed their location of Key Coalition, while the remaining four participants wrote in Jackson County. Their educational attainment included one participant who has some college, no degree, three participants had a bachelor's degree, and one participant having a graduate degree. Lastly, four of the five participants have an annual household income of $31,000–$60,000, and one participant has an annual household income of $61,000–$90,000.

THEMATIC AND KEYWORD ANALYSIS

The interview question topics were the starting point of the thematic analysis process. *Environmental Awareness*, *Water Insecurity*, and *Rainwater Harvesting* were the three major themes analyzed for the interview portion without imagery. Upon further investigation, two supplementary themes of

Water Usage and Maintenance at Establishment, and *Water Department Related Issues* were revealed – resulting in five total themes for the interview portion without imagery.

Thematic Analysis for Interview Questions without Imagery

Using the transcription of the interviews, themes were revealed through a thematic analysis process. Repetitive phrases, words, and important points were noted for further investigation. For the thematic analysis, there was an inductive approach, meaning there were no preconceived ideas or notions pertaining to the analysis.

The coding of each transcription document included highlighting individual phrases or keywords that corresponded to the appropriate theme identified from the interview questions. As an example, a participant expressed their concern that if "Water shortages keep going the way they are, eventually that's going to trickle down to increased food costs…Im [sic] pretty concerned about [flood and drought]." This participant's concern was coded into the *Environmental Awareness* theme, which was finalized under the topic of *Drought and Flooding*. This category and response were developed based on the specific interview question asked, for example "What concerns do you have, if any, about future drought and flooding events?" This process concluded with 14 unique topics identified from the portion of the interview without imagery. These topics were identified under five major themes.

All coded data was organized in an Excel file consisting of three spreadsheets: one sheet presenting the demographics, one sheet analyzing the interview responses without imagery, and analyzing the interview responses including imagery. The spreadsheet for this analysis can be found in Appendix C. Further descriptive details will be discussed in the following sections.

For the interview analysis with no imagery, interview participants are listed on the left side of the sheet, with topics and themes across the top. Each interview participant has a unique identification name and number for reference. The topics across the top have a color-coded highlight that corresponds to the highlighted text in the transcribed Microsoft Word document. The highlighted text was then copied to the spreadsheet to the correct theme or topic column and participant row. The spreadsheet can be reviewed in two ways. First, the columns with the themes and topics as the header allow the viewer to read the participants' responses corresponding to that topic. The rows allow the viewer to read each participant's response to each theme – resulting in a comprehensive understanding of that participant in the entire interview without imagery.

A conceptual diagram revealing the steps to getting to the topics is shown in Figure 4.5.

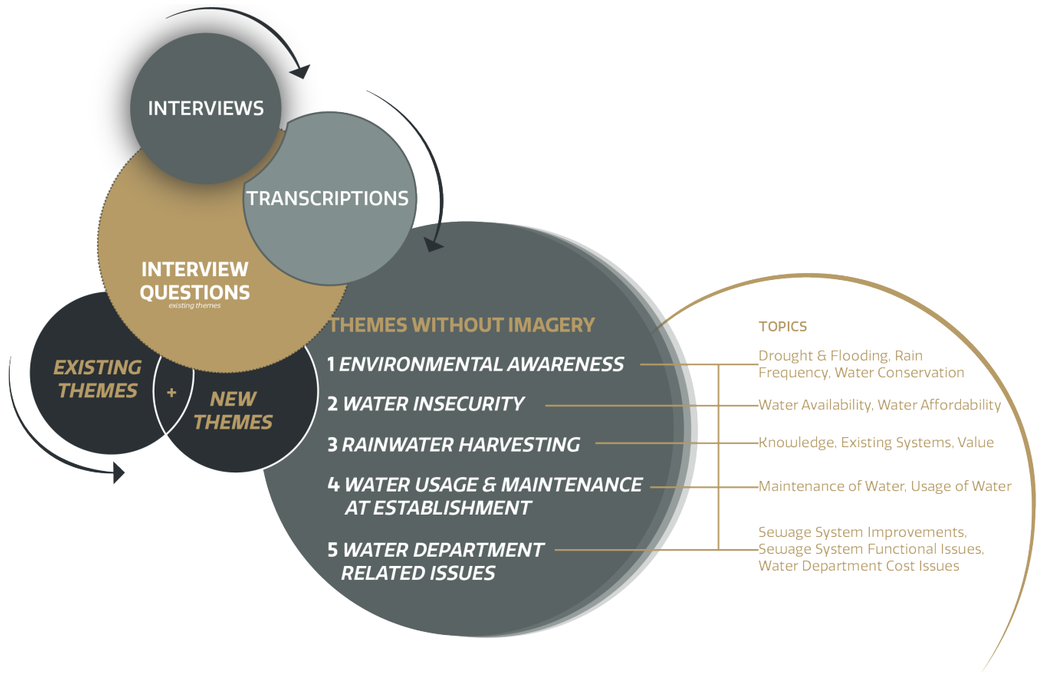


Figure 4.5 Conceptual diagram of the processes taken to concluding themes and topics distinguished from the transcipts of the interviews.

Environmental Awareness

The questions revolved around participants' environmental awareness regarding drought and flooding, rain frequency, and water conservation.

Most participants had a general knowledge of the environment, with approximately 46% of participants being concerned about flooding and approximately 26% concerned about drought. Other factors that contributed to this environmental concern were storms, global warming, climate change, and carbon emissions. For example, one participant states, "Global warming has created droughts and flooding. More storm systems." This reveals their personal experience with the environment. Lastly, there is a concern about the lack of environmental awareness and education available to the public and specific study area neighborhoods. A participant stated "...what it would cost to get it...learning curve for some people," which expresses the participants' concern for the lack of education in their neighborhoods about the environment and rainwater harvesting. Figure 4.6 shows the breakdown of environmental awareness.

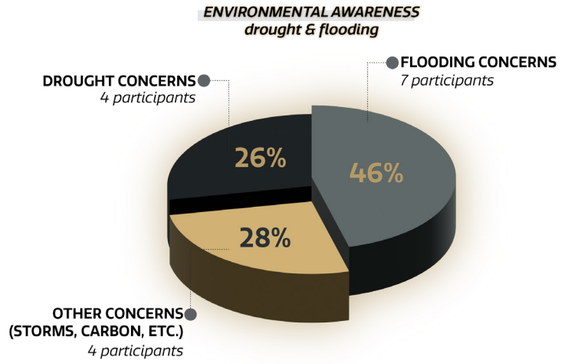


Figure 4.6 A chart showing the environmental awareness of drought and flooding and if the participants had concerns.

The second topic of rainfall frequency resulted in participants expressing their concern, or no concern, with the amount of rainfall currently experienced. Approximately 53% of participants felt concerned about rain frequency, whether this was too much or not enough rain. For example, a participant expressed their worry with the unpredictability of weather as, "Yes, because I think in the areas where it's needed, it's not happening and the areas where it's not, there's an overabundance of it." Whereas 20% of participants had no concerns, the remaining 17% either did not have enough environmental knowledge or had no comment on the subject. Figure 4.7 visualizes these results.

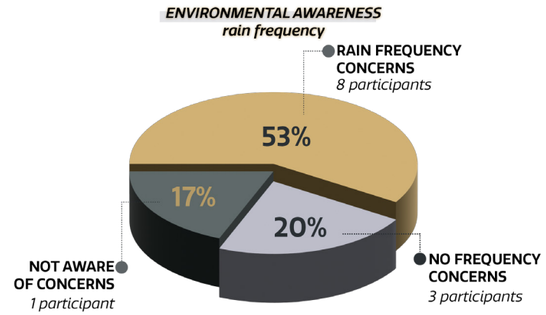


Figure 4.7 A chart showing the environmental awareness of rain frequency and if the participants had concerns or were aware of current weather patterns.

In terms of water conservation, the last topic in the environmental awareness theme, approximately 20% of participants practice some type of water conservation. Approximately 46% do not practice water conservation. However, this does not mean participants are not conscious about their water use. Since approximately 66% of participants are conscious about their water use, it is likely that they think about the water they use but may not take the extra step of practicing water conservation. In contrast, approximately 33% of participants are not conscious of their water use. This reflects the diverse understanding on the issue of water conservation. For instance, one participant stated that, "I am very conscious about my water use. I've been conserving water. I've been very conscious about how much I use." However, another participant stated, "Nothing in particular [regarding water conservation or consciousness]. So I don't know how big of a problem water conservation really is." This shows the diverse understanding of how one person may go through the extra steps of conserving, while another is not knowledgeable on the concept of water

conservation. Figure 4.8 shows the participants responses about water conservation.

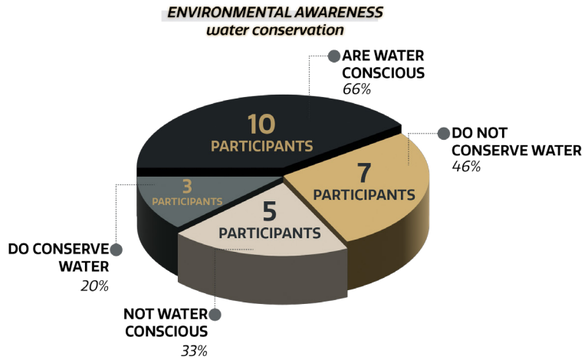


Figure 4.8 The environmental awareness and the participants conciousness of water, and if they practice water conservation.

Unlike the responses to questions with imagery, the participants' responses to the questions without imagery were not specific to each of the three land use categories defined earlier. Therefore, these responses are more generalizable.

Water Insecurity

The second set of questions was regarding participants' perception of water insecurity (Appendix C) and more specifically, water availability and affordability. There was not a high concern for water availability as approximately 80% of participants had no concern about water not being available at their establishment. The remaining 20% that did have concerns were due to other circumstances, such as pipes freezing – not directly related to the drought or flooding. For example, one participant stated, "My pipes [froze], and so at that point where now we're just dripping water and then in my mind, I'm like, I feel I am wasting water…But to drip the water, which is a waste to make your pipes not freeze." This reveals participants' awareness and care for the water they are using. Figure 4.9 reveals the makeup of participants responses of water insecurity.

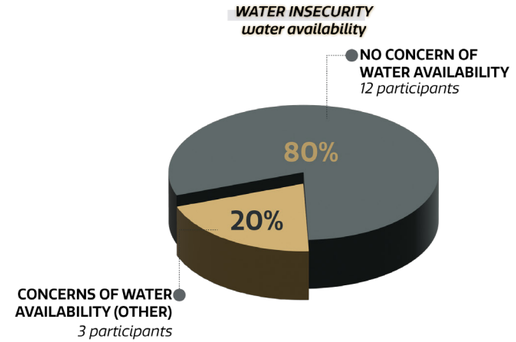


Figure 4.9 The level of concerns regarding water insecurity and if participants are concerned regarding water availability at their establishment.

Regarding participants' perceptions of affordability, approximately 92% of participants have not struggled to pay their water bill in the past year. The remaining 8% of participants did not know their water utility due to their landlord including the utility bills in their monthly rent. In terms of the water bill, approximately 46% of participants felt their water bills were too high for the amount of water they used, whereas 26% of participants felt their water bill was reasonable or not high. The remaining 20% of participants struggled to answer these questions due to on-going water concerns, issues, and discussions with the water department. These participants revealed that their meters were broken, and they were being reimbursed by the water department. This caused some participants to see a spike in their water bill from $200 to $1,100. One participant stated, "We got an $1,100 bill for one month. Sometimes it's $200 or $300 sometimes." Another participant stated, "We've had some issues with our water bill went up in the last year. It was running $600 or $700 a month. Well, I started looking into it and then we had some bad flappers. My water only runs about $90 a month here, but you see where it jumped up." These participants, while affording their water bill, are being charged significantly more than normal for their water even though they are not at fault. Figure 4.10 shows the participants responses.

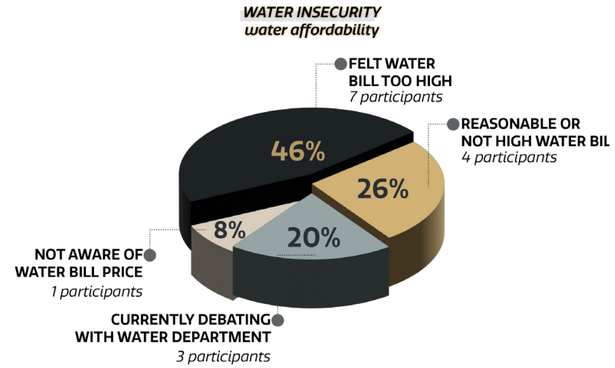


Figure 4.10 A breakdown on the participants feedback about water affordability and if they thought they paid too much for the amount of water they used.

Rainwater Harvesting

The major theme of rainwater harvesting had four topics – participants' rainwater harvesting knowledge, knowledge on existing systems near their establishment, perception on the value in rainwater harvesting, and supplementary comments after learning of rainwater harvesting.

Participants had a general understanding of rainwater harvesting and what it entails. Approximately, 66% of participants had knowledge of what rainwater harvesting was and were able to discuss in depth their understanding. One participant described rainwater harvesting as, "People put the barrel outside and they can collect…water [for] in their gardens." Another participant was able to provide more information, "I think I know the general idea about it…At the end of the gutter I hope to implement a bin, so to speak, to collect that rainwater…I can use the water directly out of the bin for watering the lawn and the garden and whatever I need. But if I do want to drink the water, I will have to somehow include a filter…" This reveals the varying knowledge between participants, and the possibility of awareness being a factor in application. The remaining approximately 34% of participants have no knowledge of rainwater harvesting. Figure 4.11 shows the participants responses on rainwater harvesting.

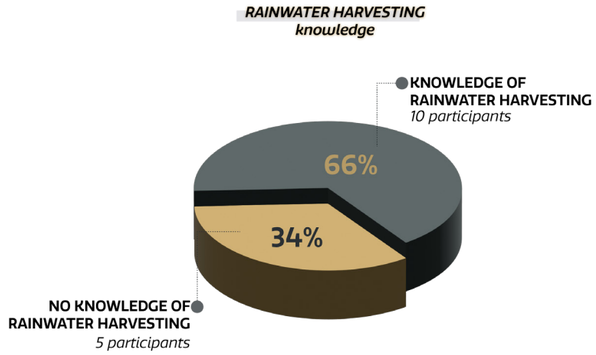


Figure 4.11 A chart showing the general knowledge of rainwater harvesting among the participants.

Of all the participants, only 20% knew of existing systems near their establishment. One participant was able to further describe their knowledge on the system, "Garden Chestnut Community Center…I know they've got a pretty large tower for water collection. 31st and Harrison. Two of the places that I know of that sure are actually doing some water collection." The 20% helps develop a sense of existing systems within the site, as well as the lack of systems and experiences that participants have with rainwater harvesting systems. The other 80% did not know of any existing systems and were not able to elaborate.

After being asked on their knowledge of rainwater harvesting, participants were read an informative paragraph describing rainwater harvesting and the value that it provides. When asked if participants saw value in rainwater harvesting after having heard the informative paragraph, approximately 86% of participants expressed their support and saw value in rainwater harvesting. Approximately, 14% did not see any value due to their time availability or did not see it as an important part of their establishment at the moment. For example, one participant stated, "On the assumption that structures, city structures don't collapse, I don't feel an urgency for it." Although participants were well aware of rainwater harvesting at this point in the interview, it did not deter from participants not seeing any value in them at the moment. Figure 4.12 shows the participants responses on rainwater harvesting value it provides.

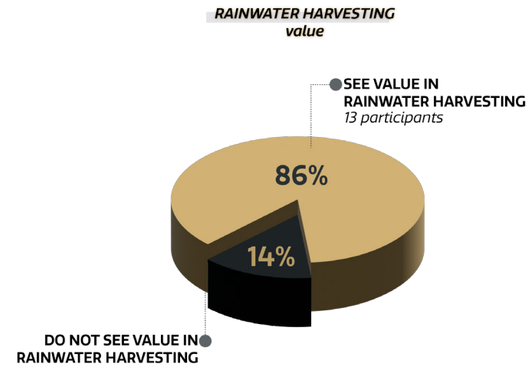


Figure 4.12 A breakdown of participants and if they see a value in rainwater harvesting after learning about it.

Lastly, there were general comments collected from participants after reading the informative paragraph about rainwater harvesting. These included general comments of their support in how they could see rainwater harvesting improving their water bill, such as "I would like to see how you would do that, but if you are able to do that, I guess it would save people on their water bill." It also revealed some participants' knowledge on larger environmental systems: "California…The reservoirs there, they're limited on the… water they can store because [they] were put in place to help for flooding…if they get too full, then it doesn't help flooding purposes." The overall environmental and rainwater harvesting awareness in the participants was relatively higher than anticipated.

Water Usage and Maintenance at Establishment and Water Department Issues

Under the two themes of Water Usage and Maintenance at Establishment and Water Department Issues, there were five topics identified: Maintenance of Water, Water Usage, Sewage System Improvements, Sewage System Functional Issues, and Water Department Cost Issues. This section will not go into depth of each of these but will highlight several important components.

Most of the participants do not have any unusual maintenance or use of water at their establishment.

However, one participant highlighted that the city is requiring them to implement a large underground cistern to collect stormwater and direct it into the stormwater drains; "I put a building up, then I got to find ways to get this run off to a certain area…and that's like a $200,000 investment." This specific individual is required to spend $200,000 to direct their stormwater runoff away from the buildings and into the existing system. Another participant is frustrated as "..the city charges me for rainfall. So if we get so much rainfall, I get more expense, which when you know, start looking at your bills, you're charging me for more rain. So they need to make it as feasible to them as they can too." These quotes express functional shortcomings experienced by the residents of these neighborhoods. Other water department concerns are meter issues and pipeline issues experienced by participants. This includes faulty water meters, street sewage backup, and the prevention of freezing pipes by dripping water.

Overall, there are concerns with the water department. Several participants are having to deal with meter readings being wrong and charging them, water bill spikes, new stormwater infrastructure costs, and water quality.

Inequity and Inequality

Three participants revealed their knowledge on sewage system improvements taking place throughout Kansas City. One participant stated, "Old sewer system, supposedly the sewers are going to be replaced. A billion dollars supposed to set aside." While another participant stated, "I know that they've been doing a lot of work with updating, upgrading right." Although these participants are aware of the sewer upgrades, they have not personally experienced any improvements. Based on the participants' comments, as well as through further investigation, it appears all improvements are north, west, or south of the eight-neighborhood study area. This poses the potential for water inequity to the residents east of Troost Avenue. As improvements are one issue, one participant also reported their concern for the quality of the water they receive, "Water quality. So that is a concern to me especially in communities of color. What is the quality of the water that we're ingesting and the sources of that water? What processes and things are filtering? Is it going through before it gets to the bottling

or establishment?" Participants are revealing the potential for significant inequity, and inequality in their water infrastructure maintenance, and water quality. There appears to also be an educational component to this topic. There is the possibility that residents are not aware of the opportunity that they could benefit from this program.

The diagram presented in Figure 4.13 expresses significant keywords repeated by participants in each land-use category, and how they relate to the major theme.

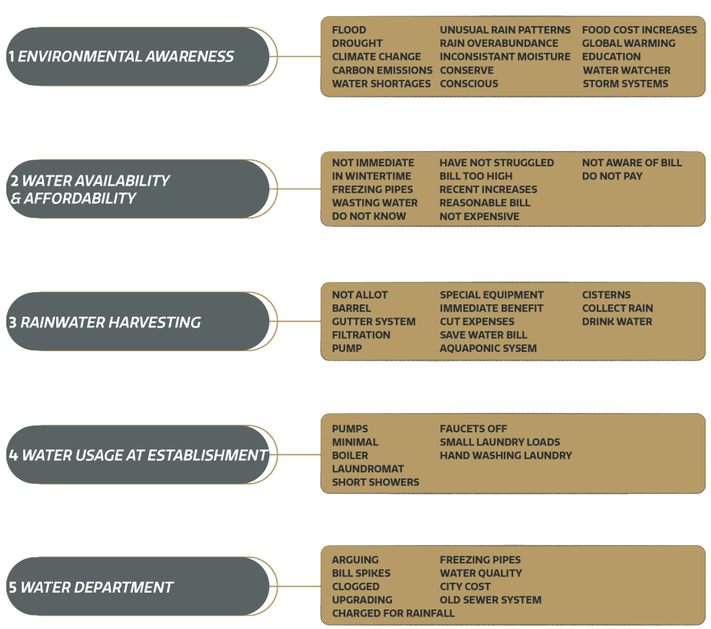


Figure 4.13 Conceptual diagram of the major keywords developed from the themes. Keywords are repeated words stated among all participants.

THEMATIC AND KEYWORD ANALYSIS WITH IMAGERY

The thematic analysis for the imagery portion of the interviews followed the same process as the interview portion without images. The coding of each transcription document included highlighting individual phrases or keywords that corresponded to the appropriate topic or concept identified from the interview questions. The process concluded with five unique themes identified from the portion of the interview with imagery coinciding. There are also corresponding comments per image, as well as comments per specific question asked. The responses and spreadsheet can be viewed in Appendix C.

All coded data was organized in an Excel file. The columns are organized per participant with a unique identification name and number. The rows correspond to each image shown in the interviews, as well as the topics that were developed per interview responses. The columns represent the participants in each of their respective categories. There are three categories of imagery, 1) Cultural and Educational Institutes, 2) Industrial, Restaurant and Retail, and 3) Residential and Living Centers.

Each category consists of three sets of images that relate to that category. The image themes are *Current Rainwater Harvesting Systems, Functional Use Diagrams,* and *Artistically Designed Systems.*

Upon analysis, five major themes were developed based on participants responses of the imagery and interview questions. These five themes for the imagery portion of the interview include *Uses, Concerns, Implementation, Appearance,* and *Preferred Images*. The following sections will break down these themes into descriptive detail and reveal how the participants responded.

Cultural and Educational Institutes

Current Rainwater Harvesting Systems

This section of imagery discussing current rainwater harvesting systems is more informative rather than getting responses from participants. The researcher described each image and how it works, and then asked the participant if they had any questions or comments. For this category and theme of imagery, there were minimal comments and no questions. One participant stated that they had never seen Image 6 C (C), "...makes sense because you can hold more water. Underground, it maintains its temperature.....that for toilets is ideal." Image 6 C (C) can be viewed in Figure 4.14.

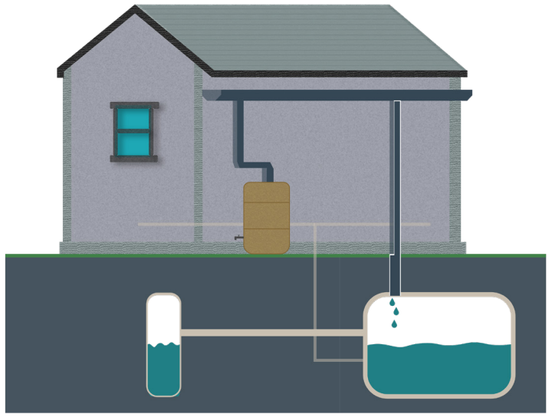


Figure 4.14 Image 6 C (C): Example of a current rainwater harvesting system that has both above and underground storage tanks to collect rainwater for later use.

Functional Use Diagrams

The functional use diagrams were explained by the researcher, and then were followed by a series of questions that can be viewed in Appendix B. The five images shown to the participants were relatively evenly chosen across this category of Cultural and Educational Institutes. For example, two participants chose Image 1 F (C), three participants chose Image 2 F (C), two participants chose Image 3 F (C), and three participants chose Image 4 F (C). Whereas only one participant chose Image 5 F (C). The participants that chose Images 1-4 F (C), pointed out specific keywords from the imagery. For example, a keyword from Image 1 F (C) is **Baptisms**. This was pulled from a quote of a participant saying, "Yes, the baptism, I'd probably have a filter." Whereas the word **Filter** was also another keyword distinguished for this image. This similar process was practiced for each image in this category. Another example would be one of the most picked images, Image 2 F (C), participants stated, "The toilet... the basement toilets.", and "Maybe as a backup for the utilities in the building?". The least chosen image, Image 5 F (C), only had one comment, "Yes." Revealing that only one participant thought "play and gatherings" would be useful in a church establishment. Image 2 F (C) and Image 5 F (C) can be viewed in Figure 15.

Figure 4.15 Image 2 F (C) (left) shows the most preferred image of existing connections, and Image 5 F (C) (right) shows least preferred - play and gatherings.

Artistically Designed Systems

Similar to the other two image themes in this category, keywords were distinguished from the participants responses of the images shown to them. Image 1 A (C) was the popular choice from the artistically designed system images. Three of the participants chose Image 1 A (C) and stated, "This one here.", or "...that's a big fella...", also "That is interesting". Therefore, keywords **Big** and **Interesting** were distinguished. The least popular choices were Image 2 A (C), and Image 4 A (C). The same participant chose both these images and stating, "That one.", and "So then something like that would definitely work." Again, this similar process was practiced for each participant's comments through the three categories and each image theme. Image 1 A (C) and Image 4 A (C) can be viewed in Figure 4.16.

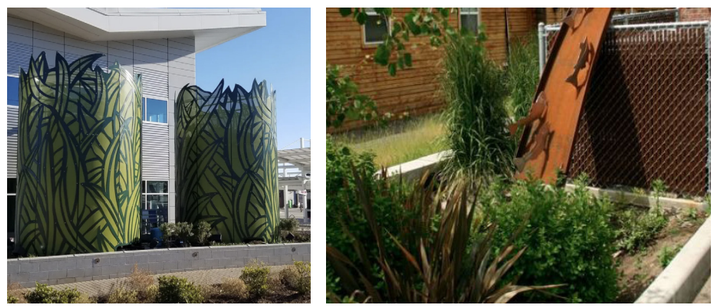


Figure 4.16 Image 1 A (C) (left) shows the most preferred image of artistic systems, and Image 4 A (C) (right) shows the least preferred image.

Industrial, Restaurants, and Retail

Current Rainwater Harvesting Systems

Explanation was given to each participant about the images of current rainwater harvesting systems. There were no specific image that stood out to a participant. However, there were several general comments stated after the researcher's explanation of imagery. For example, one participant stated, speaking towards all images, "Seems pretty cool to me." While another participant stated, "I'm not sure if I've seen rainwater collection systems or not." This revealed the benefit of showing current rainwater harvesting systems in the Industrial, Restaurants, and Retail category.

Functional Use Diagrams

Five images of potential functional use of collected water were shown to participants. Two images, Image 3 F (I), and Image 4 F (I) were the most popular with three priority comments each. Image 3 F (I) had several comments towards watering such as, "For the water or other plants.", and "Plants for watering as well." Therefore, the keyword(s) **Watering**, and **Plants** were distinguished from this image. Image 4 F (I) had several comments towards human use and consumption such as, "Consumption here versus anything else.", or "Human use would be huge.", and "Hooking up for gray water for sinks and toilets and thing would certainly be convenient." Therefore, keywords **Consumption**, **Human Use**, and **Sinks and Toilets** were distinguished from the participants responses. The least chosen images were Image 1 F (I), and Image 2 F (I). Two separate participants chose one of each. For Image 1 F (I) the participant stated, "I would say at least the car washing aspect of it." Therefore, revealing the keyword of **Car Washing**. For Image 2 F (I) the participant stated, "I would say definitely the cleaning" – distinguishing **Cleaning** as the keyword. It is important to note that Image 5 F (I) was not chosen at all – showing water collection from impervious lots. Image 4 F (I) and Image 5 F (I) can be viewed in Figure 4.17.

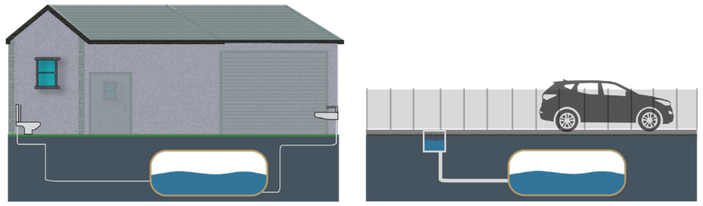


Figure 4.17 Image 4 F (I) (left) shows the most preferred image of functional use, and Image 5 F (I) (right) shows the least preferred image.

Artistically Designed Systems

Four images of artistically designed rainwater harvesting systems were shown to the participants of this category. All images were well received except for Image 2 A (I). Image 1 A (I) had comments regarding its appearance such as, "I would say number one, so I liked how they concealed that.", and "The top left [1] with the plant disguise barrels.". Therefore, keywords **Concealed** and **Disguised Barrels** were distinguished. Image 3 A (I) had comments about its appealing nature, "Number three. Yeah. Number three. It's more appealing to the eye.", and "That looks appealing". Therefore, the word **Appealing** was distinguished from the respondents. Lastly, Image 4 A (I) had several varying comments regarding its appearance and one of them being negative, "I'm thinking that's tacky enough that it might pull my real estate value down right?". Therefore, the keyword **Tacky** was revealed. The least chosen image was Image 2 A (I) which also had a negative comment, "I don't look at that and think rainwater [harvesting]." Image 2 A (I) and Image 3 A (I) can be viewed in Figure 4.18.

Figure 4.18 Image 2 A (I) (left) shows the most preferred image of functional use, and Image 3 A (I) (right) shows the least preferred image.

Residential and Living Centers

Current Rainwater Harvesting Systems

Post explanation of images to each participant, there were several comments about the images, some more in depth than others. For example, one participant states, "No, I think I have a general understanding these look like they're kind of added on later in." Whereas another participant stated, "Those look cool. I like the underwater underground one." Lastly, "No, I'm actually trying to consider number six for my own house." These images revealed the variety of perceptions and uses of current rainwater harvesting systems. Image 6 C (R) can be viewed in Figure 4.19.

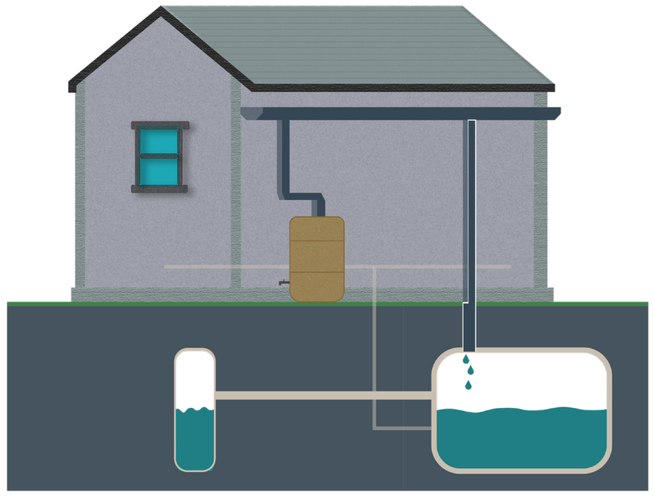


Figure 4.19 Image 6 C (R): Example of a current rainwater harvesting system that has both above and underground storage tanks to collect rainwater for later use.

Functional Use Diagrams

Six images were shown of how participants could potentially use collected rainwater at their residential home. All images were popular among a variety of participants. However, two images were consistently chosen, Image 2 F (R), and Image 3 F (R). Image 2 F (R) showed how the system could be hooked up to an irrigation system. Participants stated, "Yeah, definitely, I think having a system like this in place instead of a traditional irrigation system would motivate people to plant more sustainable landscapes.", or "...all very useful.", "Irrigation I guess would work.", and "I wanted to build a system for number...two..." Therefore, keywords **Irrigation**, **My House**, and **Useful** were keywords distinguished from this image. Image 3 F (R) was showing potential habitat support. Participants were stating, "...very useful.", or "Yeah, I think especially the ones for watering habitat support. I could see that working really well.", and "I want to build a system for number...three..." Therefore, keywords **Habitat Support**, **Useful**, and **My House** were distinguished. There were no images that stood out to be the least chosen, as Image 1 F (R), Image 4 F (R), Image 5 F (R), and Image 6 F (R) all had two votes. Image 2 F (R) and Image 4 F (R) can be viewed in Figure 4.20.

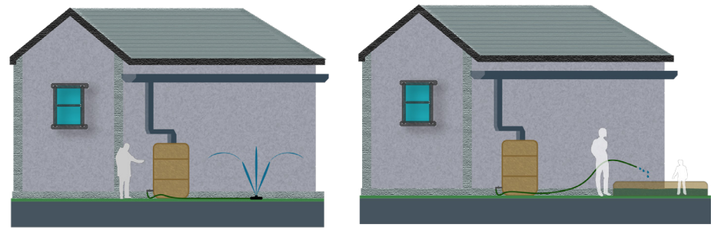


Figure 4.20 Image 2 F (R) (left) shows the most preferred image of functional use, and Image 4 F (R) (right) shows the least preferred image.

Artistically Designed Systems

Six images were also shown to participants of a more artistically designed system in a residential setting. Through explanation and responses, all images were received well by the participants. One image that was chosen the most by participants was Image 4 A (R) showing a rain chain. There were varying comments such as, "I really like the kind of artistic aspect that it brings in with the sound and the visual aspect.", or "This one, because I love hanging stuff.", and "Well, aesthetic, aesthetically, I would say...four.". Therefore, keywords **Artistic**, **Hanging**, **Aesthetic**, **Sound**, and **Visual** were distinguished. Image 2 A (R), and Image 6 A (R) were the least chosen images with two votes per image. Image 5 A (R) and Image 6 A (R) can be viewed in Figure 4.21.

Figure 4.21 Image 5 A (R) (left) shows the most preferred image of functional use, and Image 6 A (R) (right) shows the least preferred image.

Thematic and Keyword Analysis for Interview Questions with Imagery Across the Three Categories

Interview questions were asked during the showing of all the images. Those questions and images can be viewed in Appendix B. Through thematic analyses and keywork analysis, four themes were developed from the responses of the interview questions with imagery. These themes include *Uses, Implementation, Appearance,* and *Concerns*. The keyword analysis helped distinguish the commonalities across all categories, as well as the differences. The following sections will further explain the commonalities and differences across the three categories and four themes. There is also a descriptive detail of the commonalities and differences in the following paragraphs. Table 4.1 at the end of this section is a comprehensive understanding of the analysis and how it related to the themes, topics, and keywords.

Commonalities Across the Three Categories

Uses

The first theme of Uses is one of the most important, as it learns how each category would potentially use collected rainwater. Upon conducting keyword analysis, the common uses across all the categories included **toilets and utilities**, **irrigation**, and **human consumption**.

Implementation

Effort includes working individually or as a community to create a set of integrated rainwater harvesting systems. All categories were willing to put in effort to create this at an individual level, and all categories were willing to put in effort to create this at a community level for an integrated system. Some keywords identified include **willing**, **interested**, **collaborate**, **community**, **work with community**, and **surrounded by businesses willing**.

Appearance

Appearance commonalities included **aesthetics**, **functionality**, **appearance**, and **functional**.

Concerns

There were several concerns that were consistent across all the three categories. These concern keywords include **cost**, **perceptions and aesthetics**, **water quality**, **installation**, and **maintenance.**

Differences Across the Three Categories

Uses

While there were commonalities, there are also differences that distinguish each category from one another. In terms of the use of collected rainwater, the category Cultural and Educational Institutes had the following differences than the other categories; they would use the water for **mopping and cleaning**, **washing cars**, and **baptisms**. The Industrial, Restaurant, and Retail category would use the water for more of a **functional** operation opposed to aesthetics. Lastly, the category of Residential and Living Centers would use the collected water for **pools**, **splash pads**, **fountains**, and **fire hydrants**.

Implementation

The differences for the effort of each category are as follows. For the Cultural and Educational Institutes, one participant saw **no vision** of how an individual or community effort

could work. The Industrial, Restaurant, and Retail category had a participant who was willing to take an extra step and **partner with neighborhood associations**. Lastly, the category of Residential and Living Centers were willing to work as a community effort, but some residents were either **unsure/I don't know**, or they were worried about the **financial** aspects that may come with the process.

Appearance

The differences for the appearance for the categories are as follows. For the Cultural and Educational Institutes, one participant stated they preferred it to be **hidden**. The Industrial, Restaurant, and Retail category, one participant stated that they had **no care in visual appearance**. Lastly, the Residential and Living Center category had a difference in that they wanted an **artistic** appearance of the system(s).

Concerns

There were several concerns when it came to the differences per category. For the Cultural and Educational Institutes, they were worried about **accessibility (age)**, and **return on investment** into the systems. The Industrial, Restaurant, and Retail category had concerns about **space**, the **learning curve**, **landlords**, and **spending money to save money for their business**. One participant also stated there was **no need** as their current water bill is low. Lastly, the Residential and Living Center Category had concerns of **available resources**, **high-rise apartment buildings**, **construction**, and **implementation**.

Table 4.1 Common and Different keywords across all three categories; as well as how they relate to the themes.

Themes:	Common Keywords Across all Categories:	Differences in Keywords Across all Categories:
Uses	*Uses of Systems* Toilets & Utilities (3) Irrigation (3) Human Consumption (5)	*Uses of Systems* Fire Hydrants (R) Fountains (R) Splash Pads (R) Pools (R) Baptism (C) Wash Cars (C) Mop/Clean (C) Functional (I)
	Willingness to Have a System? Yes (7)	*Willingness to Have a System?* Artistic (R) Cost (C) More Information (C) Space (C) Human Consumption (I)
Implementation	*Willingness to Create Individually?* Definitely Interested (4)	*Willingness to Create Individually?* No Vision (C)
	Willingness to Create as Community? Willing (2) Invest In (2) Collaborate (1) Community (3) Yes, Businesses (1) Not Opposed (1) Be a Part Of (3) Would Like to (1)	*Willingness to Create as Community?* I Don't Know (R) Financial (R) No Vision (C) Partner with Neighborhood Associations (I)
Appearance	*Aesthetic Appearances and Perceptions* Aesthetics (3) Functionality (3) Appearance (2)	*Aesthetic Appearances and Perceptions* Artistic (R) Hidden (C) No Care in Visual Appearance (I)
Concerns	*Barrier Expenses as Concerns* Cost (7)	*Barrier Expenses as Concerns* Implementation (R) Construction (R) Return on Investment (C) Saving Money/Water Bill is Low (I)
	Potential Concerns Percpetions/Aesthetics (2) Water Quality (1) Installation (3) Cost/Maintenance (4)	*Potential Concerns* Accessibility (C) Landlord (R & I) Time (R) Resources (R) High Rise R) Space (I) Learning Curve (I)

LEGEND: (#) – NUMBER OF TIMES PARTICIPANTS STATED KEYWORD
(LETTER) – LAND-USE CATEGORY THAT STATED KEYWORD

Wedel, S. MidJourney, (2023). MidJourney on Discord, Version 4.0. Computer Discord. https://discord.com/channels/1025488369192550423/1026560283520532550

Wedel, S. Midjourney. (2023). Midjourney on Discord. Version 4.0. Computer Discord. https://discord.com/channels/1025180826919255042 3/1026560283520532550

CHAPTER 5

APPLY

GUIDELINES & RECOMMENDATIONS

GUIDELINES FOR IMPLEMENTATION

Starting a rainwater harvesting system within an urban community can begin to provide a resource to those in need. It can also serve as an educational tool for neighborhood residents and offer instruction on how to create their own systems. The systems can be land-use specific or specified to a certain type of use for the collected rainwater.

This guide is a toolkit for potential users of rainwater harvesting systems to understand the appropriate type of rainwater harvesting system, size, use of collected water, and visual aesthetics of such systems. This guide will discuss overall rainwater harvesting types, land-use categories and appropriate systems, cost, installation, maintenance, and use of collected water.

The purpose of this guide is to increase rainwater harvesting awareness and help educate on rainwater harvesting, water conservation, economic benefits, and environmental benefits provided by rainwater harvesting. The broader implications are to share this guide with neighborhood residents and the city of Kansas City to act as a resource in consideration of their future water conservation efforts.

RAINWATER HARVESTING SYSTEM TYPOLOGIES

Rainwater harvesting systems will be different depending on the land-use, users of the water, where it is located, and how the collected water will be used. The following types of rainwater harvesting systems are estimated recommendations based on precedents and possibilities available across different land-uses and square footages. These different system typologies have been primarily based on capacity and space that would apply to different types of land-uses based on their variety of surface typologies and potential uses of the collected rainwater.

All recommendations are based on previous resources, research, and examples presented in this document, as well as community feedback from neighborhood residents and representatives of the study area. All recommendations are from a student design-expert perspective. It is important to note that any installation following these guidelines should be consulted with a licensed professional prior to implementation, such as a rainwater harvesting specialist, contractor, water conservationist, licensed landscape architect, urban planner, plumber, or personnel from the Water Department.

Each system typology is a recommendation. Therefore, there can be the possibility that multiple containers be used in one system typology by the land-use category. The multiple containers would primarily benefit from multiple uses desired for the water or real estate space.

Considerations of System Typologies

The process for developing the categories included randomly selecting buildings of each land-use category to get an approximate range of square footage. This range was used to estimate the amount of water able to be collected in a month of moderate rainfall. All calculations for water able to be collected are based on constants and data collected from the Kansas City Water Utilities and Department. Refer to Table 3.1 in *Chapter 3: Technique* for an example calculation.

Checking the market was a part of the process and understanding tank size availability and tank size increase frequency. The tank size recommendations were developed based on this availability and frequency, the needs of the different land-use categories, and the land-use impervious roof surface square footage. Through this, four major system typologies have been developed based on the square footage, tank size, and material. For rainwater harvesting users that wish to have more specific container size determinations, refer to the below calculation to determine an exact appropriate size of the container needed for their establishment and desired use of collected rainwater.

$$\textit{Catchment Area } (ft^2) \times \textit{Rainfall (Inches)} \times \textit{0.5 (Gallons Per ft)} = \textit{Harvest Water (Gallons)}$$

SYSTEM TYPE 1

POTENTIAL LAND-USE TYPE:

Land-use types that may fall into this typology can include, but are not limited to, sheds, residential homes, small retail and restaurants, and small education and cultural establishments.

SIZE:

This system typology will contain a 55-gallon – 5,000-gallon storage container(s) for the harvested rainwater. A 55-gallon rain barrel is 2' in diameter and 4' in height, and a 5,000-gallon rainwater storage container is 11.5' in diameter and 7.5' in height.

SQUARE FOOTAGE OF COLLECTION SURFACE:

This is estimated based on an approximate 20 – 5,000 square-foot of roof surface able to be collected from.

COST:

The cost of installation would range from approximately $50 to $4,500. This is dependent on the size and complexity of the system.

MATERIAL:

For the sizes of these containers, and a cost-effective approach, it is recommended that Polyethylene (plastic) or Fiberglass be used as the material.

AMOUNT OF WATER ABLE TO BE COLLECTED:

For a 20 – 5,000 square-foot roof surface, there is potential for approximately 70 – 16,700 gallons of water to be collected in a month with moderate rainfall.

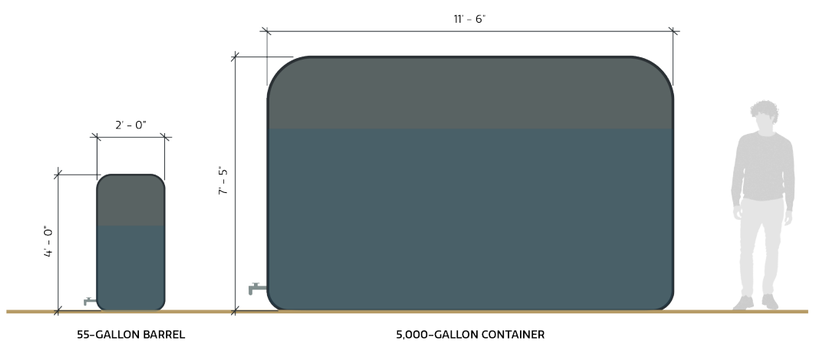


Figure 5.1 Rainwater Harvesting System Typology 1.

SYSTEM TYPE 2

POTENTIAL LAND-USE TYPE:

Some land-use types that may fall into this typology are large residential homes, restaurants, retail, small apartments or living centers, and education or cultural institutes.

SIZE:

Container(s) approximately 5,000-gallons – 10,000 gallons in size are estimated for this typology. A 5,000-gallon rainwater storage container is 11.5' in diameter and 7.5' in height, and a 10,000-gallon container is 11.5' in diameter and 13.5' in height.

SQUARE FOOTAGE OF COLLECTION SURFACE:

This is estimated on an approximate basis of 5,000 – 10,000 square-foot of roof surface able to be collected from.

COST:

The cost for installation would range approximately $4,500 - $16,000.

MATERIAL:

Due to the sizing of the container, and a cost-effective approach, Polyethylene (plastic) or Fiberglass is recommended.

AMOUNT OF WATER ABLE TO BE COLLECTED:

For a 5,000 – 10,000 square-foot roof surface, there is potential for approximately 16,700 – 33,500 gallons of water able to be collected in a month with moderate rainfall.

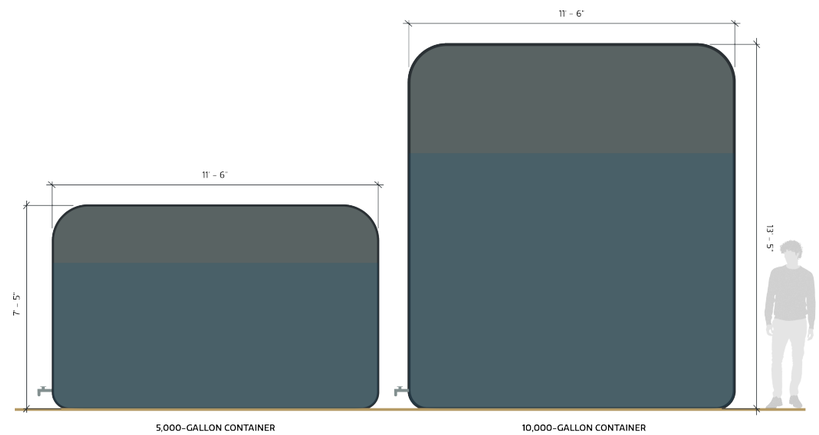


Figure 5.2 Rainwater Harvesting System Typology 2.

SYSTEM TYPE 3

POTENTIAL LAND-USE TYPE:

System Type #3 may include industrial land-uses, large restaurants and retail, educational institutes, and apartments or living centers.

SIZE:

For System Type #3, a container(s) approximately 10,000-gallons – 15,000-gallons is estimated. The 10,000-gallon rainwater storage container is 11.5' in diameter and 13.5' in height, and a 15,000-gallon container is 12' in diameter and 20.5' in height.

SQUARE FOOTAGE OF COLLECTION SURFACE:

This is estimated on an approximate 10,000 – 15,000 square-foot of roof surface able to be collected from.

COST:

The installation cost would range approximately $16,000 - $25,000. Add up to an additional $5,000 – $15,000 for steel.

MATERIAL:

The sizing of the container in this typology would allow for Polyethylene (Plastic), Fiberglass, or Steel. Steel should be considered for the possibility of damage occurring to your tank, depending on the land-use/business.

AMOUNT OF WATER ABLE TO BE COLLECTED:

For a 10,000 – 15,000 square-foot roof surface, there is the potential for approximately 33,500 – 50,400 gallons of water able to be collected in a month with moderate rainfall.

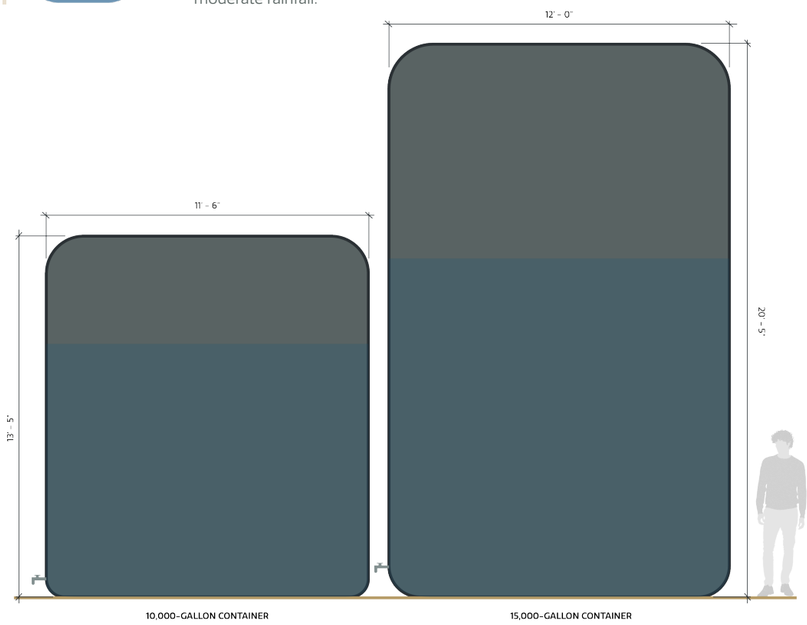


Figure 5.3 Rainwater Harvesting System Typology 3.

SYSTEM TYPE 4

POTENTIAL LAND-USE TYPE:

Land-use types that may fall into System Type 4 are industrial, educational, large cultural establishments, apartments and living centers.

SIZE:

This typology will estimate a 15,000 – 20,000-gallon container for storing collected rainwater. A 15,000-gallon rainwater storage container is 12' in diameter and 20.5' in height, and a 20,000-gallon container is 14' in diameter and 20' in height.

SQUARE FOOTAGE OF COLLECTION SURFACE:

The container sizes are estimated on an approximate 15,000 – 20,000 square-foot of roof surface able to be collected from.

COST:

Installation costs range approximately $25,000 - $40,000. Add an additional approximately $5,000 $10,000 for steel.

MATERIAL:

Land-uses with containers of this size should begin considering galvanized steel for their storage containers. They are more durable and can endure more damage than plastic, and they are also easier to repair. However, Polyethylene (plastic) and Fiberglass are still acceptable.

AMOUNT OF WATER ABLE TO BE COLLECTED:

There is the opportunity for approximately 33,500 – 67,000-gallons of water able to be collected in a month of moderate rainfall.

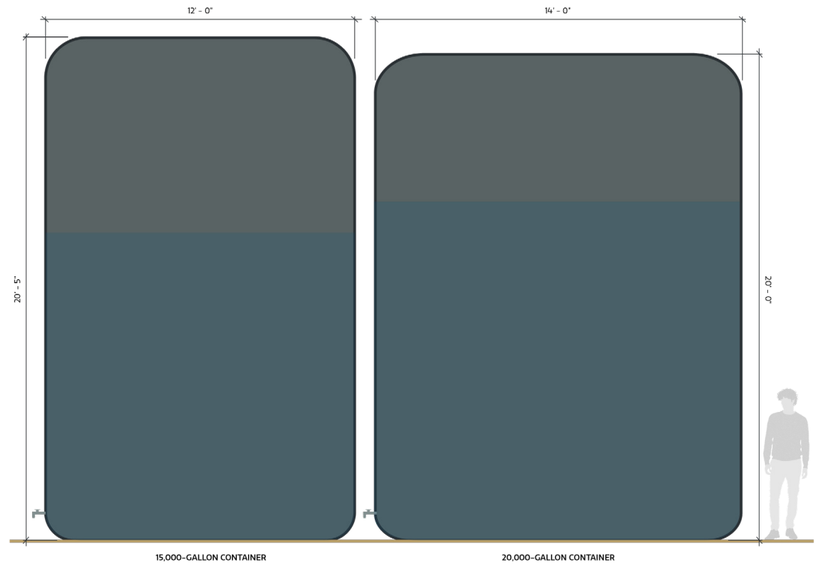


Figure 5.4 Rainwater Harvesting System Typology 4.

SYSTEM TYPE 5

POTENTIAL LAND-USE TYPE:

Some land-use types that may fall in type #5 are large industrial buildings, large educational institutes, living centers, large cultural institutes, and large apartments.

SIZE:

Approximately 20,000 gallons or larger container.

SQUARE FOOTAGE OF COLLECTION SURFACE:

The container sizes are estimated on an approximate 20,000 + square-foot of roof or impervious collection surface.

COST:

Installation cost is no less than $35,000.

MATERIAL:

It is recommended at this size of unit that Steel containers to be used. However, Polyethylene (plastic) and fiberglass will suffice. For an additional cost, concrete can also be poured, cast, and used as a storage container.

AMOUNT OF WATER ABLE TO BE COLLECTED:

At 20,000 + square feet, approximately 67,000-gallons of water can be collected in a month of moderate rainfall. This figure increases with the square footage.

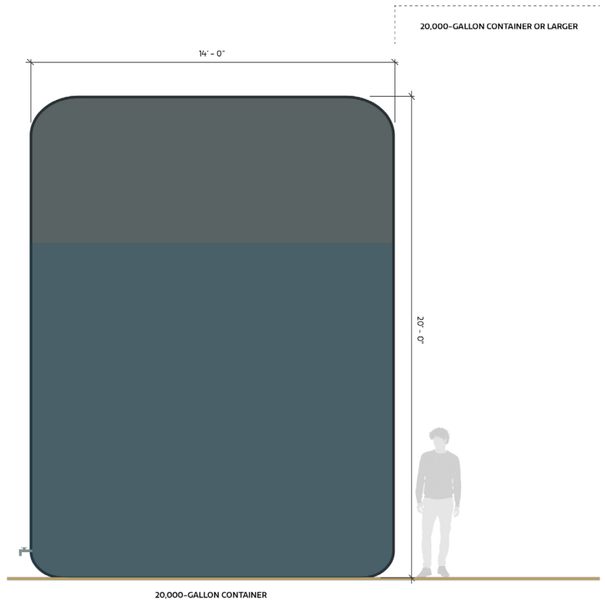


Figure 5.5 Rainwater Harvesting System Typology 5.

ORGANIZATION OF THE RAINWATER HARVESTING SYSTEM

Prior to installing a rainwater harvesting system, there needs to be an understanding of all the components and processes that go into the installation and maintenance. The following phases and steps describe specific topics that need to be considered from an individual and community effort. The following two phases were adapted from GROW (2018) and Hunt (2021) and changed to fit to this study:

Phase 01 – Pre-installation Considerations

Step 1: Understanding 'What it Takes'
It is important to understand what it takes to implement and maintain a rainwater harvesting system. Is it going to be an individual project? A community-led initiative? It is important to ask general questions: What are the goals of the rainwater harvesting system? Where do I want it located? Do I have the space for it?

This is also the first step in knowing the funding sources, budget, and developing a system of care and maintenance. This could also be a first step to potentially testing a 'trial and error' system. Collecting recycled materials and building a test-system to see if it is something that can be maintained and used to collect the rainwater.

Step 2: Organize a 'Committee' or Meeting with Participants
This step is primarily for a community-level rainwater harvesting system. This will reveal the amount of community support for the system, as well as the desired system typology and use(s) of the collected rainwater. Questions to consider during this step:

1. Which category do you identify with, and which system is appropriate for the community?
2. What is the most important aspect you want out of the system?
3. What is the existing educational and environmental awareness of rainwater harvesting systems in the community?
4. Who wants to participate?

5. How should the water be distributed? What limitations apply?
6. Is it appropriate to have one collection tank or multiple?

The intention of this step is to learn and inform community members about rainwater harvesting systems. This meeting should also establish a set of 'leaders' to promote, initiate, and follow the project to completion. It is also important to establish which, if any, community members (if not funded by a grant) wish to financially invest in a system like this.

Step 3: Identify Available And Needed Resources

Step 3 is the process of identifying what resources are available and what expertise is needed to implement the rainwater harvesting system. Is the system able to be implemented by the user solely, as a group, neighbors with expertise, or is hiring a contractor needed – these are all important factors to consider.

This is also when any community members can reveal their expertise in these areas. This will help reduce costs if community members, neighbors, friends, or family are able to help with installation.

Step 4: Selecting a Location for the System

There are several factors to consider when choosing a location for the rainwater harvesting system. One of the most important factors is space. The space will differ per land-use and system typology. It will be important to consider not only the storage container, but the space that supplementary piping, gutters, filters, spigots, and any overflow containers may require. Refer to the system typologies for spacing and dimensions of the rainwater harvesting systems.

Step 5: Identifying Supplies Needed

Once the system type and location are established, it will be important to consider the supplies needed to install the system. While contractors will primarily provide a majority of the materials, for this example, materials will still be discussed for users who wish to install independently. The

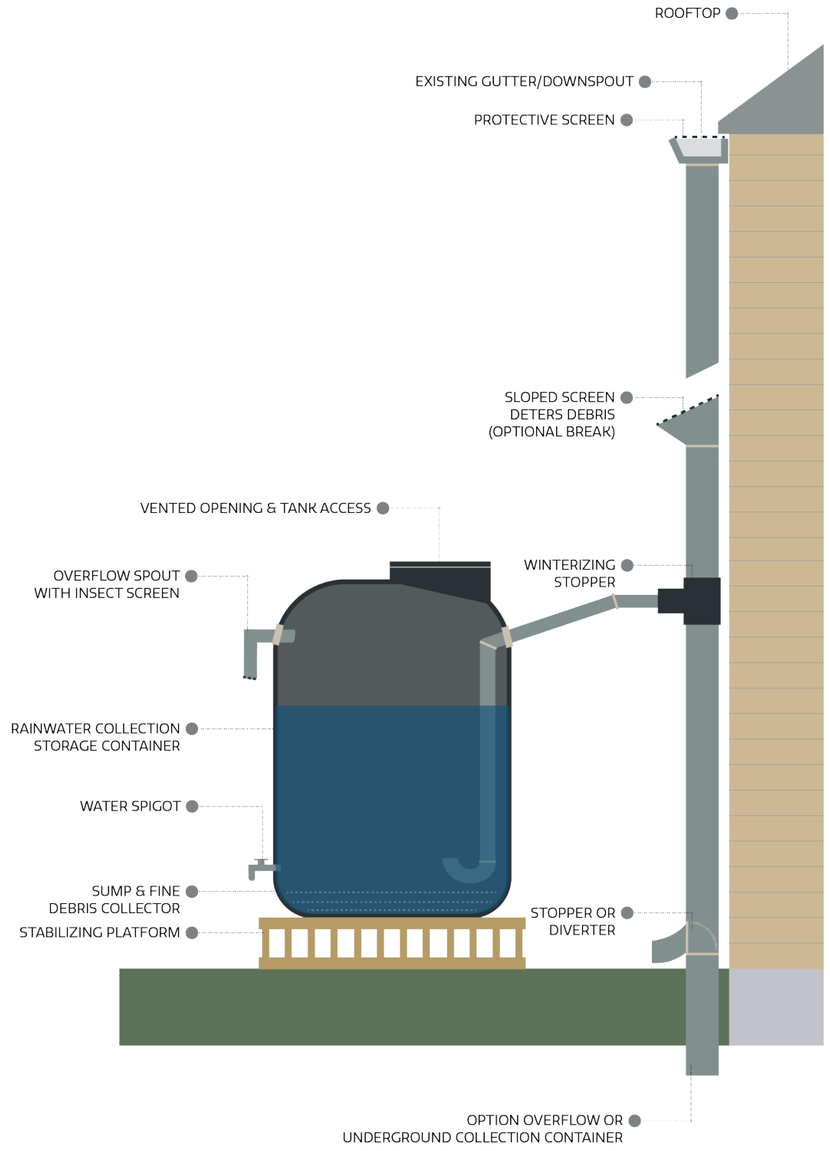


Figure 5.6 Common supplies needed for the proper installation of a rainwater harvesting system

diagram presented in Figure 5.5 demonstrates the different system materials and components.

Step 6: Consider Funding Options
There are several local funding options for implementing rainwater harvesting systems or water conservation projects. The following is a list of local Kansas City programs that promote water conservation. Accessible links to these programs are provided in Appendix E.

Bridging the Gap
A local Kansas City program that offers several water and energy conservation programs. They have 55-gallon rain barrels for purchase for approximately $65.00.

Mid-America Regional Council
A program called Clean Water KC Metro with specific information on rain barrels. They have a guide on how to and why to plant native plantings and implement rainwater harvesting systems. There is also a guide to build a system for as low as $12.00 to $15.00.

Cultivate KC
Cultivate KC is a local program that has water access funding. They offer grants to grow vegetation to help mitigate stormwater runoff, as well as funding for water conservation projects such as rainwater harvesting. Up to 90% of a water conservation project can be funded by a grant.

Phase 02 – Installation of Rainwater Harvesting System

Step 1: Prepare for Installation
Depending on the land-use typology, there are several recommendations for installing the rainwater harvesting system. If the system is above ground, place it on a stable surface such as a platform or level ground. It is also important to consider the height of the container in relation to the building. Since the gutter will need to drain the water, using gravity, into the container, there will need to be ample space for the gutter systems, pipes, and vertical space to direct the water to the container.

Step 2: Installation
Level Ground or Platform: If the container is not sub-surface, then it will be important to consider leveling the soil or placing the container on a platform. This elevates the tank for easier access to the spigot, as well as reduces the chances of the container tipping over due to uneven terrain.

Excavation: Excavation may be necessary if the system is to be implemented underground. A contractor will be necessary, or correct tools and licensed professionals to operate the tools. This will need to be considered in budgeting as well.

Anchoring the Tank: A precautionary method that can take place is anchoring the rainwater harvesting tank. This can be achieved by using ropes to strap the container to the building, ground, or platform. This is more relevant in regions with more severe weather patterns.

Bulkhead Fittings: Bulkhead fittings allow for the containers to be connected to the existing water infrastructure such as the plumbing, hosing, or irrigation. These are the connection points to the container.

Plumbing, Pipes, and Gutters: Whether the system is being attached to existing gutters or plumbing system, or new piping systems are being installed, it will most likely be necessary to gather materials to support in this process such as hangers, fasteners, sealant, downspouts, pipe cleaners, water-proof glue or tape, and spigots. These components are the main accessibility points to obtaining and collecting rainwater. The piping systems, aside from guttering, are typically PVC pipes. Unless the user or someone in the community is skilled in this field, it may be necessary to consult a plumber.

Optional Components: When the container reaches water capacity, it will be important to consider where the overflow water drains to. It can be directed to rain gardens, another storage container, or recharge underground aquifers. Another component is the aesthetics of the system. There are various artistically created and sculptural-like systems that can be implemented. However, there are also

attachments that can be applied, or painting the container can increase the aesthetic appearance. Lastly, signage can be an important key to educating the users, passersby, or labeling the components of a system for personal reference. Depending on the system that is implemented, the water is either potable or non-potable. Therefore, this is an example of when signage would be important to display the intended uses of the collected water. The aesthetics and educational component will be discussed further in later sections.

Step 3: Maintenance
One of the most important aspects of a rainwater harvesting system is maintenance. Regular maintenance of the system will result in a longer-lasting system and a cleaner source of water. Seasonal maintenance routines will be discussed further in the following.

Seasonal Maintenance:
Spring: Clean debris from gutters and rooftops, repair leaks, clean the barrels of any debris, and direct the transportation system back to the barrel (if directed elsewhere during the winter) to begin collecting water again. Flushing the system may be necessary to clear any blockages or to test the system is responding properly.

Summer: Periodically check the roofs and gutters for debris and unclog if necessary – this includes filters, mesh, or screens. Consider checking the system after weather events to ensure proper functioning and no overflow issues. Another method is to consistently have the container remain shut and use the water regularly. Open containers can collect bugs, algae, or sediments. If this occurs, draining and cleaning the tank may be necessary.

Fall: This is the beginning process of winterizing if in a cold climate. One method of maintenance includes preventing freezing water. The freezing of water in colder climates or seasons can cause drains, pipes, and barrels to crack. It is important to either divert the water to an underground tank, a garden, or to not collect water during the winter months.

Winter: Periodically check for debris and any functional problems such as cracks from freezing water. Depending on complexity of the system, the containers and pipes may be disassembled and moved into a garage, shed, or warm environment.

Resources

Contractor Resources
There are various contractors and landscaping companies in the Kansas City area that either specialize in rainwater harvesting or do rainwater harvesting implementation. The following is a list of contractors and landscaping companies, as well as plumbers, water conservationists, and the water department. Links and contact information can be found in Appendix E.

OVERALL GUIDELINES SPECIFIC TO LAND-USE CATEGORIES

The following sections describe a variety of collected rainwater use interests expressed by the participants. These uses are commonalities across all land-use categories. The differences and specifics of each land-use category will be explained in later sections.

Uses

Utilities & Human Consumption
There was significant interest in all the categories for collected rainwater to be used for utilities within the establishment or for human use and consumption. For example, one participant stated, "I would say drinking water, but…[needs] filter[ed]," whereas another participant blatantly stated, "…human consumption." For a rainwater harvesting system to be used in this capacity, it would be necessary to have a large storage container to maximize the amount of rainwater to be collected. The ideal system would be underground to reduce the amount of real estate taken up by the storage container as well as to prevent contamination of the filtered water. The piping system would need to be connected to the existing water infrastructure, and a series of filters installed. It is recommended that **System Type 2** to be utilized for this use. This is so there is ample storage space, as well as water available for use. Depending on the specific land-use, and available real-estate, there is potential for multiple rainwater storage containers to be implemented to maximize rainwater storage capacity.

Irrigation
The irrigation system would not require filtered water, therefore reducing the cost of installation and maintenance significantly. Many participants revealed their preference for collected rainwater to be used for irrigation purposes. One participant stated, "Of course, irrigation in the garden…" The system would need to be hooked up to the existing water infrastructure but not to the same capacity as human consumption – as the water would lead directly to the irrigation or hosing system to be used in a garden or on a lawn. According to WSSC Water, typical irrigation occurs for one hour three times a week. This uses approximately 1,020 gallons of water. This comes out to be approximately 12,300 gallons per month (WSSC 2023). Due to the amount of water used, it is recommended **System Type 3** be utilized for this use. This can also be dependent on the size of the yard being irrigated. Due to the amount of water typically used during irrigation, the larger the container size the better so more water can be captured and then used.

Implementation of Systems as a Community

Collaboration
There was excitement from the participants in the idea of implementing a rainwater harvesting system as a community and working together with other community members to build an integrated system. Participants stated "…say work with community members… surrounded by so many businesses" and "…yea, we definitely can partner…with neighborhood associations." This interest in working as a community could lead to several different components and processes for implementation.

1. Developing a Neighborhood 'Committee' or Advocacy Group
2. Partner with Neighborhood Leaders and Associations
3. Partner with local Churches, Schools, Businesses, Organizations, and Support Groups
4. Work with various organizations and grant groups for financing

The community collaboration and implementation of a rainwater harvesting system could look several different ways. For example, if the community effort land-use was to be a church establishment, they might go with **System Type 1**. As many of the participants who worked at the churches stated, they were not full-time occupancy and, thus, did not need an extremely large system. One participant stated, "We're basically here, what, Thursday, Friday, and then Saturday. Okay. That's when we have the biggest number of people here." This reveals that the water consumption would not be throughout the entire week but rather specific days. The container could be located on the church property and collecting water from the churches roof. For people to begin using the water, and for the community to benefit from it, there would need to be an honor system, or a structured system so water can be evenly distributed to those in need. However, the distribution aspect of the water would ultimately be up to the leadership of the church. If the purpose of the rainwater harvesting system was to be for an "all are welcome" basis, they may go with either **System Type 2 or 3.**

Another example of a community effort in a specific land-use could be a residential neighborhood. Many participants stated they would be willing to work with their neighbors: ""Yeah, I'd be very willing to bring this up …... in my own community, I would definitely be willing to come together and invest in something like this." A community effort with several residential properties may go with **System Types 1 – 3**, depending on the number of participants. The more participants, the larger the system that is needed. In a residential neighborhood, the system would most likely not be connected to existing infrastructure for human consumption. The water could be used for watering plants, cleaning indoors and outdoors, supplying splash pads, pools, and other water features.

RECOMMENDATIONS SPECIFIC TO LAND-USE CATEGORIES

Cultural and Educational Institutes

Specific Uses

Mopping & Cleaning
For the specific category utilizing rainwater for mopping and cleaning, it would be suggested that **System Type 1** be

used. Mopping and cleaning is not typically a task extensively practiced daily at an establishment. Therefore, the water usage would be an estimated one to three-times a week. The rainwater storage container can remain on the exterior of the building with a simple spigot and one drainage gutter connected. A bucket, container, or other form of cleaning utility can be filled through the spigot for cleaning.

Fundraisers (Car Washing, etc.)
For washing cars, it would be recommended for **System Type 1** to be used. Fundraisers are typically quarterly or annually. Due to the infrequent use of the water, the water storage container would not need to be extremely large. The rainwater storage container can remain on the exterior of the building, preferably near a parking lot or paved area where cars drive. The water can be accessed through a hose connected to the spigot to spray the vehicle directly or a bucket or container can be filled through the spigot.

Baptisms and Sprinkling
Baptisms and sprinkling differ per religious institute and practice. However, most have a commonality of utilizing water. To be used for religious practices, there are two possibilities of system typologies. The first one is having a container or rain barrel on the exterior of the building and above-ground. A singular gutter would suffice to fill the container. Ideally, the system would be removeable in order to more easily fill the interior 'bath' or container where religious practices take place.

Another option is to have a container within the building that feeds directly to the 'bath' or container that the religious practice occurs. The piping system would go to the interior of the building to the container. A proper overflow or water-stopping system would need to be in place to prevent excess water. A spigot or hose would lead to the religious practice setting.

For both options, **System Type 1** would be recommended due to the infrequency of baptisms, sprinkling, and other religious practices that require water.

Industrial, Restaurant, and Retail

Specific Uses

Human Consumption & Utilities
Most of the industrial, restaurant, and retail category participants expressed an interest in human consumption and utilities. Due to most of the establishments in this category containing a large square footage of collection surface, as well as having a higher number of employees, **System Type 3** is recommended. This allows for ample amounts of water to be collected, stored, and then used. Since an assumption of this land-use category is that there are many manufacturers with equipment and work processes that may damage the container if it is above ground, it is recommended that a steel container be used. Ideally, the system would be underground to reduce real estate consumption. The piping of the water would need to be connected to the water infrastructure and a series of filters installed.

Machinery
For industrial machinery, it would be highly recommended to include a licensed professional such as an engineer or machinist in the process of implementing a rainwater harvesting system. Depending on the size of the machinery, and how much water is used, **System Types 3–5** are recommended. For example, some machines use pressurized water to cut materials, resulting in a high amount of water being used. Therefore, it would be necessary to have the most storage capacity possible. The piping system would be directly connected to the machinery to pull the appropriate amount of water directly from the storage container. It is best to consider the material to be steel, as previously noted.

Residential and Living Centers

Specific Uses

Splash Pads, Fountains, Pools, and other Water Systems
There were several comments regarding water being used for splash pads, fountains, and pools. The unique component about these water features is that they are not typically connected to the existing city water infrastructure when

on private property such as residential and living centers. Typically, they have their own recycled water and filtration system and require filling when water evaporates or is removed from the feature.

The average pool holds approximately 13,000 – 20,000 gallons of water depending on the size. Therefore, it is recommended that **System Type 4** be used. This would also depend on the frequency at which these features are in use. If the water is being utilized for a 'kiddie pool', or a small fountain feature, then **System Type 1** would suffice.

For **System Type 4**, an underground container would be ideal due to the size. Both system typologies would be connected directly to the water feature to be integrated when water is in short supply in the feature. The system typologies could also use a hose to insert more water into the feature if direct connection is not desired.

Fire Hydrants
It is important to express that cooperation with the city would have to take place for a cistern or underground tank to be installed at local fire hydrants.

However, there is an opportunity for rainwater harvesting systems to serve as a primary or secondary source for fire hydrants. In the case that a fire hydrant was used, it would use the stored water in the rainwater harvesting system first before pulling from the city water infrastructure. This would reduce the amount of city water used. The recommended system would be **System Type #4** or **#5**. Depending on the amount of underground space due to utilities and streets, there is an opportunity to have a large collection source beneath the fire hydrants.

RAINWATER HARVESTING CONTAINER AESTHETICS

The aesthetics of a container depend on the user preferences and resources, as well as what is available in the market. All system typologies previously discussed can be aesthetically enhanced, hidden, or have adjustments made to them. Many of the participants expressed interest in aesthetic enhancements, this is due to the imagery presented, but also in part due to not having knowledge of the artistic approaches that could be taken to aesthetically enhance a system.

Some of the overall aesthetic and appearance comments made by participants included the words or phrases, **aesthetics, functional,** and **appearance**. There were also keywords that revealed preferences that the system be **artistic, hidden**, or there is **no care in visual** appearance. This reveals once participants knew of aesthetic enhancements that could be done based off the imagery presented to them, that most participants were interested in the enhancements. However, there were two participants that expressed their lack of care for the visual aesthetic.

The following section discusses each land-use category in detail regarding the aesthetic enhancements that can be done to rainwater harvesting systems based on participant's feedback. The imagery and keyword analysis can be viewed in Appendix C for reference.

Aesthetics Specific to Land-Use Categories

Cultural and Educational Institutes
The major descriptive keywords that were revealed from the artistically designed imagery portion of the interview included **interesting, big, definitely work, out of sight/mind,** and **conservative**.

Based on participants feedback, it appears for Cultural and Educational Institutes the aesthetic appearance could include providing a wrapping around the containers, encasing the container in an outbuilding or enclosure, or introducing a new system in which the transportation system is an artistic piece opposed to a gutter system.

There are three aesthetic recommendations for the rainwater harvesting system containers in the Cultural and Educational Institutes land-use category. The recommendations are as follows.

1. **Artistic Wrapping**
2. **Enclosure**
3. **Artistic Transportation System**

Industrial, Restaurant, and Retail
Feedback from the participants was constructive and revealing in the Industrial, Restaurant, and Retail land-use category. The major descriptive keywords revealed by the participants include **concealed, plant designed barrels, appealing, neat,** and **tacky**.

The keywords then revealed the potential enhancements that could be applied to the storage container. The rainwater harvesting containers for this land-use category could include a concealed wrapping, a system in which looks like a functioning element opposed to a rainwater harvesting system (car port, shade structure, etc.), or a system that is hidden or underground.

1. **Artistic Wrapping**
2. **Appears as a Functioning Element**
3. **Hidden or Underground**

Residential and Living Centers
The participants' feedback for Residential and Living Centers was the most insightful of all land-use categories. All imagery presented to the participants were well received and revealed major keywords that support the recommendations for aesthetically enhancing the rainwater harvesting collection systems. These keywords included **artistic aspect, hanging, sound, visual, easy, appealing,** and **usage**.

These keywords revealed that the aesthetic enhancements could include a hanging system to some degree, a vertical attachment that connects directly to the house and stores or transports the water and is not visually invasive, a simple container attachment to the existing gutters or pipes, or a typical rainwater storage container or barrel that is artistically painted.

1. **Hanging Elements**
2. **Vertical Attachment to Establishment**
3. **Small Attachment to Existing Gutters**
4. **Painted Water Storage Container**

IMPLICATIONS OF GUIDELINES AND RECOMMENDATIONS

A major outcome of the guidelines and recommendations for rainwater harvesting in urban neighborhoods is the development of a Rainwater Harvesting System Typology Selection Table – Table 5.1. This table helps potential users of rainwater harvesting systems understand the appropriate system typology to place within urban neighborhoods. The selection table will be discussed further in this section through five different typologies. This section will also discuss the development of an integrated network of rainwater harvesting systems and what the network entails. Lastly, a brochure has been created as a 'quick guide to rainwater harvesting' and the typologies available to residents. The brochure can be viewed in Appendix F.

An Integrated Network of Rainwater Harvesting Systems
There is the possibility of the rainwater harvesting systems being an integrated network among urban neighborhoods and residents. This network could look a variety of ways, either through linking land-use typologies, or targeting micro-core communities to work together in creating rainwater harvesting systems for multiple households or establishments to benefit from. The terms 'micro-cores' and 'integrated networks' will be defined in the following section.

In developing such a network, the mixture of land-use categories such as residential, industrial, restaurant, retail, churches, and schools can increase the social bonds between different users of the land-use units and users of the rainwater harvesting systems.

It is important to consider the systemic problems that the neighborhoods in this study are facing. As they are historically disinvested and marginalized, they serve as an opportunity to find innovative methods to address climate issues such as drought and flooding, as disinvested communities are disproportionately affected by climate consequences which directly correlate to the social injustice experienced by communities (Levy et al., 2015, p. 312).There is value in considering the diversity of land-uses and the opportunity they provide in creating an integrated network. This is

through the participants' willingness and perceived ability to work together in these neighborhoods to mitigate at least one aspect of their concerns with environmental awareness supports the creation of an integrated network.

Addressing the environmental and water concerns that the residents have through community engaged efforts will have more meaningful outcomes and broader implications as they will work together to create solutions. These solutions can ultimately contribute to engaged activities that could help with their quality of life and sense of belonging or attachment to the neighborhood.

The following section will further define the development and implementation of rainwater harvesting 'integrated networks', and how they are developed through a series of 'micro-cores'.

Implementing the Integrated Network

Prior to identifying where the development of the integrated network can be implemented, it is important to understand a set of terms to define these efforts. Two terms will be defined, 'micro-cores' and 'integrated networks' and what they mean in rainwater harvesting and urban neighborhoods. Further, this section will discuss how micro-cores can translate into the broader integrated network of rainwater harvesting systems with supporting diagrams and examples pertaining to this study.

A micro-core would consist of a cluster of units/parcels within a block of a neighborhood that would have a collective source of water for common uses. For example, as Figure 5.6 shows, a block could consist of two-to-four (more or less depending on participants and preferences) rainwater harvesting systems - depending on the number of units on that block. Every four-to-eight units, depending on the spacing of units, would work together to collect rainwater and share a common resource and collection system. These units working together would be defined as micro-cores. The units or establishments could be a specific land-use category, or a mix of land-uses.

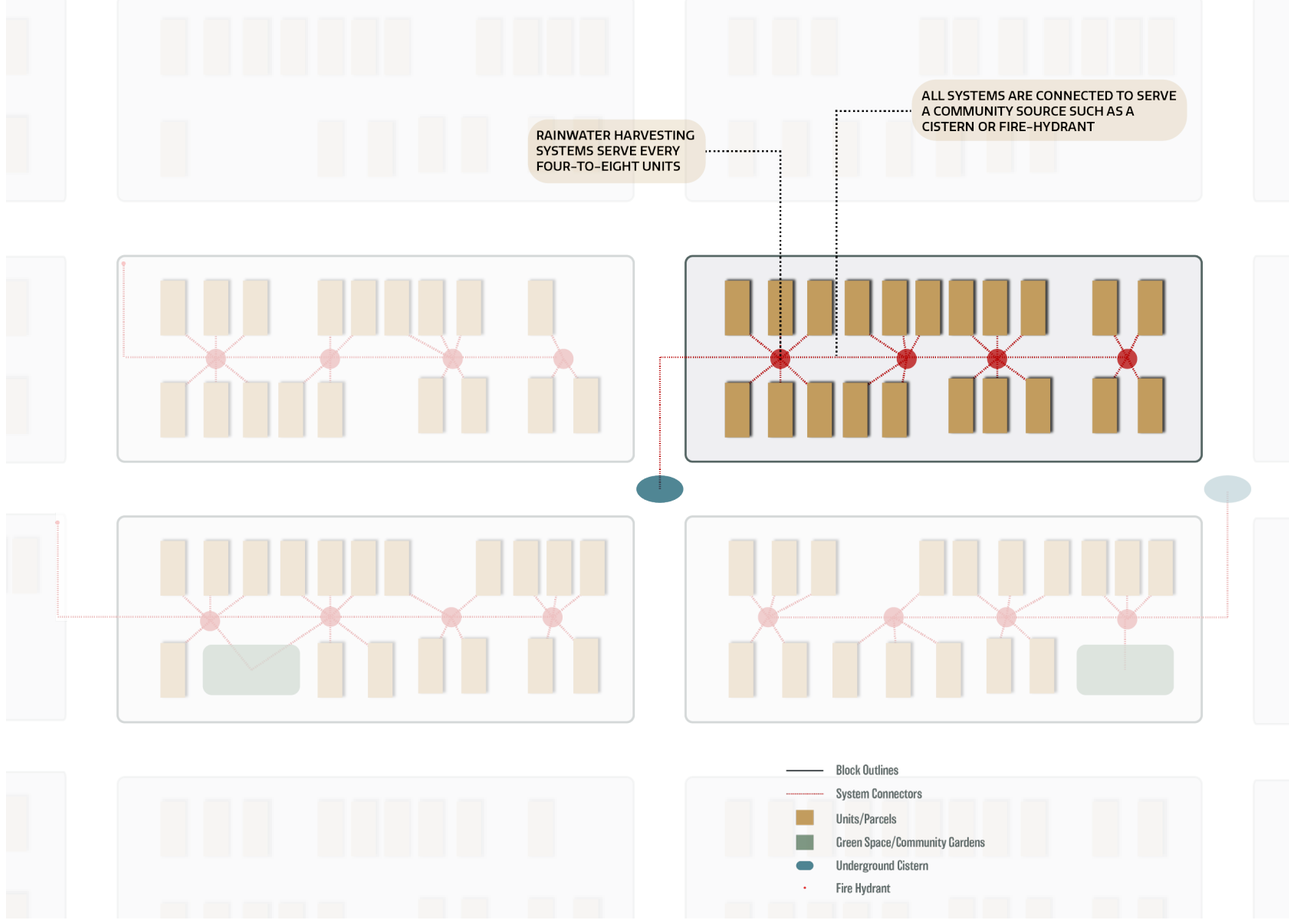


Figure 5.7 Micro-cores within neighborhoods. A collaboration of neighbors to implement and maintain a set of rainwater harvesting systems.

Upon community members and neighbors working together to have a common water resource, these micro-cores could take a step towards supporting residents on a neighborhood or citywide scale. Shown in Figure 5.7, the blocks that contain the rainwater harvesting systems could also contribute to a common resource that would benefit a larger context of a set of blocks or an entire neighborhood. These larger links would support the development of the 'integrated networks'. These larger contributions could consist of fire hydrants, community cisterns, irrigation of green spaces, or community gardens.

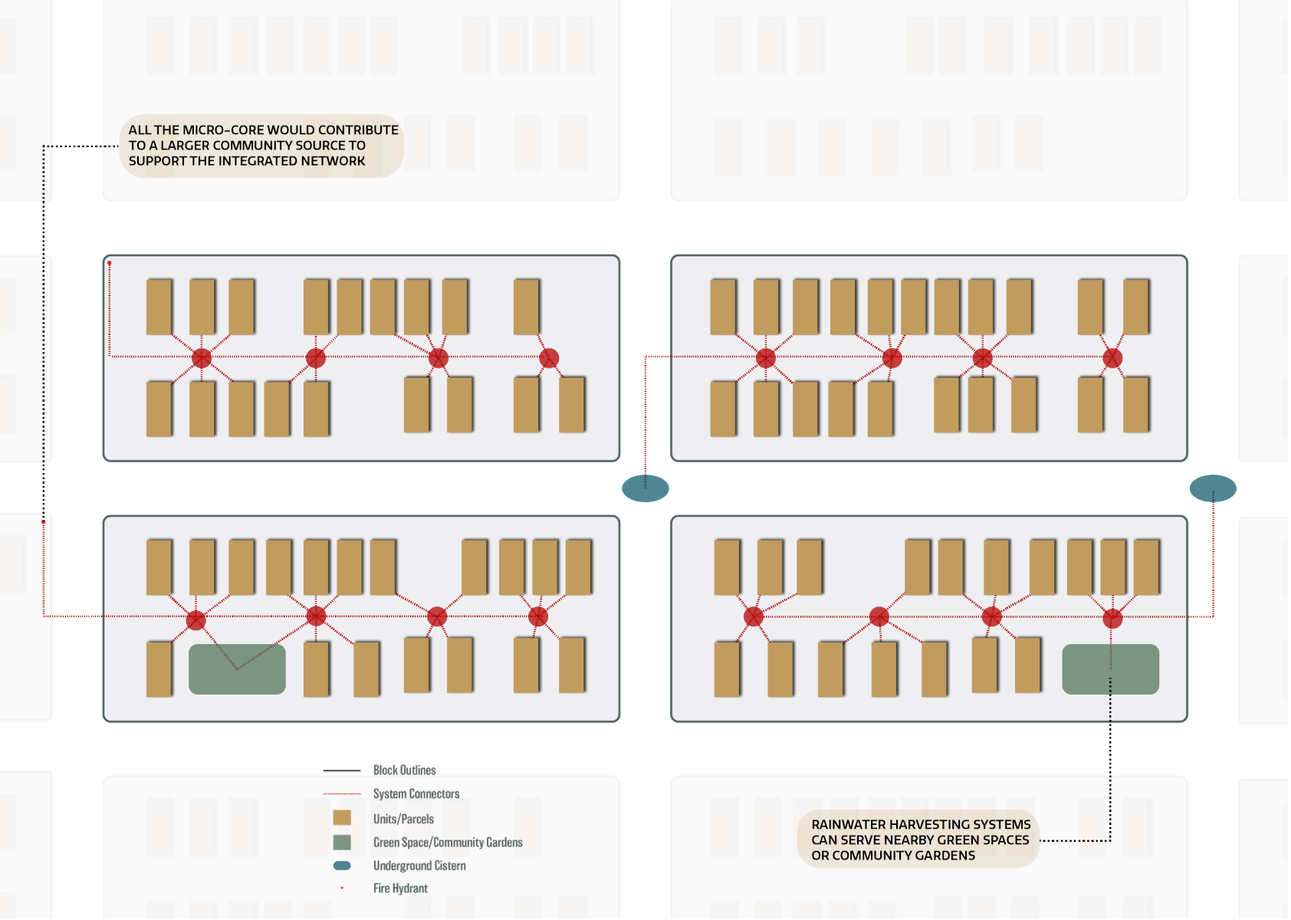


Figure 5.8 Integrated networks within neighborhoods. A collaboration of neighbors and blocks to implement and maintain a set of rainwater harvesting systems. The micro-cores support this larger network.

The implementation of the micro-cores and integrated network would follow a series of steps. The steps presented in the sections *Phase 01 – Pre-Installation Considerations*, and *Phase 02 – Installation of Rainwater Harvesting Systems* would be followed, however, there are a set of additional steps that will be needed to complete implementation through neighborhood collaboration. The additional steps are as listed:

1. Organizing a Committee or Appoint a Representative: The committee would represent all land-use categories, whereas a representative may only advocate for one land-use category. The committee or representatives should be engaged and identify specific needs, as well as the amount of water needed for each type of land-use that is involved in the micro-cores. The committee or representatives would serve as the project leaders and coordinate all activities.

2. Identifying Locations for Micro-Cores: The location of the micro-cores would need to be identified through neighborhood discussion. Residents would need to be willing to donate a portion of their exterior space to have a rainwater harvesting system implemented. The location should also be able to serve an appropriate number of units without extensive piping systems needing to be emplaced; therefore, the need for more than one system per block or group of land-uses.

3. Identifying Locations for Development of Integrated Network: Once the micro-cores locations are identified, the integrated network would need to begin development. This broader scale of a resource would contribute to fire hydrants, community cisterns, community gardens, irrigation of green spaces, or any other needs identified by the community.

Figure 5.6 and Figure 5.7 show the process of micro-cores and integrated network working in an urban neighborhood.

Figures 5.8 and 5.9 show the broader context of the combined land-uses and vacant lots. The images start to develop a sense of where rainwater harvesting systems could be constructed to benefit a set of land-use establishments, blocks, or neighborhoods. The vacant lots can begin to serve as an opportunity for implementation, or future implementation of rainwater harvesting systems. The vacant lots can also begin to be considered for preferred neighborhood resident uses such as community gardens, fire hydrants, cisterns, or water features – where the collected water could be used for as well.

Figures 5.10 and 5.11 show zoomed in examples of the integrated network working within the neighborhoods or blocks of the Kansas City community and study area.

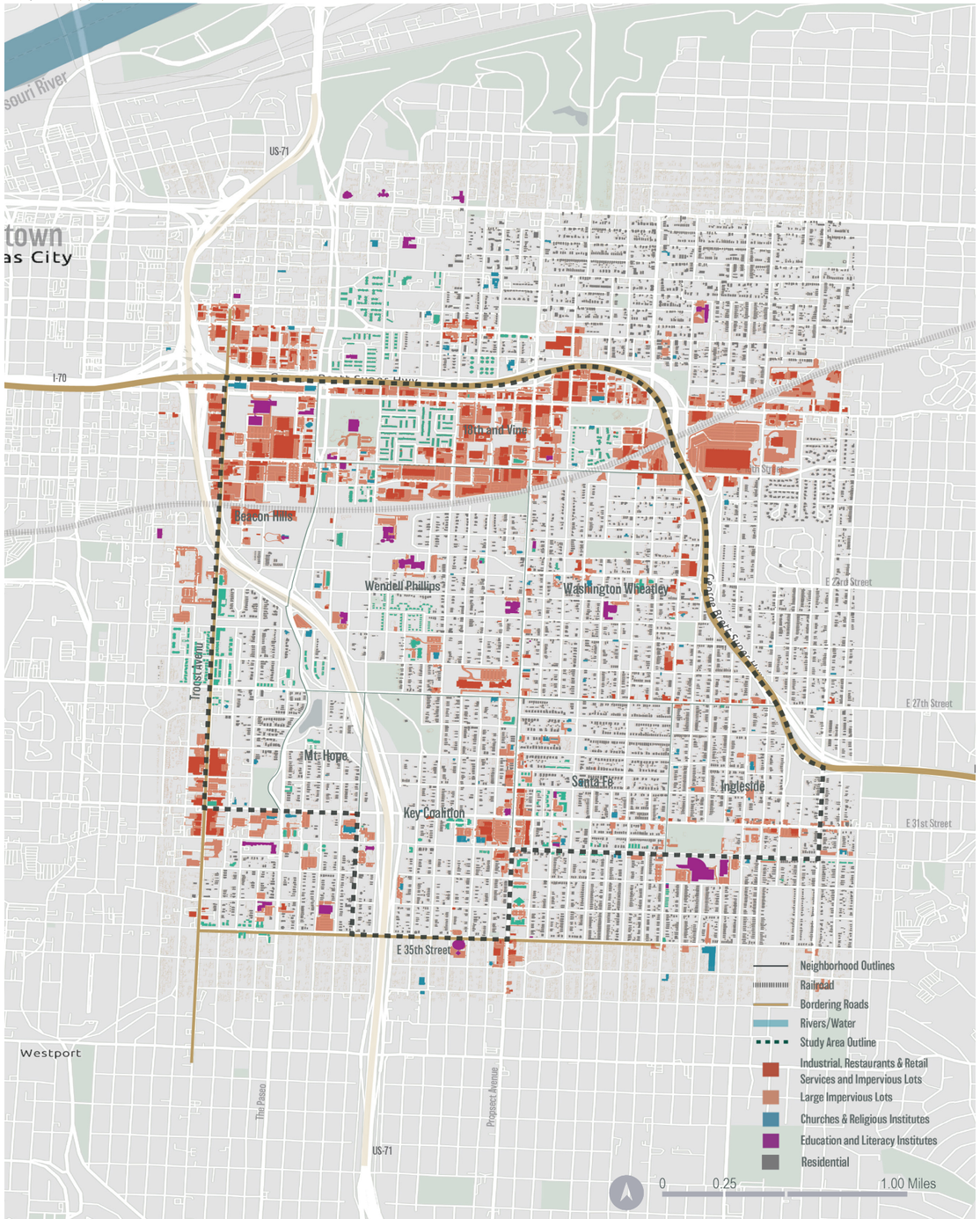


Figure 5.9 Combined land-use categories. It helps to better understand the opportunity of micro-cores within neighborhoods.

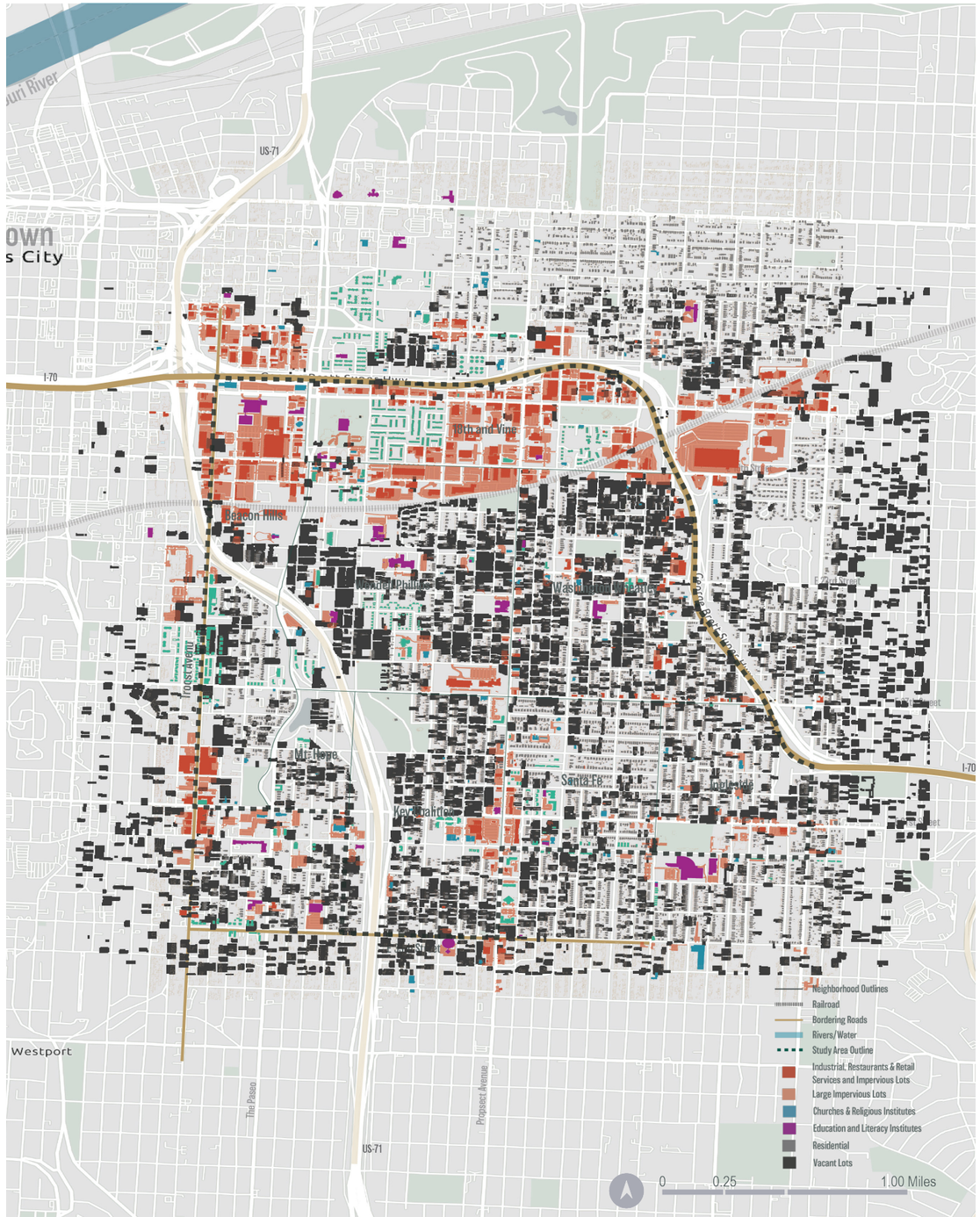


Figure 5.10 Combined land-use categories and vacant lots. It helps to better understand the opportunity of integrated networks among neighborhoods.

Figure 5.11 An example of a micro-core within the Kansas City study area. It shows the locations of the rainwater harvesting systems, as well as the various land-use categories..

Figure 5.12 An example of an integrated network within the Kansas City Study area. It shows the locations of the rainwater harvesting systems, as well as the various land-use categories and where the community water use would be directed to.

Visualizing the Systems in the Integrated Network

The rainwater harvesting systems in the micro-cores could begin to look various ways. The implementation and aesthetics of the systems would ultimately depend on the users preferences, as well as the effects of the budget and time available. However, the follow list should be considered in implementation of the rainwater harvesting systems:

System Considerations:

Location of System: The rainwater harvesting systems would need to share a common space either in the alleyway or utilizing a portion of one or several yards of the establishments using and contributing to the system. Another option would be utilizing nearby vacant lots to implement the system(s). This would need further coordination with the city or owner of the vacant lots.

Size of System: The size of the system would need to take into account the amount of water able to be collected from multiple establishments, as well as the available real estate for the system. The larger the tank, the more water able to be collected, as well as the longer the users can use collected rainwater in periods of no precipitation.

Materials: Ideally, there would be multiple tanks per block. Each tank would have at least one pipe leading water from an establishment to the container. The containers could also be connected themselves through piping, which would allow overflow from one container to the next. This integrated piping system would also allow for the water to be directed to a common use for that neighborhood or even beyond the neighborhood.

Common Use of Collected Water: The multiple rainwater harvesting systems can come together for a common use to benefit a variety of residents and land-uses. These common uses include but are not limited to fire hydrants, community cisterns, irrigation of green spaces (parks), or community gardens. These common uses would need to be identified by the committee or representatives of the project.

Above or Underground Storage: The rainwater harvesting systems can either be above or underground – this would depend on the budget and preferences of the contributors.

The integrated networks would benefit not only on a block scale, but at a neighborhood and potentially citywide scale as well. Community members working together to create these networks can potentially have more meaningful outcomes and broader implications. These solutions have the possibility of contributing to engaged activities that could help with their quality of life and sense of belonging or attachment to the neighborhood.

SYSTEM TYPOLOGY SELECTION CHART

SYSTEM TYPOLOGY	POTENTIAL LAND-USE CATEGORIES	SIZE	SQUARE FOOTAGE OF COLLECTION SURFACE	COST	MATERIAL	AMOUNT OF WATER ABLE TO BE COLLECTED
SYSTEM TYPOLOGY 1	Sheds, residential homes, small retail and restaurants, and small education and cultural establishments	55-gallon – 5,000-gallon storage container(s). 55-gallon rain barrel = 2' in diameter & 4' in height; 5,000-gallon rainwater storage container is 11.5' in diameter & 7.5' in height.	Approximate 20 – 5,000 square-foot of roof surface	Approximately $50 to $4,500. This is dependent on the size and complexity of the system.	Polyethylene (plastic) or Fiberglass	70 – 16,700 gallons of water to be collected in a month with moderate rainfall
SYSTEM TYPOLOGY 2	Large residential homes, restaurants, retail, small apartments or living centers, and education or cultural institutes	5,000-gallons – 10,000 gallons storage container(s). 5,000-gallon rainwater storage container is 11.5' in diameter & 7.5' in height; 10,000-gallon container is 11.5' in diameter and 13.5' in height	Approximate 5,000 – 10,000 square-foot of roof surface	Approximate $4,500 – $16,000	Polyethylene (plastic) or Fiberglass	16,700 – 33,500 gallons of water able to be collected in a month with moderate rainfall
SYSTEM TYPOLOGY 3	Industrial land-uses, large restaurants and retail, educational institutes, and apartments or living centers	10,000-gallons – 15,000-gallon storage container(s). 10,000-gallon container is 11.5' in diameter & 13.5' in height; 15,000-gallon container is 12' in diameter and 20.5' in height	Approximate 10,000 – 15,000 square-foot of roof surface	Approximately $16,000 – $25,000. Add up to an additional $5,000 – $15,000 for steel	Polyethylene (Plastic), Fiberglass, or Steel	33,500 – 50,400 gallons of water able to be collected in a month with moderate rainfall
SYSTEM TYPOLOGY 4	Industrial, educational, large cultural establishments, apartments and living centers	15,000 – 20,000-gallon container(s). 15,000-gallon container is 12' in diameter & 20.5' in height; 20,000-gallon container is 14' in diameter & 20' in height	Approximate 15,000 – 20,000 square-foot of roof surface	$25,000 – $40,000. Add an additional approximately $5,000 $10,000 for steel	Land-uses with containers of this size should consider galvanized steel. Polyethylene (plastic) and Fiberglass are still acceptable	33,500 – 67,000-gallons of water able to be collected in a month of moderate rainfall
SYSTEM TYPOLOGY 5	Large industrial buildings, large educational institutes, living centers, large cultural institutes, and large apartments	20,000 gallons or larger	Approximate 20,000 + square-foot of roof or impervious collection surface	Approximately $35,000 or higher	Steel containers recommended. Polyethylene (plastic) and fiberglass will suffice. For an additional cost, concrete can be poured, and used as a storage container	67,000-gallons of water can be collected in a month of moderate rainfall

Table 5.1 System Typology Selection Chart for Urban Neighborhoods

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Wedel, S., MidJourney. (2023). MidJourney on Discord. Version 4.0. Computer Discord. https://discord.com/channels/1025488369192550423/1026560283520532550

Wedel, S. MidJourney. (2023). MidJourney on Discord. Version 4.0. Computer Discord. https://discord.com/channels/1025488369192550423/1026560283520532550

CHAPTER 6

CLOSING

CONCLUSIONS

OUTCOMES

This project explored the potential for utilization of rainwater harvesting systems based on the residents' functional use of the collected water and their attitudes and perceptions of such systems. It has revealed the respondents' level of environmental awareness, their awareness and opinions about rainwater harvesting systems, and their willingness to get involved in individual or community-based projects for creating an integrated rainwater harvesting system.

Observation and mapping, and semi-structured interviews were conducted in Eastside Kansas City, Missouri to get participants responses on their attitudes and perceptions of rainwater harvesting systems, as well as how they would use collected rainwater. The findings from this research have revealed a high interest in rainwater harvesting systems for urban neighborhood residents and various land-use categories. The findings from this research have been applied to a set of curated design guidelines and recommendations for three strategically identified categories of land uses and users.

Another outcome of this research resulted in the development of rainwater harvesting system typologies that community members and residents can use as a learning tool and guide for integrated implementation. The findings are expected to serve as an evidence-based guide for rainwater harvesting systems in Kansas City and present the opportunity for rainwater harvesting system to urban neighborhoods and residents and to mitigate costly water consumption.

LIMITATIONS

One of the major limitations of this study relates to the sample population. The interview locations of the three categories can be inferred that a certain population has been excluded. This includes individuals with a full-time job from 9AM – 3PM Monday through Friday not at one of the three land-use categories identified, and those who did not use the establishments targeted for interviews. The times of day, day of the week, and consistency or randomness of the interviews conducted, also had influence on the type of population being interviewed. Another limitation is the time limit of this research project. To effectively represent the entire population of the neighborhoods, a larger sample size is needed. However, the limited time frame did not allow for interviewing a larger sample, which reduces the generalizability of the findings. It is also important to note that the number of curated design guidelines and categories included is limited. Therefore, this is not a comprehensive investigation of all possibilities, but a useful sample for methodology that could be applied in future studies.

Other limitations included recruitment of participants interest and lack of awareness for the project which resulted in many residents declining to participate. Weather was another contributing factor for the number of days the researcher was able to travel to the study area, as well as the number of community members out in public for potential recruitment.

FUTURE RESEARCH

Future research can use the analysis and findings of this study, while targeting a larger sample size from a wider range of land use. The number of themes and topics developed from participant feedback could be broadened accordingly. A larger sample size would increase and strengthen the generalizability of the findings of this research.

Further research could also be applied to either individual or community-based implementation efforts. The studies can investigate what these efforts would look like, and how the community engagement aspect would develop. Furthermore, detailed breakdowns of micro-cores and how they translate to a broader integrated network would be another aspect of future research.

Lastly, future research could strengthen the system typologies by analyzing, measuring, and approaching more establishments in each land-use category. Collaboration with suppliers, specialists, and contractors would support this development.

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END MATTER

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APPENDIX A
IRB Exemption Letter

KANSAS STATE UNIVERSITY | University Research Compliance Office

TO: Sara Hadavi
Landscape Archit & Comm Plan

Proposal Number: IRB-11452

FROM: Lisa Rubin, Chair
Committee on Research Involving Human Subjects

DATE: 12/19/2022

RE: Proposal Entitled, " "Integrated Rainwater Harvesting in Urban Marginalized Communities Based on People's Needs and Preferences" - Master's Project Report."

The Committee on Research Involving Human Subjects / Institutional Review Board (IRB) for Kansas State University has reviewed the proposal identified above and has determined that it is EXEMPT from further IRB review. This exemption applies only to the proposal - as written – and currently on file with the IRB. Any change potentially affecting human subjects must be approved by the IRB prior to implementation and may disqualify the proposal from exemption.

Based upon information provided to the IRB, this activity is exempt under the criteria set forth in the Federal Policy for the Protection of Human Subjects, **45 CFR §104(d), category:Exempt Category 2 Subsection ii.**

Certain research is exempt from the requirements of HHS/OHRP regulations. A determination that research is exempt does not imply that investigators have no ethical responsibilities to subjects in such research; it means only that the regulatory requirements related to IRB review, informed consent, and assurance of compliance do not apply to the research.

Any unanticipated problems involving risk to subjects or to others must be reported immediately to the Chair of the Committee on Research Involving Human Subjects, the University Research Compliance Office, and if the subjects are KSU students, to the Director of the Student Health Center.

Electronically signed by Phill Vardiman on 12/19/2022 4:47 PM ET
On Behalf of IRB Chair

203 Fairchild Hall, Manhattan, KS 66502 | (785) 532-3224 | fax: (785) 532-3278

APPENDIX B
Interview Questions

Informed Consent [Verbal]

You are invited to participate in this research study. This form has information to help you decide whether or not you wish to participate. Research studies include only people who choose to take part—your participation is completely voluntary, and you can stop at any time.

Please ask the project investigator (Shaedon Wedel), any questions you have about the study or before deciding to participate.

This study is being conducted by Shaedon Wedel, overseen by major professor Dr. Sara Hadavi.

You are eligible to participate in this study if you are 18 years of age or older. You should not participate if you are not 18 years of age or older.

The purpose of this study is to ask you questions about rainwater harvesting systems and your knowledge and preferences about these systems. In order to gain knowledge on the functional use of collected rainwater, and your perceptions and attitudes regarding the systems.

If you agree to participate, you will be asked to answer a series of questions verbally, look at and speak about a series of images, and complete a 30-second written questionnaire. Your participation will last approximately 10-15 minutes.

It is hoped that the information gained in this study will benefit you and your neighbors by increasing environmental awareness, rainwater harvesting awareness, and the likelihood of working with your community to develop a series of integrated rainwater harvesting systems.

To protect confidentiality of the study record and data, research records will be stored on a passcode protected computer only obtainable by the researcher, Shaedon Wedel. They will be stored for no more than 3-years.

The future use of the data could be used for publication or conference presentations. The findings of this study will be shared with the city for potential implementation in the future in your neighborhoods; and I am excited to share the findings with you as well.

Contact information for this study is available:

Shaedon Wedel: scwedel@ksu.edu

Sara Hadavi: sarahadavi@ksu.edu

Interview questions remain the same for each category. However, the imagery shown during the interviews will differ per category.

Semi-Structured Interview Questions:

Introduction by Interviewer:

My name is Shaedon Wedel, and I am a landscape architecture graduate student at Kansas State University in Manhattan, Kansas. The research project I am conducting is called **Integrated Rainwater Harvesting in Urban Marginalized Communities Based on People's Needs and Preferences**. This study aims to ask you questions about rainwater harvesting systems and your knowledge and preferences about these systems. Your participation in this interview is voluntary and anonymous. You are free to withdraw at any point or skip any questions you do not wish to answer. Your participation will take approximately 10-15 minutes. Audio of the conversation will be recorded for transcription purposes and will be kept anonymous.

Interview Questions:
Targeted Specific Questions

Environmental awareness:

1. What concerns do you have, if any, about future drought and flooding events? Do you have any concerns about the amount of rainfall we currently experience?
2. Do you currently practice any type of water conservation? Such as storing water or being conscious about your water use.

Water insecurity:

3. Do you have any concerns about water availability at this establishment?
4. Have you struggled with paying your water bill over the past year? Do you think your water bill is too high?
5. Have you ever worried about not having enough water at this establishment? Please explain the scenario.

Rainwater harvesting

6. How much do you know about rainwater harvesting and what it does?
7. Can you tell me of any buildings near your block that collect rainwater? If so, how does the system work, why do you think they collect water? Please explain.

If they do not know of any systems in their community, or do not know what rainwater harvesting is, the following information will be verbally provided to them:

[**Information to verbally provide them**: One way of addressing drought and flooding is through rainwater harvesting. This process allows residents or users of the harvesting systems to store collected rainwater from the roof of their building(s), or other surfaces, for later use, which can help reduce the impacts of drought, flooding, and water costs for households or other establishments. The water can be supplied to households, animal and human communities, irrigation systems for land, soils, agriculture, toilets, laundry, car washing, swimming pools, heating, cooling, and can improve the quality of life for people to use in potable and non-potable forms.]

8. Do you see any value(s) in collecting rainwater for later uses? Please explain.
9. To what extent do you think collecting rainwater is important?

At this point in the process, the participants will be shown a curated set of images through three phased steps: 1) Sample of current rainwater harvesting systems, 2) Function diagrams of how the water can be used, and 3) Samples of artistically designed rainwater harvesting systems – with targeted questions. These images will also be targeted to the correct category.

Questions Specifically about the

Establishment During Photoset Viewing
Step 1: Sample of Current Rainwater Harvesting System Questions or Comments
Clarify how the systems work in the images to the respondent if needed, otherwise, allow them to view the images as long as they need.

Step 2: Functional Diagrams of Rainwater Harvesting Systems Per Category
Showing the diagrams and talking about them.

1. Do any of the uses of the water appeal to you? What other ways would you use collected rainwater?
2. Do you think this establishment would benefit from a system like this? If yes, in what ways? How would you use the water collected?
3. To what extent are you willing to have something like this in/at your neighborhood or at this establishment?
4. To what extent would you be willing to be a part of a process of creating something like this individually? How about collaborating with your community members?
5. What are your potential concerns about implementing these ideas in your building? What may keep you from getting involved in projects like this?

Step 3: Artistically Designed Rainwater Harvesting Systems
Showing the photos.

6. Which of these systems is more appealing to you? Why? Please explain.
7. Do you think this is possible to be made at your establishment?
8. Is making something like this of interest to you?
9. What would keep you from having something like this in this establishment?

Questions to ask post photoset discussion

If cost is a concern, the following question(s) will be asked:

1. To what extent are expenses a barrier for you to decide to have a system like this?

Demographic Questionnaire

1. A small sheet of paper with these questions will be handed to them post verbal interview questions **Gender orientation (circle one):** Male | Female | Transgender | Non-binary | Prefer not to answer
2. **Age range (circle one):** 18-25 | 26-35 | 36-45 | 46-55 | 56-65 | 66+
3. **Are you a current resident of/working in (circle one):** Beacon Hill | 18th & Vine | Wendell Philips | Washington Wheatley | Key Coalition | Mt. Hope | Santa Fe | Ingleside
4. **Educational attainment (circle all that apply):** No school completed | some high school, no diploma | High school graduate, diploma, or the equivalent | Some college, no degree | Trade/Technical/Vocational school | Associate Degree | Bachelor's Degree | Graduate Degree
5. **Household Annual Income range (circle one):** $0 - $30,000 | $31,000 - $$60,000 | $61,000 - $90,000 | $91,000 - $120,000 | $120,000+

CURRENT RAINWATER HARVESTING SYSTEMS

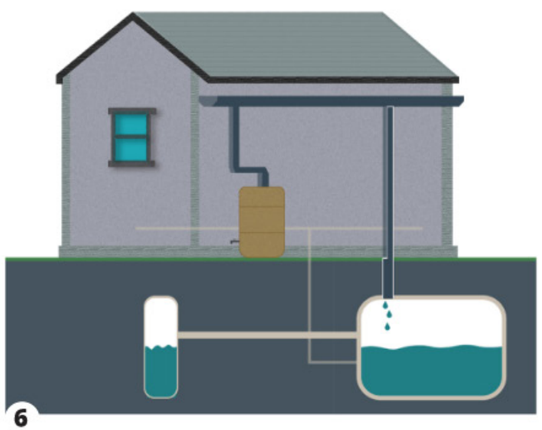
1

2

3

4

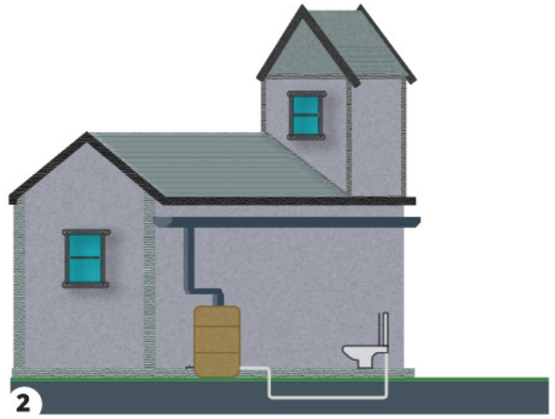
5


6

FUNCTIONAL USE DIAGRAMS

1

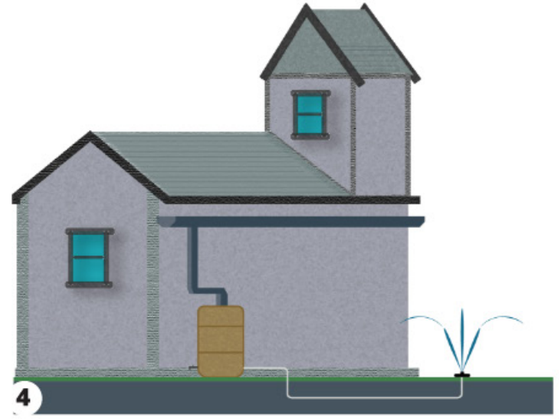
RELIGIOUS PRACTICES


2

CONNECTIONS TO EXISTING WATER

3

WATERING


4

IRRIGATION

5

PLAY & GATHERINGS

ARTISTICALLY DESIGNED SYSTEMS

1

2

3

4

5

CURRENT RAINWATER HARVESTING SYSTEMS

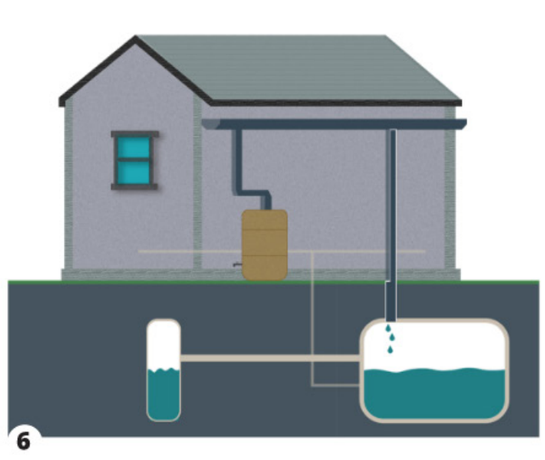
1

2

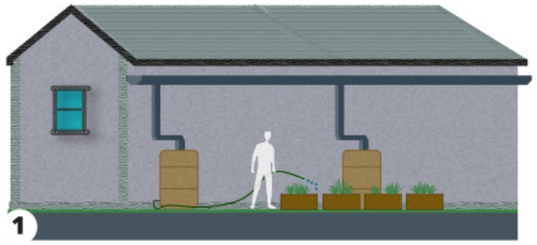
3

4

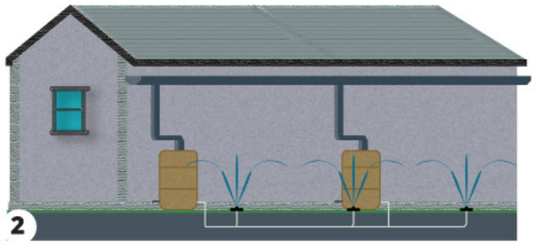
5


6

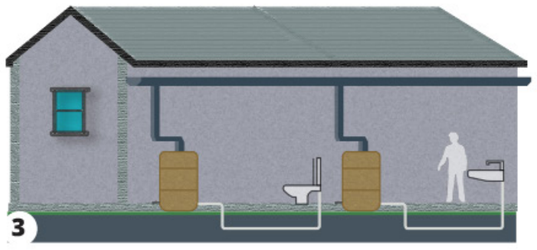
FUNCTIONAL USE DIAGRAMS



WATERING



IRRIGATION



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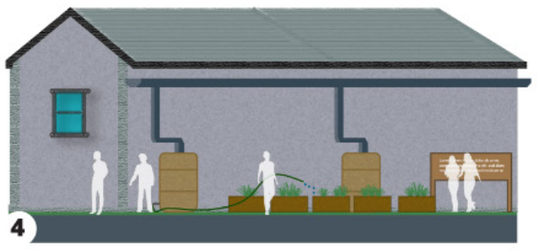

EDUCATIONAL COMPONENTS

ARTISTICALLY DESIGNED SYSTEMS

CURRENT RAINWATER HARVESTING SYSTEMS

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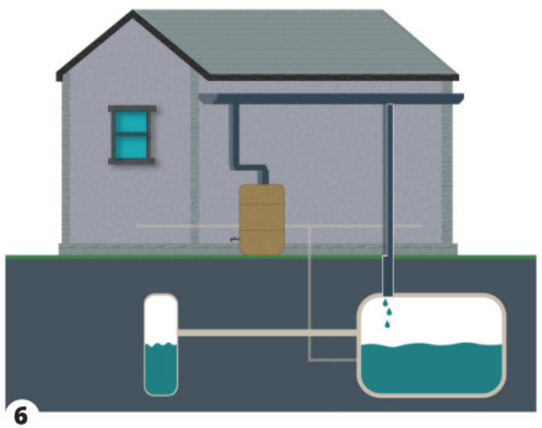
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FUNCTIONAL USE DIAGRAMS

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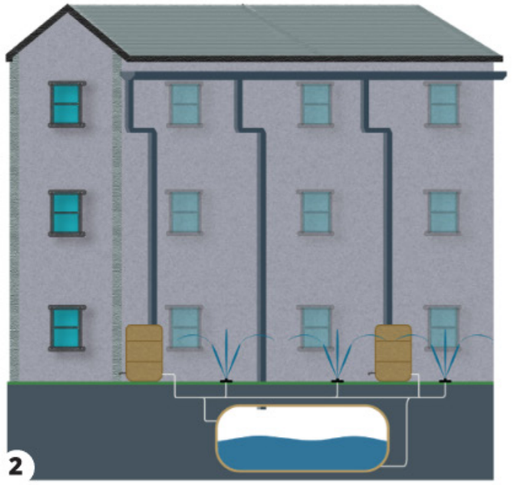
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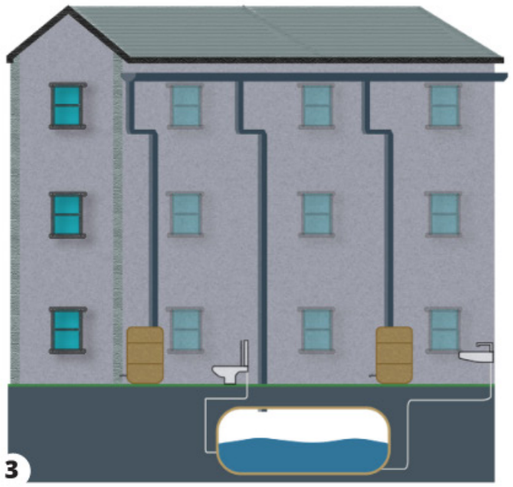
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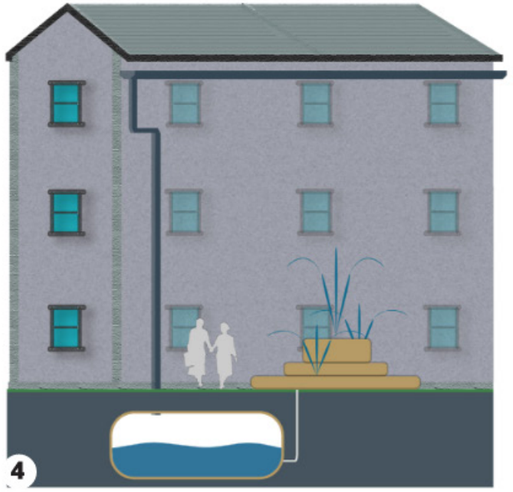
4 THERAPEUTIC

5 PLAY

ARTISTICALLY DESIGNED SYSTEMS

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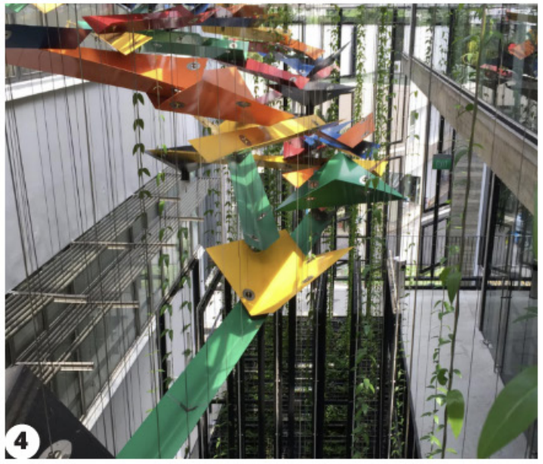
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CURRENT RAINWATER HARVESTING SYSTEMS

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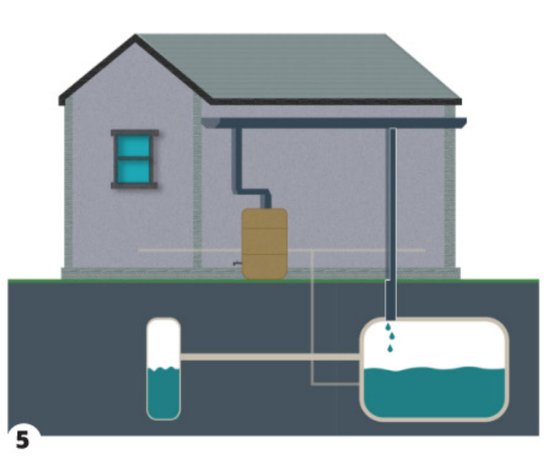
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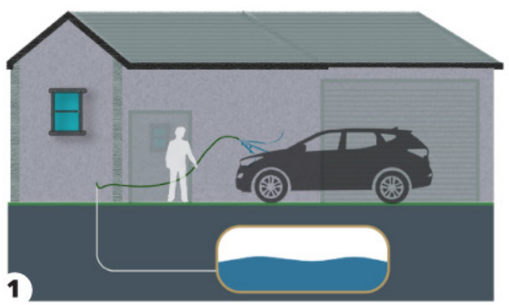
FUNCTIONAL USE DIAGRAMS



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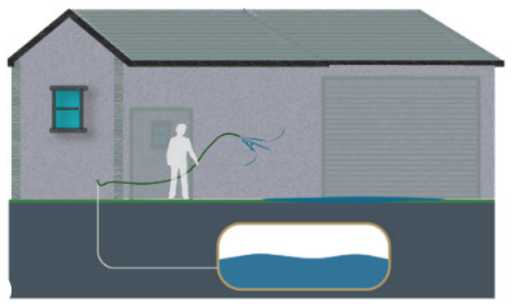
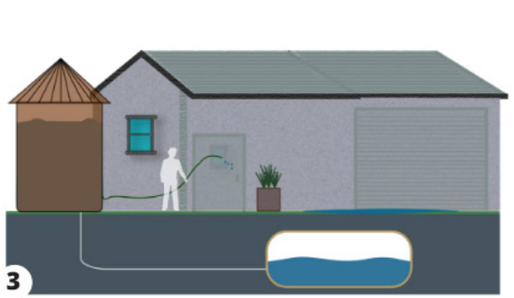
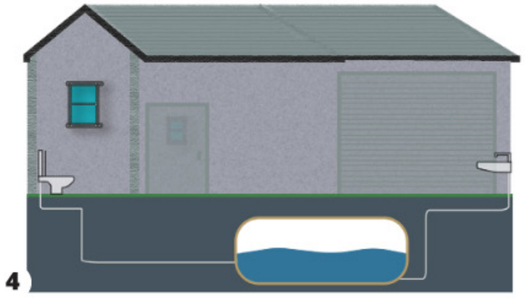


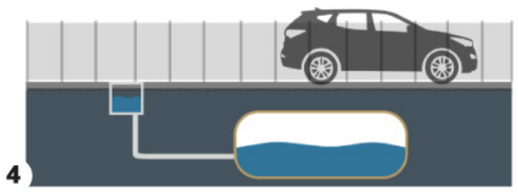
CLEANING (MANUFACTURER



WATERING (RESTAURANT)



HUMAN USE



IMPERVIOUS LOTS

ARTISTICALLY DESIGNED SYSTEMS

RESIDENTAIL
PHOTOSET

CURRENT RAINWATER HARVESTING SYSTEMS

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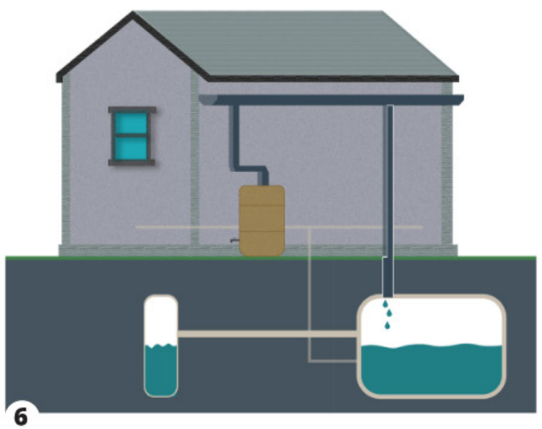
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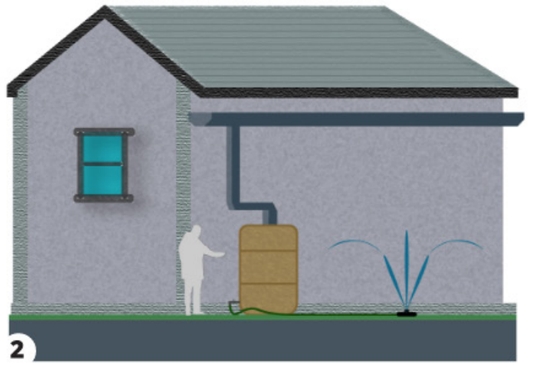
FUNCTIONAL USE DIAGRAMS

1 WATERING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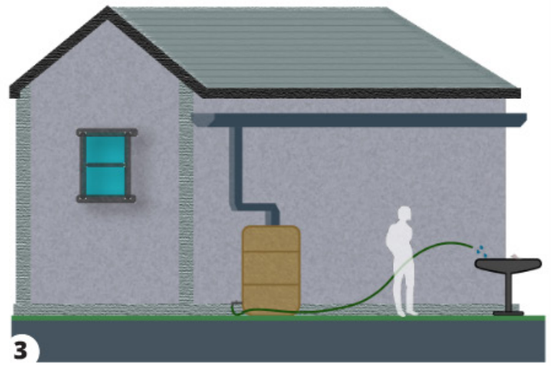
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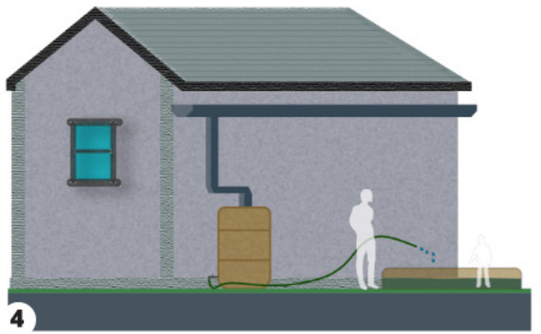
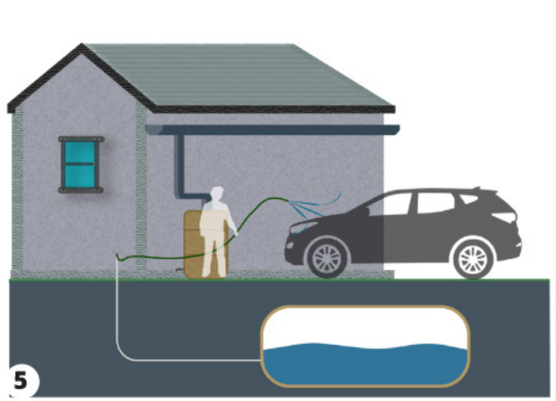
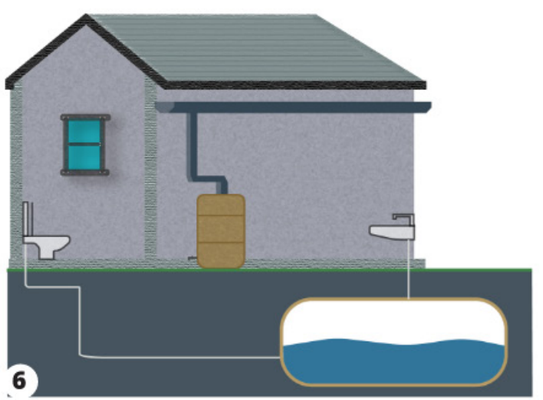

4 PLAY


5 CLEANING/CHORES


6 HUMAN USE

ARTISTICALLY DESIGNED SYSTEMS

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APPENDIX C
Thematic and Keyword Analysis for Interviews

QUESTIONNAIRE DATA COLLECTION

PARTICIPANT/ID	CATEGORY	GENDER	AGE RANGE	CURRENT RESIDENT OF/WORKING IN	EDUCATIONAL ATTAINMENT	HOUSEHOLD ANNUAL INCOME
PARTICIPANT #1 | Q (1) C (L)	Cultural & Education Institutes	Male	66+	Ivanhoe	Graduate Degree	$91,000 – $120,000
PARTICIPANT #2 | Q (2) C (L)	Cultural & Education Institutes	Male	66+	Beacon Hill	High School Graduate	$0 – $30,000
PARTICIPANT #3 | Q (3) C (M)	Cultural & Education Institutes	Male	56–65	18th & Vine	Graduate Degree	$91,000 – $120,000
PARTICIPANT #4 | Q (4) C (V)	Cultural & Education Institutes	Male	36–45	Mt. Hope	Graduate Degree	$0 – $30,000
PARTICIPANT #5 | Q (5) I (C)	Industrial, Restaurant & Retail Services	Male	36–45	Wendell Phillips	Bachelor's Degree	$61,000 – $90,000
PARTICIPANT #6 | Q (6) I (B)	Industrial, Restaurant & Retail Services	Male	18–25	Key Coalition	Bachelor's Degree	$31,000 – $60,000
PARTICIPANT #7 | Q (7) I (F)	Industrial, Restaurant & Retail Services	Male	46–55	N/A	Bachelor's Degree	$120,000 +
PARTICIPANT #8 | Q (8) I (M)	Industrial, Restaurant & Retail Services	Male	26–35	18th & Vine	Bachelor's Degree	$91,000 – $120,000
PARTICIPANT #9 | Q (9) I (W)	Industrial, Restaurant & Retail Services	Male	26–35	N/A	Bachelor's Degree	$91,000 – $120,000
PARTICIPANT #10 | Q (10) I (R)	Industrial, Restaurant & Retail Services	Male	56–65	Washington Wheatley	Some College, No Degree	$120,000 +
PARTICIPANT #11 | Q (11) R (M)	Residential & Living Centers	Female	18–25	Jackson County	Graduate Degree	$31,000 – $60,000
PARTICIPANT #12 | Q (12) R (H)	Residential & Living Centers	Female	26–35	Key Coalition	Some College, No Degree	$61,000 – $90,000
PARTICIPANT #13 | Q (13) R (N)	Residential & Living Centers	Male	56–65	Jackson County	Bachelor's Degree	$31,000 – $60,000
PARTICIPANT #14 | Q (14) R (F)	Residential & Living Centers	Female	56–65	Jackson County	Bachelor's Degree	$31,000 – $60,000
PARTICIPANT #15 | Q (15) R (C)	Residential & Living Centers	Female	46–55	Jackson County	Bachelor's Degree	$31,000 – $60,000
		Male: 11 **Female:** 4	**18–25:** 2 **26–35:** 3 **36–45:** 2 **46–55:** 2 **56–65:** 4 **66+:** 2	**Ivanhoe:** 1 **Beacon Hill:** 1 **18th & Vine:** 2 **Mt. Hope:** 1 **Wendell Phillips:** 1 **Key Coalition:** 2 **Washington Wheatley:** 1 **Jackson County:** 4 **N/A:** 2	**High School Graduate:** 1 **Some College, No Degree:** 2 **Bachelor's Degree:** 8 **Graduate Degree:** 4	**$0 – $30,000:** 2 **$31,000 – $60,000:** 5 **$61,000 – $90,000:** 2 **$91,000 – $120,000:** 4 **$120,000+:** 2

PER CATEGORY

GENDER	AGE RANGE	CURRENT RESIDENT OF/WORKING IN	EDUCATIONAL ATTAINMENT	HOUSEHOLD ANNUAL INCOME
Male: 4	**36–45:** 1 **56–65:** 1 **66+:** 2	**Ivanhoe:** 1 **Beacon Hill:** 1 **18th & Vine:** 1 **Mt. Hope:** 1	**High School Graduate:** 1 **Graduate Degree:** 3	**$0 – 30,000:** 2 **$91,000 – $120,000:** 2
Male: 6	**18–25:** 1 **26–36:** 2 **36–45:** 1 **46–55:** 1 **56–65:** 1	**Wendell Phillips:** 1 **Key Coalition:** 1 **18th & Vine:** 1 **Washington Wheatley:** 1 **N/A:** 2	**Some College, No Degree:** 1 **Bachelor's Degree:** 5	**$31,000 – $60,000:** 1 **$61,000 – $90,000:** 1 **$91,000 – $120,000:** 2 **$120,000 +:** 2
Female: 4 **Male:** 1	**18–25:** 1 **26–35:** 1 **46–55:** 1 **56–65:** 2	**Key Coalition:** 1 **Jackson County:** 4	**Some College, No Degree:** 1 **Bachelor's Degree:** 3 **Graduate Degree:** 1	**$31,000 – $60,000:** 4 **$61,000 – $90,000:** 1

KEY:

Q = QUESTIONNAIRE

T = TRANSCRIPTION

(#) = ID

C = CHURCH & RELIGIOUS INSTITUTES
I = INDUSTRIAL, RESTAURANT & RETAIL SERVICES
R =

(LETTER) = IDENTIFICATION OF LOCATION
Example: (L) = Linwood Church

TRANSCRIPTION DATA COLLECTION (KEYWORD/THEMATIC ANALYSIS)

THEME	ENVIRONMENTAL AWARENESS			WATER INSECURITY		RAINWATER HARVESTING					WATER USEGE & MAINTENANCE AT ESTABLISHMENT		WATER DEPARTMENT RELATED ISSUES		
TOPICS	ENVIRONMENTAL AWARENESS (Drought & Flooding)	ENVIRONMENTAL AWARENESS (Rain Frequency)	ENVIRONMENTAL AWARENESS (Water Conservation)	WATER INSECURITY (Water Availability)	WATER INSECURITY (Water Affordability)	RAINWATER HARVESTING (Knowledge)	RAINWATER HARVESTING (Existing Systems)		RAINWATER HARVESTING (See Value?)	GENERAL COMMENTS AFTER PARAGRAPH	MAINTENANCE OF WATER IN ESTABLISHMENT	WATER USAGE AT ESTABLISHMENT	SEWAGE SYSTEM IMPROVEMENTS	SEWAGE SYSTEM FUNCTIONAL ISSUES	WATER DEPARTMENT COST ISSUES
INTERVIEW QUESTION ASKED:	*What concerns do you have, if any, about future drought and flooding events?*	*Do you have any concerns about the amount of rainfall we currently experience?*	*Do you currently practice any type of water conservation? Such as storing water or being conscious about your water use.*	*Do you have any concerns about water availability at this establishment?*	*Have you struggled with paying your water bill over the past year? Do you think your water bill is too high?*	*How much do you know about rainwater harvesting and what it does?*	*Can you tell me if any buildings near your block that collect rainwater? If so, how does the system work, why do you think they collect water? Please explain.*	**short description explaining rainwater harvesting and its benefits given to participant after previous two questions (left), and before the next two questions*	*Do you see any value(s) in collecting rainwater for later uses? Please explain. To what extent do you think collecting rainwater is important?*	**Comments made by participants after rainwater harvesting paragraph read to them.*	*Hou existing water is being maintained and diverted. As well as flood prevention.*	*How water is being used at the establishment.*	*Improvement to the cities water infrastructure.*	*Participant concerns with the water department and water.*	*Water department specific comments.*
PARTICIPANT ID															
PARTICIPANT #1 | T (1) C (L)	Flooding, biggest issue. ...**flash flooding** off and on downstairs. I **don't think we're in a drought** area at this time. **Climate Change**	**No.** It's just that when we get that **unusual, hard, fast rain.**	**No.**	**Never.**	**Got an $1,100 bill** for one month. Sometimes it's [usually] **$200 or $300**.	**About it. Not really.** People **put the barrel outside** and they can collect ...**water [for] in their gardens.**	**I can't.** I dunno. At **Benton and Linwood, they have community garden**. I **thought they collected rainwater**, but I don't know for sure.		I guess you have to get some sort of **special equipment** to **pump it back** in and filter it and all that?	I would like to see how you would do that, but if you are able to do that, **I guess it would save people on their water bill.**	Cause we've got, what, **four pumps downstairs.**	**Thursday, Friday, and then Saturday**. Okay. That's when **we have the biggest number of people here.**			**We're arguing with your water department at this time**. Well, you'd have days where it's just steady, **no usage, and then all of a sudden it jumps up.** It's **always on your side. It's your problem**. that's the problem that we've been having with the last two to three months.
PARTICIPANT #2 | T (2) C (L)	**Flooding**, downstairs, a few inches.		**We do not**.	**Not that I know of.**	**Have not struggled**. Bill was **high.**	**I don't know anything.**	**I'm not sure** if they do or not.		Yeah.		**Four pumps and a pit.**				
PARTICIPANT #3 | T (3) C (M)	Volume of [rain] is much more than what is considered normal. I think that there's awareness that's coming about...not fast enough. [Older] homes...dont have sewer systems...to handle that much water at one particular time. **We have had flooding in this area.** **Carbon emissions.**	**Yes**, because I think in the areas where it's needed, **it's not happening** and the areas where it's not, there's an **overabundance** of it.	Toilets are operating properly. **Removed water fountains.** **Censored water systems (COVID).**	**Don't have any concerns** about availability.	**I wouldn't say it's too high**....we're not 24-7, 365.	**I'm kind of familiar with it.** We've got a community garden that we operate and ... **talked about how do we... harvest the water so that we can irrigate our fruits and vegetables** and the plants that we plant around the community, around the property without actually having to pay for water.	**Garden Chestnut Community Center**....I know they've got a pretty **large tower for water collection. 31st and Harrison.** Two of the places that I know of that sure are **actually doing some water collection.**		**Absolutely. Absolutely.** I think it has its **immediate benefit** and then if you're able to harvest it for later on, like I said, saving for, **why pay for it if it's rain.** then I can save some of that and **use it next week** if it's not going to rain.				I know that they've been doing a lot of work with **updating, upgrading right.**	There's a period of time before that runoff kind of subsides **sewage systems that are clogged by leaves and or other debris**. So if there are **not enough sewers** or enough **rain systems or drainage from the streets**, then that water carries and again, creates **more prominent problems, creates more damage because** now it's resting in a place that **wasn't built to hole that much water**. So you get the erosion that occurs there as well.	I think the **cost of it is an issue. I think that cost**, even though it's being passed off to the customer, is **really something that the city should own**. It is a system that they are providing.
PARTICIPANT #4 | T (4) C (V)	It definitely **seems dry** to me. I'm **certainly concerned**...at the base level [about **drought**].	**I don't dunno** if it's a atypical year or not.	Nothing in particular. So **I don't know how big of a problem water conservation** really is.	**No.**	**No.** And **no.**	**Next to nothing.**	I cant. **I don't know.**		On the assumption that structures, city structures don't collapse, **I don't feel an urgency for it.**	Again, on the assumption that city structures don't collapse, **I don't feel an urgency for it.**	And so the runoff...the the **retention** takes, **maybe that would be necessary make** this a interesting subject for me.				
PARTICIPANT #5 | T (5) I (C)	**Water shortages** keep going the way they are, eventually that's going to trickle down to **increased food costs**... I'm **pretty concerned** about [flood and drought].	**No. No**...little **weather systems** kind of really affect the **amount of moisture** we get the rain throughout over few years, it definitely seemed like **it's been down, up and down the moisture**. It is probably **definitely down.**	Would likely consider exploring. **We do not.** **We are definitely conscious about our water.**	I think **that's the biggest concern** for me directly. **[Not] immediately** but I do think that's a concern. **Only in the wintertime.** **Pipe[s] freezing** up.	**No, we haven't struggled with it.** It's usually around a hundred or $110 a month. **I think it's pretty fair cost.**	...Just have the water system where **it's collecting it through a gutter system or something like that**. I always wonder how it would taste what, I mean going through that process. I never seen them really have a **filtration system on it**. That's all I really know.	I know a guy here that has a aquaponic system here. **I would say the aquaponic system**....There's a couple **community farms** around here that I think are doing it, but other than that, that's all I know.		**Yeah, I definitely do.** Particularly with self-sustainable farming...the cost of food and grocery stores. I think that makes more sense to be focused on trying to do that more and **having a water supply system would be excellent** for that. But it's a, as far as collecting the water and **having it be able to cut some of your expenses, costs in some other aspect** is having a second source.						
PARTICIPANT #6 | T (6) I (B)	Concerns about **droughts** in this particular area. I **really don't have any concerns**. I **haven't seen any implications** that in the future we'll have problems with **droughts.**	**We [don't] get the amount of rainfall** that we're supposed to [get]....**I don't have any concerns at the moment.**	**No.**	**No.**	**Nope.**	**No idea.**	**No**, not at the moment.		**I see a lot of value in rainwater collecting.** Because it actually puts it to get to good use **instead of wasting the water.**						
PARTICIPANT #7 | T (7) I (F)	Seems like **droughts are getting worse.**	**I don't think it's enough** sometimes.	We **try to conserve** as much as we can.	**No.**	**We've had some issues with our water bill went up**. Water....**runs about $90 a month** here. It was **running $600 or $700 a month**....had some bad flappers.	**I know a little bit** about it....**55 gallon drums at the end of their gutters** and then they use that probably **for gardens** or whatever they're doing.	**No, because this area**....But I don't think you're going to see, it's just probably more of a low income area. So there's not going to be that kind of a people going to be harvesting that kind of stuff. **I don't see it anyway.**		**I do**, but I don't know what, I mean, **I don't know how would you collect that?**		I put a building up, then I **got to find ways to get this run off to a certain area**....and that's like a **$200,000 investment.**		I know I put in a lot of, they're putting a lot of money into **replacing lines and stuff.** Because they were saying today that how many, there's been what **20 water breaks or something like that.**	But the **city charges me for rainfall.** So if we get **so much rainfall, I get more expense**, which when you know, start looking at your bills, you're **charging me for more rain.** So **they need to make it as feasible** to them as they can too.	
PARTICIPANT #8 | T (8) I (M)	**Flooding** events gets **worse and worse and more**.	**Not to my knowledge.**	We are **conscious about water** use. Have very little **irrigation** for the grass	**No.**	**It is high**, but we use a lot of water.	**A little bit** just your, the like **DIY stuff for homes.**	Not auware of any, **no.**		**Yes for sure.** Potentially creating a **community garden** and with as large of a footprint as our roof is to **use that water directly for that.** **Watering the grass**. But it would, just due to pressure, we'd have to **have outside pressure pumps and stuff.**		All rain water is collected from the roof and it's taken strict as storm sewer? No, as far **as runoff or anything, it's all closed plumb system.**	Use water as well for our **dirt and field for moisture managements.**			
PARTICIPANT #9 | T (9) I (W)	**Not worried** [about flood or drought].	**Only when it makes its way into our buildings**...the rainwater **wasn't diverting properly**, then it'll sneak in.	**Do not.**	**No.**	**No**, haven't had any issues. **I'm sure it is [high).** Water was **up like 30% or 40%.**	**Not a lot.** I know **rain barrels can be a popular one for gardens** or other outdoor landscaping type activities.	**I do not know of any.**		In our case specifically, **I would say no.**			Our water **consumption is pretty minimal.** Our **equipment does use a water, water-based coolant.** It's really kind of a lubricant. So it's like a 95, 90 **6% water** and there's 4% a soluble oil			
PARTICIPANT #10 | T (10) I (R)	I'm **[not] educated enough** about it to have specific concerns. **Ice Shelf.** **Hurricanes.** **Global Warming.**	**No, not currently.**	**Not really.**	**No, and no.**	**No, and no.** If there is a spike in the water bill, then it tells me that there's water being wasted.	**I know just the basics**	I'd yet to see one on a business that I can think of, **not in the area.**		**I can see values.** I **don't** think that I could see a **value that would probably warrant the initial cost or time spent**.					**We don't use a lot of water around here.** **We do have a boiler that water is treated.** It's used to make steam for that autoclave. So depending on how many times we've run autoclave, we may have slightly more or less usage.	
PARTICIPANT #11 | T (11) R (M)	Hundred year **flood events** are becoming **more and more common.** Plan for these **really large flood events.** **Climate Change.**	We're already experiencing a lot of flooding events. So right now **it's concerning** and I think it's only **going to get worse.**	**Yeah, I'm definitely conscious.**	**I do not.**	**I don't know what the water bill is every month.** My landlord pays it...	**I know a decent amount in terms of planting**....kind of creating different areas to **percolate water** instead of just running it off.	Buildings that collect rainwater? **I don't know of any buildings**.		**Yes, definitely.** I think that would **benefit everyone.** It would be **free.** Coming from the sky and having those systems in place already will prepare us for the future...						
PARTICIPANT #12 | T (12) R (D)	**Water pools up** in the potholes...it's like a freaking pool almost. **Downfall.** **Melting.** **Global Warming.**	**We don't get a lot**...just the weather changing and how even now as of snow today.	So we **definitely try to conserve** as far as we will go.	**My pipes [froze]**...and so at that point where now we're just **dripping water** and then in my mind, I'm like, I feel **I am wasting water.** But to **drip the water**, which is a waste to make your pipes not freeze.	**No concerns for [paying] water bill**....water [is] **expensive.**	**I don't know anything.**	**Not that I know of.**		I mean, **yeah, definitely.** Even as far as something as simple as **watering your indoor plants.**					**We will go to a laundromat**.... And my girls...they want to take their time in the showers.....Hey, you guys, **limited time.**	They need to come up with something better as far as that **warming the pipes**. And I know it's hard, it's underground. They need to make **some kind of insulation for pipes so that they're not wasting more water**. Cause someday it has to come to an end someday day.
PARTICIPANT #13 | T (13) R (N)	It's **so dry now**, with gardening.	**Yeah,** actually in our area, I **am concerned** about it.	We **don't store water**....but **we do watch** how much **water we use.**	**No concerns** for that at this point.	**Haven't necessarily struggled** with paying for [water]. I do think that **we do pay a lot** for water...	**Don't know a whole lot**. Talked about getting a **barrel** that **collects the water at our house** and using that for **watering and watering our garden**.	**I don't believe there are any** that I'm aware of.		**Oh, absolutely. Yeah, absolutely.** Well, just to **save the environment**, pretty much that simple. And with **climate change,** obviously we're not getting as much rain as we used to and other places are getting more than they need. Yeah.			Take **short showers and turning off faucets** when you're not actually using the running water trying to do **small loads of laundry**.			
PARTICIPANT #14 | T (14) R (P)	Global warming has created **droughts and flooding.** More **storm systems**. **Drought** here now...a good year. **Global Warming.** **Aquifers.**		**We do watch** how much **water we use.**	**I don't.**	We **have not struggled to pay a water bill.** **I don't feel like it's too high.**	I think **rainwater harvesting** when I think about **big cisterns**. **underground cisterns.** Some people have **above ground tanks** where they would get **rainwater off of their roofs** where they **store for future use.**	I don't think so, **no.**		**I think that's a great idea.**	California....The reservoirs there, they're **limited on the...water they can store** because [they] were put in place to help for flooding....if they get too full, then it **doesn't help flooding purposes.**					
PARTICIPANT #15 | T (15) R (O)	map of the state, and it's surrounded by a river, but you don't know how reliable that source is. **Drought in summertime.** **No reserve for water.** **Reliable source.**		I am **very conscious** about my water use. I've been **conserving water.** I've been **very conscious** about how much I use.	**I don't know yet.**	**I haven't seen the bill.**	I think I **know the general idea** about it At the end of the gutter I hope to **implement a bin**, so to speak, **to collect that rainwater**. I can use the water directly out of the **bin for watering the lawn and the garden** and whatever I need. But if I do want to **drink the water**, I will have to **somehow include a filter**.	**I cannot tell you that.**		**...it will definitely help cut the cost of water.** And like I said, it will give **me some sort of freedom** because then I'll **have some reserve** that I can use **in case there is a drought.**		I was thinking of maybe creating a system where I can **collect rain water** and **connect it to my bathroom and to the washing machine.**	I do a lot of **hand washing if I can, small items for my laundry**. So I **don't use up so much water in the washing machine**. I take **very short showers**.			

KEYWORDS:	Flooding, Drought, Climate Change, Carbon Emissions, Water Shortages, Food Cost Increase, Ice Shelf, Hurricanes, Global Warming, Desanfali, Melting, Education, Aquifers, Storm Systems, Reliable	Unusual Rain Patterns, No Rain Overabundance Rain, Inconsistant Moisture	Removed existing water systems, Conserve, Conscious, Watch Water
Environmental Awareness Individual Conclusions:	Flooding (7) Drought (4) Storms (2) Climate Change (2) Global Warming (4) Carbon Emissions (1) Concerns (1) Non Enough Awareness/Education (2) No Concerns (2) No Reliable Source (1)	Rain frequency Concerns (8) No Rain Frequency Concerns (3) Do not Know (1) No Comment (3)	Yes Conserve (3 No Conserve (7) Water Conscious (10) Not Water Conscious (5)
Environmental Awareness Combined Conclusions:	There are flooding and drought concerns, concerns about global warming, concerns about not enough awareness or education. Low number of people (3) try to conserve water, approximately 50% of people do not conserve water. Approximately 10 people are water conscious and 5 people are not water conscious.		

KEYWORDS:	No, Not Immediate, In Wintertime, Freezing Pipes, Wasting Water, Do not know	Have not struggled, bill too high, Recent increases, bill is reasonable, not expensive, not asuare of water bill
Water Insecurity Individual Conclusions:	No Concerns (12) Indirect Concerns (3) – Not due to drought or flooding but other circumstances such as pipes freezing. Don't Know (1) – Neu to Kansas, had not received water bill yet.	Yes Struggled (0) No Struggled (14) Yes too High (7) No too High (14) Other Circumstances (3) – Water departments fault or not, at residence long enough
Water Insecurity Combined Conclusions:	There are no concerns specifically to water availability due to drought or flooding. However, there were a few participants that expressed their concerns for pipes freezing. One participant has not been in Kansas long enough to receive a water bill yet. No participants struggled with paying their water bill. However, this does not mean that they do not think it is too high. Seven participants think it is too high, four participants think its reasonable, and three participants either had to be reimbursed for water department issues or have not been at their residence long enough to know.	

KEYWORDS:	Not allot, Barrel, Gutter System, Filtration, 55 Gallon Drums, Gardens, Cisterns, Underground Cisterns, Store Water, Collect Rainwater, Drink Water	Benton & Linwood, 31st & Harrison, Aquaponic System, No
Rainwater Harvesting Individual Conclusions:	High Knowledge (4) Medium Knowledge (6) No Knowledge (5) Discussed their knowledge (9)	Yes Know of Place (3) Might Know of Place (1) Do not Know of Place (11 Described Location (3)
Rainwater Harvesting Combined Conclusions:	There is a relatively general understanding of rainwater harvesting out of all the participants. They were also willing to and openly discussed their knowledge on the topic as well. However, when discussing their knowledge on places near their current establishment, only three participants were able to vaguely discuss their knowledge on existing systems and know of a place nearby. Whereas one might have known of one, and eleven had no recollection of any systems nearby. After verbally reading the description on rainwater harvesting, twelve participants were extremely interested in the topic and concept of rainwater harvesting, while two participants still saw no value in the systems. Nine of the participants continued to provide an explanation on why, and input their perceptions and attitudes on the systems.	

KEYWORDS:	Speed, Equipment, Pump, Immediate Benefit, No Urgency, Cut Expenses, Not Sure How, Community Garden, Watering Grass, Warrant Initial Cost, Benefit Everyone, Save, Save Enjoyment, Reserve	Save Water Bill, Don't Feel Urgency, Limited on Water to be Used
	Yes Value (13) No Value (2) Provide an Explanation? (9)	

KEYWORDS:	Pumps, minimal consumption, boiler, laundromat, short showers, turn faucets off, small laundry loads, hand washing laundry	KEYWORDS:	old sewer system, arguing, bill spikes, clogged, charged for rainfall, upgrading, freezing pipes, water quality, city cost, problem
Water Use at Establishment Conclusions:	A majority of the partipants do not have out of the ordinary maintenance in terms of water at their establishment. One participant did express their concern of the number of pumps that they have had to implement, as well as the pit along with those pumps. Other participants discuss they try to reduce their usage by taking short showers, and washing clothes by hand to not use the washing machine too much.	Water Department Conclusions:	There are several concerns with the water department. Several individuals are having to deal with pump readings, water bill spikes, as well as building $200,000 worth of runoff infrastructure due to a new building being built on their property. One participant also expressed their concern with the water quality and not knowing where their water is actually coming from.

SUPPLEMENTARY THEMES AND CODES

KEY:

Q = QUESTIONNAIRE

T = TRANSCRIPTION

(#) = ID

C = CHURCH &
RELIGIOUS INSTITUTES

I = INDUSTRIAL, RESTAURANT
& RETAIL SERVICES
R = RESIDENTIAL

(LETTER) =
IDENTIFICATION OF
LOCATION
Example: (L) = Linwood
Church

IMAGE DATA COLLECTION (KEYWORD/THEMATIC ANALYSIS)
#1 FUNCTIONAL & EDUCATIONAL INSTITUTES
#2 INDUSTRIAL, RESTAURANT & RETAIL
#3 RESIDENTIAL & LIVING CENTERS
CURRENT RAINWATER HARVESTING SYSTEM IMAGES
EXPLANATION OF IMAGES WAS GIVEN
QUESTION ASKED: Do you have any questions or comments about any of these images?
ARTISTICALLY DESIGNED RAINWATER HARVESTING SYSTEM IMAGES
QUESTIONS ASKED WHILE VIEWING IMAGES - SUPPLEMENTARY ANSWERS
FUNCTIONAL DIAGRAM IMAGES
1. Do any of the users of the water appear to be missing out on how/where rainwater could you use collected rainwater?
2. Do you think this establishment would benefit from a system like this? If yes, in what ways? How could you access the water collected?
3. To what extent would you be willing to be a part of a process of creating something like this individually? How about collaborating with your community members?
4. What are your potential concerns about implementing these ideas in your building? What may keep you from getting involved in projects like this?
*answers can be viewed at the end of these columns or next to each image in appropriate participant column
CATEGORY
IMAGE
IMAGE/ID
PARTICIPANT #1 (1) (1) C (L)
PARTICIPANT #2 (1) (1) C (L)
PARTICIPANT #3 (1) (1) C (M)
PARTICIPANT #4 (1) (4) C (V)
PARTICIPANT #5 (1) (5) C (E)
PARTICIPANT #6 (1) T (5) I (M)
PARTICIPANT #7 (1) T (7) / (F)
PARTICIPANT #8 (1) T (8) I (M)
PARTICIPANT #9 (1) T (9) I (M)
PARTICIPANT #10 (1) T (10) I (D)
PARTICIPANT #11 (1) T (11) (I) (N)
PARTICIPANT #12 (1) T (12) (I) (D)
PARTICIPANT #13 (1) T (13) (I) (N)
PARTICIPANT #14 (1) T (14) (I) (F)
PARTICIPANT #15 (1) T (15) (I) (C)
PARTICIPANT #16 (1) T (16) (I) (C)
INCREASED "I THINK/I'M IMAGE WAS CHOSEN/PREFERRED 5-KEYWORDS
IMAGE 1: C (1)
IMAGE 2: C (1)
IMAGE 3: C (1)
IMAGE 4: C (1)
IMAGE 5: C (1)
IMAGE 6: C (1)
Pretty simple to me.
Simple
I've never seen this one... underground well/or large collection. It makes sense because you can hold it there. Water temperature remains at temperature, doesn't evaporate. And like I said, that for toilets & shed.
1 Toilets Hold More Water
Seems pretty cool to me.
So basically, once you get the water filled up in these tanks, like structed, does it it trucks come in and haul it off? Is how does that work?
I'm not sure if I've seen rainwater collection systems or not.
Cool Not sure if...seen rainwater collection systems
CURRENT CONCLUSIONS:
IMAGE 1: Simple
IMAGE 2: Simpler
IMAGE 3: Simpler
IMAGE 4: Simple
IMAGE 5: Simpler
IMAGE 6: Makes sense, hold more water. Ideal for toilets.
IMAGE 1: Cool. Not sure if realized they were rainwater harvesting systems in public.
IMAGE 2: Cool. Not sure if realized they were rainwater harvesting systems in public.
IMAGE 3: Cool. Not sure if realized they were rainwater harvesting systems in public.
IMAGE 4: Cool. Not sure if realized they were rainwater harvesting systems in public.
IMAGE 5: Cool. Not sure if realized they were rainwater harvesting systems in public.
IMAGE 6:
IMAGE 1:
IMAGE 2:
IMAGE 3:
IMAGE 4:
IMAGE 5:
IMAGE 6: Underground component, could see this.
IMAGE 1: Yes, good systems very useful
IMAGE 2: Replace of a traditional irrigation system, good system.
IMAGE 3: Very useful, watering habits/irrigation, good systems.
IMAGE 4: Very useful, good system.
IMAGE 5: Very useful, good system.
IMAGE 6: Don't think I'd use it, good systems.
IMAGE 7: Simple
IMAGE 8: Simple
IMAGE 9: Simple
IMAGE 10: Makes sense, hold more water. Ideal for toilets.
Yes, the baptism, fd probably have a filter.
Yes.
Yes.
Yes.
Yes.
3 Freshwater/potable Systems (Don't Dig Bathroom) Filter
3 Toilets Utility Backup
2 Watering
1 Sprinkler Irrigation
1
IMAGE 7: Freshwater, they symbols, they dont dig
IMAGE 8: The toilet ...the basement toilets.
IMAGE 9: Maybe a sprinkler system for watering, if it could be drier climates.
IMAGE 10: Yeah, that's a big fella.
IMAGE 7: Yes, good systems very useful
IMAGE 8: Yeah, definitely. I think having a system like this in place instead of a traditional irrigation system would really maximize people to plant more sustainable landscapes.
IMAGE 9: Yeah, I think especially the ones for watering habitat support. It could see that working really well.
IMAGE 10: Yeah, I'd be very willing to bring this up ... to my local community. I could definitely be willing to come together and invest in something like this.
3 My House Useful
5 Irrigation Traditional Irrigation System Useful
4 Habitat Support Useful My House
2 Useful
3 Useful My House
I (wouldn't) live it My house
FUNCTION CONCLUSIONS:
IMAGE 7: Yes, good systems very useful
IMAGE 8: Replace of a traditional irrigation system, good system.
IMAGE 9: Very useful, watering habits/irrigation, good systems.
IMAGE 10: Very useful, good system.
IMAGE 11: Yes, good systems very useful
IMAGE 12: Replace of a traditional irrigation system, good system.
IMAGE 13: Very useful, watering habits/irrigation, good systems.
IMAGE 14: Very useful, good system.
IMAGE 15: Very useful, good system.
IMAGE 16: Don't think I'd use it, good systems.
IMAGE 11: Sure
IMAGE 12: Sure
IMAGE 13: Sure
IMAGE 14: Sure
IMAGE 15: Sure
IMAGE 16: Sure
IMAGE 11: Yes, good systems very useful
IMAGE 12: Replace of a traditional irrigation system, good system.
IMAGE 13: Very useful, watering habits/irrigation, good systems.
IMAGE 14: Very useful, good system.
IMAGE 15: Very useful, good system.
IMAGE 16: Don't think I'd use it, good systems.
IMAGE 7: Yes, good systems very useful
IMAGE 8: Replace of a traditional irrigation system, good system.
IMAGE 9: Very useful, watering habits/irrigation, good systems.
IMAGE 10: Very useful, good system.
IMAGE 11: Very useful, good system.
IMAGE 12: Don't think I'd use it, good systems.
IMAGE 13: Yes, good systems very useful
IMAGE 14: Replace of a traditional irrigation system, good system.
IMAGE 15: Very useful, watering habits/irrigation, good systems.
IMAGE 16: Very useful, good system

APPENDIX D
Email Recruitment Template
The email template sent to each participant and business within each of the three categories.

Email Draft

Dear xxx,

My name is Shaedon Wedel, and I am a graduate student of landscape architecture at Kansas State University. I am currently conducting a research project on the possibilities of implementing integrated rainwater harvesting systems within neighborhoods based on people's thoughts and attitudes. I am focusing on eight neighborhoods of Eastside Kansas City, and five categories of impervious structures within these neighborhoods that have the potential to collect rainwater. One of my categories includes [insert category type], and your establishment falls under this category.

I am seeking individual(s) to interview, preferably a person(s) in charge, or a person who is the primary decision maker for the establishment such as a [pastor or administrator (church & religious institutes)], [teacher, principal, administrator, or librarian (schools and literacy centers)], [property manager or administrator (living and care complexes & childcare centers)], [administrator, manager, or property owner [industrial, retail & restaurant and lots)]. This is to gain information on the roles and eligibility of the establishment and how rainwater harvesting can be of value. The interview questions will be open-ended for casual discussion. The conversations will be anonymously audio-recorded and later transcribed for analysis. The interview(s) will take approximately 10-15 minutes. If possible, I would like the location of the interview to be at the [insert building type]. This is for familiarity and comfort for the individuals being interviewed.

I am looking to conduct interviews December 19 – 22, 27 – 31, and January 12-22. If you are interested in participating, please respond to this email. Also, please share this email with other individuals who would be interested in participating.

I appreciate your consideration, and please reach out with any questions or concerns you may have. Due to time limitations of the project, please respond as soon as possible. Your help is greatly appreciated.

Thank you,

Shaedon Wedel

APPENDIX E
Resources

A list of funding resources for Rainwater Harvesting Systems:

Bridging the Gap
A local Kansas City program that offers several water and energy conservation programs. They have 55-gallon rain barrels for purchase for approximately $65.00.

Mid-America Regional Council
A program called Clean Water KC Metro with specific information on rain barrels. They have a guide on how to and why to plant native plantings and implement rainwater harvesting systems. There is also a guide to build a system for as low as $12.00 to $15.00.

Cultivate KC
Cultivate KC is a local program that has water access funding. They offer grants to grow vegetation to help mitigate stormwater runoff, as well as funding for water conservation projects such as rainwater harvesting. Up to 90% of a water conservation project can be funded by a grant.

A list of Contractor resources for Rainwater Harvesting System:

KC LANDSCAPES & POOLS: info@kclandscapes.com**,** 913-681-5263

JW RAINWATER COLLECTION

PRO FOUNDATION TECHNOLOGY, INC.: Kansas City Office: 816-358-3300

BRAE: 800-772-1958

TOTAL LANDSCAPE CARE: jcull@randallreilly.com**,** (800) 633-5953, ext. 1046

APPENDIX F
Brochure

RAINWATER HARVESTING

RAINWATER HARVESTING IS THE COLLECTION OF RAINWATER FROM A SURFACE SUCH AS A ROOF, STORING THE WATER, AND USING IT FOR VARIOUS USES SUCH AS UTILITIES, IRRIGATION, OR PLAY.

FUNDING

BRIDGING THE GAP:
A local Kansas City program that offers several water and energy conservation programs. They have 55-gallon rain barrels for purchase for approximately $65.00.

MID-AMERICA REGIONAL COUNCIL:
A program called Clean Water KC Metro with specific information on rain barrels. They have a guide on how to and why to plant native plantings and implement rainwater harvesting systems. There is also a guide to build a system for as low as $12.00 to $15.00.

CULTIVATE KC:
Cultivate KC is a local program that has water access funding. They offer grants to grow vegetation to help mitigate stormwater runoff, as well as funding for water conservation projects such as rainwater harvesting. Up to 90% of a water conservation project can be funded by a grant.

CONTRACTORS

KC LANDSCAPES & POOLS:
info@kclandscapes.com
913-681-5263

JW RAINWATER COLLECTION

PRO FOUNDATION TECHNOLOGY, INC.:
Kansas City Office: 816-358-3300

BRAE:
800-772-1958

TOTAL LANDSCAPE CARE:
jcull@randallreilly.com
(800) 633-5953, ext. 1046

for more information refer to-

RAINWATER HARVESTING:
the possibilities of an integrated network in urban communities based on people's perceptions, attitudes, and neighborly efforts

located at: https://krex.k-state.edu/

author: SHAEDON WEDEL

RAINWATER HARVESTING

SAVE
RAIN
SAVE
MONEY
SAVE
ENVIRONMENT

PURPOSE

THE PURPOSE OF THIS GUIDE IS TO SHOW YOU HOW TO BENEFIT FROM RAINWATER HARVESTING SYSTEMS. YOU CAN BENEFIT FROM THIS FINANCIALLY AND ENVIRONMENTALLY, AND BE A PART OF A COMMUNITY WORKING TOGETHER TO BUILD A STRONG INTEGRATED NETWORK OF RAINWATER HARVESTING SYSTEMS.

YOU COULD SAVE $115.00 PER MONTH, OR $1,400 PER YEAR!

INDIVIDUAL EFFORTS

STEP 1: UNDERSTAND WHAT IT TAKES

STEP 2: IDENTIFY YOUR GOALS AND EXPECTATIONS OF THE SYSTEM(S)

STEP 3: IDENTIFY AVAILABLE AND NEEDED RESOURCES

STEP 4: SELECT A LOCATION FOR THE SYSTEM(S)

STEP 5: IDENTIFY AND GATHER SUPPLIES

STEP 6: CONSIDER LOCAL FUNDING OPTIONS AVAILABLE

STEP 7: INSTALL RAINWATER HARVESTING SYSTEM

COMMUNITY EFFORTS

STEP 1: ORGANIZE A COMMITTEE OR APPOINT A REPRESENTATIVE

STEP 2: IDENTIFY LOCATIONS FOR SYSTEM(S) TO BE IMPLEMENTED IN A 'SHARED' OR COMMUNAL SPACE

STEP 3: COMMITTEE OR REPRESENTATIVE IS TO IDENTIFY PREFERENCES FOR THE USES OF COLLECTED WATER AND MANAGING THE NETWORK

STEP 4: CONSIDER COMMUNITY-WIDE BENEFITS SUCH AS FIRE HYDRANTS, IRRIGATION FOR GREEN SPACES AND COMMUNITY GARDENS.

STEP 5: INSTALL RAINWATER HARVESTING SYSTEM

TYPOLOGIES

CHOOSE YOUR SYSTEM

	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5
POTENTIAL LAND-USE TYPE	HOUSES, SMALL RETAIL AND RESTAURANTS, SMALL EDUCATIONAL AND CULTURAL ESTABLISHMENTS	RESIDENTIAL, RESTAURANTS, SMALL APARTMENTS, LIVING CENTERS, AND EDUCATIONAL AND CULTURAL INSTITUTES.	LARGE RESTAURANT AND RETAIL, EDUCATIONAL INSTITUTES, AND APARTMENT OR LIVING CENTERS.	INDUSTRIAL, EDUCATIONAL, LARGE CULTURAL, APARTMENTS AND LIVING CENTERS.	LARGE INDUSTRIAL BUILDINGS, LARGE EDUCATIONAL INSTITUTES, LIVING CENTERS, AND LARGE APARTMENTS.
SIZING OF SYSTEM(S)	5-GALLON TO 5,000 GALLON 2' DIA. & 4' HEIGHT – 11.5' DIA. & 7.5' HEIGHT	5,000 GALLON TO 10,000 GALLON; 11.5' DIA & 7.5' HEIGHT AND 11.5' DIA & 13.5' HEIGHT	10,000 GALLON TO 15,000 GALLON; 11.5' DIA & 13.5' HEIGHT AND 12' DIA & 20.5' HEIGHT	15,000 GALLON TO 20,000 GALLON; 12' DIA & 20.5' HEIGHT AND 14' DIA & 20' HEIGHT	APPROXIMATELY 20,000 GALLON CONTAINER OR LARGER
SURFACE COLLECTION SQUARE FOOTAGE	20 SQ. FT. TO 5,000 SQ. FT.	5,000 SQ. FT. TO 10,000 SQ. FT.	10,000 SQ. FT. TO 15,000 SQ. FT.	15,000 SQ. FT. TO 20,000 SQ. FT.	20,000 SQ. FT. OR LARGER
INSTALLATION COST	$50 TO $4,500	$4,500 TO $16,000	$16,000 TO $25,000	$25,000 TO $40,000	NO LESS THAN $35,000
MATERIALS	POLYETHYLENE OR FIBERGLASS	POLYETHYLENE OR FIBERGLASS	POLYETHYLENE, FIBERGLASS OR STEEL	GALVANIZED STEEL RECOMMENDED	GALVANIZED STEEL RECOMMENDED
AMOUNT OF WATER ABLE TO COLLECT	70 GALLONS TO 16,700 GALLONS	16,700 GALLONS TO 33,500 GALLONS	33,500 GALLONS TO 50,400 GALLONS	33,500 GALLONS TO 67,000 GALLONS	67,000 GALLONS AND INCREASES WITH SQ. FT.

APPENDIX G
Project Timeline

MASTERS PROJECT/REPORT TIMELINE