JACK N. AVERITT COLLEGE of GRADUATE STUDIES GEORGIA SOUTHERN UNIVERSITY

Georgia Southern University

Digital Commons@Georgia Southern

Electronic Theses and Dissertations

Graduate Studies, Jack N. Averitt College of

Spring 2020

Public Perception of Different Planting Techniques using Augmented Reality

Sultana Quader Tania

Follow this and additional works at: https://digitalcommons.georgiasouthern.edu/etd

 Part of the Design of Experiments and Sample Surveys Commons, Other Social and Behavioral Sciences Commons, Transportation Engineering Commons, and the Urban Studies and Planning Commons

Recommended Citation

Tania, Sultana Quader, "Public Perception of Different Planting Techniques using Augmented Reality" (2020). *Electronic Theses and Dissertations*. 2041.
https://digitalcommons.georgiasouthern.edu/etd/2041

This thesis (open access) is brought to you for free and open access by the Graduate Studies, Jack N. Averitt College of at Digital Commons@Georgia Southern. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of Digital Commons@Georgia Southern. For more information, please contact digitalcommons@georgiasouthern.edu.

PUBLIC PERCEPTION OF DIFFERENT PLANTING TECHNIQUES USING AUGMENTED REALITY

SULTANA QUADER TANIA

(Under the Direction of Celine Manoosingh)

ABSTRACT

The objective of this study was to measure public perception of the different planting techniques (block and matrix), which are used at visitor information centers (VICs) and other rights of way (ROW) areas. The main factors that affect public perception of planting techniques were identified through an extensive literature review and qualitative survey from four welcome centers in the state of Georgia. The ranking of those indicators, based on public preferences, was discovered through a quantitative survey. During the first phase of the quantitative survey, images of block and matrix were used. An iOS-based user-friendly and cost-effective augmented reality (AR) app was developed, and a significant difference was found between data with and without AR. Participants were more interactive and engaged in the survey process, largely due to the addition of the AR visuals questionnaire. The ranking of the factors being obtained from the study were: environmental benefits, sustainability, color and aesthetics, cost, maintenance, and restorative effect. The majority of the respondents expressed that block planting configuration was more aesthetically beautiful. However, when all the factors were considered, the public largely preferred matrix planting, as it tends to be more beneficial to the environment. It is sustainable, cost-effective, and requires less maintenance. Results from this study indicated that environmentally beneficial and sustainable planting was more preferred by traveling people for ROW planting.

INDEX WORDS: Augmented reality, Public perception, Planting techniques, Sustainability, Color and aesthetics, Mix method survey

PUBLIC PERCEPTION OF DIFFERENT PLANTING TECHNIQUES USING AUGMENTED REALITY

by

SULTANA QUADER TANIA

B.S, Bangladesh University of Engineering and Technology (BUET), Bangladesh, 2016

A Thesis Submitted to the Graduate Faculty of Georgia Southern University

in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

© 2020

SULTANA QUADER TANIA

All Rights Reserved

PUBLIC PERCEPTION OF DIFFERENT PLANTING TECHNIQUES USING AUGMENTED REALITY

by

SULTANA QUADER TANIA

Major Professor:	Celine Manoosingh
Committee:	Roger Purcell
	Junan Shen

Electronic Version Approved:

May 2020

DEDICATION

I want to dedicate my thesis to my parents for their love and support throughout my life and belief in me, also to my husband, Rana, who inspires me every day.

ACKNOWLEDGMENTS

I want to express my gratitude to my thesis supervisor, Dr. Celine Manoosingh, for her constant support, guidance, and for being such a great mentor. I would also like to thank my committee members, Dr. Shen, and Dr. Purcell, for their assistance in my graduate study. I am thankful to my friend and brother, Zayed Upal, fellow GSU graduate student from the Computer Science department, for helping me to develop the augmented reality app. Lastly, thank you to all my friends and family here in the USA and Bangladesh, who have supported me.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background

Roads play an important role in the socio-economic development of any country by providing significant ways of communication among the different cities (Harper, 2001). The 20th century triumph of the automobile makes for easy movement over long distances and provides comfort, which was previously not afforded (Webber, 1992). With the increasing use of roads for transportation in modern life, roadside vegetation has become one of the major elements of the roadside environment that people experience daily. Efficient roadside vegetation management strategies are desired since roads have become the dominant feature of the modern landscape. During the late 1980s and early 1990s, researchers began to investigate the strengths and weaknesses of the wildflower movement in North America. Nationally, sustainable roadside vegetation management strategies encourage an integrated design approach that addressed the reduction of expenses, minimization of maintenance, and incorporation of regionally appropriate vegetation and utilization of context-sensitive solutions (Lucey & Barton, 2010). Sustainable roadside vegetation contributes to better water quality, conductivity (Forman et al., 2003) and saves cost while also benefiting the socio-economic health of the state (Barton et al., 2005). Currently, sustainable roadside vegetation management calls for an extensive and integrated approach balancing beautification, costs, functionality, and environmental benefits. Many studies explained the advantages and disadvantages of using vegetation and flora in ROW areas. Many state DOTs (Minnesota, Indiana, California, Florida, etc.) in the USA have done extensive research about the benefits of sustainable roadside vegetation management. One Minnesota based study

explored the wildflower route, which is now considered a model for the management of rights of way prairie across the state. The new management program helped to increase populations of rare plants and developed high species diversity. They also discussed the practical, economical, ecological, and aesthetic benefits of wildflower routes with Minnesota's native prairie plant communities (Jacobson, 1990). Indiana Department of Transportation investigated the usage of wildflowers on Indiana highways. It explained the performance difference between garden wildflowers and prairie plants. The study also provided a management system to explain the cost and establishment that could be used to design the rights of ways, using wildflowers in other states of the USA (Dana, 1996). O'Dell et al. (2007) discussed the benefits of native roadside perennial grasses in Sacramento Valley, California, in terms of low maintenance, drought-tolerance, and stable cover and persistence. Roadside vegetation has great economic value too. Florida's State Highway ROW ecosystem's value was estimated at nearly half-billion dollars (Harrison, 2014). The value would be doubled with sustainable vegetation management practices and even would be nearly tripled with wildflower areas through remnant native plant communities and wildflower plantings. The detailed findings of these are discussed more elaborately in the literature review section (Chapter 2).

Besides environmental benefits, roadside vegetation provides numerous psychological benefits to drivers. Environmental psychologists found that properly and maintained roadside scenes reduce travel-related stress and may improve the driver's attention (Mok, 2006). Roadside vegetation also has restorative effects (Cackowski, 2003). These researches explained the benefits

and advantages of the roadside vegetation, but there was no discussion about the factors directly impacting public perception of roadside vegetation.

Guyton et al. (2014) quantitatively evaluated the effects of mowing activities on plant changes, deer presence, and public perception of less manicured ROW in Mississippi. The study showed that people were supportive of wildflowers in ROW areas. The participants of the study also mentioned that it is nice to have less manicured plants if they are more cost-efficient, safe for roads, and cause less litter on the road. Images were used in the questionnaire survey to learn public perception (Guyton, 2014). Even though there is a good amount of information about the factors impacting public perception, no data or analysis is provided to quantify and rank those factors. In addition, these studies have used images and videos of roadside planting to learn public perception. In this research, cutting edge augmented reality was used to get public perception about different planting techniques.

Additional studies also provided the theoretical foundation and quantitative justification for factors impacting perception, preference, and behavior. However, those frameworks were not for public perception in planting techniques and sustainable vegetation management. Gobster et al. (1987) developed a model with physical, artistic, and psychological dimensions to predict aesthetic preference among different landscape types using color photographs of selected scenes taken in the summer (Gobster and Chenoweth, 1989). Macdonald et al. (2008) developed quantifiable performance measures to quantify the impact of the design features of transportation corridors on user behavior, environmental quality, economic vitality, and public health.

Due to the lack of adequate research, it is uncertain to know what factors are more important to people about roadside planting. This study filled the gap in these previous researches and overcame the limitation regarding public perception and roadside planting.

1.2 Georgia Wildflower Program

Georgia initiated the wildflower program in the right of ways (ROW) facilitated by the Georgia Department of Transportation (GDOT) in 1974, with the intention to plant and preserve wildflowers growing along the roads. The program is widely supported in terms of aesthetic enhancement, low maintenance cost, and environmental and ecological benefits. However, it is still uncertain whether flower pots are appealing to the public. For instance, when flowers complete their blooming cycle, plots containing these crops may look weedy and not well maintained, eliciting a negative public perception. Although public perception is an essential factor when using vegetation as a sustainable approach to manage right of way (ROW) areas, in some cases, it is ignored.

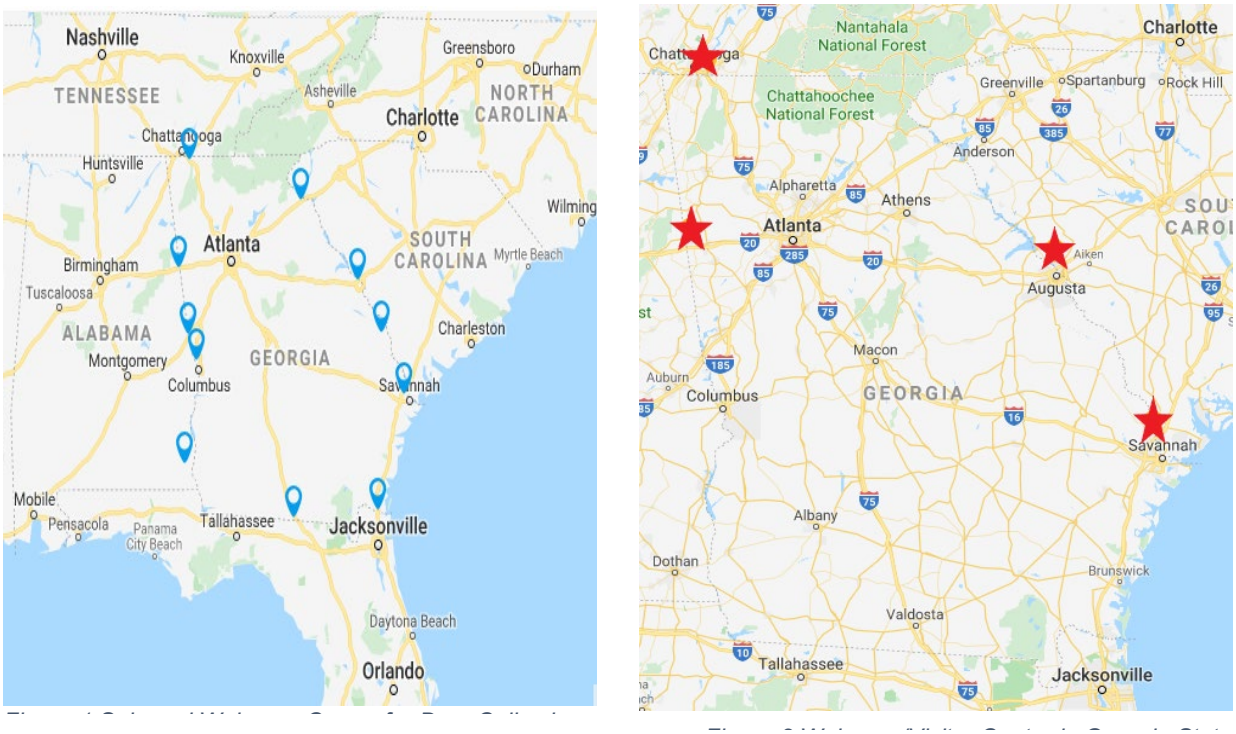
1.3 Georgia Welcome Center

Welcome centers are an essential part of the USA's promotional tourism and recreation facility (Perdue 1995). Travelers stop at the welcome centers for various reasons. The main reasons are to use restroom facilities, obtain state maps or brochures, to walk their pet, or to buy refreshments and picnic (Gitelson and Perdue 1987). Welcome centers generally have support facilities (e.g., parking lots, attractive grounds, outdoor seating, walkways, and vistas) and other conveniences for the traveling public (e.g., toilets, water, maps, literature, telephones, and vending machines) programs (USBR, 2007). Many studies have found that information obtained from

welcome centers help tourists to spend more time effectively (Fesenmaier and Vogt,1993). Several studies have examined the effects of welcome centers on visitor's behavior, the necessity, and the importance of the centers. Still, no study revealed the public perception of the vegetation around the welcome centers. In Georgia, visitor centers have more than 13 million guests each year (Exploregeorgia, 2019). This population significantly represents the motorist traveling through Georgia. In this study, public perception towards different plantings was determined by collecting data from Georgia's welcome centers.

1.4 Study Area and Populations

The population for this study was the public, including residents and travelers driving through the state of Georgia. A study conducted on visitors of welcome centers showed that users of welcome centers are largely different from highway travelers. People who visit welcome centers tend to travel in larger groups or on a pleasure tour and have a higher income than non-users (Muha, 1977). There is a total of eleven welcome centers in Georgia shown in Figure 1 with blue and white markings. Among them, three were selected for representative data collection. Figure 1 shows a portion of Georgia with the selected visitor center (marked with red stars).



(a) (b)

Figure 1.1: (a) shows all welcome centers in the State of Georgia (with blue and white marks) (b) a portion of Georgia with selected welcome centers (marked with a red star).

Name and location of the selected welcome centers are given below:

Table 1. 1: Name and location of the selected welcome centers

No	Name of the Centers	Border	Address
1	Georgia Visitor Information Center-Port Wentworth (Savannah)	GA – SC	I-95, Port Wentworth, GA 31407
2	Georgia Visitor Information Center-Augusta	GA – SC	I-20 West, GA-SC Line, Augusta, GA 30917.
3	Georgia Visitor Information Center-Ringgold	GA – TN	I-75, Southern Dr, Ringgold, GA 30736
4	Georgia Visitor Information Center-Tallapoosa	GA – AL	I-20 East, GA-AL Line, Tallapoosa, GA 30176.

1.5 Planting Techniques

For planting techniques, matrix and block planting techniques were used as they are the most popular planting techniques in the USA. Matrix planting is a naturalistic garden technique that consists of a large number of small ground-cover plants. Large natural drifts filled with complementary textured layers of ornamental grasses establish the matrix while herbaceous perennials provide structure, together forming grand sweeps of plantings with strong visual impact. It mostly has blue fescue, blue grama, and sedge as a structure and some other colorful wildflowers in between to enhance the visual beauty of the planting technique (Figure 1.2). Block planting is a mono-layer within each block, and the larger the block, the more wildflower it contains. Block planting has a colorful and embellished layer of wildflowers such as black-eyed Susan, purple cornflower, iris, daylily, phlox, salvia, and a coreopsis layer in the central and a final layer with sedge grass on the outer circle (Figure 1.3). Block planting looks more attractive and produces a dramatic display during winter (Cameron, 2016). Both of these techniques use the same kind of flowers, although the orientation of the flowers is different. Matrix planting has a lot of environmental benefits such as attracting beneficial insects, supporting natural pest and weed control, improving soil fertility, encouraging biodiversity, and retaining moisture, which conserves water (Fix, 2016).

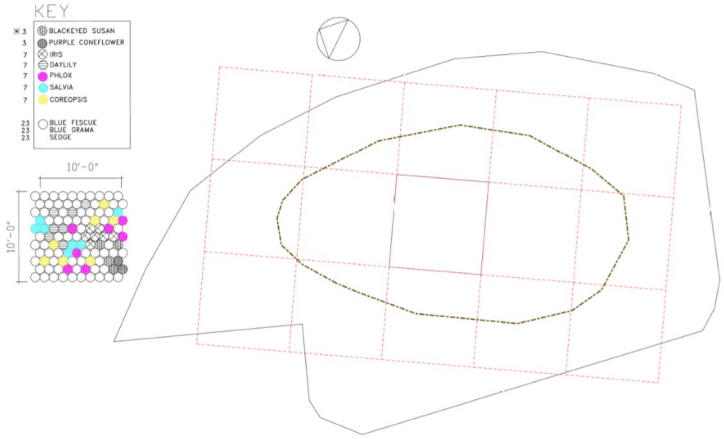


Figure 1.2: Graphic representation of matrix planting technique

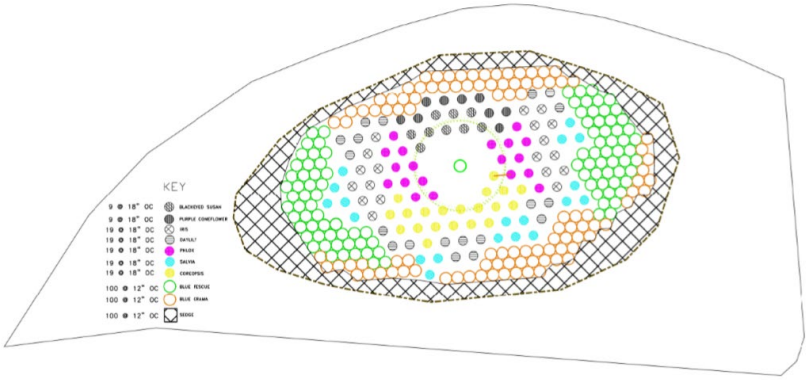


Figure 1.3: Graphic representation of block planting technique

1.6 Problem Statement

Every year, the Department of Transportation of each state dedicates a significant amount of expenditure for improving and maintaining roadside vegetation. It is not clear whether people are satisfied with how this expenditure is utilized. This research provided data regarding public perception through mixed qualitative and quantitative methods to suggest which planting

technique results in the highest satisfaction among people. For this study, an augmented reality app was developed, which showed different planting techniques. This app would help GDOT to get a better visual representation of those planting in different scales or spaces.

1.7 Research Questions

To examine public perception of different planting techniques, we posed these following questions:

1. What are the indicators impacting public perception regarding different planting techniques (block and matrix) to people traveling to Georgia?
2. How do public responses change with different control indicators for different planting techniques?
3. What is the public perception of sustainability roadside planting?
4. Does the use of augmented reality affect survey engagement?

1.8 Research Significance

The findings of this study have significant practical and theoretical contributions to the roadside landscape. This study identified some factors that influence people's perception of different planting techniques, including block and matrix. This study had acknowledged the public opinion of roadside planting based on environmental benefits, maintenance, sustainability, restorative effects. This research also ranks these two planting techniques based on people's responses with different control indicators. Besides, augmented reality was used to determine public preference for planting techniques. The same AR model can be used in other related studies related to landscape design to determine public perception or preferences.

1.9 Methodology

The solution to the research questions was studied through the following methodologies,

i. Literature Review

ii. Qualitative and Quantitative Surveys

iii. The use of augmented reality as a visual supplement

CHAPTER 2

LITERATURE REVIEW

The population of cities is steadily on the rise, mainly due to the development of transportation systems. Urban growth leads to the construction of new roads and motorway expansions. Roads and highways occupy a great deal of land, altering the surrounding landscape immensely. In the United States, over 8 million acres of land are devoted to roadways, and an additional 12 million are dedicated to acquiring their rights-of-way. U.S. Departments of Transportation (DOTs) are recognized as the stewards in charge of public land and property. Roads have a significant impact on urban and suburban areas. They also affect the landscape, ecology, environment, aesthetics, and scenic beauty of the altered areas (Alberti 2008).

2.1 Roadside Wildflower's Benefits

Many studies have explored the environmental benefits of native and non-native roadside vegetation. The Minnesota Department of Transportation and Natural Resources conducted one study on prairie plants. Prairie plants have practical, economical, ecological, and aesthetic benefits. Prairie grasses and wildflowers have a longer root system than turfgrass. They are more effective in preventing soil erosion. This native plant helped to maintain high species diversity and several rare plants flourish after maintaining prairie plants in the right of way. The study proposed a highway management program, which was a model for the management of the rights of prairies throughout Minnesota. Their management program helped to reduce the use of herbicides and to mow for weed control. People appreciated six wildflower routes, and the local communities became a part of the promotion of these routes (Jacobson, 1990).

Another study based in Indiana explained the questions concerning the usage of wildflowers on several Indiana highway right-of-ways. This Indiana Department of Transportation (INDOT) funded project investigated the cost of establishment and management of wildflowers varied with different types and management. In their study, they found that wildflowers were more cost-effective with respect to grass monoculture vegetation strategy. Garden wildflowers cost less to establish, but their life cycle cost was higher. On the other hand, prairie wildflower plants were cost-effective when long term management costs were considered in the analysis. They also compared the quality of the seed of native prairie and garden wildflower species.

Another study based in California discussed the benefits of native roadside perennial grasses in the Sacramento Valley, California. It was claimed in their study that the restoration of native grassland along roadsides could offer a relatively low-maintenance, drought-tolerant, and stable perennial vegetative cover with reduced weed growth, as opposed to the high-maintenance invasive annual cover. They surveyed established native grass planting in Yolo County. The survey revealed that if the native planting could be protected from disturbance, they could persist with minimal maintenance for more than a decade. (O'Dell, 2007).

2.2 Sustainable Roadside Vegetation Management and Associated Benefits

A sustainable roadside is one that is designed, constructed, and maintained with an emphasis on long-term appropriateness and maintaining a low lifecycle cost. "A roadside that fulfills design intent and roadside functions over the long term, and protects the environments wherever possible, within the present and future available funding, personnel, equipment, and methodologies" (RCP, 2007). To achieve sustainable roadsides, roadside partners must strive to

utilize, protect, and support the physical and ecological resources necessary for a fully functioning roadside. In-state and federal policy establish goals to ensure that roadsides are managed for sustainability. Sustainable roadsides contribute to the benefits for present and future generations that include cost savings, better water quality, and hydraulic conductivity, increased bio-diversity, and improved socioeconomic health of the state (Lucey, 2010). Sustainable roadside vegetation has immense economic benefits. Florida's State Highway ROW ecosystem was estimated to be valued at nearly a half-billion dollars, which would be doubled with sustainable vegetation management practices and even nearly tripled with Wildflower Areas through remnant native plant communities and wildflower plantings. Aesthetics were valued at over $2.2 million, significantly impacting Florida's economy through travel business and increased employment (Harrison, 2014). The Delaware Department of Transportation's (DelDOT) study showed that by expanding their strategy, including the release of turf from routine mowing, DelDOT decreased their mowing expenditure by increasing the visual beauty of areas. Erosion and sediment flow were also reduced by following sustainable roadside vegetation management strategies (Forman, 2003). Vegetation acts as a barrier and provides phytoremediation of organic pollutants and increases the amount of organic carbon in the soil, which, in turn, stimulates beneficial microbial activity (Schnoor, 1995). In 2008, the National Research Council of the United States identified urban stormwater as a leading source of water quality problems in the US (EPA, 2010). When rainwater and snowmelt cannot percolate into the earth, it runs off onto roads and it absorbs petroleum and other harmful toxins before making their way into the water supply. Native grasses have been shown to capture precipitation better than mown turf, and their deep roots provide deeper channels to help runoff infiltrate more efficiently into the soil (Harper, 1999). By increasing infiltration and decreasing

surface runoff, fewer toxins are deposited into local water supplies. Roadsides are very important for the conservation of biodiversity. Animals are generally attracted to transportation corridors for habitat, natural movement, and food availability. By efficiently utilizing land already precluded from development, DOTs could significantly help to restore ecological balance and build a better ecosystem (Hopwood, 2008). Several studies investigated the use of roadside vegetation in reducing air pollution around roads and highways. Richard, in his study, described the characteristics of roadside vegetation that can improve local air quality. His design conditions included height, thickness, coverage, porosity/density, species considerations, etc. Besides, he mentioned some characteristics that should be avoided to protect air. He also suggested that his design considerations could be used to mitigate impacts from air pollution occurring from ground-level emission (Richard, 2017).

2.3 Driver's Benefits

Roadside vegetation has significant environmental and psychological benefits to drivers. Many studies have shown that natural landscapes can effectively lower crash rates and cause less frustration and stress to the driver. Parkway design and right of way vegetation has a restorative effect and can help the frustration of the drivers. Parsons et al., 1993 examined the contribution of greenery to stress relief. A total of 160 college-age participants watched one of four videotaped simulated drives. Those who experienced artifact-dominated ride faced elevated blood pressure and electrodermal activity (Parsons, 1993).

On the other hand, those who viewed a nature-dominated trip showed quick recovery from stress and higher immunization. Cackowsk conducted a similar kind of experiment with 106 participants, where participants watched a video of a varied amount of vegetation and human-made

material. Results from the research suggested that exposure to more plants can facilitate recovery from anger and frustration (Cackowsk, 2003).

Cole et al. (2014) explored the relationship between the size of the clear zone and the presence of roadside vegetation on vehicle speed and lateral position. (Cole, 2014). Roadside planting is also an essential part of residents of urban areas. Trees and other vegetation can mitigate adverse environmental conditions in road corridors, which is particularly important in vulnerable neighborhoods that are deficient in green spaces. Enhancing the facility value of streetscapes might also positively affect public health by encouraging physical activity (Saumel, 2015). The American Association of State Highway and Transportation Officials (AASHTO) has long recognized that the proper landscape and aesthetic development of urban streets provide a charming touch of natural beauty in a man-made environment. These improvements are often the means of improving the economic values of the areas adjacent to the streets and creating a sense of community identity (AASHTO, 1970). Environmental psychologists developed theories that attempted to explain the relationship between people's interest and attention to their environment. The aesthetically pleasant environment gives people the chance to improve the quality of human life. One study on parkways suggested that carefully landscaped roadside edges give the driver a more pleasant experience than the interstate highways. It also contributes to higher degrees of attentiveness (Mok, 2003). In another study, Mok showed the effect of landscape development impact on roadside safety. Mok and his team selected 61 road sections in Texas, which were designed as urban arterial or state highway. They compared crash data in those road sections before and after landscape improvement. It was found that the crash rate decreased by a significant amount to those places where landscape improvements were executed (Mok, 2006).

2.4 Measuring Public Perception of Roadside Vegetation

The current literature review suggested that public perception is a significant factor when using vegetation as a sustainable approach to manage right of way areas. Lucey and Barton (2010) composed a comprehensive review of the evolution of roadside landscape and vegetation management, the benefits of sustainable vegetation management strategies, and the importance of public awareness and perception in Delaware. A study in northern England suggested that the majority (83%) of the respondents described the scenic quality of roadside vegetation as a vital feature of roadside environment representing consciousness among the public about the landscape aspects of the roadside environment. For the integration of beautification into the management programs, it is important to know the opinion and preferences of the road user as they are the actual target of the all roadside beautification plan (Akbar, 2003). Hoyle (2017) showed public perception towards native and non-native planting in the UK. Considering climate change, they identified four key factors driving the acceptance and rejection of non-native planting. They were aesthetics, locational context, historical factors, and perceptions of invasiveness (Hoyle, 2017). Guyton et al. (2014) quantitatively evaluated the effects of mowing activities on plant changes, deer presence, and public perception of less manicured ROW in Mississippi (Guyton, 2014). Even though there was a right amount of information about the factors impacting public knowledge, no data or analysis was provided to quantify and rank those factors. In this research, the ranking of factors influencing public opinion regarding roadside vegetation is provided.

2.5 Mixed Method Survey

In this study, a mixed-method survey was used for determining public perception about ROW planting. A questionnaire was used for both qualitative and quantitative surveys. Surveys are widely used to learn about the perceptions and preferences of the sample of populations. It has been used for ages in censuses. The definition of a survey is given as:

"The survey is a systematic method for gathering information from (a sample of) entities for the purpose of constructing quantitative descriptors of the attributes of the larger population of which the entities are members" (Babbie, 1989).

A questionnaire survey has the benefits of collecting information from a group of representative people within a short period. It gives data such in such a way that it can be quantified and analyzed and give the researchers a chance to assess different issue by collecting view of people with the different social, economic and geographical background (Oppenheim, 1992). Akbar (2003) used a questionnaire survey to know the road user's view about the scenic beauty of roadside vegetation. In their study, cartographic representation, simulated assessments, and questionnaire surveys were used to know public opinion. For cartographic representation, landscape features were recorded. In simulated assessment, participants assessed the photographs, videos, and slides of a landscape and express their thoughts. One hundred eighty-three questionnaires were filled out where most of the answers were designed on a Likert-scale (Akbar, 2003). Guyton surveyed people of Mississippi to determine public perception about wildflower on ROW, what people’s response about less manicured plants, the relationship between cost, and reduced mowing regimen. Most questions included a Likert-scale design and images of roadside vegetation with native wildflowers, native grass, non-native plants, etc. were shown to respondents

to get their response about wildflowers. Their results suggested that people preferred roadside wildflowers, but they did not like litter due to vegetation (Guyton,2014). In this study, quantitative survey questions were prepared with images of different planting techniques.

A mixed-method survey was used in this study. Valerie Caracelli explained the definition of mixed-method as below:

"A mixed-method study is one that plans fully juxtaposes or combines methods of different types (qualitative and quantitative) to provide a more elaborated understanding of the phenomenon of interest (including its context) and, as well, to gain greater confidence in the conclusions generated by the evaluation study."

2.6 Augmented Reality

Augmented Reality (AR) is "a variation of Virtual Reality which allows the user to see the real world with virtual objects superimposed upon or composited with the real world. Therefore, AR supplements reality" (Azuma, 1997). AR is a system with these three following characteristics:

1. Combines real and virtual elements
2. Interactive real-time
3. Registered in 3-D

AR increases the user's perception and develops interaction with the real world. By bringing practical information to the user's immediate surroundings, AR simplifies the user's life. AR technology augments the sense of reality by overlaying simulated objects and cues upon the real world in real-time (Carmigniani, 2011). Information provided by virtual objects helps users to accomplish real-time everyday jobs. Azuma (1997), in his renowned paper, "A Survey of

Augmented Reality," mentioned six potential applications of AR: medical, maintenance and repair, annotation, robot path planning, entertainment, and military (Azuma, 1997). Nowadays, the use of AR is not bound to only these sectors. There are many potential ways to use AR in innovative ways, the most common ground for using AR research are: advertising and commercial, entertainment and education, medical, and mobile application for iPhones (Carmigniani, 2011). Augmented reality has been used for urban planning design too. Allen et al. (2011) considered smart-phone based AR for helping public participation in urban planning. In this study, they developed a user-friendly smart-phone prototype system with a suitable interface that had shown 3D virtual representations of the proposed design on top of the existing architecture. They demonstrated a new application of AR, where people can participate and express their opinion about the proposed plan. Their research also suggested that younger generations are more familiar with mobile technology than older people. Besides, younger people are more willing to participate in these types of events (Allen, 2011).

CHAPTER 3

METHODOLOGY

This study aimed to measure public perception of optimal design approaches that are aesthetically acceptable, cost-efficient, and environmentally responsible, such as block and matrix planting techniques. The study used a mixed-method approach. It included both qualitative and quantitative surveys in a single research project. The mixed-method signifies a methodological approach that combines qualitative and quantitative research approaches, which allows researchers to explore complex phenomena in detail (Halcomb & Hickman, 2015). In this study, qualitative data were collected through one to one interviews and focus group discussions of visitors of designated visitor information centers to identify the indicators that influence public perception of vegetation. Then, quantitative data were gathered from using images and Augmented Reality.

3.1 Participants and Study Area

The population for this study consisted of travelers driving through the state of Georgia. A representative sample was identified from rest areas and visitor information centers (VICs). There is a total of 11 Georgia welcome and visitor centers; 4 of them were selected as these are the busiest welcome centers in Georgia. Descriptions of those four welcome centers are given below:

Georgia Visitor Information Center-Port Wentworth (Savannah)

It is the busiest welcome center in Georgia. It is located on the I95 interstate highway as you enter Georgia from South Carolina. Around 2000/3000 individuals visit this center each day due to its proximity to the historic city of Savannah, Florida, and South Carolina.

Figure 3.1: Georgia Welcome Center- Savannah

Georgia Visitor Information Center- Tallapoosa

This Georgia Welcome Center is located on the I20 interstate highway at Tallapoosa (Figure 3.2). It is also close to the State of Alabama. For its proximity to the capital of Georgia, this center welcomes 1000-1200 visitors per day.

Figure 3.2: Georgia Welcome Center- Tallapoosa

Georgia Visitor Information Center- Ringgold

This Georgia Welcome Center is located on the I75 interstate highway at mile marker 352. This center welcomes 1000-1200 visitors per day. This welcome center is near the border of Chattanooga, Tennessee, and is located 126 miles from the capital of Georgia, Atlanta.

Figure 3.3: Georgia Welcome Center- Ringgold

Georgia Visitor Information Center- Augusta

This Georgia Welcome Center is located on the I20 interstate highway at the GA/SC line. This center welcomes 600-700 visitors per day. Most of the visitors use this center when traveling through Georgia to reach Atlanta.

Figure 3.4: Georgia Welcome Center- Tallapoosa

A random sample of welcome center stoppers was gathered on-site and asked whether they were willing to take a survey. Responses from commercial vehicle drivers were also collected.

The methodology is divided into three phases:

Phase I: Development of Measurement Indicators

Phase II: Quantitative Data Collection

Phase III: Data Analysis and Conclusions

Figure 3.5 shows a full research task and procedure for this study that includes three phrases.

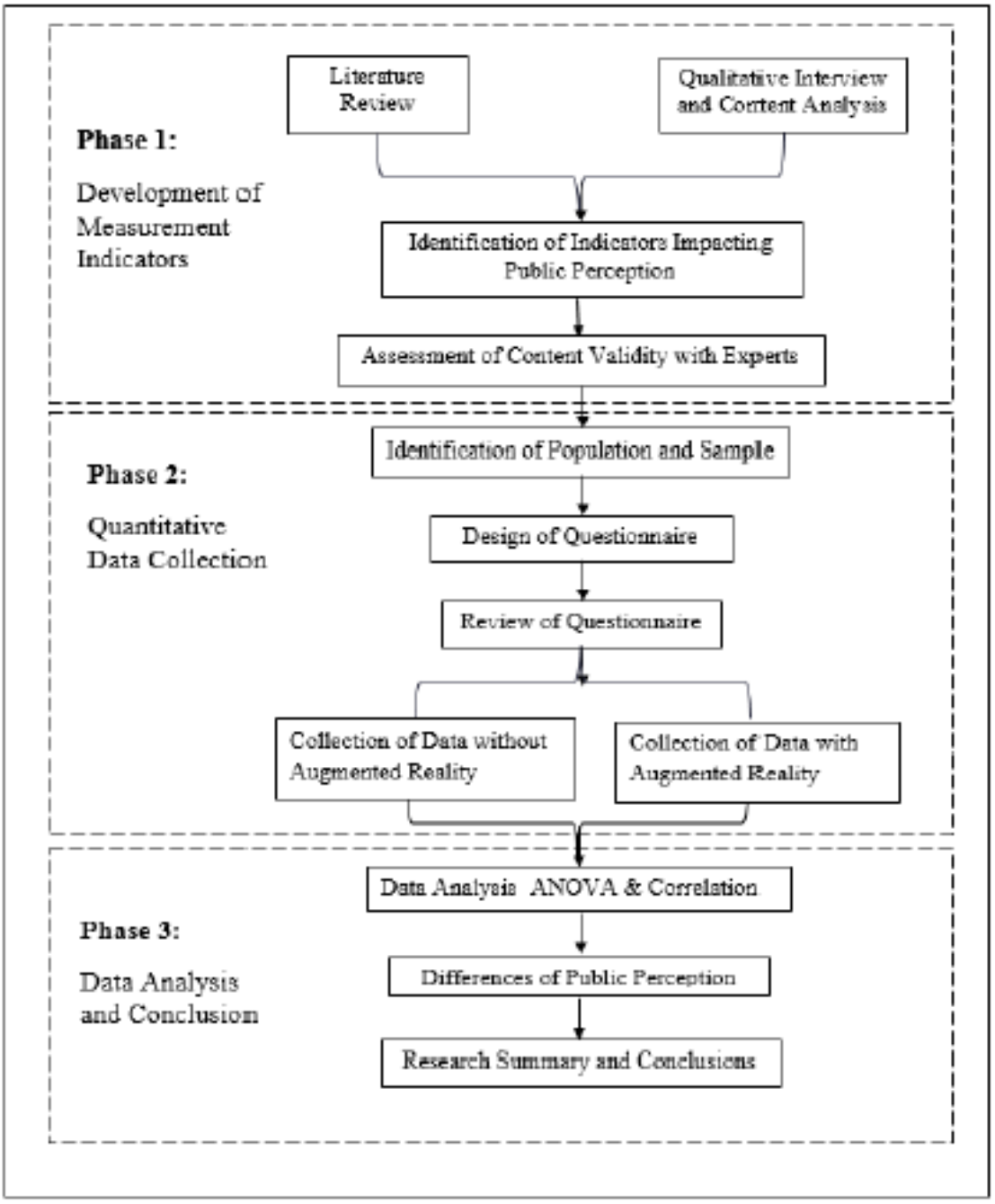


Figure 3.5: Overview of the study task and process

3.2 Phase I: Development of Measurement Indicators

Literature Review

The initial step of this study was an extensive literature review. This process was continued throughout the thesis process. Research related to sustainable roadside vegetation, its benefits and public perception of roadside vegetation was studied. Emphasis was given to those studies which used qualitative, quantitative, or mixed-method surveys in their research. The findings of the literature review are described in chapter two and are integrated appropriately into the remaining section.

Through the literature review, some initial indicators that affect public perception of different planting techniques were identified. The literature review suggested that aesthetic beauty such as color, pattern, and a combination of plants are important factors when planting. Sustainable roadside vegetation has numerous environmental benefits such as increased biodiversity, better water quality, improved air quality, and it can create soil stability, natural cooling, prevent air pollution, etc. Moreover, planting has a restorative effect on drivers and passengers. People also consider the cost of each planting technique. With the increase in the cost, people's response changes. Also, maintenance and mowing of plants is an important factor that affects public perception about planting. Moreover, recent studies have suggested that sustainability and green technology are important factors for people. Some indicators were identified from the literature review, and these are the following:

i. Aesthetic beauty: color, pattern, combination
ii. Environmental benefits
iii. Sustainability

iv. Maintenance, mowing

v. Establishment and maintenance cost

vi. Restorative effect

Collection and Analysis of Qualitative data

After narrowing down a list of indicators from the literature review, qualitative survey questions were designed. Survey questions were designed to solicit data on the developed research questions. The first research question of this study is to identify the indicators impacting public perception of planting techniques. Open-ended and Semi-structured survey questions were designed using the indicators obtained from the literature review. The main goal was to gather information about people's attitudes and perceptions towards planting techniques and roadside vegetation. The project team visited all four-welcome centers during the holiday season in December. The visitors who were in groups or by themselves were approached whether they were interested in talking about roadside planting techniques. The participants were encouraged to talk spontaneously about planting techniques used in different visitor centers or any other amusement park or ROW areas.

The project team surveyed 50-70 travelers in each of the four study sites. The interview method was mainly a focus group interview, which consisted of 4 or 5 people. For individual interviews, in-depth conversations were conducted among participants. Survey responses were collected during a highly trafficked holiday time-frame (12/20/18- 1/4/19). Discussions with participants were recorded manually on paper.

3.3 Phase II: Quantitative Data Collection

Quantitative data collection was the central part of this research. For the quantitative study, the same study areas and the population were used. A survey questionnaire was designed considering the research objectives. Questionnaires were divided into two parts: demographic and broad questions. The questionnaire had a total of 16 questions. Among them, five were demographic, and eleven were within a broad category. For demographic questions, researchers asked the participant's gender, age, and state of residence. The research team collected data about the frequency of visits in the welcome centers. No question containing identifiable characteristics were asked in the survey questions.

For broad questions, most of the questions were designed using a 5-point Likert-scale. A Likert scale is a psychometric scale commonly involved in research that employs surveys. Respondents can specify their level of agreement or disagreement on a symmetric agree-disagree range for a series of statements. Most indicators identified by the qualitative study were also the same for these two-planting techniques. Participants were asked how important the factors were to them. Five questions were designed utilizing 5-point Likert-scale about those indicators. Respondents were told to rank the factors in order. For initial data collection, we collected survey data without Augmented Reality (AR). Images of two planting techniques were used along with the questionnaire.

Review of Questionnaire

The questionnaire was first piloted in May 2019. Surveys were administered at the welcome center located at Port Wentworth. The study site was chosen because of its high visitor number and proximity to Georgia Southern University. The questionnaire was tested so that the

research team could ensure the questions would be clear and understandable to the population. A few changes in language and order were made to increase understanding.

Data Collection without Augmented Reality

During summer 2019 (01 June – 31 August), data was collected from three visitor centers (Savannah, Augusta, Tallapoosa). During the summer, 857 people were surveyed. Among them, 227 were received from Savannah, 152 from Augusta, and 478 from Tallapoosa. As the summer is a peak time for high travel, data were collected during that time.

3.4 Design of Augmented Reality

The research team developed an augmented reality app designed for two planting techniques for the iOS mobile platform. Images are 2D, and the position of the camera influences the quality of the picture. AR combines the digital and real-world into one visual experience, which has advantages over traditional representative tools (2D drawing, images, and videos). Therefore, two planting techniques were designed in AR, where the plants could be observed from every angle. Further, users/participants could change the plane where they viewed the plants in order to fit their preferences. Procedures for developing the AR app are mentioned below:

There are some renowned tools in the current industry for AR app developers to use on mobile devices. Android has it's own AR tool named ARCore. iOS also has it's specific AR tool called ARKit. Native app development for iOS or Android is a possible solution for developing AR apps on mobile platforms. Some 3D game engines are also trendy for AR app development. Two of them are:

1. Unity Engine

2. Unreal Engine

The main target device for our project was the iPad. The surveys were conducted on the iPad and AR apps were installed on the iPad. Unity was chosen as our development platform because it not only supports iOS app development but also supports Android app development. Additionally, integration with multiple platforms using Unity is more comfortable than other options on the market. The limitation of the Unity is that the devices must have support for ARCore (for Android) or ARKit (for iOS).

Methodology:

The following processes were taken for developing user-friendly augmented reality on iPad. Unity 2018.3.5 was installed for the development of the app. XCode was built for iOS devices. A Unity project was created, and the project was fixed for settings building in iOS devices (Figure 3.6). Some packages, settings, and permissions were required for supporting AR. The packages were:

- AR Foundation
- ARCore XR Plugin
- ARKit XR Plugin

Another plugin named Lean Touch was used for handling touch inputs.

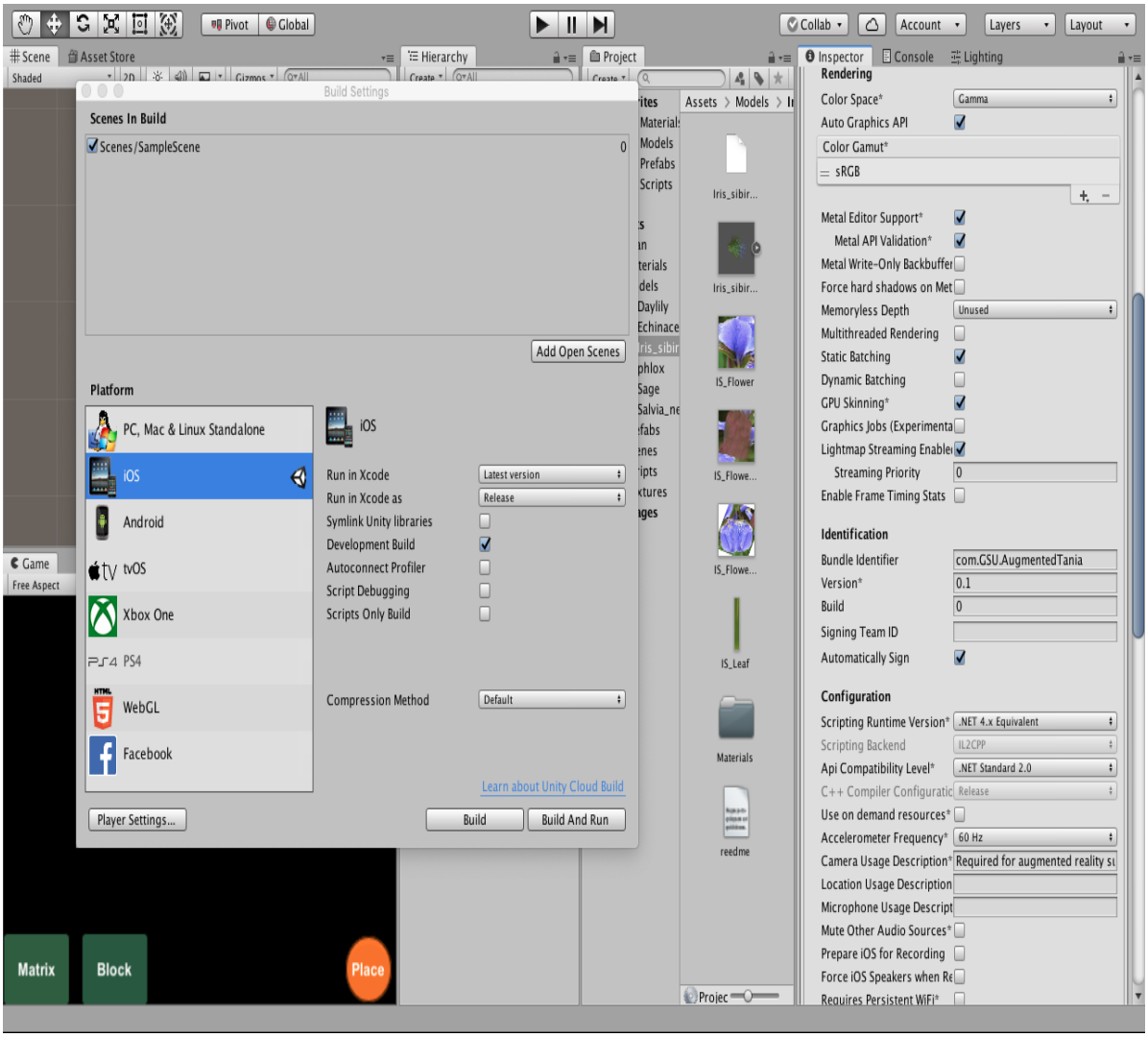


Figure 3.6: Inputting iOS setup in Unity

Scene Setup:

First, the project team placed three objects in the scene, which controls the basic AR camera functionalities. They are AR Session, AR Session Origin, and AR Camera, which handle the camera functionality, plane detection, and AR input. PlacementIndicator was placed in the scene,

which contained a quad 3D model for the users to understand the place where objects will be placed (Figure3.7).

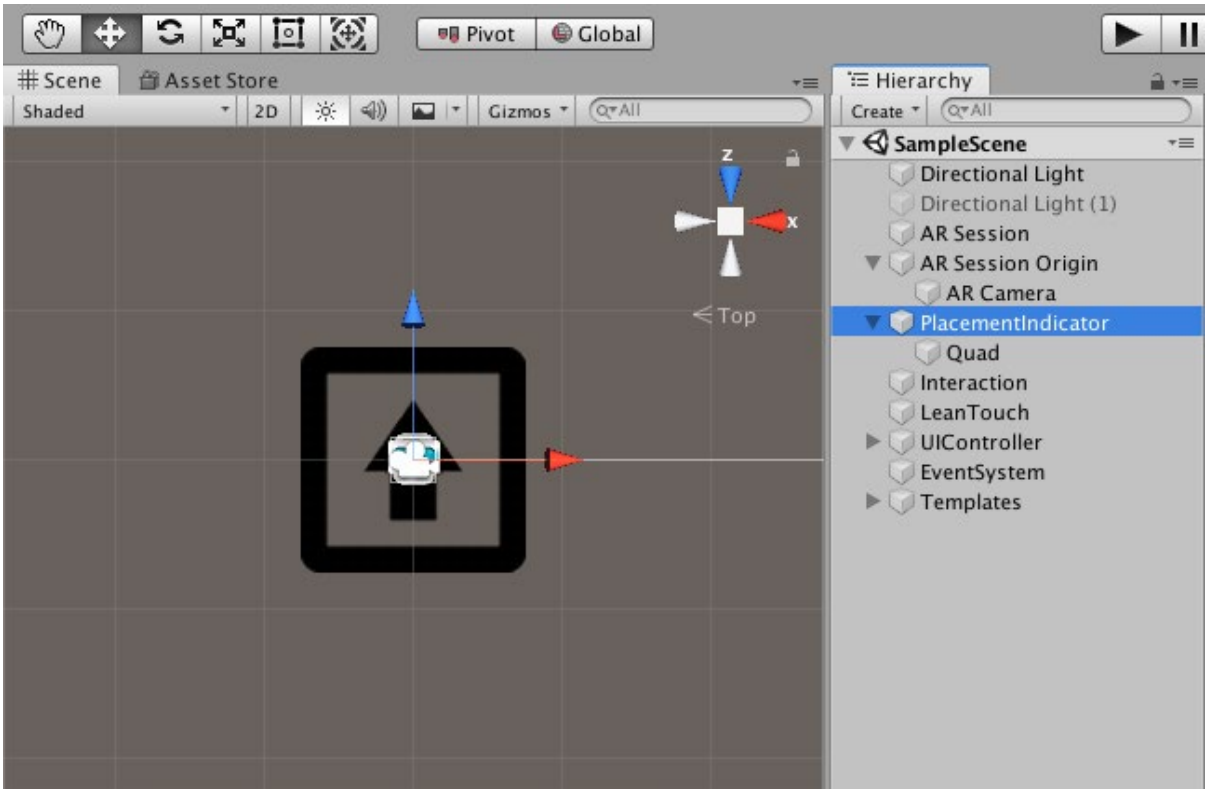


Figure 3.7: PlacementIndicator in the scene for quad 3D model and plane detection

Two templates were created, which represented the matrix and block planting techniques. 3D plant models were obtained from different online sources such as TurboSquid, FREE 3D, etc. After getting those 3D plant templates, the team modeled two planting techniques following formations shown in Figure 3.8 and Figure 3.9. Shadows and sunlight were maintained so that it gave a real-time visual presentation.

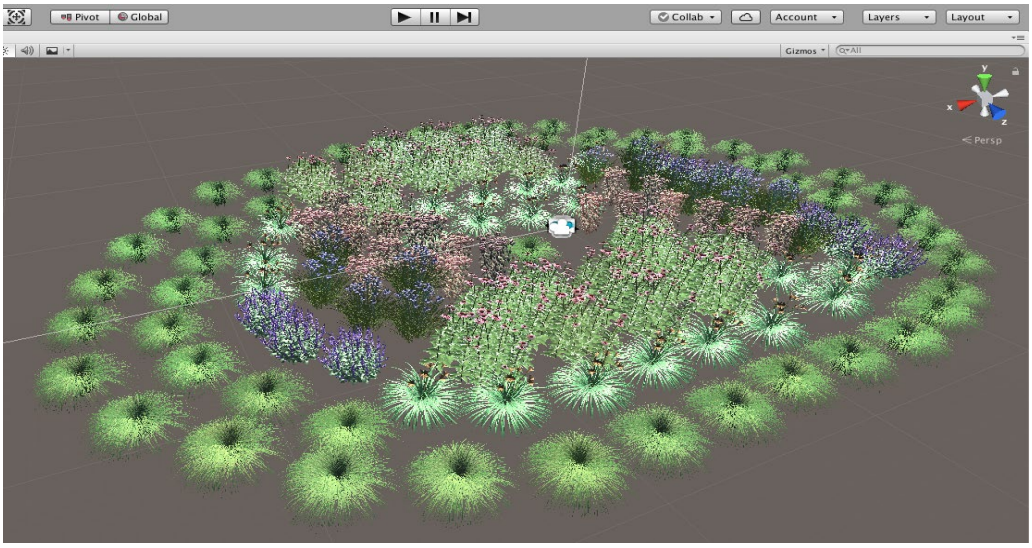


Figure 3.8: Design of block planting techniques using plant's 3D templates in Unity

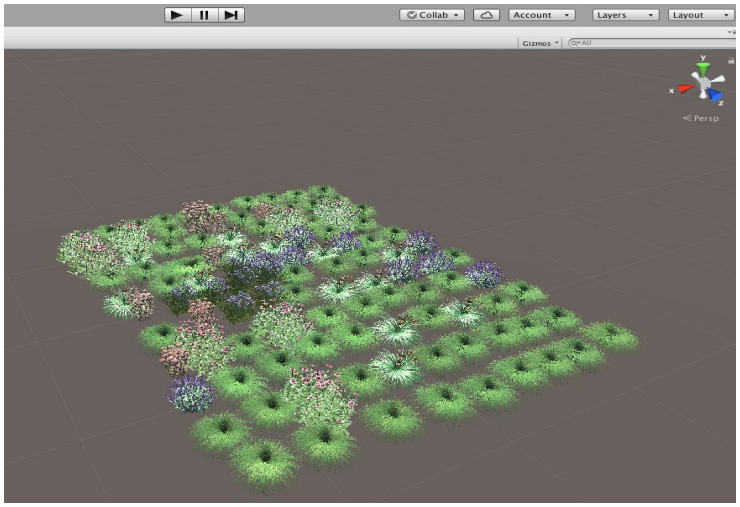


Figure 3.9: Design of matrix planting techniques using the plant's 3D templates in Unity

In the above objects, the Lean Pinch Scale was attached to the script, which helped to scale the objects at runtime. Then, the project team created a game object named Interaction. A C# script was written for giving the functionalities of Interaction. The main purpose was to take the user

input and place the 3D objects at runtime in the correct position and proper rotation. The ARKit SDK of iOS provides detection of the plane's position and rotation. After getting the position and rotation of the plane, the indicator object was placed in that location.

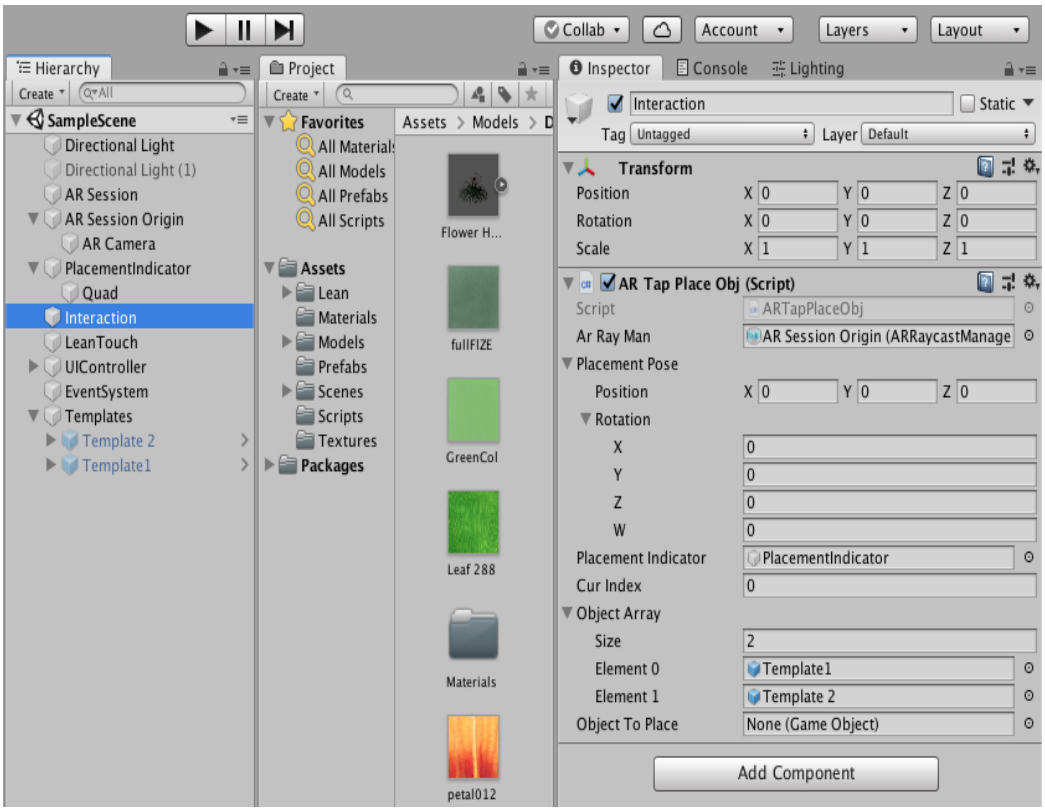


Figure 3.10: Interaction setup in Unity 3D

UIController was created to handle the functionalities of the three buttons: Matrix, Block, and Place. The final display of the AR app is shown in Figure 3.11 & Figure 3.12. The figures show two options: Matrix and Block (Green Square Block) and Place (Yellow Circular) button.

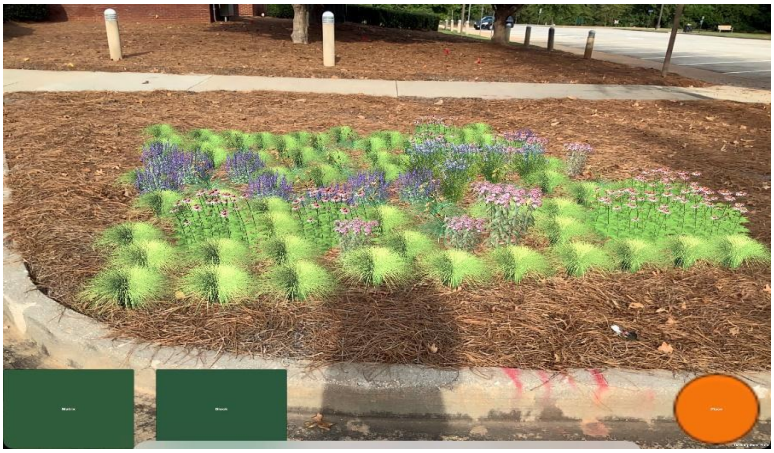


Figure 3.11: Screenshot from iPad showing the final output of AR (Matrix Planting)

Figure 3.12: Screenshot from iPad showing the final output of AR (Block Planting)

3.5 Data Collection with Augmented Reality

After developing the AR, data were collected again from three welcome centers. Three welcome centers were surveyed each weekend from September 25th to October 20th. Before conducting the survey, the project team asked for permission from the welcome center authorities.

The surveys were conducted during the peak time of these centers around 9.00 AM to 5.00 PM. During each visit, a table was set up on one corner of the visitor center. The visitors were approached and asked whether they were willing to take a survey. All participants were offered a small token from Georgia Southern University's Civil Engineering & Construction Management Department.

3.6 Data Analysis

Numerous data analysis methods were performed for this study. Demographic information (gender, age, residence, duration of stay) of the participants from the visitor centers was analyzed. Pearson correlation was determined using R programming, whether the parameters had any correlation with each other or not. In the survey, participants were asked to rank different factors based on the importance of various factors. To understand the relationship between different parameters, one-way ANOVA was conducted. Analysis of variance (ANOVA) is a statistical model. ANOVA indicates which variable is more significant than the others to determine the dependent variables. R and python programming software were used for data analysis. In this study, a weighted decision matrix (WDM) was utilized for recommending the better planting technique for roadside planting. WDM is a simple tool that can be very useful in making complex decisions because it is very efficient when many alternatives and criteria of varying importance are being considered.

CHAPTER 4

RESULTS AND DISCUSSIONS

This study consisted of a mixed-method survey where both qualitative and quantitative surveys were conducted. For, the quantitative survey, two surveys were demonstrated: one without AR and another with AR. Results from both the qualitative and quantitative surveys (both with AR and one without AR) are presented in this chapter. This chapter is divided into three parts:

1. Results of Qualitative Survey
2. Results of Quantitative Survey without AR
3. Results of Quantitative Survey with AR

4.1 Results of Qualitative Survey

The main objective of this study was to measure public perception of different planting techniques (block and matrix) that are commonly used at VICs and other ROW areas. A qualitative survey was conducted to answer the first research question. Four welcome centers along the State of Georgia borders were selected, as the study area, because travelers frequently use these centers to obtain information and buy refreshments. Georgia welcome centers in Savannah, Augusta, Ringgold, and Tallapoosa, were selected as study areas. The Savannah Welcome Center is the most popular of all visitor centers in the State of Georgia. The Augusta Welcome Center is a medium-range visitor center, however, it has a great number of visitors because of its proximity to Atlanta. Welcome centers in both Ringgold and Tallapoosa have a high frequency of visitors as they are close to Atlanta as well.

During the qualitative study, respondents were given open-ended questions to mention the most important factors to them about planting techniques in ROW. Focus group discussions were also conducted to learn about people's preferences. Most respondents expressed that while observing one particular planting technique, they mostly noticed the color, pattern, and combination of the planting. People consider sustainable vegetation as an important part of roadside vegetation. One participant expressed, "if the planting technique is sustainable, they will be beneficial to the environment and cost-effective, roadside plants should not need more maintenance." To most of the participants, both planting techniques looked similar, as both of them contained similar plants. Participants interested in gardening noticed significant differences between the two planting techniques. After screening qualitative survey data of 125 people, several indicators that affect public perception about planting techniques were recognized. They are:

i. Aesthetics (Color, pattern/design, the combination of plants)
ii. Restorative effect (level of comfort, rejuvenating)
iii. Environmental benefits (air purification, saving water, preventing pollution)
iv. Invasiveness (fast) growing, hard to control, native and non-native vegetation
v. Sustainability (little maintenance required)
vi. Establishment and maintenance cost

These factors matched with our literature review findings.

4.2 Results of Quantitative Survey Results without AR

Participants Demographic Characteristics:

A total of 857 people participated in a quantitative survey during the summer of 2019 without the augmented reality app. Among them, 426 were male and 431 were female. The average age of the participants was 51.1 years (Figure 4.1). The distribution of the graph was uniform. Specifically, 45% of the respondents were younger than 45 years old, and 55% of the population were older than 45 years old.

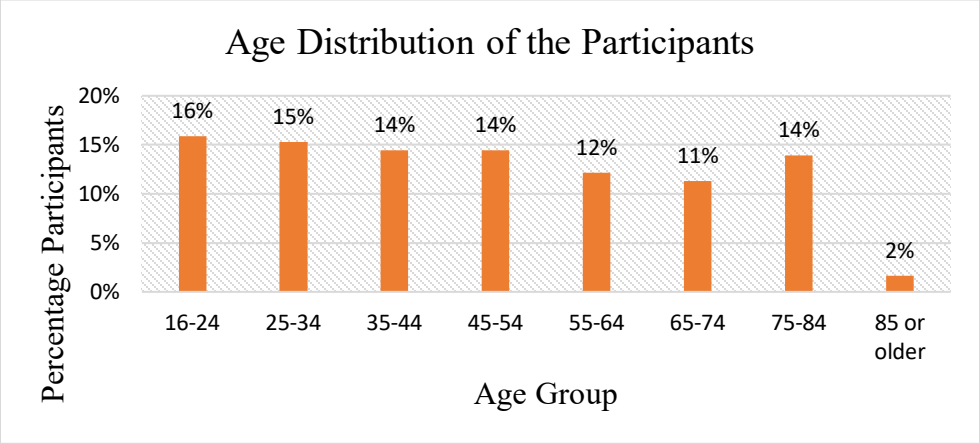


Figure 4.1: Age distribution of the participants' (without AR)

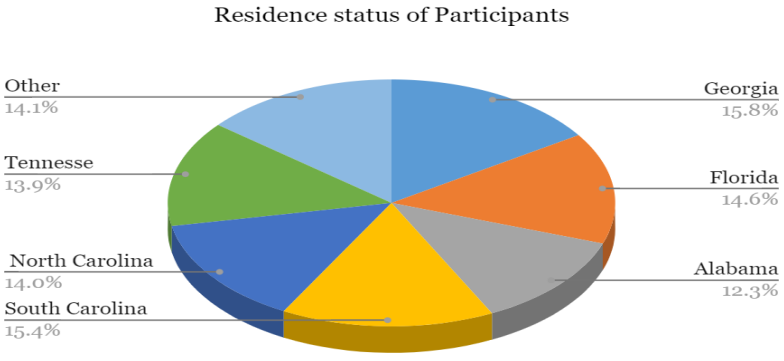


Figure 4.2: Residence profiles of the participants' (without AR)

70 % of the survey participants were from South Carolina, Florida, North Carolina, Tennessee, and Alabama. 15.8% of the participants were from the State of Georgia (Figure 4.2).

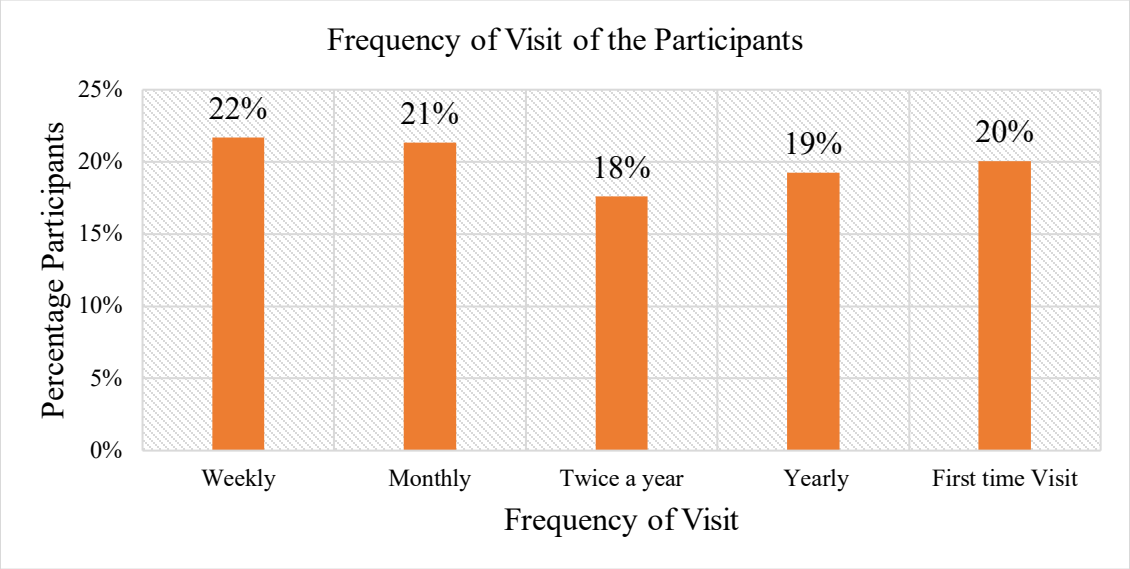


Figure 4.3: Frequency of visit of the participants' (without AR)

In addition, participants visited Georgia welcome centers in all different frequencies (Figure 4.3).

Measuring Public Perception of Planting Techniques:

The respondents were asked to rank different factors, which could affect their perception of one particular planting technique. The responses are shown in Figure 4.4. There was a total of seven factors: color and aesthetics, environmental benefits, restorative effect, cost, sustainability, invasiveness, and maintenance. No pattern was found from the responses of participants.

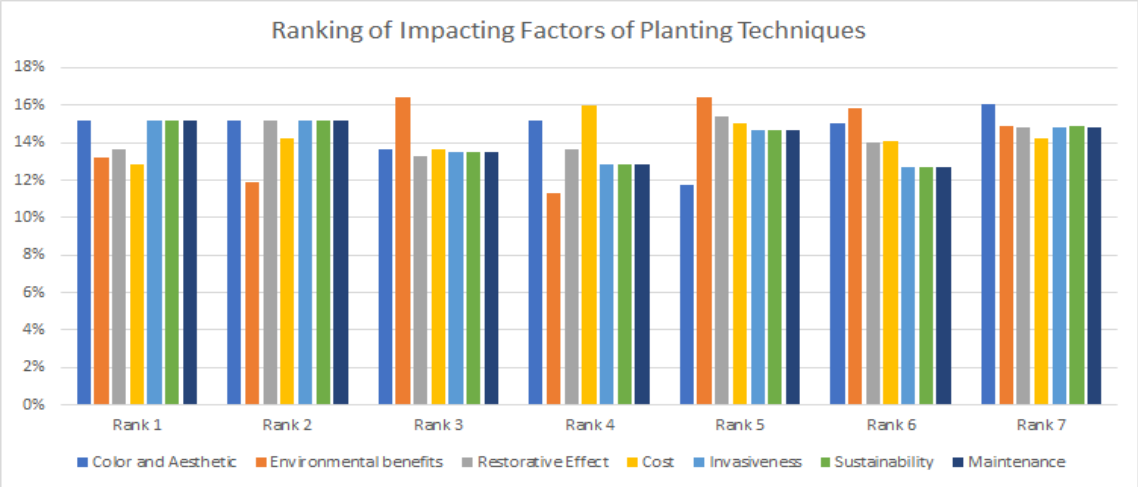


Figure 4.4: Ranking of different factors based on planting choice (without AR)

Figure 4.5 shows public preferences for matrix or block planting techniques. A close percentage was observed between these two plantings techniques. 51% of the total 858 participants preferred block planting, and 49% of them preferred matrix over the block.

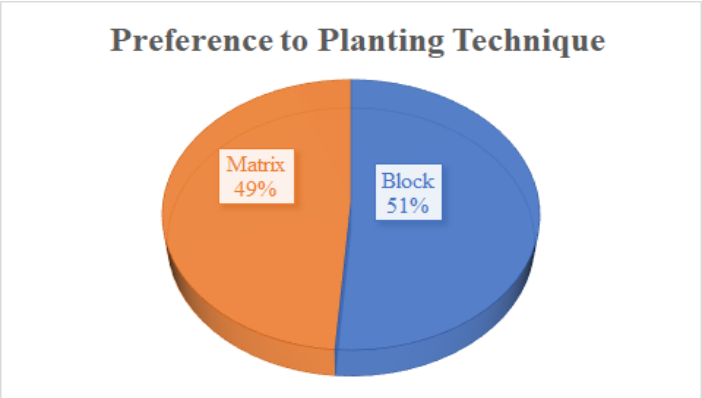


Figure 4.5: Preference for one planting technique (data without AR)

ANOVA and correlation analysis were used for data analysis. No direct correlation among factors was found from the quantitative data collected without AR. Moreover, no relationship was identified between demographic characteristics (age, gender, residence) and planting choice. Cutting edge AR was used to get a better understanding of public perception about the planting techniques.

4.3 Advantages of AR over Images

AR increases the user's perception and encourages interaction with the real world. It enhances the sense of reality by overlapping computer-generated objects and cues upon the physical world in real-time. For the second phase of data collection, an iOS-based user-friendly AR app was developed. The AR app showed a 3D representation of two plantings. Participants could easily toggle between the plantings and select their preferred one. Participants were more engaged with the questionnaire while AR was used.

4.4 Results of Data with Augmented Reality

Participants Demographic Characteristics

A total of 207 survey data was collected from three visitor centers (Savannah, Augusta, Ringgold) using AR. Among them, 80 were received from Ringgold, 103 from Savannah, and 24 from Augusta. The participants' profiles consisted of 87 males and 119 females. The average age of the participants was 55.43 years (Figure 4.6).

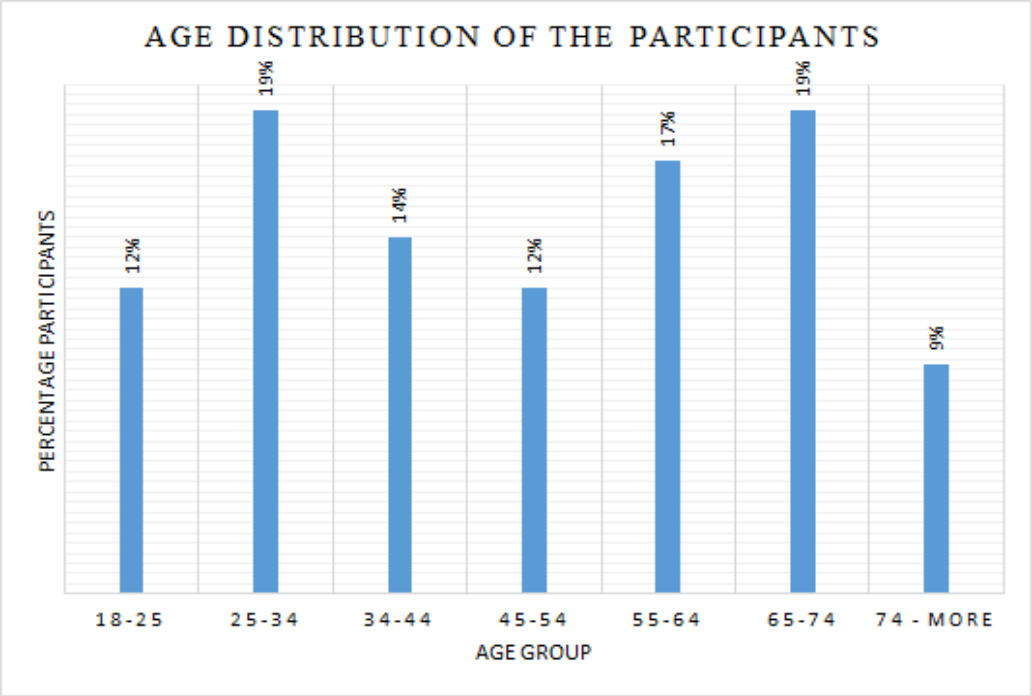


Figure 4.6: Age distribution of the participants (data collected by AR)

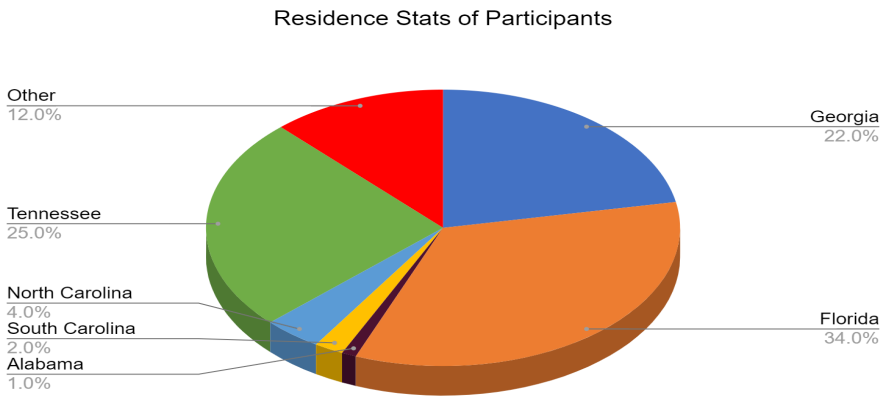


Figure 4.7: State of residence of the participants' group (data collected by AR)

According to figure 4.7, participants traveled from many states. The highest number of participants were from Florida (34%), Tennessee (25%), and Georgia (22%).

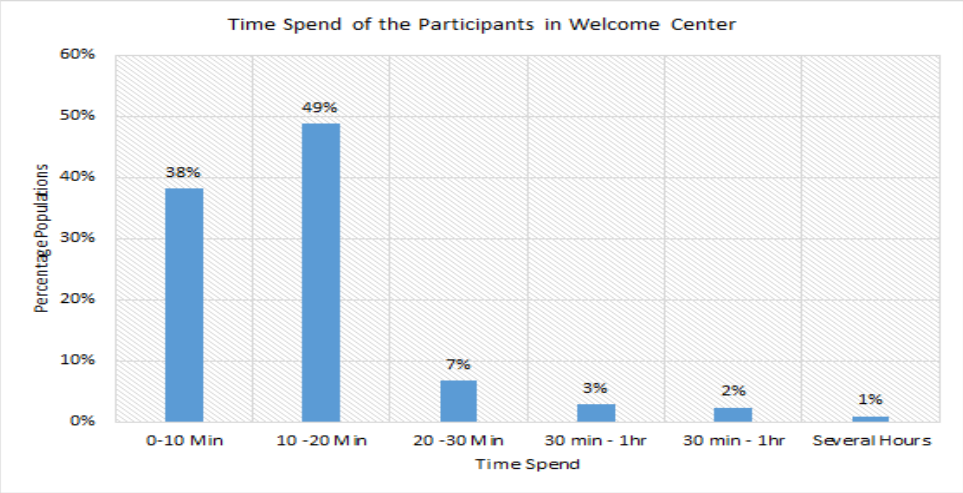


Figure 4.8: Time spent by the participants in welcome centers (data collected by AR)

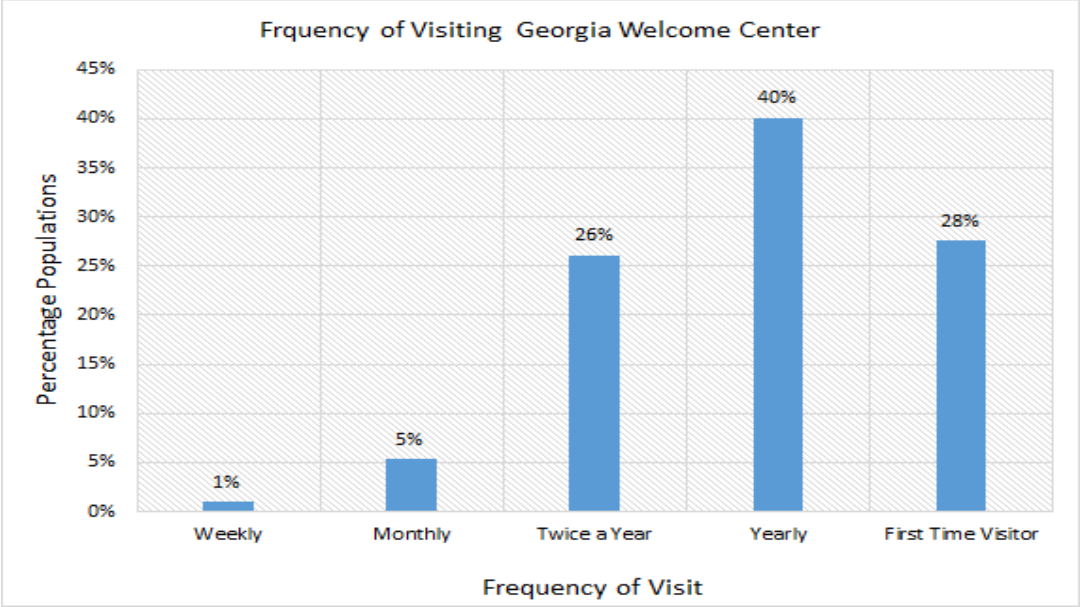


Figure 4.9: Frequency of visiting Georgia welcome center of the participants (data collected by AR)

Figure 4.8 shows that higher percentages of people usually spent around 10 to 20 minutes during their visit. Figure 4.9 presents the frequency of visiting Georgia welcome centers. Around

28% of the respondents were new visitors. Out of 207 respondents, 40% visited the center once a year, 26% visited twice a year. Very few participants (6%) visited these welcome centers monthly or weekly.

Measuring Public Perception of Planting Techniques for Data with AR:

From the qualitative survey, it was identified that environmental benefits, color and aesthetics, sustainability, cost, and maintenance were significant factors that affect public perception. Respondents were asked to express their opinion about these identified factors. Participants' responses are presented in Figure 4.10 to Figure 4.14.

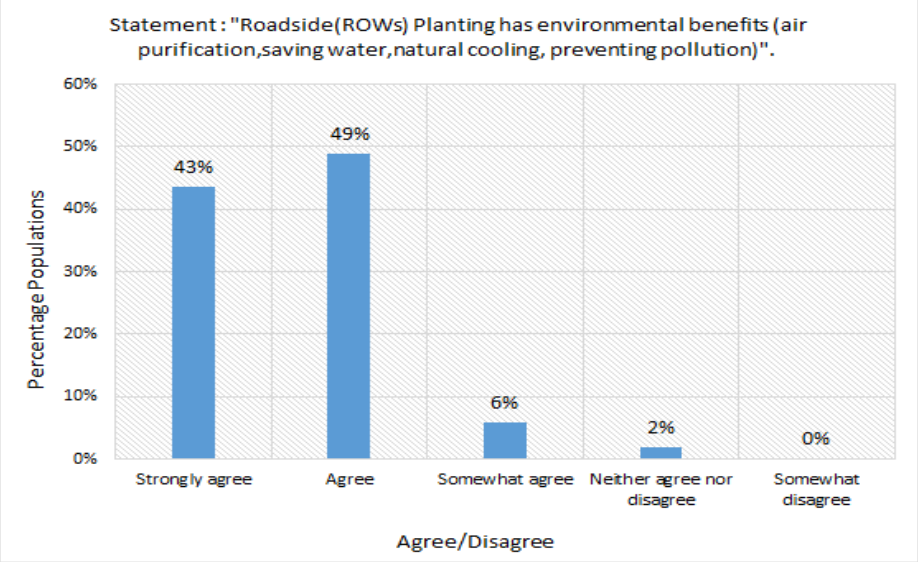


Figure 4.10: Participants' response to roadside (ROW) planting. Factor: environmental benefits (data collected by AR)

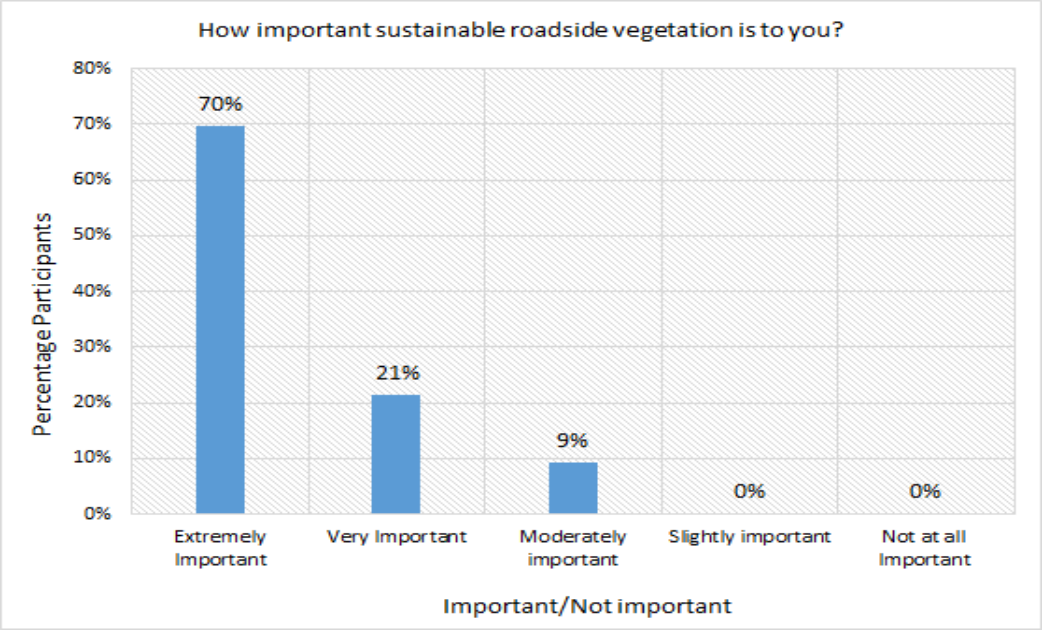


Figure 4.11: Participants' response to roadside (ROW) planting. Factor: sustainability (data collected by AR)

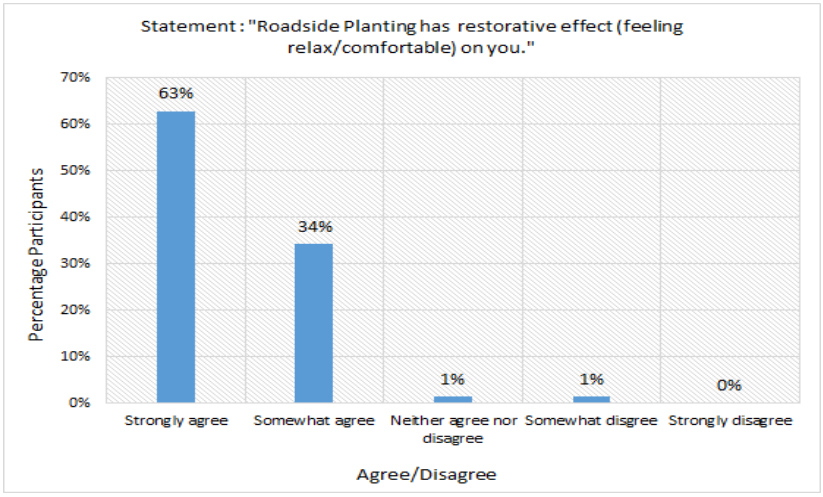


Figure 4.12: Participants' response to Roadside (ROW) planting. Factor: restorative effect (data collected by AR)

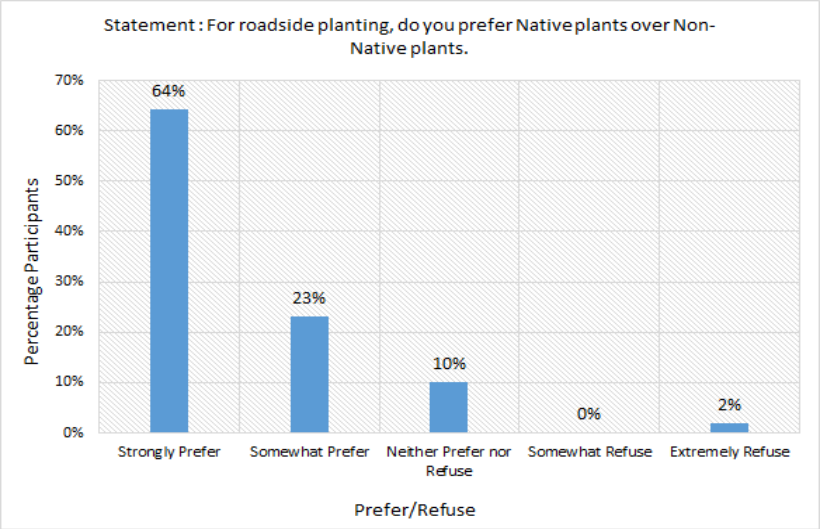


Figure 4.13: Participants' response to roadside (ROW) planting. Factor: native or non-native plants (data collected by AR)

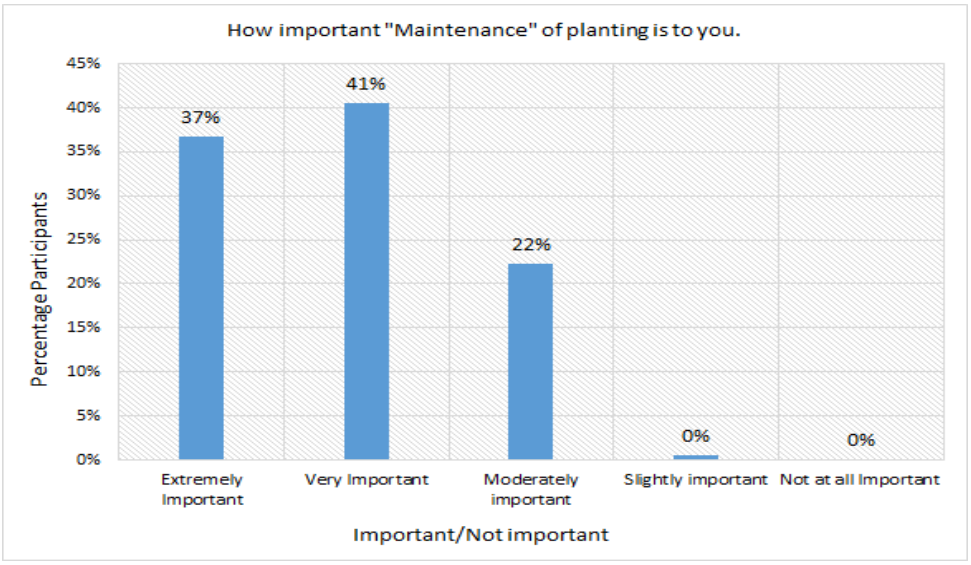


Figure 4.14: Participants' response to roadside (ROW) planting. Factor: maintenance (data collected by AR)

Figure 4.10 summarizes the respondents' answer to the statement, "Roadside planting has environmental benefits." 92% of the respondents overwhelmingly agreed to the statement.

Besides, the majority of the respondents (70%) favored sustainable vegetation along the road (Figure 4.11). Figure 4.12 represents how the public responded to the statement, "Roadside planting has a restorative effect on you." Most (63% of 207) of the population strongly agreed with the statement.

Another important finding of this study was that 87% of the sample population greatly preferred native plants over non-native plants for roadside planting (Figure 4.13). It could be assumed that they chose native plants over non-native plants because native plants have more environmental benefits and require less maintenance. Maintenance of roadside planting is also an important factor for people. 78% of the respondents expressed that maintenance is very important for planting. Additionally, 22% of the population recommended maintenance as moderately important (Figure 4.14).

4.6 Perception of Different Planting Techniques

Among the 207 responses, 58% preferred block planting over matrix planting. 38% of the respondents preferred matrix planting rather than block planting (Figure 4.15). They made the decision based on color and aesthetics.

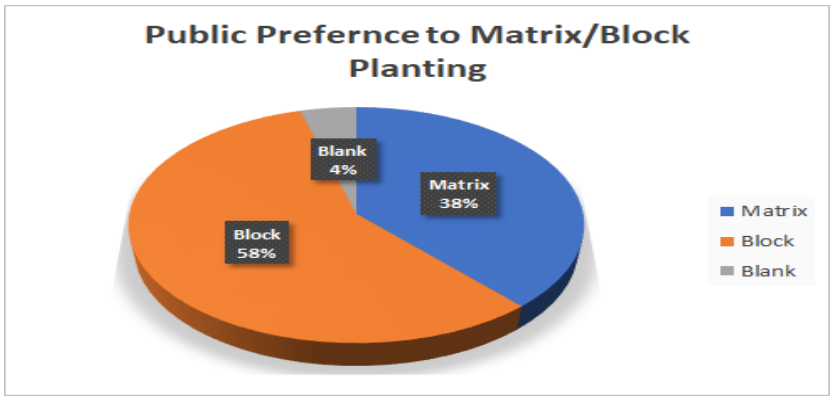


Figure 4.15: Participants' preferences to one type of planting technique (with AR)

ANOVA model and t-test were run in R programming to identify the relationship between planting technique choice and demographic characteristics. The results from Table 4.1 show that residence ($p = .00183 < 0.05$) and gender ($p = .0184$) were significant factors for choosing a planting technique.

Table 4.1: Results of ANOVA analysis between the choice of planting techniques and demographic characteristics.

	Df	Sum_Sq	Mean_sq	F value	Pr(>F)
Gender	1	1.677	1.677	5.6502	**0.018392 ***
Age	1	0.001	0.00076	0.0025	0.95979
Residence	1	2.962	2.96197	9.9791	**.001828***
Frequency	1`	0.321	0.32084	1.0809	0.29974
Time	1	0.336	0.3355	1.1305	0.288934
Residual	201	59.66	0.29682		

Although the sample chose block planting, the residence from the states of Florida (58%), North Carolina (75%), and South Carolina (80%) showed a strong preference for matrix planting while the residents from Georgia and Tennessee preferred block planting (Table 4.2). The findings suggested that people from coastal regions preferred matrix planting over the block planting.

Table 4.2: Relationship between the choice of planting techniques and residence.

State of Residence	Planting Choice	No of Responses
Georgia	Matrix	17
	Block	29
Florida	Matrix	39
	Block	28
Tennessee	Matrix	18
	Block	32
South Carolina	Matrix	4
	Block	1
North Carolina	Matrix	6
	Block	2
Others	Matrix	6
	Block	15
Alabama	Matrix	0
	Block	2

The results from Table 4.3 show that the choice of planting techniques varied based on gender. Among male respondents, no variation was noticed in the results. The female respondents showed a strong preference for block planting.

Table 4.3: Relationship between the choice of planting techniques and gender.

Gender	Planting Choice	No of Response	% of Gender
Male	Matrix	44	48%
	Block	41	48%
Female	Matrix	41	31%
	Block	71	64%

The majority (82% of 207) of the respondents preferred environmental benefits more than color and aesthetics. Also, 61% of the participants selected sustainability over color and aesthetic beauty (Table 4.4).

Table 4.4: Relationship between the choice of planting techniques and rank 1 for their preferences.

Planting Technique	Rank 1	No of Response
Matrix	Color & Aesthetics	11
	Environmental Benefits	56
	Sustainability	15
	Maintenance	4
Block	Color & Aesthetics	20
	Environmental Benefits	62
	Cost	6
	Sustainability	23
	Maintenance	1

Table 4.5: Ranking of different control indicators affecting public perception.

	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6
Color and Aesthetics	16%	10%	46%	17%	4%	10%
Environmental Benefits	59%	30%	11%	3%	4%	17%
Restorative Effect	0%	17%	9%	20%	12%	36%
Cost	3%	14%	23%	32%	16%	7%
Sustainability	18%	20%	5%	13%	22%	21%
Maintenance	3%	9%	5%	15%	42%	9%

Respondents were asked to rank different factors for choosing one particular planting technique. Most respondents (59%) chose environmental benefits as their top priority. Sustainability of planting was ranked second with 38 responses (18% of 207). People chose color and aesthetics as the third priority. The cost was also an essential factor for people. Maintenance was typically ranked as 5th priority by the sample (Table 4.5).

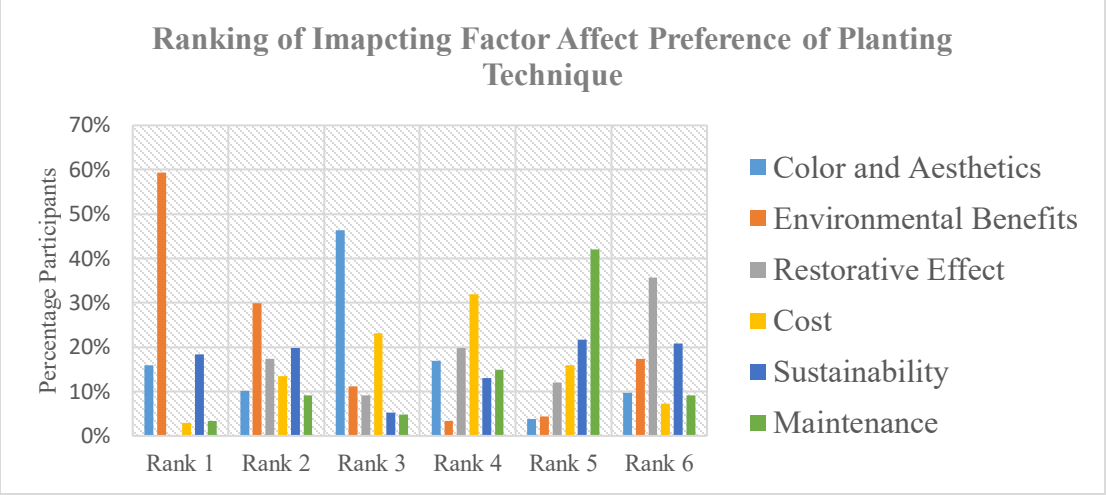


Figure 4.16: Ranking of different control indicators affecting public perception (with AR)

From the results (Table 4.5 and Figure 4.16), it could be concluded that the final ranking is as follows :

1. Environmental benefits
2. Sustainability
3. Color and aesthetics
4. Cost
5. Maintenance
6. Restorative effect

Weighted Decision Matrix was designed considering the ranking of factors. Because environmental benefit was the first priority to the public, it was given the highest weight: six. Number six priority, the restorative effect was assumed weight one. As matrix planting has better environmental benefits and sustainability, it was scored one in these criteria. Further, the block was perceived as more aesthetically beautiful and had a more restorative effect on people. In color and aesthetics, and restorative effect criteria, block scored a one. The matrix planting was considered less expensive than the block. Moreover, matrix planting requires less maintenance. In the cost and maintenance criteria, the matrix planting technique was recorded as one (Table 4.6).

Table 4.6: Weighted Decision Matrix for block and matrix planting

Criteria	Weighting	Block		Matrix	
		Score	Total	Score	Total
Environmental Benefits	6	0	0	1	6
Sustainability	5	0	0	1	5
Color and Aesthetics	4	1	4	0	0
Cost	3	0	0	1	3
Maintenance	2	0	0	1	2
Restorative Effects	1	1	1	0	0
Sum			**5**		**16**

The total score of each criteri was determined by multiplying weight score with an individual score. The overall score of matrix planting was sixteen, whereas the block planting scored only five. This WDM matrix made it clear that matrix planting was more acceptable to individuals who travel.

CHAPTER 5

CONCLUSIONS

This study was conducted to measure public perception on optimal planting techniques (such as block and matrix) that are aesthetically beautiful, cost-effective, and environmentally beneficial. The following paragraphs describe public perception considering different planting techniques.

The main indicators that affect people's preference for one planting technique over another were identified through literature review and qualitative survey. The identified indicators were color and aesthetics, environmental benefits, cost, sustainability, maintenance, and restorative effect. There was a significant difference between the data collected using photographs and the augmented reality (AR) app. People showed interest and enthusiasm during the surveys when AR was used in this study.

The respondents strongly agreed that roadside vegetation has significant environmental benefits. The majority of the respondents expressed that sustainable planting is a very important element of roadside vegetation. The participants, in general, preferred native plants over non-native as they require less maintenance. The respondents, in general, favored well-maintained plants. One important finding of this study was the ranking of the identified factors. The ranking is the following: 1. Environmental benefits 2. Sustainability 3. Color and aesthetics 4. Cost 5. Maintenance 6. Restorative effect. The respondents believed that environmental benefit is the most important element contributing to roadside vegetation. Respondents also preferred sustainable roadside vegetation more than aesthetically beautiful planting.

Regarding the choice of planting techniques, 58% of the sample selected block planting over matrix planting based on color and aesthetics. However, when all the factors were considered, the public largely preferred matrix planting, as it tends to be more beneficial to the environment.

REFERENCES

Alberti, Marina. Advances in Urban Ecology: Integrating Humans and Ecological Processes in Urban Ecosystems. New York: Springer, 2008.

Jacobson, R. L., Albrecht, N. J., & Bolin, K. E. "Wildflower Routes: Benefits of Management Program for Minnesota Right-of-Way Prairies." Paper presented at the Proceedings of the Twelfth North American Prairie Conference, Cedar Falls, Iowa, 1990.

Cackowski, Jean Marie, and Jack L. Nasar. "The restorative effects of roadside vegetation: Implications for automobile driver anger and frustration." Environment and behavior 35, no. 6 (2003): 736-751.

Fitzpatrick, Cole D., Curt P. Harrington, Michael A. Knodler Jr, and Matthew RE Romoser. "The influence of clear zone size and roadside vegetation on driver behavior." Journal of safety research 49 (2014): 97-e1.

Forman, R.T., Sperling, Bissonette, Clevenger, Cutshall, Dale, Fahrig, France, Goldman, Heanue, Jones, Swanson, Turrentine, & Winter. 2003. Road Ecology: Science and Solutions. Island Press, Washington, DC.

Schnoor, J.L., Licht, L.A., McCutcheon, S.C., Wolfe, N.L., and Carreira, L.H. 1995. “Phytoremediation of Organic and Nutrient Contaminants.” Environmental Science & Technology 29(7) 318A-323A.

Environmental Protection Agency (EPA). Last updated 13 January 2010. Date retrieved: 11 May, 2010. http://www.epa.gov/nps/facts/point1.htm Morrison, Darrel. 1999. Roadside Use of Native Plants.

Harper-Lore, B. L. Roadside Use of Native Plants. Washington, DC: USDOT, Federal Highway Administration Pub. FHWA–EP–99–014, 1999.

Akbar, K. F., William HG Hale, and A. D. Headley. "Assessment of scenic beauty of the roadside vegetation in northern England." *Landscape and Urban Planning* 63, no. 3 (2003): 139-144.

Barton, Susan, Rick Darke, and Gary Schwetz. "Enhancing Delaware highways: Roadside vegetation concept and planning manual." (2005).

Dana, Michael N., Ricky Darrell Kemery, and Brian S. Boszor. "Wildflowers for Indiana highways." (1996).

Gobster, Paul H., and Richard E. Chenoweth. "The dimensions of aesthetic preference: a quantitative analysis." *Journal of Environmental Management* 29, no. 1 (1989): 47-72.

Forman, Richard & Sperling, Daniel & Bissonette, John & Clevenger, Anthony. (2003). Road Ecology: Science and Solutions. Bibliovault OAI Repository, the University of Chicago Press.

Guyton, John W., Jeanne C. Jones, and Edward D. Entsminger. *Alternative Mowing Regimes' Influence on Native Plants and Deer*. Mississippi Department of Transportation (MDOT), Jackson, MS, 2014.

Harper, D. (2001). Horse boating (Web). The Horse boating Society. Retrieved on April 9, 2014.

Lucey, Anne, and Susan Barton. "Public perception and sustainable roadside vegetation management strategies." *Newark, Delaware, University of Delaware University Transportation Center* (2010): 1-15.

Harrison, George L. *Economic impact of ecosystem services provided by ecologically sustainable roadside right of way vegetation management practices*. No. BDK75-977-74. Florida. Dept. of Transportation, 2014.

Hopwood, Jennifer L. "The contribution of roadside grassland restorations to native bee conservation." *Biological Conservation* 141, no. 10 (2008): 2632-2640.

MacDonald, Elizabeth, Rebecca Sanders, and Paul Supawanich. "The Effects of Transportation Corridors' Roadside Design Features on User Behavior and Safety, and Their Contributions to Health, Environmental Quality, and Community Economic Vitality: a Literature Review." (2008).

Mok, Jeong-Hun, Harlow C. Landphair, and Jody R. Naderi. "Landscape improvement impacts on roadside safety in Texas." *Landscape and Urban Planning* 78, no. 3 (2006): 263-274.

Visitor Center Policy, Directive and Standard, and Guidelines, U.S. Department of the Interior Bureau of Reclamation Denver, Colorado, 2007.

Webber, M. M. "The joys of automobihty In the Car and the City the Automobile, the built Environment and Dady Urban Life eds M Wachs and M Crawford." (1992): 274-284.

Baldauf, Richard. "Roadside vegetation design characteristics that can improve local, near-road air quality." *Transportation Research Part D: Transport and Environment* 52 (2017): 354-361.

Lewis, Alan. "Oppenheim, A. (1992). Questionnaire Design, Interviewing and Attitude Measurement, London, Pinter." *Journal of Community & Applied Social Psychology* 4, no. 5 (1994): 371-372.

Babbie, Earl. "The Practice of Social Research, fifth edition." (1989).

O'Dell, Ryan, S. Young, and Vic Claassen. "Native roadside perennial grasses persist a decade after planting in the Sacramento Valley." *California Agriculture* 61, no. 2 (2007): 79-84.

Perdue, Richard R. "Traveler preferences for information center attributes and services." *Journal of Travel Research* 33, no. 4 (1995): 2-7.

Gitelson, Richard J., and Richard R. Perdue. "Evaluating the role of state welcome centers in disseminating travel related information in North Carolina." *Journal of Travel Research* 25, no. 4 (1987): 15-19.

Parsons, Russ, Louis G. Tassinary, Roger S. Ulrich, Michelle R. Hebl, and Michele Grossman-Alexander. "The view from the road: Implications for stress recovery and immunization." *Journal of environmental psychology* 18, no. 2 (1998): 113-140.

Chenoweth, Richard E.; Gobster, Paul H. 1990. The nature and ecology of aesthetic experiences in the landscape. Landscape Journal 9(1):1-8

Mok, Jeonghun, and Harlow C. Landphair. "Parkways and freeways: safety performance linked to corridor landscape type." In *Transportation Research Board 82nd Annual Meeting*. 2003.

Robertson, Iain, Luanne Smith, and Ray Willard. "Sustainable Roadside Design and Management for Urban Freeways in Western Washington." *Report No. WA-RD* 774 (2011).

Azuma, Ronald T. "A survey of augmented reality." *Presence: Teleoperators & Virtual Environments* 6, no. 4 (1997): 355-385.

Carmigniani, Julie, Borko Furht, Marco Anisetti, Paolo Ceravolo, Ernesto Damiani, and Misa Ivkovic. "Augmented reality technologies, systems and applications." *Multimedia tools and applications* 51, no. 1 (2011): 341-377.

Allen, Max, Holger Regenbrecht, and M. Abbott. "Smart-phone augmented reality for public participation in urban planning." In *Proceedings of the 23rd Australian computer-human interaction conference*, pp. 11-20. ACM, 2011.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. Educational Evaluation and Policy Analysis, 11, 255-274.

Pennington-Gray, Lori, and Christine Vogt. "Examining welcome center visitors' travel and information behaviors: Does location of centers or residency matter?" Journal of Travel Research 41, no. 3 (2003): 272-280

Horton, Robin. 2016. "Matrix Gardening". Partselect.Com. Accessed October 31 2019. https://www.fix.com/blog/matrix-gardening-for-beginners/.

"Environmental Horticulture". 2019. *Google Books*. Accessed October 31 2019. https://books.google.com/books.