

INVESTIGATING THE ROLE OF MOBILE AUGMENTED REALITY IN
ASSESSING THE ENVIRONMENTAL ATTITUDES OF COASTAL GEORGIA
RESIDENTS

by

MICAH TAYLOR

(Under the Direction of Brian Orland)

ABSTRACT

Mobile Augmented Reality (AR) opens new opportunities for environmental communication and crowd sourced planning for future climate related problems. Foundational practices of ethical environmental planning and design are representing landscapes and including the public in the process of decision making. AR can place visual and auditory information onto real places, asking a wider audience for input more than traditional planning tools. It is important that the planning and design community research emerging tools like AR to ensure they are used inclusively and result in both the planners and public making more educated decisions about our environmental future. Using a crowd storytelling approach that connects both the history of the landscape and imagined future, this research gauges the environmental attitudes of residents of Darien, Georgia, a rural coastal town that has a history of hurricanes, flooding, and landscape changes, before and after using a custom mobile AR application, *youARhere*, to determine if those attitudes were impacted by the digital intervention. Environmental attitudes have been strictly defined in the environmental psychology community to

quantitatively score perceptions of the human/nature relationship as either utilitarian (human dominant) or preservationist (nature dominant). This research finds that these deeply held environmental worldviews are not changed after using the app, but that a concern for the future of climate related problems is expressed through stories that were prompted because of the app content. Furthermore, confidence drops in perceptions of a positive future for coastal life revealed through an attitude of uncertainty about beliefs long held about climate skepticism and a belief that science and engineering could solve any future environmental woes. The stories derived from this intervention as well as those registered in the app can be considered a new type of qualitative data that assists in environmental planning. They offer a glimpse into the collective thinking of threatened populations while involving the public in the process by collecting and sharing their experiences and insights in an effort to make more educated decisions. Lastly, this research benefits the field of environmental psychology by suggesting the concept of environmental attitudes include perceptions of an unknown climate future.

INDEX WORDS: storytelling, augmented reality, environmental attitudes, climate change

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DOCTOR OF PHILOSOPHY

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DEDICATION

I dedicate this dissertation to Brian Orland, for the help, support, and partnership researching wild ideas in the field of environmental planning and making sure I write and speak about them correctly. I also dedicate this work to Jingxian Li, Gretchen Bailey, Harriet Langford, and Adam Spickard - *youARhere* and this research would not have been possible without your hard work and valuable inputs. Thank you, so very much.

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CHAPTER 1

INTRODUCTION

Environmental change is something we all experience. People realize the landscape around them changes over time and their recollections may be cloudy when trying to determine when and how it happened. Climate change, the global phenomenon that is driving landscape, weather, and human change is not easy to discern at its local scale, but the evidence is all around us that something is changing – earlier Spring green-up, more severe summer storms, erratic rainfall, and temperatures. This is the vision statement developed for an application of the mobile app *youARhere*, parallel to this dissertation, as part of the project *Experiencing the Past and Future History of Coastal Georgia: A Global Georgia Initiative* from the Willson Center for Humanities, funded by the Andrew Mellon Foundation.

The environment is changing. Global climate change, predicted by scientists, marred by political tension, and seemingly irreversible, is too distant and abstract (too Global) for a person to feel immediately threatened. It is, admittedly, hard to understand and difficult to act upon amid the demanding chaos of current life. However, *the local changes* to the landscape, appearing as symptoms of a global climate crisis, *can be seen, felt, and understood by all....* These stories and insights will be our next history ---- an environmental history as told by those people living in this place and time. With your help, we can digitally preserve our personal history with the landscape and how we imagined the future as well as have a growing collective story around real places.

-youarhere.net

To adequately plan for the future, it is increasingly necessary to include the attitudes and values of the people of the place in formal planning processes at the municipal, regional and global levels. However, it is also necessary to widen the ways in which citizen input is made available to planning processes. The public meeting and social science survey have value but are inadequate at capturing and expressing the full range of cultural and personal associations that rightly should play a role in public decision-making. Exploring means to expand our understanding of how people perceive local environmental changes, the future of landscapes and life, and what they intend to do about it are the foci of this dissertation. They will be examined through the intermediary of emerging technology, specifically mobile augmented reality and related data collection abilities. Along with life and landscape, technology is a relatively new and constant presence in our daily lives. The life altering nature of mobile social media, limitless information, automated constant headlines, simplified tasks, and virtual social spaces has caused, for better or worse, a paradigm shift in the formation and expression of personal and societal attitudes. Can these technologies be understood and harnessed for a more informed and authentic understanding of our environmental future? The focus of this dissertation is on a specific type of emerging technology, augmented reality, as a vehicle for the expression of *Attitudes and Storytelling*. Social media have dramatically enlarged people's ability to develop their own narratives about daily life and leave behind an account about the places and times they lived, supplementing the formal histories, official reports, and journalism on which we relied previously. Adding visual, audio, interactive, and other *augmenting*

experiences to real places expands the individual's ability to help create the narrative of this place and time. Believing that these narratives have authenticity, relevance, and legitimacy in making plans for the future, it is the goal of the *youARhere* app to let people tell their stories through the mobile, digital social space, bringing to the surface their environmental attitudes expressed in what they really see and feel, what they really experience in their daily lives, and what they really think the future will be like in a world of changes. We will test these ideas with a custom-built mobile application, *youARhere*, in coastal Georgia where the threat of climate-related sea-level rise, hurricanes, and heat are a current (and likely future) problem. We will explore the stories that are gathered via *youARhere*, will examine how the tool might enable or inhibit changing environmental attitudes, and will evaluate the utility of the tool and possible ways to enhance its effectiveness.

The research uses McIntosh County, one of six counties that line the Atlantic coast of the US state of Georgia, as a testbed for idea-development and evaluation. Georgia has more than 178,000 acres of human inhabited land (along with infrastructure) and 350 miles of road that lies less than 3 feet above the high tide line (Strauss, Tebaldi, and Pulp 2014). While Savannah, the major historic city on the northern side of Georgia's coast, and Saint Simons Island have the highest property values (Strauss, Tebaldi, and Pulp 2014), the highest percentage per county of impacted residential land is in McIntosh County where income and recovery ability is lower than the more populated, higher income urban areas (TGC 2020). 10 percent of coastal Georgia's residents face the possibility of displacement before 2100 (Hauer, Evans, and Mishra 2016) with hurricanes likely to increase between now and then. Even in the face of inevitable environmental

challenges to place and person, residents along the coast want to stay close to the land and people they know, and while concerned with increasing frequency and severity of storms, would rather move within the community, or defend against future disasters than abandon the area regardless of age, race, or income (Welch-Devine and Orland 2020). Coastal Georgia is a uniquely ‘natural’ place because the majority of its salt-marsh-lined coastline, abandoned for rice-farming in the 19th century, was bought by wealthy families in the early 20th century as vacation homes with extensive landholdings and therefore shielded from extreme development making it ideal for people who desire living around a healthy, quiet, coastal ecosystem (Battis 2020). Reflecting the values of the past, the wealthy homeowners closest to the ocean today are far less concerned with property safety than their less-wealthy counterparts because it is likely a second ‘get away’ home (Orland, Welch-Devine and Taylor 2022). The working people of the coast are closely connected to their cultural heritage of shipping and shrimping, which is marked on the landscape all along the coast (Figure 1). There are cultural enclaves such as the Gullah-Geechee people and the McIntosh County Shouters, a southern black gospel style of music that survives only in coastal Georgia. The area has historically seen native tribes, Spanish, French, Norwegians, Scottish, and English along with stories of slavery, rice, war, rum, corruption, ecology, and industry that is visible (for now) all over the place and recorded on the many historic markers dotting the landscape. These markers, as you will read later in this dissertation, are vital anchor points for prompting new stories from the residents who live there, digitally preserving these stories, and encouraging more educated decisions about the future of the Georgia coast.

The combination of rare ecosystems and historic tabby-walled architecture give coastal Georgia a character of its own, and the residents must reconcile their deep connection to these cultural landscapes, an awareness of the threat they are under, and a strong desire to develop and improve. Protecting these landscapes from increasingly frequent storms, rising temperatures, and a rising sea may be impossible, and it is a goal of this research to evaluate the role of mobile emerging technological means to capture and articulate the human side of responses to climate-related change.

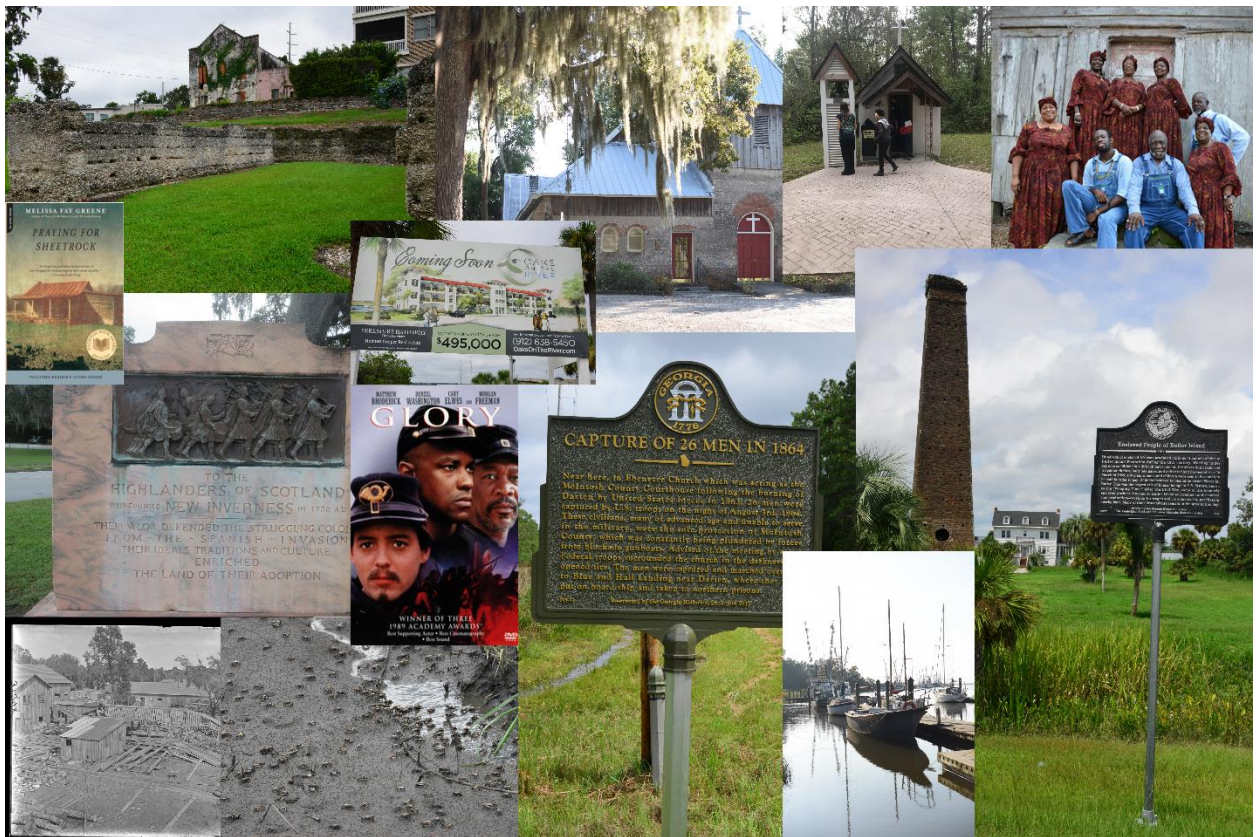


Figure 1 – Collage of images of coastal McIntosh County Georgia, including historic markers, landscape and architecture, and a reference to the movie ‘Glory’ and book ‘Praying for Sheetrock’ that tell some of the stories of this coastal community over the years. - Micah Taylor

Upcoming Chapters

This dissertation will include a literature review and critical discussion of the three main elements of this research, Chapter 2) People's perceptions of environmental change and future risk, and a new humanities storytelling approach to environmental communication, Chapter 3) Technology in planning and how augmented reality is a storytelling tool, and Chapter 4) Environmental attitudes and how they are measured and understood in the era of climate change. Chapter 5) Introduction to the idea of mobile augmented reality and storytelling as an intervention to common perceptions of environmental problems, Chapter 6) The technical side of the custom mobile application, *youARhere*, and how it compares to previous tools built for this project, Chapter 7) The methodology this research used to engage the public with augmented reality, collect stories, and measure shifts in various constructs of environmental attitudes and intentions, Chapter 8) Discussion of the results of these shifts and anomalies found when users engage with on-site augmented reality and tell a story of their own, Chapter 9) Discussion of how these stories are useful to planning and what the next steps are in researching emerging augmented reality technology for environmental planning, and Chapter 10) will be a conclusion and summary of the research topic followed by the author's own thoughts of people's relationship to technology and the environment.

Chapter 2.

CLIMATE CHANGE, RISK PERCEPTIONS, AND STORYTELLING

Environmental attitudes shape our actions toward environmental challenges and how our history with climate change will be documented. Telling the story of environmental change as part of our history acknowledges that climate change is, in fact, an on-going occurrence, although problematic to plan for because of the politically and scientifically complex debate around the action that we, living in this time and place, should take. To understand the environmental attitudes around environmental change we examine the scientific and social complexity of anthropogenic climate phenomena. Historically, environmental disasters caused by humans (anthropogenic) are understood as specifically located events where ‘*this* thing that people did, caused *that* thing to happen.’ Climate change, on the other hand, is global, has many culprits, is not completely understood by the scientific community, and the timing and severity of impacts is uncertain. Many of the world’s more important problems may not seem environmentally related, but stem directly from climate change. What is this almost invisible monster called climate change? What problems and challenges does it threaten for the future of humans?

2.1 What is Climate Change?

Climate change is when the general weather conditions of a place ‘vary significantly over several decades or more’ as a result of an increase in the average global temperature near the earth’s surface, referred to as Global Warming (Denchak 2017). For example, a

warmer than usual summer in Maine may seem an occasional occurrence (weather), but a 20-year streak of record-breaking heat in every location of earth along the same latitude as Maine is a frightening trend (Climate). These surface temperature spikes have effects for all the world's weather and come from the heat of the sun being trapped in our atmosphere (instead of reflecting out of the atmosphere) by a blanket of gases, functioning like a greenhouse. This is not new science. John Tyndall (1863) was the first known scientist to publish about the heat-trapping nature of greenhouse gases in the 19th century when it was a matter of physical science and not yet the politically volatile debate of our time. Greenhouse Gases such as water vapor, nitrous oxide, ozone, chlorofluorocarbons, but primarily, carbon dioxide (CO₂) float in the atmosphere, forming a blanket that traps the heat close to the surface of earth, therefore, raising the global average temperature (EPA 2019). There is conflicting evidence that climate has naturally fluctuated since the beginning of the planet and that no scientist can possibly predict that human activity is causing the increased heat. However, through examining columns of ice, tree rings, ocean sediments, and sedimentary rock, measuring the carbon and earth responses found within these ancient sources, we now know that the current increase in heat is related to the rapid acceleration of CO₂ being released into the atmosphere; 250 times faster than any other time in at least the last 800,000 years (Figure 2) (Lüthi et al. 2008). The surface temperature has risen 2.12 degrees Fahrenheit since the 19th century, with record-breaking years in 2016 and 2020 (NOAA 2020).

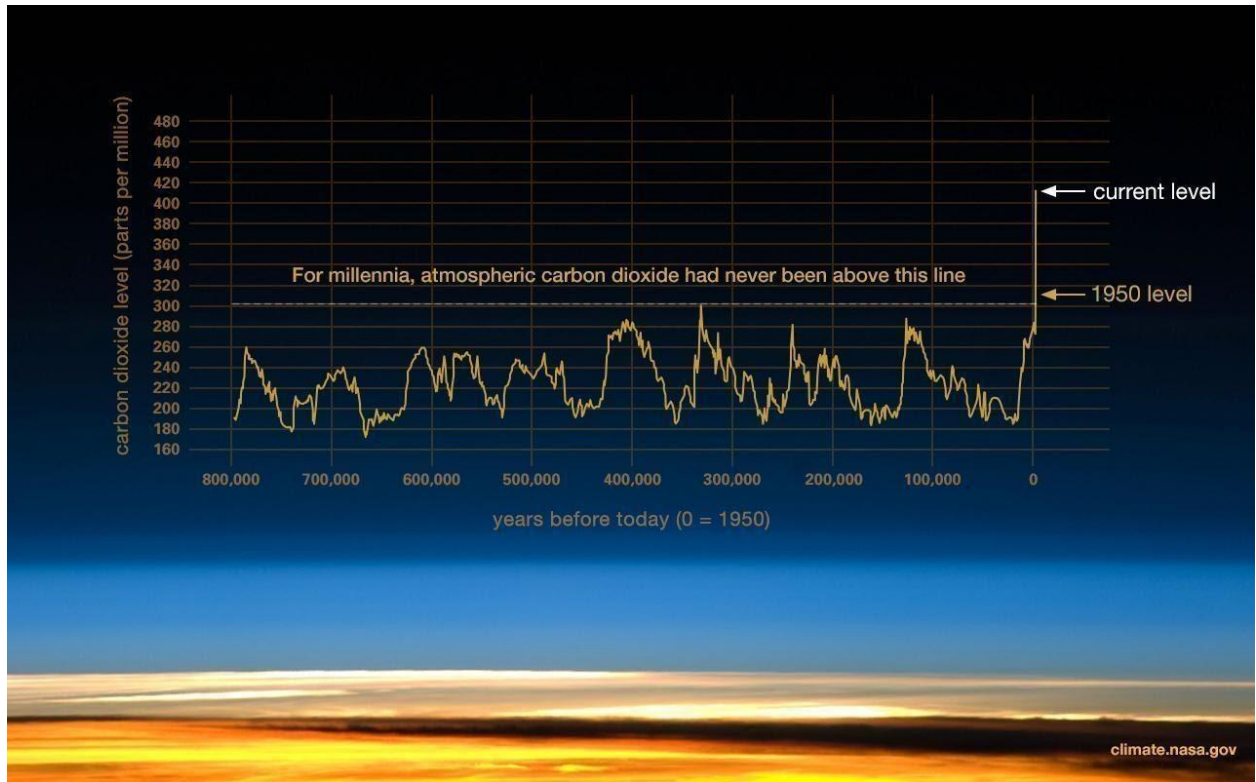


Figure 2. Graphic showing the carbon dioxide levels in the atmosphere over the last 800,00 years where year 0 is the 1950 level from which carbon is rapidly rising still today (JPL 2021).

It is an overwhelming consensus in the scientific community that human activity has caused this unprecedented rise in global temperatures (IPCC 2019) (Oreskes 2004). Primarily beginning in the Industrial Revolution, activities such as fossil fuel consumption for energy, goods production, deforestation, land use change, unsustainable agriculture, mountaintop removal, and increase in landfills are the principle causes of a rapid human-made greenhouse gas release, and therefore, unprecedented global temperatures (JPL 2021) leading to the era of anthropogenic climate change; sometimes referred to as a new geologic era called the Anthropocene. The United States leads major nations in per capita emissions (IPCC 2019). In recent years, China has overtaken the

USA in total CO₂ emissions followed by India in 3rd (Review 2019) making up 52% of the world's emissions because of fossil fuel consumption and China's rapid economic development. The threats resulting from climate change are urgent enough that the Intergovernmental Panel on Climate Change, a multi nation authority on foreign policy agreements aiming to shrink emissions chartered by the United Nations, has indicated that a 2 degree rise in global temperatures would create an irreversible catastrophe for the planet. While identifying actions people and governments of various countries could take to curb the rise in temperature, the reports existing at the time of this writing still claim a rising global temperature and carbon release trend. The often-overlooked aspect of the climate change discourse in mainstream media is the specific ways in which it will affect our daily lives.

2.2 Problems caused by Climate Change

The problems created by climate change are inevitable, have local as well as global consequences, and are already present. On the one hand, there is an unprecedented global effort to *mitigate* the source of the problems by removing carbon dioxide from the air, reducing its emissions from point sources, or sequestering it in hopes of keeping the global temperature below the 2-degree limit that experts have decided will be irreversible and terrible for the planet, and therefore, human beings (United Nations 2015). On the other hand, are regional efforts to *adapt* to the inescapable realities of environmental change by reducing vulnerabilities through planning, engineering, individual lifestyle changes, and, in some cases, retreat. Furthermore, there are two categories of climate related problems simmering beneath the surface of the impending environmental disaster

of irreversible climate change: direct impacts, such as sea-level rise, and indirect consequences such as loss of biodiversity or introduction of new diseases. A problem that environmental planners face in a future impacted by climate change is getting the public to imagine and act on impending changes and support adaptation strategies for both direct and indirect problems. Climate related threats we are likely to face around the globe are extreme heat waves (Berwyn 2019), crop loss (Gustin 2018), large-scale immigration, migration, and social disorder (Benko 2017, Goins 2018), increased exposure to disease (WHO 2003) and other emerging factors that threaten vulnerable communities (Wallace-Wells 2017). It is likely that there will be 250,000 more deaths per year because of climate change after the year 2030 through heat, extreme weather, and vector borne diseases and that the mental health of many more will be negatively affected (Hayes et al. 2018, Watts et al. 2017).

2.2.1 Coastal Georgia – Sea-Level Rise and Extreme Weather

Coastal Georgia is experiencing localized manifestations of the challenges of environmental change and is the focus area of this research. The state of Georgia, in the southeast United States, has roughly 100 miles of coastline along the Atlantic Ocean. Georgia's coast is physically unique in that between its mainland and barrier islands stretches half a million acres of salty marshland, 4 to 8 miles wide, along the 100-mile coast (Grant 2020). This coast has dealt with a 3mm per year rise in sea levels for 70 years and that pace is rapidly increasing (GDNR 2018). While other coasts are certainly facing challenges of sea-level rise, Georgia's case is extremely vulnerable because of the nearly 8-foot tidal range (in its regular state) that directly impacts the land,

animals, and people living in the wide coastal marsh region (Grant 2020) (Figure 3); a different situation than a sand banked beach immediately connecting to a freshwater mainland. The southern region of Georgia has experienced hurricanes Matthew (2016), Irma (2017), Florence (2018), Dorian (2019), and Isaias (2020) as well as extreme drought for 5 of the last 12 years (GDNR 2018). This has caused harm to the landscape, people, wildlife, property, and economy in the region. With the large tidal rise and populated marshland, these hurricanes and droughts wreak more havoc than usual because of the direct relationship of the marshland rivers and seawater.

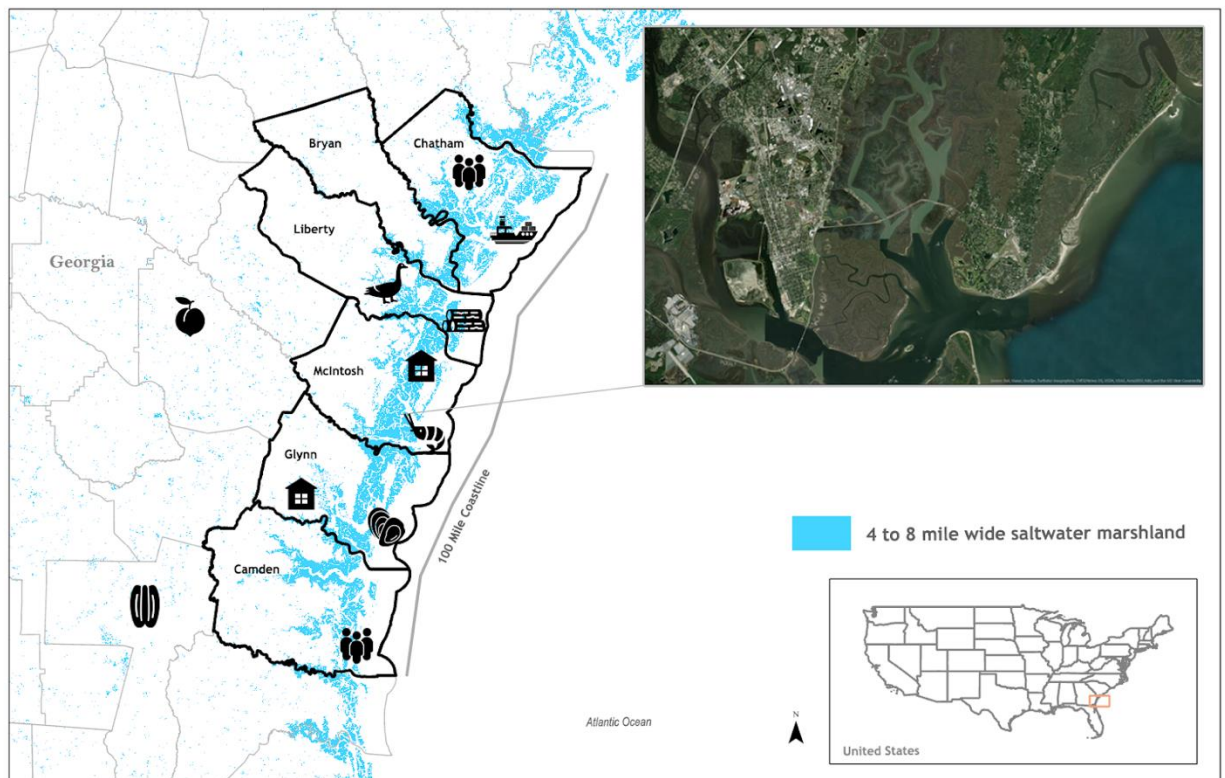


Figure 3. Coastal Georgia’s marshland region where tides are high, the land is dynamic and shifting for many miles inland, and sea-level rise and hurricanes pose a threat to people, wildlife, property, cultural heritage sites, and the economy. - Micah Taylor

2.2.2 Coastal Georgia – Climate Change Impacts on Human and Wildlife Health

The increased salinity of the water as a result of an encroaching sea causes the marshland to deteriorate, and when the tide recedes, the already salt weakened marsh is exposed to the air for further decay causing salt marsh dieback (GDNR 2018). Figure 4 illustrates the physical inland encroachment process onto human inhabited land that grows worse with increased sea-level rise (Clough 2012). This causes the marshland to *creep* inland affecting property, wildlife habitat, and human health. Salt water is already encroaching into the drinking water as well as breaking down septic tanks around the marshland homes potentially infiltrating the drinking water alongside the salt water (Mallin 2013). Three wastewater treatment plants, four hazardous material containment facilities, and a landfill are also under threat to structural integrity in the marshland region (TGC 2020).

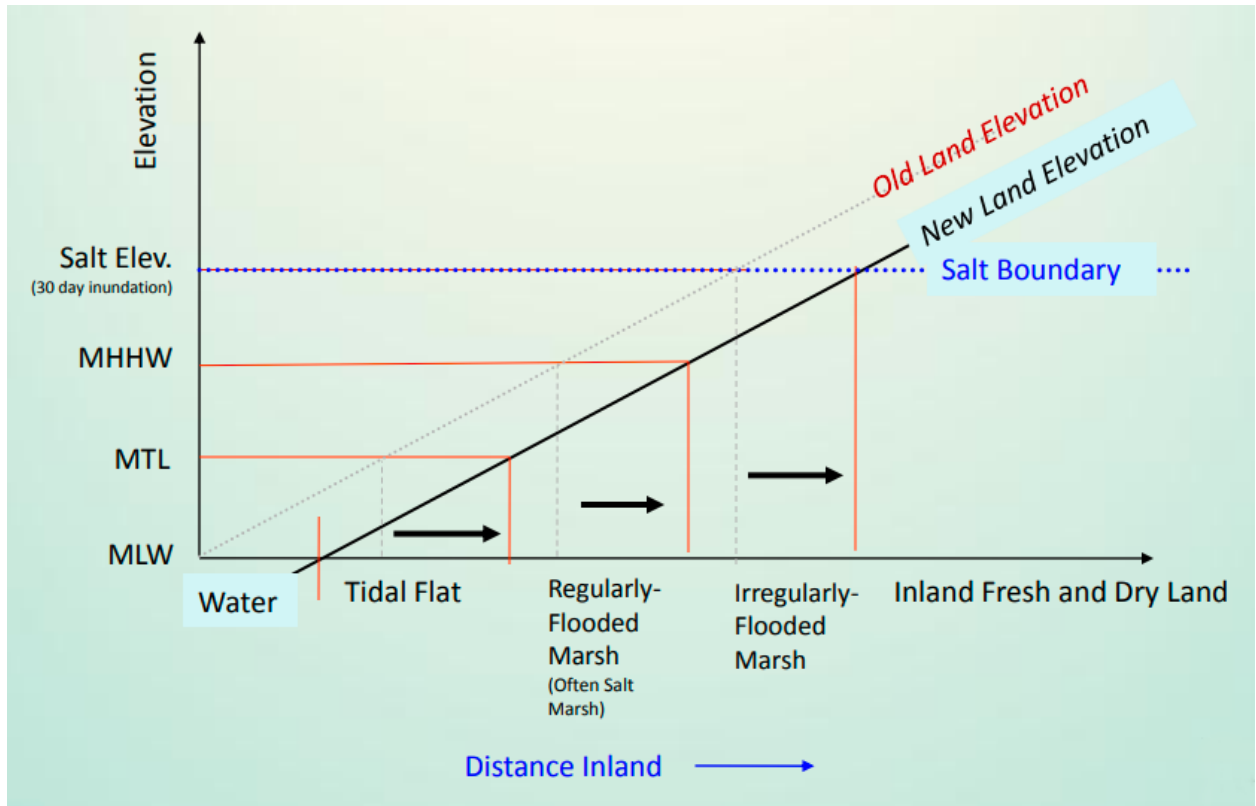


Figure 4. Diagram from the Sea Level Affecting Marshes Model (SLAMM), the industry standard for global monitoring of marshland dieback, explaining how sea level rise not only increases flooding to marsh and dry land, but alters the landscape permanently in which property, wildlife, infrastructure, and industry depend (Clough 2012).

Natural ecosystems that are essential for oyster, shrimp, fowl, and staple crops such as peaches and pecans are already experiencing declines and there is further concern for human health from disease, higher likelihood of wildfires, and increased flooding (Corwin 2018, Terando et al. 2018). The rural south, and especially coastal Georgia where people live and work within the marshland region or are dependent on its vitality, is especially vulnerable to these challenges. The weather and environmental degradation are the direct impacts to the population of coastal Georgia, but the indirect impacts are likely to snowball into a social and economic catastrophe. The Fourth National Climate

Assessment (2018), a cumulative report from scientists based in the southeast and federal and state level environmental agencies, summarizes, “rural communities tend to be more vulnerable due to factors such as demography, occupations, earnings, literacy, poverty incidence, and community capacities” (p.37), highlighting the facts that people in the southeast heavily rely on the environment for jobs in agriculture, timber, fishing/hunting, tourism, and environmental health. Furthermore, the demographics pointing to disadvantaged, vulnerable, and minority communities in coastal Georgia indicate it is likely their trajectory toward extreme environmental conditions will be accompanied by loss of income and a overburdened health system in rural, poor, minority areas (figure 5 and 6) (Lal, Alavalapati, and Mercer 2011) (Terando et al. 2018).

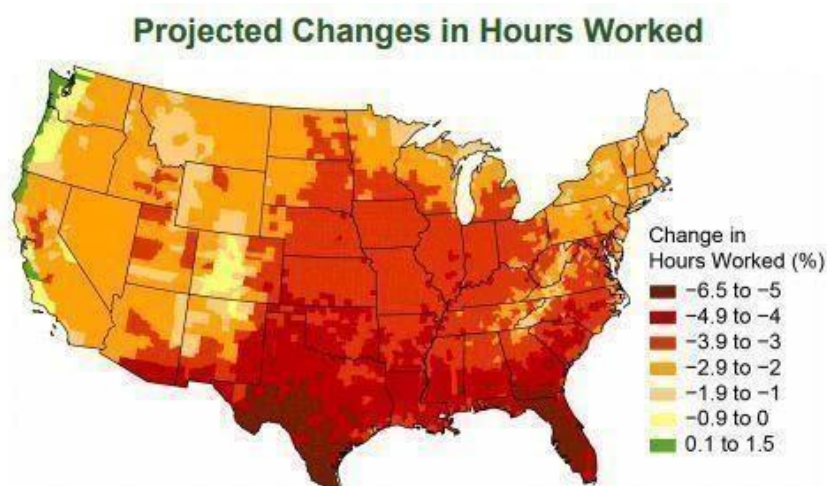


Figure 19.21: This map shows the estimated percent change in hours worked in 2090 under a higher scenario (RCP8.5). Projections indicate an annual average of 570 million labor hours lost per year in the Southeast by 2090 (with models ranging from 340 million to 820 million labor hours).³⁵ Estimates represent a change in hours worked as compared to a 2003–2007 average baseline for high-risk industries only. These industries are defined as agriculture, forestry, and fishing; hunting, mining, and construction; manufacturing, transportation, and utilities. Source: adapted from EPA 2017.³⁵

Figure 5. Map from the 2018 National Climate Assessment showing the vulnerability of the south in losing jobs, income, and social stability as a result of climate change impacts on the local environment and ecosystem. (Terando et al. 2018)

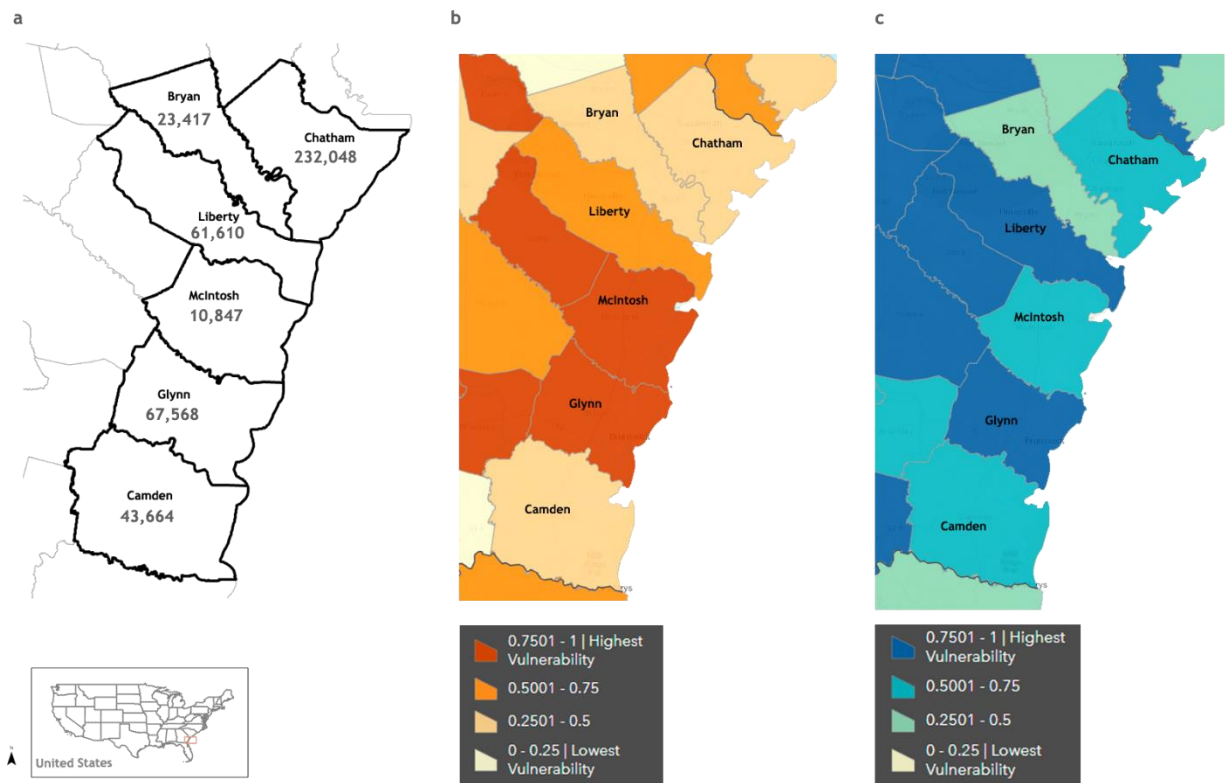


Figure 6. a) Population of coastal Georgia by county, b) Vulnerability level based on household disability to act in the event of natural disasters, and c) Vulnerability level based on the CDC Social Vulnerability Index from numerous attributes from income, race, age, employment, and more (ATSDR 2021).

2.3 Self-Identity and The Psychology of Environmental Change

Coastal Georgia, with a constantly changing system of marshland and rivers, and communities with varying levels of affluence and poverty, are under threat of sea-level rise but have no solid consensus between the public, planners, or government on actions to take nor how people will react (Hauer, Evans, and Alexander 2015, Hauer, Evans, and Mishra 2016). The complexities of dealing with environmental change at the local level have caused the planning community to shift its focus from the prevention of

anthropogenic climate change into adaptation strategies for the impending change. Unfortunately, empirically derived, hard-science reports, maps, visualizations, and calls-to-action are not creating the sense of urgency needed to make coherent decisions at the public level. The non-scientific vantage point from which the broader public sees the environmental future contrasts with the urgency advocated by the scientific community (Slovic 2000, Weber 2006). Several reasons may be behind this contrast. People have emotional connections to places (Relph 1976, Altman and Chemers 1980), a psychological distance from the threat overpowering their physical distance from environmental disasters (Spence, Poortinga, and Pidgeon 2011, Trope and Liberman 2010, Jones, Hine, and Marks 2017), and a sense of identity tied to cultural roots and social connections (Hornsey and Fielding 2017) that overpower the sense of risk living near areas of climate threat, making planning for future risk a psychological interaction (Figure 7).

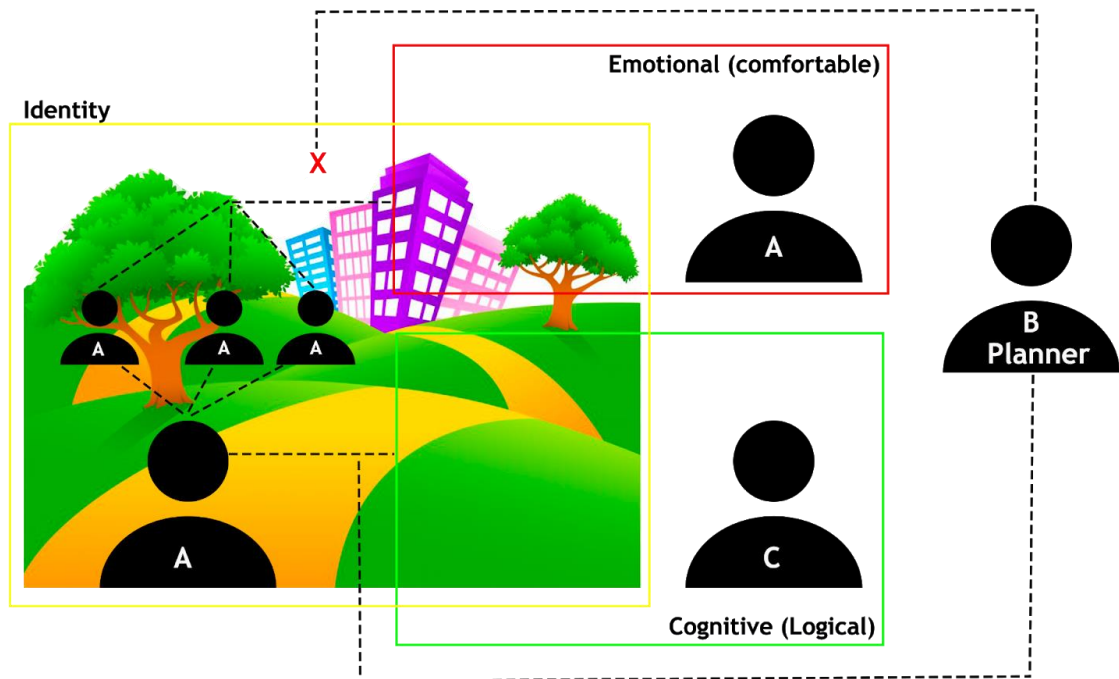


Figure 7. Place, experience, and social connections make up the identity of a person (A), and planners (B) face the difficult challenge of using their tools to make people think logically about the future of environmental risk and become logical (C) about decision making, free of the influence of their peers (other As) and emotional connection to the place. The idea is that the sense of risk is made more immediate because of the connection to place, and not hindered by it. - Micah Taylor

2.3.1. Emotional connection to place and people

Place is an important concept in people's identity and relation to the environment at the affectual / emotional level (Relph 1976) that creates a psychological distance that can be much further than the physical distance to a threat from climate-related extremes (Spence, Poortinga, and Pidgeon 2011). Place is so deeply tied to a person's actions and belief in what is *right* that engaging human beings in planning for life changes, in the case of this research meaning environmental adaptation decisions, must consider that

perceptions and behaviors have been ‘mapped’ mentally over cues given in the backdrop landscape of people’s life (Tuan 1979). Edward T. Hall (1966), one of the most important thinkers and authors on space, connects place closely to people and cultural identity. He emphasizes the experience of life as something that happens in *places* and shapes who we are:

“A keystone in the arch of human understanding is the recognition that man at certain critical points synthesizes experience. Another way of stating this is that man learns while he sees and what he learns influences what he sees.”

This is important because environmental planners must represent the futures of places and therefore people’s very being. What people see in their environments shapes who they are and how they think, making the work of altering that thinking for safety a deeply personal journey for the endangered individual. This is a key psychological feature of people that will be important in the later discussion of augmented reality and its augmentation of experienced *places*.

2.3.2. Psychological distance

Psychological distance as an emotional understanding of distance from a threat is different than a physical distance from a threat which humans process cognitively and react accordingly (Spence, Poortinga, and Pidgeon 2011, Trope and Liberman 2010, Jones, Hine, and Marks 2017). Why would a person not act logically (cognitively) in the face of increasingly frequent environmental threats? Locally experienced disasters

stemming from climate change are certainly scary and acted upon in the immediate situation (hurricane, flood, wildfire, for example) but once they pass and the visible effects diminish, the increasing psychological distance from the occurrence of such events works to lessen the urgency of taking long term, adaptive action. As well as separation in time, the psychological distance is also shaped by the emotional connection people have to the places they live, as discussed above. Orland et al. (2017) confirmed that an individual's attachment to an environment and social identity in coastal Georgia can overpower a seemingly logical move away from danger. This is the case even when the individual has experienced disaster (Rickless et al. 2019).

Proximity to immediate threats does not necessarily mean immediate and predictable action. The psychological proximity may be more immediate in the mind of an individual because of the attachment, connectedness, and social situation of the environment under threat. For example, living near the Atlantic coast in a hurricane prone region does not stop development or long-held cultural ties that motivate people to stay (Figure 8). Furthermore, the emotional reaction to places that is almost impossible to accurately measure (Ulrich 1983), is a variable in the unpredictability of 'what-people-will-do' in uncertain futures. Equally vexing is that many people simply do not feel threatened by climate change (or perhaps do not believe it is happening), a psychologically based mystery clarified in Milfont (2014) and Weber and Elke (2006). This phenomenon of denial is social and even more psychologically complex.

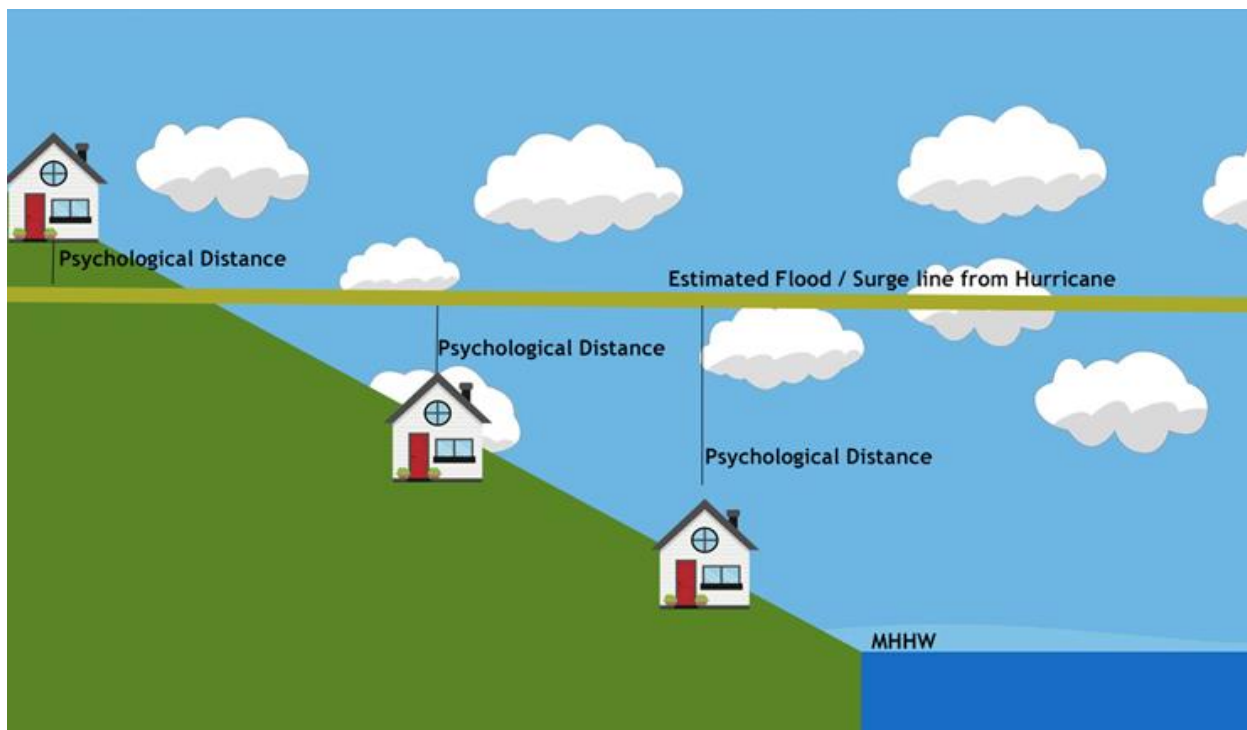


Figure 8. People in coastal Georgia with sea-side homes tend to have greater psychological distance from future threats for many reasons, while the residents further inland of the marshland are aware of the fragile nature of staying in place because of the uncertainty of the future and their ability to recoup. MHHW is the *Mean Higher High-Water* mark - delineated to be the maximum reach of the tide in non-storm conditions. - Micah Taylor

2.3.3. Identity, roots and social connections

Further entrenching the influence of self-identity on decision-making is the persuasion of social connections with others in the community (Hornsey and Fielding 2017, Weber and Elke 2006). People tend to adapt, on the surface, to mirror the beliefs (social norms) of their friends and family when it comes to many topics, including the immediacy and saliency of climate change (Markowitz et al. 2012) in people's lives. As a result, the collective narrative of an environmental future is likely made up of entire communities thinking similarly, with the same place identity and connection, and the same

psychological distance from a risky environmental future all reinforced by the group regardless of personal experience with environmental disaster. This phenomenon can be useful to planners in communities that have a belief in climate science and know the risks but can be detrimental to planning in communities of denial (Steentjes et al. 2017) and is often cited as a ‘dragon of inaction’ in climate change psychology (Gifford 2011, Steentjes et al. 2017).

Planning for people and places in danger then, is deeply psychological, asking people to consider a world outside their social norms and place identity. Therefore, the physical forms represented by site plans, blueprints, graphics, pictures, maps, virtual immersion, etc. must not be considered as separate from the people whose lives will be played out in these places but should be used to meet the intervention needs (Salerno 2017).

Cummings (2007) argues that people (non-professional stakeholders) are not going to take the time to look over, analyze, or understand a prediction or situation from complex technologically derived data no matter how good, accurate, or well collected the data is. This is justification for the professional to disseminate that data in a way that is easier to understand; a separate action from prescribing an action that may seem confusing or unnecessary to people who are not (or do not trust) scientists. Digital representations of the future to aid the individual in adjusting their own identity and belief is better for a non-scientific audience than raw scientific data, or even analysis results. The stories and feelings solicited from digitized visualizations becomes new data. The idea is to create a process that is not totally without computers but not totally within computers (Al-Kodmany 2001). The professional’s job, then, becomes facilitating the information and

visualizations needed to get people to tell their story as part of the impending environmental paradigm shift and make a more educated decision about places from which they are connected in hopes of changing the social norms on climate adaptation thinking for the better.

2.3.4 Perception of future risk

Consider the issue of environmental health. Fischer (2000) discusses the concept of a *risk society* as put forth by German sociologist Ulrich Beck (p.47-51). This proposes that environmental risks affect us all, but because the risks are invisible, we depend on experts (sometimes discredited by elements of the society) to ‘negotiate our understanding’ of the environmental risk or threat. Unlike a more common policy problem such as social risk from uneven distribution of wealth, the negative impact of environmental risk cannot be seen in the streets every day, so it is extremely complex and difficult to deliberate (Fischer 2000). Climate change, regardless of its evident immediacy, is a topic about the future. It is seen by many as something that *might* be happening in the distant future and therefore, a topic for casual talk about what that future might be. It has not been thought of as something urgent or threatening to the individual’s lived time (although the impacts of global climate change are more evident in some places than others). A good starting point for piecing together an understanding of this type of future thinking is with *prospection* – the narrative we create in our minds of how the future might be (Szpunar, Spreng, and Schacter 2014). Prospection is the cognitive act of simulating a possible future with some information, predicting what will happen using that information, and usually biased toward the benefit of the self, securing an intended goal (intention), and

creating a mental plan (planning) on how to reach that goal. We do this in our daily lives by imagining ourselves in situations or futures we would like to see happen, almost a daydream-like process. However, it is also used in environmental threats.

Coulter et al. (2019 p. 59) gives the example of someone who is made aware of an impending heat wave and *simulates* how it will affect them, *predicts* that air conditioning would help them adapt, *intends* to sit in an air conditioner, and *plans* on how to get to an air conditioner. This is the full spectrum of imagining a future with some information (that a heat wave is coming) and getting to a planned action (going to an air-conditioned building). People use this process to evacuate during hurricanes, seek shelter from tornados, and seek medical attention. Interestingly, it is difficult to predict how people will react even if they have experience with an event, they would, presumably, plan to act on in the name of self-protection. Experience with four consecutive hurricanes in coastal Georgia, for example, is part of the story of lived-time in coastal Georgia but is not an accurate predictor of people's intention (or planning) to move away (Welch-Devine and Orland 2020). Both the heatwave and hurricane example, two environmental threats predicted to be more frequent with increased anthropogenic climate change, are usable for understanding cognitive prospection because they exist within someone's lived time. Climate change is typically viewed outside of lived time, something affecting people of the future, and steeped in a political arena of uncertainty, therefore, prospects of how to handle it can vary between social groups, places, and individuals, become weak in adaptation strategies, and lack any sense of urgency that one would adopt in the face of an immediate, localized threat (Coulter, Serrao-Neumann, and Coiacetto 2019, Mulgan 2017, Scranton 2015).

2.3.5 Human Perception of the Future of Environmental Change

Lucien Holscher (2018) adds a humanistic and historic perspective to the discussion of how people perceive the future. He proposes that the future is a ‘gift to humankind’, not that other living beings cannot possess the future, but only humans have the capacity to think about a distant future. Within the history of considering exclusively human thinking about the future it was only at the dawn of technological development after the 17th century, the ‘proliferation of prognostic tools’, or the contemporary age that the future was no longer a ‘fate’ in which the landscape around our unpredictable future stories would unfold but became subject to ‘human molding’, still challenging to predict but acknowledged as deeply affected by human decisions (Holscher 2018). Previously, Snowing and harvesting, death and health, rise and fall of kingdoms would continue until the end of time. “The cathedral would stand but the scenery would be the same” and “the circular expectations of life and experience of little fundamental change mean the future did not exist” (p. 18). Technology gave people choice in the outcome of the future, seen today through planning for the future using technology to visualize different ‘scenery’ and outcomes. From this contemporary age of thinking about the future as something drastically different (as exemplified by sci-fi entertainment and scientific projects), Mulgan (2017) argues that even utilitarian minded people who would lean toward a better environment for all people but discount the future because it is distant and do not act outside of the immediately present threats. This type of ‘discounting’ increases with time; adding a temporal variable that almost predicts the amount of weight someone gives to scale environmental catastrophe that has not happened yet (Mulgan 2017, Weber 2006). Engaging the future in people’s minds and getting a visual glimpse of how people

prospect about the future of the landscape and cultural change in the face of climate change will need to be more in line with the various ways people imagine the future as opposed to assuming everyone will take the ‘early warning’ of climate catastrophe offered by science. Using future images and media depicting potential environmental change might be an effective” early warning signal” to harness the imagination of individuals, prompting more effective responses (Bremer 2017). The task is to marry that effect with a more cognitive analytical consideration of the science behind the visuals in an effort to prompt informed action about a distant future (Weber 2006, Yusoff and Gabrys 2011).

2.4 Storytelling

The gap between the scientific community and the public may signal an opportunity to focus on a more humanistic view of adaptation to impending environmental challenges (Scranton 2015), blending cultural and social science approaches. People have insights into the culture and history of themselves and their homes (stories) gained through lived time and experience with tangible environmental events that have shaped emotions, dreams, sense of place, and aspirations. The non-scientific public can offer insights from personal narratives and first-hand accounts of the environmental change they experience that shape their belief and action towards environmental change. These responses may come in the form of denial, retreat, or an embrace of the change in the landscape. It seems, though, that to motivate ‘good’ change, people need to be involved in determining what specific change needs to take place during the process of planning (Al-Kodmany 2000, Nasar 1990). Just as bottom-up approaches to realize people’s desire to author

have been adopted in collecting and organizing real-world content such as NPR StoryCorps, Wikipedia, and social media (Kelly 2017, McAfee 2006) so can this be applied to humanities-based environmental narratives; especially with the increasing availability of inter-connected mobile technology (Deyan 2019) that can facilitate a new digital public space for both scientists, planners, and the public to continue the discourse on the human relationship to environmental change.

2.4.1 Storytelling as Historical and Future Perspective

Narratives are constructed by, and particular to, the people who tell them and will be different if told by someone else. It is recognized that new perspectives will be inherent in any re-telling of events. That is why, to assure authenticity, that it is important to have the narrative from the original teller and their perspective, however biased, on a ground truth experience. The ‘collaboration ethos’ that underpins social media, for all its many faults, has today created a digital environment where the collective memory and knowing of a place or subject can be created through juxtaposition of many perspectives as opposed to the pre-internet time of expert competition for a single dominant voice (Suiter and Voorhees 2018). Narratives as ways of knowing, understanding, and constructing a story is nothing new. Jerome Bruner (2004) states that, “We seem to have no other way of describing ‘lived time’ save in the form of a narrative.” He goes further to quote the French philosopher George Gusdorf, “the man who takes the trouble to tell of himself knows that the present differs from the past and that it will not be repeated in the future” (Bruner 2009). He compares the way Plato defines art by how it imitates life and Oscar Wilde’s later declaration that life, in

turn, imitates art with how the narrative imitates life and life, in turn, will imitate the narrative that was previously constructed by someone that told it in ‘lived time’. Burgess (2007) introduces vernacular creativity in which the narrator is constructing their own story as a non-expert but is equipped with the ability to author content by having access to social technology. It is a reality of today that many people have a smartphone, continuously available, so that networked storytelling is easier than ever and available as a tool for planning that is more inclusive in which we all own the decisions made.

2.4.2 Storytelling in the Technology Boom

In a technologically networked planning environment, the everyday citizen, visitor, or impacted party serves as a “creative consumer” who is engaged in constructing the medium just as much as the developer or scientist. By contributing stories, pictures, or feedback to a mobile app, social media, wiki, blogs, or any other internet-based medium that reaches beyond traditional person-to-person channels the user is exercising a form of citizenship and participation in story-making; with the potential of creating more authentic historical records and planning that is “owned” by the community (Burgess 2006, Gaffield 2018, McAfee 2006, Suiter and Voorhees 2018). The ontology of collaboration ethos (Suiter and Voorhees 2018) addresses the uneven access to ‘voice in the global media space’, as crucial to any democratic agenda in content creation, and is a disruption to the [expert-driven] dominance of commercial media (Burgess 2006). How do we get the media consumer involved in Digital Storytelling? Starting from the requirement for ground-truth narratives and feedback over traditional quantitative ‘office’ approaches to data collection, how do we get citizens and visitors of a place to

participate? Why do people feel compelled to adopt a certain technological medium over another?

A popular theory, framed in the Technology Acceptance Model (TAM) of Fred Davis, is borrowing from psychological theories of Planned Behavior and Reasoned Action (Fishbein & Ajzen 1975, Ajzen & Fishbein 1980) as reported by Marangunić and Granić (2015). See figure 9 for a concept diagram of technology acceptance. It states that the two determining questions of technology adoption are 1) Will it make my life easier? and 2) Is it free of effort? The original TAM model, just like the planned behavior theory, included the establishment of the users' attitude but was later found to be a driver of intention to adopt a specific technology platform. Simply put, a person will more likely use a technology instance (for example, Facebook app, google map, Wikipedia, or Alexa) if it benefits them, is easy to use, and those tokens of adoption have driven them to the point of intention-to-use. Coupling this adoption model with people's 'desire to author' (McAfee 2006) and having a level of control over the output of the cumulative data (Suiter and Voorhees 2018) or collective cultural memory (Moirá and Makris 2018) seems to be the recipe for viral adoption of a social communication tools. To increase public participation in projects, we must understand, firstly, why do people participate in the project?

Goodchild (2007), who coined the term *volunteered geographic information* (VGI), explains that self-promotion and personal satisfaction are important motivators. The desire to author has been shown to increase use of technology. Game developers veered away from the term 'player' for their users and adopted 'productive player' as an

alternative for those who contribute to and modify game worlds, actions that subsequently result in an increase in game popularity (Burgess 2006). Burgess discusses the cult popularity of movies and games as ‘fandom’ that is always being ‘made’ because the fans are adding to the movie or game by their demands, desires, interpretations, and contributions as fans. Is it possible for *places* to have fandom in the theoretical context of ‘participatory media’? Wikipedia, arguably one of the most extensive crowd-sourced technology-based repositories of definitions, stories, and record, is built on the idea of constantly being ‘made’. Wikipedia founder, Ward Cunningham, recalls, “I wanted people who wouldn’t normally author to find it comfortable authoring, so that there stood a chance of us discovering the structure of what they had to say” (McAfee 2006). He attributes the success of the site to the Informal Rollout Model in which solicitation and initial content were not explicitly defined, documented, or purposefully managed so that that people (the crowd) could be the source of the data and its organizer of output; organization being the tagging system referred to as *folksonomy* (referring to an alternative to expert designed *taxonomy* by allowing design of the content by *folks*). It has also been shown that the unlimited reach of platforms (social media) is more widely adopted than channels (person to person text or email) because of their open-ended content creation (McAfee 2006, Suiter and Voorhees 2018). Social media became popular because of its social and sharing nature, constant new content, and rapid updates (McMahon 2015) and continues to be among the top reasons people are on the internet (Auxier & Anderson 2021). The ability to type what one wants in a Facebook status, upload any picture of any content to Instagram, discuss issues on specific Reddit threads, or modify a Wikipedia record to match one’s understanding is the conferring of output

control to end users that makes those media significantly more adopted and used than an institutional website, research survey, or highly vetted site of information sharing. This does not mean the crowdsourced information is always credible (Aroyo et. al. 2015, Bhuiyan et. al. 2020) but that crowdsource style, social sites and apps are more adopted and can be more accurate at documenting stories when used with exclusivity of certain topics and purposes set by the expert or designer (Bhuiyan et. al. 2020, Luther et. al. 2010, Surowiecki 2004).

StoryCorps on NPR is a good example of a narrative creating medium that is entirely driven by people's personal desire to have their voice heard and archived (Storycorp 2019). The 'social' aspect and the ability to let others hear what is said is the motivating force. Suiter and Voorhees (2018) describe many definitions of 'social media' but the common terms across all interpretations are *co-create Internet*, *share*, and *consumer-generated content*. Storytelling is a place for deliberation to be authentic and provide educated and inclusive deliberation.

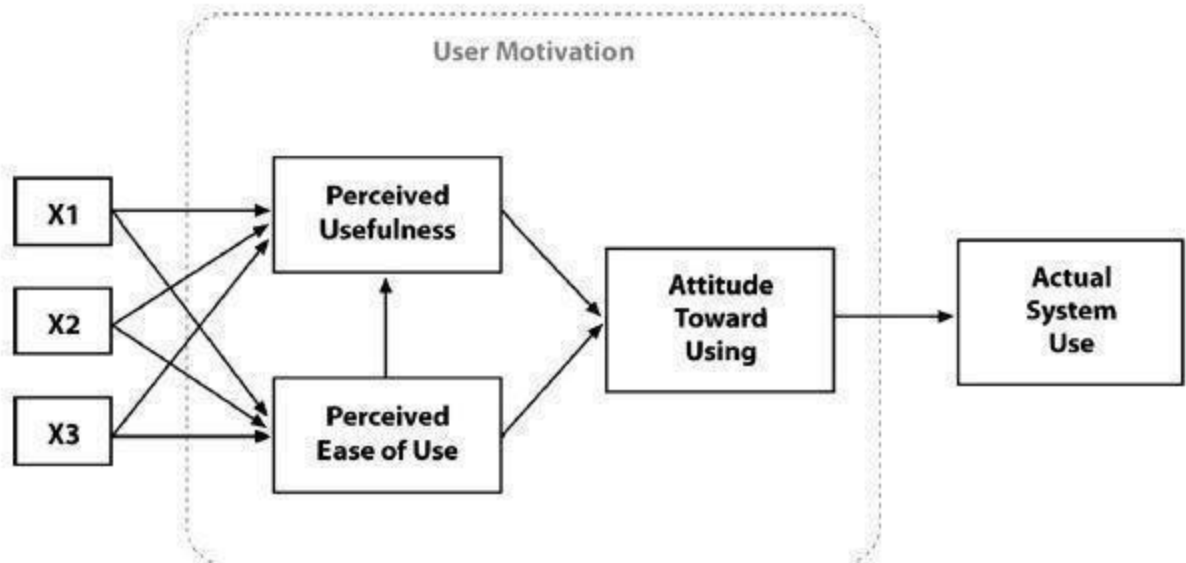


Figure 9. *Diagram of Technology Acceptance Model (Marangunić and Granić 2015).*

2.4.3 Storytelling and Participatory Planning

There is extensive argument that by means of perception taking (Ahn et al. 2016), social learning (Al-Kodmany 2001, Innes and Booher 2010) crowd-sourcing feedback (Gordon and Manosevitch 2010), and experiential simulation through narratives (Piga 2017) that emerging technology has the ability to enhance the understanding of professionals and lay-persons alike; therefore, making a more inclusive decision-making process. Social interactions, in reality and through well designed technological intervention, spur perception change and a social learning experience in which individuals understand the environmental impacts around them and hold closer regard for the culture of the people that live in that environment. This assumes a direct behavioral change approach as opposed to a collectively derived story ending in an agreed upon approach based on data derived as well as personally derived stories from lived time. Ideally, a comprehensive

involvement of everyone (the stakeholders) in the planning process to adapt to change could provide the “*correct*” solution, as opposed to experts actively trying to change people’s minds. It is more likely that a truly comprehensive and accessible tool to share insights, ideas, and beliefs will provide the *most-correct* collective view of a situation and, therefore, potentially drive the solution to something more in-line with the actual risk (Brown 2015, Surowiecki 2004).

Participatory planning, debate, and discourse are popular terms in the techniques and research toward more efficient and inclusive planning, but often lack any tangible collective view by which to make a truly inclusive decision. Fischer (2000) discusses how technocratic methods rely on the experts, through scientific advancement of technology, to make decisions and how public thinking during modernism assumed expert decisions were unquestionably the best options for life and happiness. The public started questioning the validity of science; especially when science created the technological advances that cause harm (Fischer 2000). It has been argued that the visualization tool, rather traditional or immersive, is used by the *expert* to corroborate the desires of the political elite because they were instructed to do so regardless of the ‘true’ research results (Moore 2007). This is a result of a public that has, after a long history of environmental and health disaster, become skeptical of heuristic science and a political elite that disguises truth by controlling the experts working beneath them (Fischer 2000). Al-Kodmany (2002) states, “Visual information is a common ground for the transmittal of information that overcomes racial, social, and language barriers”, and “GIS is empowering only when it is controlled and operated by the community and that simply

providing information is not enough to empower community groups.” This means that the visual needs to be modifiable based on new input derived from the iterative arguments of deliberative planning. Placing the construction of those visualizations in the hands of the public through crowd-sourced information forces the expert to become a participant. Visualization technology then becomes less of a technocratic tool for economic gain and more of a *visioning* tool for incorporating individual views and ‘visions’ being heard and argued (Grant 2007). While this is not a perfect participatory democratic planning process absent of any dominant political elite it does bring the expert and layperson to the virtual planning table. The expert is not dominant over citizens in participatory planning and instead acts as an “expert citizen”; helping the citizens learn by informing so they can make the decision.

Surowiecki (2004), in *The Wisdom of Crowds*, connects many examples of how the public is often the most accurate predictor by finding a collective *average* from public input; not as a quantitative middle statistic but as ‘excellence’ in that the average is almost always closer to the correct answer than the best individual guess. He makes this point using examples from point spreads in game betting, students guessing the number of marbles in an urn, and the stock market’s power as a predictor of impending change. Furthermore, he gives examples of how issues of the future that do not have definite nominal categories (such as a bet on a football game having only 2 possible outcomes of a winner) but are incalculably unknown are often predicted closely to what really happens because of the collective perception already motivating decisions along the real outcome’s trajectory (Surowiecki 2004, Holscher 2018).

2.5 Visualization Technology and Collaboration

The scientific and public collaboration proposed here requires that both are contributing authentic and ecologically valid content to the narrative. Modern problems are inevitably turning to technology by making it accessible and driven by the public to find solutions (Kelly 2017). These emerging radical bottom-up approaches function independently of experts or policy and potentially offer the most successful way forward for adaptation to environmental change (Wainwright and Mann 2018) and use narrative as its new data, driving people's desire to author and make tangible change, and use technology as a major tool for communicating and collaborating (Kelly 2017, Gordon and Manosevitch 2010, Diamond and Plattner 2012, Surowiecki 2004). The use of visualization to communicate environmental change is increasingly common because of the combination of accessibility of visual information vs. complex verbal or data descriptions, and the relative power of the visual over text or numerical data. Some researchers claim that visualizations of imagined futures from the research community must not mislead the public with false images of dystopian futures (Yusoff and Gabrys 2011) but offer an educated view of how local places might look and function in the future of environmental change. Other suggest that displaying local views of known landscapes (for example, in coastal Georgia) inundated with sea-level rise, while not an exact portrait of an unknown future, might prompt an emotional reaction and the desired type of knowledge production from the viewer, but the visualization must be based on ecologically valid predictions of previous events, low scientific uncertainty, and mediated by experience (Bremer 2017). From the perspective of this research, the experience and the authenticity of

narratives contributed by the public as data to drive visualization may carry greater validity when collected on site, *in-situ*, where environmental change is progressing, and *in-vivo*, in the course of daily life (Orland et al. 2018), and in the absence of an official researcher or operating in a traditional research laboratory (Bernard 2000).

Mobile-based augmented reality offers the chance to have this real-time, on-site experience of otherwise unseen phenomena. A smartphone or tablet camera can recognize static objects in the landscape to use as a ‘target’ from which to display images, videos, 3D models, and infographics directly into the scene. Furthermore, due to the wide capabilities of mobile applications, it can collect typed or recorded voice responses, images, and geo-locations from the user to enhance the environmental narrative. Therefore, this approach allows researchers to *communicate* localized visual experiences of the past and future to the user “in the field” while seeing an augmented world, and collect they’re *in situ*, *in vivo* assessments by providing the user a channel to *contribute* their insights, perceptions, and suggestions; connecting the scientific and cultural, expert and non-expert, with the aim of dealing with environmental change more inclusively.

Chapter 3.

TECHNOLOGY IN PLANNING

This research focuses in one arena of technological tools that are believed to have an important place in planning - Mixed Reality. Researchers and users of Mixed Reality (MR) have grappled with the term 'Mixed Reality'. Some view it as something apart from virtual or augmented reality while others regard it as a term encompassing virtual reality (VR) in which users are completely immersed by artificially created visual, aural, and even haptic sensations, while augmented reality (AR) is the addition of digital content, usually visual, onto the viewer's immediate reality. This research focuses on the latter. To understand AR as a useful tool for environmental communication and collaboration, the following sections will discuss how other media technologies have changed the way planning is conducted, and how AR has integrated the benefits of many of them. All these tools are for the purpose of 'representing' places at some point in time, maybe even the future.

Representation is a critical aspect of deliberative planning since the subject matter is usually too extensive, distant, or still speculative, to enable immediate inspection during deliberation. The tools used to visualize, represent, design, sell, experience, understand, and communicate design and planning decisions have implications and effects on the process and outcome of planning; not always good, not always bad. Their use has been documented and tested extensively throughout the history of environmental

planning. Visualization has been a central area of focus since the visual sense is so important to our understanding of the world around us and how it might change. As a result, the evolution of representational tools has been dominated, especially in recent years, by advances in visualization tools and techniques. However, there is a growing need for analysis and critique of the fast-growing technology in the realm of visualization and simulation. Specifically, my interest lies in how the thinking processes of individuals shift in response to the stimulus of mixed reality. Throughout the review, I will focus on the specific use and results of visualization tools used for purposes including sales, design, storytelling, and communicating the experience of environmental change in the name of trying to make informed decisions. Finally, I will explore some of the most recent innovations in visualization technology highlighting areas where further research and development is needed to understand new technology's role in the practice of deliberative planning.

3.1 History

Visualization *tools* can be described chronologically, but their introduction and development overlap. Historically they have not been created, used, and formally abandoned to be replaced with the latest visualization technology. Instead, there has been an accumulation of tools, new ones supplementing rather than replacing earlier ones. Drawing has seen different forms and uses, from communicating in times and places without language, to making maps, to creating art. The advancement of these tools has not only been that *images*, meaning the full spectrum of visual communicators – photos, videos, web, virtual reality (VR), and augmented reality (AR)) became 'better' with more

color fidelity and image resolution but that they could also be coupled with the technological and digital revolution, networked, and interactive abilities that have developed over the last fifty years (Al-Kodmany 2002). Figure 10 is a timeline of visualization technology that either improved on or created new ways of engagement with visualization accompanied by Al Kodmany's (2002) temporal connection (Figure 11) between visualization technologies and what is *new* about how we use them. The age of computerized assistance in creating images, as separate from the invention of the camera, saw the first photo-voice landscape research in 1971 using filmed images. Video was also gaining broad adoption in the 1970s as "rich, thick, cultural documents" (Garrett 2010) although the first use of film in anthropology may have been as early as 1898. The advent of interactive 3D tools via the internet opened the door for image and data visualization shareable across computers. Visual analytics is an emerging field blending live data streams with visualization techniques, often in real time. VR / AR allowed free-movement immersion and a new way of viewing digital content.

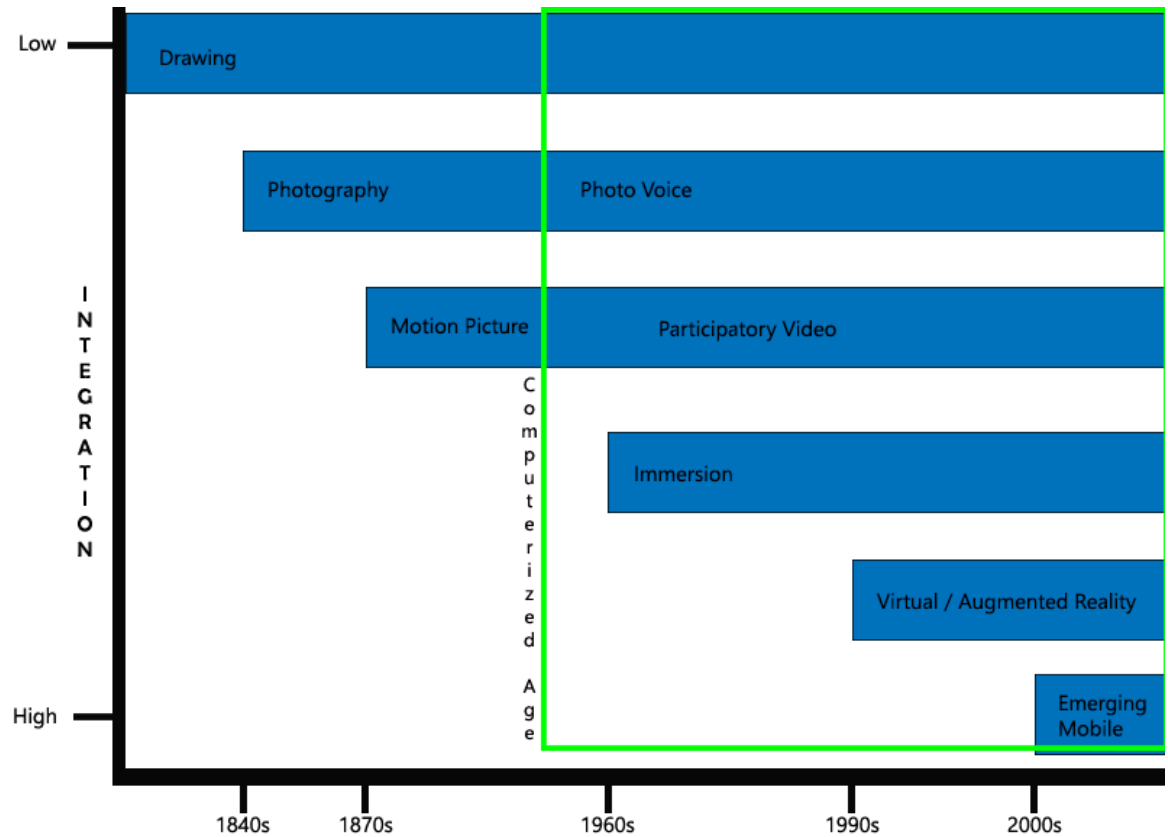


Figure 10. Timeline of visualization mediums and their integration into emerging technology. - Micah Taylor

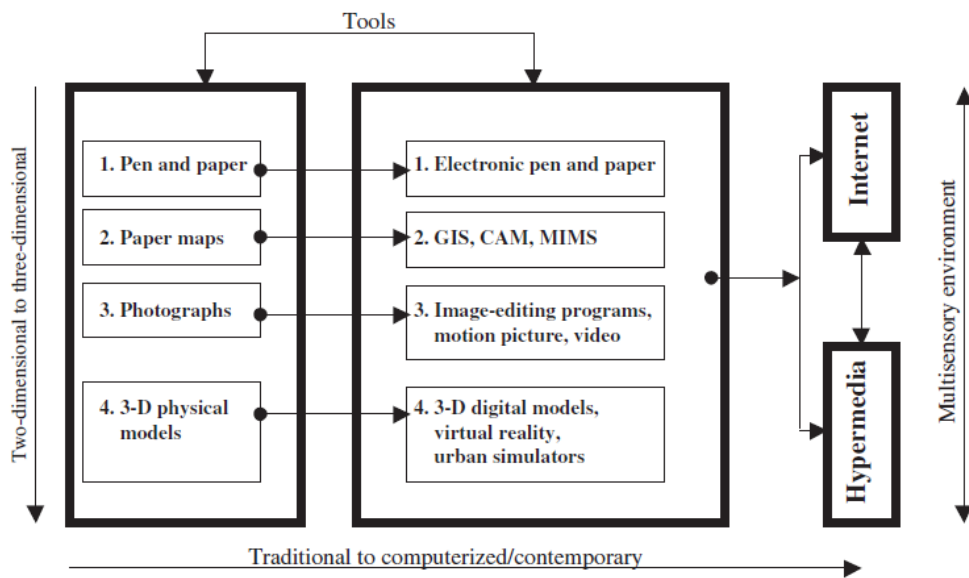


Figure 11. Traditional and computerized enhancements on visualization tools with their upward trajectory towards 3D visualization. Taken from (Al-Kodmany 2002)

3.1.1 Photographs

Photography, as one element of the media discussed in the following sections, has its roots in science and learning. Louis Daguerre, inspired by his creation of the Diorama that displayed detailed illusions onto landscapes by combining paintings with light manipulation, created the daguerreotype (Figure 12) that used light to permanently imprint a scene onto a silver coating of a metal plate (Locke 2015). Shortly after, in 1843, the first adopters of the tool were archeology and botany. The first scientific publication to use photographs was English Botanist Anna Atkin's *Cyanotypes of British Algae* (Figure 13) starting the movement of photography as both a science and art (The New York Public Library 2021). The use of photographs as aiding storytelling in art and for representing places in scientific inquiry are now fundamental environmental planning tools. Using photos of landscapes means 'representing' landscapes. Photo representations of landscapes are present in many multi-media, and scenic beauty (esthetic) research is notable for discovering the validity and utility of photographs in landscape management and planning. Understanding that scenic beauty is not a tangible trait easily measured by science and is a natural resource that governing authorities should consider in management plans, research in measuring scenic beauty pursued the discovery that photos of landscape scenes, 'representing' the real place, can be used as surrogates for the natural environment to assess people's scenic beauty preferences to identify scenic resources (Daniel and Boster 1976).

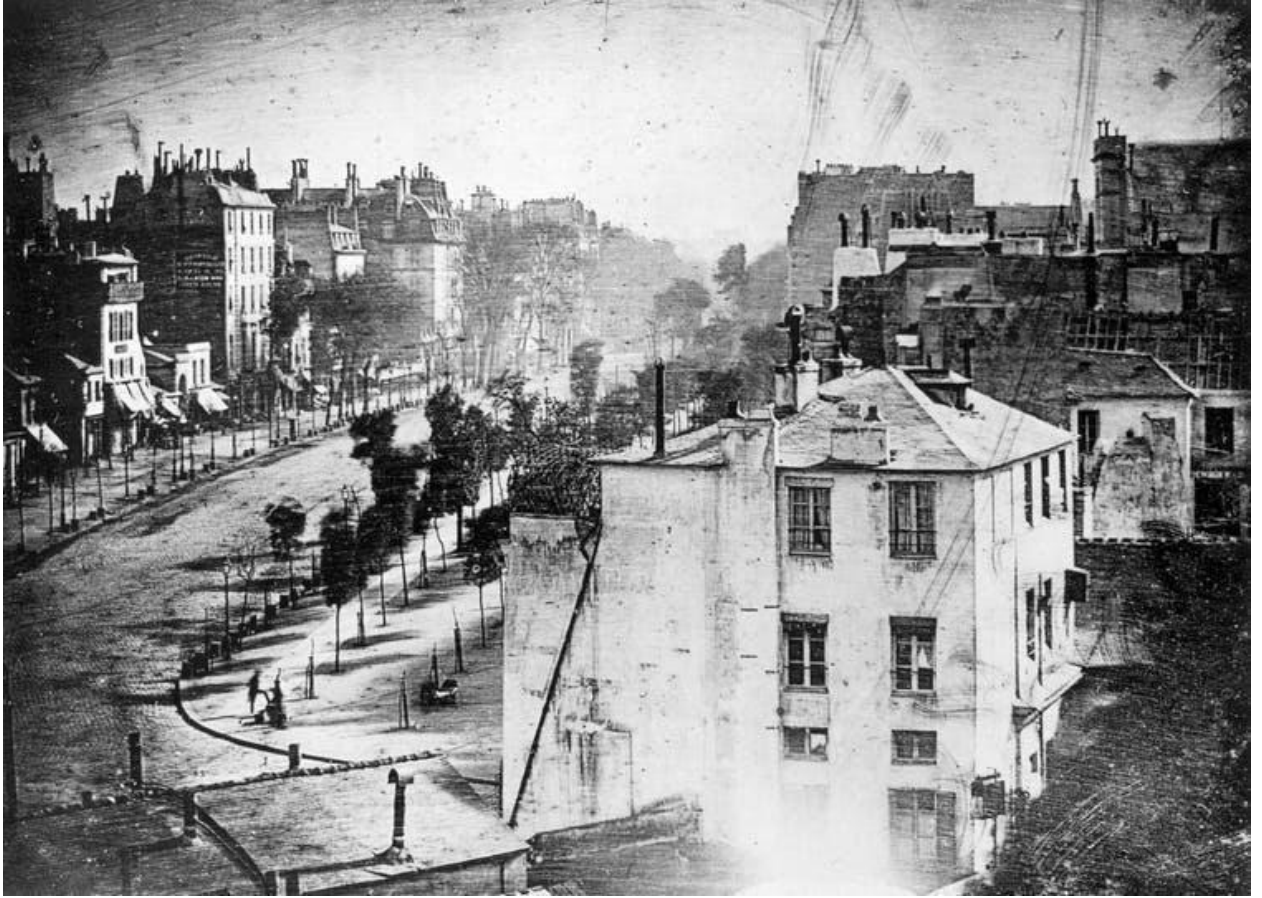


Figure 12. The first publicly displayed daguerreotype shown to the world as a demo in Paris, 1839 (Daguerre 1839 from Locke 2015).

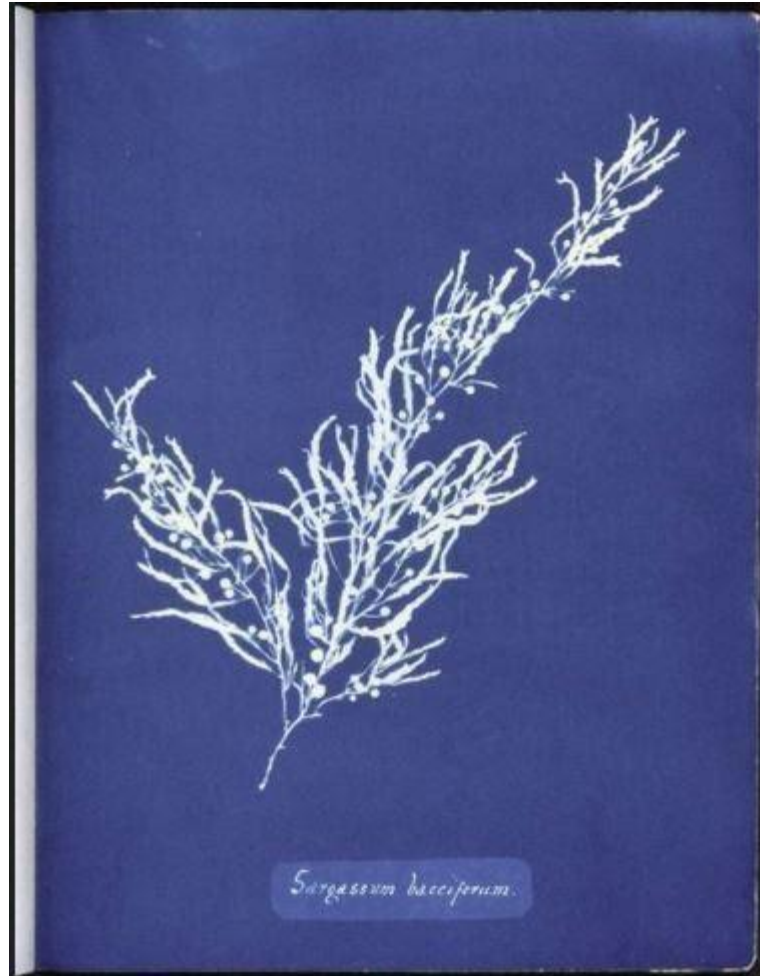


Figure 13. *Sargassum bacciferum* - a daguerreotype (early version of a photo imprinted on silver plated metal) by Botanist Anna Atkins in the first published work using photographs (Atkins 1843 from Locke 2015).

While photography is an obvious first choice for representing environmental conditions, the means by which photographs are taken, and by whom, has presented opportunities for investigating the experiences of viewers when in the act of taking the photographs themselves. Cherem and Traweek (1977) used Visitor Employed Photography (VEP) for public engagement with visualization. Their project allowed the user, while engaged in the experience of canoeing or hiking, to take photographs and answer questions regarding

visual preference in the absence of the researcher. The user was not shown additional information about the view to stimulate any consideration of the *future* but was asked only to collect views and answer questions in that instant. Mobile technology has the potential to improve on photo-oriented approaches through access to much larger numbers of participants and by augmenting the experience with digital content such as images, sounds, animations, or hyperlinks to supplementary information. Broader accessibility and more communication functions expand on pioneering techniques like VEP. While climate change research is not specifically asking for a scenic preference or evaluation of a place for its view or aesthetic quality, the methodologies applied in VEP model those applicable to other environmental assessments requiring visual aids and can evolve to fit many modern environmental planning needs. Chenoweth (1984) suggests that the VEP approach in effect asks the user to *tell us what we have missed* about cultural and/or historic significant places (removing the preconceived significance of cultural value by the expert) but does not depend on (or allow) explicit ‘recall’ (the user is answering questions about places and futures while being *in-situ* of that place).

3.1.2 Motion Pictures

It makes sense that the next step after photos would be video. Video, technically, strings together photos (frames) to create motion, the first being 24 still photographs of a horse by English photographer Eadweard Muybridge meant for research to determine if all four of a horse’s legs are ever off the ground at the same time when they run (Hickmore 2019). Video for environmental communication would grow as a useful tool just as in other fields. The earliest days of video immediately saw its use in learning, training,

(Bailenson 2018) and anthropology with ‘participatory video’ (Garrett 2010). The public likes to watch participatory videos, or documentaries, more so than other environmental communication mediums simply because people in the developed countries like watching television or streaming video services often (NEA 2007, Ritcher 2020) naturally making the video a good tool for scientific communication. The emotional and cognitive response to climate centered films such as Ronald Emmerich’s *The Day After Tomorrow* (Mossner 2012), Davis Guggenheim’s fact-synthesizing *An Inconvenient Truth* narrated by climate activist and United States Senator Al Gore (Nolan 2017), and BBC’s nature-centered *Blue Planet II* (Frost 2020) was unprecedented in environmental communication, not because of its scientific complexity or rigor, but because of its entertainment-meets-environmentalism style of engagement with people’s emotions and its wide viewership (CRP 2020, Frost 2020, Mossner 2012). This was great for the scientific community because of the amount of people that would consume the final message of their cumulative scientific work; the often-missing aspect of science spurring a response. However, making films is costly and does not capture the temporal shift in landscape visualization or climate-related change beyond the scope of the video. Video is still ‘static’ in the broader space/time sense because the viewer still has no control over the viewpoint, nor can they interact with the data presented as supplemental to the video (Orland et al. 2001) but video does allow a continuation of the landscape and an enhanced representation of events through motion and sound which gives it utility and popularity. Video, however, is still growing. People can record / create content and upload to streaming services and this will likely not be replaced by the more advanced virtual technologies anytime soon. On the other hand, the more immersive and visual

analytic tools emerging recently have the potential to add the subtle but powerful function of interactivity and multi-layered, up-to-date information (VR, AR, interactive 3D web, streaming) to the already visible power of pictures and video.

3.1.3 3D Graphics and Simulation

Computer representations of landscapes have been around in various qualities and levels of interaction, but it was not until the advent of consumable 3D environments on a 2D display that these tools became something more than bulky and costly concepts. The first to pursue the idea that computers could be used interactively to allow for manipulation of 3D content by the user for the purpose of *simulating* things that would cost too much to render as physical models, were David Evans and Ivan Sutherland when they created the first Computer Aided Design software and hardware called LDS-1 at the University of Utah in 1968 (later sold as the E & S Picture System). The lab from which the Evans and Sutherland Corporation was eventually created would drive the development of higher resolution devices and multi-functional programs later such as Adobe's and Pixar's suites of graphic software. The simulation of 3D objects in motion on computer displays is a visual effect produced by strategic rapid changes in pixel values of the device display. Apple II, in 1977, was the earliest mainstream device to render 3D characters on a display. The reach of this type of communication was increased by the ability to host interactive 3D visualization on a web browser - made possible by a library of graphic primitives called WebGL – an offshoot of the Canvas 3D project produced by Mozilla (Mozilla Corporation 1998). With growing computational power came more possibilities

of representing ‘places’ as arrays of pixels on a display with results that have enhanced the possibilities of gaming, engineering, and design (Figure 14).

3D visualizations (often referred to as ‘3D models’) became surrogates of real places.

WebGL using the Java programming language allowed interaction with 3D surrogates on modern home / office computers and changed what could be done in the field of

landscape and place communications. Google Earth is the flagship example of web

surrogates for design and environmental communication. The ability to place WebGL

objects (3D models and content) onto a WebGL landscape (Google Earth imagery and

terrain) was mixed with crowd sourced photos and UI elements providing a new and

accessible way for people to collaborate with designers on a ‘realistic’ canvas (Harwood,

Lovett, and Turner 2015). Similarly, complete remakes of places could be used to place

environmental concerns in context, such as biomass crop planting (Lovett et al. 2015) and

coastal change studies (Newell, Canessa, and Sharma 2017) and more. More is discussed

about the utility and effectiveness of varying levels of realistic appearance and

functionality of simulated environments/scenarios in section 3.8.

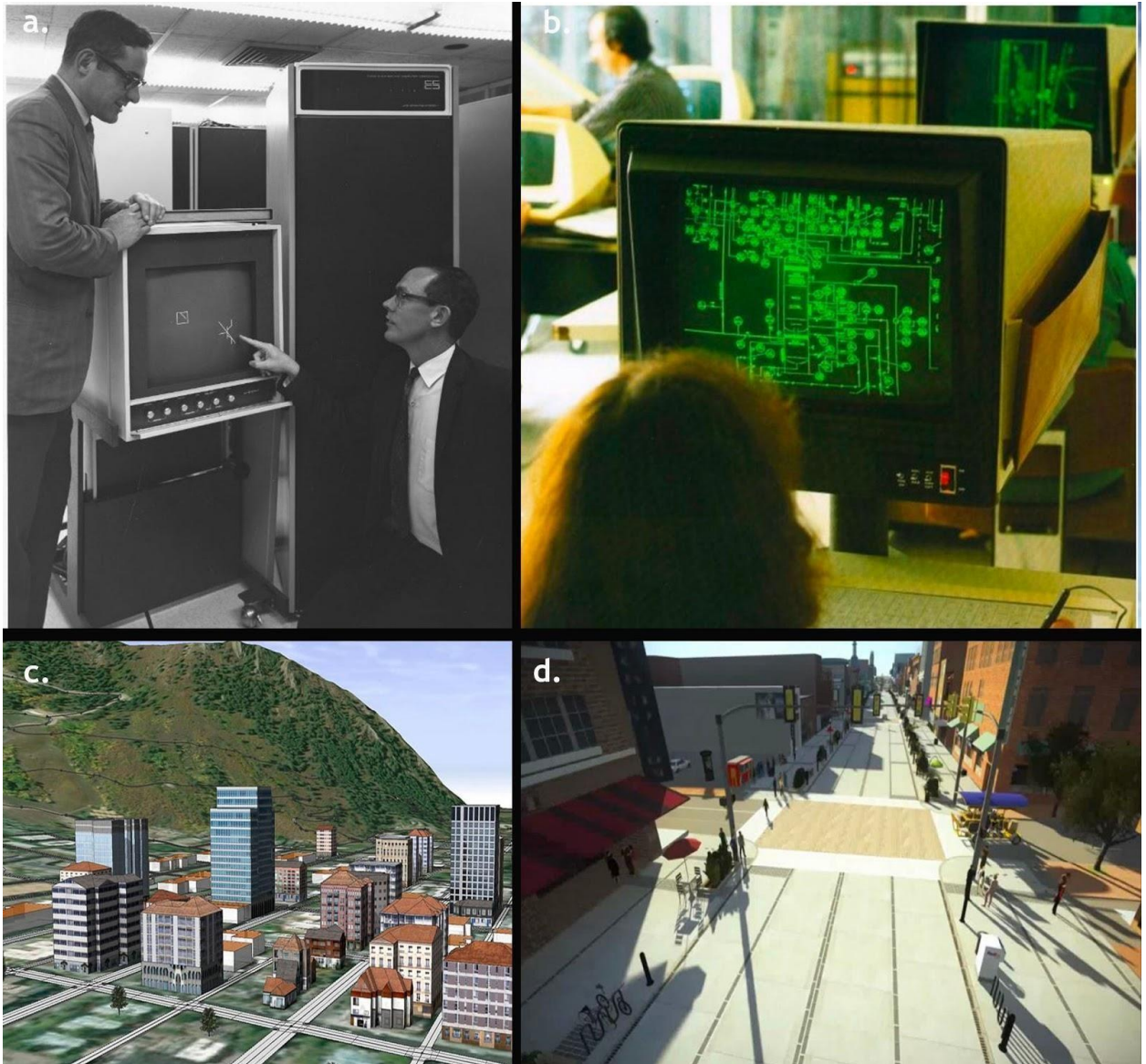


Figure 14. **a)** 1969 - Graphic lines on the first LDS-1 (Carlson 2006). **b)** 1980s - Early AutoCAD software (Creative Mechanisms 2015). **c)** Esri CityEngine rendering interactive 3D models usable in a browser. **d)** High-definition simulation using CityEngine and LumenRT for rendering realistic facades and atmospheric elements (Micah Taylor).

3.2 Immersion

Immersion, in the context of computer visualization, is when the user feels they are present and have some physical control in a simulated environment and situation. This is

enabled in Virtual reality (VR), when an individual feels they are ‘present’ in an immersive virtual environment at varying levels of realism with varying levels of corporeal control (move, jump, touch, hear, pickup object, etc..) usually facilitated with a head mounted display or wall screen enclosure (Bailenson 2018, Heeter 1992, Lombard and Ditton 1997). Augmented reality (AR) is a 'middle ground' between [virtual environments] (completely synthetic) and the everyday world (completely real) with three distinct characteristics. 1) It combines the real and virtual. 2) It is interactive in real time. 3) It is registered in three dimensions. People are drawn to this experience because it can “enhance a user’s perception of and interaction with the real world” (Azuma 1997).

3.2.1 The beginnings of VR and AR

VR and AR work, and have worked, in learning and training realms since their creation. Table 1 lists some AR and VR applications for environmental communication, what was the observed result, and what level of public participation the tool facilitated (not an exhaustive list). The common approach in these projects was to have the user experience VR or AR and learn something in a more personal way, be somewhere they could not really be, or experience something that would not be known without immersion or the ‘real thing’. Learning and training fighter pilots was a notable early use of VR when the pioneering application *Link Trainer* was made in 1929 (Bailenson 2018) although American Cinematographer cc is considered the ‘father of VR’ for his ‘*theater immersion*’ (Figure 15) device prototyped in 1960 because of the attention received as an entertainment VR (Federov 2015). Evans and Sutherland released the CT-5 *Sword of*

Damocles (Figure 16) head mounted VR display for training pilots with VR in 1968 (Evans and Sutherland Co. 2021). Similarly, the early idea of augmenting digital information onto real world objects was also used for fighter pilots and in the medical field by Boeing, one of whose engineers, Thomas Caudell, coined the term ‘Augmented Reality’ in 1990. (Azuma 1997, IDF 2020). However, the original idea of AR is documented as coming from a 1901 sci-fi book, *The Master Key*, where the main character is given the *Character Maker* spectacles that allows him to see information about a person's character overlain on their face (like an early Snapchat filter, which is also AR) (Carmichael 2016).

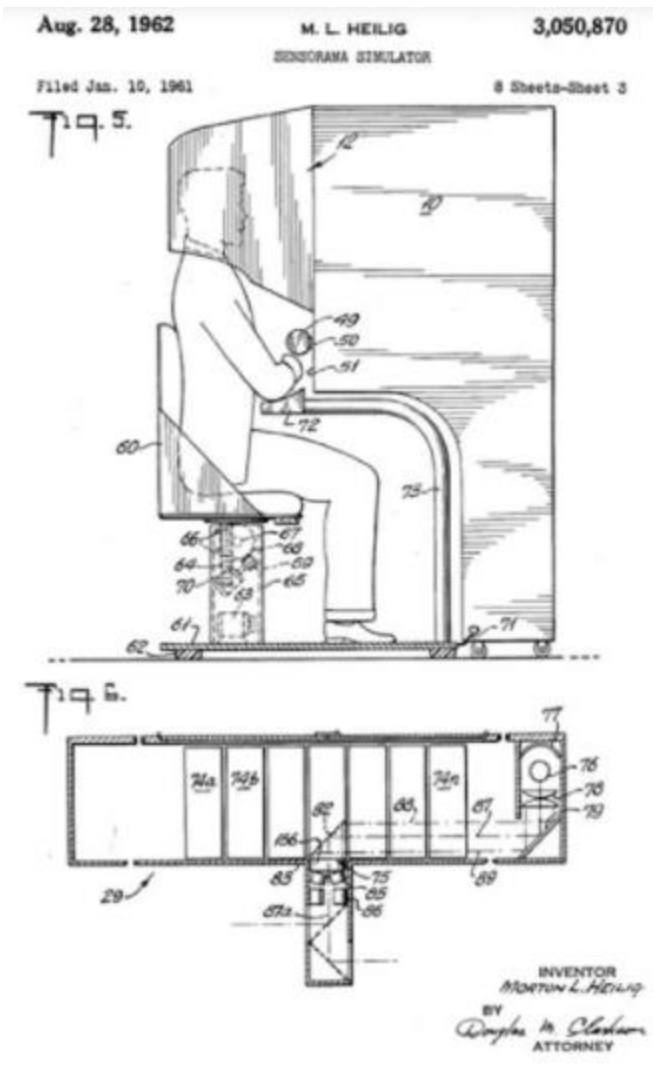


Figure 15. *Theater Immersion* copyrighted design by Morton Heilig (Federov 2015).



Figure 16. *Sword of Damocles*, 1968, -head mounted VR from Evans and Sutherland (Evans and Sutherland 2021).

The first true AR application in which the digital content stayed positioned relative to the user's real-world position and interacted with real-world objects (in this case, fake robotic arms that perfectly aligned to the users arms) was in 1992 by inventor Louis Rosenberg in the Brooks Air Force Base in San Antonio, Texas and was called 'Virtual Fixtures' (Figure 17) (IDF 2020). This was used to research and improve human productivity in workplace environments by augmenting sensory information onto a work *environment* (Norman 2004). This is important to highlight because the immediate benefit of AR, understood early on, was that it could be used in real environments.



Figure 17. Louise Rosenberg used the first AR system, Virtual Fixtures, to move digital robotic arms that move relative to his real arms to research human productivity at work.

3.2.2 VR and AR in Environmental Work

Virtual Reality technology is increasingly improving and being used for changing behaviors. This approach is a step beyond raising awareness, communicating, or planning and is an intense intervention of the mind because virtual reality is meant to put the individual in a place they are *not* while giving them controlled corporeal abilities (limiting what someone can do in the virtual environment) of actions and surroundings. While this type of simulation is effective, it also has many disadvantages

compared to mobile augmented reality for environmental work. “Whereas virtual reality replaces your vision, augmented reality adds to it” (Greenwald 2018).

It is beneficial for environmental communication and research to take place using the real sites of study or areas of concern, for reasons found in research like photovoice and visitor employed photography (Cherem and Traweek 1977, Daniel and Boster 1976, Fantini 2017) which were aiming to get as close as possible to the real thing while still reaching the most people for input. AR can be used in real places and therefore removes the need to model the surroundings to communicate environmental research and communication because it augments real-world objects and places. Newer AR applications are primarily operated on mobile devices, meaning the AR experience can be transported to almost anywhere. Mobile AR is ready to be used by anyone with a smart device at any time, whereas VR requires complicated computer infrastructure to be present and usually complicated instructions given to participants on how to use the device. Secondly, the processing power needed to run VR systems limits the amount of digital landscape detail and breadth needed to capture the place authenticity and spatial complexity of environmental change whereas mobile AR uses far less computing power because it uses the real landscape around you and renders its augmented content with the available power of the mobile device (Cardinal 2019). There is also less physical intrusiveness and hardware in mobile AR as the users do not have to worry about realistic ‘scary’ or nauseating experiences or wear a head-mounted display, and researchers do not have to set up powerful computers, sensors, or cables (Falmann 2018).

One of the most important advantages of mobile AR is its accessibility. With most people in the developed world owning smart mobile devices that are within reach nearly all the time, AR is useful for reaching the most people (PRC 2019a, b). This is not to say that VR does not have a place in the work of environmental science, but AR is more equipped to give the most useful information *in-situ* (on-site) and *in-vivo* (in the course of daily life), to the most people, without intrusive and complicated hardware, at any time and almost any place.

Table 1. VR and AR applications, their purpose, the results of public use, and the level of involvement in designing and distributing.

Name	Type	Purpose	Methodology	Result	Level of Participation
Pokemon Go (Denyer-Simmons 2016)	AR	Entertainment / Gaming	interviews, online questionnaire	enhanced appreciation for physical nature, an increased wellbeing through greater exercise, as well as an aesthetic appreciation for blended reality images.	expert design, players physically visit places
LayAR mobile AR browser (Liao and Humphreys 2015)	AR	Information on site (Airbnb price, jobs, hospitals, etc..)	interviews, online questionnaire	shifts interpretation of places, users created their own narratives of places in interviews based on augmented information	expert and market design, users physically visit places
Mateio AR in Celoria (Calabrese and Baresi 2017)	AR	Visualize designs on-site	participant time using the app in single location given higher	improve the communication among stakeholders and ease the	design students input content, public views content on site

			usefulness points	presentation of the project	
Archioguide AR (Dahne 2002)	AR	Visualize ancient Olympia, Greece at site of modern ruins	user experience from observation	not popular due to weighty headset, computer, and battery connected to participant. Success in visualizing ruins when positioned precisely as needed.	expert design, users stand at specific location with head mounted display attached.
Heraklion, Crete AR (Moiras and Makris 2018)	AR	Recontextualization of city narrative	Observation	popular among historians	built with classic literature content, users get access to literary content as AR on-site
FreshAiR (Kamarainen et al. 2018)	AR	Ecosystem and water quality learning by augmenting real ponds of water	focus group after use	"Teachers also reported that students demonstrated deeper understanding of the principles of water quality measurement than was typical on prior field trips "	expert designed; students use as student-centered teaching tool.
Google Expeditions (Tudor et al. 2018)	VR	visualize ecological change as a result of development	compare student responses between a real site visit and a virtual site visit.	students showed interest in ecological change and wrote letters to leaders expressing concern for ecological health.	students wear phone-based VR rig from Google and experience 'expeditions' of ecological information designed by Google.
Turner Station Climate Impacts (NPR 2019)	VR	To display possible futures of SLR in Turner Station, Baltimore	focus group during use	discussion from community members about tradeoffs between adaptation solutions and impacts	expert designed, only public meeting participants had access, requires lots of technical help on site
Kumamoto University Flood Evacuation VR (Fujimi)	VR	Evacuation behavioral change	observation	students showed more willingness to evacuate as peers began to evacuate.	students use VR head mounted display and make evacuation

and Fujimura)					decisions in VR - one time meeting
Google Earth with Cardboard (Tim et. al. 2016)	VR	Promoting understanding of human impact on Great Barrier Reef	observation	Increased awareness of coral reef problems	participants wear head mounted display and view expert created content

The important distinction between VR and AR for this research is virtual reality's complete disconnect from a real place and its current inaccessibility to entire communities as an inclusive and participatory planning tool. Juliano Calil (2019), developer of the Turner Station Flooding VR project says,

“Virtual reality is an immersive experience that can trick the human brain into thinking it's real. But tricking people is not the goal of the sea level rise simulation being used at Turner Station. The goal is to start a conversation and help folks visualize the impacts [of climate change] and the solutions and discuss the trade-offs between them.”

This research is using AR in a similar capacity. AR, as mentioned above, opens new opportunities for learning (Kamarainen et al. 2018, Chen, Chou, and Huang 2016).

3.2.3 AR in Places

If ‘place’ is one of the key ingredients in self-identity (Relph 1976) then augmented reality adds new possibilities for engaging people's emotions through *place*. Prior to mobile device's AR capabilities, it would have taken a VR image or video surrogate based on complicated engagement protocols, data collection wrapped in procedural

rigidity, and suspension of the viewer's awareness of their off-site location to bring immersion into public engagement. AR, along with mobile data collection capabilities, offers the chance to allow the individual to combine the benefits of these other tools and remain in the landscape unhindered by equipment or procedural interference; yet the researcher can augment information into that experience to prompt different ways of thinking. Pokémon Go, the popular AR game that requires users to physically travel to real-world locations to collect 'Pokémons' has been shown to increase place connection and foster positive memories through increased game play (Denyer-Simmons 2016, Wang and Hsieh 2018). Place-based applications offer a whole new set of information and experience to learning, storytelling, and planning. VR and AR have been used in environmental planning (Liao and Humphreys 2015, Calabrese and Baresi 2017, Moira and Makris 2018) and communication (Orland et al. 2018, Chung et al. 2018). The continued and fast-paced advancement of these emerging visualizations technologies are rapidly improving and, undoubtedly, will open new techniques for immersion and place augmentation.

3.3 Augmented Reality for Storytelling

Augmented reality is not only capable of *communicating* but *collaborating*. People augmenting content overlain on a real site of interest can be mentally prompted to give feedback, new information, or tell a story. The ability to tell a story into the same mobile device from which you are hearing a story is ready-made technology for more inclusive, full, and authentic narratives of places. Two mobile AR applications that pioneered the function of allowing user input into the narrative of place are *TraceReaders* (Georgiou

and Kyza 2017) and *Layar* (Liao & Humphreys 2015). Trace Readers (Figure 18) uses an inquiry-based learning approach where students see a video augmented over a lake and are prompted to answer a question (ex. Why are mallard duck populations declining in this lake? Why did Neolithic people choose to settle on this site?) and the student works to answer it. The physical world is *augmented* with new information meant to encourage the student to elaborate. Students are encouraged to collect data, take annotated pictures, make graphs, and perform other interactive tasks. Then they must develop an evidence-based answer to the beginning question.

The mobile AR application *Layar* (Figure 18) was developed to reappropriate public space. It also augments content onto real places and prompts users to add their own stories that critique dominant narratives by overlaying alternative ones as a tactic of placemaking. The idea is that voices that are normally excluded may be heard. The group of insurrectionist artists called Manifest AR uses *Layar* creatively to reveal unseen stories. One notable layer, “Border Memorial: Frontera de los Muertos” by John Craig Freeman and Mark Skwarek, overlays *calacas* (traditional Oaxacan skeletons commemorating the dead) on places where people have lost their lives trying to cross the US/Mexico border. (Liao & Humphreys, 2015).

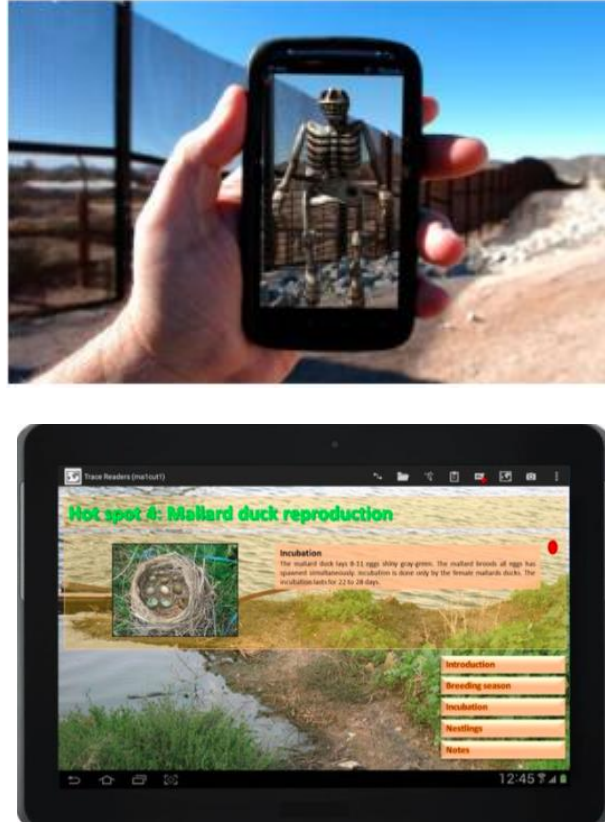


Figure 18. LayAR (left) and TraceReaders (right) augmented reality mobile application interfaces used for visualizing information about places on site and collecting information from users about the site.

This method of narrative-based storytelling gives users time to experience, reflect, and provide feedback. It has educational and entertaining components and does not require the traditional meeting space and time. They are narrative, storytelling tools, arguably one of the best at getting to the individual experience in that they distill certain ideas about futures (Zapata 2007). In a world dominated by information it seems increasingly important to include stories, perceptions, and personal experience as part of that information in order to prevent the technology from becoming too rational. Storytelling, much like Lange suggests for visualization development (Lange 1994), can be used in

planning to find a common thread at the beginning of a planning process (Sandercock and Lyssiotis 2003). Situations of conflict where storytelling has been used have resulted in a “therapeutic, cathartic, and healing” (186) planning process that incorporates those stories into conflicting parties or communities.

3.4 Representation – as information, persuasion, deception

Emerging technologies for representing potential futures have been used extensively in planning and communication, and the critique of new tools as they become more widely used is always needed to make sure that the authenticity of the world these tools portray meets its intended purpose. This does not mean they need to be expected to portray exactly what the future will be, which is impossible given the range of uncertainties as the future unfolds but need to be adjusted towards helping all stakeholders better understand consequences and aid in making educated decisions. Different levels of interaction, realism, and scales are useful for different audiences and purposes. Photographs, 3D model tours with sound, virtual and augmented reality allowing for life-like movements (Bailenson 2018), and most recently, the Wiki style where multiple inputs and interpretations are used have introduced new opportunities for the communication of complex ideas (Dave 2008). While in most cases the intent has been to improve understanding, the increasing sophistication of images is accompanied by a concomitant need to understand how people respond to the emerging media, and how that matters. Further complicating matters has been the deliberate introduction of distortions in order to better represent experienced reality. For an early example, Dave (2008) describes how the Gothic cathedral at Chartre, France, was drawn as it ‘ought’ to

be but distortion of the image geometry was revealed by photography in 1936. This exaggeration, distorting, lack of realism, or simplification in representing environments can be both deceiving and useful for both science and designers.

3.4.1 State of Visualizations Depicting the Future

Digital content that is trying to offer a glimpse into the future will never be perfect nor will it convey the salience of environmental issues evenly. While it is important to resist using digital visualization to deceive people about scientific projections that are uncertain, it may be very useful to use artistic expression to raise concern and prompt discussion about the future of climate related problems even if the exact form of those problems is unknown (Frost 2020; Lewis, Rogers, & Wilcock 2008; Mossner 2012; Perovich 2018; Roosen, Klöckner, & Swim 2018). Visualizations about the potential future of the landscape are useful tools at the crossover of art and science to draw needed attention to contemporary issues. Figure 19 shows some of the imagined future scenarios that are plausible but cannot be projected with certainty in the landscapes of McIntosh County. They are not meant to claim accuracy of the disasters and challenges they depict, but to nudge the public toward thinking about future challenges that are expected to come. Piga (2017) states, “Often, technical drawings are not effective for studying and expressing our personal impression of a place, while imaginative or artistic representation can better fit the communicative goal”. Arias (1996) argues, “The real need is not to force a choice between the social benefits of low-tech methods and the efficiency and power of high-tech methods; rather, we need tools that support the integration of real

worlds and virtual worlds by providing users with the flexibility to move along the continuum”.



Figure 19. Current and imagined future images of McIntosh County locations as depicted in *youARhere*.

3.4.2 The Utility of Emerging Visualization and Immersion Tools

The computational power behind recently emerging visualization technology has created the ability to represent historical and cultural experiences (Hincapie et al. 2016, Pedersen et al. 2017), situations of real-time change (Salter et al. 2009), experiential sensory environments (Ahn et al. 2016, Piga and Salerno 2017), interactive planning through gaming environments, and methods that incorporate scenario-based planning from the individual perspective (Salerno 2017, Boffi and Rainisio 2017). Sheppard (2012) asserts that “visual communication media in general, and 3D visualization in particular, have been shown to increase engagement”, facilitate learning, and communicate environmental issues that are part of the complexity of modern planning. When considering coupling the information from engagement with the visualization, modern technology, such as GIS, can assist in analyzing proposals better than drawing on an envelope (Tomlin 2012). The Iterative process of collaborative design has a propose/dispose cycle; modeling or viewing physical change, discussing the implications with as many stakeholders as possible, and re-designing with those implications in mind, and repeating. While creativity is still the job of the designer, the public needs to be able to make changes, and computational and digital visualization tools make these changes quicker, easier, and more informative during the process. This need to see change defends the use of 3D visualization, the ‘reality’ of augmented reality, and the multi-layered understanding of GIS over more traditional visual tools. Interactively engaging the public is needed in planning, not rejecting traditional visualization but ensuring that modern technology is used effectively so that the increased investment is matched by increased value in those

interactions. These newer tools are useful for planning when they can tell an individual's story or illustrate a participant's desires and ideas in the broader context of places.

Healey (1994) claims that planning should be enriched with discussion of moral dilemmas and aesthetic experience using '*a range of presentational forms*' for the sake of telling stories. If stories are the roots in communicative planning, then visualization is a powerful tool for communicating stories in planning (Al-Kodmany 2001). The existing literature on emerging visualization technology points to a base of environmental psychology (Siegfried Streufert 1982, Piga and Salerno 2017, Boffi and Rainisio 2017, Morello 2017). People's interactions with their environments, their behavior and experiences, and different individual's perceptions make planning for any environment complex (Innes and Booher 2010, Dana Tomlin 2012). This means that the 'whole' experience must be considered, not just the person and the space. The relationships, dialogue, and senses all play a part. Therefore, the design of tools useful for simulating experience must consider issues such as presence and flow of consciousness (Boffi and Rainisio 2017). Viewers must feel as if they are physically immersed in a physical or cultural environment. Users must be able to act within that environment and receive feedback so that they can adjust accordingly (2017). This does not mean undirected guessing about what the future holds but using a combination of science-informed data and artistic flexibility to stimulate the emotions and the mind to engage with possible future scenarios.

3.5 Extreme Visualizations for Salience of the Future

Planning discussion has often critiqued the use of realistic-looking forecasts as causing people to reject the message out of fear or disbelief. Griffon (2011) states that, “Planners recognize realism as an important factor in this type of visualization” and urges designers to strongly critique modern immersive simulations to prevent the ‘photorealism’ from giving a false sense of how environmental change will look. Simply put, if something meant to look ‘real’ has a flaw, it creates disbelief in the image’s message. Historically, virtual representations supplemented and sometimes supplanted traditional representations, sometimes facilitating the ‘selling’ of the plan as well as being used as a tool in the process of planning (Neuman 2007). However, as the consistent flow of traditionally accepted scientific visualizations has not slowed the progress of global climate change, it is worth experimenting with a more artistic, humanities centered, storytelling approach. More entertainment-style driven visualizations (even ones that are meant to look ‘real’) and media prompt more awareness and thought about issues. Using frightening content might cause people to reject messages in order to cope with the fear, however, giving salience to the issue can still be achieved. Social scientists David Lewis, Dennis Rogers, and Michael Woolcock (2008) argue,

“Not only are certain works of fiction ‘better’ than academic or policy research in representing central issues relating to development, but they also frequently reach a wider audience and are therefore more influential”

As mentioned in section 3.1.2, *The Day After Tomorrow* (Figure 20) (Mossner 2012), Al Gore’s fact-synthesizing *An Inconvenient Truth* (Nolan 2017), and nature-centered *Blue Planet II* (Frost 2020) were unprecedented in environmental communication, not because of their scientific complexity or rigor, but because of their entertainment-meets-environmentalism style engagement (CRP 2020, Frost 2020, Mossner 2012). They illustrated a real issue in the abstract. None of these films predicted an exact future for local areas (an impossibility as it is unknown), but regardless of the extreme ‘real’ visuals used to artistically guess that future, they were pivotal in changing climate change attitudes and increasing concern more so than previous communications about climate change. These ideas can be applied to environmental planning; not only trying to represent the today that we know, but also the tomorrow that we do not know but should be concerned with! “Symbolic and abstract means of increasing awareness of the future does not have the salience of everyday experience but can possibly increase the salience of the future” (Myers 2007).



Figure 20. Scenes from the movie, *A Day After Tomorrow* (Leiserowitz 2004).

Mobile augmented reality is powerful in the same way other abstract entertainment tools have been. It can deliver symbolic views into everyday lives and challenge deeply held expectations of the future.

Considering the psychological aspects of how people perceive environmental change when using technology loaded with visual stimulation and a collaborative ability, this research will measure environmental attitudes in people who use an AR mobile application. Attitudes are an accessible construct that can functionally be measured and has a robust history of research to show how they can be predictors of intentions and actions. We will discuss the history of environmental attitude research in Chapter 4 and fit this into a critical look at how attitudes shift, change, or manifest when people experience their environment with the computerized value of AR.

Chapter 4.

ENVIRONMENTAL ATTITUDES

At its core, the work of the environmental planner is that of presenting plausible alternative future scenarios, and aiding people in moving to make rational choices of behavior that will lead to the realization of their chosen future. While the previous chapter described the technical advances in communication that have been made with the goal of improving decision-making to that end, the mechanisms that result in behavior change are psychological. Peoples' intentions to act are shaped by their attitudes toward current and anticipated future conditions, their susceptibility to adopting or rejecting the values of those around them, and their self-efficacy, the extent to which they feel empowered to act upon and influence decisions.

Other research (Orland, Welch-Devine, and Taylor, 2022) has indicated how firmly people resist changing their behavioral intentions in the face of evident climate-related change. The means by which people receive relevant information is clearly germane to how their attitudes are shaped. At the heart of this current research is the question whether emerging visual technologies with supposed power to shape understanding and guide behavior can do so in ways that can meaningfully change behavior.

4.1 Emergence of Collective Environmental Attitudes

Pre-nineteenth century, many documented descriptions of the natural world framed it as the “margins of civilization,” a dark and scary place where you could “lose oneself in moral confusion and despair,” and a place that was the “antithesis of all that was orderly and good” (Cronan 1996). The nineteenth century, with pivotal environmental figures such as Henry David Thoreau and John Muir spreading the word, saw people beginning to appreciate the natural world for its aesthetic and natural qualities (Eisenstein 2018, Cronon 1996). Thoreau declared the embrace of wildness to be the means to achieve the preservation of the natural world, and Muir famously declared, “No description of Heaven that I have ever heard or read of seems half so fine” (Muir 1911). In the United States, this new attitude of appreciation and the placing of priceless value on nature led to the designation of sites like Niagara Falls, the Catskill Mountains, Yosemite Valley, and Yellowstone (the first official national park), as important destinations for contemplation and preservation of the natural wild landscape (*Route 1987* from Cronon 1996). From there, the twentieth century era of modernism introduced conservation (as opposed to preservation) attitudes towards the environment in which we utilize large amounts of resources from nature for technological progress, primarily energy and transportation (Li 2019, Moore 2014, Caron, Lindfield, and Vandehey 1996), in hopes that we can manage these resources in a way they do not become depleted or extinct, displaying a need for the natural world but also a strong desire to control it. Following this sentiment into the 1970s Environmental Movement, we saw activism and attitudes toward pin-point environmental problems stemming from industrial progress such as air and water pollution, energy sources, hazardous waste and products, loss of aesthetic quality, and

other results of overuse and conservation failures (Dunlap et. al. 2000). Nature, in this movement and subsequent movements, needed protecting from us, in order to ensure our survival. The values and beliefs secured and adopted during these periods of human / nature relations helped make the attitudes about the environment people have today.

It is challenging to persuade people with strongly held values and beliefs to change behavior. The attitudes that arise from values and beliefs are not physically measurable variables, so measurements are inferred by methods of observation and response (Himmelfarb 1993). If the attitude cannot be compared to a real-world, observable action (behavior), then researchers use psychological measurement methods that determine an *intention* to take an action as determined by scale-measurable beliefs (information held) and attitudes (mental response) from questionnaires (Fishbein and Ajzen 2009, Eagley and Himmelfarb 1987, Fishbein and Ajzen 1975, Kraus 1995). This progress of beliefs, attitudes, intentions, and behaviors came to be known as the Theory of Reasoned Action (Fishbein and Ajzen 1975), later adding the functional ability to perform that behavior as a variable to become the Theory of Planned Behavior (Fishbein and Ajzen 2009). Figure 21 is a conceptual framework as put forth by Fishbein and Ajzen demonstrating how attitudes proceed to intentions which inform possible behaviors.

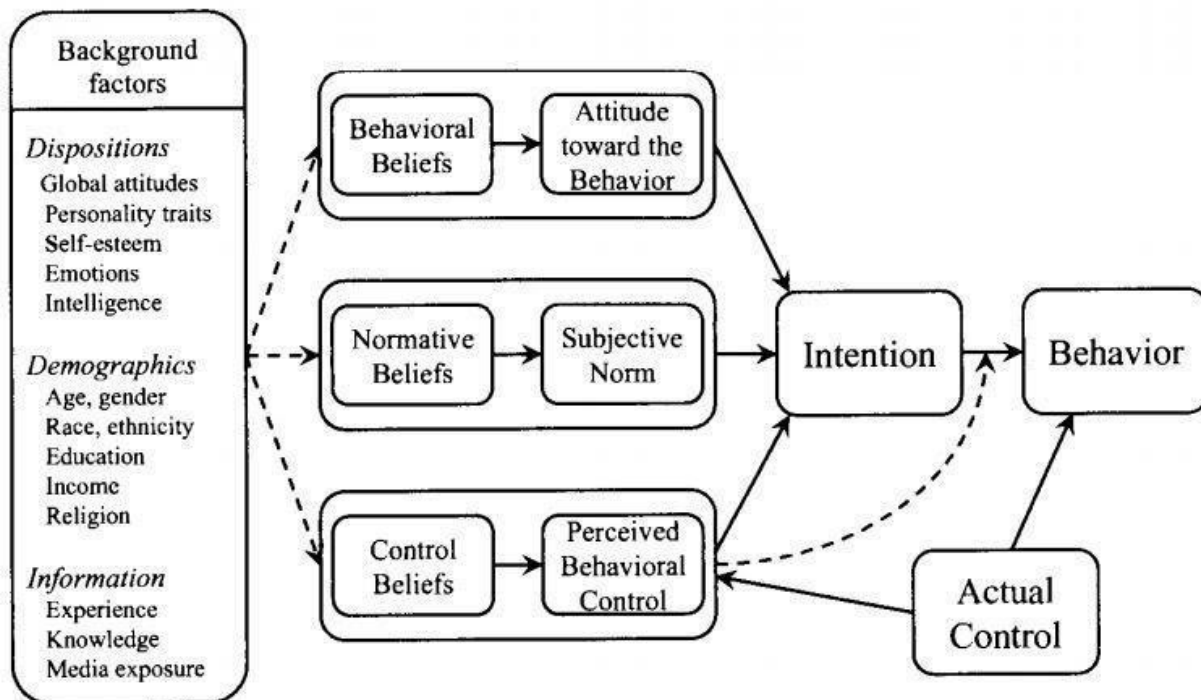


Figure 21. The Theory of Planned Behavior (Fishbein and Ajzen 1975, from Fishbein and Ajzen 2009).

Taciano Milfont, a climate change centered environmental psychologist states that Environmental Attitudes (EAs) “have been defined as a psychological tendency expressed by evaluating the natural environment with some degree of favour or disfavour” (Milfont 2007). This aligns with Martin Fishbein and Icek Ajzen’s (1975) definition of ‘attitudes’ as an intervening shaping factor between *beliefs* (held knowledge about an object) and *intentions* (the intended behavior regarding the object) produced during a decades-long argument among psychologists and sociologists about the definition:

“Most investigators would probably agree with a description (or definition) of attitude as a learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object”

Rosa (2019) extends the investigation of attitudes to include observations of specifically *environmental* behavioral intentions, defining EAs as “a collection of beliefs, affects, and behavioral intentions a person holds regarding environmentally related activities or issues”. As shown in Figure 20, Fishbein and Ajzen viewed the advancement of Attitudes to Intentions as further moderated by Social Norms, the attitudes of admired others, and Perceived Behavioral Control, the ability of the individual to exert control over the outcomes of their attitudes.

4.2 Current Environmental Attitudes

Many of the pressing environmental problems of the current era are global in nature, unseen except by local evidence of change. Environmental attitudes have shifted again to viewing the environment as something that creates jobs, drives the economy, and as “a passive stage on which everything human happens” (Iskander 2020). In this scenario, people are challenged to respond to environmental issues by attempting to become sustainable users of the environment while holding the production economy as primary (Eisenstein 2018, Dunlap et. al. 2000, Fisher 2019, Moore 2015, Iskander 2020).

International meetings and climate accords are full of language about ‘stimulating economies’ as much as they are about protecting the planet. Simply put, the current trajectory of environmental discourse and policy does not view the environment as

worthy of protection because of its own innate worth, humans need to be shielded from specific environmental harms, or protection because we need it to survive, rather, it *must* be protected as an instrument that can sustainably grow economies (make money) and provide jobs (Iskander 2020).

Over time, then, how people have viewed themselves as a part of the natural world has diminished into debate over specific behaviors and issues around people *using* the natural world; a *utilitarian view* (an important term for this research in later sections). Thus, the attitudes that have been identified have changed throughout the eras of exploration, modernism, the environmental movement, and the current green movement, emerging today with many seeing themselves as victims of unseen global environmental threats necessitating big personal changes to adapt to an uncertain future. Robert Fisher (2019), writing on the modern understanding of climate change, states:

“The premises of the conversation [of environmentalism] shifted away from love of nature and toward fear of survival. [From there] we moved from the heart to the mind, asking that we be motivated by distant consequences” [e.g., heating up, weather extremes, water levels rising] (p.131).

4.3 Measuring Environmental Attitudes

The human/environmental worldviews discussed above are important for understanding EAs because they can indicate how a person intends to (or observably does) act through

measuring basic environmental viewpoints. EAs have been evaluated in many ways, but three have been validated for use in environmental psychology (Dunlap and Jones 2003, Fransson and Gärling 1999) - The Ecology Scale (Maloney and Ward 1973, Maloney, Ward, and Braucht 1975), the Environmental Concern Scale (Weigel and Weigel 1978), and the New Environmental Paradigm (NEP) Scale (Dunlap and Van Liere 1978, Milfont 2010), according to a review article by Milfont and Duckitt (2010). The Ecology and Environmental Concern scales dealt with specific topics (pollution, clean water, etc) and have become dated as climate change has extended the threats to the environment and people, both in quantity and scale (Milfont and Duckitt 2010). The NEP, however, created by Dunlap and Van Lier (1978) in response to contradictions between then emerging environmentalism and society's utilitarian view of the human / nature relationship, has been much more widely adopted. In its original form it was a 120-item instrument designed to capture environmental attitudes on each of 15 different dimensions of environmental response (Dunlap and Van Lier 1978). It was created to move past dated and redundant constructs of environment-attitude relationships and returns to questions that search for ecocentric beliefs that would indicate the extent to which a respondent views themselves as a component of nature and, therefore, would feel more compelled to protect the environment as opposed to avoiding it or putting anthropogenic demands first (Dunlap et. al. 2000). This reflects the paradigm shift mentioned in 4.2 that people have begun to see the environment as something we need to use, but currently struggle with how that might affect our survival as affected by the more extreme predictions of climate change. Figure 22 shows the connection between the prevailing environmental worldviews and how surveys measuring EAs aim to gauge how

closely people fit within them. Because of the cognitive, affective, and behavioral measurement strategies within the NEP, anything eliciting improvements on that ecocentric scale in a person can potentially be said to be improving pro-environmental attitudes (Milfont and Duckit 2010).

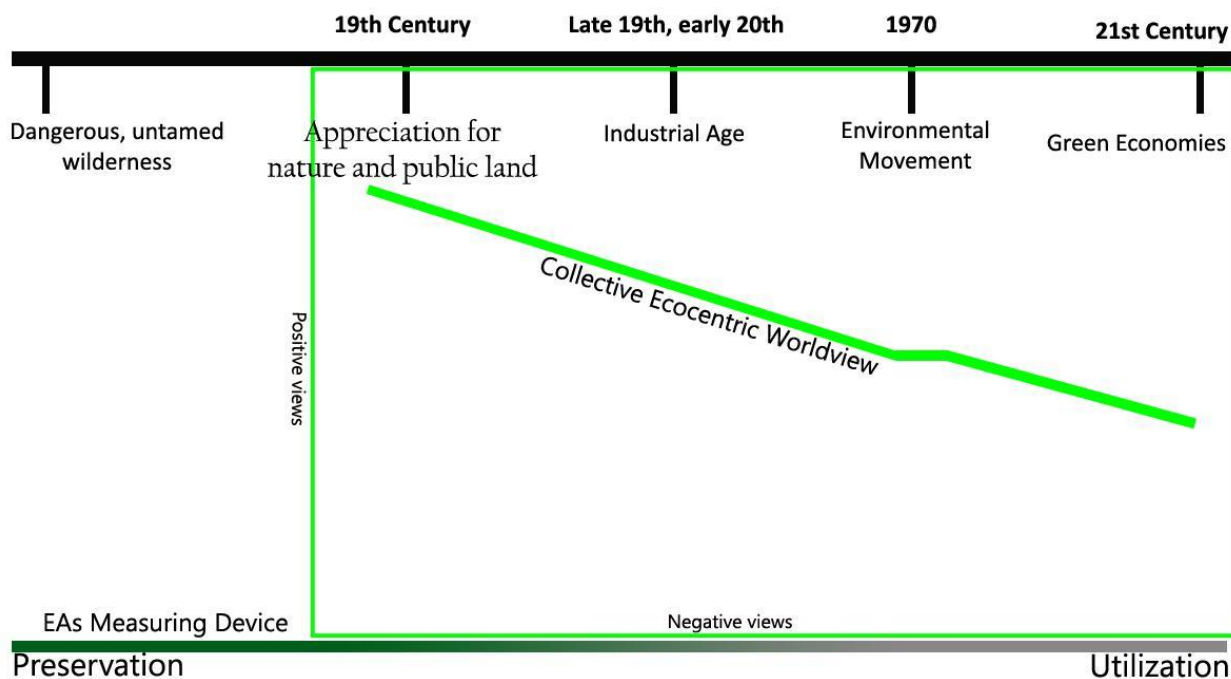


Figure 22. Prevailing environmental worldviews over time and where EAs measuring devices (green box) try to fit a person's attitude toward the environment as adopted in certain periods of history.

4.3.1 Environmental Attitude Inventory

Questionnaires measuring attitudes rarely ask directly, “what is your attitude about x, y, and z”? Instead, they examine attitudes via expressions of respondents’ *likes, dislikes, values, opinions, recommendations, and perceptions of pleasant or unpleasant, fun and*

not fun etc., and others found to be measuring an attitude (Fishbein and Ajzen 1975, p.4). These terms have been used, critiqued, analyzed, and reused over time from the earliest attitude research on job performance, discrimination, and health (Thurstone 1928), and later in examining protesting, church attendance, environmental concern, donating blood, using birth control, and in many other domains (see Table 4 in Kraus 1995 - meta-analysis). Developing domain specific questionnaires requires adjusting questions and terms, but within the limits of the definition of attitude quoted above (Ajzen 2009). This research uses this theoretical framework exploring the connections between environmental attitudes and expressed behavioral intentions.

In its original long format, the NEP is multidimensional and complex. The questionnaire is long (120 items) because of the number of questions needed to accurately measure all 15 factors it requires. However, it was used and extensively evaluated and validated over many years and would set the stage for the Environmental Attitudes Inventory (EAI), created by Milfont and Duckitt (2010), that has become the principal modern psychological tool for assessing environmental attitudes. The EAI drew upon years of research and quantitative techniques to ‘power test’ the NEP survey questions and the factors they claim to pinpoint (Byrne 1995, Milfont and Duckitt 2004, Milfont and Duckitt 2010). Those questions and their associated factors fully accepted from the NEP Scale (Dunlap et al. 2000), Ecocentric and Anthropocentric Environmental Attitude Scales (Thompson & Barton 1994), Ecological World View Scale (Blaikie 1992), and the Environmental Perception Scale (Bogner & Wiseman 1999) (compiled in Milfont and Duckitt 2010) were used to create a cross-context, ecocentric, and easily measurable set

of 12 factors that gauge a respondent's 'propensity to agree' (Daykin and Moffatt 2002) on either a *utilization* or a *preservation* view of the environment, creating a 2 -way quantitative scale of individuals' environmental attitudes. The EAI factors and definitions can be seen in Table 2.

Table 2. The 12 factors used to place individuals' environmental attitudes between utilization and preservation of the environment (adapted from Milfont and Duckitt 2010).

Factor	Positive View	Negative View
Enjoyment of Nature	Prefer spending time in nature instead of urban areas	Nature is dull and not as enjoyable as urban areas
Support for Conservation Policies	Support for policies regulating raw material use, and subsidizing eco friendly alternatives	Opposition to eco friendly policies
Environmental Activism	Personal readiness to support organized action for environmental protection	Disinterest or refusal to get involved in organized action for environmental protection
Conservation motivated by anthropocentric concern	Support for conservation policies motivated by protection of people as opposed to protection of nature	Support for conservation policies motivated by protection of nature as valuable in itself
Confidence in science and technology	Belief that human ingenuity can solve environmental problems	Belief that human ingenuity cannot solve all environmental problems
Environmental fragility	Belief that the environment is fragile and human damage could soon have catastrophic consequences	Belief that the environment is resilient and no human damage is causing irreversible consequences
Altering nature	belief that humans have a right to alter nature to our needs	Belief that the natural environment should be preserved and in no way altered by humans

Personal conservation behavior	Taking care to preserve resources in everyday behavior	Lack of desire to conserve or take care of resources in everyday behavior
Human dominance over nature	Belief that nature exists primarily for human use	Belief that nature and humans have the same rights
Human utilization of nature	Belief that economic growth should have priority over environmental protection	Belief that environmental protection should have priority over economic growth
Ecocentric concern	A sense of loss over environmental damage	Lack of concern or regret over environmental damage
support for population growth policies	Support of policies regulating population growth	Lack of support for regulating population growth

Each factor in the EAI has 10 questions, getting both positive and negative attitudes, from which the factor can be scored. The questions within each of the factors can be as specific as asking if grass growing between paving stones is *'untidy'* or as broad as asking if the person thinks humans are meant to *'rule over the rest of nature'*. For example, the question of support for, *"I would donate some of my extra income to an environmental organization"* is within the Environmental Activism factor along with the opposing view, *"I would not help raise funds for an environmental organization"*. The reason for these specific questions is that those exact wordings were tried across multiple studies and tested against each other, with the EAI removing the outdated or redundant items making a simple, almost universal measurement scale. For example, someone stating they do not turn the heat up too high in the winter and take shorter showers to conserve water can be said to have a higher value on protecting the environment (preservationist attitude) than someone who does not do the same and believes in human

comfort and economic growth over conservation (utilitarian attitude). However, as we will discuss later about a shorter EAI, showers and economic growth are not universal to all people whereas the terms '*conserving water*' or '*conserving resources*' more broadly applies across different people. The environmental psychology community uses these factors to score a respondent between two opposing top-level themes, Preservation or Utilization, measured with the EAI (Milfont and Duckitt 2010).

4.4 Attitudes to Intentions and Observations

Fishbein and Ajzen's extensive work to determine scalable measurements of attitude to correlate to intentions and behavior, identifies subtle distinctions between research projects connecting environmental attitudes to environmental intentions and behavior.

There are studies that 1) use a stated attitude and intention to predict a behavior in certain situations, 2) observe a change in behavior and correlate that to a change in attitude, and 3) observe a change in attitude and behavior from some intervention event or object.

Table 3 lists some of the research projects and the interplay between attitudes, intentions, and behaviors.

Table 3. Various research projects and the connection between Attitudes, Intentions, and Behaviors.

Research	Type of Change
Willingness to pay for adaptive measures based on a perception of climate change - (Danielson 1995, Graham 2019, Torgler 2007)	Attitudes predicting Intentions not yet performed
Would adopt farming techniques based on scientific consensus - (Ryan and Grass 1959, Francis et. al. 2017, Woods et. al. 2017)	Attitudes predicting Intentions not yet performed
Attitudes towards science after intervention with environmental news - (Engelke 2019)	Observed change in Attitude after Intervention
Attitude towards environmental change after intervention with a storm event - (Song and Peng 2017, Groenewold et. al. 2012, Welch-Devine and Orland 2020)	Observed change in Attitude after Intervention
Reduction in energy use after displaying real time energy metrics - (Houde et al. 2013, Jain et al. 2012)	Observed change in Behavior after Intervention
Changing views after engaging in conversation on social media or blog posts - (Baldwin and Mussweiler 2017, Lewandowsky et. al. 2019)	Observed change in Behavior after Intervention

The research conditions most closely aligned with this research are ones where a change in attitude is observed after an intervention (in our case, using a mobile AR application). The effect and direction of changing behavioral intentions will indicate the utility of the AR app intervention in catalyzing beneficial changes in behavior.

Chapter 5.

AN AUGMENTED REALITY INTERVENTION

This research engaged people on-site within landscape settings of significant cultural and historical relevance and exposed them to imagery, audio, and online content illustrating the environmental changes that have occurred at those locations historically and changes that plausibly might occur in the future. The effectiveness in alerting respondents to the necessity to take adaptive action was gauged through the changes in environmental attitudes before and after use of an augmented reality smartphone app.

The mobile application *youARhere* was conceptualized and designed based on previous work by Orland and colleagues (2018) exploring the usefulness of AR in viewing the landscape with representations of its otherwise invisible aspects. Starting from connecting AR as a tool to the research and process of designating scenic corridors along the highway (Clay and Smidt 2004, Evans and Wood 1980, Muck 2006, Rottle 2006) and crowdsourced photography, experiments and prototypes were developed around the idea that these AR experiences prompt a participatory, grass-roots collection of stories, insights, places, and photographs that would build on scenic byway designations, history, and the AR experience for the next users. The collective stories built upon the individual experience would become the app content and allow the stories to be contributed by the broadest feasible range of participants. During this thought experiment it became clear that framing localized climate related change as part of history grounded these stories in

real places. Priming the app with projected ecological and climate-related data alongside historical information about the place was meant to prompt embellishments, corrections, and additions. The prototype application, *Landscape Recon*, developed by Orland et. al. (2018) used *geofences*, or boundaries based on geospatial coordinates that trigger a mobile device when driving in or out, to deliver auditory cues when vehicles were in a cultural or scenic ‘hotspot’ (Figure 23). They were then prompted to comment on their surroundings and upload photographs. Users could also upload content in any new places, at any time, to help increase the number of documented places with ecological and cultural information. Following the feedback from the *Landscape Recon* concept, another AR prototype, *MacCoAR* (Taylor et. al. 2019), was developed to view unseen aspects of the landscape using large, printed images of historical areas of McIntosh County, Georgia to test the app on individuals that were not driving along scenic byways in coastal Georgia. *MacCoAR* was tested on students in the UGA College of Environment and Design to find out what technical and functional aspects of the AR experience (historic text, maps, imagined future visualizations, audio narratives, etc.) were more engaging to thinking about climate related change among design students (discussed more in Chapter 7). That foundational work from *Landscape Recon* and *MacCoAR* has guided the development of an AR app, *youARhere*, for this current research (Taylor et. al. 2020).

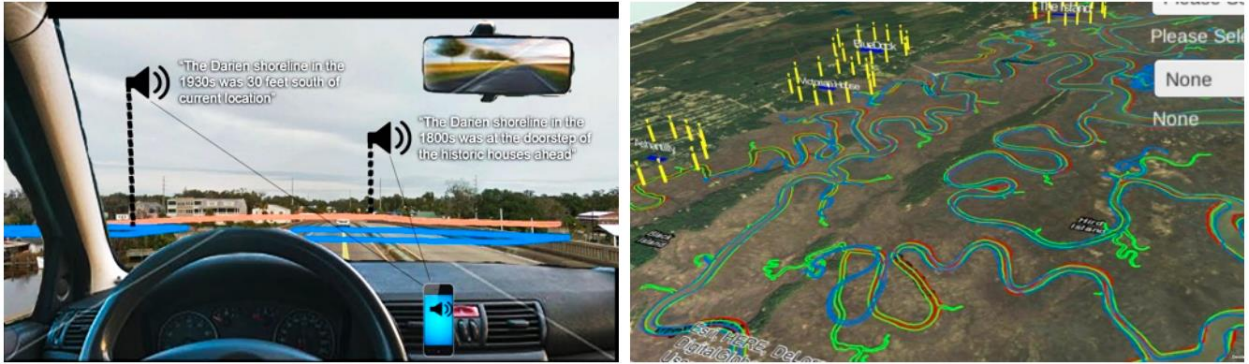


Figure 23. Audio cues (left) for drivers along scenic byways triggered by geofences (right) distributed along roads in McIntosh County Georgia.

5.1 youARhere

The custom mobile smartphone application, *youARhere*, uses target-based augmented reality (Shi & Zhao 2021) to communicate historical and future information around known landmarks in McIntosh County, Georgia. As users visit one of the historic markers in the county, the camera on their mobile device scans, locates, and recognizes the marker, or “target”, and overlays the camera scene with a blue timeline over the marker. This timeline shows historic images corresponding to the story told in the physical marker’s text as well as images of projected future events or situations. For example, the marker depicted in Figure 24 recounts one of the largest sales of slaves in a single slave auction. The historic image on the left of the timeline can be clicked to access more information about this site on the web. The image on the right can be clicked to enlarge and hear an audio describing how vulnerable this site is to rising seas because it is adjacent to a tidal stretch of the Altamaha River. These *floating* images act as web page links to access more online information about the place and its story or to

hear audio explaining some unseen aspect of the history, culture, or environmental future of that location. The user is then given two options to contribute to the project.

(1) They can choose to add their own insights, stories, or images to the location where they are currently using the application (Figure 26). Other people using the app can visit that location and see/hear that contribution as augmented content.

(2) Alternately, they can move to and contribute a completely new location of their own choosing with their own accompanying story and images to register as a *target* for others to investigate with *youARhere*. There is also an interactive map to register the new location in the event it is too far away to access at the time.

These contributions, either elaborating on existing target locations or adding new ones, can also be viewed via an online interactive story map (Figure 41) for those who are not out using the mobile application. The stories elaborating on existing historic markers extend the narrative of culturally significant places on the landscape and collect respondent impressions of how environmental change will change their future. The new stories for added locations address perceived gaps in available information both within and beyond the borders of McIntosh County.

Based on review of the literature, we expect the intervention of a powerfully engaging planning communication medium to affect people's attitudes toward environmental change and adaptation through them becoming more informed, risk-aware, or action-oriented. We expect those effects to be further strengthened when participants are telling

personal stories to enhance and authenticate the narrative (and therefore, the past and future histories) of each place. This research seeks to test whether using mobile AR to augment the landscape that is the backdrop to participants' daily lives can change their behavior (here represented by self-reported *intended* behavioral outcomes) in the face of environmental change.



Figure 24. Augmented content lay over a historic marker titled ‘Famous Butler Authors’ at the Butler Island plantation.

5.2 The Digital Content of *youARhere*

The digital contents augmented onto the historic markers with *youARhere* are intended to display historic and future aspects of that location's story to supplement the information on the sign. The content is principally images, which also serve as clickable buttons to access other information online, and sometimes play audio narratives or videos about that story. Connecting history and environmental change in these significant places, the content is designed to be specific enough to the site to encourage investigation but open enough to solicit stories from the users themselves. The augmented historical images range from historic portraits (Figure 25a) and photographs (Figure 25b) to historic documents (Figure 25c) while the imagined future images depict plausible scenarios for that location related to the potential impacts of climate change – more severe storms, sea-level rise, coastal erosion, etc. (Figure 25a - c).

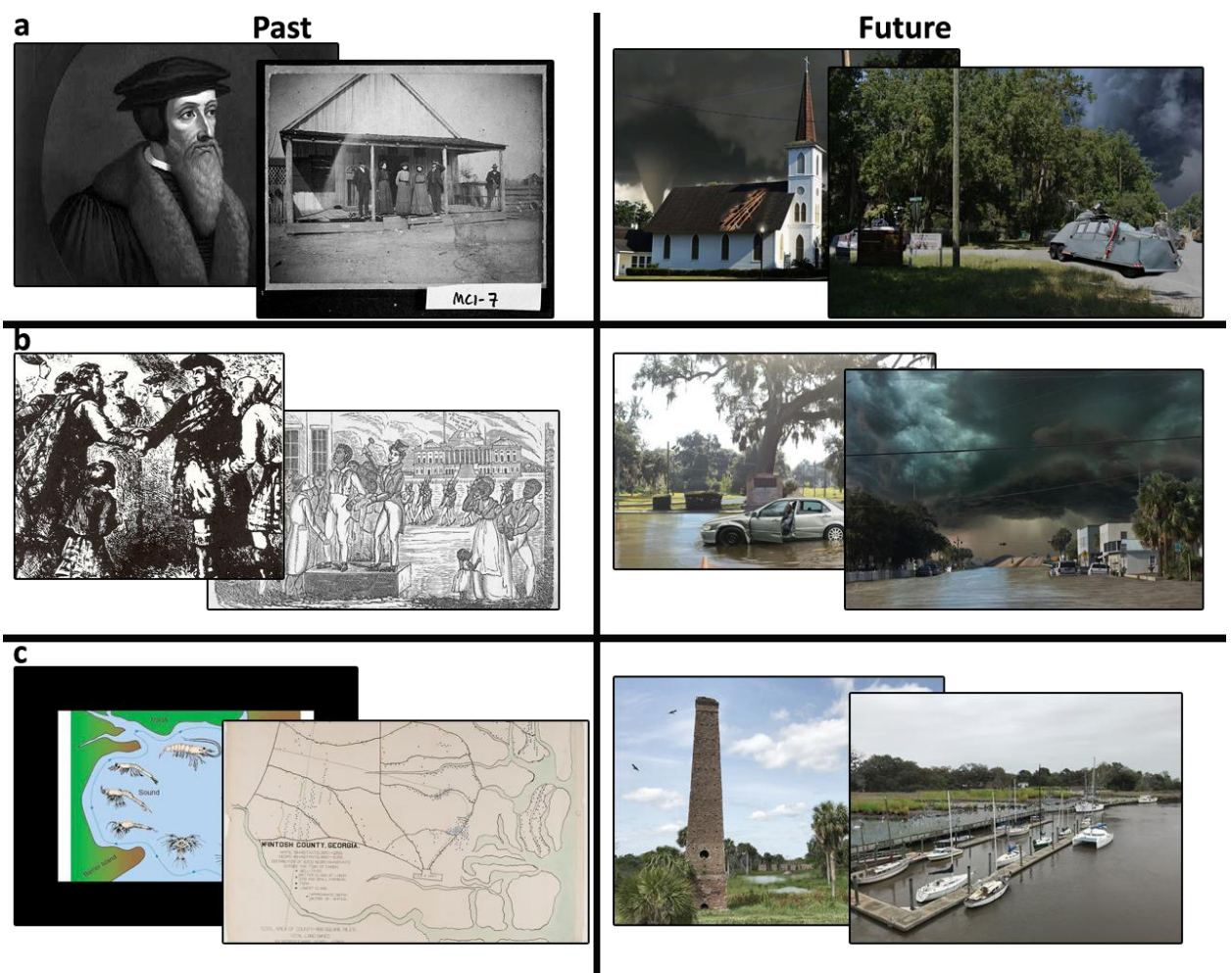


Figure 25. AR images, also clickable buttons to other online information, on the past and imagined future AR timeline at some of the 44 historic markers used in the initial deployment of *youARhere*.

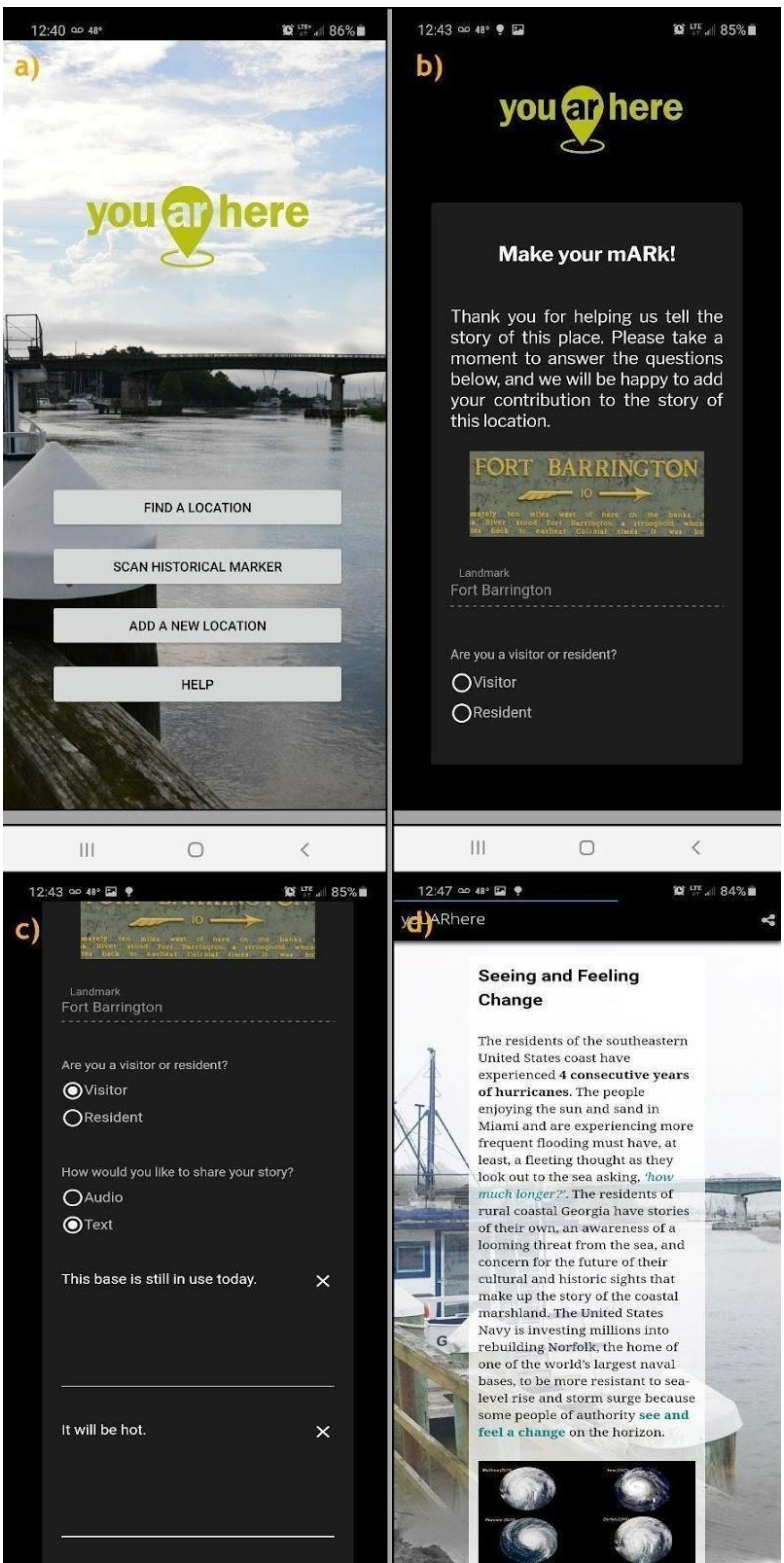


Figure 26. a) youARhere opening display. b) and c) youARhere response displays. d) The youARhere website with additional explanatory material.

The primary content, however, will eventually and continually come from the users as prompted by the app pages shown in Figure 26. These stories can be read/heard at each respective location from a list of contributions accessed via the app. Furthermore, new locations and their accompanying stories can be used to create additional new AR content beyond that linked to the historic markers and their locations in McIntosh County. All this content, combined with contributor experience of AR storytelling *in situ* and *in vivo*, comprises the intervention described here.

5.3 *youARhere*'s Benefits from AR and Digital Storytelling

Al-Kodmany (2002) points to potential improvements in the way the public are engaged in decision-making regarding public policy and projects:

“Traditional, non-computerized tools are not capable of the sophisticated analysis, display, and visualization that may enable the public to make more informed decisions. However, if used alone, computerized tools may lack the ability to draw people into meaningful interaction with the data and each other”

The development of *youARhere* directly responded to Al-Kodmany's critique. While the application uses images that could readily be printed, videos that could be sent in an email, and audio that a researcher could orally pass along to residents of Georgia, the added *computerized value* of the application is that these traditional media are enhanced by using an already connected network of users and delivering the media to the real places where change will happen, with the information the public need to form judgments

while standing in the place affected. The computational power behind recently emerging visualization technology discussed in section 3.4.2 (Ahn et al. 2016, Boffi and Rainisio 2017, Hincapie et al. 2016, Pedersen et al. 2017, Piga and Salerno 2017, Salter et al. 2009) opens new ways to approach planning and environmental communication and AR is another example of this forward progress. The extent, variety, and sophistication of these tools will continue to improve. Secondly, this digital content of *youARhere* is not 'used alone' as the app is interactively engaging the public by encouraging their stories and insights as part of the experience. The challenge the application faces is in achieving public adoption among so many other daily distractions. Looking at success stories of storytelling / collaborative technology such as Wikitude and Storycorps discussed in section 1.4, is a step toward unfolding the mystery of why people choose one tool over another.

5.4 Technology Adoption

A challenge anticipated early on was how to get the public to willingly adopt *youARhere*. While technology adoption is beyond the scope of this research, it is an inherently important question for the larger work of finding the best tools and best way to use them for environmental work. This project actively highlights the benefits of the app on the website, has the potentially attention-grabbing aspect of new technology, and is made available as a modern digital tool that works on the most common mobile devices and operating systems. However, it is not likely to get the same user traffic as popular social media apps or more well-known, well-branded digital spaces such as Facebook, Instagram, Twitter, etc. (Hamonn et. al. 2007).

While branding and popularity certainly play a part in adoption, a factor potentially favoring adoption of *youARhere* is the personal interest aspect of a digital site of networked users (some of whom become *friends* or join *groups*) that leads people to want to invest time into a certain topic, cause, or community. Kurt Luther (Luther et. al. 2010), a prominent researcher on the roots of successful online communities, says that open digital communities, similar to *youARhere*, are not a ‘success’ just because they are collaborative, but when they communicate an ‘effort to attract co-developers’. Luther refers to DeLone and McLean’s (2002) Process Model for Information Systems (Figure 27) as the framework for a popular and well-adopted digital tool. The successful take-up rate of digital communities is 20%, and depends on creation, maintenance, quality, use, and consequences (Luther et. al. 2010). The developer’s role is to set a clear vision while the users are actively involved in creating and maintaining the direction of the tool or ‘investigating’ the topic of the community. Successful applications of this digital, open model don’t have large numbers of casual members (such as most traditional social media applications) but have relatively smaller numbers who are actively participating out of a very specific interest (Venkatagiri et. al. 2021).

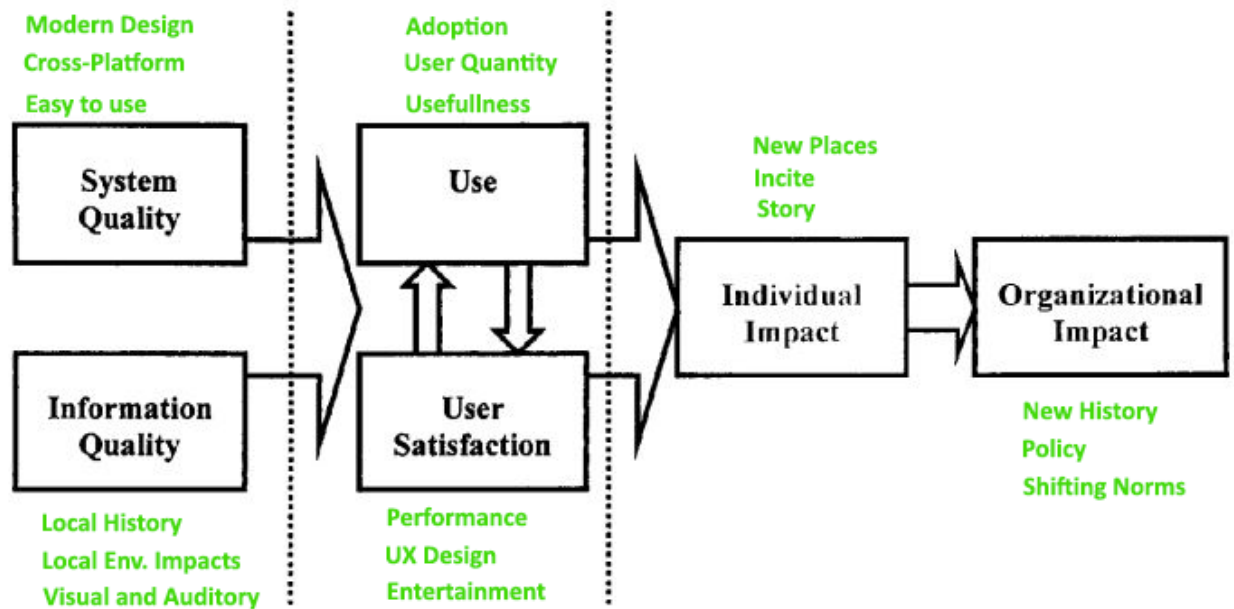


Figure 27. DeLone and McLean (2003) Process Model for successful, well-adopted, information systems with some added notes on the respective types of content from *youARhere* (in green text).

Luther discusses the example of police and journalists creating a space where the public helps solve a crime by having access to the evidence and working in a ‘community of investigators’ (Venkatagiri et. al. 2021). The motivation to adopt was that people were joining this community, not out of popularity of an app or website their friends were using, but out of a desire to be part of the cause. Ideally, users of *youARhere* would find interest in using the application/website to become recognized storytellers of their community, documenters of the next history, or investigators of environmental problems, for example. The current version of *youARhere* was built using the best guidance found in the literature and was tested to see the extent to which the app matches up to expectations. The recruiting methods and process are discussed more in section 7.3.

Chapter 6.

DEVELOPMENT OF THE AUGMENTED REALITY APP *YOUARHERE*

Mobile AR was the chosen platform, among the many available mixed reality tools, to use for community engagement and intervention and *youARhere* is the mobile, augmented reality application developed to implement this research. *YouARhere* emerged from a series of experiments with other mixed reality approaches such as virtual reality, head-mounted AR, and one-way communication AR. After testing these tools and engaging different crowds with environmental scenarios, it was decided to develop a networked, publicly available, two-way communication, AR application. *YouARhere* was developed using an array of software tools (listed and explained in Appendix E) and several versions were released and tested as new ideas unfolded. While the intervention with a mobile AR application to gauge environmental attitude changes is the primary research for this project, there was also extensive development and testing of mixed reality tools and methods throughout the life of this project. This chapter will cover the development, technology, and methods changes that happened over time.

6.1 McIntosh County and Storytelling Opportunity

Darien, Georgia was chosen as the area of interest for this research because, as a peninsula jutting out into the unique coastal Georgia marshland it is a place familiar with extreme environmental change and frequent extreme weather events. The environmental history and the physical attributes of this coastal region (detailed in Chapter 1) were ideal

for a study focused on the impacts of environmental change of a relatively un-settled population – of all the Georgia coastal counties, McIntosh is the least developed and has experienced population decline in recent years. Furthermore, a stretch of Georgia Highway 99 and US 17 has been designated a Georgia scenic highway, running through the marsh along the coast, passing through much of McIntosh County and the town of Darien. This highway is rich in history written on the landscape and might serve as a catalyst for new stories from people using *youARhere*. Although many of these historical and cultural landmarks are recorded and documented (figure 28), there are numerous gaps that could be filled by residents who have had their own experiences and know more about the deeper, less well-known life of coastal Georgia residents. That these stories can, and likely do, have environmental change as a theme makes this place suitable for using mixed reality to communicate current and potential future landscape changes. Orland and colleagues (Orland et. al. 2018) speculated that an augmented reality application could be a vehicle for delivering location-specific historical and cultural information to drivers on the scenic byway, and that the smartphone required could then also be used to collect geo-located personal narratives from those passers-by – a means of delivering useful and interesting contextual information at the same time as collecting crowd-sourced, informal yet authentic local recollections about the “gaps “ in the historical record (Figure 28).

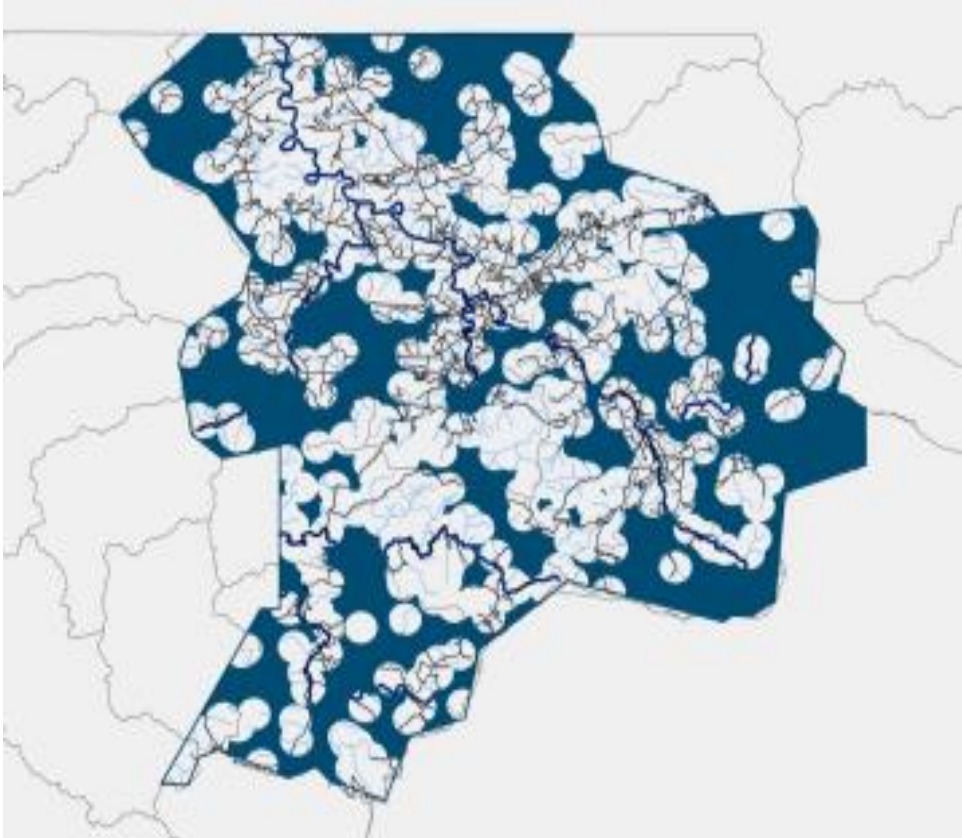


Figure 28. The clear circles are 0.5-mile buffered areas around documented cultural and historical locations. The solid areas and much of the buffered areas are gaps in the historic record. - Mary Scales, UGA Laboratory of Archaeology

6.2 Virtual Darien

To experiment with the idea of developing a mechanism for delivering otherwise hidden contextual information, a virtual reality (VR) app was built depicting Darien, Georgia. Being the most popular and immersive of the mixed reality platforms, VR seemed appropriate to create an immersive experience containing a simulation of places, people, and environmental occurrences. Using Unity Gaming Engine, an open-source software to develop interactive digital experiences (like video games) for computer, web, mobile, and gaming consoles, a virtual reality scene of Darien was developed with

talking avatars representing citizens with stories (Figure 29a), a sea-level rise simulation (Figure 29b), and a dockside ‘button’ to switch river bank locations (Figure 29c) associated with different years in the historical records to show the shift, or ‘creep’, in the marshland along the banks of the Altamaha River in Darien (Taylor, Yan, and Thomas 2018). GIS data for McIntosh County was used to get relative alignment of the terrain relief, physical structures (houses and businesses), and street layout. Assets such as plants, trees, cars, boats, and road signs were collected or created from Trimble Sketchup 3D warehouse (Trimble Sketchup 2018) or Blender (Blender, GNU GPL, 2018). These were all rendered into a relatively accurate, low-level, depiction of Darien using Esri's CityEngine, which allows for the creation of 3D models and placement of assets using GIS data.

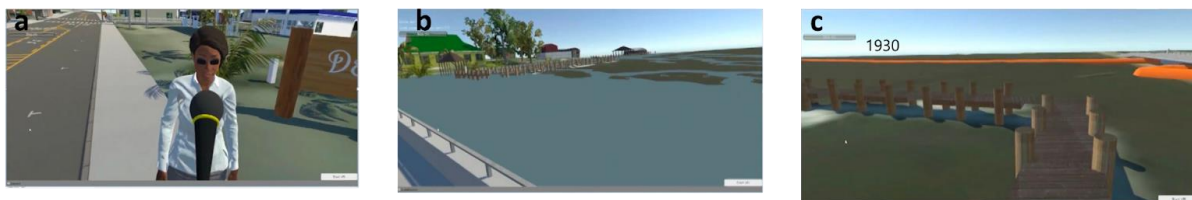


Figure 29. Virtual Darien game for the HTC Vive VR headset - a) a talking resident avatar that can be interviewed, b) a sea-level rise simulation, and c) a historic shoreline viewer from the docks in virtual Darien (Taylor, Yan, and Thomas 2018)

6.2.1 Virtual Reality Limitations for Public Engagement

The virtual Darien had the benefit of rendering 3D items and animations across a digital terrain in real-time, something lacking in AR development at the time of this writing but

lacked many aspects of the mobile AR approach that was eventually adopted. After engaging people with the VR on campus, at conferences, and community events, for all the impressive experiences someone could have in virtual Darien, the disadvantages of the VR approach for real-life environmental communication became clear. First, the intense amount of coding it takes to create functionality within the scene made it improbable to network the VR for user input (stories, images, etc.). Secondly, users had a difficult time learning to use the VR unit (HTC Vive, in this case) with respect to motion, taking virtual pictures, and engaging the functions within the VR and often would not keep the head-mounted display on long enough to get familiar with the program (Geszten et. al. 2018). Lastly, and the most disadvantageous, was accessibility. The VR unit can only have 1 person at a time inside the virtual Darien, and only at certain places where the VR rig is tethered to a high-graphics capable computer. The mobile version, Google Cardboard, could only render the virtual graphics and functionality that the user's mobile device could handle, drastically more limited than the high-graphic machines used for the tethered VR setup. Figure 30 shows some of the hardware and space requirements for a VR public event.

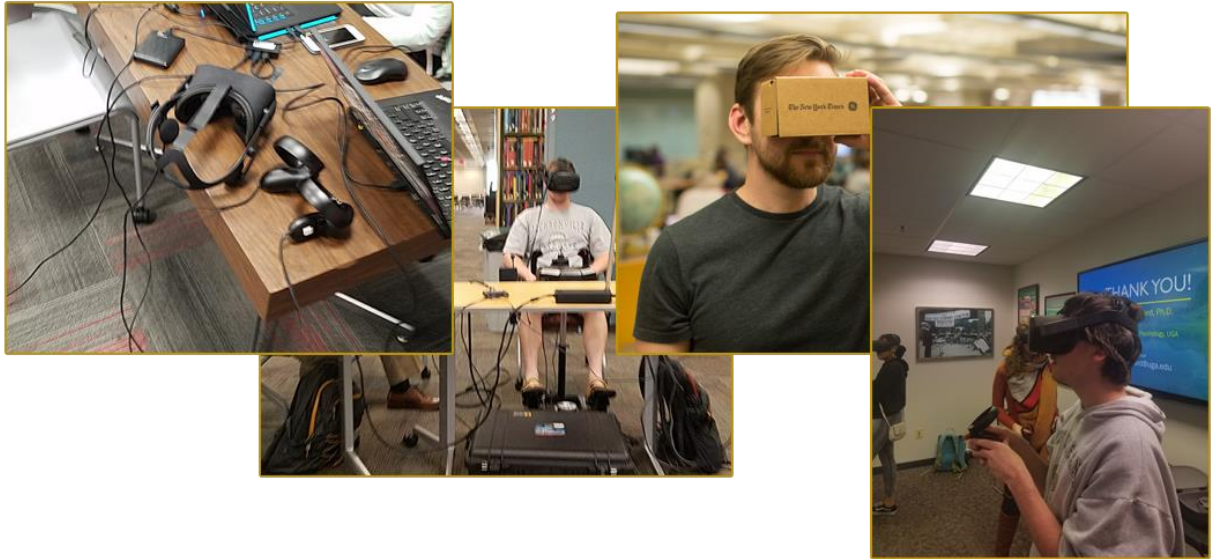


Figure 30. HTC Vive Virtual Reality gear, heavily dependent on powerful computers and hardware, and the Google Cardboard VR viewer that works for low resolution scenes on a mobile phone. Images from various campus events at UGA.

Given the already widespread use of mobile technology and the easy-to-use interface options available for augmented reality (AR), the VR approach was set-aside in favor of the AR benefits of exploring the environment while immersed in those real places vs. a headset simulation.

6.3 MacCoAR

The first mobile AR experience developed for the McIntosh County project was *MacCoAR* (Taylor et. al. 2019), a custom-built AR application that reacts to images of historic landmark locations by showing AR content through a mobile device display. Using the same Unity Gaming Engine used to develop VR Darien, an AR mobile application was developed that augments current images of Darien with overlays

of historic and plausible future changes to those scenes (Figure 31). Two-dimensional images, three-dimensional objects, and animations were visually registered to their appropriate location onto the current images of Darien (Figure 32). The current images were ‘targets’ that the mobile device would recognize and scale the augmented content appropriately to the printed size of the target (or picture of Darien, in this case). Because we were using images of these places, content ranged from overlay images of design decisions, a 3D-modeled shrimp boat, canoe riders, and underground pipe infrastructure, to map pop-ups showing where the scene was located relative to the NOAA flood inundation map.

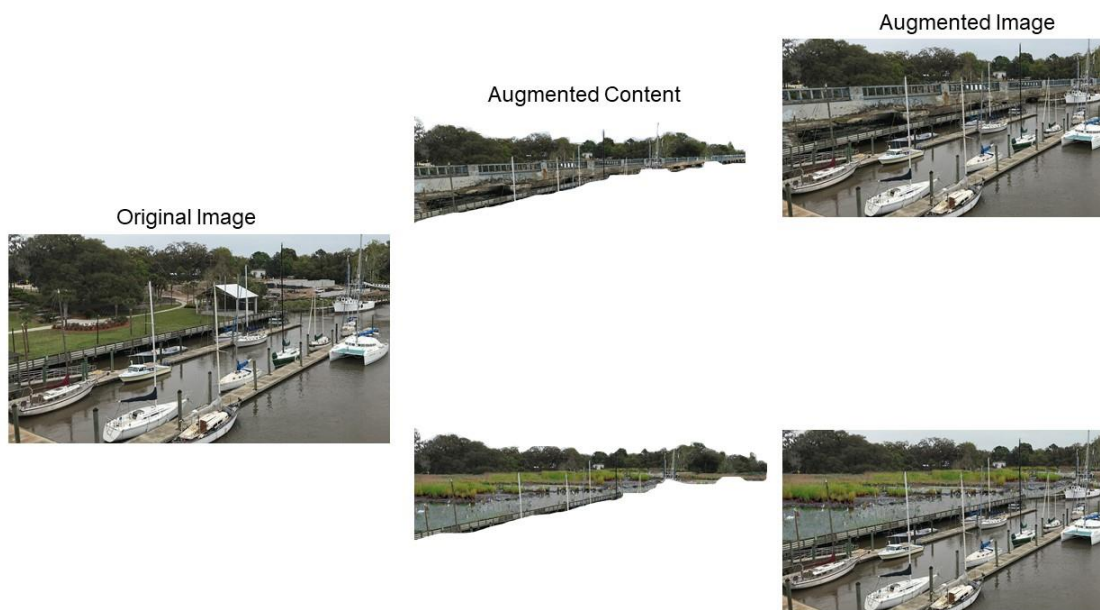


Figure 31. An original image of the waterfront in Darien, GA, the imagined future AR overlays of a seawall and ecological reclamation buffer, and the overlays aligned onto the original image as shown through the mobile device camera.

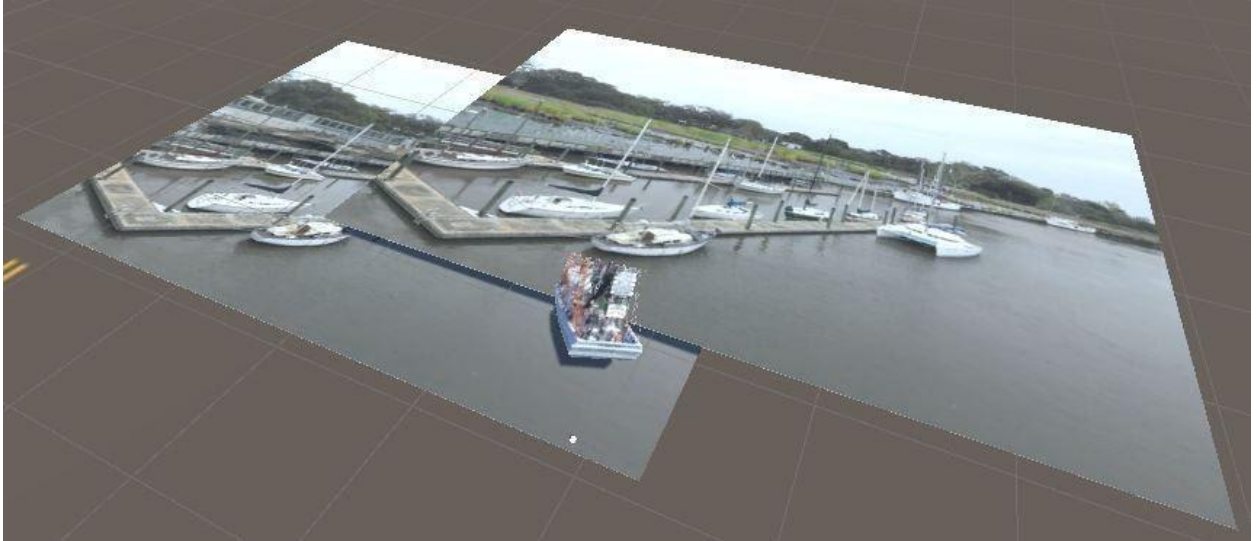


Figure 32. Unity Gaming Engine canopy showing an original image (“target”), the overlay image with a different waterfront, and a 3D animated shrimp boat that moves along the dock when being augmented through a mobile device.

Regarding AR development, this technique is achieved in two principal ways. In one, the target-based method, the background setting is scanned to create reference points that are unique to the image (Figure 33) so the mobile device camera can align and scale the AR content appropriately based on those points. This was the approach used in the development of MacCoAR. In the second approach, the Geo-Location method, the display device uses its internal geo-locating capacity based on GPS and inertial systems to locate the display device in space and then render the overlay material using the geometric relationships between viewing location and the size of the augmented material. This is how *Pokémon Go* works. Unlike the popular AR game that augments person sized Pokémon characters onto a flat surface, we needed to augment landscape scale AR material onto significantly larger scale surfaces. AR content spans a large amount of space along the Darien waterfront, currently only attainable by augmenting

images. Comparatively, a geo-located AR Pokémon in a real place is attainable because it only needs one location and a flat surface to render the lone figure (Figure 34). Field testing revealed limitations in both methods for our intended purposes. The first technique was impractical for extensive outdoor locations and the scale of changes to be represented while the second technique lacked sufficient locational precision to represent the foreground changes that would probably evoke most viewer reaction.

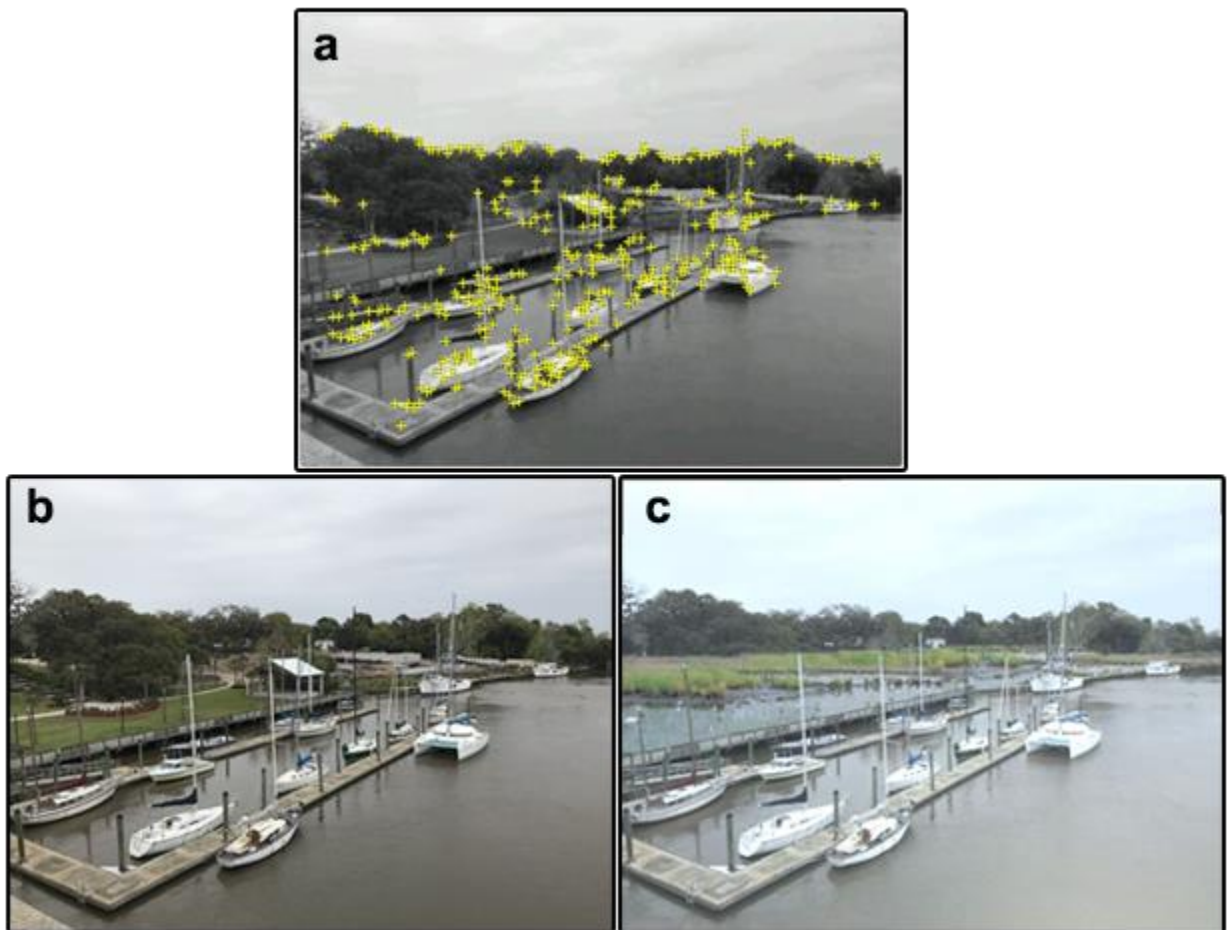


Figure 33. An original image of the Darien waterfront (b), loaded into Vuforia (Unity's AR engine) (b), and registered as a target. The yellow crosshairs are the reference points the mobile device looks for in order to appropriately align and scale the AR shoreline (c) onto the image.



Figure 34. AR content (area in red polygon) along Darien shoreline spanning a large swatch of the landscape (left). An AR Pokémon at a single location (right).

6.3.1 MacCoAR as a Pilot

At an early stage in the development of this research the project team for the umbrella funded project (Global Studies of the American South, Orland, Welch-Devine, and Berry 2018) had systematically surveyed McIntosh County by visiting the fifty-five historic markers recorded in the Historic Marker Database (<https://www.hmdb.org/>). Most of the markers were intact and in place. Using the historical markers as targets for an AR app would address both locational concerns above. This became a central component of the subsequent development of *youARhere*.

At this stage, though, we recognized an opportunity to examine aspects of the *MacCoAR* app's usability. University design students participating in summer classes were asked to download the application and engage with images of eight locations in McIntosh County. Images were printed at 36"x36" to serve as targets and were hung on the walls

of the students' summer classroom space (Figure 35). Although this study was framed to gauge design students' judgments of cultural landscape value and of climate change-oriented design decisions that might affect those (Figure 36), we also surveyed students about the app and its preferred features i.e., historic narratives and imagined future images, and its methods of communication, i.e., audio plus text instead of text alone, to guide the development of *youARhere*.



Figure 35. Students at the University of Georgia College of Environmental Design trying the *MacCoAR* application which later evolved into the on-site *youARhere*.



Figure 36. Potential design decisions rendered on images of the Altamaha River bank in Darien, Georgia (images by Gretchen Bailey and Jingxian Li of the UGA College of Environment and Design).

6.4 *YouARhere*

The experimental evaluation of *MacCoAR* as well as peer review of the app led to several key conclusions about the development of *youARhere*:

While central features of the app would be the representation of augmented timelines, the goal of *youARhere* was to be a catalyst for users' own insights and a vehicle for collecting those. The existing historic markers revealed a wide array of content (Table 4) as well as a wide array of locations: early settlement and 20th century; coastal and inland; formal and informal historical significance; urban and rural. In the judgment of the project team, it would be useful for *youARhere* to draw upon and feature as many historic markers in McIntosh County as possible (Table 4). The example of those existing locations and their histories would provide a framework upon which users would contribute their own insights about those historic marker locations or stories of their own that took place nearby. Most importantly, the markers themselves were ideal as targets, with consistent and distinctive shapes within the logos and texts, serving as clear visual

references that were distinctively different for each marker, providing a means for the app to work in the real-world location at the real-world historic marker in a manner functionally equivalent to the prior use of printed image targets. The research team took multiple trips to McIntosh County to capture high-resolution photos of the historic markers to register as “targets”. *YouARhere* uses 44 of the total 55 markers, augmenting each location with additional content. Having this much augmented content and allowing for limitless user contributions meant, however, that using the streamlined processes available in Unity Gaming Engine would not suffice, as all the application media content and user contributed content in a Unity based game is stored in the application, with the result that user-determined text and image content could drive the app to becoming increasingly larger in size, cumbersome to operate and consuming too many of the users’ smartphone resources. A custom application accessing and using a personal server was needed to host AR content outside of the application.

Table 4. The names of the historic markers in McIntosh County registered as targets for *youARhere*.

Historic Markers - McIntosh County	
“The Thicket” Sugar Mill - Rum Distillery Ruins	William Bartram Trail
1836 Methodists at Darien	Columbus Square
Ardoch	Jonesville
Ashantilly	McIntosh County
Baisden Bluff’s Academy	Oglethorpe Oak
Birthplace of John McIntosh Kell	Old Belleville or Troup Cemetery
Butler Island Plantation	Old Court House at Sapelo Bridge

Captain William McIntosh	Old Fort King George
Capture of 23 Men in 1864	Port of Darien
Colonel John McIntosh	Rice Hope
Confederate Post in 1864	Saint Andrew's Episcopal Church
Darien Presbyterian Church	Saint Cyprian's Episcopal Church
Darien's Railroad and Depot	Sapelo Island
Enslaved People of Butler Island	Site of Bank of Darien
Famous Butler Authors	Site of Early Spanish Mission
Fort Barrington	South Newport Baptist Church
Fort Darien	St. Andrew's Cemetery
Fort King George	Sutherland's Bluff
General's Island	Guale Indian Village
John Houston McIntosh	Lower Bluff Sawmill
The Burning of Darien	New Inverness
The McIntosh Family of McIntosh County	The Savannah Lumber Company

6.4.1 Custom Application

Parts of the *MacCoAR* application useful to *youARhere* but built in Unity were rebuilt in the Wikitude AR Engine (Wikitude AR 2020). Wikitude allowed for placement of the AR content around its target (historic markers, in this case) in an online design portal called Wikitude Studio (Figure 37). Like the reference points in Figure 33, Wikitude referenced unique points on the historic markers around which AR material could be organized. Instead of exporting the app ready for the device, the AR portion of the app can be exported as native code (base functional code that works in all devices that can read it) in order to customize, add functionality other than AR, and develop for specific

platforms or updates of those platforms. The AR content, such as *youARhere*'s audio and high-resolution images, would be hosted by Wikitude using an Amazon Simple Storage Service (s3) server space as opposed to taking up space in the mobile application; shrinking the size of the application and making it work as fast as possible. This native code was passed to an outside developer, Technoke (Adam Spikard of Athens, Georgia), who added modern user interface (UI) elements (buttons and text boxes), mobile app logic (shifting from page to page as items and tasks are selected by the user), and a pathway to and from an Amazon s3 server where all the app and user content are stored. Lastly, to locate incoming user content geographically would require the data to first arrive at an ArcGIS online Feature Service before being forwarded to *youARhere* for other users to read, hear, or see (Figure 38). The feature service allows researchers to use the input as geo-located data in the ArcGIS suite of software and analysis tools as opposed to pulling them as raw data from the server. This also enables content monitors to approve submitted material to weed out any inappropriate content before moving it to the publicly accessible app.

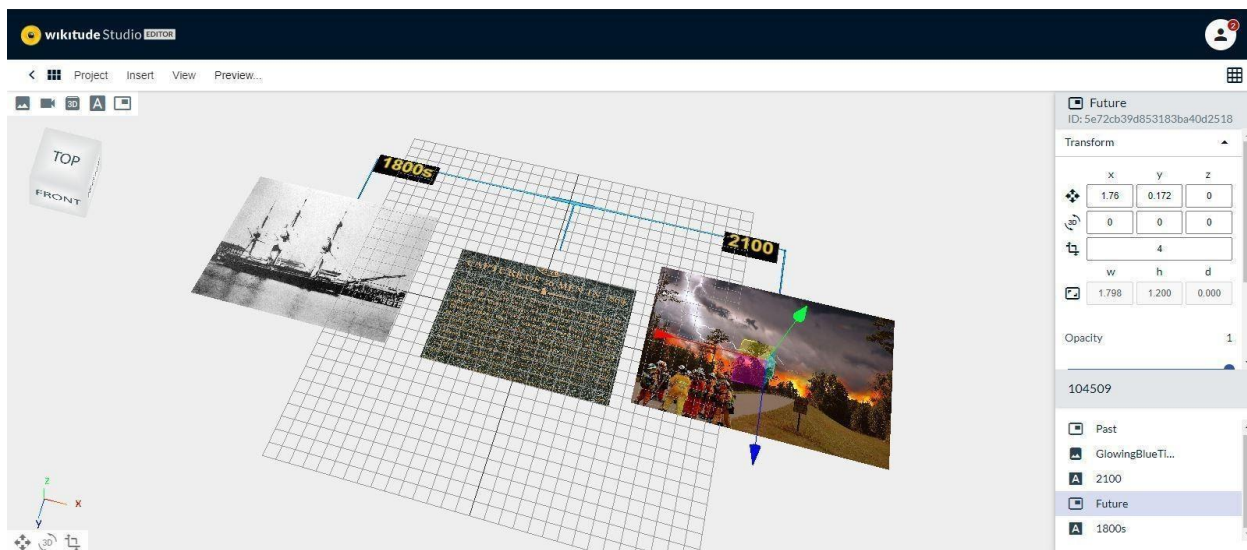


Figure 37. The online graphic interface to place AR content and have the code automatically written in Wikitude Studio.

youARhere_data									
Overview									
Data									
Visualization									
Usage									
Table									
Double-click a value in the table to change it.									
Data Last Updated: May 16, 2021									
storystrata_data (Features: 3, Selected: 1)									
Latitude	Longitude	Attachment Link	Approved	Sig_ID	Type	Updated	Created	Visitor	
33.9678246754082	-83.4026839791307	jpeg	0	10503	audio	2021-03-05T01:52:11.147Z	2021-03-05T01:52:11.147Z	1	
33.9192492437414	-83.3530950351407	jpeg	0	11081	text	2021-03-22T20:08:15.909Z	2021-03-22T20:08:15.909Z	1	
31.3686256785206	-81.4351168441766	jpeg	0	10591	text	2021-05-16T23:31:45.424Z	2021-05-16T23:31:45.424Z	1	

Figure 38. ArcGIS online Feature Class data table screen. The 'Approved' attribute can be switched between 0 and 1 to allow user contributed content to be seen by other app users.

6.4.2 Custom Application - Version Two

After testing a first version of the app and clarifying a vision statement for the project as a whole (found on the Internet at <http://youarhere.net>), it was decided to add two new features to complete the initial public version of the *youARhere* application. First, users

needed to be able to contribute stories about any place, not *just* at the historic markers in McIntosh County. Secondly, a feature was needed to help users navigate from their current location to nearby signs. The '*Add New Location*' option was added in the second version to allow users to text input or voice record a story, upload images or videos about that story, and set a pin on a map where the story takes place (Figure 39). That allows *youARhere* to create a new AR experience at the specified place using the user-supplied narrative and images of that location. This function was developed by embedding an ArcGIS Survey123 form (pre-formatted mobile survey) into *youARhere* that is accessed when the user clicks '*Add New Location*'. These new locations are also received by *youARhere* as a feature service in ArcGIS online. That feature service, which also contains the 44 historic marker locations in McIntosh County, is web mapped and fed into a '*search for target location*' function in *youARhere* to help people find nearby historic markers using a geo-fence, or distance buffer, around the marker. When the user is inside that geo-fence the marker location will be visible via a mobile web map within *youARhere*.

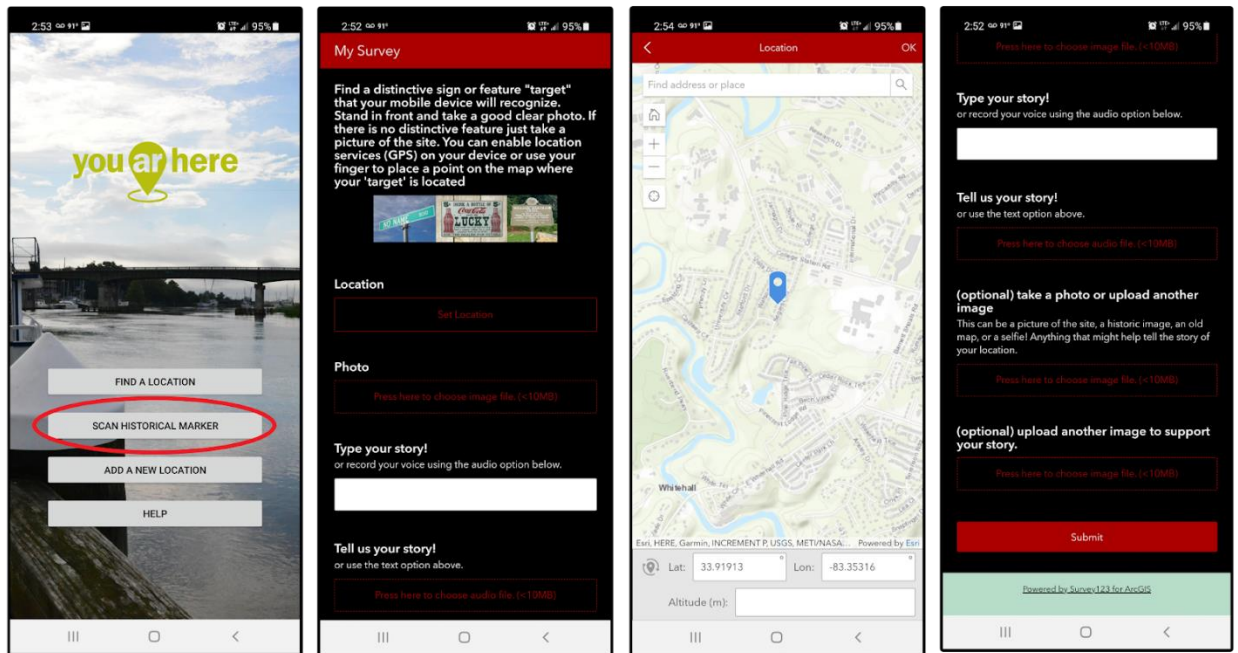


Figure 39. An ArcGIS Survey 123 form embedded in *youARhere* to allow people to contribute new stories and relevant AR content anywhere in the world.

6.5 Network ability

A centrally important aspect of *youARhere* as a planning and environmental communication tool is that it is networked, as are other social media applications, so that users can experience other user's stories. Furthermore, *youARhere* stores data in multiple places, making a solid geo-referenced infrastructure for researchers to access and analyze story and place relationships. Figure 40 is a trace diagram of how data and content move about a network for the benefit of both the public users and the researchers who can see it. While the project is targeted for stories of historical and environmental change, the networked, place specific, and open nature of *youARhere* makes it malleable to other types of stories and place-based communication. What separates *youARhere* from other traditional, *person*-profile oriented social media is that it is *place*-oriented and has a

vision statement that is specific to a cause; storytelling about specific places. This aspect mirrors Luther's descriptions of successful digital communities where members are rallied around a certain cause, goal, or topic (Luther et. al. 2010, Venkatagiri et. al. 2021).

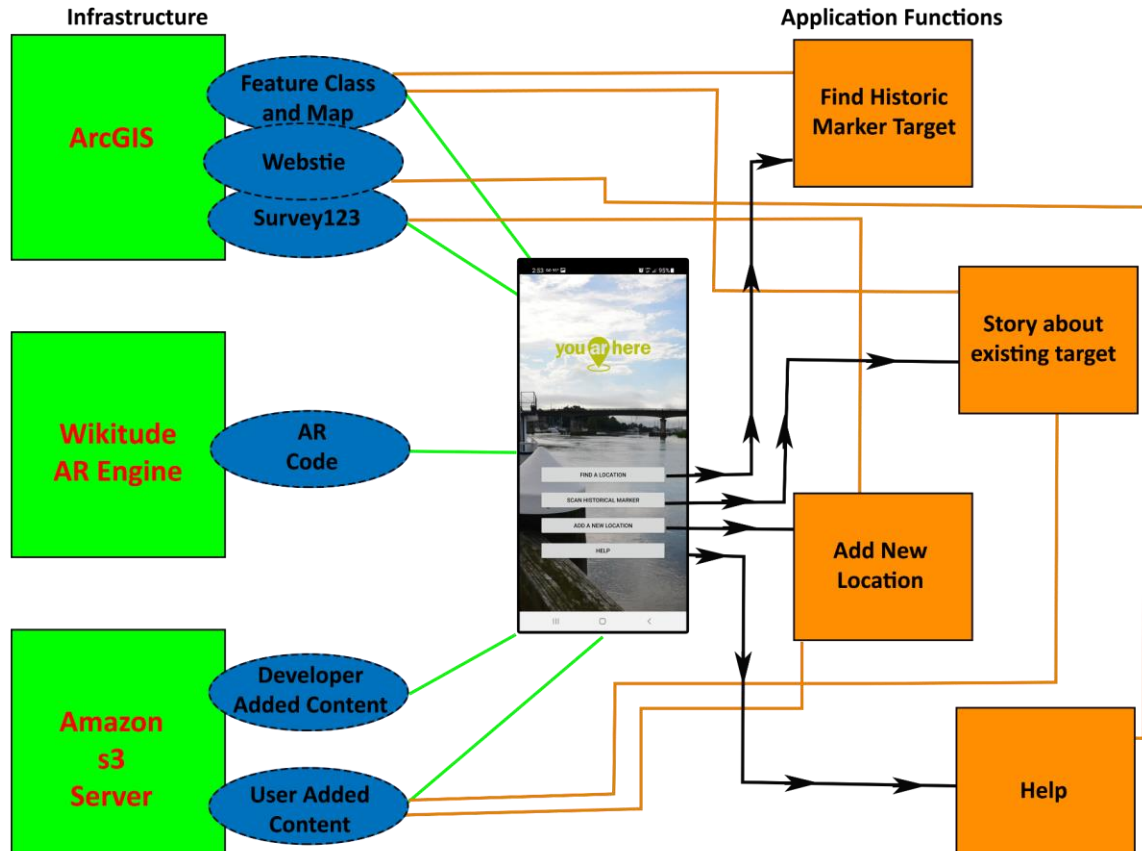


Figure 40. A trace diagram of where content flows within the *youARhere* mobile application. The green lines are where user and developer input return to the application. The lines with arrows are where users navigate to when buttons are clicked, and the orange lines are where data is stored in the background.

6.6 YouARhere Website

youarhere.net is the website that accompanies the project. It serves as the outward-looking public face of *youARhere*. It includes the vision statement for the project:

The environment is changing. Global climate change, predicted by scientists, marred by political tension, and seemingly irreversible is too distant and abstract (too Global) for a person to feel immediately threatened. It is, admittedly, hard to understand and difficult to act upon amid the demanding chaos of current life. However, *the local changes* to the landscape, appearing as symptoms of a global climate crisis, ***can be seen, felt, and understood by all.***

Those of us in an office (or more recently on a computer at home) doing research at institutions, surrounded by likeminded people and immersed daily in the big picture of environmental change cannot possibly know all the minuet ways individuals and places out of our periphery are impacted by these global changes.

"We cannot see what you see! "

Have you ever had the feeling that something in your current landscape or environment is different? Have you ever wanted to tell the history of a place in a different way?

youARhere collects stories from the past and dreams for the future of the men and women on the front line as they struggle to document and adjust to the climate-driven social and ecological catastrophe that is already upon them. **We want you to be a part of a community of people writing our next history through personal stories, acknowledging the environmental change you see in your life, and digitally preserving a more honest story of us.**

It also has instructions on how to download and use the mobile application, *youARhere*, for AR content at existing target locations as well as how to contribute new locations to the application. The website links to an Esri Storymap (Li et. al. 2020) that contains interactive maps (Figure 41) and information about historic marker locations in McIntosh County accompanied by user contributed stories. The website will be the long-lasting record of *youARhere* users, growing as additional content is contributed and acting as an online digital archive of stories and history. Stories are archived as digital journal entries with their own photos, text, video, and mapped location and can easily be scrolled through.

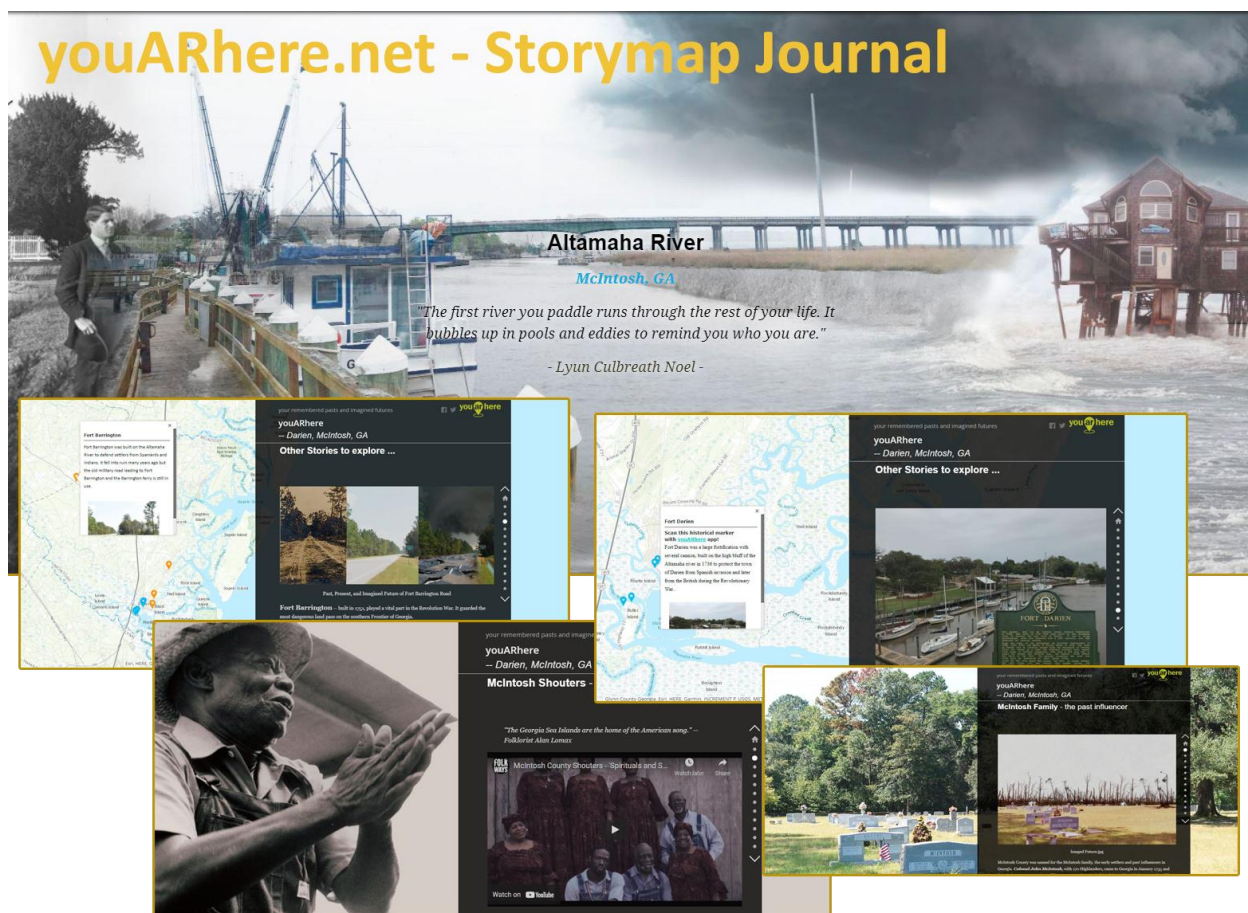


Figure 41. *youARhere*'s website contains these Esri story maps to hold user contributed content. It serves as a desktop method of viewing and as a digital storage of stories and images.

Chapter 7.

RESEARCH METHOD

The method framework for this research involves people *in situ* (in real places) and *in vivo* (in the course of daily life). Independent variables include their social context, local knowledge, experiences, and stories. Dependent variables include the environmental attitudes that shape a person's perception of the future in regard to environmental change in coastal Georgia, and their behavioral intentions, how they intend to respond to anticipated changes. Figure 42 illustrates the framework of a technological intervention, in this case the use of *youARhere*, and how it potentially re-shapes the environmental perceptions, and thus behaviors, of coastal Georgia storytellers. Predicting that a more broadly informed perception of the future and a hands-on involvement in the story of coastal Georgia, via an intervention with *youARhere*, the mobile AR collaborative storytelling application developed for this project, commenced in July, 2021 and is continuing.

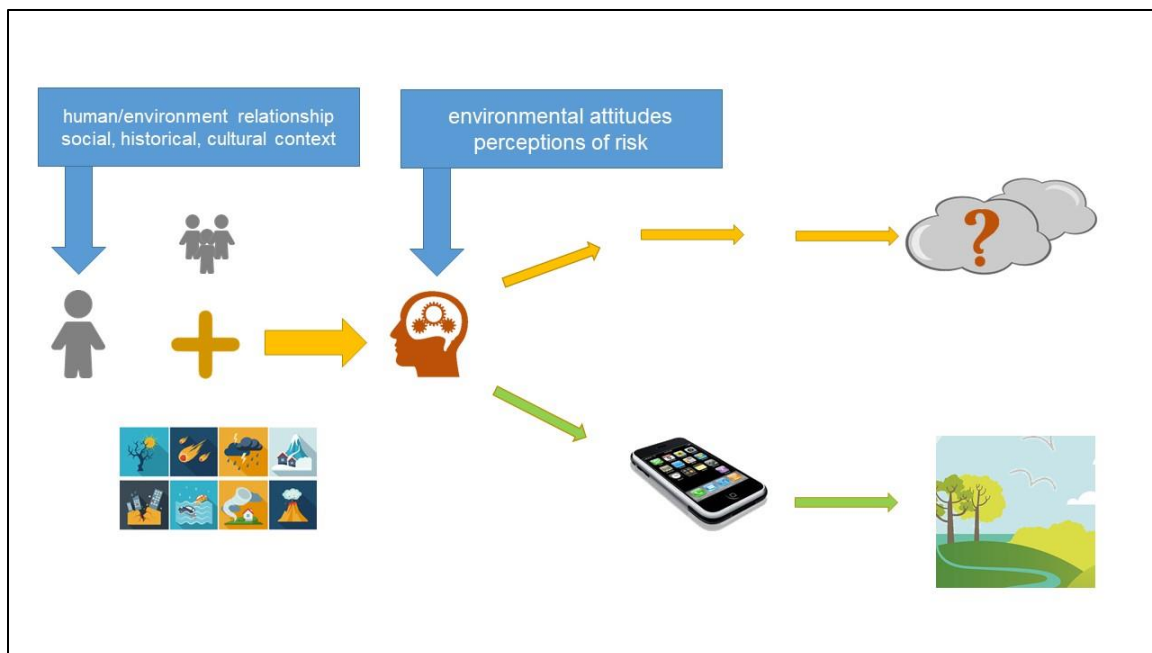


Figure 42. The framework of a technological intervention and how it potentially shapes the environmental psychology of coastal Georgia storytellers.

Measuring Environmental Attitude:

An environmental attitude survey was administered before and after participants used *youARhere*. We looked at how use of the application affected attitudes and intentions, including the interactions between attitudes and intentions, as well as any demographic or other independent variable that may have affected those interactions. The surveys were originally intended to be administered during and after a series of public meetings in Darien, Georgia where the mobile application and project could be introduced and discussions of the app as a planning and communication tool could be had with the residents. However, due to Covid - 19, these meetings were not held. To add to that barrier, people were not as motivated to take two surveys and travel to a historic marker location in order to help test the app or participate in environmental attitude research. Therefore, as of July 2021, interviews were also conducted with separate application

users from those that did take the survey where questions were asked before and after using the application. The interviews offered a deeper qualitative analysis to supplement the attitude survey and viewpoints expressed in the conversation were connected to the attitudes found in the survey responses. The interviews also revealed new sentiments not considered in the survey.

7.1 The shortened Environmental Attitude Inventory

A shorter, 24 item environmental attitudes scale (Adjukovic et. al. 2019) was used, based upon the 120 items scale constructed by Milfont and Duckitt (2010). The shorter scale, tested and validated using the same technique as the larger scale, was shown to measure attitude along the utilitarian and preservationist continuum established by Milfont and Duckitt and Bogner and Wiseman (2006). Adjukovic and colleagues state,

“Pro-environmental behaviors can be predicted by this scale, mainly through the dimension of preservation...This unidimensional perspective refers to the idea that an individual has a relationship with the environment on a continuum which ranges from a pro-environmental attitude ([preservationist leaning]) to a counter-environmental attitude ([utilitarian leaning]), with one orientation excluding the other.”

The reason for the shorter survey is because it is more in tune with individuals being able to possess some of both constructs and works across location contexts. For example, Adjukovic and colleagues show that the environmental activism measurements did not apply to the French context of environmental behavior, and so having those questions

was not accomplishing the task of gauging respondents' position along utilitarian / preservationist lines. Furthermore, the shorter item survey is less likely to be an impediment to participation, which was important due to the low number of potential participants available in McIntosh County, the least-populated county in rural coastal Georgia. With fewer items on the survey, there are also fewer subdimensions beneath utilization and preservation which are more relevant to any contextual place (Ajdukovic et. al. 2019, Bogner and Wiseman 2006). The following highlights the top tier worldviews, the subdimensions, and the corresponding items (questions) derived from the original Environmental Attitude Inventory in Milfont and Duckitt (2010) and simplified by Ajdukovic (2019).

Preservation

Enjoyment of Nature

1. I really like going on trips into the countryside, for example to forests or fields.
2. I think spending time in nature is boring.

Support for Conservation Policies

3. Governments should control the rate at which raw materials are used to ensure that they last as long as possible.
4. I am opposed to governments controlling and regulating the way raw materials are used in order to try and make them last longer.

Environmental Movement Activism

5. I would like to join and actively participate in an environmentalist group.
6. I would NOT get involved in an environmentalist organization.

Environmental Threat

7. Humans are severely abusing the environment.
8. I do not believe that the environment has been severely abused by humans.

Personal Conservation Behavior

9. I am NOT the kind of person who makes efforts to conserve natural resources.
10. Whenever possible, I try to save natural resources.

Ecocentric Concern

11. It makes me sad to see forests cleared for agriculture.
12. It does NOT make me sad to see natural environments destroyed.

Support for Population Growth

13. Families should be encouraged to limit themselves to two children or less.
14. A married couple should have as many children as they wish, as long as they can adequately provide for them.

Utilitarian

Conservation Motivated Anthropogenic Concern

15. One of the most important reasons to keep lakes and rivers clean is so that people have a place to enjoy water sports.

16. We need to keep rivers and lakes clean in order to protect the environment, and NOT as places for people to enjoy water sports.

Confidence in Science

17. Modern science will NOT be able to solve our environmental problems.

18. Modern science will solve our environmental problems.

Altering Nature

19. I'd prefer a garden that is wild and natural to a well-groomed and ordered one.

20. I'd much prefer a garden that is well groomed and ordered to a wild and natural one.

Human Dominance over Nature

21. Human beings were created or evolved to dominate the rest of nature.

22. I DO NOT believe humans were created or evolved to dominate the rest of nature.

Human Utilization of Nature

23. Protecting peoples' jobs is more important than protecting the environment.

24. Protecting the environment is more important than protecting peoples' jobs.

*The **bold** letters are the subdimensions of the Utilization and Preservationist top level worldviews. Adapted from Ajdukovic et. al. (2019) which was adapted from Milfont and Duckitt (2010)

7.2 Survey Design

The repeated-measures surveys for this intervention with an AR app are taken before the participant uses *youARhere* and within three weeks after using *youARhere*. Both surveys employ the same questions except that the post-use survey has, in addition, a series of questions about the functionality of the app and what participants found most useful. The surveys were created using Qualtrics and contain a randomized version of the 24 item Environmental Attitudes Inventory (section 7.1), intentions to perform certain tasks in future extreme environmental events, questions about demographics, and personal attributes known to shape views about the role of science in everyday life.

7.2.1 Demographics and Personal Traits

Demographics were collected based on previous environmental attitudes research findings, synthesized in Li et. al. (2019), on which demographics were known to potentially influence EAs toward pro-environmental behavior. The adoption of these questions kept the focus on the environmental attitude shifts around the mobile application intervention without overfilling the survey with attributes studied in the past.

Therefore, the following demographic and personal trait questions were asked due to their previously found importance in other research.

A comprehensive analysis of environmental behavior research between 1987 and 2017, compiled by Li et. al. (2019) finds that women, young people with higher education and good income, married couples, and urban residents tend to exhibit more pro-environmental behavior, but no demographics are significantly strong determinants of environmental attitudes, beliefs, or intentions. Gender has been found to be slightly related to pro-environmental behavior in previous research that claimed that women's traditional role as 'caregivers' results in their being more 'caring and compassionate' toward the environment (Torgler and García-Valiñas 2007). Groups with higher education and/or younger age tend to have more familiarity with pro-environmental behavior because of awareness of damage from 'neglect of the environment' (Danielson et al. 1995; Van Liere & Dunlap 1981; López-Mosquera, Lera-López, & Sánchez 2015; Welsch and Kühling 2010). Higher income within urban areas has also been shown to mean more pro-environmental behavior (Fan et al. 2013) as well as married couples, which are shown to care more for the next generation's environment than singles (Dupont 2004). Therefore, the following demographics were added to the survey.

Gender - [male, female, prefer not to answer]

Education -What is the highest level of education you have completed? [Not finished HS, HS/GED,College but no Degree, Assoc/vocational degree, Bachelors, Some graduate work, graduate degree, prefer not to answer]

Age - [18-24, 25-44, 45-64, 65+, prefer not to answer]

Income - Which of the following best describes your household income in 2016? [<25k, 25-35k, 35-50k, 50-75k, 75-100k, 100-150k, >150k, prefer not to answer]

Because the political system is involved in planning and has increasingly seeped into the social norms of groups, it is important to account for these personal trait variables as they are a modern intervention into people's daily lives. Many authors use a single question for political orientation, and it has been widely validated (Tankard and Paluck 2017, Milfont and Duckitt 2010).

Political Orientation - On a scale from 1 to 7 with 1 being 'very progressive' and 7 being 'very conservative', how would you rate your world view? (Scale)

Social media use has been known to propagate beliefs and ideas about climate change, regardless of their integrity or truthfulness, and increase polarization and retreat into tribes that think alike on many issues as more links and comments are shared (Cann, Weaver, & Williams 2021). This is especially true in the United States where influential climate skeptics on social media are widely followed and shared (Tuitjer and Dirksmeier 2021). While typical research articles measure social media as time spent or measure its influence directly in comparison to something else (e.g., What I read on Facebook is more persuasive than the Tweets I receive) (Trifiro and Gerson 2019, Escobar-Viera et al. 2018), this research did not need to go into that depth but does benefit from knowing if respondents are receptive or resistant to using social media because of its propagation of

climate thought on modern social norms. Furthermore, social media use is a good starting point to determine reasons for take-up of an app as these apps, though not beneficial to climate discourse, are increasingly popular (Cann, Weaver, and Williams 2021). Therefore, social media use about environmental issues were measured through the following questions.

Social Media Use

I consider myself a regular user of social media. (1- strongly disagree, 7 – strongly agree)

I often contribute to information sources (Wikipedia, radio shows, publications, etc.) about local environmental issues. (1- strongly disagree, 7 – strongly agree)

While imagined futures, entertainment-style media, and direct experience may reach more people on the salience of climate related change (discussed in section 3.1.2), it is the scientific community’s role to measure uncertainty about human-caused climate change, and it has stated its consensus (IPCC 2019) (Oreskes 2004). However, that does not mean everyone trusts the science behind climate change. There is a notable difference in the *trust* research community between measuring ‘trust’ and ‘credibility’. This means people may ‘trust’ a certain outlet for their news (some of which are climate topics) out of a social norm or preference but may not necessarily find other outlets ‘uncredible’ all the time. There is a similarity between trust in ‘journalism media’ and this research’s trust interest in ‘climate media’ (Kohring and Matthes 2007). A single item question was chosen from Engelke, Hase, and Wintterlin (2019) to

generalize a measurement of trust in the consensus on climate change to make sure that the science being trusted or not was specific to the topic of ‘climate’.

Trust in Climate Science -I trust in the scientific community consensus that we are causing rapid climate change.

7.2.2 Behavioral Intentions

Finally, we ask about behavioral intentions towards a more challenging environmental future on the Georgia coast. Intentions are couched in the context of a person in coastal Georgia, assuming some hurricane frequency and severity, sea-level rise, and familiarity with alternate responses. Asking about someone’s willingness to pay for something regarding climate change adaptation (Danielson et al. 1995, Torgler and García-Valiñas 2007, Graham et al. 2019) and direct, localized, tangible adaptations (Francis et al. 2017, Torgler and García-Valiñas 2007) have been used in multiple countries as a metric of ‘intentions’ in adaptation research. The chosen questions speak directly to the individual living in the southeast U.S. as something specific they might consider (or not) which is in line with a call for more localized, context specific survey questions in attitude/intention environmental behavior research (Rosa and Collado 2019).

Intentions

-I would support a small tax on my income to build coastal defenses against future hurricanes, storm surges, and sea-level rise.

- I don't think I should pay taxes towards adapting to climate change.
- I am going to acquire sandbags to fortify my property because there will be more frequent hurricanes in the future.
- I will not acquire sandbags to fortify my property because hurricanes will not be frequent enough to need them.
- I am going to start telling others that it is not a good idea to invest in a permanent home this close to the ocean.
- I encourage people to make the coast their permanent residence.
- I would move away from the coast if I had the ability due to increased risk of storm damage in the future.
- I will continue living close to the ocean regardless of predictions that hurricanes will become more frequent.
- I do NOT support pro-environmental science leaders.
- I support politicians who believe in climate change.

7.3 Recruiting and Administering the Surveys

It is important that participants get involved with *youARhere* on their own volition; out of an interest in exploring the project, deciding to be a part of it, and answering questions in the absence of the researcher. However, the project would have been ill fated without priming the app with initial users and spreading the word through any means possible. Recruiting participants was conducted by email flyers at local businesses, and a Twitter and Instagram project page using tags (Table 5) to digitally connect local

interests and keywords with the project website and participation request flier (Figure 43). A \$20 dollar Wal-Mart gift card was offered to participants as incentive, the only method of incentive available per the rules of the University of Georgia.

Table 5. The hashtags used in participant recruiting on the youARhere Twitter and Instagram social media pages.

hashtag	connection
#McIntoshCounty	Found tags from McIntosh County
#DarienGA	Common tag for events in Darien, Georgia
#coastalgeorgia	Many environmental posts have this tag.
#Altamaha	Found in many watershed posts on Instagram
#Hurricane	Common in hurricane damage and forecasting posts.
#Humanities	Drawing attention to <i>youARhere</i> in humanities groups and social media users.

Seeking Research Participants!

We are seeking people living in or visiting McIntosh County to take part in a study of environmental attitudes. You will receive a \$20 Wal-Mart gift card for your time. After contacting Micah Taylor, a researcher at the University of Georgia, you receive an electronic survey (through your email or text) that should take about 10 minutes to complete. Then some of you will be asked to visit one of the historic markers in McIntosh County and use the app, youARhere, to interact with the sign. Some of you will not be asked to use the app. Finally, all participants will be asked to complete a 2nd survey within 3 weeks. A gift card will be mailed to the address provided to the researcher.

-*youARhere* is an app that overlays historic content into the real world using historic markers as 'targets' for you to explore. It also allows you to create your own story.

-Must live in or be willing to visit McIntosh County, Georgia.

-Must be able to download and use *youARhere*, a free mobile application for Android or IOS devices and take a little time to explore McIntosh County.

-While the objective of the app is to collect and share your stories about McIntosh County, to maintain your privacy, no identifiable information will be shared.



If interested, please email, text, or call Micah Taylor - PhD student at the University of Georgia College of Environment + Design.

mst90194@uga.edu

931-244-5303

Project Principal Investigator:
Meredith Welch-Devine,
mwdevine@uga.edu



Figure 43. The recruitment flier used on business windows, social media, and email campaigns to find research participants for this research.

The most successful recruitment came from local citizens that met with the author to get questions answered, see a demo of *youARhere*, and have conversations about what the local community has to offer to the storytelling of the area. Leaders and key figures of the Ashantilly non-profit Center, The Nature Conservancy, Sapelo Island, teachers from McIntosh Academy, local business owners, and well-known citizens of Darien all shared the flier on their respective social media pages as well as by word of mouth. Every effort was made to get a demographically diverse group of respondents given the sparse pool of participants that could be recruited in the rural area. Although the Covid-19 pandemic hampered the original public meetings planned to kickstart the project, recruitment was still possible through smaller meetings, social media, and connections over email and text obtained by the author networking in the community.

7.3.1 Supplemental Interview Recruitment

Interviews were also conducted to supplement the survey data because of the more revealing and open-ended nature of the qualitative approach. Questions used to elicit viewpoints expressed in these conversations were connected directly to the strict constructs (Preservation and Utilization) found in the EAI along with their subdimensions. For example, a user expressing a lack of support for environmental policy in an interview could be connected to the EAI Utilitarian sub-dimension '*human utilization of nature*'. Furthermore, it was possible to determine the perceptions of individuals about the future through conversation that might not be apparent in strictly preservation / utilitarian categories of a survey measuring method. This mixed method approach strengthens the findings about environmental attitudes and mitigates the small

number of survey responses from the sparsely populated county. The author contacted residents of McIntosh County and offered a \$20 dollar Walmart gift card to potential interviewees. The participants varied in demographics and included residents, city officials, business owners, and newer residents. The interviews lasted about 30 minutes, were conducted mostly over zoom but with some in-person meetings with the author and consisted of questions (Table 6) that encouraged open discussion but were framed strategically to get stories that could be qualitatively connected with the survey data.

Table 6. Interview questions to supplement the survey responses. Three were selected from the questions in yellow for each interviewee to save time and repetition if they already answered in the conversation.

Interview Questions	
What do you think is different about McIntosh County today than when you first came here? or than when you were a child if you were born here?	I would move away from the coast if I had the ability due to increased risk of storm damage in the future.
Do you think the natural environment and weather of coastal Georgia is changing? If so, how?	I support politicians who believe in climate change.
What do you think about development along the marshland in coastal Georgia? Would you like to see more, less, or is this enough?	What do you think coastal Georgia, especially McIntosh County, will be like in the year 2050?
Do you think science is correct in predicting more frequent storms? What do you think is driving it?	On a scale from 1 to 7 with 1 being ‘very progressive’ and 7 being ‘very conservative’, how would you rate your world view? (Scale)
Do you think predicted Sea-Level Rise will be a problem for coastal Georgia?	Do you use social media, such as Facebook, Twitter, or Instagram? If so, which ones and how often?

I would support a small tax on my income to build coastal defenses against future hurricanes, storm surges, and sea-level rise.	Do you engage with people on social media about environmental topics? Do you feel its productive?
I am going to acquire sandbags to fortify my property because there will be more frequent hurricanes in the future.	What do you think about youARhere? Do you think its useful? What parts of the app interested you mostly and why?
I am going to start telling others that it is not a good idea to invest in a permanent home this close to the ocean.	Various follow up questions depending on the story being told.

7.3.2 Interview Data Methodology

Similar to the survey responses, the interviewees were asked a series of questions about their experiences in McIntosh County and perceptions of the future, and afterwards, to test *youARhere* on images of historic markers sent via the zoom chat or printed on a 36"x36" poster board if in person. Some interviewees would elaborate on a question and therefore, unscripted follow up questions were asked. In order to save time and keep from repeating an already answered question, 3 of the 5 behavioral intention questions, the same questions found in the survey, were selected for each interviewee (shown in yellow in Table 6). The demographic questions were given in a Zoom poll and matched the questions asked in the survey - Gender, Education, Age, Income, and whether they had experienced loss from environmental change. Finally, they were asked to answer the questions again taking into consideration their experience with the application.

7.3.3 Sentiment Analysis

Because the post-app-use portion of the interview was naturally shorter in length than the initial interview, considering they had already answered the questions at length before using the app, a weighted sentiment analysis was used to gauge the shift in attitudes between the before and after app use portion of the interview. Sentiment analysis means assigning a value to a textual phrase that has been coded. These values depend on the research and represent a numeric measurement of things like confidence, intensity, emotion, or certainty of a statement. This method has been applied to climate change discussion *intensity* considering online friends vs. online strangers, news vs. social media when discussing climate issues (Teemu 2018), service learning where the level of knowledge of the participant had to be decided from interview transcripts based on a researcher applied weight (O’keef and Feinberg 2014), as well as research (similar to *youARhere* attitudes) where a *change* in climate related sentiments is what is being addressed (Jost et. al. 2019). Dedoose (Version 9.0 2021), one of the primary qualitative analysis software available, describes the benefit of this mixed methods approach:

“In our experience, qualitative text analysis is far more effective—and ‘mixed methods’—when not only are codes/themes applied to tag and subsequently count meaningful content or words/phrases..., but when the ‘value’ of each application is further tracked and understood. This is where code weighting by sentiment comes in. Sentiment weighting is used to add a value scale—and, hence, another dimension of qualitative text analysis—to each code/theme application to account for intensity.” (Dedoose 2012)

This method is beneficial in this research for two reasons. One, since the comparison of counts of coded statements would be confounded by the unequal transcript length between the before and after app use portion of the interview, weighting the statements based on *intensity* has the benefit of normalizing the two sections of the interview, regardless of statement quantity, and only considering the change in sentiment quality. A 1 to 7 weight scale was applied to the codes based on the confidence and intensity of the statements instead of using a quantity of code instances in order to compare the pre and post app use portions of the interviews. For example, if an interviewee stated in 5 locations in the pre-app-use interview that they did not trust scientific findings on climate science, each of the 5 weighting between 1 and 4, then a single, confident statement after using the app indicating belief in science weighting a 7 would indicate a change without being skewed by the shorter length of the conversation after using the app.

7.3.4 Data processing

The interviews were recorded via zoom or mobile device and transcribed with audio and text analysis software, Descript (Version 26.2 2021). The transcriptions were then processed in the qualitative analysis software, Dedoose (Version 9.0 2021), to find common themes and patterns similar to those in the survey data by coding phrases based on both environmental attitude dimensions and discovered sentiments. Again, appendix E has a list of all the software and reasons for their use in this research. Coding is taking phrases from text (usually a transcript from recordings of talking) and categorizing them based on either A) predetermined ‘codes’, or sentiments, such as belief in science, anger,

tendency to spend money, or any other possible thing a researcher wishes to assess or B) discovered categories revealed through repetition found while reading the transcript. The codes are then used to find patterns in themes in transcripts to make claims about a research question or topic of discovery. As illustrated in Figure 44, three rounds of coding were performed by the author. The first round was reading through interview transcripts and listening to audio recordings and coding sections of the conversation as preservationist or utilitarian as pre-coding determined categories. The second was reading transcripts carefully and coding the subdimensions of preservationist or utilitarian sentiments from the coded sections in Round 1, matching the EAI in a qualitative format. Lastly, newly discovered themes (codes) were highlighted and analyzed to discover unanticipated topics and attitudes. Weights for sentiment analysis between before and after using *youARhere* were added to the top-level codes. Figure 45 illustrates how the codes were organized and phrases selected for the codes in Dedoose. The example gives the statement a weight of 4 on the preservationist code because the interviewee is not suggesting no one live there, only that they be cautious, displaying a concern for environmental damage (flooding in this case) and a relatively negative outlook on the future of coastal Georgia living.

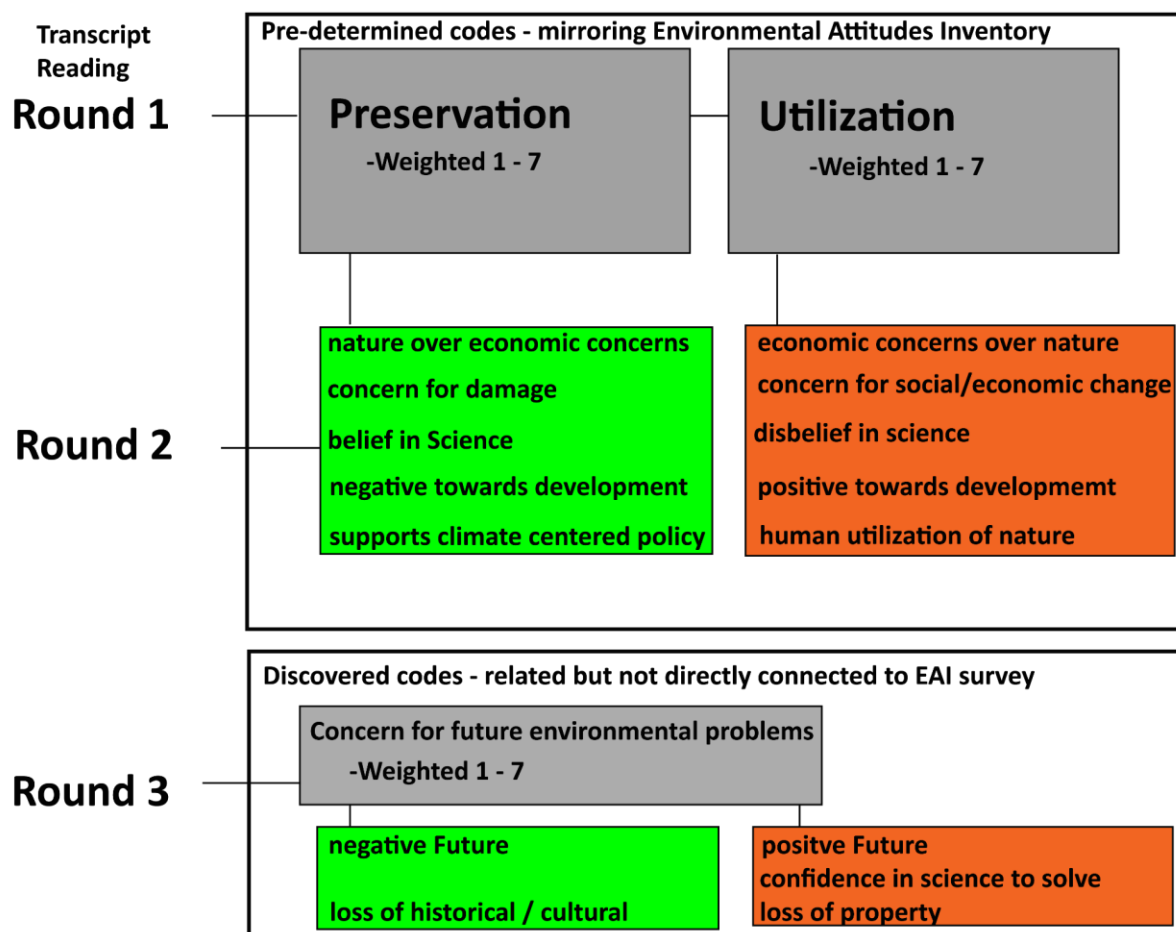


Figure 44. The coding strategy for the interview data. Rounds 1 and 2 had predetermined codes based on the EAI while Round 3 highlighted discovered codes based on unforeseen findings in the transcripts. These were framed along the preservation (green) and utilization (orange) top level constructs of the EAI.

Transcript Excerpt:

I would tell people to be very cautious that I would say, yes, it's a beautiful area, but, um, you have to know that it's coming and it would be if you don't care and you've only got what you think is 10 more years, you might get away with it 10 more years. But I think if you're looking at 20 to 25, 30 years, I would not recommend. Being in any of the flood zones.

Codes:

Attached Codes

- Preservation Qual 4 / 7.00
- Negative Future
- negative towards development
- concern for damage

Codes

- Concern for future environmental pr...
- Negative Future
- Positive Future

Figure 45. An example excerpt with the attached codes from the coding list created and used in Dedoose (Version 9.0 2021). - Micah Taylor

Chapter 8

RESULTS

Fourteen participants responded to the surveys but only resulted in five usable entries owing to some respondents not completing the survey, not doing the second, follow up, survey after using the app, or doing the follow up survey first and failing to correct their action. While these were not sufficient responses to perform adequate statistical analysis, the quantitative responses do reinforce findings that later emerged from the interview data, which will be noted where appropriate below. The survey respondents were three females and two males ranging in age, income, education level, and political orientation. Out of fourteen people interviewed for this research, eleven were rich and lengthy conversations, ranging from 30 minutes to 1.5 hours, and used to perform qualitative analysis for this research. The interviewees were two females and nine males with various ages, income and education levels, and a mostly conservative leaning group with no participant self-identifying as “most progressive” on the political orientation scale. Interviewees came from various socio-economic situations from low wage workers, business owners, and city officials, to recent (no less than 10 years) retirement age transplants from non-coastal areas. Each interview was given a unique identifier that is used for reporting in the following sections. Table 7 lists the demographics of each interviewee and survey respondent.

Table 7. Demographics of the interviewees and survey respondents. Self-reported political orientation runs from 1=most progressive to 7=most conservative.

Interview ID	Gender	Education	Income	Age	Political Orientation
INT_1	Female	Graduate	50 - 75k	45 - 64	2
INT_2	Male	Bachelors	75 - 100k	45 - 64	5
INT_3	Male	Not Finished HS	100 - 150k	65+	4
INT_4	Female	College No Degree	100 - 150k	65+	3
INT_5	Male	Bachelors	75 - 100k	24 - 44	5
INT_6	Male	College No Degree	75 - 100k	65+	3
INT_7	Male	Bachelors	50 - 75k	25 - 44	7
INT_8	Male	Bachelors	100 - 150k	45 - 64	6
INT_9	Male	College No Degree	25 - 35k	25 - 44	4
INT_10	Male	HS/GED	<25k	25 - 44	5
INT_11	Male	College No Degree	<25k	25 - 44	6
Survey ID	Gender	Education	Income	Age	Political Orientation
SURV_1	Female	Bachelors	100 - 150k	45 - 64	3
SURV_2	Female	HS / GED	<25k	18 - 24	7
SURV_3	Male	Graduate	75 - 100k	25 - 44	4
SURV_4	Male	Bachelors	<25k	18 - 24	6
SURV_5	Female	Bachelors	<25k	25 - 44	7

8.1 Qualitative analysis and Survey responses

Transcripts from the interviews were thoroughly analyzed using the coding strategy in

Figure 44. The coding strategy used in analyzing the transcripts was developed using the

same Preservation-Utilization framework as the Environmental Attitudes Inventory (EAI), reflecting the long-studied analysis of human- vs. nature-dominated attitudes discussed in chapter 4. For round one, *Preservation* and *Utilization* were weighted 1 to 7 based on the confidence and intensity of the corresponding statements using the sentiment analysis method. For round two, all subdimensions codes were unweighted and used as the textual evidence justifying the weighted codes applied. EAI survey results are reported with their corresponding qualitative code in the interviews to reinforce any finding.

The third round was not based on the EAI framework, and the codes were discovered during the reading unlike the first two rounds, which were predetermined codes. This third analysis revealed unsolicited stories about previous environmental disasters and feelings about the future of the environmental situation that were coded as '*concern for future environmental problems*' with subdimensions of positive and negative future stemming from statements made about the future.

8.1.1 Overall Vocabulary and Demographics

The coding strategy used in analyzing the transcripts used the framework of the Environmental Attitudes Inventory in accordance with the substantial history of analyses of the human-oriented vs. nature-oriented attitudes discussed in chapter 4. *YouARhere* represents climate related problems, using well-known local historic landscapes, in order to prompt a response (comments or a story) from residents and visitors. This response comes after engaging historic images, maps, and websites about the locations and their

surroundings using buttons within the on-site AR images. Participants view or hear about an imagined future situation and are prompted to tell their own stories. The resulting stories are meant to be experienced by other users who visit that location as a way to be involved in a cumulative writing about history and environmental change at the public level. This research captured those stories from the users immediately after using *youARhere* to gauge environmental attitudes and look for common sentiments among the respondents before and after using the app – any changes that might be attributable to use of the *youARhere* app. The two top level constructs, Preservation and Utilization, and their respective sub dimensions were coded in the first two rounds of qualitative analysis of the transcripts. The revealed sentiments and common feelings were coded in the third round. Figure 46 is a guide to all three rounds, the resulting shifts from utilitarian scored sentiments to preservationist, and will help organize the following sections into the analysis workflow. Results are discussed more in chapter 9.

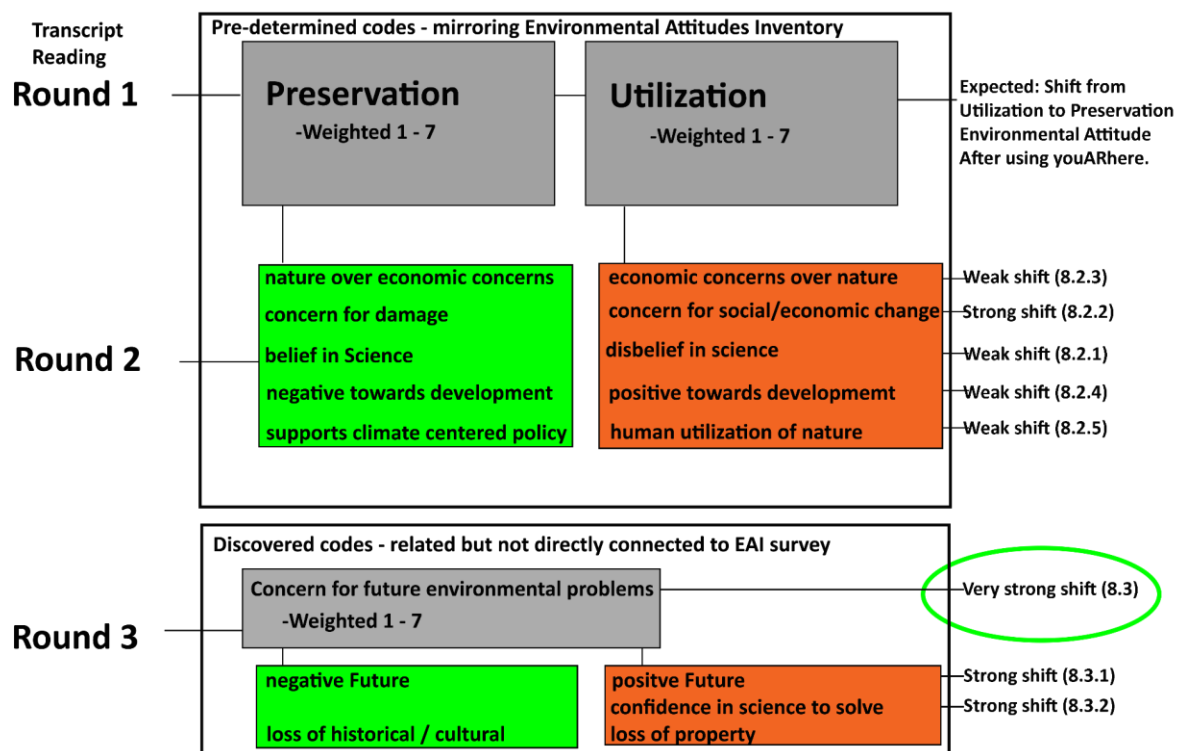


Figure 46. The results of the 3 analyses of the interview transcripts reported as a relative shift (weak, strong, or very strong) from preservationist to utilitarian attitudes with the relevant discussion section from chapter 8 in parenthesis on the right. The green circle is the strongest finding in the research.

Preservation Qual and *Utilization Qual*, the two top level ‘parent’ codes used in this qualitative analysis, along with their sub dimensional ‘child’ codes, dominated the analysis in the first 2 rounds of reading and coding. Figures 47 and 48 give a snapshot of the types of themes found before and after participants explored *youARhere* on their mobile devices. The mix between preservationist viewpoints and utilitarian were balanced in the pre-app-use part of the interview. This is sort of the state-of-thinking in the interviewee pool. Concern, preservationist minded sentiments, and a negative future outlook came to the surface after using the app. These terms and how they came to be

part of the sentiment analysis is found in the following sections and discussed in chapter 9.



Figure 47. A word cloud showing the prevalence of codes in the interview transcripts before participants explored *youARhere*.



Figure 48. A word cloud showing the prevalence of codes in the interview transcripts after participants explored *youARhere*.

The third and final round of reading and coding revealed common sentiments such as ‘*concern for future environmental problems*’ and ‘*confidence in science to solve*’ climate related problems. These concerns, weighted 1 to 7 in the interview transcripts based on confidence and intensity, and their qualitative significance, are discussed in the following sections.

Participants were demographically diverse (Table 7) but leaned conservative in political orientation. Counts of coded responses on both parent and sub dimension codes were mixed among all demographics except for Preservation coded statements that came more often, and more consistently, from progressive leaning people (figure 49) whereas more

conservative people showed utilitarian perceptions but less consistent (figure 50) with those views. This slight shift in the conservative with utilitarian perceptions (figure 51) is associated with items coded *concern for future environmental problems* after using *youARhere*, which is discussed more in section 8.3. This potentially represents *uncertainty* in the utilitarian thinking amongst the interviewees, which is also evident in the education demographic (figure 52), where less educated respondents revealed utilitarian perceptions in discussing environmental change before using *youARhere*, but weighted lower and with a slight shifting toward preservationist coded perceptions after using the app.

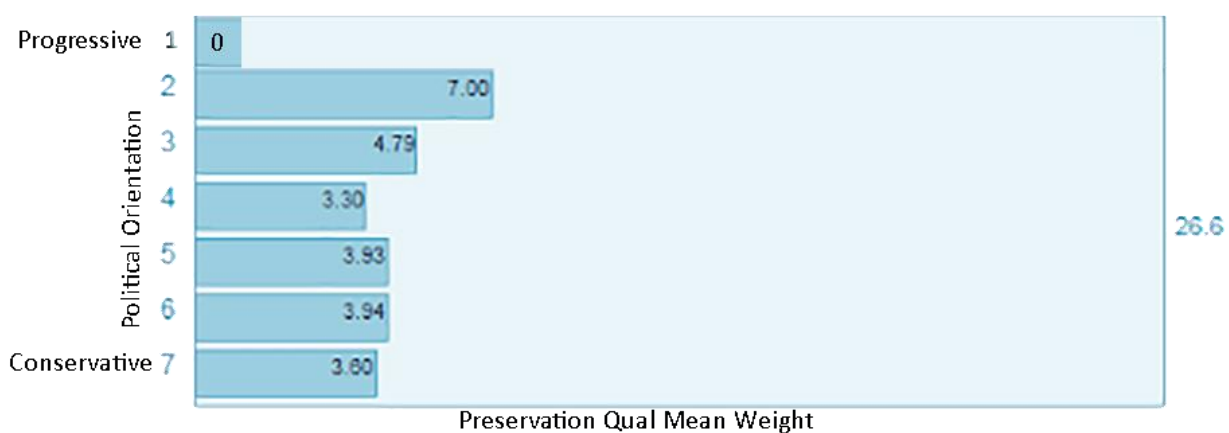


Figure 49. Interviewee political orientation (y axis) to mean preservation qualitative statement weight (x axis). No interviewee was a 1 - very progressive.

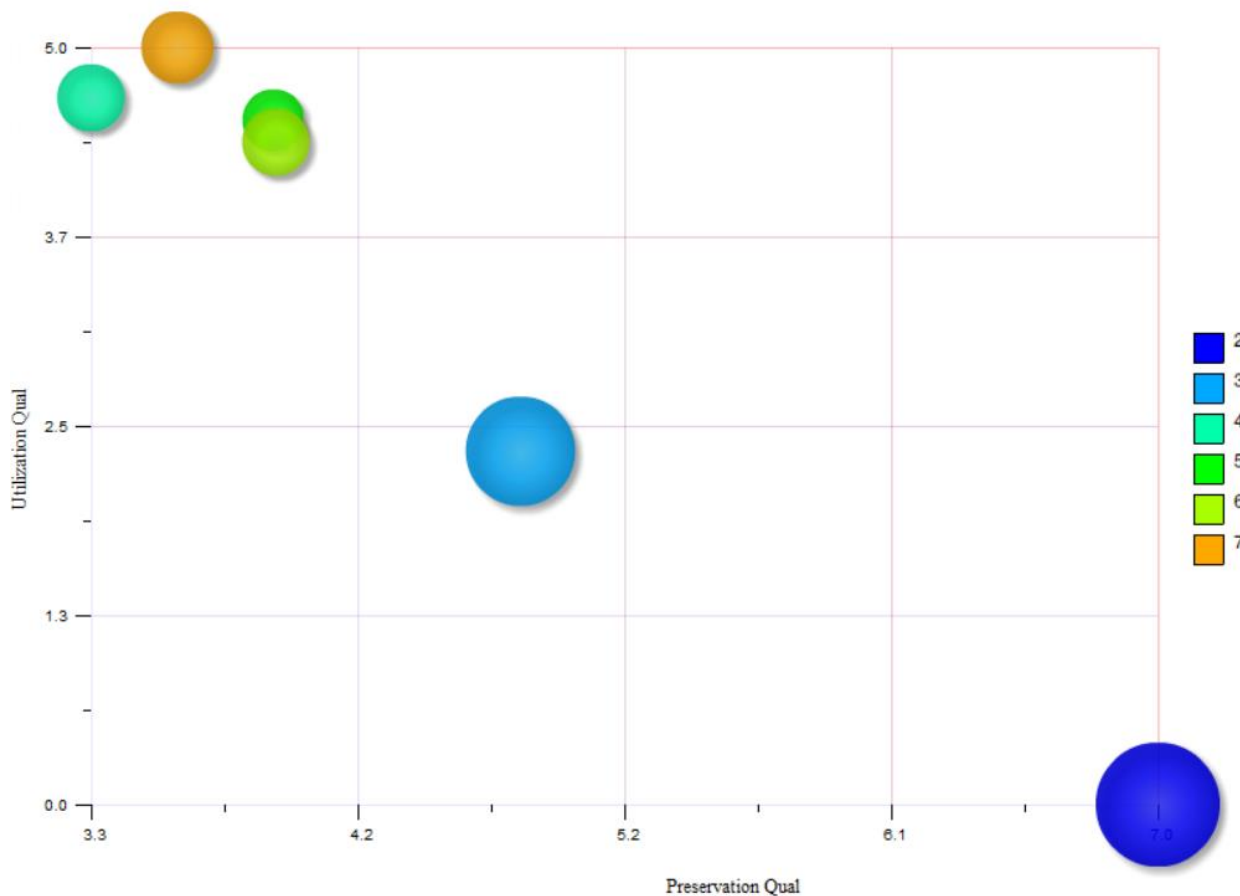


Figure 50. *Preservation* and *Utilization* weighted statements from interviewees (x and y axis) with color codes from blue to orange representing political orientation, where dark blue is most progressive among the interviewees and orange is most conservative.

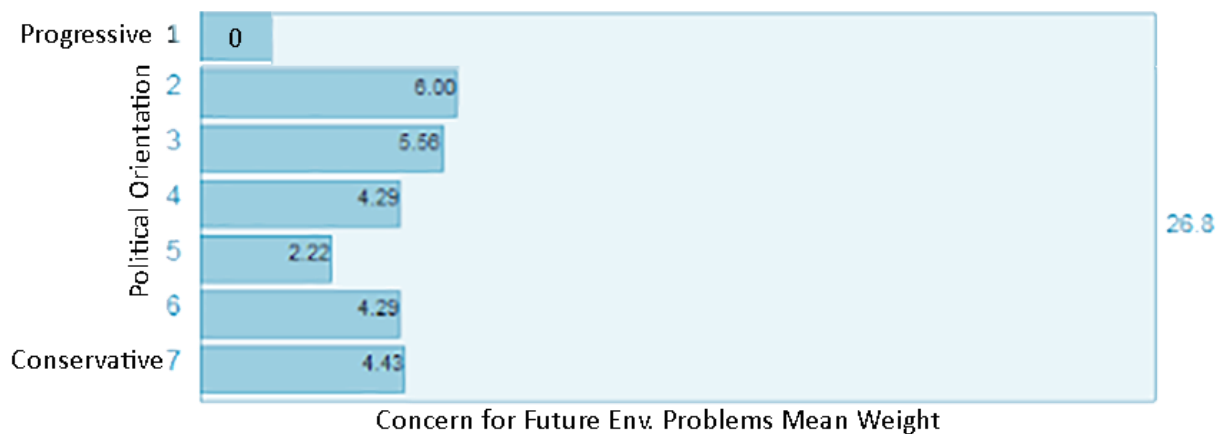


Figure 51. Interviewee political orientation (y axis) to mean *Concern for Future Environmental Problems* weight (x axis). No interviewee was a 1 - very progressive.

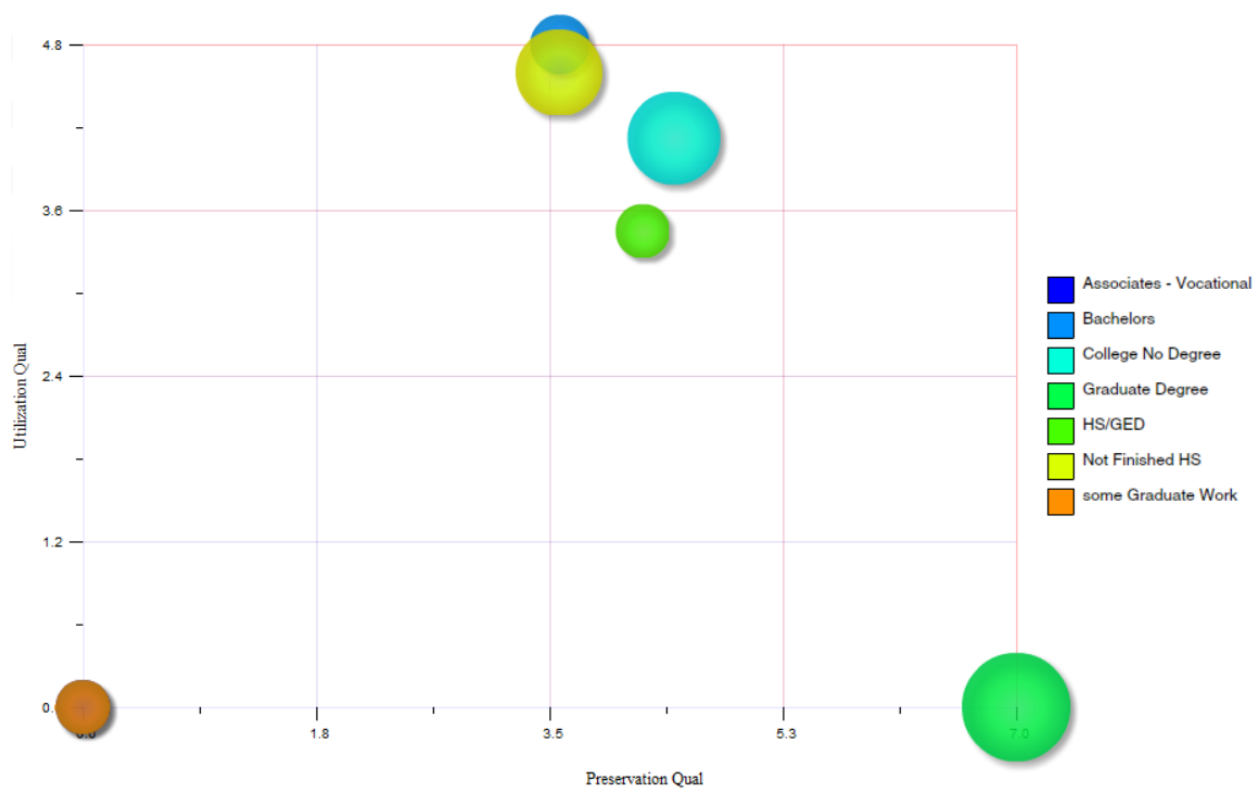


Figure 52. *Preservation* and *Utilization* weighted statements from interviewees (x and y axis) with color codes from blue to orange representing educational attainment.

8.2 Preservation and Utilization Results

Statements coded *Preservationist* increased slightly in weight after using *youARhere* from 3.93 to 4.85 mean total weight (from the 1 to 7 scale assigned before analysis) and discussions revealing utilitarian viewpoints decreased, although less strongly, after using the app during the follow-up questions and conversation from 4.49 to 4.20 (figure 53). The variance among the preservation minded interviewees was slightly less than the

utilitarian minded interviewees, 1.22 to 1.56 respectively (Table 8). This indicates that preservationist perceptions held slightly more conviction to concern for the natural environment and concern for environmental change than the utilitarian perceptions were toward their lack of concern for the natural environment or change. This is possibly owing to utilitarian-inclined interviewees showing concern for environmental change, but out of concern for property or socio-economic change as opposed to concern for the intrinsic value of the natural environment. This contextual effect can be seen in the high (4.4) variance of ‘*concern for future environmental change*’. This concern scale is discussed more in section 9.2. For example, a statement like this, coming from a participant less concerned for the future, when referring to future environmental problems:

Interviewee 11 - “*There's like, people who are concerned about it now [as if they are deceived], before we're not really concerned about it*” - low weight

Indicates a *slight* concern of the future by using the word ‘not really’, but not the same intensity of concern coming from another person predicting a positive future,

Interviewee 7 - “*the picture on the right-hand side is, I would say, frightening for anyone. Um, it's frightening to me.*” - high weight

The subdimensions warranting these preservationist / utilitarian results, mirroring those found in the EAI survey, are discussed in sections 8.2.1 through 8.2.5.

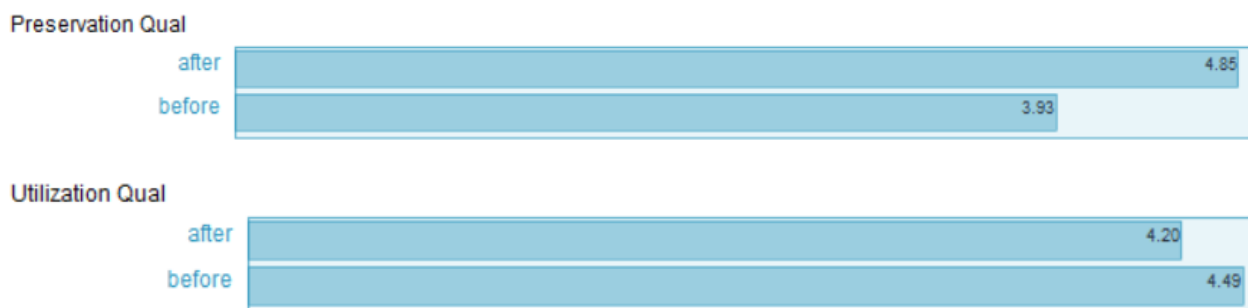


Figure 53. The top-level constructs (codes) under which all subdimensions are categorized, mirroring the EAI. There was a slight increase in preservationist leaning sentiments after using the app and slight decrease in utilitarian sentiments.

Table 8. Statistics on the 3 weighted codes under which all other codes are categorized.

Code	Count	Min	Max	Mean	Median	Range	Sum	SD	Variance
Concern for future environmental	40	1	7	4.17	4	6	167	2.1	4.4
Preservation Qual	67	2	7	4.1	4	5	275	1.1	1.22
Utilization Qual	62	2	7	4.47	4	5	277	1.25	1.56

8.2.1 Representing Sea-level Rise and Increased Storm Damage

The app represents many facets of environmental change and is inherently anchored in history because of its reliance on historic markers and storytelling. Interviewees got a sense of localized sea-level rise consequences and increased damage from storms through visual and sometimes audio augmentation. The content depicted in figure 54 shows the General's Island historic marker with its AR content displayed using *youARhere*. The historic image of a rice crop at that location was familiar to the residents who were using

the app as they had heard rice was grown there but were clearly more interested in the image on the right side of the augmented timeline. This depicts the highway running south out of Darien as flooded by the rising Altamaha River adjacent to the General's Island location. When users clicked the picture, an audio description of the scene played on the device speakers:

“Generals island is connected to Darien’s downtown by US highway 17 Bridge. Barely above water level, the road across the island is increasingly threatened by rising sea level, high tides, and storm related surges.”

The interviewees were asked beforehand about their belief in climate science or that the future of coastal Georgia would have more frequent storms and problems related to sea-level rise. The shift in sentiments for believing in these predictions was coded as *belief in science* and was expected to be triggered by representations like figure 50.



Figure 54. AR content over *Generals Island* Historic Marker located south of Darien, GA. The AR image on the left of the timeline is a photograph of rice fields in the location of the sign. The AR image on the right is an imagined future image of this location inundated by sea-level rise and future storms. The future image plays audio about the location when clicked on the mobile device screen.

Belief in science was a sub-dimension code of the top-level factor preservation with an opposite viewpoint, *disbelief in science*, as a sub-dimension of utilization. Interviewees did display differences in their beliefs in science before and after using the app when asked about the scientific community's correctness in predicting more frequent hurricanes and sea-level rise. People that expressed agreement with the tenets of climate science before using the app generally held those beliefs and were reaffirmed by the

visualizations in the app, only with more extreme statements, after using the app. For example,

Before:

Interviewee 6: “*uh, climate change and other stuff, like global climate change...it's quite, it's quite, uh, obvious the way climate conditions are.*”

After:

Interviewee 6: “*That'll be an island.*” - when looking at the Generals Island future image of a flooded road south of Darien.

-see other responses in Appendix A1

Interviewees who did not believe in predictions of sea-level rise and more frequent storms generally held to those beliefs after using the app. Although their stories showed more concern for *change* in general, they were directed to socio-economic (people moving in) or aesthetic (ugly condos) change as opposed to human safety or protection of cultural landscapes. Even though some utilitarian leaning respondents displayed instances of preservationist thinking in other subdimensions, all but one interviewee held strong to their disbelief in climate centered science. While they showed a non-hostile appreciation

for the imagined future images of the app, many seemed confused as to why these pictures did not match their convictions:

Before:

Interviewee 2:” *I'm not convinced about sea level rise. Look at, look at, look at Venice. Erosion would have happened anyway.*”

After:

Interviewee 2: “*It ain't happening, so what are you doing it for?*” - after looking at the Port of Darien AR content showing a future of marshland reclamation along the waterfront of Darien.

-see other responses in Appendix A

The EAI survey matches these findings with only 1 of the 5 respondents changing from a 4 - *neither agree nor disagree* to a 7 - *strongly agree* on the statement ‘*humans are severely abusing the environment*’ and reinforcing by going from a 5 -*somewhat agree* to a 2 - *disagree* on the randomized check statement ‘*humans are NOT severely abusing the environment*’. The other 4 respondents to the EAI survey stayed consistent on their disagreement that humans are causing damage to the environment, however, all 5 respondents tended to agree, before and after using the app, with the scientific

community consensus around climate change. Despite the investigator's efforts to avoid bias, people who believe in science were strongly represented in the respondent and interviewee pools. As for the interviewees stating skepticism to climate science, seeing Highway 17 through the center of Darien flooded triggered a response in most interviewees showing they believed it possible, but did not go as far as to make the skeptical individuals say that humans were causing it.

8.2.1 Representing Risk to Individuals

Danger is a common theme in the app content. This is a way to remind people of the likely dangers of the future and highlight some from the past that might encourage people to address the issue. Residents of coastal Georgia are no strangers to natural disasters yet still have a pride in the stories and landscape as if future disasters are of no concern. The desire to have economic success in the area, to retain the small-town life, and yet be aware of the fragility of the area can be at odds. Figure 55 shows the AR content for the *Sapelo Island* historic marker located in the parking lot of the Sapelo Island visitor center. Being one of the most treasured cultural places in coastal Georgia and situated in the complex marsh river system, the idea of extreme weather events comes close to home for the app user. Target locations such as Sapelo engage the climate skeptic and reinforce those that imagine environmental challenges in the future. For example, seeing a historic development from the island at the same time as seeing a projected violent storm on an adjacent island in the backdrop of the marker location should trigger the user to think about concern for people and places. These types of images, and the response to them, intervenes with residents' concerns for an economic and social change from the influx of

new residents, businesses, and asks them to think of how new residents and themselves might need to have more concern for damage to person and property vs. concern for change in the economic and social life of McIntosh County. These sentiments are coded below as *concern for social / economic change* (utilitarian) and *concern for damage* (preservationist).



Figure 55. AR content over *Sapelo Island* Historic Marker located north of Darien, GA along the marshland at the visitor center for the island. The AR image on the left of the timeline is a photograph of an old Sapelo structure. The AR image on the right is an imagined future of this location with a severe storm and damage.

Concern is a sub dimension of both preservation - '*concern for damage*' and utilization - '*concern for social / economic change*'. This is different from the '*concern for future environmental change*' expressed through stories discussed later in section 8.3. 7 of the 11 interviewees expressed concern for economic / social change more times than any mention of concern for damage resulting from hurricanes or sea-level rise. Interestingly, only 1 of those 7 continued statements, for or against, economic and social change after using *youARhere*. Furthermore, 4 of the 7 went so far as to react in a concerned way for environmental damage after using the app. For example,

Before:

Interviewee 9: "*I feel there should be more development basically, uh, because, uh, from the look of things Uh, we look quite developed, but there needs to be a couple of more development to help, especially, uh, you know, young graduates, yeah. For, you know, uh, provision of jobs and, you know, to make the county more comfortable for living.*"

After:

Interviewee 9: "*Yeah, yeah, yeah, yeah, yeah. I would say yeah, especially the, um, uh, the futuristic, uh, picture, you know [causes concern for future environmental problems], It's a mix, you know, I'm trying to study the picture and yeah. Um, the future of McIntosh County seems, whoa!*"

Interviewees who already held a concern for environmental damage tended to maintain that concern after using the app. An augmented image of a storm and old historic home that was taken away by weather naturally reinforce these viewpoints. This does not mean that participants who expressed concern for social / economic change did not express concern for environmental damage to themselves or the landscape and vice-versa, but both had more statements than the opposing view in the before-app-use part of the interview while the concern-for-damage group stayed consistent in the after-app-use part of the interview. For example,

Before:

Interviewee 7: *“honestly, it's affecting... mankind every day because we're in a disaster”*

After:

Interviewee 7: *“but the part of it that gets me like, I'm like, wow, this is so great. It's the part where it forecast[s] about future occurrence.”*

-see other responses in Appendix B

Statements like this also indicate the interviewee finding value in their use of *youARhere*.

Providing visualizations of the future changes of historic locations reinforces thinking

that something about the environment is changing and the future will have challenges and challenged skepticism found early in the interviews.

8.2.2 Representing Risks to Nature and Economic Well-being

AR augmentations of the Darien waterfront were among the most effective in getting people interested in the app. The waterfront is the primary visual of the town and represents the economy through shrimping, tourism, recreation, and new development. Any potential re-shaping or destruction of the physical waterfront almost means loss of the identity of the area. Using the app to show the waterfront returned to a more natural state poses a possibility that resists the economic, utilitarian mindset. For example, figure 56 shows a species map of shrimp along the waterfront and an imagined future image of the currently developing waterfront returned to an ecological buffer state. The user is engaged with the shrimping map and potential future at the *Port of Darien* historic marker located at the waterfront layering the experience with the past (shrimping), current (development and tourism), and future (return to nature) all in one place. Reactions may range from concern, disregard, or curiosity but forces the user to consider the possibility of such a future landscape.



Figure 56. AR content over *Port of Darien* Historic Marker located on the waterfront in Darien, GA. The AR image on the left of the timeline is a generic shrimping map. The AR image on the right is an imagined future of the waterfront reclaimed by the river.

Like the sub-dimension ‘*concern*’ from section 8.2.1, these codes were applied to statements of concern, but with the interviewee specifically expressing either nature over economics or vice versa. Neither viewpoint, economy-over-nature or nature-over-economy veered away from their stance for this sub-dimension. Neither side elaborated on this view after using the app. Extreme changes to the waterfront shown in youARhere was met with an increase in concern and sometimes a downright denial of the possibility. The utilitarian perceptions were possibly reinforced with a personal stake,

financially or with identity, in living in McIntosh County that fostered concern for the economy and property regardless of the message from *youARhere*.

Economy over nature:

Interviewee 3: *“I’m living in one of the most poorest counties in the state of Georgia. Uh, so I want to be able to take care of that side of, uh, my community too”*

Nature over economy:

Interviewee 10: *“And the best thing I loved about it was you used to be able to come right here to the harbor store and you used to go over this bluff right here and you can look out and see nothing, but fricking miles of stretching marsh land. Then to the rear, nothing. Yeah. What God put here. [Now], there’s the house, there’s a condo, but nobody is really getting to live in it. Yep. And I mean, you could just, from here, literally, if you looked right here at the end of this conduct, you could see literally from there all the way up looking at nothing for miles.”*

-see other responses in Appendix C

The EAI survey results were similar with only 1 of the 5 respondents slightly shifting their viewpoint towards nature-over-economy after using the app. Respondents stayed within 1 point (out of 7) in both before and after using the app for the questions,

-Protecting people's jobs is more important than protecting the environment

-Protecting the environment is more important than protecting people's jobs.

Because the interviewee respondents expressed their stakes in the economy of McIntosh County early on in the interviews, or directly expressed their admiration and enjoyment of the natural environment of the area, they typically maintained their preference for economy or nature. This is to be expected given the various life situations of the residents. Some talked of a booming fishing economy or the benefits of private property while others expressed concern for a changing *natural* environment that is the prized trait of the area for them, usually coupled with a fear and belief that environmental change is coming. Representing the economy and environmental change in single locations such as the area around the *Port of Darien* historic marker sparked conversations about the potential for future change, but any voiced change in the attitude of economy-first or nature-first did not happen, although the app clearly started a conversation about the potential for landscape change.

8.2.3 Representing Development changes

Representing development in *youARhere* forces the user to consider that more development in McIntosh means increased potential for damage or loss, not just loss of

the old look and feel of the county. The AR content challenges the decision of future development by showing localized scenes of what damage areas might look like. For example, Figure 54 shows the AR timeline at the Burning of Darien historic marker. Structures historically were burned, and loss of place was experienced through the workings of the Civil War and other events. Currently, old tabby structures are falling or being degraded by development (left side of figure 57). In the future, it is likely that flood, storm, and heat will cause loss of structures as well. For example, the Burning of Darien target shows an old photo of a tabby walled building on the waterfront that is currently fragile and threatened as well as a future scene, common to storm damage areas, of fallen trees, big machinery, and trash cleanup. These types of scenes are common in places hit by climate change events and showing this happening in Darien prompts the residents to consider development from a different perspective. This was measured as an attitude by categorizing interviewees as positive or negative towards development.



Figure 57. AR content over *Burning of Darien* Historic Marker located in Darien, GA. The AR image on the left of the timeline is a photograph of an old waterfront structure. The AR image on the right is an imagined future of this location with storm wreckage.

All respondents mentioned the increased and rapid development taking place in McIntosh County. This is the situation on the ground in Darien at the time of this writing and served as a catalyst to deduce environmental viewpoints from the discussion. ‘Positive towards development’ is a sub-dimension of *utilization* and ‘negative towards development’ is a sub-dimension of *preservation*, aligning with the EAI gaging rather humans should (or should not) dominate nature and that the natural resources should (or should not) be used for the benefit of humans. 7 out of 11 interviewees expressed

positive views of development while 4 expressed negative views towards development. They did not tend to sway from their opinions after using the app, with 9 out of 11 not mentioning development, for or against, in the post-app portion of the interview:

Negative towards development:

Interviewee 10: *“In my honest opinion, I think it'll be all demolished. All the old ruins and everything, and it'll be a big city. Yeah, I think it's going to take everything that people lived here before for and ruin it, like all the waterfront, just going to be nothing but condos and houses. Like just to destroy crabbing and shrimping and everything”*

Interviewee 6: *“I would love to see a big hurricane come through and just smack all these idiots that are building on a park.”*

Positive towards development:

Interviewee 8: *“I understand business and development and people discovering this place because this has been a little hidden gem for so many people over these years. This is where people come to get away from Atlanta or the big city, and now, It just is... what it is. And it's, it's just a sign of the times. I mean, yeah. They discovered it. Developers have seen, and this is a great opportunity. Um, and so I, I understand the development”*

Interviewee 9: “*it doesn't really make me feel any different.*” - when asked about their pro development stance after using *youARhere*.

-see other responses in Appendix D

However, many of the pro-development group would reminisce about the days of less development and talk old Darien as the ‘*hidden gem*’ and how new condos are ‘*destroying history*’ while still discussing, with pride, the ‘*great property values*’ and ‘*rights of private property owners to do what they want*’. The app plays with these themes in its visuals at locations where development has been, is currently, and will likely be in a future of environmental disaster. Only 3 of the 11 expressed genuine concern for further environmental disasters harming newly developed structures as opposed to newly developed structures disrupting the familiar look-and-feel of the landscape. However, several expressed more concern after seeing the speculative localized instances of damage on culturally appreciated sites via *youARhere*.

8.2.4 Representing the impacts of Policy change

YouARhere does not directly show or talk about ‘policy’ in the sense of environmental law or land management, but it does augment places with physical alterations that could be a result of such policies. For example, policies meant to mitigate environmental change or adapt to future disasters could result in landscape features like those illustrated at the location of the Fort Darien historic marker shown in figure 58. The historic branch

of the Fort Darien AR shows a 'wall' in the form of a bastion fort which was the plan for the fort in defending against Spanish encroachment in the 19th century. The projected future visualization depicts the locally popular waterfront with a sea 'wall' separating the businesses and condos in the commercial heart of Darien from the docks and river - a structural move reflecting a policy stance to "armor" the waterfront against flooding and storm damage, connecting the future possibility of a seawall protecting from rising water and storm surges to the past need for walls protecting against attack. Policy changes are also represented in the sea walls, raised (or even floating) houses, ecological buffer areas, reclaimed land, and other present in the on-site experience of *youARhere*. Support, or lack of, for conservation or environmental policies is readily investigated via conversations prompted by AR content representing policy driven change.



Figure 58. AR content over *Fort Darien* Historic Marker located on the waterfront in Darien, Ga. The AR image on the left of the timeline is a photograph of a bastion style fort. The AR image on the right is an imagined future of this location with a seawall to protect from the encroaching river.

AR representing government sponsored adaptation or preservation measures, regulation of natural resources, or rebuilding after an environmental disaster might stimulate support for climate centered policy (a preservationist perspective, in this case) or lack of support for climate centered policy (a utilitarian perspective, dislike of regulation). Out of the 11 interviewees, 7 displayed support for climate centered policies (usually yes or no answers) while 4 showed lack of support for such policies.

8.3 Clarifying the Dimensions of Concern for Future Environmental Change

The third and final round was to discover new emerging themes out of the conversation and register them as *new* codes. The most discovered and noticeable theme, as well as the most interesting finding in this research, was ‘*concern for future environmental problems*’ that came from the stories the interviewees told of their experience in McIntosh County (round 3 in figure 46). Furthermore, embedded in these excerpts were sentiments that science and engineering could solve future environmental problems. Finally, after expressing viewpoints, telling stories, and intervention with *youARhere*, it was easier to fit the interviewees into an attitude of a *positive future* for coastal Georgia or a *negative future* for coastal Georgia; a way to solidify the concern expressed after using the app.

The most visually compelling element of the app experience is the imagined future images depicting localized environmental change. Floods, storms, and physical human elements surrounding these disasters (bulldozers, storm chasing vehicles, and debris, for example) are all found in the AR content and stimulate the user, for better or worse, to consider the future. In both the app and interview questions, interviewees were asked about their view of the future of McIntosh County in the year 2050, which is part of the collective story of the place and here serves as a means to collect qualitative data that is used to reveal concerns for the future, and whether that future will be positive or negative.

These responses formed the sentiment (and code) “*concern for future environmental change*” and revealed much more about future perceptions than the rigid categories of the EAI primarily found upon AR content from the app such as that in figure 59. A debilitating flood in downtown Darien might be a shocking image to a resident of McIntosh County, and might lead to a more telling conversation than before using the app. Coupled with a historic map showing a surrounding river system in a different location than now reinforces the inevitability of change and thoughts about the future.



Figure 59. AR content over *McIntosh County* Historic Marker located in Darien, GA. The AR image on the left of the timeline is an old marshland map. The AR image on the right is an imagined future of downtown Darien with severe flooding during a storm.

Concern for future environmental problems increased after using the app, as expected, however, the stories became more intense, authentic, and confident after using the app, weighted higher in the direct talk of environmental problems after using the app (figure 60) from mean weight 3.59 to 5.38 (reminder, from the means of a 1 to 7 scale), the largest change of any weighted code in this research between before and after using *youARhere*. This shift in concern was seen in statements such as,

Before:

Interviewee 3: *“I don't know whether the weather had anything to do with it, to see it.. change dramatically, uh, there...Everybody talks about like, something has happened, but we don't know exactly what that something is.”* - when asked about flooding.

“developers want to come in and myself, as an entrepreneur, [want] land near the marsh, because, you know, value wise, it is through the roof”

Interviewee 8: *“I understand, I think. I think, you know, when it comes to, okay, there's a storm brewing. We see it's coming, but predicting basically, I think it's, I think it's a 50 50. I mean, it's, I don't think they, I don't think it's exact. Yeah. I don't really think they [know]”* - When asked about scientific community consensus on hurricanes and sea-level rise.

“Does anyone talk about it? That had never entered my mind.” - when asked about considering environmental change when moving to Darien.

After:

Interviewee 3: *“Wow. That that's, that stops. They, uh, not only just, it stops everything when you can't cross over. And our case it's like being on an isolated island and need to get to the hospital”* - after reviewing Butler Island Plantation and General's Island signs using the app.

“Now I do remember we had to shut the city down, even since I've been on city council. We have to shut it down more than once before. We had to shut the whole highway down. You couldn't even drive to Brunswick.” - told with audible excitement and concern.

Interviewee 8: *“Well, you know, one thing I've noticed, and this is just recently, I've noticed the rising waters...this is off cuff, so to speak, but I've just noticed that our, the watersheds, I know we've got a lot of rain, but I've just seen, I've never seen it this high before, and I've seen roads covered.*

I mean, even on St. Simons or Jekyll, I've seen them. They're encroaching water. I was like, all right, where's this coming from?”

“That's the one that's so close to our house, the black island road is near where we're living now. Some people walk...wow, I think things are changing”



Figure 60. The mean of the weighted interviewee statements about ‘concern for future environmental problems’ before and after using *youARhere*.

However, these findings do not indicate that the participant stopped supporting development, adopted support for climate policy, or stopped having a distrust in science that was stated *before* using the app. Their environmental attitudes remained consistent, but a rethinking of their previous answers after using the app prompted stories of environmental change they had previously not mentioned. Using the app-initiated statements about environmental concern for human health and well-being perspective while remembering environmental extremes they have seen in their time in McIntosh. Even before using the app, interviewees who tended to view the environmental future as positive and displayed utilitarian perceptions on most subdimensions still expressed a concern for the future through their stories of change in the discovered theme of *concern* but stopping short of acknowledging extreme change in the future. For example:

Interviewee 2: “*Yeah, as you, because the sand shifted. So I'm not convinced that about sea level rise. Look at, look at, look at Venice. Erosion would have happened anyway.*”

Interviewee 10: *“It wasn't really much to, it, it just basically the practical storm. It wasn't much to it. I mean, there was a few down trees and things like that along those lines. I mean, because I am in [the] fire department, so I had to go help cleanup...but other than that, it wasn't terrible. And you had a few roads that were blocked in my life, severe water covering them. But other than that, it wasn't nothing terrible.”*

8.3.1 Confidence in Science to Solve the Problem

Alongside concern for future environmental problems were unsolicited statements about how science and engineering entities could fix any environmental challenges that lay ahead and appeared in many conversations. AR content such as figure 55, the Darien waterfront AR, reminded the viewer of potential policy changes to the waterfront that could also be interpreted as science and human engineering's ability to protect us from climate related change. Both before and after using the app, people talked about physical interventions they had seen before. Therefore, the code ‘*confidence in science to solve*’ was used in this third round of analysis. A slight decrease in ‘*confidence in science to solve*’ climate related problems (figure 61) after using the app came mostly from statements like ‘unstoppable’, ‘uncontrollable’, ‘nature will take its course’, as opposed to the engineering minded / trust-in-adaptation-measures statements mentioned before using the app. There were 14 statements similar to this:

Before:

Interviewee 7: *“[We would] probably have handled, have handled, uh, you know, issues of sea level rise and issues of hurricane and level of development, education, scientific discovery, and, uh, uh, other issues making McIntosh County a very comfortable place to live.”*

Interviewee 8: *“It was the last big storm, and I don't know why it was the one that hit the coast... It looks horrible. And we're heartbroken cause they had just revived. They have just redid their house to have a 60 foot sunroom overlooking the marsh. And it was beautiful. But when I came there, there was debris and docking systems and, and wood and Styrofoam and flotation, all over the yard...but then what's so crazy, a year later I came back and they had the Army Corps, whoever did it, removed everything and is right now is actually the most beautiful I've ever seen.”*

And 2 lower weighted statements like:

After:

Interviewee 7: *“[is this a] possibility? I don't think it's too farfetched.”*

Interviewee 8: *“I know we've got a lot of rain, but I've just seen, I've never seen it this high before, and I've seen roads covered.”*



Figure 61. Statements revealing a confidence in science and engineering’s ability to fix any climate related issues decreased in both weight (mean 5 to 4) and quantity (14 to 2) after using *youARhere*.

The EAI survey respondents all responded 5 - agree or higher on the statement, “Modern science will solve our environmental problems”, with 2 of the 5 respondents raising their agreement from 3 - disagree to 5 - agree for the statement, “Modern science will NOT solve our environmental problems”. This indicates moderately strong agreement amongst the survey respondents that science can fix the problem.

8.3.2 Perceptions of the Future of Coastal Georgia

Finally, interviewees give an idea about their perceptions of the future, either from their own stories or by answering the question, “*What do you think the coastal Georgia landscape will look like in the year 2050?*”. These were generally in the form of a *negative* or a *positive* outlook of the future, and therefore, were coded as such. While most of the AR content in the app depicts a bleak future, it prompted both agreement and disagreement amongst the interviewees, not shattering deeply entrenched beliefs but opening the conversation to consider the possibility. 4 of the 11 interviewees shifted from positive statements about the future to negative after using the app. 3 of the 11 made statements about an environmentally challenging future and held to those beliefs

after using the app. The other 4 maintained a positive, development driven, confident expectation for the future before and after using the app. Statements indicating a slight shift in future perception of coastal Georgia included statements such as:

Before:

Interviewee 3: *“opinions are different sometimes, but I do see that, uh, 50 years from now I think is going to get better.”*

Interviewee 5: *“I think it'd be better. I think it'd be better. More upgraded.”* - regarding the environmental conditions in 2050.

After:

Interviewee 3: *“you got a visual of seeing the water is in a spot that it wasn't even built to be that way. Um... it will affect everything “*

Interviewee 5: *“I'm a bit concerned. Maybe this could actually really be, will happen in the future, [It won't] be nice.”*

Similar to concerns about future environmental problems, these statements do not mean that environmental attitudes or disbelief in climate science was changed but does indicate a possible break in the confidence in the future held before using *youARhere*. This slight break with confidence in the future and uncertain confidence in science to solve those problems is more of an effect the app had on the users than any noticeable change in strictly defined EAI environmental attitudes.

Chapter 9

DISCUSSION

The findings of this research are summarized in figure 62, showing the relative strength of any shift from *utilitarian* to *preservationist* environmental attitudes before and after using *youARhere* - termed *weak shift*, *strong shift*, or *very strong shift* to place the resulting reaction to using the app relative to each other. The first 2 rounds of reading and coding and results of the EAI survey reveal that *youARhere* does not dramatically change entrenched environmental attitudes except for a strong shift in the types of issues users are most *concerned* about; economic and social changes vs. environmental changes that affect people and places. However, what is significant here is the apparently strong change in concern for *future* environmental problems (circled in green in figure 62) discovered in round 3 in individuals who revealed utilitarian perceptions who were prompted by the app to tell stories of environmental change they had witnessed and were concerned about moving forward. Most interestingly is that this concern for the future is coupled with a belief that science will solve any climate related problems, but this belief feels uncertain.

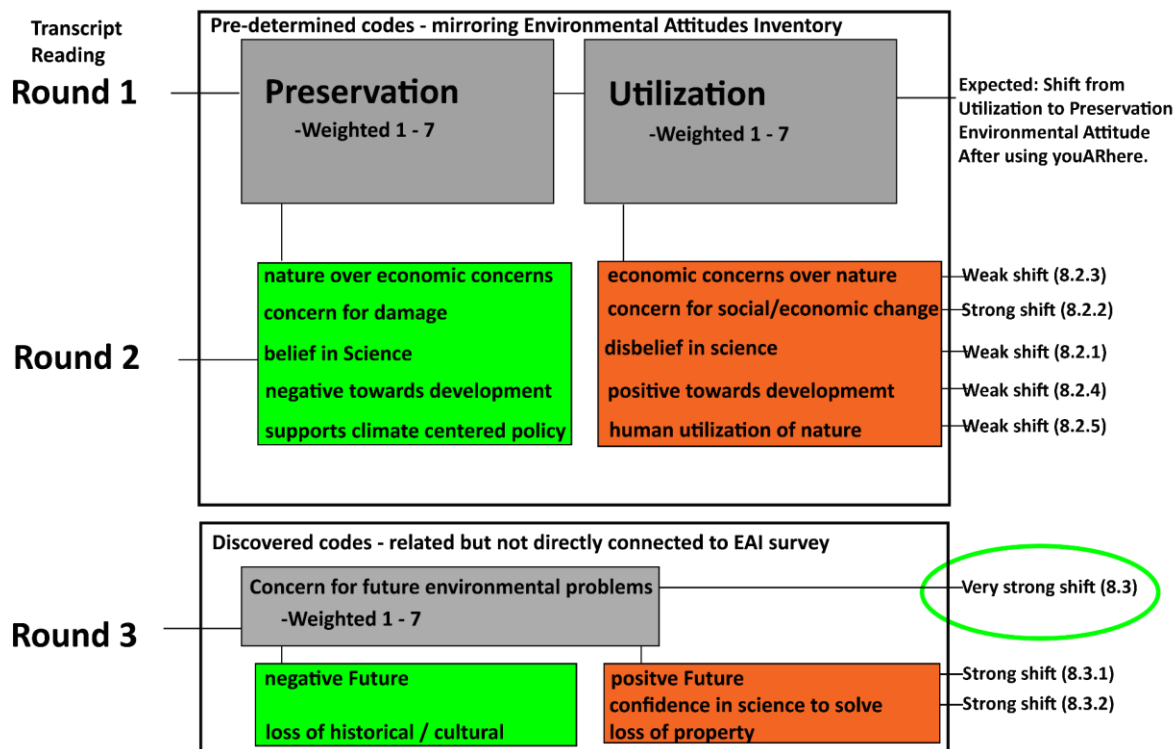


Figure 62. The results of the 3 analyses of the interview transcripts reported as a relative shift (weak, strong, or very strong) from preservation to utilization attitudes with the relevant discussion section from chapter 8 in parenthesis on the right.

9.1 Persistent Environmental Attitudes

Why would the utilitarian environmental attitudes of residents of McIntosh County remain so entrenched in the face of scientific consensus, artistically rendered messages shown on site through augmented reality, personal experiences, and an on-site AR storytelling stating that environmental change will be a part of the next history of Coastal Georgia and is driven by climate change? Clues to the answer lie in the underlying traits of the environmental attitude inventory. These constructs - *preservationist* and *utilitarian* environmental worldviews, and their subdimensions - *nature vs human needs*, *belief in science*, *support for policy*, *concern for damage to life and property*, and *personal actions*

are not just formed from one experience. These are developed over many life experiences and exist as perceptions, almost involuntarily connected to a person. Therefore, having a single AR experience is not likely to change these deeply complex views of the human / nature relationship; especially when mediated by the political, social, and demographic situations of people (discussed in the beginning of chapter 8). This does not mean that measuring environmental attitudes and looking for shifts to more climate change aware thinking is a failure in the research on environmental communication technology. Measuring environmental attitudes is, indeed, a tested and scrutinized method (see chapter 4) of discerning someone's view of themselves in nature and proves an organized and sensible starting point in investigating changes in *attitude* about environmental situations, including climate change induced environmental disasters of the future. Breaking down the sentiments found in these attitudes helps pinpoint where thinking is shifting after an intervening experience like *youARhere*, even if entire attitudes are not changing all at once. Consider the subdimensions of the EAI themselves and how much life experience goes into forming the beliefs within each and what using a mobile AR communication tool does or does not do to better inform future decision making. Utilitarianism, as a philosophical position, does not mean that someone does not believe in science, nor does Preservationist mean someone does not appreciate the luxuries of owning private property or living on the coast. However, considering these terms as perceptions of the relationship between human and nature, can help organize thought into people that have a stake in dominating nature or those that respect it, and see the value in protecting it. Therefore, it is likely that these viewpoints are catalysts to research shifts in thinking when climate change demands our attention.

9.1.1 Interpreting Reactions to AR Representations of Risk

Visualizations like those in figure 54 - 59 all extracted responses to a future of environmental problems that, for most of the interviewees, had been obscured by positive outlooks on the future that ignored past personal experiences and predictions of environmental disasters. Seeing the concrete representations of places, they know and identify with, in plausibly altered AR content, reinforced the views that environmental change was inevitably coming and challenged the views that do not consider such a future. Seeing the possible impacts of property destruction at a familiar location with the app made those concerned with private property value and rights react defensively. Representing a blow to the economy by having a waterfront reclaimed by the river had the same effect. The mobile app illustrated the risks that citizens of coastal Georgia face. However, those that already believed in a future of climate related challenges posing a risk to property, the economy, and individuals before using the app, felt their attitudes simply reaffirmed and thus were not as intense in their responses. Harm to property rights or the economic benefits of McIntosh County citizens and business was illustrated in the augmented content representing a potential future. The one sub dimension of the EAI where use of the app did lead to a strong shift was *concern for damage vs. concern for social or economic change*. This shows that interviewees are thinking about possible damage in the future. However, where concern for change was talked about alongside utilitarian perceptions it was as a shift away from the small hidden gem' shrimping town with tabby ruins into a new condo town with vacation and Airbnb homes. After using the app, the concern became more focused on changes in human health and safety and

physical change to the landscape from environmental occurrences. This indicates that while the dominant belief is in a positive future with minimal environmental damage, there is increasing concern for future damage embedded in those conversations. Simply put, talking about the loss of the old waterfront town because of economic reasons sometimes transformed into talking about loss of the old waterfront town because of damage from both development and encroaching water or storms.

9.1.2 Interpreting Reactions to Underlying Threats to Nature and Economy in AR Content

The app content is not only meant to show threats to individuals. Visualizing the Darien waterfront with a seawall also indicates a threat to economy, property rights, and a natural landscape. Regardless of environmental attitudes the AR content reflected and represented layers of threat as well as layers of history and place. Responses to images that represented changes to nature and the economy showed concern for both direct and indirect impacts of change. Interviewees were involved in different economic situations and had different stakes in the future success and safety of McIntosh County.

Developers, retirees who invested in homes, city officials on the hook for keeping the economy growing, figure heads in conservation, and anti-development, nature-first, longtime residents made up the interviewee pool. For them, *nature vs. economic concern* revealed concerns with more immediate impacts, that environmental damage would harm the natural environment that preservationist minded people tend to enjoy and, for others, that environmental damage would harm the thriving influx of people and economic gains of the community.

Taking a longer-term view of change, *concern for damage* reflected concern for damage to person and property vs *concern for social and economic change*, the concern that the social makeup of McIntosh was changing and was more of an important issue than future damage from a storm. Individuals might worry about a hurricane occurring sometime in the future or about new people moving in from somewhere else and ruining the good ol' shrimping town, but both come from a different perspective.

Individuals concerned with future damage causing events find support for their thinking in *youARhere*. They might find some benefit in a more developed area or a slight hope that environmental changes will not come, but overall are believers in climate change and stay strong in that perception of the future. The climate skeptics have been confronted with climate change discussion and imagery before and are not easily swayed towards a different viewpoint. The developer is likely seeing benefits to life from developing, the city official maintaining the will of the people benefiting from a growing economy, the retiree wanting their investment in a McIntosh home to be a good, fulfilling decision. This would naturally place them in a utilitarian mindset that is strongly shaped by the psychological need to have made the right decisions confirming the "learned disposition" found in the attitudes of people based on life experiences as put forth by Martin Fishbein and Icek Ajzen's (1975). While the experience with *youARhere* recalled memories and concerns of a problematic environmental future for McIntosh County, it makes sense that an extreme environmental shift from perceiving a positive future of economic growth and

good life on the coast to a cautious, educated, and preservationist mindset would not come all at once, from one piece of information, from experiencing (or telling) one story.

9.1.3 Interpreting Reactions to AR Representations of Sea-Level Rise and Increased Storm Damage

Resistance to considering nature and environmental change in economic and property considerations, interestingly, appears alongside *disbelief in science*, which was also found to be a weak shift among interviewees. Flooded roads, islands, and images of tornados behind famous churches and tourist locations created concern but did not seem to affect belief in climate science or make people indicate they would vote for climate forward leaders. Often, the concern for these types of extreme events, after using the app, came from the historic side of the timeline where previous floods or structures no longer standing were presented. This indicates that the app's historical aspect triggered more concern for floods and storms than the future images, evident in the stories of storms and floods seen by the interviewee. For example, showing the Butler Island Plantation house flooded in a photo from the 1930s did more in persuading users that did not mention flooding that the river is very close to the house, and this could easily happen again. The futuristic image, with a raised walkway above a permanently river-reclaimed Butler Island home from sea-level rise did not spark the same interest in the likelihood of a flood happening. So why the disbelief in future predictions of such storms? As stated, these people have likely heard some version of climate change centered arguments for sea-level rise and hurricane frequency and have a skepticism, if not denial, of the scientific consensus on climate change and predictions of environmental change in coastal Georgia.

This tendency towards disbelief, amongst the utilitarian perceptions found in the transcripts at least, is strengthened by an economic-over-nature viewpoint. Although not directly measured, this is potentially a reaction to a fear of having to change life situations from disaster, especially among the participants who have always lived in McIntosh County or have no financial concerns either way. Furthermore, a lack of support for climate policy accompanies the disbelief in science. Although there were a few instances of statements like, ‘*what are they going to do about it*’ and ‘*something needs to be done*’, the skeptical individuals still did not support a tax for adaptation or show a willingness to vote for leaders based on climate centered policy agenda. Again, this lack of intentions was borne out of many life experiences and contexts. They are not easily abandoned.

9.2 AR Content and Prompting Concern for the Future

The real discovery in this research was found in the unsolicited patterns of the qualitative analysis, outside the parameters of the EAI. Specifically, the significant finding here is in the *concern for future environmental problems*, discussed in section 8.3, found in almost all the interviewees after using *youARhere*. While reading through the transcripts the first two rounds looked for statements fitting predetermined codes based on the constructs and subdimensions of the EAI, it became apparent that a more generalized coding for “concern for future environmental problems”, negative and positive outlooks on the future, would be a useful exercise to reveal patterns of concern noticed during the transcript readings, but not addressed in the strict coding EAI structure. Furthermore, the psychological and philosophical constructs Preservationist and Utilitarian, while efficient

in categorizing thought about the human and nature relationship in individuals' attitudes and behaviors, could not reveal the current state of concern around modern day *un-*natural disasters related to climate change, they could only address a perception held about the natural world in general. Simply put, people can lose confidence in perceptions, feel threatened by environmental catastrophe, and show concern for a potentially negative future, yet they believe in unrestricted use of the natural world for human gain, stand for preserving the natural world for human safety from climate change, or some level of conservation in between. An alternative framework for perception of climate related problems would be to adopt *positive* or *negative* views of the future, levels of *concern*, or levels of *loss of confidence* in views once held. These terms might be more indicative of attitude changes after the intervention of landscape-based AR communications.

9.2.1 Reacting by Telling Stories

The app prompted users to tell stories of damage they had seen before, environmental change, and display concern from talking about those stories. This concern was expressed in stories of experienced environmental change and intense expressions of concern for the landscape and the people living there. While not being a lightbulb moment signaling a change in environmental attitudes, the post-app interview prompted stories and concern for environmental damage that were either not present or not as strongly stated in the pre-app-use part of the interviews. The flooding of roadways, the damage to docks, homes, and marsh front property (in and outside of McIntosh County),

the flooding causeway leading to Tolomato Island, talk of hurricane experiences and those of neighbors, *noticing* more rainfall, destruction of cultural elements, and of what *might* happen if the imagined future images were reality, and that it was a *possibility* - all came to the surface after using the app. Furthermore, several interviewees expressed their belief that science and technology would save the coast from any environmental woes that would come in the future. There were acknowledgments of ‘*nature taking its course*’ and perhaps making the landscape ‘*better than it was before*’, of hopes of the US Army Corps of Engineers fixing problems along the waterfront properties, of FEMA maps that were (or were not) *wrong* about a potentially flooded area in the future, of forecasters *doing the best they can but do not actually know*, and statements about *youARhere* and how ‘*tools like this could help developers*’ mitigate these problems yet still continue business as usual. The interviewees’ stories of loss of property or historic landscapes seemed more authentic after using *youARhere*. While not having the quantitative support identifying changing environmental attitudes that might have been found in a more rigorous application of the NEP Scale (Dunlap et al. 2000), the qualitative findings of subtle changes in the conversations that followed residents experiencing *youARhere* on their mobile devices indicate that use of the AR app disturbed previously held attitudes and beliefs in intuitively reasonable ways.

9.3 Uncertainty as a Response

While only some of the interviewees made statements anticipating a *negative future* for coastal Georgia, almost all talked about concern for future environmental damage. While there were several whose interview statements revealed a positive view of the future, they

also revealed uncertainty in their thinking. On the surface, interviews with people suspecting a positive future expressed a pro-development, private property rights, economic centered, perception of the future coupled with a disbelief in climate science together with a firm belief in the effectiveness of mitigation measures. Nevertheless, although science would have '*figured it out*' and fixed any problems in the future of the coast, there is still an underlying uncertainty in that belief. Use of *youARhere* increased their uncertainty and nudged the science skeptic resident into making more thoughtful decisions.

The interviewees' frequent return to the theme of uncertainty may mask a renewed fear of the natural world in the form of climate change, hurricanes, and sea-level rise.

Harnessing that fear to form educated, logical, and humanities-based decision making is the next phase of planning for a climate change altered future, reinforcing Robert Fisher's (2019) statement,

“The premises of the conversation [of environmentalism] shifted away from love of nature and toward fear of survival. [From there] we moved from the heart to the mind, asking that we be motivated by distant consequences” [e.g., heating up, weather extremes, water levels rising]. (p.131).

Chapter 10

CONCLUSIONS

Representing environmental change through the context of history at documented and marked locations across McIntosh County with mobile AR content and user stories is proposed as a supplement to traditional tools and a case for mobile AR in environmental communication and planning. The *youARhere* app displays representations of environmental change, relevant to the site where the app is being used, and makes them local, displaying them on a timeline “attached” in augmented reality to a historic marker, presenting the imagined future as another layer across the landscape and its history. The aspect of the tool that is different from currently existing emerging technology tools for environmental work is that it immediately asks for responses to the content so that users can augment the experience with their own insights and understandings. Observing user reactions to *youARhere* provided a look at the pros and cons of these types of tools. It showed how perceptions of human/nature relationships, in the context of anticipated climate change, can be affected, shaken out of the social context in which they are entrenched, and what types of digital experiences cause people to consider alternative futures. Attitudes are the product of an individual's psychological traits molded over time by various sources of information, social connections, and many other life events. The conversations with the residents of McIntosh County revealed attitudes about the environment, a changing landscape, and living in McIntosh County. Seeing people

reinforce their current thinking or question it based on AR images of localized scenes of speculative future scenarios showed which aspects of environmental change were considered plausible by the app users; which were responded to with skepticism; and which caused a shift in thinking or concern for the future. Because the general feeling about the environmental situation in McIntosh County can easily be discerned from talking with the residents does not mean those feelings are easily changed after a one-time use of a mobile AR application. However, in most cases, there was already concern about the on-going changes in coastal Georgia present in the conversations before using the app, revealing a sense of uncertainty about the future of coastal Georgia. The app seemed to encourage residents' storytelling; talking about environmental change they had seen during their time living in McIntosh County and playing out in their responses what that *could* mean for the future. Seeing historic tabby walls alongside futuristic sea walls, old historic structures alongside a reclaimed waterfront, or seeing flooding in the prominent, valued, picturesque downtown Darien recalled examples of environmental damage that participants had seen and prompted them to consider their thoughts about the future. This was interesting because the after-app-use portion of the interview started with the author asking, "*now that you have used youARhere, does it make you think any differently about the things we talked about earlier*", and before getting to more specific questions, the interviewees tended to talk about similar situations to the imagined future images shown as AR content they had seen or were concerned about in the future. This is an important pattern because *youARhere* is meant to collect stories and among the interviewees, stories were prompted. How seeing/hearing other people's stories and participating in AR experiences can shape someone's overarching environmental attitude

over time will emerge from observation of increasing instances of AR and storytelling but communicating environmental change and *eliciting* stories of environmental change is attainable with tools such as *youARhere*.

10.1 Limitations and Importance of the Research

This research depended heavily on residents of McIntosh County, Georgia, using the mobile app, *youARhere*, and reporting back deeply personal perceptions through answering questions, having conversations, and telling stories. The advent of the Covid-19 pandemic in March 2020 created a debilitating impact on this research, requiring significant redesign before any progress could be made. The original intention was to conduct an online survey, then face-to-face introduce people to the app at a series of public meetings in Darien, then conduct a follow-up survey. This face-to-face public engagement was impossible during the pandemic. This limited the ability to make conclusions about users' responses if they were on site, by themselves, experiencing and contributing to *youARhere*. However, on the positive side of these unforeseen circumstances, the interviews provided much greater insight than survey responses into the potential role of an app like *youARhere* in revealing citizens' concerns for future environmental problems and into the app's ability to affect users' attitudes and intentions to act in the face of projected significant change.

10.1.1 Development of Mobile Apps

The development of a mixed reality tool like *youARhere* has various levels of complexity. Even relatively simple system designs require an array of tools, including software

engines that perform core functions, coding libraries, graphic user interface toolboxes, and online services, each of which requires programming and may need customization as more functions are added. For example, creating a survey online and having a user click a button or link to open that survey is straightforward. However, if the users' responses are expected to populate a table on a website, a map inside an application, or a database accessible to a research group, for example, then it takes additional technical steps to automate moving between the required components. This movement of data is often referred to as '*the background*' when talking about public facing applications. The background design is where programming becomes necessary. *YouARhere* has a complex background design. Figure 63 shows how a user's contributed data moves throughout the system architecture and where programming or database management knowledge was required for the app to function properly. One example is the series of steps required to make images along the AR timeline visible when a person is pointing the device camera at a historic marker. Those images are also buttons that open websites, audio, or videos when clicked. It is relatively easy to display an image on an AR timeline when the device recognizes an AR target (like a historic marker). However, adding the ability to click that image and navigate to something else meant creating a script in the C# programming language within Unity that '*listens*' for clicks of objects then translating that script to work in Wikitude, the software development kit (SDK) used to create the augmented reality functions. Another hurdle when developing for networked mobile devices is the operating system compatibility. Many of the AR, survey, and web creation tools currently available will work on the primary mobile operating systems - IOS, Android, Windows, and Google. However, when you connect those tools into a custom

application, there are other additional specifications and code libraries that each operating system requires. Each of these updates independently of the functioning survey, mapping, AR, or web page tool and potentially requires additional programming to call in or extract the functions that enable the app to work properly when updated. These are issues that were addressed with *youARhere* and took many iterations of the app to get to a best-working version.

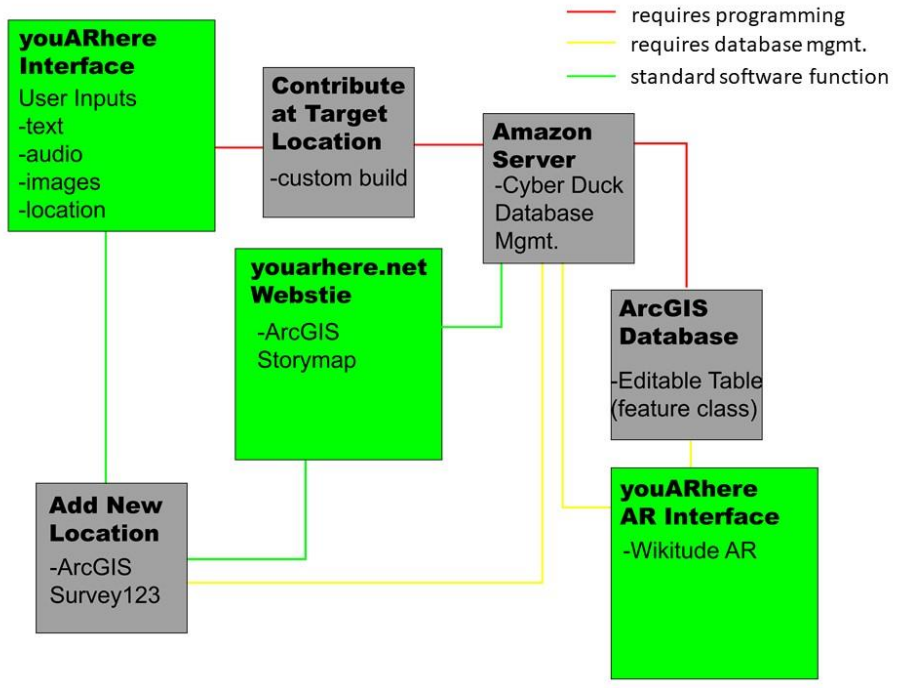


Figure 63. The path of user input data from the app interface to the website and/or back to the app, along with tech skills required to develop each part.

10.1.2 Maintenance for Mobile Apps

A notable problem for complex networked apps, such as *youARhere*, is not development but maintenance. As discussed above, the required stringing together of many out-of-the-box tools for mobile devices (as well as for web, desktop, gaming system, or other platforms) increases the complexity of the app and makes updates and maintenance constantly needed as a result of the different sources and goals of the tool makers. Simply put, individual augmented reality functions might work indefinitely once they are embedded in a device, such as a phone or tablet for example. The same can be said for a survey 'form' like those created in Qualtrics or ArcGIS Survey 123. However, when you combine the two along with the required intervening data transfers between ArcGIS online or an Amazon Server, the app can potentially malfunction if one of those organizations, or Android or IOS for that matter, decides to update or change their platform. These companies are not working in tandem for the benefit of any one person or organization's application who has mixed them all together. That is why mobile application, web, and desktop software companies have IT on staff; to handle maintenance upon updates. These independent updates were a major concern for *youARhere*, and the author and developer attempted to minimize aspects of the app that would need constant maintenance. On the other hand, a simple AR experience *OR* a survey experience that are not linked would likely not require these fixes as often, if ever, but would lack the advantages and opportunities that can arise from integrated apps. It is important for planners to not shy away from using emerging technology tools, but to be aware that more functions bring more complexity and maintenance. Judging by how common this problem is across sectors, both inside and outside environmental work, tools

to automate maintenance are likely to be available in the future just as development, in the past, required programming but is now available for all with code-free tools.

The need to embrace this level of technological development seems to be a barrier to the adoption of such apps in environmental communication, planning, and design because it is assumed that high level programming skills or software development staff are required to participate. At the time of this writing, AR experiences, location-based surveys, and websites for mobile devices can be built and delivered without programming skills thanks to tools such as ArcGIS Survey123, Storymaps, Unity Gaming Engine, Wikitude AR, and many others (tools for this project and research listed in Appendix E). *YouARhere* was built mostly with these coding-free tools except that connecting them into the custom application required servers (database management) and automation (coding/programming). Because of the various software instances used in creating *youARhere*, high level system design skills, programming, and database connections were required. Fortunately, emerging technology companies and open-source developers are quickly releasing tools that make the development process easier. In this case, that aspect of app development was outsourced to a specialist company.

It is important for environmental entities aiming to harness the power of mobile development to consider how simple or complex the functionality needs to be, and, if connecting many tools into a custom application is required, who will develop *AND* maintain it once it is released. Currently, many tools are adopted and used with no real direction or quality assurance. This is fine for simple tasks and can increase adoption

because of its simplicity. For example, for simple augmentation of an existing setting with additional simulated features, the only purpose of the application, then the streamlined process in Unity Gaming Engine may be adequate. However, if the app has larger goals and entails many data sources moving content across many platforms, then technical challenges arise in stringing many functions together. Extensive system design and planning is essential because these tools in the background are complicated and only operate in particular ways. Unless the developer can dig into the code structure of say, Wikitude or ArcGIS Survey123, and understand how to alter code and system design to meet custom needs, then resorting to out-of-the-box functionality is the only option.

10.2 Benefits of the Research

This research is important to understanding the roles and limitations of emerging technology in the fields of environmental planning and design. At the time of writing this dissertation, mixed reality is growing rapidly as a medium for inquiry and application in many fields. The fields of environmental planning and design are still learning the benefits, limitations, and consequences of these tools. Augmented reality offers a way to view unseen aspects of the world, such as environmental data; to view a scene as if from the past or the future and to project artistic content onto *real* places. Considering AR as a new extension to methods of communication and research crafted by visitor employed photography (Cherem and Traweek 1977, Daniel and Boster 1976, Fantini 2017), GIS, and other planning visualization tools, it can help in getting as close as possible to the real thing when communicating change across landscapes. Coupled with mobile

networked technology, mobile AR can readily reach more people than the traditional media of planning and place visualization. This does not mean that AR, VR, or mobile devices will replace traditional planning environments or tools, but that these new emerging tools are available to present or elicit new insights.

10.2.1 Environmental Attitudes About a Climate Change Future

This research also has the potential to contribute to the research on environmental attitudes in the environmental psychology perspective. While the EAI is meant to place individual perceptions along a preservationist / utilitarian scale, the subdimensions measuring these highly philosophical worldviews do not consider storytelling as a source of information that could challenge the idea that ‘attitudes’ are more than preservationist or utilitarian when dealing with modern day climate change. *Conservation* is the current trajectory to managing climate change and human need of the natural world without disregard to environmental health and sustainability and displays of *concern* potentially indicate climate skeptics are not inescapably entrenched into utilitarian perceptions of the world nor are pro environmental attitudes indicators of being prepared for the future.

10.2.2 Improvisation as a Research Approach

The dual challenges of app development as the technology evolves and the shifting demands of deployment of the app in the field called for constant improvisation and adaptation. Each of the two preconditions to this research led to evolving methods and expectations. First, there is no accepted model or method directing the development of emerging technology other than trial and error investigation guided by traditional user

experience research such as preference, ease-of-use, or technical analysis of user interface design and the ergonomics of the emerging features of new tools. Developing an app that delivers information that end-users already know they need is a well-researched area. Finding a good restaurant and comparing merchandise prices examples of these. In contrast, *youARhere* needed to engage people sufficiently to encourage them to explore the issues around a politically charged topic such as ‘climate change’ and then share their views when many others might have opposing views. Achieving this required much more consideration of the psychological engagement and perception aspects of *youARhere*. Getting to the point of unlocking the stories shared in the eventual interviews required significant focus on the app’s purpose as an environmental communication medium beyond the necessary technical functionality and user experience design decisions. Beyond the three phases of development described above were numerous intermediate steps of testing, appraisal and adjustment. Second was the challenge of developing a protocol to test the efficacy of *youARhere* during the global Covid-19 pandemic. Initially the intention was to engage many users in the use of *youARhere*, surveying them before using the app using a standard environmental attitude instrument, and then re-test after a suitable time. The surveys, if the number of respondents had been large enough, would have revealed some direct quantitative measures of the tool’s effects, easily relatable to previous research regarding environmental attitudes. However, while that would have revealed some useful information about users’ engagement with AR apps, it would not have provided as rich an understanding of coastal Georgia resident’s responses to an environmental AR application as the interviews that were subsequently necessary to continue the project.

Changing the evaluation methodology away from the strictly defined protocols and tools of a traditional evaluation of emerging technology revealed what may be a new norm in user engagement research because of its potential to reveal otherwise immeasurable surprises and insights. The discoveries of improvisation are important as new research territory in technology continues. The development of *youARhere* played an important role in revealing the perceptions of the users but it may be the free-flowing stories that we sought where the true extent of environmental concern will come to the surface.

10.3 Future work

Three new research demands became apparent throughout the life of this research. First, adoption of these emerging technology tools drastically needs more research. Whereas traditional methods of engagement have relied on simple incentives – catered outreach meetings, prize drawings, or financial payments, social media such as *youARhere* depend on new strategies to encourage adoption and dissemination and to be useful, the planning community will need to understand and develop the strategies by which people are led to adopt these tools on their own volition, out of curiosity, or out of a need for them.

Adoption is especially important if we are to understand how tools like *youARhere* can engage, address limitations in populations where interest in new technology is low and explore other options in situations where emerging tools are not available. Secondly, research is needed on how these tools can be used to educate in non-classroom settings.

The Covid-19 pandemic has forced us to rethink classrooms, social engagement, scientific advocacy, and many other facets of life. Where does augmented reality fit in these situations? During this research there was an opportunity to use the app as a

classroom tool in McIntosh County schools, until another change in Covid-19 protocols took that opportunity away. Can AR provide a learning experience in situations of unrest and keep us moving forward in an educated way? Lastly, emerging technology is still emerging, and quickly. Research is needed on the next generation of these tools just as it is on our current use of mobile AR, immersive VR, and increasing dependence on the internet. How will environmental communication and storytelling change when we have smart vehicle windshields, widely adopted AR glasses, or data so fast and rich that environmental metrics will be unquestioned and constantly available to our mobile devices? Even more importantly, how do people change psychologically when using them, for good or worse, or what is the benefit of these new emerging tools in our drastically different environmental future? These are all questions that are ripe for research beyond the uses of *youARhere*.

Use of a mobile-device app for collection and dissemination of stories is, admittedly, a distinct technological departure from traditional storytelling. There is increasing unease with the unanticipated impacts of technology use on daily life and interactions mediated via tools like augmented reality. AR is rightfully questioned and critiqued in order to discriminate between the valuable, less valuable, and detrimental or dangerous when responding to the rapid pace of creation of new technological devices and techniques. However, it is increasingly evident that new visualization media and interconnected mobile technology can facilitate storytelling in ways that might be beneficial to the work of adapting to our environmental future and all the myriad of challenges that result from climate change acceleration. Furthermore, interconnected

technology is inevitable. As such, though, new tools need to be researched so that the planning and scientific workers know how to apply them properly and with benefit to all, and so that both their benefits and limitations are fully understood. As stated in chapter 4

- At its core, the work of the environmental planner is that of presenting plausible alternative future scenarios, and aiding people in moving to make rational choices of behavior that will lead to the realization of their chosen future - and storytelling, augmented reality, and the wide accessibility of constantly improving mobile devices has a bright future for planning communication.

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Appendices

Appendix A - Belief and Disbelief in Science

Disbelief in Science

Before using app:

Interviewee2: “So I'm not convinced that about sea level rise. Look at, look at, look at Venice. Erosion would have happened anyway. Look at Venice, Italy. Okay. Venice has, has water coming up through the sewer system. Okay. Storm drain system. But when you get down to figuring out what happened, it's not, it's not sea-level rise.” - 7

“I'm a, one of those part of the guys that thinks erosion is, is the real culprit ...of like the water of the water of the, the, the shore. [sea-level rise] not the season that you're getting more water. Okay. It's just erosion. It's rotting away, right.” - 4

interviewee 10: “I really dont know [if sea-level rise is real]” - 2

interviewee 9: “No, no, no, no, no. I'm not sure I support it. yeah, no way.” - 5

“you also talked about, um, sea level rise. Uh, for that, I wouldn't, I wouldn't really say I can concur with the scientist or yeah” - 5

interviewee 8: “That’s a subject. I Question because they [scientists] can take it one way or the other, right.” - 4

“Um, it's going to be a hundred degrees and, um, no rain. And then of course what happens, it's, it's 85 and it's beautiful weather. And so the predictability of that, I,

in other words, I know they can see things coming and have seasonal things, but I think it's, so I think it's inaccurate” - 4

“And I understand, I think. I think, you know, when it comes to, okay, there's a storm brewing. We see it's coming, but predicting basically, I think it's, I think it's a 50 50. I mean, it's, I don't think they, I don't think it's exact. Yeah. I don't really think they” - 5

interviewee 3: “everybody talks about like, something has happened, but we don't know [00:08:00] exactly what that something is” - 5

After using app:

interviewee 2: “Eventually water up, then nothing. Oh, wow. Yeah. What are the, when that happens to me, we'll probably grab it up for Riverwood [to sale]...when it comes down to me that if it was from your property, you get what you find.” - 5

“Yeah. It ain't happening. so what are you doing it for?” - 7

interviewee 8: “we went from one extreme to the other. So there's no rhyme or reason to anything. And that's why it's so hard to predict environmental [things]”

Belief in Science

Before using the app:

interviewee 11: “I would leave if I had the option” - 6

“I believe they have the tools and I would love to believe they [are] most likely correct” - 4

“So it's quite, it's quite, uh, obvious the way the conditions and climate conditions are” - 4

interviewee 4: “I would first tell them don't buy anything without checking your flood plain zone. Um, and don't buy any property that you haven't seen after a lot of rain, I'm thinking Houston, you know? Oh boy” - 4

interviewee 9: “Oh, okay. Okay. Okay. Yeah. Uh, to some extent, uh, [they are]correct. Because looking at the county, like I said earlier... we're quite developed, uh, out, I'll say normal. For a station to, uh, you know, act against uh, issues like, um, hurricanes [is possible]... there's lots of level of deforestation and [we] know this” - 3

interviewee 5: “Im not a science guy. So I don't really know what, but I will say yes. Yes. I think it will cost us. They really do try ...but I don't really know” - 2

interviewee 3: “I'm not talking in circles, but I want to say yes, all of it needs to be stopped, but I also know that's just a nice thing to say. It's just not going to happen any time soon” - 1

interviewee 7: “Well, I believe to me, that they have been trying their best in doing [predictions]. Although sometimes it doesn't work out well, but I believe they have really done the best here. Predicting requires a very high level of, you know, uh, putting up technology and human resources, thinking, and calculating. So I think they have done their best [at this point] in time, which is very brave.” - 2

interviewee 6: “it was kind of funny when you drive it on 17 past the high school, then all of a sudden, you know, that the whole highway kind of drops down into another plane. This is where it's [changing]. Right here on the high ground, It's not going to flood, so it's not, doesn't take, that's why, that's why I kept looking at that

FEMA map, trying to figure out, you know, where's it going to flood, blah, blah, blah” - 4

“they are selling their product houses to an unsuspecting public” - 4

After using the app:

interviewee 4: “And I don't know that kids are, I know in certain areas, I'm sure children are learning how bad climate change is and what it's going to potentially do for their lives. But there are a lot of places that probably don't teach it [unfortunately].” - 5

“And I personally believe that it is climate change caused by our humanity not doing what we know we ought to do. That's, that's my personal belief.” - 6

interviewee 6: “that will be an island”

Appendix B - Concern for Damage and Concern for Social / Economic Change

Concern for Damage

Before using the app:

interviewee 11: “Yeah, I think, I think it's, I think the development is quite much...there should be like reduction, like decrease. So as to save lives. Yeah. Mostly because of human, human security and human lives, [in order to protect]. So like just trying to be environmentally conscious, then [think of] others also.” - 5

interviewee 4: “And one of the walls is like this...Here's the hotel. Yeah. I mean, literally you can't walk through it. The wall is still the Tabby wall and that, you know, you, you think about how much they've already jarred it with their pounding of

their steel. What do you call them? Pilings? I don't know the structural parts of the hotel in particular. Um, I hate to say it. Won't it all of a sudden one day, just slide off?" - 6

"You've seen the condos, you've seen the new restaurant and now the new hotel is going in, in between them. And that's taken over the waterfront. We don't know how high the tides will start getting on the Darien and river. It is titled." - 6

"I would tell people to be very cautious that I would say, yes, it's a beautiful area, but, um, you have to know that it's coming...you've only got what you think is 10 more years, you might get away with it 10 more years. But I think if you're looking at 20 to 25, 30 years, I would not recommend [moving here]." - 4

interviewee 10: "There was nothing but big oak trees and stuff and right where we lived, they took it out. Yeah. S###. Hey, they literally took it out. All right" - 4

interviewee 9: "because for now, um, I would encourage them [to move here], but even if the level of storms go higher, I might be forced to discourage them, but for now I wouldn't. But, you know, you can just live here for a couple of years, you know, see how things go" - 4

interviewee 3: "Yes, I would [support an adaptation tax]. If it's small" - 4

interviewee 7: "Yeah, I believe it's environmental changes. And the climate concentration is very important when a leader asks [for my vote]." - 6

After using the app:

interviewee 1: "That, that, yeah, I would feel like..some kind of environmental or conservation efforts need to be in place to help not make that happen, whether they need to build up more so that there's more to absorb land and plant wise, land

wise or whatever environmental wise, but yeah, I think that would be concerning”

- 7

interviewee 11: “The first picture is like saying, uh, Florida farmland...like a desert...

isn't something I would really want to happen. It's not something I would love to see. So yeah, not something I would love to see” - 5

interviewee 3: “You got a visual of seeing the water is in a spot that it wasn't even built to

be that way. Um, and then how can we? It affects everything.” - 4

interviewee 7: “but the part of it that gets me like, I'm like, wow, this is so great, the part

where it forecasts about future occurrences.” - 5

interviewee 8: “I've never seen so much beach and I've never seen, and it's just that it's

extremes above...” - 4

interviewee 5: “I'm a bit concerned. Maybe this could actually really be.” - 4

Concern for Social / Economic Change

Before using the app:

interviewee 2: “If you put in a distribution center or an industry here, all you can do is go

north, south, and then you have to, you know, it's an hour and then across. Why not go where you can go in all directions?” - 4

“This, this town was the last bastion of, uh, of English rule and the, the English ability to keep the Spanish away, to keep them in [Florida]. The architecture would reflect English and Scott's Presbyterian architecture and not Spanish colonial architecture, which is what is coming.” - 5

interviewee 10: “Yeah, it's going to small country for people in the cities. Yes. Because for instance, over here, these new condos and stuff, that's gone, those who, for someone living in this town is actually going to be able to live in one of those, with the price of them. They're 500,000 or something like that. And then you've got these back here behind you, right? That you've got certain people that live in them, but the majority of them have moved out. There was no purpose in building them. It's crazy” - 3

“No, no, no [adaptation tax] because that, because that would be more, less hurting the actual working man in the community, like the commercial fishermen and stuff like that.” - 6

interviewee 8: “You sell it for one [house], they'll pay for it. Basically. they think there's two.” - 6

“[Conversations about environmental disasters] had never entered my mind.” - 6

interviewee 3: “I'm talking about things that I have seen people lose their jobs over because they were strongly opinionated. And I hate it when someone loses their job and they need to take care of their family because, uh, environmental situation..using that one topic.” - 4

“I'm living in one of the most poorest counties in the state of Georgia. Uh, so I want to be able to take care of that side of, uh, my community too” - 4

“But I see a whole lot in the middle of the next 50 years, because in my area, there is a major boom of building, a major boom of eliminating some of these areas because it's so economically rich” - 4

After using the app:

interviewee 4: “Prices here have risen so drastically. It's unbelievable. It would have been a good time for us to sell” – 5

Appendix C - Nature vs. Economic Concern

Nature over Economic

Before using the app:

interviewee 11: “Uh, I think there should be like a decrease, not increase [in development]. much too much.” - 4

interviewee 4: “The sea island thing. There was that little spot on the south end to sea island that they wanted to develop, and it's, it's not only going to be prone to flooding, but it's, it's right close to a, uh, a migrating bird nesting site. It's just critical.” - 5

interviewee 6: “They were, they were to make a pond and the... nesting area needs to be protected so that the raccoons can't come up and eat all the babies and such. So they have to be in a lake basically. And so what they did is they made all those little islands and planted all the little islands with the kind of trees and shrubs that would grow. That'd be a good nesting site. And they did that. God knows 40, 30 years ago. Very very successful. Obviously that whole place is all man-made islands and all it used to be, of course, like I say, the whole area, it used to be a black fishing community.” - 6

”

After using the app:

interviewee 6: “It's still there. It's great, it's one of the most incredible birding places anywhere.” - 6

Economic over Nature

Before using the app:

interviewee 8: “ I understand business and development and people discovering this place because this has been a little hidden gem for so many people over these years. This is where people come to get away from Atlanta or the big city. And now, it's just it's it, it is what it is. And it's, it's just a sign of the times. I mean, yeah. They discovered it.” - 6

interviewee 2: “Darien has a, um, a good, uh, cost of living” - 4

interviewee 5: “Uh, I think it needs to be better development. I don't think much has really changed.” - 5

interviewee 3: “When I lived in Maryland, oh boy...when you couldn't keep the car going, most people did what I did. I just give the car to a relative that lives in another state that doesn't have major emissions control so that they can get to work until they can buy another vehicle because they have no vehicle because there are towns that come saying,uh, you know, any cars better than none at all. Uh, when you are in a poor county, uh, rich on the top, right? The retirees got, you know, they've got a nice nest egg there and the rich folks move in, but there's not much for the workforce. And those that live below the workforce. That's, that's the hat-trick for me.” - 5

“But I see a whole lot in the middle of the next 50 years, because in my area, there is a major boom of building a major boom of eliminating some of these areas because it's so economically rich.” - 4

“Land is gold near the marsh front. How do I feel about that? I truly believe in some development. But I also see it's almost an in stoppable train.” - 5

After using the app:

interviewee 2: “Eventually water up. Oh, wow. Yeah. What are the, when that happens to be, we'll probably grab it up for riverwood [to sale].” – 6

Appendix D - Positive or Negative Towards Development

Positive Towards Development

Before using the app:

interviewee 2: “I would like to think that it will be that this area here will remain residential, [with a majority] residential income.” - 5

“it was all private property and a private developer came in and bought the property and, you know, he's within his rights to put up those two monstrosities.

Yeah. Um, my ...public feeling is, you know, it's private property.” - 7

“it's Florida living in Georgia prices” - 4

interviewee 10: “it would be, have to be 50 50” - 4

interviewee 9: “Yeah. Yeah, absolutely. Absolutely. Even with storms and everything, I still encourage them to [move here].”

After using the app:

interviewee 9: “it doesn't really make me feel any different.”

interviewee 2: “Eliminating the buildings from the picture...what are you doing that for?”

Appendix E - List of Development and Research Software Used in this Project

Unity Gaming Engine - A free game development software that can be used to streamline creation of virtual and augmented reality applications.

Vuforia - A free augmented reality development kit, library of code, and online host of AR content for various devices - connects to Unity.

SteamVR - a free virtual reality development kit, library of code, and online host of VR content for various devices - connects to Unity.

Wikitude AR - A premium augmented reality development kit, library of code, and online host of AR content that can be edited without code in a browser based 3D canvas (Wikitude Studio). The code can be downloaded after development to use in other mobile applications. An efficient way to have AR in a mobile app that has other functions, such as *youARhere*.

Amazon Simple Storage Service (S3 Server) - Servers provided by Amazon through the Cloud to host content for a yearly price. It can hold incoming and outgoing content (images, videos, databases, accounts, 3D model files, and more) in web based applications.

CyberDuck - A desktop application that allows you to organize, edit, and access files in a cloud server such as Amazon S3.

ArcGIS Online - A web-based GIS data hub and development tool for making maps and geospatial applications for use in applications of various sources - websites, software, mobile apps, games, and other app managing devices.

Survey123 - A survey creation tool that uses the data and functions behind ArcGIS online, primarily geared towards location-based analysis.

Qualtrics - A survey creation tool with data analysis tools for various types of incoming data.

Descript - A transcription software that converts audio or video into text form and allows you to organize large amounts of text into categories and organized text files.

Dedoose - A transcript analysis software used for qualitative analysis of text, pattern identification, and visual representation of textual data.