A FRAMEWORK FOR PARTICIPATORY AUGMENTED REALITY IN GEORGIA'S WIND ENERGY FUTURE

by

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(Under the Direction of David Spooner)

ABSTRACT

Wind energy can help reduce global carbon emissions, but poor planning and unilateral development schemes have contributed to public opposition against the wind industry in Europe and North America. To change these practices, new public engagement methods can benefit from mobile augmented reality (AR) technologies to expand their accessibility and interactivity, but choosing the most effective functions for an application will depend on perceptions of valid authorship and planning stage-specific objectives. This thesis explores how project actors can design engagement tools that respond to development contexts by proposing a theoretical framework to guide the AR engagement method design process. The framework identifies development contexts, establishes participation goals, and determines authorship and participation objectives to guide the design process. This study then evaluates the framework by applying it to several completed case studies and then testing the framework as a design tool on an abandoned development proposal along the Georgia coast.

INDEX WORDS: wind energy, augmented reality, participatory design, visual impact assessments, landscape perception, landscape aesthetics

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DEDICATION

This thesis is dedicated to anyone who loves their “spot” in this big broad world.

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CHAPTER 1

INTRODUCTION

The Context

For much of the last century, the world's primary energy production systems have relied on densely concentrated components: dense energy in the form of fossil fuels, dense power production in the form of centralized power plants, and dense capital resources in the form of enormous power companies. In many ways, the transition to a low-carbon energy production chain will rely on theopposite to these components: dispersed energy resources, dispersed energy harvesting, and dispersed energy management. Wind energy is a perfect example of this dispersion. The energy stored in moving air masses spreads over enormous portions of the Earth's surface, and the energy available for harvesting at any one location is limited. Consequently, wind energy harvesting also must be dispersed, because there is no effective way to artificially concentrate the energy in the air. Since the harvesting of wind energy must inherently be dispersed and the capital resources necessary to begin harvesting this energy is significantly less than those required for traditional fossil fuels, community-based energy production has become an increasingly viable and popular option (Martin J. Pasqualetti, Gipe, and Righter 2002b).

As these renewable energy landscapes grow, they will become an increasingly ubiquitous element of our day-to-day landscape. In the last decade alone, wind energy production has tripled in the United States ("Renewables on the Rise" 2020), and with this kind of growth, Apostal (2017) estimates that wind turbines could have some degree of visual impact across roughly half the continental United States in the near future. In Europe, renewable energy projects have already become common across the continent, and despite social acceptance of renewable energy as a concept, opposition to individual projects maintains a steady presence (Martin J. Pasqualetti, Gipe, and Righter 2002b).

In the United States, wind energy developers have been navigating public opposition since the earliest wind farms were installed in California in the 1980's. At the time, there was little engagement between the energy developers and the broader public, and there was relatively little regulation regarding the visual impacts of wind farms. Today, visual impact assessments (VIA's) are an integral part of every wind farm development process, and legally defensible visual simulations are a necessary component of each assessment.

Improvements in digital visualization tools, Geographic Information Systems (GIS's), and photography have all contributed to a tremendous growth in VIA methodologies. Today, visualization specialists are capable of generating photorealistic simulations of proposed wind farms using combinations of advanced GIS software, digital 3D modeling, photography, and photo editing software. These visualizations are used to communicate a proposed project's visual impacts to the public, and significant debate exists over which presentation methods are the most effective and true-to-life. These methods include static print outs of edited photographs taken at particular focal lengths, panoramas of physical images, and traditional and immersive digital images.

As part of this last group, Augmented reality (AR) is an emerging technology which merits consideration as a visualization tool. AR superimposes digital imagery over the real world to give viewers the impression that a digital object is physically present. AR holds potential as a VIA tool and a broader public engagement tool, but like all visualization and digital tools, AR needs proper evaluation as a tool in order to be effective.

This thesis investigates how AR tools can be tailored for deployment as public engagement tools on renewable energy development projects. Specifically, this paper asks, "How might AR tools be evaluated for their capacity to facilitate public participation in the planning and design ofrenewable energy projects that have significant impacts on landscape aesthetics?" Additional subquestions explored in this paper include:

1. What is the relationship between wind farms and landscape aesthetics?
2. How has that relationship shaped the growth of wind energy developments?
3. How do researchers describe landscape aesthetics?
4. How are landscape aesthetics assessed?
5. How have landscape professionals communicated landscape aesthetics to the public?
6. How has the public historically engaged with the creation and interpretation of landscape aesthetics?

Finally, this paper hypothesizes that AR tools for public participation in renewable energy developments can be effectively evaluated and selected for a project based on broad goals and specific objectives that are identified through an analysis of the project's development context, planning stage, and available digital infrastructure.

Purpose & Significance of the Study

To answer this question, this thesis proposes a framework for connecting participation needs with AR capabilities. Participation needs are defined based on the power dynamics of involved actors, the desired participation level, and the planning stage at which the engagement occurs. The capabilities of an AR tool are based in the types of information created and transferred by the tool and the degree to which that information is credible, salient, and perceived as legitimate.

Rapid advances in digital technologies used in landscape architecture and related disciplines have often outpaced the ability of professionals and academics to evaluate these types of tools. Insufficient research currently exists to comprehensively assess how well visualization and communication tools facilitate participation in landscape design and planning. In renewable energy developments, these tools are typically used to objectively assess the visual impact of proposed developments on surrounding landscapes, but debates regarding the aesthetic theory underpinning this method suggest that a purely objective assessment of a landscape's "inherent" aesthetic value misses crucial social values. Consequently, the implementation of participatory tools may have the potential to combine subjective aesthetic assessments with objective visual impact calculations for a more complete picture. This paper's proposed framework attempts to do just that.

Methods & Overview of Chapters

To build this framework, this thesis primarily combines theoretical works from a literature reviewing public participation, digital technologies in landscape architecture, and landscape aesthetics. First, I examine how Walker and Cass (2014) proposes a three-pronged approach to describing the development context for any given renewable energy project. These prongs are social organization, actors, and deployed energy technology. Second, I then refer to how Hayek (2011) breaks down land use planning projects into stages with respective goals and a suitability analysis of differing graphic communication techniques in each stage. Third, I draw from Arnstein's (1969) definitions of citizen participation and describes necessary elements for projects to reach each level. Finally, I combine Hayek's (2011) work with Broschart and Zeile's (2015) basis for a framework matching digital infrastructure needs to various AR types and functions.

This thesis then builds a framework for analyzing participation context and matching the involved actors' needs with AR tools. A case study approach is used to evaluate this framework's ability to describe participation contexts, after which an abandoned project proposal called Southern Wind (2007) is used to explore the framework's ability to guide participation strategy planning. The project is analyzed using the proposed framework, and a suite of AR tools are recommended to facilitate public engagement in early project stages.

The following chapters are ordered to introduce the relevant literature review, describe methods in depth, and examine the framework's evaluation:

Chapter 2 explores a history of wind energy development in the last forty years, a history of public landscape perception studies and visual impact analyses, and the use of digital tools in environmental design professions. The chapter ties public engagement to the relationship between landscape professionals and laypersons and examines the need for evaluating communication tools.

Chapter 3 covers the creation of the proposed framework. This argument begins with an examination of the three primary papers in close detail and moves on to the methods of matching AR functionalities to the proposed variables. The chapter closes with a description of the produced framework.

Chapter 4 examines the case study evaluations, lessons learned from that process, and applies the framework to the Southern Winds project context.

Chapter 5 offers a discussion of the framework's evaluation and implementation before providing concluding thoughts.

The appendix contains the template for case study evaluations and data sheets for each case study.

CHAPTER 2

LITERATURE REVIEW

A Brief History of the Wind Energy Industry

Wind has provided a direct source of energy for civilizations using sailing vessels and wind- powered mills in centuries past, and collecting this readily available energy continues with increasing prevalence in the current era. Recent technology allows energy suppliers to harvest wind energy to turn turbines and generate electricity in an easily renewable manner. Given modern concerns over the effects of climate change (IPCC 2014), many governments are establishing benchmarks for more of these low-carbon, renewable energies in order to mitigate the worst effects of carbon emissions contributing to climate change. The low density of these distributed energy sources, however, creates new threats and opportunities for landscape aesthetics that are bound up in the rise of the wind energy industry and relevant regulatory measures.

American wind energy took several starts in California before becoming a major industry. In the 1920's, Dew Oliver, a Los Angeles real estate developer, was credited with using a "blunderbuss" to generate wind energy, but the device never attained commercial success. Fifty years went by before a test turbine was placed in North Palm Springs, CA to collect data for several years. In 1978, the Public Utilities Regulatory Policy Act set premium rates for renewable energy at a national level and required utilities to purchase renewably generated power. These requirements later expanded into state and federal tax credits, which then set off a Wind Boom that, true to precedence, got a running start in California (M. Pasqualetti, Gipe, and Righter 2002a).

In the early 1980's, the first commercial wind farm in the US was built in Altamont Pass, California and received mild pushback. At the time, opposition arose from citizens and environmental groups on the grounds of incompatibility between the wind farm and conservation efforts in the desert valley as well as concerns that the mechanical towers degraded the landscape's bucolic qualities (Figure 2.1). To establish empirical data on the public opposition, Thayer and Freeman (1987) conducted the first assessment of public perceptions regarding a wind farm in the United States and focused on the Altamont Pass development.

Figure 2.1. The Altamont Pass Wind Farm in 2008 (Laporte 2008)

This involved mailing a questionnaire and photographs of the area to participants, and results indicated a broad range of attitudes that certainly were not explained by any singular cultural theory. Variables such as familiarity with the site, aesthetic preferences, and symbolic interpretations all affected participants' attitudes. Significantly, the most positive attitudes correlated with strong symbolic associations between the wind turbines and concepts such as safety and progress, and the most negative attitudes focused on visual and aesthetic concerns.

Altamont Pass was quickly joined by wind farm developments in Tehechapi Pass and San Gorgonio Pass, and the last of these developments became the first wind farm to produce significant public backlash (Figure 2.2). Residents living near the San Gorgonio development opposed efforts by the developer to ignore environmental impact mitigation stipulations, nonfunctioning windmills, eyesores, mismatched sizes and shapes of turbines, and claims that wind energy development damages aesthetic experiences and tourism potential. These complaints echoed concerns about the other new wind farms including aesthetics, noise, wildlife threats, structural failure, and aircraft and electrical interference. In response, the surrounding Riverside County held hearings, financed a public opinion survey, and generated a planning document to guide future land use and wind development to include the preferences of local residents. In response to this opposition, collective efforts in the wind energy industry began a campaign publicizing education, site tours, and the benefits of wind energy over fossil fuels. These efforts, however, failed to address visual and aesthetic concerns, and counties continued to regulate the expansion of wind farms. Quickly, wind farm developments had to meet requirements for zoning, setbacks, buried cables, colors, height limits, advanced visualizations, noise levels, decommissioning bonds, and legal protections for rare and charismatic birds. Despite these various regulations and mitigation requirements, aesthetics continued to be the largest source of opposition to wind energy development (Martin J Pasqualetti 2002).

Today, wind farm development in the US is largely regulated under a handful of federal laws,and relatively few state or local governments have established planning practices to address the needs of wind energy. The 1969 National Environmental Policy Act (NEPA) created a national legal mandate to "assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings" Sec. 101 [42 U.S.C. § 4331]. Collectively, these demands gave rise to environmental impact statements, and specifically, the aesthetic component spurred the creation and implementation of diverse visual impact assessment methods over the decades.

Figure 2.2. San Gorgonio Pass Wind Farm in 2014 (Lund 2014)

Later, the Energy Policy Act of 2005 and American Recovery and Investment Act of 2009 required the study of national wind resources and provided tax incentives for their development. These acts also authorized the construction of wind farms on federal land overseen by the Bureau of Land Management (BLM), which is legally mandated to protect scenic values under the Federal Land Policy and Management Act of 1976. Despite these national requirements for conserving scenic values and ensuring aesthetically pleasing landscapes, local planners often have relatively few policy guidelines for implementing those federal mandates (Apostol et al. 2016). Since many visual impact assessment methods used today rely on a determination of reasonableness to determine whether they are approved or rejected (Vissering, Sinclair, and Margolis 2011), tools such as comprehensive plans and character area maps can quickly become the only aesthetic guidelines for communities and developers.

Similar opposition and policy quandaries appeared in Europe as wind energy expanded in the continent's major economic powers. In Germany, a 1991 electricity feed-in law (stromeispeisungsgesezts) allowed for excess energy from distributed power generating operations to be fed back into the major utility grids for a profit to the producer. Most early projects were rejected based on associated decreases in land values even as public sentiment towards environmental improvement called for expansions of renewable energy options (Schwahn 2002). As efforts for increased citizen participation and local ownership increased, project acceptance rates rose as well (Hoppe-Kilpper and Steinhäuser 2002). In Sweden, similar exclusion of public participation in planning and management activities resulted in many early rejections of wind energy projects, and increasingly realistic and advanced visualizations did not help the matter (Hammarlund 2002). To address concerns of exclusion and visual impacts, projects in Denmark prioritized compositional qualities to harmonize wind farms with their surrounding landscapes. Fundamental design elements such as geometry and rhythm are used to convey order, especially in projects like the first offshore installation near Vindebay, which consisted of two parallel rows of towers and was considered a huge success (Nielsen 2002).

Clearly, wind farms pose significant landscape problems that transcend idiosyncratic opposition from isolated communities, and this reality reflects fundamental connections about western ideas of landscape. Righter (2002) examines early opposition as a combination of individual and broader cultural responses. Culturally, critiques of machines in any landscape are part of established American traditions establishing a strong dichotomy between "Nature" and "Technology", such as in 19th century paintings depicting locomotives winding through a pastoral countryside (Figure 2.3). Brittan Jr (2002) suggests wind turbines and wind farms cannot reconcile with embedded concepts of western pastoralism and beauty in part because the modern turbines lack history and visible connections to an organic aesthetic. As a result, the turbines simply remind viewers of other contemporary technologies that are ubiquitous and conceal their interconnections, which alienates users.

Figure 2.3. "Lackawanna Valley" by Georgia Inness, 1856. Concepts of Technology vs. Nature were prevalent in North American landscape paintings as early the 19th century. Courtesy National Gallery of Art, Washington.

Hoppe-Kilpper and Steinhäuser (2002) note that urbanists seek out rural beauty and may view wind farms as an existential threat to pastoral aesthetics while rural dwellers may see wind farms as simply another iteration of working landscapes for resources and livelihoods. In contrast to these qualitative hypotheses, scholars in the visual assessment field have also developed a broad range of tools to quantify and measure attitudes, perceptions, visual preferences, and emotions in response to wind farms (Maehr et al. 2015; Bishop and Miller 2007; Ladenburg 2009; Maslov et al. 2017). The qualitative and quantitative evaluations of landscape aesthetics and aesthetic experiences are vital to this paper's central argument and will be discussed in detail later in this chapter.

Aesthetic Paradigms

Studies on landscape preference and perception in the 20th century began with studies of reactions and attitudes towards differences in "natural" and "built" environments—what came to be called scenic aesthetics. These studies later came to debate different roots of human landscape preference resulting from evolutionary demands, cultural interpretations, and full-body experiences (Jorgensen 2011), and following the aesthetic mandates of NEPA, researchers and institutions began quantifying and empirically describing landscape qualities and human reactions to the same in the 1970's. These practices gave rise to the practice of visual landscape assessments, in which designated experts inventory the fundamental visual elements of a landscape and then assign a value to the overall scenic quality using either formal design elements or subjective measures. These assessments tend to be interdisciplinary and combine elements of landscape planning, landscape architecture, forest management, and other socio-environmental sciences. Visual assessments can be then used as baselines for measuring visual impacts, which refer to the effect of proposed landscape changes on the surrounding scenic quality (Gobster, Ribe, and Palmer 2019).

Following a proliferation of methods in the 1970's, researchers began attempting to catalogue and evaluate the different available approaches. Terry C. Daniel and Boster (1976) categorized scenic quality assessment methods as descriptive inventories, surveys and questionnaires, or evaluations of perceptual preference. These methods, respectively, quantify landscape visual features, ask verbal or textual questions to people, and use graphic or visual examples to elicit preference ratings from people. Zube, Sell, and Taylor (1982) later conducted a broad literature review and proposed an underlying model of landscape perception that could underpin four theoretical paradigms that broadly captured the existing visual assessment approaches. These paradigms included the expert, psychosocial, cognitive, and experiential, and the model proposed that perception is the outcome of interactions between human psychosocial variables and landscape element*s* (Figure 2.4). Each paradigm represents a different conceptualization of landscape perception, and the implications of each led to widely different management styles and priorities (Table 2.1). The expert paradigm, relying mostly on an individual's evaluation of a landscape, most often involves descriptive inventories, while the other paradigms required surveys, questionnaires, and preference evaluations to measure human experiences.

Lothian (1999) then assessed Zube, Sell, and Taylor (1982) and the broader literature of visual assessments to conclude that two paradigms succinctly captured the dominant methods. Lothian's objectivist paradigm encapsulates the expert paradigm, in which trained professionals describe landscapes in terms of their formal design elements and quantified visual components. The psychosocial, cognitive, and experiential paradigms fall under Lothian's subjectivist paradigm, which measures landscape visual quality by measuring human preferences and the effects experienced by viewers. In short, the objectivist paradigm assumes beauty is inherent to the landscape while the subjectivist paradigm assumes beauty is in the eye of the beholder. Rather ironically in this model, the subjectivist paradigm objectively measures subjective human experiences while the objective paradigm often relies on subjective, expert opinions, and for this reason, Lothian argues that the objectivist paradigm should be discarded in landscape professions and research. The dichotomy of objectivist and subjectivist paradigms provides an ideological foundation that this paper will now use for reflecting on a history of visual assessment methods and implications for future wind energy visual impact assessments.

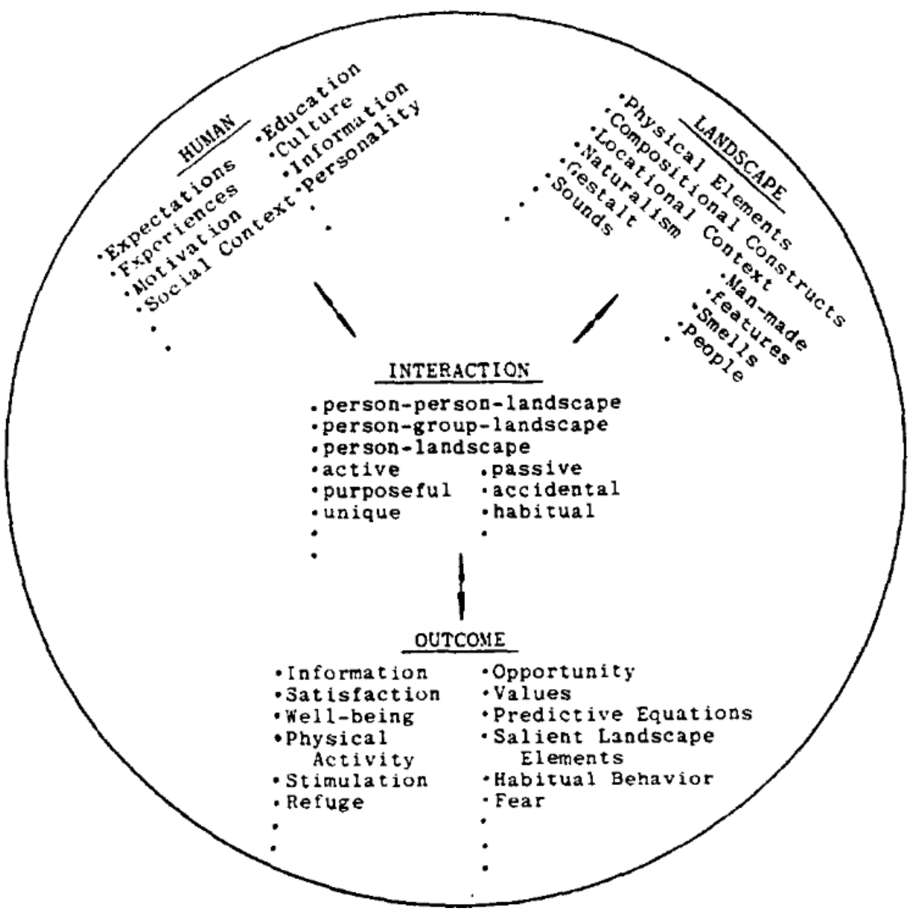

Figure 2.4. Model of landscape perception from Zube, Sell, and Taylor (1982)

Table 2.1. Landscape perception paradigms from Zube, Sell, and Taylor (1982)

	Expert	Psychophysical	Cognitive	Experiential
Human model	Elite, highly-skilled trained observer	Observer as respondent	Observer as processor	Active participant
Landscape properties	From principles of art, design, ecology, and resource management: Form Balance Contrast Character Diversity Ecological principles — diversity Silviculture — timber stand improvement Pollution control	Specific landscape properties manipulatable through management and design: Cover Water Topography Structures	Associated with obtaining information and meaning: Mystery Legibility Identifiability Prospect Refuge Hazard	World of everyday experience: Familiarity Social space Landscape style
Interaction outcomes	Statement of landscape quality Enhanced sense of landscape	Numerical or statistical expression of perceived values Related landscapes or landscape features	Meaning Ratings of satisfaction—dissatisfaction and preference Stress reduction Adaptation Arousal	Habitual behavior Understanding of human and landscape development Change Statements of landscape taste Enhancement of sense-of-self

Objectivist Assessments

Objectivist assessments have been incorporated into many federal visual assessment methodologies, in part due to simpler procedures that are faster and cheaper than subjectivist methods requiring extensive public engagement (Lothian 1999). This section will cover a few of the major objectivist methods used by federal agencies.

In 1984, the Bureau of Land Management adopted the Visual Resource Management (VRM) system for addressing scenic resource needs on public lands. The system relies on authorization from the Federal Land Policy and Management Act of 1976, which calls for the conservation of scenic values. The act also defines "scenic values" as a resource "for which public lands should be managed" and that these resources should be included in continual inventories of public lands. The VRM system identifies visual values using formal design elements, assigns goals through a management planning process, and provides input to activities disturbing public land surfaces to mitigate visual impacts. These inputs seek to conserve scenic values by harmonizing disturbance activities with the visual elements in surrounding areas (Manual 8400 - Visual Resource Management 1984).

Specific methods required for these inventories use scenic quality evaluations, sensitivity level analyses, and distance zones to identify visual resource classes which correlate with visual resource values. Scenic quality evaluations classify landscapes as A, B, or C based on seven factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications. The combination of these factors creates a profile for comparison against similar reference ecoregions, and "areas with the most variety and most harmonious composition" (Manual H-8410-1 - Visual Resource Inventory 1986, 3) are deemed to have the greatest scenic quality. Following this evaluation, a sensitivity analysis then gauges the type and abundance of users, the significance to public interest, and adjacent land uses to determine the degree of public concern for the subject landscape. Finally, quantitative distance zones are assigned from various viewpoints to measure relative visibility. Notably, this system directs users to gauge the intensity of their inventory based on the visual characteristics of the subject landscape. For instance, the "barren manco shale area in southeastern Utah should not be given the same treatment as the rugged and colorful formations of the Colorado River area" (Manual H-8410-1 - Visual Resource Inventory 1986, 3). Such a judgement on the part of the observer may arguably introduce bias from the beginning by relyingon subjective judgement to select an inventory intensity.

For similar goals to BLM's VRM system, the US Army Corps of Engineers (USACOE) instituted the Visual Resource Assessment Procedure (VRAP) in 1988. NEPA's mandate required that USACOE's mission marry existing priorities of engineering, economy, and efficiency with aesthetic management goals, but prior to the establishment of VRAP, the organization's decentralized, watershed-based structure led to a lack of standardization across visual assessment practices. VRAP was then developed to standardize aesthetic considerations across USACOE activities and consists of two parts: the Management Classification System for documenting existing visual resources and the Visual Impact Assessment to measure scenic outcomes of proposed projects. Much like VRM, VRAP establishes procedures for an individual expert to define and inventory a study area (Management Classification System) before preparing simulations and quantifications of impact assessments (Visual Impact Assessment).

VRAP also includes a framework for public involvement and encourages users to actively invite participation of affected stakeholders through public meetings and workshops using standardized response forms. The public response forms use a combination of Likert scales and short-answer positive or negative comment sections to collect public reactions to photo slides of landscapes and their components (Smardon et al. 1988). This encouragement for public involvement did not permeate all agencies at the time or in the present. The Federal Highway Administration's *Guidelines for the Visual Impact Assessment of Highway Projects* (2015) provides familiar practices for first quantifying landscape character and scenic quality, but public involvement is encouraged only for complex projects. Other projects may only require inferring the types and locations of impacted communities during a visual assessment (FHWA 2015).

In 1995, the US Forest Service (USFS) introduced their own Visual Management System (VMS) in response to growing public concerns for the dual demands of visual resource management and increased forestry products from impacted landscapes. This method inventoried USFS lands and established character types, which are areas sharing distinct visual patterns such as topography, geology, hydrology, and vegetation. These character types would be established in comparison to a reference landscape, called the "characteristic landscape", and then each character area receives a variety class rating of A, B, or C. This rating process begins by assigning a rating of B to a character area of modest variety, and then areas with greater or less variety, contrast, or uniqueness receive ratings of A or C, respectively. Once the variety classes are established, sensitivity levels and distance zones are defined in much the same manner as in the VRM method. Finally, map layers of variety classes, sensitivity levels, and distance zones are overlayed in a McHargian fashion to determine needs and assign goals to the resulting areas (Bacon 1979). Ultimately, VMS, like the other objectivist methods, relies implicitly on expert, supposedly objective classifications of landscape aesthetic values, but in doing so, introduced subjective expert opinion in establishing fundamental assumptions (Lothian 1999).

Subjectivist Assessments

In contrast to the objectivist paradigm's focus on physical visual landscape features, the subjectivist paradigm emphasizes the cognitive, emotional, and physical experience of landscapes in order to assess scenic quality. In practice, Terry C. Daniel and Boster (1976) offer a quintessential example of the subjectivist aesthetic assessment. Their model, the Scenic Beauty Estimation Method (SBE), relies on a two-part model of scenic beauty: an observer's perception of a landscape and their internal judgmental criteria. These components can be thought of as the visual information the subject receives and mental metric against which they judge the received information. In the SBE, respondents view sets of photographs of randomly selected views within a landscape and then numerically rate each view. These numeric data are statistically normalized to create easily compared distributions of responses for each landscape, and the average is then taken to be the primary measure of that landscape's scenic value. Consequently, this method places the entirety of visual aesthetic evaluation on the objective measurement of subjective judgements and demonstrates the core tenet of the subjective paradigm.

Other early subjectivist methods also relied heavily on photographs, slides, and cognitive models for exploring landscape preferences and information processing. Zube (1973) presented slides of mundane rural landscapes in pairs and asked subjects to rank their preferred landscape in each case. Additionally, subjects were asked to describe four slides using 14 bipolar semantic scales in order to correlate perceived landscape qualities with preferences. Semantic qualities included subjective binaries such as "flat" versus "mountainous" and "obvious" vs "mysterious". Findings concluded that subjects had strong preference for scenes with greater "naturalism", the degree of which was decided by a panel of judges scaling the image on a scale of one to five, and qualities such as interesting topographic relief and the presence of water increased preference ratings as well. This study incorporated photographs and drawings together in order to control minute changes in some scenes for comparison, and interestingly, while the subjects consistently treated the photographs as appropriate proxies for landscapes, only design students did so with the drawings. While photographs were widely used in subjectivist studies of landscape preferences, the debate over media representations continues to this day, and later chapters of this study will continue this exploration of medium in landscape communication.

Researchers sought out predictive models and root causes for landscape visual preferences. Kaplan, Kaplan, and Wendt (1972) asked subjects to rate their enjoyment and perceived complexity of photograph slides on numerical scales to explore visual preferences related to natural and urban landscapes. The slides were subjectively categorized as containing scenes that were entirely or predominantly natural or man-made. In the data analysis, these categories were reevaluated using a mathematical dimensional analysis for objective validity. A final regression analysis found a significant preference for entirely and predominantly natural scenes as well. Kaplan (1987) reviewed existing literature and found that a visual preference for naturalistic scenes was commonplace and proposed a framework for predictive factors contributing to these preferences. This framework organized four landscape qualities by the type of affective impact they tended to have on subjects and the timing of the experience relative to the initial experience. The affective impacts were “understanding”, which described a feeling of comprehension as to what the landscape was or meant, and “exploration”, which referred to a desire to experience more of the landscape. A landscape conveying immediate understanding was said to have “coherence”, and if that understanding was sustained, then the landscape was considered “legible”. Likewise, “complexity” in a landscape described an immediate sense of exploration, and a sustained desire for exploration meant the landscape had “mystery” (Table 2.2). Kaplan’s literature review supported an evolutionary explanation for landscape preferences, in part based on humans’ constant evaluations of landscapes’ usefulness. As a result, Kaplan suggested that aesthetics are a set of preferences directing individuals toward or away from physical, cognitive, and affective environments.

Table 2.2. Framework for Predictors of Preference from Kaplan (1987)

	Understanding	**Exploration**
Immediate	Coherence	Complexity
Inferred, Predicted	Legibility	Mystery

As theory within the subjectivist paradigm embraced evolutionary and psychological foundations for landscape preferences, ecological models of landscape preference were also gaining ground. Gibson (1977) explored the nature of humans’ interactions with their environments from a philosophical perspective with psychological and ecological ramifications.

In his theory, the environment consists of “surfaces that separate substances from the medium in which the animals live” (67). Light bouncing off these surfaces provides living creatures with information about “affordances”, the resources and services available in the environment. These affordances are perceivable and tangible although their value is relative to every different living being. For instance, a child’s car seat affords a place to put a child for safe transportation by an adult person. For the child, the seat affords a secure location in which to sit, but to the adult, the car seat’s affordance as a seat has little value. Furthermore, land and its “furniture” (walls, vegetation, other objects in the landscape) afford occlusion, and the absence of these objects affords exposure. These affordances are inherent and always present within their mediums although they may not always be perceived. The perception of an affordance, however, conveys meaning to the viewer, such as when a person recognizes the fruit afforded by a tree and understands that the fruit can provide sustenance. Consequently, the meaning of a landscape becomes a complex construction of different affordances relative to each individual organism perceiving its surroundings. Gibson refers to this set of affordances as an organism’s niche, which parallels an ecological niche in its basic function. Taken together, Kaplan’s model of landscape preferences inclines a person to a particular kind of environment, and Gibson’s niche then provides that personthe desired affordances. The person’s sensory perception then recognizes the afforded niche, and their aesthetic preferences draws them into the given environment.

Reconciling the Two Paradigms

At its core, the theoretical disagreement between the subjectivist and objectivist paradigms focuses on the existential nature of landscape aesthetics. The subjectivist paradigm says aesthetic values exist as internal experiences and ideas of living organisms perceiving external substances while the objectivist paradigm says aesthetic values are inherent qualities of the substance itself.

Taken to their extremes, these ideas could be seen as a purely socio-culturalist perspective squaring off against a child of deep ecology in a debate over whether all environmental values are ephemeral cultural constructions up for interpretation or the idea all environmental values follow preexisting ecological laws that must subsume culture in order for humanity to survive (T. C. Daniel 2001).The debate between the two paradigms did not start as a controversy over the roots of Human- Nature conflicts. In part, this debate took place in a series of exchanges through literature in the1970's and 80's. Carlson (1977) first described contemporary trends in aesthetic assessments as a response to a growing interest in "environmental intangibles", what today have come to be called ecosystem services. A combination of social sciences and resource management then took that interest and sought to classify those intangibles as quantifiable resources. Carlson notes that four major themes shaped these assessment methods: objectivity, quantification, egalitarianism, and formalism. As goals, objectivity relates to the unbiased examination of landscape aesthetics. Quantification describes the pursuit of numerically analyzing landscape aesthetics. Egalitarianism describes the equal weighting of every individual's analysis, and formalism describes the use of strictly formal design elements (line, form, color, texture) to describe landscape aesthetics. According to Carlson, studies that prioritize these goals and use public perception to quantify landscape aesthetics are fundamentally flawed for two reasons. First, landscapes aesthetics and public perception are different variables, and second, proper evaluation of a landscape's aesthetics requires ecological and design knowledge, the awareness of which makes someone an appropriate "environmental critic". These critics and other experts then shaped much of the public's aesthetic perceptions, and thus quantifying public perception of landscape aesthetics only reveals what experts view to be high quality landscape aesthetics in a circular manner. Furthermore, Carlson viewed studies focusing on strictly formalist assessments as equally unsuitable attempts at quantifying scenic beauty, because the formalist components over simplified and cropped the experience down to a photographic window.

In direct response to Carlson, Ribe (1982) defended the quantification of scenic beauty by distinguishing between quantifying the subjective experience and quantifying the objective environment. In Ribe's argument, formalist components of a landscape (e.g., the visual textures of vegetation or the lines created by topography) cause an initial affective reaction in viewers, and secondary associations then bring the viewer to identify the aggregated components as majestic, cozy, etc. This model then benefits from measuring and correlating both steps of the aesthetic experience. Additionally, gauging public perceptions enables majority and minority voices to both be heard rather than solely relying on the experts from the dominant culture, such as Carlson's environmental critic. Ribe especially advocated for the application of this quantifiable data within adversarial land-use decision models to empirically support the more qualitative landscape assessments. Two years later, Carlson (1984) responded with clarifications on his position but ultimately called for an assessment process in which public input and environmental critics both contributed to aesthetic management practices.

The debate over quantification, objectivity, subjectivity, and the roles of experts and the public continues today. T. C. Daniel (2001), in recognizing the potential conflicts noted earlier, calls for a similar marriage of expert and public assessments as Carlson (1984). Daniel sees the role of the environmental critic as a key stakeholder and advocate for ecological functions and necessities, which should be weighed in conjunction with public perceptions and cultural values that contain and impart meaning within a landscape. In contrast to calls from Lothian (1999) to scrap the objective paradigm entirely due to its paradoxical reliance on subjective expertise, Daniel and Carlson see roles for both paradigms in future landscape assessments. This paper agrees with

Daniel and Carlson on this point, because public perceptions are vital to ensuring the social sustainability of any landscape intervention (Nassauer 1995) while expert assessments are necessary for ensuring the credibility of environmental knowledge on which those interventions are based (Fazey et al. 2006).

Current wind farm visual impact assessments methods, such as Vissering, Sinclair, and Margolis (2011), rely heavily on the objectivist paradigm and, similar to federal program's established methods, includes public participation in reactionary roles. Public perceptions are used to establish the sensitivity of surrounding landscapes and the intensity of visual impacts on viewer populations. Together with essentially formalist quantifications (such as number of turbines in view, proportion of a field of view occupied by the turbines, dominance of the turbines in the view, duration of viewing time, etc.), public sentiment data are used for comparison with local aesthetic goals as laid out in official plans or design guidelines. In this scenario, the impact assessment becomes a defensive maneuver in adversarial land use planning. While objectivist assessment paradigms rooted in traditional hierarchies dominate current assessment methods, Wolsink (2018) concludes that these practices only measure visibility and that measuring true visual impacts requires looking into the meanings and experiential changes that occur in viewers as a result of a landscape change. Such exploration would inherently require elevating the role of the subjectivist paradigm in the visual impact assessment and the role of effected stakeholders in the data collection process.

The Rise of Digital Visualization Tools

Recent advances in visualization technology have included highly realistic digital vegetation models, data-driven displays of terrain, and applications of georeferenced aerial imagery. Although the technology has changed tremendously, digital video and static renderings still use the similar before and after concepts as Humphrey Repton's Red Books for comparative landscape visualization (Figure 2.5). In the last century, photomontage became the premier visualization technique, but more recently, this analog technique has been replaced by its digital twin through advanced graphic editing software. Similar trends occurred in landscape modeling as physical constructions were increasingly replaced with digital 3D models. Realism has been a significant goal in many of these digital renderings, especially for visual impact analyses. In the pursuit of realism, visualization software has developed photorealistic terrain, vegetation, animals and humans, water, built structures, atmosphere, and light (Figure 2.6). These additional technical elements, however, mean that effective visualization requires a high degree of expertise, which limits its accessibility and adoption by untrained professionals (Lange 2002).

Given the broad capability of digital rendering tools, Lovett et al. (2015) developed a framework that describes how to select an appropriate visualization tool. The framework considers a visualization's setting ("When?"), content ("What?"), and presentation format ("How?") in order to guide practitioners in their selection (Fig. 2.7). Using this framework, Lovett et al. (2015) generated a comparison of digital still images, animations, and real-time models in terms of their appropriate uses and weaknesses (Table 2.3). The comparison concluded that static images and some animations were effective for realism but left viewers in a passive role while real-time models improved interactivity, but the complexity of the models often resulted in lower realism and subsequent losses of credibility.

Figure 2.5. “Gidea Hall” by Humphrey Repton, 1797. These hand-drawn renderings often included page flaps that enabled viewers to look at the landscape’s existing and proposed conditions.

Figure 2.6. A modern landscape visualization using digital 3D modeling and rendering software. Courtesy of David Evans.

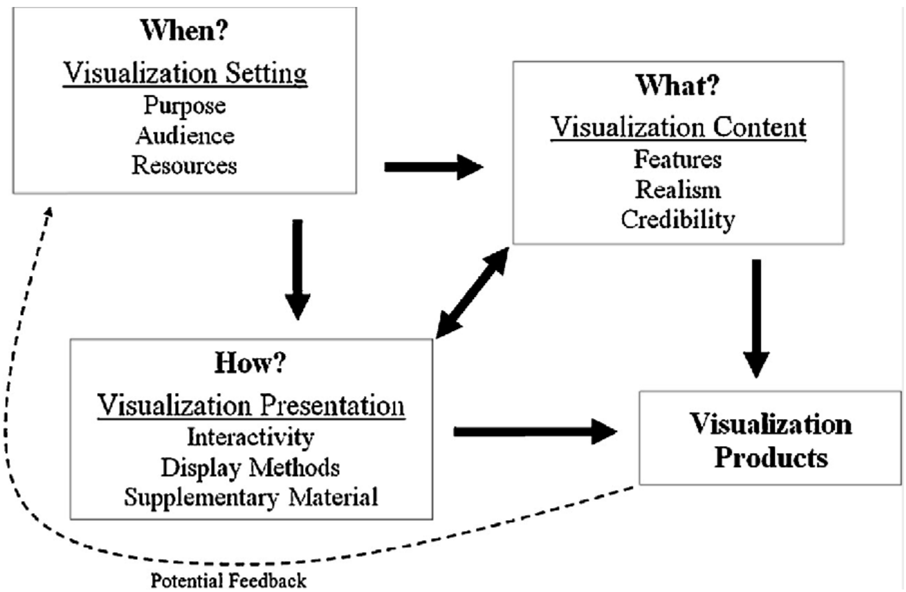

Figure 2.7. A proposed decision framework for evaluating visualization tool selection from Lovett et al. (2015)

Table 2.3. From Lovett et al. (2015), the comparison of appropriate uses and complications of three different digital visualization formats.

	Rendered Still Images	Animations	Real-time Models
Visualization Purpose	Can incorporate a high level of feature realism, though interactivity is generally limited	Useful when landscape dynamics (e.g., change overtime) are important. Can convey a sense of movement through, or movement of, landscape features	Provides the interactivity that can be especially useful for engagement and collaborative functions
	Good for communication and education functions, especially where multiple possible changes or scenarios need to be shown on a comparative static basis	Particularly appropriate when movement needs to be combined with a higher level of feature detail than possible in real-time models	Feature realism may need to be limited, depending on availability of computer processing power and facilities for level of detail management
Visualization Audience	Can reach audiences via a range of media including print, digital display at events and the Internet	Straightforward to display at events; possible to make available via the Internet although file size may be a concern for some viewers	Most effective in workshop settings. More immersive and interactive displays typically require participants to attend a meeting venue, though some models can be distributed via the Internet
Resources Required	Much depends on the level of detail required. Representation of foreground features is particularly important for ground-level views	Prepared in advance of use. Compiled animations require more effort than single still images but less than a real-time model. Animations recorded from real-time models may require supplementary editing	Can be demanding in terms of both preparation time and equipment needed for model creation and presentation, although display may also be possible on standard hardware. A panoramic display capability is particularly advantageous
Communication	Detailed representations and straightforward links to contextual information can enhance credibility. Salience depends on the viewpoints provided	Can provide a balance of credibility and salience, though the predefined nature of content may limit both aspects. Movement gives limited interactivity and immersion which may increase engagement	Exploratory capabilities can increase salience for stakeholders. The novelty can capture initial interest and may increase engagement
Communication strength	Viewer has a passive role so engagement may be limited. Predefined viewpoints make it difficult to respond to audience requests for alternative perspectives	Predefined viewpoints make it difficult to respond to requests for alternative perspectives or to compare before and after views Internet distribution requires manageable file size, reducing frame size and/or image quality	Limits on detail can impair credibility in certain situations. Immersive motion is disconcerting or uncomfortable for some viewers

Questions of how and when to use digital design tools are of interest in many landscape-level professions. For instance, Rozmi et al. (2019) documented 41 commercially-available immersive visualization software packages for designing renewable energy systems to investigate their purposes and strengths. Of those 41, only two (Windographer and WindPro) solely dedicated to wind energy, and none were meant for mobile applications. These programs were also categorized by the planning stage for which they would be most effective, and the wind-related software packages were deemed most appropriate for planning and design stages, respectively.

Despite the abundance of digital visualization production methods, debate over presentation modes continues to value analog methods. In an analysis of decision maker's responses and long-term uses of various visualization products, Schroth, Pond, and Sheppard (2015) found that physical presentation media were seen as more "sustainable" in the long term. Following a participatory planning workshop, decision makers remembered digital and physical visualization materials used in the process, but after the event, physical elements such as posters continued to be used more often than digital materials such as a virtual globe. The authors attributed this gap, in part, to lower user familiarity with the virtual materials. Consequently, the researchers recommended using visualization media that meets the available infrastructure of the recipients in order to support on-going decision processes. These findings echo Lovett et al. (2015)'s conclusions that static images can be easier for presenters to implement and that more immersive digital materials can become cumbersome when additional infrastructure is required to support the presentation.

Although digital visualization tools present challenges for public presentations, researchers are using real-time models and immersive digital experiences to explore landscape perception and participatory design strategies. Yu et al. (2017) utilized Google Cardboard, a low-cost virtual reality headset that uses a smartphone to display images, to expose subjects to a visual and audible experience of a wind park. Video from an undeveloped sample site and audio from an existing wind park were used to create a virtual reality simulation in Unity 3D that was "illustrative, interactive, and intensive" (Yu et al. 2017, 2). Measurements of subjects' self-reported and physiological responses indicated that individuals perceived aural annoyance more readily than visual annoyance, which reflects subjects' holistic experience of the landscape and that sound plays a significant role when viewers are less than 500m from a wind turbine.

Of the available digital visualizations tools, augmented reality (AR) is this paper's primary focus, and navigating the use of AR also require an understanding of different formats' strengths and weaknesses. Augmented reality involves the layering of virtual and real environments in sucha way as to make them seem combined. This overlay may contain text, pictures, audio, video, 3D models, or other graphic user interface components superimposed onto a physical surface or a field of view. In order to achieve this combination, every AR experience requires four components: a camera, a tracking unit, a render unit, and a monitor. Respectively, these components collect information about the physical environment into which the virtual environment will be situated, track the camera's position within the overlapped environments, calculate the correct image to display based on the camera's position within the virtual environment, and display the overlaid images. Early AR methods often required extensive headgear and equipment backpacks, but modern smartphones and tablets are rapidly increasing the public's accessibility to this suite of equipment. AR also comes in different display formats. On smartphones and tablets, AR is considered mobile, or MAR. AR may also be projected onto surfaces or be integrated into dedicated headsets that are either transparent or display a video of the physical environment (Broschart and Zeile 2015).

AR can enhance users' spatial cognition by providing visualizations that facilitate exploration and the creation of spatial meaning. In an experiment where users explored proposed landscapes in AR, subjects were able to describe spatial relationships within the proposed landscapes more accurately after walking through a 3D model as compared to comprehension after only viewing the model from fixed points. Walking through the model increased the users' spatial understanding by enabling interpretation through proprioception and dynamic visual relationships to other landmarks (Soria and Roth 2018).

Given the benefits of AR visualization, interest in using AR to visualize sensitive landscape features like wind farms has grown. Dekker et al. (2013) developed a mobile, tablet-based AR application as an educational tool for training wind energy professionals and visualization specialists. The app, MARWind, enables users to place 1:1 scaled 3D virtual turbines into physical environments using latitude, longitude, and elevation on a touch map. After placing the turbine, users can view the models using the camera on their device, which uses GPS and Wi-Fi to track their geographic location as well as the device's gyroscope, accelerometer, and compass for measuring the device's orientation and fine moments. At the time, the developers used Unity Game Engine, a free game development platform that primarily relies on a graphic user interface rather than traditional coding to make programs.

Public Participation in Land Planning

In the mid twentieth century, urban renewal efforts, anti-poverty work, and the federal Model Cities program often resulted in development projects that marginalized communities' voices, wants, and needs. In response, community engagement and participatory planning activities came under increased scrutiny. Perhaps the most influential of these analyses came from Sherry R. Arnstein. Arnstein (1969) proposed an eight-rung ladder to describe different strategies meant to engage citizens in community development and public planning initiatives. While this model certainly does not capture every mode of possible participation, the ladder model effectively captures a broad and logical spectrum of shifting power dynamics between citizens and government agencies.

The rungs are organized into groups of increasing citizen control (Figure 2.8). At the bottom, the Nonparticipation group generally involves instances where decision makers entrenched within governing bodies provide misleading information or seek to cure citizens of their concerns in order to subtly coerce consent from the public. In the middle of the ladder, Degrees of Tokenism includes strategies where members of the public are given impotent roles with increasing agency in the decision-making process. Finally at the top, Degrees of Citizen Power describe situations where members of the public hold substantial resources and influence over proposals' final outcome. These rungs provide a valuable building block for this paper's central framework and will be discussed further later.

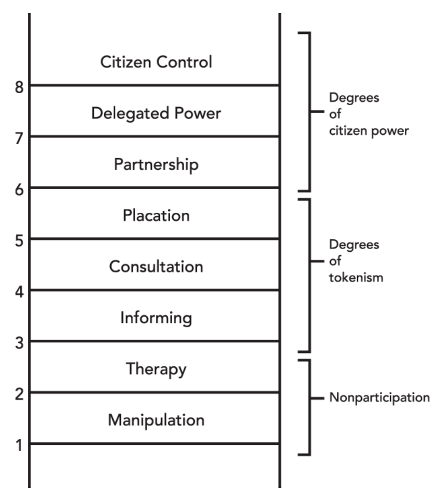

Figure 2.8. Arnstein's Ladder of Citizen Participation (Arnstein 1969)

In the last fifty years, social and environmental researchers have called for landscape architects and planners to empower citizens through participatory design strategies, which like Arnstein's Ladder, can involve a range of substantive power sharing dynamics. Part of the foundation for such power sharing comes from the visual discourse in a participation framework. Raaphorst et al. (2019) propose a three-part model to describe visual discourse as process through which nonverbal design collaboration can occur: the arrangement of the participatory process, the interactivity of the medium, and the visual rhetoric of the image. Together, these pieces represent the context of participation, the ease with which participants can visually comprehend and respond to an image, and the style and contents of an image under debate. The authors find that appropriate management of these components supports clear communication and increases the validity of the participatory process. In light of Arnstein (1969), this "validity" reflects a movement up the participatory ladder by ensuring proper accessibility of information within an image and providing tools for participants to comfortably respond in kind, thereby making giving community voices more equal footing within the visual discourse. Orland (2015) notes that landscape professionals believe compelling visual imagery and narrative text may reduce the degree of public objection to landscape changes, but that many viewers remain unaware of the relationships between visual data sets within development proposals. Within participatory contexts, this challenge could, in part, reflect poor management of visual discourses.

Some planners and designers have turned to gamifying public participation as a means of managing visual discourse. Gamification involves increasing interactivity and often introducing reward systems based on that interaction, and Klamert and Münster (2017) sought to inform such gamification tools by categorizing participation case studies according to the agency and power which each gave to participants. These case studies revealed participation tools that fell into three categories: unidirectional flow of information to participants, two-way flow of information within limits established by the facilitators, and two-way flow of information where citizens and other public stakeholders could initiate their own information flows in a collaborative manner. The authors especially noted challenges to developing gamified participation platforms such as early stage needs for two-way communication and later stage needs for visualization. Furthermore, digital participation games encountered problems with heterogeneous digital literacy among participants, accessibility of appropriate hardware, and prevalence of particular communication channels that made uniform applications difficult. These barriers contributed to the authors cautioning against fully replacing in-person participation models with digital experiences. Despite these challenges, the authors found that AR tools presented attractive opportunities for participation in each of the three method categories (Table 2.4)

Table 2.4. Gamified participation opportunities in AR. Adapted from Klamert and Münster (2017)

Informing	**Consulting**	**Collaborating**
Real-time visualization. 2D image tracking to 3D model display. Geo-referenced 3D models.	Real-time interactions with 3D model. Users can edit the model along established parameters. Collect local knowledge through mapping or activated device sensors. Gamified priority or ranking scenarios.	All users can initiate issues or information feedback loops. Gamifying planning meetings Facilitating co-creation.

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While Klamert and Münster (2017) answers questions about the participatory arrangement and interactivity of visual discourse through digital gamification, Berry et al. (2011) investigates qualities of visual rhetoric in digital web-based visual impact simulations. In their study, Berry et al. (2011) assessed subjects' ratings of different digital visualization styles for wind farms including 2D zone of visual influence maps, 3D wire frame diagrams, digital photomontages, and GIS-based 3D landscape visualizations (with static and animated versions). The study measured each simulation methods' clarity, effectiveness in communicating visual impacts, and perceived accuracy. In the end, the photomontage and static 3D visualization were rated for highest clarity. The photomontage and animated 3D visualization were rated as most effective for communicating visual impacts and were perceived as the most accurate. Landscape professionals in the subject sample, however, rated an interactive 3D model higher than other subjects and wanted metadata on the visualizations to rate their accuracy. This last observation suggests that professionals in environmental and landscape fields have different priorities than the general public when engaging with landscape visualizations.

Many of these digital and gamified participation platforms are taking advantage of mobile technologies to facilitate civic participation in landscape design and planning, and Boone (2015) demonstrated how these methods can broaden the audience of participation beyond majority voices. In Boone's study, a mobile app called "Cellphone Diaries" allowed users to geolocate video and audio materials in a park slated for redevelopment. Boone calls this mode a "critical visualization approach" (Boone 2015, 235). By representing these perspectives and expanding their audience, the app "moved [users] from 'subjects' to 'agents of change'" (Boone 2015, 241), spurred additional community involvement such as a gallery exhibit and radio interview, and actively influenced the park's new master plan. By providing an initial, novel platform for stakeholders to express their views for a targeted purpose and audience, the app facilitated substantive changes around the park's proposed changes.

Other mobile participation strategies put users into an active design role rather than simply responding to impact simulations or providing local knowledge. Grassi and Klein (2016) propose such a strategy for AR public participation in wind farm designs by enabling users to identify and select potential development sites based on GIS-based zones of visual influence. The authors' framework outlines a conceptual workflow for users to use GIS data on a mobile device to identify areas sufficiently removed from existing structures to meet a basic distance criterion before geolocating turbine models and viewing them in AR.

Trials of AR in educational settings indicate that the attractiveness of AR applications, like the beauty or realism of any visualization, does not necessarily correlate with the clarity of the images produced and, consequently, the users' comprehension of the information. Schroth and Zhang (2014) found that AR improves the appeal and clearness of flat contour maps by superimposing a correlated 3D landform model using image-based tracking, but the display can become cluttered with excess information, which decreases the information's legibility. In the study, subjects were able to choose between several textures to render 3D landform models, and aerial imagery, perhaps reflecting realism, was the most visually appealing. The same texture, however, was also rated as having the lowest clarity for interpreting topography, which was the goal of the exercise. In contrast, s 3D model with color-coded elevation had the greatest clarity. These findings suggest that AR visualizations will need to balance clarity and visual appeal as part of their visual discourse management. Engagement strategies attempting to do so would likely benefit from tailoring visualization methods to specific tasks or project development stages.

AR engagement tools appear to increase participants' self-reports interest regarding participation in planning initiatives. Goudarznia, Pietsch, and Krug (2017) tested a marker-based tracking AR application in a public setting for random subjects to view a proposed memorial structure and plaza renovation and found that 72% of subjects reported an increased interest in projects using similar technology. Given this strong public interest and mobile AR's cheaper and more common hardware requirements compared to virtual reality, AR provides an attractive, affordable opportunity for planners and designers to create semi-immersive experiences and accessible tools for participatory collaboration.

The Necessity of Evaluating Participation & Visualization Tools

Today, digital visualization technologies are evolving faster than environmental design professionals' understanding of how to effectively use those tools. Current research shows that cognition, emotion, and interpretation all influence how viewers engage with the produced visualizations, but design professionals' uncritical application of the latest visualization technology can readily ignore those factors in favor of realism or novelty and at the cost of clarity or accuracy. To understand the role of visualizations in design, Foo et al. (2015) adapted Gobster et al. (2007) to place "critical landscape visualization" as an intermediary between landscape patterns and viewers' interpretations in a model of human-landscape interactions. This criticality implies that visualizations account for how stakeholders engage the design and planning processes, understanding of which calls for visualizations to respond to the cognitive, emotional, and interpretive factors shaping participation. Critical landscape visualization stands to mirror critical cartography, which seeks to challenge existing power dynamics around cartographic authorship through democratizing cartographic tools and challenging cartographic traditions. In order to make those challenges, environmental design professionals and researchers must evaluate the cartographic and visual traditions defining existing power dynamics in their respective fields. Such movements require personally and directly engaging stakeholders rather than only focusing on generating maps or visualizations from easily accessible, remote data (Kim 2015).

Consequently, digital tools and workflows will continue to require direct engagement with affected stakeholders in order to expand substantive citizen participation in landscape visualization and planning.

In recent decades, social research has demonstrated that engaging the general public's personal and experiential knowledge can contribute to disassembling power hierarchies like those established in traditional planning or visualization participation that fall into Arnstein's "nonparticipation" or "tokenism" categories (Kim 2015). Further research into multi-sensory understandings of landscapes beyond simply visual representations can contribute to understand these corporeal experiences through biological, social, political, and economic lenses. Smartphones and other mobile devices provide a range of sensors to capture aural and haptic experiences necessary for that research, and scholars should capitalize on related voluntary user-generated data from these devices that are becoming increasingly ubiquitous. However, these shifts toward intimate knowledge collection will require new methods, ethics, and understandings of how lay persons contribute to the production of knowledge (Cope 2015).

Cash et al. (2003) proposed that knowledge produced by science and technology needs to be credible, salient, and legitimate in order to achieve public acceptance. In these authors' model, "credible" refers to scientific accuracy. "Salience" implies relevance of the knowledge to decision makers receiving that knowledge, and "legitimacy" involves an understanding that the information's creation was inclusive, unbiased, and fair to opposition. These principles are especially important when the knowledge acts as a boundary object between communities transferring knowledge to unfamiliar audiences. Lovett et al. (2015) successfully applied Cash et al.'s (2003) definitions in the analysis of landscape visualization methods and further analysis of visualization tools should continue to do so in order to maintain intellectual and professional integrity.

In the pursuit of credibility and saliency, landscape visualizations have achieved incredible levels of verisimilitude. This concept is distinct from realism in that verisimilitude gives the appearance of being real whereas realism actually concerns itself with the factual accuracy of reality (Stoehr 1969). This distinction between verisimilitude and realism succinctly summarizes the need for evaluating and carefully applied visualization practices, especially in participatory contexts. While verisimilitude can attract attention and increase engagement with an image, the appearance of realism without accuracy can easily mislead or bias viewers. As such, practitioners should ask how much stakeholders take a visualization to be true and openly express the limitations of an image or select production methods that transparently convey uncertainty where it exists (Nassauer 2015). This transparency will be vital where communicating fairness and eliminating bias in the pursuit of visual legitimacy.

Taken together, this literature review identifies a need for tools that will facilitate the assessment of subjective landscape perceptions by the public using merging technologies. These tools will need to respond to a diverse range of development contexts with histories of contentious public-private relationships rooted in individual and cultural differences. Further, these tools will need to be capable of marrying objectivist expertise with subjective assessments to balance stakeholders' priorities within a necessarily participatory process to increase public acceptance rates of renewable energy projects. The resulting framework will need to improve users' ability to match digital capabilities with well-defined goals related to participation styles. The following chapter will further define the construction of this framework.

CHAPTER 3

THE FRAMEWORK

In light of the opposition to wind farm development, the need for subjective landscape assessments and similarly democratized (i.e., egalitarian and pluralistic) participation methods, and an evident need for the evaluation of participatory frameworks and the digital tools that support them, this paper now proposes a theoretical framework for analyzing the incorporation of AR participatory tools into environmental design. The framework considers contextual factors of an environmental design program to determine what AR functions and auxiliary infrastructure requirements will best support a desired participatory process, and this section will first describe the separate pieces of the framework and their connections before providing the framework in full. Methods for analyzing and demonstrating the framework will follow.

To begin, the framework considers the people involved with a given project and their existing power dynamics. This paper draws on Walker and Cass (2014) for a useful categorization of these variables, referred to as "actors" and "social modes" respectively (Table 3.1 and 3.2). Each type of actor is distinguished by a distinct set of roles and attitudes in renewable energy development projects, and any collection of actors in a development project is inherently embedded within the identified social dynamic. By identifying the actors and social modes at the beginning, the framework establishes a baseline of potential audiences and the relationships defining existing decision-making processes.

Table 3.1. Actors involved in renewable energy development. Adapted from Walker and Cass (2014).

Actor	Definition
Active Consumer	Actively choose between suppliers, including carbon offsets or green energyoptions which partially or entirely involved renewable generation
Service Users	Use the services provided by energy generated using renewable technologies
Financial Investors	Invest in shareholding or interest-earning arrangements ranging from specificprojects to the broad financing of renewable energy projects, or to the investment choices of particular companies
Local Beneficiariess	Receive benefits in addition to energy services; financial, infrastructural, educational, technological, or intangible.
Project Protestors	Actively object to projects through organization of local protest groups, attending meetings, writing to the press, lobbying, signing petitions, etc.
Project Supporter	Actively engage in similar actions to protestors but move in favor of the proposed project
Project Participants	Get involved in community mode of implementation, including membership oforganizing groups, attending meetings, or hands-on installation or maintenance
Technology Host	Owners of buildings or land used for hosting technology, but not the renewableenergy technology itself
Energy Producer	Directly own and operate generation technologies of different forms

Table 3.2. Five common arrangements of social relationships in renewable energy production. Adapted from Walker and Cass (2014).

Mode of Social Organization	Definition
Public Utility	Publicly-owned generators and suppliers monopolistically provide energy directly to consumers
Private Supplier	Privately-owned generators and suppliers provide energy to consumers through a competitive marketplace
Community	Partially or completely community-owned projects generate and provide energy to local stakeholders
Household	An individual household owns or hosts energy production on their own property
Organizational	An organization, either public or private, owns or hosts energy production facilities on its own property

Following the description of the social mode, the framework also draws on and modifies a matrix of project stages and associated roles for landscape representations as proposed by Hayek (2011) (Table 3.3). These goals inform actors' objectives at a given stage, and the roles of representations similarly inform the strategies of any potential AR tool to facilitate those objectives. These goals and roles then imply needs for information transfer between participants during each stage.

Table 3.3. Planning Stages, Goals, Roles of Representations, and Information Transfer Needs. Adapted from Hayek (2011).

Planning Stage	**Goal**	**Role of Representations**	**Information Transfer Needs**
Data Collection	Inventorying information about a proposed project	Motivate data collection. Identify data needs. Document existing conditions.	Motivation, Raw data (images, text, audio recordings, videos about landscape features important to the public)
Problem Analysis	Understanding opportunities, threats, needs, and desired outcomes	Highlight aesthetic needs. Compare spatial data sets. Communicate findings.	Spatial data layers. Intangible data visualizations. Information gap identification.
Option Creation	Generating multiple solutions for the final product	Demonstrate key problems. Introduce ideas early in the discussion. Development of alternative solutions.	Summary of design problem. Design solution interaction capabilities.
Option Evaluation	Understanding comparative strengths and weaknesses of multiple solutions	Integrate diagrams and visual indicators to facilitate spatial and aesthetic comparisons. Demonstrate visual impacts. Facilitate discussion.	Summary of design options. Spatial and intangible comparative criteria for options. Feedback loops.
Selection	Identification of the most desirable solution	Succinctly represent alternatives.	Summary of design options. Voting or ranking capabilities.
Decision	Defining next actionable steps	Identifying action needs	Implementation plan. Feedback on implementation plan.

Finally, the framework's contextual analysis points toward AR functions for visualization and participation as well as the relevant infrastructure needed to support such functions. To identify possible AR functions to include in the framework, this paper again draws from Hayek (2011) and Broschart and Zeile (2015) to describe the requirements of AR tools and supportive participation functions (Table 3.4). Additionally, each type of AR functionality transfers a particular type of information, which can be related to the information goals and transfer needs of each planning stage (Table 3.5). Together with the preceding literature review, these studies inform a description of the basic uses for AR in a participatory design setting (Table 3.6).

Once the initial contextual inventory is complete, an analysis of the actors involved, their roles, and the goals of the present planning stage begins to answer questions about what information needs to be processes or transferred. To describe these variables, this paper draws on concepts of authorship from critical visualization and critical cartography (Foo et al. 2015; Kim 2015) to assign roles as "authors" or "recipients". Hayek (2011) offers a framework for describing information processing and transferal needs based on planning stages, which informs the relationship between information objectives and planning stages in this paper's proposed framework as well. Together, authorship and stage-based information objectives describe who creates and transfers knowledge at a particular design stage and who receives and processes that information. This concept will then inform the objectives and target audiences for recommended AR tools and participation strategies.

This framework uses the ladder for citizen participation from Arnstein (1969) to describe various degrees of participation available to project developers. As their original author notes, these participation levels are not comprehensive nor mutually exclusive. However, they do describe a sufficiently appropriate range of participation types to be useful for the proposed framework (Table3.7).

Table 3.4. AR Visualization capabilities and recommendations for supportive hardware

Visualization Capabilities	**Tracking Unit**	**Render Unit**	**Monitor**	**Camera**	**Data Storage**
Marker-based tracking	Camera & Image Recognition Software	Any	Any	One or more	Local or remote
Markerless tracking	Camera, Gyroscope, Accelerometer, LiDAR (Optional)	Any	Any	One or more	Local or remote
GPS tracking	GPS Unit, Digital Compass	Any	Any	One or more	Local or remote
Charts and Graphs	None	Any	Any	One or more	Local or remote
Abstract Visualization	Camera & Image Recognition Software, or Gyroscope and Accelerometer	Low quality unit is acceptable	Any	One or more	Local or remote
Photorealistic Visualizations	Camera, Gyroscope, Accelerometer, LiDAR, GPS Unit, and Digital Compass	High quality unit is required	Tablet-size or larger, high resolution display	At least two	Local or remote
Realistic Shadows	Camera, Gyroscope, Accelerometer, GPS Unit, and Digital Compass	Low quality unit is acceptable	Any	One or more	Local or remote
Animation	Any	Any	Any	One or more	Local or remote
Textures	Any	Any	Any	One or more	Local or remote
Outdoor Occlusion	Camera, Gyroscope, Accelerometer, GPS Unit, and Digital Compass	Any	Any	One or more	Local or remote
Model editing	Any	Any	Input-capable	One or more	Local or remote
Planview-to-Perspective toggle	Camera, Gyroscope, Accelerometer, GPS Unit, and Digital Compass	Any	Input-capable	One or more	Local or remote

Table 3.5. AR Capabilities and the types of information transfer accomplished by each

AR Capabilities	**Information Transferred**
Marker-based tracking	Spatial relationships between attached virtual objects and in-frame physical objects
Markerless tracking	Spatial relationships between physical and unattached virtual objects
GPS tracking	User's location
Geolocated models	Spatial relationships between physical objects and virtual objects georeferenced in the physical world
Quantified Data visualizations	Charts & Infographics. Non-spatial data.
Abstract Visualization	Spatial relationships in design concepts
Photorealistic Visualizations	Design details, realistic colors and textures, shadows
Realistic Shadows	Shadow impacts on virtual or physical objects
Motion	Visual effects of different turbine speeds
Textures	Visual Contrast
Occlusion	Visual overlap of objects from different viewing angles
Scaling	Visual dominance at different scales
Rotating	Spatial orientation of objects
Add/subtract models	Spatial relationships between physical and virtual objects
Planview/Perspective toggle	Spatial relationships among virtual and physical objects

Table 3.6 Examples of different participation levels incorporated into AR tools. Adapted from Hayek (2011).

Participation Category	**Example Functions**
Informing	Geolocating virtual signs or models for inspection, imposing 3D models on 2D plans, Augmented existing physical objects with virtual data displays
Consulting	Interactive 3D models, user accounts, platform for publishing interaction results, communication platform for sharing visual, aural, or spatial information with officials and other stakeholders on existing topics, priority or scenario ranking
Collaborating	Communication platform for stakeholders to raise new issues and for officials to provide feedback, co-creation, decision-making, incorporation of in-person collaboration

Now that all the pieces have been described, the overall framework will make more sense (Figure 3.1). In this framework, an initial inventory stage documents the existing social mode, target participation level, and current planning stage of a project (since this framework is intended for use in renewable energy development, the broad goals for siting are taken to be generally constant). The social mode describes the existing power dynamics and therefore the baseline participation level, and the target participation level becomes a goal requiring changing roles by given actors. Once a target participation level is selected, that decision informs which actors will become involved in the project and their roles as authors or recipients of information. At the same time, the planning stage determines what the actors' information objectives will be (Table 3.7). Once the information objectives and authorship roles are determined, appropriate AR functionalities can be selected and tailored to these target audiences with established goals. At the end, infrastructure needs can be determined once the AR tools have been finalized.

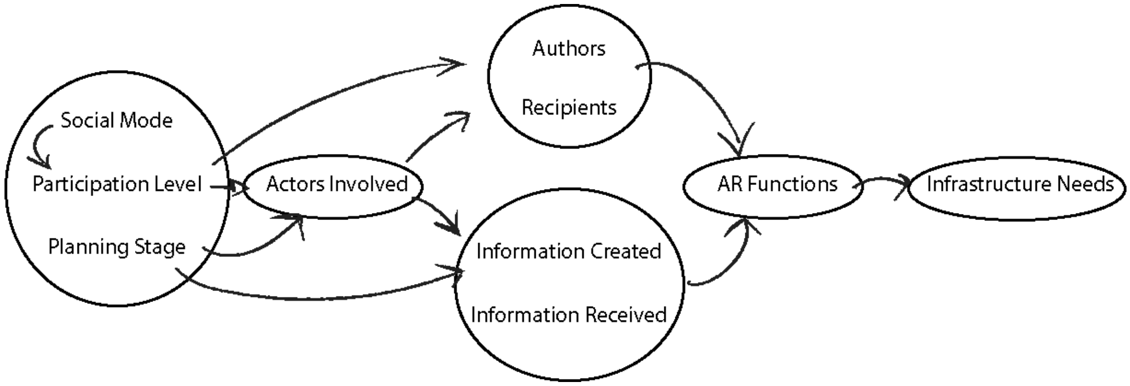

Figure 3.1. The proposed framework for incorporating AR tools into a participatory design strategy

Table 3.7. Participation levels adapted from Arnstein (1969).

Participation Level	Key Qualities
Citizen Control	A community-owned corporation exists without intermediaries between itself and the source of funds. Final approval power and accountability rests in local citizens' hands.
Delegated Power	Citizens hold the dominant decision-making authority and veto power in a development context. Citizens hold the majority of seats on a decision-making body, have clearly specified powers, and can substantively hold other parties accountable. Problems are proactively addressed by powerholders.
Partnership	Citizens negotiate rules and responsibilities for sharing decision making powers with development drivers. Community partners are substantively accountable to their constituents, and resources are available for facilitating independent, dedicated, and technically-advised work by the community partner.
Placation	Decision makers add public stakeholders to advisory committees, but powerholders retain the right to judge the legitimacy of the advice and may or may not provide technical assistance to the committee. Rights and responsibilities of the committee may be ambiguous.
Consultation	Decision makers inform the public and collect feedback on predetermined questions
Informing	Decision makers provide information to stakeholders without any means of providing feedback or negotiating
Therapy	Decisionmakers attempt to "fix" the opposition's viewpoints and concerns
Manipulation	Provision of intentionally misleading development descriptions in order to coerce public acceptance

Table 3.8. Actors' inferred information authorship and recipient roles based on participation levels from Arnstein (1969) and actor designations from Walker and Cass (2014).

Participation Level	Actors as Authors									Actors as Recipients								
	Active Consumer	Service Users	Financial Investors	Local Beneficiaries	Project Protestors	Project Supporter	Project Participants	Technology Host	Energy Producer	Active Consumer	Service Users	Financial Investors	Local Beneficiaries	Project Protestors	Project Supporter	Project Participants	Technology Host	Energy Producer
Citizen Control	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Delegated Power			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Partnership			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Placation			X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Consultation			X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Informing			X						X	X	X		X	X	X	X	X	
Therapy			X						X					X				
Manipulation			X						X									

CHAPTER 4

THE CASE STUDIES

Methodology

In order to evaluate this framework, this study examines four case studies in which digital visualizations were used as participatory environmental design tools and then describes each case study using the established framework. For each case study, a SWOT analysis will evaluate the strengths, weakness, opportunities, and threats of the described tool. This SWOT analysis and the framework's description of the tool will then inform an evaluation of the case study's participation level, participation-limiting factors, AR functions that could address those limitations, and the additional infrastructure required to support those functions. Following the evaluation of all four case studies, general trends will be assessed and incorporated into an adjusted framework.

Case studies were selected from the preceding literature review and were required to incorporate digital visualization in AR, VR, or adjacent formats as a participatory design tool for the general public to engage an environmental design problem. While case studies that focused on renewable energy development would be ideal, the implementation of these tools for public engagement in renewable energy development contexts has not been widely studied, and such case studies are rare.

Each case study will be analyzed to identify the contextual social mode, participation level, planning stage, and involved actors. The case studies will be categorized according to the preceding qualitative descriptions for each of the four context variables. Next, the participation strategy will be analyzed to identify author and recipient roles as well as what information is transferred through the participation strategy. Finally, the AR implemented functionalities will be documented along with additional digital and participatory infrastructure. Following the analysis of variables and description of the case study through the framework's lens, a SWOT analysis will identify strengths, weaknesses, opportunities, and threats based on the alignment of participation level, planning stage goals, and AR capabilities. This SWOT analysis will then inform a strategy to increase the tool's participation level by one rung on Arnstein's ladder, and a final SWOT analysis will reassess the modified strategy for comparison.

For the final evaluation, the framework is used to analyze an abandoned offshore windfarm development plan originally proposed for the Georgia coast in 2007. The framework is used to examine the available inventory variables and then create a hypothetical scenario in which the proposal could have been carried forward and incorporated AR participatory design tools as part of a broader public engagement strategy.

In each case study, the evaluative process uses a systematic data collection and SWOT analysis template. The template and completed data sheets can be found in the Appendix I. The following sections provide the case study summaries and highlight results that demonstrate the framework's flexibility, strengths, and method adjustments that came from these evaluations.

Case Study #1: Marker-based AR for Public Visualization

According to Goudarznia, Pietsch, and Krug (2017), four pillars, collectively called "The Portico", are historic components of a former market house façade on riverfront in Bernburg, Germany, but flood damage demanded a redesign of the shoreline before 2009. As part of the project, the Portico and the connected structure were removed, and the Portico was then stored offsite. Eight years later, the authors conducted a study using AR to gauge public responses to a proposal that would reconstruct the Portico as a stand-alone monument in its original location. The study prepared photomontages and marker-based AR simulations for public viewing of miniaturized and 1:1 scale models of the proposed construction during an informal pop-up engagement session at the site. Facilitators provided AR-capable tablets and fixed markers for users to view the virtual objects. For the 1:1 scale mode, the marker was fixed in placed such that the virtual object appeared in the geographically correct location. Following the AR experience, subjects received a questionnaire about their knowledge and experience with AR and public participation to compare the comparative power of AR and photomontages to arouse public interest in planning initiatives (Table 4.1).

Table 4.1. Framework description of Goudarznia, Pietsch, and Krug (2017)

Framework Variable	**Findings**
Social Mode	N/A
Participation Level	Consulting
Digital Participation Capacity	Informing
Planning Stage	Option Evaluation
Actors	Project Participants, Local Beneficiaries, Service Users
Authors	Project Participants
AR Functions	Marker-based tracking, textured visualizations, multiple scales
Digital Infrastructure	Local-only data storage and device requirements
Participatory Infrastructure	Credible and salient information, One-way communication

A SWOT analysis of the described application and its implementation found that the AR tool had the capacity to effectively communicate spatial and aesthetic information to users present at pop-up event (Table 4.2). The information was based on geographic data and calculated measurements. This factual basis provided credibility while the in-situ participation setting ensured saliency for users experiencing the physical environment where the proposed changes would occur. However, the lack of documented feedback on the design proposal itself, the limitation on participation to present stakeholders, and the lack of interaction options with the AR environment kept the project to a consulting/informing participation level. As a result, the introduction of annotation, commenting, and model interaction features would provide beneficial opportunities for feedback and ideation. Additionally, providing online access to the markers could broaden public access by increasing the number of people who could examine the 3D model. Together, these supplementary features would facilitate greater participatory interactions that would move the AR tool towards a placation/collaborative participation level.

Table 4.2. SWOT Analysis for Goudarznia, Pietsch, and Krug (2017)

Strengths	**Weaknesses**
Informs potential stakeholders about proposed changes in a credible and salient manner Communicates spatial relationships between virtual and physical objects for evaluation Addresses direct landscape users Enables basic visualization at miniature and 1:1 scales for exploration and in-situ visualization, respectively Requires minimal AR equipment, utilizes durable and reusable physical markers Provides AR equipment to users, provides more than one viewing option, acts as a publicly accessible workshop	Does not document public feedback or input opportunities on the proposed development. Generates participation late in the process Addresses only a small portion of potential stakeholders Lacks exploration of the 1:1 scale model and interactivity.
Opportunities	**Threats**
Adoption of fixed markers for AR engagement at Key Observation Points for public visualizations Combination of marker-based miniature and 1:1 scale model enables limited exploration when hardware constraints or users' digital literacy make markerless AR unfeasible Easily incorporated into pop-up engagement scenarios	Remains low on the participation ladder Excludes many potential stakeholders Introduces visualization late in the process Does not encourage public authorship or allow for citizen influence of the planning process

Case Study #2: AR-Adjacent In-Situ Visualization

Gill and Lange (2015) explored methods for providing location-based, on-demand 3D visualizations for mobile devices. While not necessarily AR by definition, this variant gives users possible methods for exploring credible and salient 3D models of proposed landscapes in-situ, which is a common goal of AR participation tools. The authors assessed two methods for varying mobile device platforms. In one option, a tablet-based platform allowed users to view a proposal plan and then select a location and viewing direction within established boundaries. The request then is processed by a remote server to render a corresponding view from a premade, complex 3D model of the proposed landscape. The second app provides similar capabilities through a web-browser based option for smartphones, in which the device's GPS and internal compass data provide the location and orientation information (Table 4.3).

Table 4.3. Framework description of Gill and Lange (2015)

Framework Variable	**Findings**
Social Mode	N/A
Participation Level	Informing
Digital Participation Capacity	Informing
Planning Stage	Option Evaluation
Actors	Project Participants
Authors	Project Participants
AR Functions	GPS tracking, geolocated models, photorealistic visualizations, realistic shadows, textures, occlusion, plan view/perspective toggle
Digital Infrastructure	Local device and remote server requirements
Participatory Infrastructure	Credible and salient information, One-way communication

The SWOT analysis found that the on-demand, complex visualizations were effective tools for informing users about proposed changes with credible and salient information, but that the lack of feedback channels prevented the tools from facilitating higher levels of participation (Table 4.4). Commenting and annotation tools through a graphic user interface (GUI) are the simplest solutions to increase the participation level to consulting.

Table 4.4. SWOT analysis of Gill and Lange (2015)

Strengths	**Weaknesses**
Provides on-demand visual information as requested by the user Applicable for early visual analyses of spatial data or for later-stage project evaluation Easily accessible by a broad range of potential actors High realism capabilities for credible and salient renderings Multiplatform capabilities with limited reliance on the device's technical specifications	Only informs viewers Not applicable for feedback or input stages in its current form Requires some digital and cartographic literacy No interactive capacities or real-time viewing. Requires an internet connection and reliance on a remote server
Opportunities	**Threats**
On-demand, high fidelity visualizations to any user Users can select key observation points to highlight Users can select and generate their own renderings with high credibility	Lacks available metadata Renderings with greater verisimilitude can more easily abuse their credibility in the absence of transparent production of the underlying model (legitimacy) Lacks supporting technical assistance explaining features of the visualized model

Case Study #3: Marker-Based AR for Design Ideation

Anagnostou and Vlamos (2011) investigated the feasibility of an interactive AR landscape design application with goal of facilitating design authorship by local stakeholders and laypersons. The app uses multi-marker targeting to anchor an aerial image onto which users can paint textures and place pre-defined 3D objects such as cars and vegetation. Subjects view the AR experience in a video-see-through mode using an external camera for the video production. The study details the app's demonstration at a conference (Table 4.5).

Table 4.5. Framework description of Anagnostou and Vlamos (2011)

Framework Variable	Findings
Social Mode	N/A
Participation Level	Placation
Digital Participation Capacity	Consulting
Planning Stage	Option Creation, Option Evaluation
Actors	Project Participants
Authors	Project Participants
AR Functions	Multi-marker tracking, phototextured models, object interaction
Digital Infrastructure	Local device requirements only. Separate camera and video headset
Participatory Infrastructure	Credible, salient, and legitimate information, two-way communication

The SWOT analysis identified model interaction tools as key two-way communication elements enabling users to fulfill tasks related to user-generated ideation and design evaluation (Table 4.6). A GUI supported users' design processes in the marker-based AR experience. Multi-marker tracking expanded the range of positions and angles at which the camera could be placed and still retain a stable model (in other single-marker based tracking systems, the whole marker must be in the field of view at all times). These interaction tools allow users to initiate input processes, elevating the application's participation level above other tools that only gather responses to defined parameters. As such, this tool begins to reach the placation participation level and its attendant needs for additional technical support. The next participation level would be partnership with digital capacities for collaboration, which involves negotiating shared responsibilities among stakeholders, increasing all stakeholders' credibility, and increasing design interactions among app users. These goals could be achieved through educational materials or tutorials to increase users' abilities to create data-informed designs. A participation server for handling comments, annotations, and user accounts would facilitate user-to-user interaction. Additionally, making the app available online with printable markers could increase the tool's accessibility beyond in-person implementation. In regard to participatory infrastructure, the digital changes would need to be paired with negotiated power sharing between stakeholders in order to truly achieve partnership, and such changes cannot be achieved through adjusting the digital tools alone.

Table 4.6 SWOT analysis of Anagnostou and Vlamos (2011)

Strengths	**Weaknesses**
Facilitates 2-way communication and user-generated ideation Enables the creation of alternative solutions and demonstrates limited visual impacts Broadly applicable Facilitates interaction with and editing of the 3D model. All components are local to the subject. No external links required. Intuitive GUI.	Does not provide substantial resources to influence final decisions. Lacks technical support to inform designs Lacks comparisons for evaluation of multiple options Additional data incorporation and technical assistance can increase the credibility of user-generated content Increases feedback and accessibility Incorporates negotiation for establishing specific goals and responsibilities
Opportunities	**Threats**
Multi-marker tracking allows larger, more stable models Input mechanisms support diversified authorship in visual discourse Simple GUI allows quick ideation	Lacks technical assistance to inform design iterations Lacks written feedback options or record keeping

Case Study #4: Vertically Integrated AR/VR For Visual Impact Mitigation

Bishop and Stock (2010) described a collection of virtual tools for facilitating stakeholder collaboration and assessment of wind turbines' landscape impacts. The software package, called SIEVE (Spatial Information Exploration and Visualisation Environment), consists of three components: SIEVE Builder, SIEVE Viewer, and SIEVE Direct. These pieces respectively create 3D environments from 2D spatial data, host collaborative viewing of the 3D environment, and facilitate real-time reciprocal manipulations of the 3D environment and 2D GIS. The case study uses a collaborative VR environment to explore individual landowners' visual impact mitigation strategies around an existing wind farm built west of Melbourne, Australia by a private company, Pacific Hydro.

SIEVE incorporates a broad range of capabilities into its possible workflows. SIEVE Builder allows users to construct topographically correct landscapes from geospatial data with scaled structures, turbine, and vegetation. While aerial imagery can be used, other raster data can also be used for ground plane rendering. SIEVE Viewer then allows users to take a perspective view of the 3D environment created from the GIS data. In this setting, users can rearrange structures and vegetation, scale or rotate objects, animate change over time, and assess visual and aural impacts from wind turbines. Multiple users can enter the same VR session at once and communicate via text, background voice channels in the background, and virtual avatars with body language. Users can also share their field of view to facilitate discussion of particular issues. These functions allow users to analyze data, iteratively create design alternatives, and then collaborative evaluate, select, and plan for design and implementation strategies (Table 4.7).

Table 4.7. Framework description of Bishop and Stock (2010)

Framework Variable	**Findings**
Social Mode	Private Supplier
Participation Level	Placation
Digital Participation Capacity	Collaborating
Planning Stage	Problem Analysis, Option Creation, Option Evaluation, Selection, Decision
Actors	Local Beneficiaries, Project Participants, Technology Hosts
Authors	Local Beneficiaries, Project Participants, Technology Hosts
AR Functions	Markerless tracking, GPS tracking, Geolocated models, Abstract visualization, Photorealistic visualization, animation, textures, occlusion, model interactions, plan view/perspective toggle
Digital Infrastructure	Local device requirements for individual uses and internet capabilities for online collaboration sessions.
Participatory Infrastructure	Credible, salient, and legitimate information, two-way communication

The SWOT analysis finds that SIEVE is a powerful, widely applicable digital participation tool for facilitating user-to-user collaboration (Table 4.8). Strengths include strong, transparent connections between site data and the modeling environment, multiple user-to-user communication methods, and useful model interaction methods to explore design alternatives and rudimentary aesthetic impact evaluations. However, the participatory infrastructure outside of the tool was lacking in this scenario. The energy producers were not directly involved, and since the wind farm was already built, the onus for mitigation visual impacts was being placed on individual landowners. Although participants had a high degree of control over their own landscapes, the participation level could only reach placation since public citizens could not substantially influence the energy development itself. Given the tool's broad range of functions and applicable planning stages for implementation, the AR functions would support essentially full participation. However, additional digital infrastructure cannot elevate the participation level for this project because the participatory infrastructure is the primary limiting factor. In order to move beyond placation into partnership or delegated power, negotiation of shared goals and responsibilities would be necessary among involved actors. SIEVE could help partners negotiate or delegate those responsibilities by establishing credibility, saliency, and legitimacy among the different actors and providing all users a strong foundation for participating in the design process in the future.

Table 4.8. SWOT analysis for Bishop and Stock (2010)

Strengths	**Weaknesses**
For individual visual impact mitigation, each citizen has high control over planning and implementation on their property. Users can provide abundant and sound input to relevant planning and design processes. Two-way communication is well integrated and intuitive. The SIEVE tools are broadly applicable across the planning process. All involved actors are given sufficient resources to achieve credibility, salience, and legitimacy. Users have a high degree of control over data and modeling. VR/AR sessions can incorporate a broad range of data types. All necessary functions are well supported, and different tools are logically integrated. Local data storage and internet connectivity can support various participation strategies. Decision-making for visual impact mitigation efforts is strongly based in citizen control.	Visual impact mitigation is a reactive after thought in this development scenario. While the tools provide citizens a high degree of input, outside factors limit their impact on the energy development itself. This case study implements the tool after the wind farm was created. Energy producers are not involved. Lack realistic shadows and nonspatial data displays High requirements for computational and rendering capabilities. Expensive hardware. Lacks direct connection to energy producers.
Opportunities	**Threats**
Participants can design and negotiate amongst themselves to evaluate alternative solutions. Some visual impacts can be assessed. Users can generate credible, salient, and legitimate visual impact mitigation strategies.	Places burden of visual mitigation on individual landowners after the fact. Does not facilitate a relationship between the development authorities and landowners.

Case Study Findings

The case study evaluations highlighted strengths of particular AR participation strategies, which could be appropriately adjusted to meet the participation needs identified in the following implementation scenario. These strengths primarily came to light through the SWOT analysis, reinforcing the necessity of the analysis step in utilizing the framework for appropriate tool identification. Specifically, the following opportunities were identified in the case study evaluations and significantly influenced the final AR recommendations:

1. Marker-based tracking provides consistent viewing for VIA or perception surveys from key observation points.
2. Markerless tracking is well suited for sharing geolocated data and facilitating exploration of a scale site model.
3. Local data storage and processing is ideal for facilitating model interactions.
4. Remote rendering can provide greater verisimilitude and complexity in static images.
5. Markerless tracking also is best suited for multiple users collaborating in an outdoor, 1:1 scale AR session.

These findings support the use of key observation points for aesthetic assessments. They also rely on key distinctions that traditional VIA methods often overlook or ignore. In traditional VIA's, the emphasis of landscape perception evaluations is on a subject's aesthetic experience, but AR tools enable users to move beyond immediate aesthetics and begin to explore spatial relationships and deeper layers of meaning that still have bearings on surface-level perceptions. Traditional VIAs also focus on communicating visual impacts, but rarely give recipients the opportunity to substantively respond beyond preference statements. By incorporating interactions and delving into greater aesthetic meaning, these AR tools could address project protestors on less combative grounds.

Framework Application: Wind Energy & Coastal Georgia

Now that the framework's capacity for case study evaluation and recommendations has been demonstrated, this paper will now explore a hypothetical application off Georgia's coast. This trial run revisits an abandoned offshore wind farm proposal from Southern Company and Georgia Power. In 2005, Southern Company and a team from the Georgia Institute of Technology's Strategic Energy Institute collaborated to examine the technical and economic possibilities for building a wind farm off Georgia's coast near Tybee Island (Figure 4.1 and Figure 4.2). Their initial joint report, published in 2007, found that additional wind resource data was required to make a final call on such a project's full feasibility. Other challenges facing the project included a lack of commercial offshore turbines designed to withstand hurricanes and a shortage of manufactured components necessary for construction (Steward 2007). Despite these obstacles, Southern Company began filing for lease permits from the Bureau of Ocean Energy Management (BOEM) in 2011. At the time, these efforts received support from progressive groups, such as the Southern Alliance for Clean Energy (SACE), which published a letter to BOEM in January 2013 expressing their endorsement of the project. The same letter also called for greater stakeholder outreach after a public comment period lasted only 30 days when a similarproject had received 45 days for public comments in South Carolina.

In 2014, BOEM published an environmental impact statement for a wind energy data collection buoy, proposed by Southern Company in pursuit of a robust wind resource assessment, several miles offshore from Tybee Island. The publication was followed several weeks later by a two one-day open house poster session displaying visual impact simulations of the observation buoy, application and environmental assessment process diagrams, and infographics on shipping

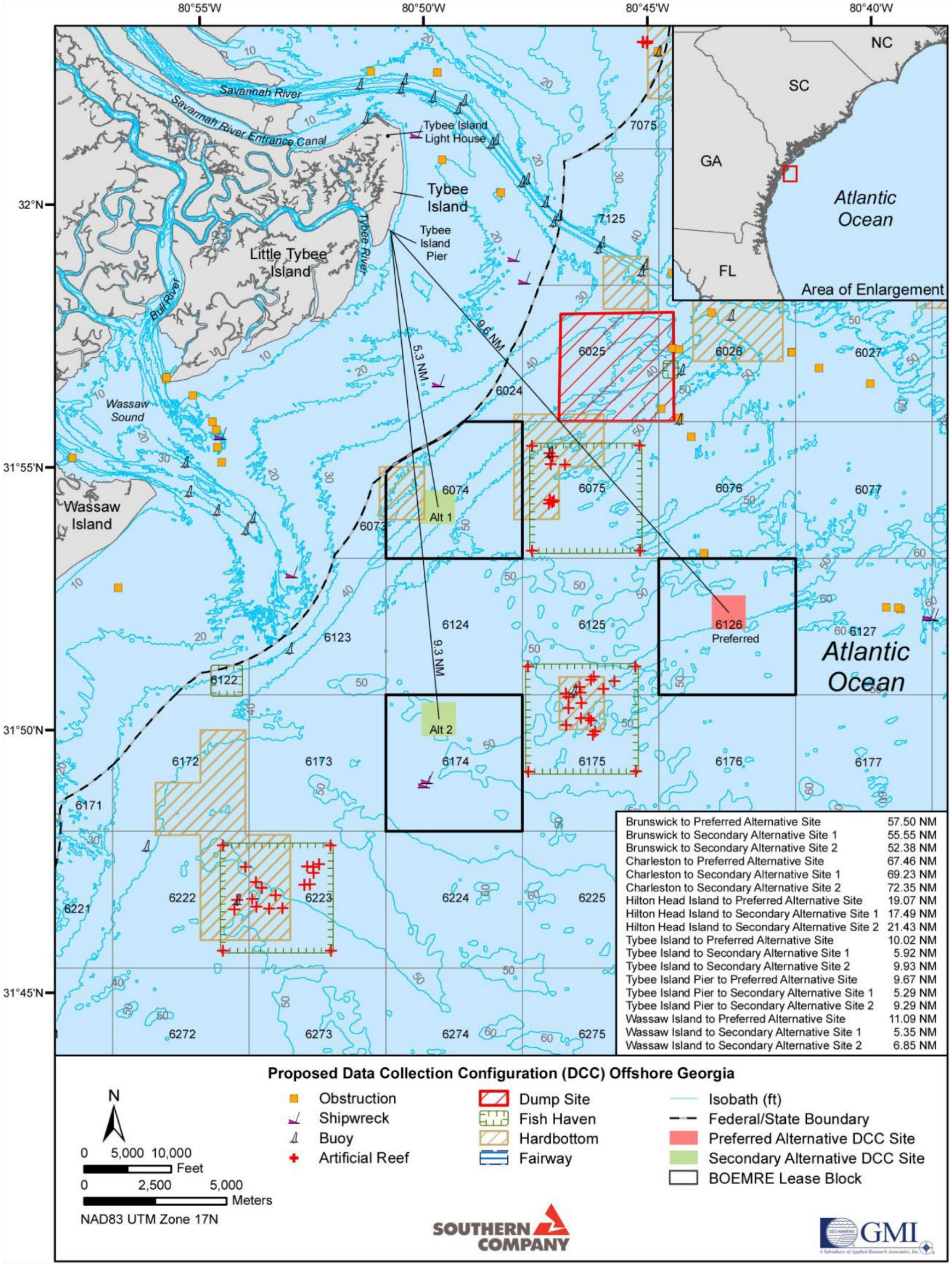

Figure 4.1. Map of proposed data collection configurations in lease blocks for Southern Company's offshore wind development. ("Environmental Assessments, Availability, etc.:Potential Interim Policy Lease Issuance and Site Assessment Activities, Atlantic Outer Continental Shelf, Georgia" 2014)

Figure 4.2. Visualizations of proposed wind farms near Tybee Island (Steward 2007)

traffic, whale sightings, and the proposed meteorological buoy (Figure 4.3). While these outreach sessions took place, no public comments on the environmental assessment or poster sessions are available from either BOEM or public media outlets to assess the effectiveness of the engagement strategy. Finally in 2016, Georgia Power, a public utility owned by Southern Company, filed to withdraw the lease permit from BOEM, ending formal pursuits of offshore wind energy development through BOEM in Georgia ("GeorgiaActivities" 2021).

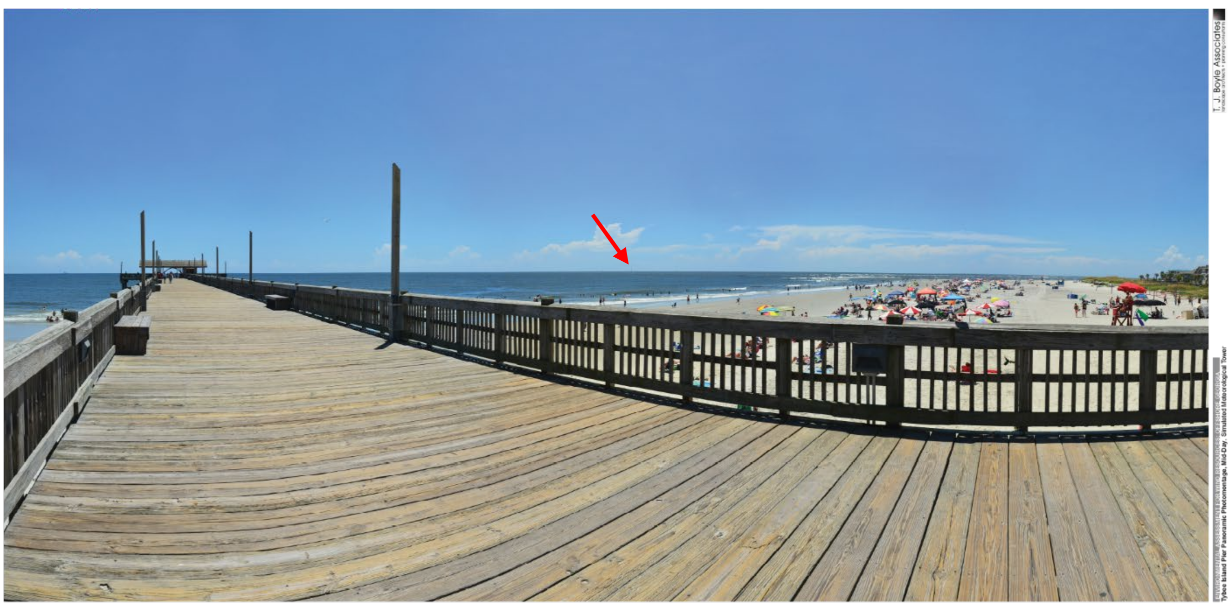

Figure 4.3. Poster of the meteorological tower as seen from Tybee Island shown during BOEM's open house sessions in 2014. The red arrow is added to indicate the tower's location.

At this point, this study uses the proposed framework to develop a digital participation strategy for collecting data on subjective landscape aesthetic experiences along the Georgia coast in a hypothetical extension of the Southern Wind project. To accomplish this goal, the proposed framework provides a clear process for identifying contextual variables, translating those variables in descriptive categories, and finally inferring needs and appropriate tools based on the initial findings. This case study will begin by identifying the social mode, actors involved, planning stage, and target participation level relevant to the digital participation strategy.

To begin, the social mode must be identified. Southern Company is a holding company owning controlling stocks of public utility subsidiaries such as Alabama Power, Georgia, Power, and Mississippi Power. Southern Company and Georgia Power compete with other private companies to generate and distribute energy across the deep South. Although these companies are public utilities, they are far from monopolistic, and consumers are able to select between private suppliers in a competitive marketplace. This dynamic means that the "Private Supplier" context is the most appropriate category for this case.

Second, the framework identifies actors and their respective authorship roles in a development setting. In the "Private Supplier" social mode, energy producers and project supporters tend to have the most credibility as authors. This authorship is demonstrated by publications such as lease permit applications from Southern Company and endorsement letters like the one from SACE. Regulating bodies, such as government agencies responsible for overseeing industry entities, are also given default authorship roles in the approval of applications and the publishing of environmental assessments or other informative documents. This analysis indicates that energy producers, project supporters, and regulating bodies are actors with author roles and that anyone else involved in the project becomes a recipient of authored information. The proposed digital participation strategy will demonstrate how this narrow group of authors can be expanded later in this section.

The planning stage is the next variable to be categorized. No offshore wind farms currently exist in Georgia's waters, resource assessments are still underway, and no installation designs have been formally proposed to the public. Together, these facts suggest that targeting an app towards data collection, the first planning stage, would be appropriate. Targeting a single planning stage, however, could create discouraging learning curves at later planning stages with separate tools, and preparing a tool to meet the demands of multiple planning stages like Bishop and Stock (2010) would increase consistency of the engagement tools and strategies across the planning process. As such, expanding an initial AR tool's ability to meet the needs of data collection, problem analysis, and option creation could be beneficial for on-going public engagement efforts before specific projects are introduced.

The final contextual variable is the participation level, and here, the framework supports the identification of a default participation level as well as an aspirational target. In the business-as-usual scenario defined by private companies filing for lease applications, waiting for approval from regulating bodies, and providing limited information resources to the general public, power over final decisions is held by the regulating body. Information provided to the public through BOEM's 2014 open house sessions was credible, factual information that was salient to beachgoers and ship operators and was partially transparent in its production (one poster briefly outlined BOEM's environmental review process). While this process is largely one-way, BOEM's notice of an environmental assessment for Southern Company's interim policy lease received 11 public comments ("Environmental Assessments, Availability, etc.: Potential Interim Policy Lease Issuance and Site Assessment Activities, Atlantic Outer Continental Shelf, Georgia" 2014) indicating that public input was accepted. Together, this engagement context fits well into the description of a "Consultation" participation level. Identifying this initial participation level can now help guide objectives for achieving increased participation that algin with "Placation" or "Partnership" participation definitions.

With the contextual variables identified, the framework now provides a summary of basic objectives for proposed AR functions to address. These objectives and their associated goals from the framework can be seen in Table. 4.9. These objectives are also considered to be the participation needs of this project.

Table 4.9. Objectives and goals of the AR tool generated by analyzing contextual variables

Objectives	**Framework-based Goals**
Provide Authorship opportunities to project participants, local beneficiaries, project protestors, project supporters, and active and service users	Expanding authorship opportunities.
Motivate data collection. Identify data needs. Document existing conditions.	Targeting "Data Collection" planning stage
Highlight aesthetic needs. Compare spatial data sets. Communicate findings.	Targeting "Problem Analysis" planning stage
Demonstrate key problems. Introduce ideas early in the discussion. Development of alternative solutions.	Targeting "Option Creation" planning stage
Increasing the transparency with which knowledge is created	Increasing information legitimacy while also maintain credibility and saliency
Support participants' comprehension of technical information for analysis and ideation	Targeting "Placation" participation level. Increasing information legitimacy. Supporting credible authorship.
Elevating public citizens' role in decision making processes. Negotiating shared powers in decision-making processes	Targeting "Partnership" participation level

To expanded authorship opportunities, the finished AR App (which will be referred to as "the App") will need to be broadly accessible at multiple levels. The App itself must be publicly available for download from an app purchasing platform or an established webpage. Free apps available through an app purchasing platform are often embedded with verifications that most mobile devices recognize and allow without adjusting the device's security settings, which may make this option slightly more attractive than the latter. The app must also account for data access requirements in remote locations, especially since much of the Georgia coastline is relatively undeveloped. A hybrid data storage structure with local and remote storage capabilities will allow users to use and save local data while in isolated locations without an internet connection and then upload data once a connection has been re-established. A participation server will be necessary to store and transfer users' data for sharing between actors.

Once the App reaches public hands, the first step to guide them through will be data collection. While many local municipalities on the Georgia coast have comprehensive master plans that identify geographic zones with similar visual and land use characteristics called character areas (Camden County 2018-2038 Joint Comprehensive Plan 2018; Community Character Map 2007; Community Character Areas Glynn County, GA 2018; Character Areas 2009), broader visual resource documentation and centralized counts of scenic vistas or overlooks are not available for the region (2021-2025 Georgia Coastal Management Program Section 309 Assessment and Strategysc 2020). Guiding users through structured and unstructured aesthetic documentation using geolocated static images, video and audio recordings, and written narratives will crowdsource the collection of existing conditions similar to Taylor et al. (2020), in which users receive background information about a location and received aesthetic assessment prompts when they interact with AR markers or use geo-tagging separate from an established marker (Figure 4.4). This combination of marker-based tracking and geolocation tracking provides defined channels for public input and enables users to initiate discussions about their own concerns.

Motivating data collection and identifying data needs may take several forms, and gamifying the collection process will involve providing some type of reward in exchange for collected data. Klamert and Münster (2017) document urban planning apps in which photos and comments are exchanged for digital coins, high scores are posted publicly to support competitive data collection, and users opt-in to allow their devices' sensors to passively collect geographic or aural data. Taylor et al. (2020) motivate users by providing unique AR experiences at distinct markers in different locations. The App should provide a combination of point rewards and unique experiences, such as highlighting known local aesthetic needs at unique locations and providing points based on the geographic remoteness or variety of collected data that a user provides. App administrators could then define "missions" for users that combine recreational activities with data collection efforts, such as providing coupons in partnership with local businesses after completing a predetermined mission. These types of partnerships would have the added benefit of directly engaging service users (the "service" being local landscape aesthetics) and local beneficiaries such as tourism-based businesses (Figure 4.5).

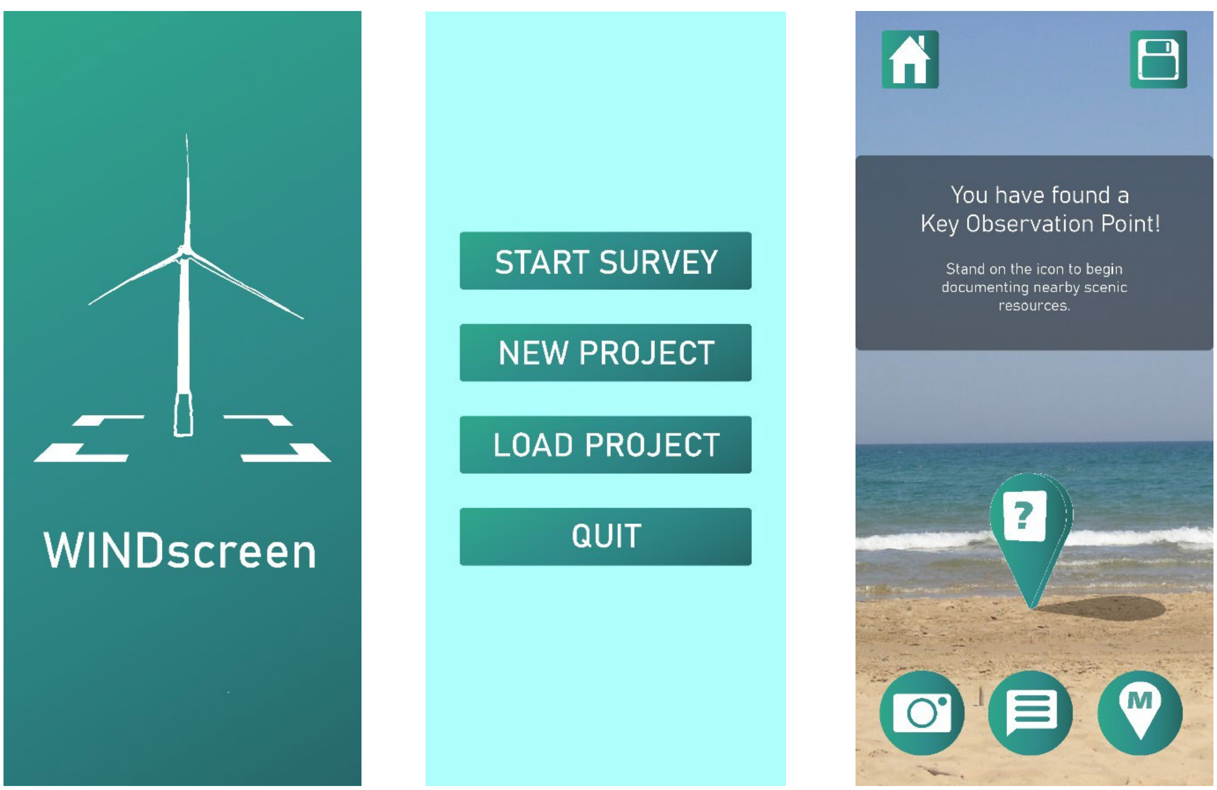

Figure 4.4. Splash screen, main menu, and graphic user interface mock-up for an AR aesthetic resource documentation app. This app would allow users to find geolocated markers for key observation points and submit aesthetic resource documentation surveys from the same spot using images, text, and map markers.

Moving beyond data collection, the App's ability to facilitate problem analysis will need to highlight aesthetic needs, compare spatial data sets, and communicate findings. These requirements dictate needs for geolocated data visualizations and actor-to-actor communication abilities in order for users to identify aesthetic threats and opportunities. While photographs and static images have been long-established proxies for landscape assessments, Carlson (1977) highlights the limitations on broader sensory experiences imposed by photographs in addition to the constraints imposed by such externally directed attention. These limitations include only having fixed observation points defined by expert methods and lack in additional sensory stimuli. Overcoming some of those limitations, the geolocated data visualizations will enable users to view aggregated data in-situ with the full experience of the surrounding landscape.

To identify threats and opportunities, the App should provide a tutorial for assessing aesthetic conflicts as perceived by the user. This step replies on subjectivist aesthetic theory to elevate idiosyncratic aesthetic experiences rather than directing users to identify conflicts from a pre-existing list generated from aesthetic "experts". To support expert meta-analysis of user-submitted aesthetic analyses, each user analysis session, or each user account, should begin with a brief landscape preferences survey to determine each users' landscape preference criteria (T. C. Daniel and Arthur 1977). This user-criteria data should be included in the data packet submitted at the end of each user evaluation session. A graphic user interface for text, image, video, and aural submissions will be necessary at this stage.

Once a user has identified aesthetic threats and opportunities, the App should use a combination of marker-based tracking, markerless geolocation tracking, a model interaction GUI, and remote rendering services to support user-based ideation and visualization capabilities. These tools will allow users to place and manipulate virtual, pre-textured wind turbine models at 1:1 scale and then view the finished result. The specific tracking system used should be context specific (Figure 4.5). For locations identified as high priority in the data collection and analysis phases, a multi-marker strategy may be most appropriate, as in Anagnostou and Vlamos (2011). Multiple fixed markers forming the corners of a vertically oriented rectangle would provide the necessary anchoring for a highly flexible, outdoor marker-based AR session, in which users could explore their prospective view with more freedom than would be possible with a single marker. The multiple markers have the added benefit of anchoring the AR models at the corners or sides of the device screen rather than obscuring the central focal point with a single, necessary marker. Fixing the markers in place using durable materials, as in Goudarznia, Pietsch, and Krug (2017), will simplify comparing design iterations using the same origin location (Figure 4.6). For less popular or well-traveled locations, GPS data and ground plane detection (i.e., the matching of a virtual ground plane to the physical ground plane) can allow users to geolocate and manipulate turbine models. Regardless of the tracking method, allowing users to establish turbine's locations on a map,similar to capabilities in SIEVE Builder from Bishop and Stock (2010), will likely facilitate communication between laypersons and professionals. Ensuring that the salient and credible GIS layers, such as bathymetry and pertinent wind speeds, are available to guide and limit turbine placements will help avoid making this activity a mere exercise in tokenism. "Save" and "Share" features should also beincorporated for users to compare designs and discuss their respective impacts in the App using commenting, annotating, and additional editing functions.

Once a user has established a design option and until mobile device computing improves significantly, a user's ability to generate a photorealistic rendering on their local device will be limited. By using a remote rendering process similar Gill and Lange (2015), however, users may be able to submit the relevant data to remotely render a desired view. In a markerless context, users would need to send their own GPS coordinates, elevation, and device pose data along with a

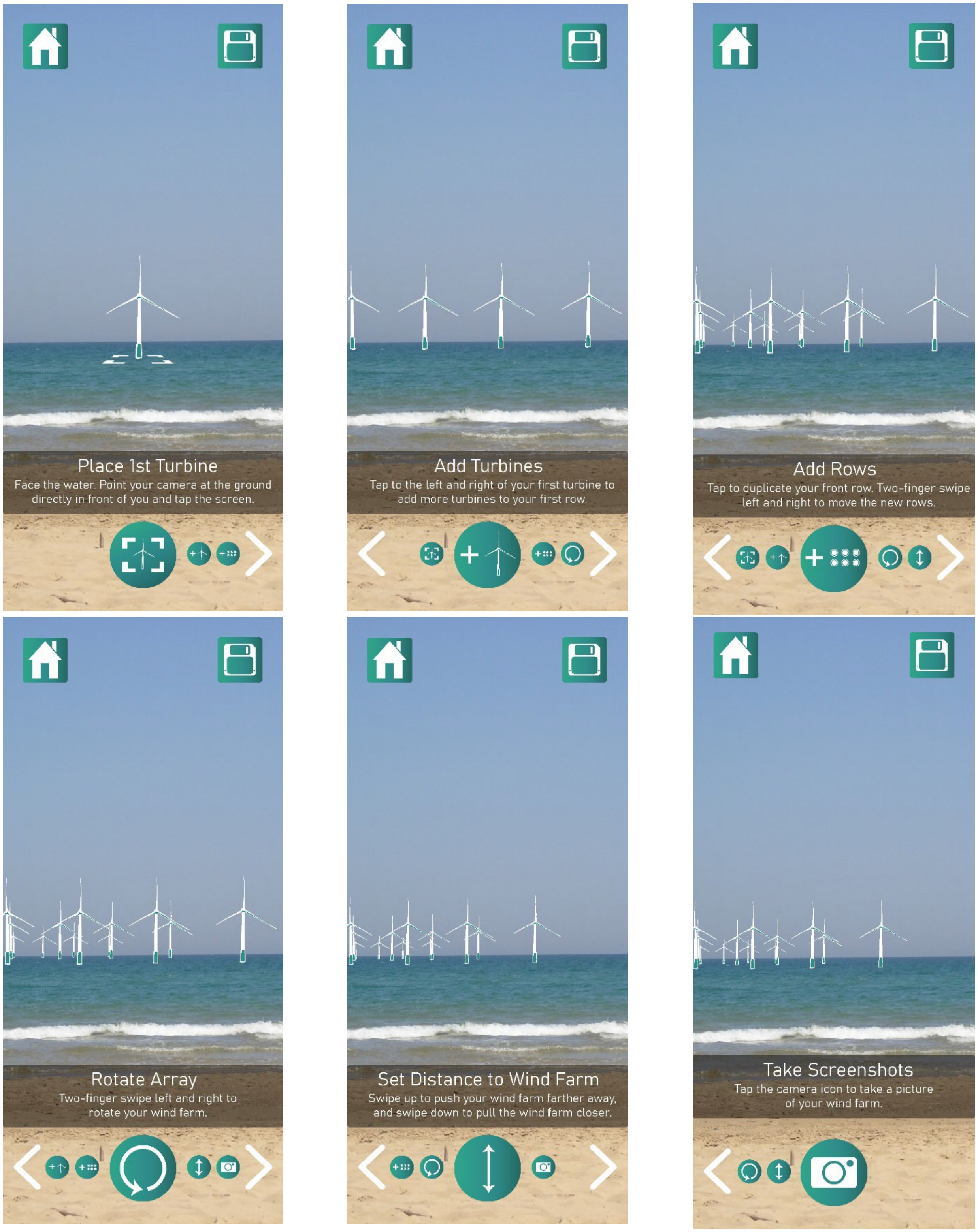

Figure 4.5. Mobile screen mock-ups for in-situ AR placement and interactions with turbine models. A scrolling toolbar across the bottom of the screen lets users select an interaction function while instructions guide the user through each step. “Home” and “Save” buttons at the top of the screen lets users navigate through the app’s menu and save work for sharing.

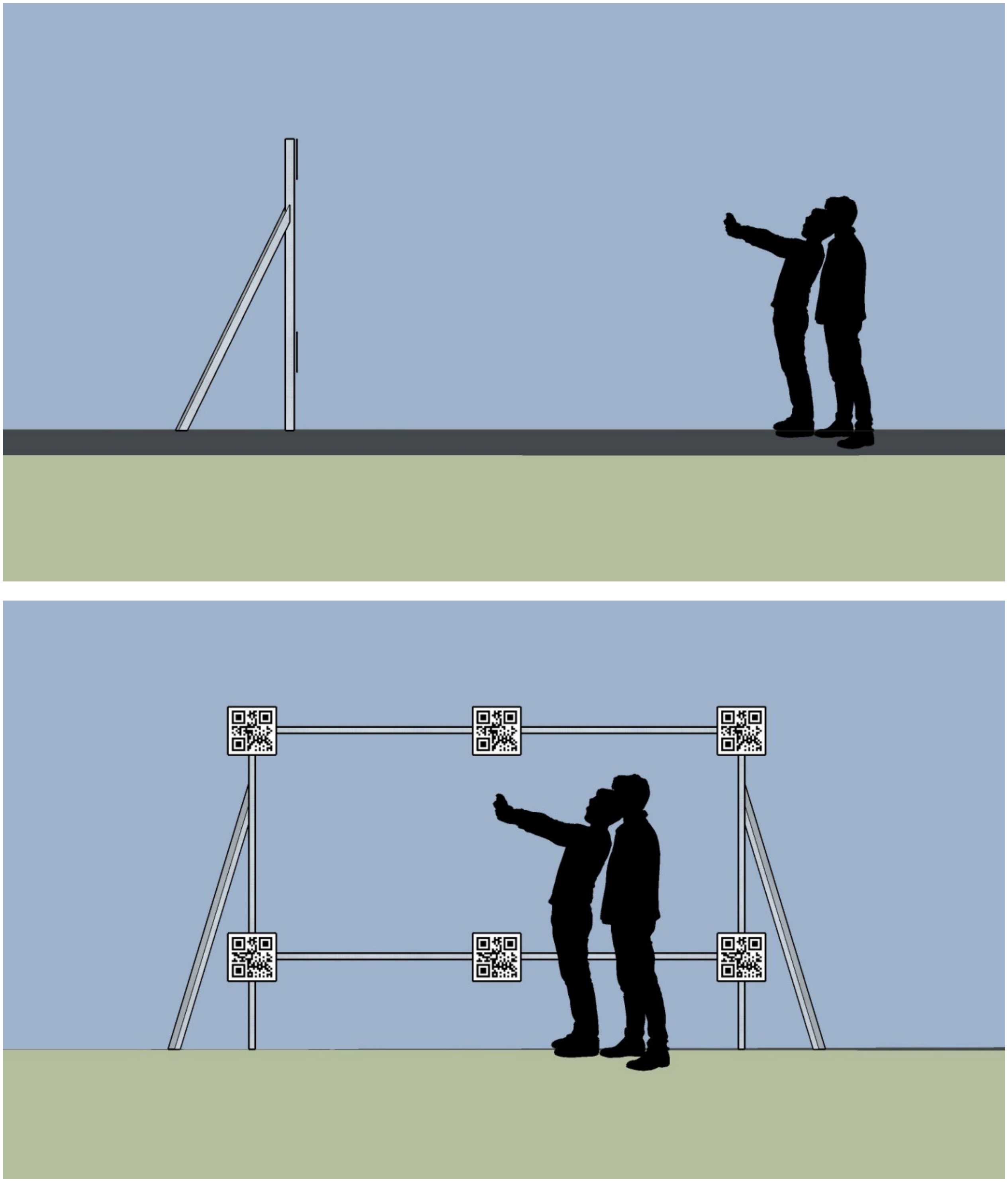

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Figure 4.6. Vertically-oriented multi-marker tracking display for AR turbine viewing and interaction at high traffic locations. Side elevation (top) and front elevation (bottom). Large, spread out markers enable multiple users to easily use the same markers simultaneously and enables each user to move their camera over a wider range of angles while still keeping the markers within their field of view.

static image from the device's camera and automatically generated GPS coordinates for their virtual wind turbines. In a marker-based scenario, the user would only need to submit an image clearly showing the markers in frame. In both cases, the information is sufficient to establish spatial relationships between a virtual camera and the models, render the models, and overlay the model rendering onto the submitted photograph. The marker-based system has an advantage in that it does not require the device's elevation, which may be difficult to determine, to correctly determine the virtual camera's correct position. To account for external factors necessary for a more credible rendering, Bishop and Stock (2010) refer to a method for calculating the proportion of the visible turbine, which could be used to account for occlusion effects of the Earth's curvature. Additional data on local weather conditions could be either provided by the user or scraped (i.e., collected through automated processes) from the internet to calculate the impact of haze on visible distance. GPS coordinates and a time stamp would also be sufficient to generate realistic shadows.

Throughout the implementation of these various AR tools, the information created and transferred must remain credible, salient, and legitimate in order to meet criteria for sustainable knowledge (Cash et al. 2003). Retaining credibility in the data sets produced by the App will require data verification and data cleaning processes on the administrators' end as well as sufficiently standardized collection methods with clear tutorials on the user's end, and due to the subjective nature of each users' entry, common problems with scientific crowdsourcing, such as repeated counting of a single phenomenon, can be easily avoided (Farah 2014). Ensuring legitimacy will require transparency in the production of visualizations and the management of participation databases. NASA (2021) provides an excellent example of clear and credible transparency in their audio-visual simulation of the Mars' surface using images and recorded audio from the Curiosity Rover. In the simulation, a series of informative panels temporarily appear to highlight the video's production methods, omissions, and inferences (Figure 4.7). Similar explanatory panels could be included within AR sessions as virtual objects. Maintaining salience will require further systematic review of landscape perception assessment methodologies in order to develop new methods using AR in subjectivist landscape aesthetic studies.

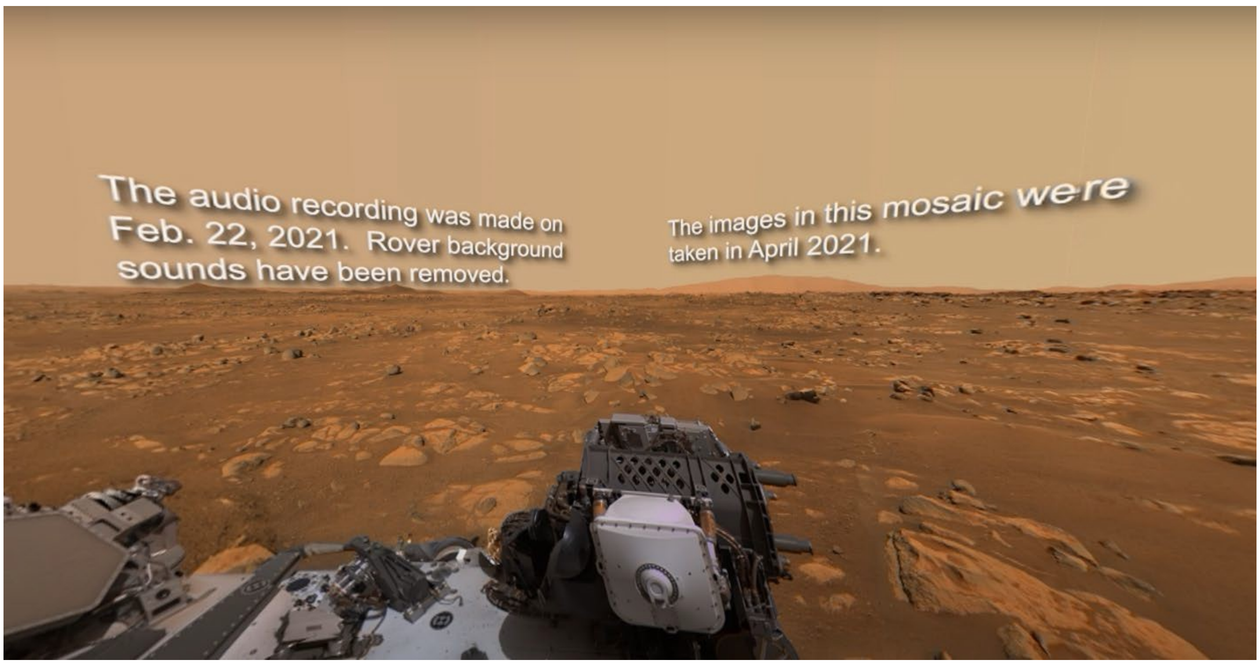

Figure 4.7. Examples of labels transparently explaining visualization's production. Courtesy of NASA.

Together, these tools and data management practices can enable users to substantively contribute to growing a collective understanding of Georgia's coastal aesthetic resources, their vulnerabilities, and acceptable visual impacts from offshore wind energy development. At the same time, if used in isolation, this additional data can only increase the participation level to "Placation" at best, where involved actors other than the deciding entities are considered merely advisors in formal or informal capacities. To move beyond this limitation, roles and responsibilities within a development process must be negotiated and defined with local communities. For the Southern Wind project, the establishment of citizen power in the offshore development process has many competing interests and actors with which to negotiate. There are sixteen state agencies alone involved in the process, and then there are local, national, NGO, and private business actors as well. While the exact path for a group of local citizens to negotiate their role as a deciding force in this long, complex process is beyond the scope of this paper, the recommendations for implementing augmented reality may provide access to some of the credibility, saliency, and legitimacy such a group would need to establish themselves on more equal footing with professionals in the process.

CHAPTER 5

DISCUSSION & CONCLUSION

Discussion

All the cases examined fell into "Degrees of Tokenism" on Arnstein's ladder, which remains a business-as-usual model in many participation strategies. The 30-day comment period and open house posters for Southern Wind's meteorological buoy are prime examples of this participation level. These strategies meet the minimum requirements for public participation but lack any significant sharing of decision power. Combined with a dearth of information on Georgia's coastal scenic resources or aesthetic values beyond local master plans' character area maps, wind energy developers will be walking into an uncharted minefield of visual impact opposition if the same participation strategies underpin future offshore wind farms in Georgia's waters.

These problems, however, are not unavoidable, and AR tools can facilitate greater, meaningful public participation at all of the identified planning stages. Documenting aesthetic resources becomes easy with geolocation tags, comments, and video or audio records. Structured surveys and tools could easily enable local stakeholders to highlight layers of meaning and aesthetics within a target area in similar methods to Boone (2015). These data can then be integrated into spatial visualizations and geolocated flags for stakeholders' exploration and analyses, which could then inform interaction design exercises and discussions during option creation and evaluation stages.

But AR tools cannot fundamentally change the power dynamics among actors in renewable energy develop. These tools can enhance the abilities of less empowered actors to add credible, salient, and legitimate information to the design process and thereby enhance their capacity to make well informed decisions, but that does not change the fact that powerful energy suppliers, financial investors, and government agencies still hold the final word.

The first significant change necessary to address those power dynamics is the introduction of negotiation of shared, definitive responsibilities and goals between wind energy developers and the communities impacted by new wind farms. This co-production partnership will need actors on all sides of the table to have resources for evaluating and producing credible, salient, and legitimate knowledge. To achieve that standard, communities will need access to financial and technical resources, and planning grants through state or federal agencies could potentially support those needs. Such grants could be offset by additional tax revenue from BOEM leases for the offshore wind farms.

Public opposition to wind farm development is more a question of "when" than "if", which makes addressing the roots of these challenges early highly beneficial for public and private entities involved in the development process. Clearly, local groups do hold sway where offshore turbines have been proposed in the US. A recent New York Times article described how homeowners were creating significant delays for a project in Virginia in just the last year. If that power is limited to only pushing back, then such relationships will remain adversarial, and the wind industry will become vilified by coastal communities.

These needs for participation changes also imply that changes to standard visual impact assessment methods could be beneficial as well. Typical governmental and industry VIAs seek highly objective results that prioritize legal defensibility, especially since the industry ends up existing in adversarial relationships with many of its community neighbors. This reliance on the objective paradigm of landscape aesthetics ignores the deeper layers of aesthetic experiences where many communities' opposition likely actually sits. Although typical VIAs do incorporate a sensitivity analysis at this point, such methods tend to focus on how often and intensely the visual impacts will bother viewers. This scenario still leaves plenty of room for increasing the role of more holistic aesthetic meanings and moving from mere visual impact analyses to broader aesthetic impact analyses.

Entrenched, powerful actors in energy development are likely to be the most resistant to changes that increase communities' influence over projects' approval and expand impact analyses into more subjective aesthetic realms. Those established actors are the entities that made the rules governing today's development pipelines, and private and government actors continue to benefit from those processes by nature of their continued dominance in the approval process. This claim is not a slander against their role, but an observation of their position. AR tools and negotiated roles hold great potential for shifting those positions in ways that are favorable to all involved actors, and understanding the effective use of each of those tools will help guide that transition.

Conclusion

Returning to the primary research question, this thesis asked, "How might AR tools be evaluated for their capacity to facilitate public participation in the planning and design of renewable energy projects that have significant impacts on landscape aesthetics?" To explore this question, this study developed a framework for connecting participation needs with AR tool capabilities in order to evaluate the usefulness of those tools for distributing decision making power in renewable energy development processes. The proposed framework inventories contextual variables, identifies existing and target participation levels, and then matches the needs of participation at a given planning stage with the type of information created and transferred by particular AR tools. This framework draws on established literature in citizen participation, renewable energy development, landscape aesthetic theories, and visualization technologies to define its variables and recommend participation goals. The framework was then evaluated through case study analyses using a systematic approach. Each case study was described using the same variables, and a SWOT analysis identified methods for potential increases in public participation through expansions of digital and participatory infrastructure. A final evaluation tested the framework's ability to guide a digital participation strategy for renewable energy developments in coastal Georgia.

This paper initially hypothesized that the appropriate selection and application of AR functions for public engagement in renewable energy development projects will depend on the project's development content, planning stage, and available digital infrastructure. In the end, this hypothesis was partially correct, if only due to its broad nature. The case studies and framework actually indicate that AR tools for public participation in renewable energy developments could be effectively evaluated and selected for a project based on broad goals and specific objectives that would be identified through an analysis of the project's social mode, participation level, planning stage, and authorship roles. While the dependence between tool selection and contextual variables remains, specifying the goals and objectives resulting from that context is a significantly more accurate statement. Without the establishment of specific goals and information transfer objectives, connecting appropriate communication tools specific development contexts becomes simply arbitrary.

Additional subquestions were considered through the literature review and are revisited here:

7. What is the relationship between wind farms and landscape aesthetics?
8. How has that relationship shaped the growth of wind energy developments?

9. How do researchers describe landscape aesthetics?
10. How are landscape aesthetics assessed?
11. How have landscape professionals communicated landscape aesthetics to the public?
12. How has the public historically engaged with the creation and interpretation of landscape aesthetics?

Exploring these subquestions established a critical foundation for the subsequent framework. The literature review revealed that significant debate over the practice of landscape and visual assessments has generated two fundamental camps trying to decide whether beauty is in the eye of the beholder ornot. On one side, resource managers and bureaucratic systems seek to quantify the inherent aesthetic value of landscapes under their care, much like the inherent value of associated ecosystems embedded in those landscapes. On the other hand, psychologists, philosophers, and other resource managers view aesthetic value as a subjective experience unique to each individual person but that these subjective experiences are what should be objectively quantified, not the perceived landscape qualities themselves. These questions inform decisions regarding the management of landscapes and seascapes where immense renewable energy infrastructure will be developed in the coming decades. As wind energy in particular takes on a growing share of the US's energy production, spinning turbines hundreds of feet high may become ubiquitous across much of the North American continent and its outer continental shelf. There is no doubt that this new infrastructure will change the aesthetic quality of the landscape it inhabits, but what that change is and means to the people around it is uncertain.

Right now, however, there is an opportunity to actively shape these outcomes in a manner that is decided by more than just bureaucrats and experts who may not live their day-to-day lives with the externalities of renewable energy. Europe, with a wind energy industry that is decades more mature than that of the US, currently experiences opposition to wind energy developments, in part because local stakeholders feel that new turbines are thrust upon them. To avoid a similar outcome, local stakeholders in the US need a greater voice in relevant decision-making processes, and to facilitate their participation, the subjectivist aesthetic paradigm must be given appropriate weight in landscape assessment practices. If the objectivist paradigm dominates, expert opinion will be all that matters, and local experiences and values will stand to be easily dismissed as uncritical or ill-informed perspectives. That type of dynamic cannot not engender the trust or respect necessary for negotiating shared responsibilities in a planning context, and in such a context, public opposition to wind farms will have all the fuel it needs.

This study is not without its flaws, and many research questions remain in the field. The most significant limitation sits in the theoretical nature of the proposed framework. While the core concepts draw on well-established literature, the actual efficacy of the strategies produced by the framework are largely untested in the proposed context. There is much research to be done regarding the effects of these tools on individuals' willingness and ability to actually participate in local energy planning and landscape assessment efforts. Such studies should isolate individual tools to assess public reactions, but there is also a need for examining the ability of these tools to support changes in decision-making power as well. Does the increased credibility of data-based tools make negotiating for partnership roles easier in a substantial way? Do AR tools get used for manipulative or therapeutic participation strategies that undermine stakeholders' trust? Do participants want rewards for their participation in a gamified planning initiative, and if so, should the rewards be symbolic to the individual, material, or social? Given the small size, can the screen of a smartphone accurately capture the quantifiable visual impact of a wind farm? How can planners effectively incorporate AR headsets for mobile viewing of visual-see-through or optical-see-through landscape models for accurate aesthetic impact assessments?

Specifically, regarding the proposed framework, there are still many questions about the variables selected and their relationships. Since this study relied heavily on Walker and Cass (2014), Arnstein (1969), and Hayek (2011), the variable definitions are narrow, and Arnstein's work in particular has been thoroughly reexamined in the literature over the past fifty years. Future work using this framework should explore more recent critiques and variations on Arnstein's ladder such as applications for climate change resilience (Collins and Ison 2009), open source digital participation applications (Falco 2019), and assessments of when participation may be actually necessary (Hurlbert and Gupta 2015).The framework also primarily focuses on aesthetic impacts and concerns, but many other factors shape how communities respond to proposed renewable energy developments. The socio-technical configurations proposed by Walker and Cass (2014) have received critical attention and been used to explore other factors affecting renewable energy acceptance such as the role of perceived health risks and economic factors (Baxter, Morzaria, and Hirsch 2013), variable definitions of social acceptability (Fournis and Fortin 2017), and the prevalence of different socio-technical configurations (Juntunen and Hyysalo 2015). Similarly, concepts from Hayek (2011) have been incorporated into relevant studies examining affective impacts of digital visualizations (Llinares and Iñarra 2014), comparative strengths of visual and non-visual exercises in participatory landscape planning (Tobias, Buser, and Buchecker 2016), and the literature gap in studies covering digital visualization implementation in real world projects (Billger, Thuvander, and Wästberg 2017).

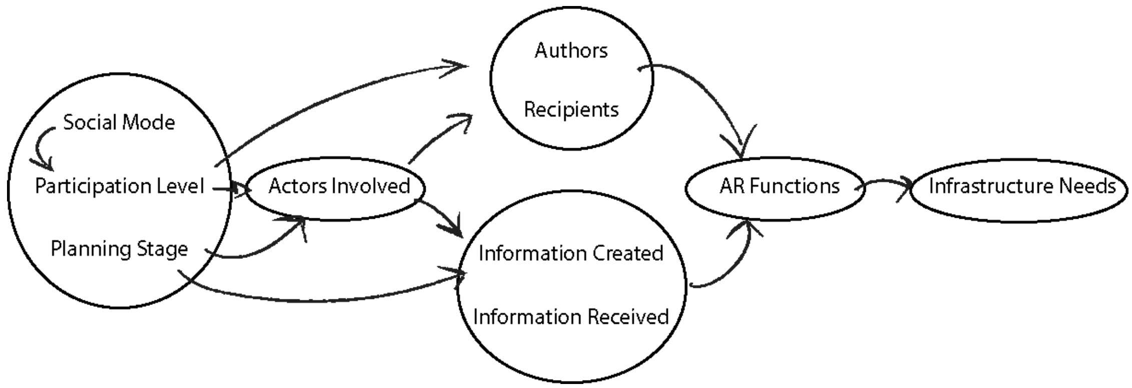

Figure 5.1. The original framework for incorporating AR tools into a participatory design strategy.

In light of the examined case studies, the proposed framework also requires adaptations to incorporate lessons learned in this study. The original framework (Figure 5.1) uses social mode, participation level, and planning stage at the contextual independent variables, however, in the course of the case studies, it became apparent that social mode is actually a product of the actors involved rather than a determinant. Furthermore, social mode may be a key lens for determining the expected default participation level for a given project based on existing power structures. To represent these changes, a revised framework is proposed in Figure 5.2. Additional modifications include changing "Authors" and "Recipients" to a single category, "Authorship". This change simplifies the framework slightly and leaves greater flexibility in defining roles for creating and transferring knowledge. Finally, "Information Created" and "Information Received" were changed to "Objectives" to define possibilities for processing individually, altering, or discussing information more broadly.

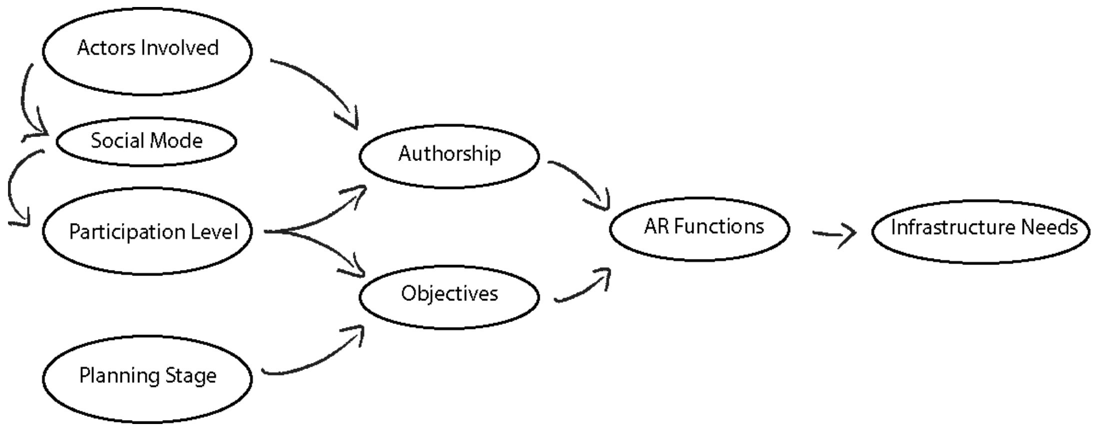

Figure 5.2. The revised framework for incorporating AR tools into a participatory design strategy.

Further work to refine these relationships, in addition to exploring more diverse variables and applications in the literature, could build on the present case studies through examining a broader range of scenarios and investigating each case on a more granular level. The case studies presented in this paper define a narrow range of AR tools and do not explore many technologies in projected AR, optical-see-through technologies, or haptic interfaces that provide virtual feedback when the user interacts with physical objects. Not only is the technology examined in this paper narrowly selected, but the participation contexts are also limited in scope. Many opportunities for participatory design exist within landscape architecture and planning, and AR has many potential uses within these fields outside of energy development. Additional case studies should expand the examination of AR's current role in professional practice to understand how these tools are currently being used, what common practices are evolving, and how well landscape professionals understand the technology, its opportunities, and its pitfalls.

The entire framework would also benefit from more quantifiable verification. Each arrow in the framework represents a theoretical relationship, and while this paper has demonstrated a logical connection through variable definitions and case study analyses, the sample size in incredibly small and the results are largely inferred. The role of social modes, especially, need additional examination to understand what a given social mode means for default participation levels. For instance, what are the typical participation levels for community-based projects vs private supplier contexts? Are there statistically significant correlations between particular social modes and typical authorship roles? On average, at what planning stage is public participation begun for renewable energy projects or other landscape design projects, and how do those decision enhance or limit participation levels? In terms of the AR tools, how should authorship roles be related to specific functions? How do experts and laypersons differ in their preferences and comfort levels regarding different AR tools? Studies into these questions will make the proposed framework significantly more robust and defensible, which will be necessary in order for AR to become a commonly tool adopted tool in a field as hotly debated as landscape aesthetics.

As AR technologies become more prevalent in environmental professions and day-to-day life, this type of framework can support decision makers at local and regional scales develop digital engagement strategies. Local officials and professionals should use the framework as a guiding framework on a team of relevant stakeholders, effectively expanding the participation phase of the project into setting communication methods and goals rather than simply using public engagement as a means of collecting data on predetermined topics. This collaborative tool design process can act as a first step toward negotiating goals and responsibilities among involved stakeholders. Once authorship roles and objectives have been set, this paper recommends that any in-house app development go through the Unity Game Engine using the Vuforia SDK, a rising AR development kit, due to its flexibility in deploying apps to iOS and Android devices.

These AR tools and decision frameworks also have a place in landscape-level projects outside of renewable energy development and aesthetic impact analyses. For example, these tools can facilitate data collection for public space proposals as demonstrated by Boone (2015), but such applications will need updated lists of actors and social modes. Additionally, since the framework presented in this paper was specifically geared towards renewable energy development, this study has built-in assumptions about a target project's goals. Other development scenarios such as public spaces, historic restorations, or private campuses will likely require new steps specifying the precise goals of participation within an identified engagement context.

In Georgia, there is a significant need for proactive assessments of coastal aesthetic resources. On-going interest in Georgia's offshore wind development, steadily improving turbine technologies, and renewable energy development plans such as the Biden administration's "Energy Efficiency and Clean Electricity Standard" and the recent infrastructure negotiations in Congress are signs that wind farms are likely to be planned for Georgia's coastal waters in the near future. Georgia's coastal counties (Camden, Glynn, McIntosh, Liberty, Bryan, and Chatham) will experience wind energy development beyond their three-mile-offshore jurisdiction, and their limited character area maps may not define sufficiently specific aesthetic objectives to establish unreasonable visual impact designations in sensitive coastal areas. On the other hand, these counties stand to benefit from local renewable energy sources and economic development opportunities that come with offshore wind energy. Each of these coastal communities stands to benefit from documenting and prioritizing their aesthetic resources in order to identify and protect their most important landscapes, establish a more robust bargaining position in future development negotiations, and to shape the future character of their homes. By using this paper's proposed framework and following recommendations set out in this conclusion, local initiatives can establish cooperative efforts to design and implement AR tools to document, understand, and respond to their communities' aesthetic resources.

REFERENCES

2021-2025 Georgia Coastal Management Program Section 309 Assessment and Strategy. 2020. edited by Coastal Resources Division Georgia Department of NaturalResources.

Anagnostou, Kostas, and Panagiotis Vlamos. 2011. "Square AR: Using augmented reality for urban planning." 2011 third international conference on games and virtual worlds for serious applications.

Apostal, Dean. 2017. *The renewable energy landscape: preserving scenic values in our sustainable future / edited by Dean Apostal, James Palmer, Martin Pasqualetti, RichardSmardon and Robert Sullivan*. Abingdon, Oxon

Apostol, Dean, James Palmer, Martin Pasqualetti, Richard Smardon, and Robert Sullivan. 2016. *The renewable energy landscape: Preserving scenic values in our sustainable future*. Taylor & Francis.

Arnstein, Sherry R. 1969. "A Ladder Of Citizen Participation." *Journal of the AmericanInstitute of Planners* 35 (4): 216-224. https://doi.org/10.1080/01944366908977225. https://doi.org/10.1080/01944366908977225.

Bacon, Warren R. 1979. "The visual management system of the Forest Service, USDA." In: Elsner, Gary H., and Richard C. Smardon, technical coordinators. 1979. Proceedings of our national landscape: a conference on applied techniques for analysis and management of the visual resource [Incline Village, Nev., April 23-25, 1979]. Gen. Tech. Rep. PSW-GTR-35. Berkeley, CA. Pacific Southwest Forest and Range Exp. Stn., ForestService, US Department of Agriculture: p. 660-665.

Baxter, Jamie, Rakhee Morzaria, and Rachel Hirsch. 2013. "A case-control study of support/opposition to wind turbines: Perceptions of health risk, economic benefits, and community conflict." *Energy Policy* 61: 931-943.

Berry, Robert, Gary Higgs, Richard Fry, and Mitch Langford. 2011. "Web-based GIS Approaches to Enhance Public Participation in Wind Farm Planning." *Transactions inGIS* 15 (2): 147-172. https://doi.org/10.1111/j.1467-9671.2011.01240.x. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-9671.2011.01240.x.

Billger, Monica, Liane Thuvander, and Beata Stahre Wästberg. 2017. "In search of visualization challenges: The development and implementation of visualization tools forsupporting dialogue in urban planning processes." *Environment and Planning B: UrbanAnalytics and City Science* 44 (6): 1012-1035.

Bishop, Ian D., and David R. Miller. 2007. "Visual assessment of off-shore wind turbines: The influence of distance, contrast, movement and social variables." *Renewable*

Energy 32 (5): 814-831. https://doi.org/https://doi.org/10.1016/j.renene.2006.03.009. http://www.sciencedirect.com/science/article/pii/S0960148106000838.

Bishop, Ian D., and Christian Stock. 2010. "Using collaborative virtual environments toplan wind energy installations." *Renewable Energy* 35 (10): 2348-2355. https://doi.org/https://doi.org/10.1016/j.renene.2010.04.003. http://www.sciencedirect.com/science/article/pii/S0960148110001552.

Boone, Kofi. 2015. "Disembodied voices, embodied places: Mobile technology, enabling discourse, and interpreting place." *Landscape and Urban Planning* 142: 235-242. https://doi.org/https://doi.org/10.1016/j.landurbplan.2015.07.005. http://www.sciencedirect.com/science/article/pii/S0169204615001437.

Brittan Jr, Gordon G. 2002. "The wind in one's sails: A philosophy." In *Wind power inview*, 59-79. Elsevier.

Broschart, Daniel, and Peter Zeile. 2015. "Architecture: augmented reality in architecture and urban planning." *Peer reviewed proceedings of digital landscape architecture* 2015: 111.

Camden County 2018-2038 Joint Comprehensive Plan. 2018. Coastal Regional Commission of Georgia.

Carlson, A. A. 1977. "On the possibility of quantifying scenic beauty." *Landscape Planning* 4: 131-172. https://doi.org/https://doi.org/10.1016/0304-3924(77)90015-6. https://www.sciencedirect.com/science/article/pii/0304392477900156.

---. 1984. "On the possibility of quantifying scenic beauty--a response to Ribe." *Landscape planning* 11 (1): 49.

Cash, David W, William C Clark, Frank Alcock, Nancy M Dickson, Noelle Eckley, David H Guston, Jill Jäger, and Ronald B Mitchell. 2003. "Knowledge systems for sustainable development." *Proceedings of the national academy of sciences* 100 (14):8086-8091.

Character Areas. 2009. edited by Georgia Department of Community Affairs.

Collins, Kevin, and Ray Ison. 2009. "Jumping off Arnstein's ladder: social learning as a new policy paradigm for climate change adaptation." *Environmental Policy and Governance* 19 (6): 358-373.

Community Character Areas Glynn County, GA. 2018. Ecological Planning Group.

Community Character Map. 2007. In *City of Tybee Island 2007 Master Plan Summary Report: Area Character Maps and Area Development Recommendations*.

Cope, Meghan. 2015. "Commentary: Geographies of digital lives: Trajectories in the production of knowledge with user-generated content." *Landscape and Urban Planning* 142: 212-214. https://doi.org/https://doi.org/10.1016/j.landurbplan.2015.08.009. http://www.sciencedirect.com/science/article/pii/S0169204615001644.

Daniel, T. C. 2001. "Whither scenic beauty? Visual landscape quality assessment in the 21st century." 2001.

Daniel, T. C., and L. M. Arthur. 1977. "Scenic assessment: an overview." *Landscape Planning* 4 (2): 109. http://proxy-remote.galib.uga.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edo&AN=8163709&site=eds-live.

Daniel, Terry C., and Ron S. Boster. 1976. *Measuring landscape esthetics: the scenic beauty estimation method*. Bibliographies

Dekker, Gerald, Qiuhao Zhang, John Moreland, and Chenn Zhou. 2013. "MARWind: mobile augmented reality wind farm visualization." Proceedings of the International Conference on Modeling, Simulation and Visualization Methods (MSV).

"Environmental Assessments, Availability, etc.: Potential Interim Policy Lease Issuance and Site Assessment Activities, Atlantic Outer Continental Shelf, Georgia." 2014. United States Goverment. Accessed June 10. https://www.regulations.gov/document/BOEM- 2014-0010-0001.

Falco, Enzo. 2019. "Digital Community Planning: The Open Source Way to the Top of Arnstein's Ladder." In *Smart Cities and Smart Spaces: Concepts, Methodologies, Tools, and Applications*, 1490-1514. IGI Global.

Farah, Jihad. 2014. "Crowdsourced Monitoring, Citizen Empowerment and Data Credibility." Cham.

Fazey, Ioan, John A Fazey, Janet G Salisbury, David B Lindenmayer, and Steve Dovers. 2006. "The nature and role of experiential knowledge for environmental conservation." *Environmental conservation*: 1-10.

FHWA. 2015. Guidelines for the visual impact assessment of highway projects. FHWA Washington, DC.

Foo, Katherine, Emily Gallagher, Ian Bishop, and Annette Kim. 2015. "Critical landscape visualization to LAND SI “Critical Approaches to Landscape Visualization”." *Landscape and Urban Planning* 142: 80-84. https://doi.org/https://doi.org/10.1016/j.landurbplan.2015.07.014. http://www.sciencedirect.com/science/article/pii/S0169204615001528.

Fournis, Yann, and Marie-José Fortin. 2017. "From social ‘acceptance’to social ‘acceptability’of wind energy projects: towards a territorial perspective." *Journal of environmental planning and management* 60 (1): 1-21.

"Georgia Activities." 2021. Bureau of Ocean Energy Management. Accessed June 6. https://www.boem.gov/renewable-energy/state-activities/georgia-activities.

Gibson, James J. 1977. "The theory of affordances." *Hilldale, USA* 1 (2): 67-82.

Gill, Lewis, and Eckart Lange. 2015. "Getting virtual 3D landscapes out of the lab." *Computers, Environment and Urban Systems* 54: 356-362. https://doi.org/10.1016/j.compenvurbsys.2015.09.012. http://proxy-remote.galib.uga.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edselp&AN=S0198971515300223&site=eds-live.

Gobster, Paul H, Robert G Ribe, and James F Palmer. 2019. "Themes and trends in visual assessment research: Introduction to the Landscape and Urban Planning special collectionon the visual assessment of landscapes." *Landscape and Urban Planning* 191: 103635.

Goudarznia, Toomaj, Matthias Pietsch, and René Krug. 2017. "Testing the effectiveness of augmented reality in the public participation process: A case study in the city of bernburg." *Journal of Digital Landscape Architecture* 2: 244-251.

Grassi, S., and T. M. Klein. 2016. "3D augmented reality for improving social acceptance and public participation in wind farms planning." *Journal of Physics: Conference Series* 749: 012020. https://doi.org/10.1088/1742-6596/749/1/012020. http://dx.doi.org/10.1088/1742-6596/749/1/012020.

Hammarlund, Karin. 2002. "Society and wind power in Sweden." In *Wind power in view*, 101-114. Elsevier.

Hayek, Ulrike Wissen. 2011. "Which is the appropriate 3D visualization type for participatory landscape planning workshops? A portfolio of their effectiveness." *Environment and Planning B: Planning and Design* 38 (5): 921-939.

Hoppe-Kilpper, Martin, and Urta Steinhäuser. 2002. "Wind landscapes in the Germanmilieu." In *Wind power in view*, 83-99. Elsevier.

Hurlbert, Margot, and Joyeeta Gupta. 2015. "The split ladder of participation: A diagnostic, strategic, and evaluation tool to assess when participation is necessary."*Environmental Science & Policy* 50: 100-113.

IPCC. 2014. *Climate Change 2014: Synthesis Report Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* IPCC (Geneva, Switzerland).

Jorgensen, Anna. 2011. "Beyond the view: Future directions in landscape aesthetics research." *Landscape and Urban Planning* 100 (4): 353-355.

Juntunen, Jouni K, and Sampsa Hyysalo. 2015. "Renewable micro-generation of heat and electricity—Review on common and missing socio-technical configurations." *Renewable and Sustainable Energy Reviews* 49: 857-870.

Kaplan, Stephen. 1987. "Aesthetics, affect, and cognition: Environmental preference from an evolutionary perspective." *Environment and Behavior* 19 (1): 3-32. https://doi.org/10.1177/0013916587191001. http://proxy-remote.galib.uga.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=1987-23709-001&site=eds-live

Kaplan, Stephen, Rachel Kaplan, and John S Wendt. 1972. "Rated preference and complexity for natural and urban visual material." *Perception & Psychophysics* 12 (4):354-356.

Kim, Annette M. 2015. "Critical cartography 2.0: From "participatory mapping" to authored visualizations of power and people." *Landscape and Urban Planning* 142: 215-225. https://doi.org/https://doi.org/10.1016/j.landurbplan.2015.07.012. http://www.sciencedirect.com/science/article/pii/S0169204615001504.

Klamert, Kevin, and Sander Münster. 2017. "Child's play-A literature-based survey on gamified tools and methods for fostering public participation in urban planning." International Conference on Electronic participation.

Ladenburg, Jacob. 2009. "Visual impact assessment of offshore wind farms and prior experience." *Applied Energy* 86 (3): 380-387.

Lange, Eckart. 2002. "Visualization in Landscape Architecture and Planning–Where we have been, where we are now and where we might go from here." *Trends in GIS and Virtualization in Environmental Planning and Design. Proceedings at Anhalt University of Applied Sciences*: 8-18.

Laporte, David J. 2008. Altamont Pass Wind Farm 2759185116. License available at https://creativecommons.org/licenses/by/2.0/deed.en.

Llinares, Carmen, and Susana Iñarra. 2014. "Human factors in computer simulations of urban environment. Differences between architects and non-architects' assessments." *Displays* 35 (3): 126-140.

Lothian, A. 1999. "Landscape and the philosophy of aesthetics: is landscape quality inherent in the landscape or in the eye of the beholder?", 177.

Lovett, Andrew, Katy Appleton, Barty Warren-Kretzschmar, and Christina Von Haaren. 2015. "Using 3D visualization methods in landscape planning: An evaluation of options and practical issues." *Landscape and Urban Planning* 142: 85-94. https://doi.org/https://doi.org/10.1016/j.landurbplan.2015.02.021. http://www.sciencedirect.com/science/article/pii/S0169204615000535.

Lund, Ken. 2014. San Gorgonio Pass Wind Farm, Near Palm Springs, California. License available at https://creativecommons.org/licenses/by-sa/2.0/deed.en.

Maehr, Anna M., Greg R. Watts, Jennifer Hanratty, and Deborah Talmi. 2015. "Emotional response to images of wind turbines: A psychophysiological study of their visual impact on the landscape." *Landscape and Urban Planning* 142: 71-79. https://doi.org/https://doi.org/10.1016/j.landurbplan.2015.05.011. http://www.sciencedirect.com/science/article/pii/S0169204615001188.

Manual 8400 - Visual Resource Management. 1984. edited by Department of the Interior. Washington, D.C.: Bureau of Land Management.

Manual H-8410-1 - Visual Resource Inventory. 1986. edited by United States Army Corps of Engineers. Washington, D.C.

Maslov, Nicolas, Christophe Claramunt, Tianzhen Wang, and Tianhao Tang. 2017. "Method to estimate the visual impact of an offshore wind farm." *Applied Energy* 204:1422-1430.

NASA. 2021. "Perseverance Mars Rover's Mastcam-Z View of 'Van Zyl Overlook' (360video + audio)." June 9, 2021, Video. Youtube.com.

Nassauer, Joan Iverson. 1995. "Messy ecosystems, orderly frames." *Landscape journal* 14 (2): 161-170.

---. 2015. "Commentary: Visualization verisimilitude and civic participation." *Landscape and Urban Planning* 142: 170-172. https://doi.org/https://doi.org/10.1016/j.landurbplan.2015.07.013. http://www.sciencedirect.com/science/article/pii/S0169204615001516.

Nielsen, Frode Birk. 2002. "A formula for success in Denmark." In *Wind power in View*, 115-132. Elsevier.

Orland, Brian. 2015. "Commentary: Persuasive New Worlds: Virtual Technologies and Community Decision-Making." *Landscape and Urban Planning* 142: 132-135. https://doi.org/https://doi.org/10.1016/j.landurbplan.2015.08.010. http://www.sciencedirect.com/science/article/pii/S0169204615001656.

Pasqualetti, Martin, Paul Gipe, and Robert Righter. 2002a. *Wind power in view: energy landscapes in a crowded world*. Academic press.

Pasqualetti, Martin J. 2002. "Living with wind power in a hostile landscape." In *Windpower in view*, 153-172. Elsevier.

Raaphorst, Kevin, Wim van der Knaap, Adri van den Brink, and Gerda Roeleveld. 2019. "Visualization, participation and rhetoric: The discursive power of landscape design representations in participatory processes." *Journal of Landscape Architecture* 14 (2): 42-53.

"Renewables on the Rise," 2020, https://environmentgeorgia.org/reports/gae/renewables- rise-2020.

Ribe, R. G. 1982. "On the possibility of quantifying scenic beauty--a response." *Landscape planning* 9 (1): 61.

Righter, Robert W. 2002. "Exoskeletal outer-space creations." In *Wind Power in View*, 19-41. Elsevier.

Rozmi, Mohd Daniel Azraff Bin, Gokul Sidarth Thirunavukkarasu, Elmira Jamei, Mehdi Seyedmahmoudian, Saad Mekhilef, Alex Stojcevski, and Ben Horan. 2019. "Role of immersive visualization tools in renewable energy system development." *Renewable andSustainable Energy Reviews* 115: 109363.

Schroth, Olaf, Ellen Pond, and Stephen R. J. Sheppard. 2015. "Evaluating presentationformats of local climate change in community planning with regard to process and outcomes." *Landscape and Urban Planning* 142: 147-158. https://doi.org/https://doi.org/10.1016/j.landurbplan.2015.03.011.

Schroth, Olaf, and Chenyi Zhang. 2014. "Augmented Landform–An Educational Augmented Reality Tool for Landscape Architecture Students." *Peer Reviewed, Proceedings of the Digital Landscape Architecture*.

Schwahn, Christoph. 2002. "Landscape and policy in the North Sea marshes." In *WindPower in View*, 133-150. Elsevier.

Smardon, Richard C, James F Palmer, Alfred Knopf, Kate Grinde, Jim E Henderson, and Linda D Peyman-Dove. 1988. *Visual resources assessment procedure for US Army Corps of Engineers*. US Army Engineer Waterways Experiment Station.

Soria, Christian, and Michael Roth. 2018. "Unreal reality: An empirical investigation of augmented reality effects on spatial cognition in landscape architecture." *Journal of Digital Landscape Architecture* 3: 150-162.

Steward, Susan; Hunt, Mary Hallisey; Shelton, Sam; Webb, Roger. 2007. *Southern Winds.* Georgia Institute of Technology and the Southern Company.

Stoehr, Taylor. 1969. "Realism and Verisimilitude." *Texas Studies in Literature and Language* 11 (3): 1269-1288. http://www.jstor.org/stable/40754061.

Taylor, Micah, Brian Orland, Jingxian Li, Stephen Berry, and Meredith Welch-Devine. 2020. "Crowdsourcing Environmental Narratives of Coastal Georgia using Mobile Augmented Reality and Data Collection." *Journal of Digital Landscape Architecture*: 140-149.

Thayer, Robert L, and Carla M Freeman. 1987. "Altamont: public perceptions of a wind energy landscape." *Landscape and urban planning* 14: 379-398.

Tobias, Silvia, Tobias Buser, and Matthias Buchecker. 2016. "Does real-time visualization support local stakeholders in developing landscape visions?" *Environment and Planning B: Planning and Design* 43 (1): 184-197.

Vissering, Jean, Mark Sinclair, and Anne Margolis. 2011. "A visual impact assessment process for wind energy projects." *Clean Energy States Alliance* 1380.

Walker, Gordon, and Noel Cass. 2014. "Public roles and socio-technical configurations: diversity in renewable energy deployment in the UK and its implications." In *Renewable Energy and the Public*, 75-88. Routledge.

Wolsink, Maarten. 2018. "Co-production in distributed generation: renewable energy and creating space for fitting infrastructure within landscapes." *Landscape Research* 43 (4): 542-561.

Yu, Tianhong, Holger Behm, Ralf Bill, and Jian Kang. 2017. "Audio-visual perception of new wind parks." *Landscape and Urban Planning* 165: 1-10.

Zube, Ervin H. 1973. "Rating Everyday Rural Landscapes of the Northeastern U. S." *Landscape Architecture* 63 (4): 370-375. http://www.jstor.org/stable/44664000.

Zube, Ervin H, James L Sell, and Jonathan G Taylor. 1982. "Landscape perception: research, application and theory." *Landscape planning* 9 (1): 1-33.

APPENDICES

APPENDIX A

Case Study Data Sheet Template

Subject Study Citation:

1.

1. Description

1. Research question:

2. Location:
3. (100-200 words description)
    i.

Figure A.1. Data Sheet Template Page 1

2. Social Mode. Circle which social mode most closely matches the subject study's development scenario. If none, circle "Other" and provide a description.

Applicable Mode	**Mode of Social Organization**	**Definition**
	Public Utility	Publicly-owned generators and suppliers monopolistically provide energy directly to consumers
	Private Supplier	Privately-owned generators and suppliers provide energy to consumers through a competitive marketplace
	Community	Partially or completely community-owned projects generate and provide energy to local stakeholders
	Household	An individual household owns or hosts energy production on their own property
	Organizational	An organization, either public or private, owns or hosts energy production facilities on its own property
	Other	

What specific dynamics place this case study within the selected category?

Figure A.2. Data Sheet Template Page 2

3. Actors. Circle all involved actors and indicate their role in the participation process.

Actor	Definition	Authors	Recipients
Active Consumer	Actively choose between suppliers, including carbon offsets or green energy options which partially or entirely involved renewable generation		
Service Users	Use the services provided by energy generated using renewable technologies		
Financial Investors	Invest in shareholding or interest-earning arrangements ranging from specific projects to the broad financing of renewable energy projects, or to the investment choices of particular companies		
Local Beneficiaries	Receive benefits in addition to energy services; financial, infrastructural, educational, technological, or intangible.		
Project Protestors	Actively object to projects through organization of local protest groups, attending meetings, writing to the press, lobbying, signing petitions, etc.		
Project Supporter	Actively engage in similar actions to protestors but move in favor of the proposed project		
Project Participants	Get involved in community mode of implementation, including membership of organizing groups, attending meetings, or hands-on installation or maintenance		
Technology Host	Owners of buildings or land used for hosting technology, but not the renewable energy technology itself		
Energy Producer	Directly own and operate generation technologies of different forms		

Who are the specific actors?

Figure A.3. Data Sheet Template Page 3

4. Planning Stage. Circle stages where the participation strategy is implemented.

Planning Stage	Goal	Role of Representations
Data Collection	Inventorying information about a proposed project	Motivate data collection. Identify data needs. Document existing conditions.
Problem Analysis	Understanding opportunities, threats, needs, and desired outcomes	Highlight aesthetic needs. Compare spatial data sets. Communicate findings.
Option Creation	Generating multiple solutions for the final product	Demonstrate key problems. Introduce ideas early in the discussion. Development of alternative solutions.
Option Evaluation	Understanding comparative strengths and weaknesses of multiple solutions	Integrate diagrams and visual indicators to facilitate spatial and aesthetic comparisons. Demonstrate visual impacts. Facilitate discussion.
Selection	Identification of the most desirable solution	Succinctly represent alternatives.
Decision	Defining next actionable steps	Identifying action needs

What aspects of the case study influenced this selection?

Figure A.4. Data Sheet Template Page 4

5. Participation Level. Answer the following inventory questions and then circle the participation level best matching the documented inventory.

1. Who makes the final decision regarding the proposed project's approval? Circle applicable actors.
   i. Public citizens
   ii. Authority entity (government body, government agency, private organization, etc.)
   iii. Unknown
2. Is the information shared among actors meet standards:
   i. Credibility (Factually accurate)
   ii. Salience (Relevant to the recipient)
   iii. Legitimacy (Unbiased and fair in its production)
3. What resources are shared among actors?
   i. Financial (funding, influence over budget)
   ii. Informative (Accurate descriptions of proposed projects)
   iii. Technical assistance (Supports comprehension of technical information by laypersons)
4. Are any of the following elements present?
   i. Community-owned corporation, community-based & direct financial resources
   ii. Community dominance in final decision making. Substantive community-based accountability.
   iii. Negotiated rules and responsibilities. Substantive accountability. Financial and technical support for community-based assessments.
   iv. Community-held seats in formal advisory roles
   v. Opportunities for community input and feedback on proposed projects
   vi. One-way communication providing information on proposed projects
   vii. Education campaigns about proposed projects
   viii. Misleading or false information about proposed projects

Figure A.5. Data Sheet Template Page 5

Based on the preceding inventory, which Participation Level best describes the subject study? Circle the most relevant option.

Participation Level	Key Qualities	Final Decisions Made by	Information Quality	Resources Shared	Key Infrastructure Elements
Citizen Control	A community-owned corporation exists without intermediaries between itself and the source of funds. Final approval power and accountability rests in local citizens' hands.	Citizens	Credible, Salient, Legitimate	Financial, informative, & technical assistance	Community-owned corporation, community-based & direct financial resources
Delegated Power	Citizens hold the dominant decision-making authority and veto power in a development context. Citizens hold the majority of seats on a decision-making body, have clearly specified powers, and can substantively hold other parties accountable. Problems are proactively addressed by powerholders rather than being reacted to as they haphazardly appear.	Citizens & Authority	Credible, Salient, Legitimate	Financial, informative, & technical assistance	Community dominance in final decision making. Substantive community-based accountability.
Partnership	Citizens negotiate rules and responsibilities for sharing decision making powers with development drivers. Community partners are substantively accountable to their constituents, and resources are available for facilitating independent, dedicated, and technically-advised work by the community partner.	Citizens & Authority	Credible, Salient, Legitimate	Financial, informative, & technical assistance	Negotiated rules and responsibilities. Substantive accountability. Financial and technical support for community-based assessments.
Placation	Decision makers add public stakeholders to advisory committees, but powerholders retain the right to judge the legitimacy of the advice and may or may not provide technical assistance to the committee. Rights and responsibilities of the committee may be ambiguous.	Authority	Credible, Salient	Informative & technical assistance	Community-held seats in formal advisory roles
Consultation	Decision makers inform the public and collect feedback on predetermined questions	Authority	Credible, Salient	Informative	Opportunities for community input and feedback on proposed projects
Informing	Decision makers provide information to stakeholders without any means of providing feedback or negotiating	Authority	Credible, Salient	Informative	One-way communication providing information on proposed projects
Therapy	Decisionmakers attempt to "fix" the opposition's viewpoints and concerns	Authority	Credible	Informative	Education campaigns about proposed projects
Manipulation	Provision of intentionally misleading development descriptions in order to coerce public acceptance	Authority			Misleading or false information about proposed projects

Figure A.6. Data Sheet Template Page 6

6. AR Functions. Circle which functions are part of the digital participation tool.

AR Capabilities	Information Transferred
Marker-based tracking	Spatial relationships between attached virtual objects and in-frame physical objects
Markerless tracking	Spatial relationships between physical and unattached virtual objects
GPS tracking	User's location
Geolocated models	Spatial relationships between physical objects and virtual objects georeferenced in the physical world
Quantified Data visualizations	Charts & Infographics. Non-spatial data.
Abstract Visualization	Spatial relationships in design concepts
Photorealistic Visualizations	Design details, realistic colors and textures, shadows
Realistic Shadows	Shadow impacts on virtual or physical objects
Motion	Visual effects of different turbine speeds
Textures	Visual Contrast
Occlusion	Visual overlap of objects from different viewing angles
Scaling	Visual dominance at different scales
Rotating	Spatial orientation of objects
Add/subtract models	Spatial relationships between physical and virtual objects
Planview/Perspective toggle	Spatial relationships among virtual and physical objects

Describe the digital participation tool's capabilities.

Figure A.7. Data Sheet Template Page 7

Digital Infrastructure. Use the following table to document which AR functions are used in the subject study and describe the required digital infrastructure.

Visualization Capabilities	**Tracking Units**	**Render Unit**	**Monitor**	**Camera**	**Data Storage**
Marker-based tracking					
Markerless tracking					
GPS tracking					
Charts and Graphs					
Abstract Visualization					
Photorealistic Visualizations					
Realistic Shadows					
Animation					
Textures					
Outdoor Occlusion					
Scaling					
Model editing					
Planview/Perspective toggle					

Figure A.8. Data Sheet Template Page 8

Mark which Digital Participation Categories are met by the available AR functions.

Digital Participation Category	Example Functions
Informing	Geolocating virtual signs or models for inspection, Displaying 3D models on 2D plans, Augmented existing physical objects with virtual data displays
Consulting	Interactive 3D models, user accounts, platform for publishing interaction results, communication platform for sharing visual, aural, or spatial information with officials and other stakeholders on existing topics, priority or scenario ranking
Collaborating	Communication platform for stakeholders to raise new issues and for officials to provide feedback, co-creation, decision-making, incorporation of in-person collaboration

Describe additional Participation Infrastructure used in the subject study.

The study utilized a public pop-up kiosk on-site with comparative photomontages printed out.

Figure A.9. Data Sheet Template Page 9

Subject Study SWOT

Strengths	
Variable	**Description**
Social Mode	
Participation Level	
Planning Stage	
Actors	
AR Functions	
Digital Infrastructure	
Participatory Infrastructure	

Weaknesses	
Variable	**Description**
Social Mode	
Participation Level	
Planning Stage	
Actors	
AR Functions	
Digital Infrastructure	
Participatory Infrastructure	

Figure A.10. Data Sheet Template Page 10

Opportunities

Threats

Figure A.11. Data Sheet Template Page 11

Based on the preceding inventory and SWOT analysis, how could the subject study effectively move the described citizen participation level up one level, and what AR tools could facilitate that improvement?

Steps:

1. List the identified Participation Level and Digital Participation Category
    a. Participation Level:
    b. Digital Participation Category:
2. What are the next highest levels of each variable?
    a. Participation Level:
    b. Digital Participation Category:
3. Using the SWOT analysis, what aspects of the subject study are preventing the increase in participation?
    a. Description:
4. What AR functions could overcome these limitations?
    a. Description:
5. What additional digital and participatory infrastructure will be required to achieve the increased participation level?
    a. Description:

Figure A.12. Data Sheet Template Page 12

Recommended Practices SWOT

Strengths	
Variable	**Description**
Social Mode	
Participation Level	
Planning Stage	
Actors	
AR Functions	
Digital Infrastructure	
Participatory Infrastructure	

Weaknesses	
Variable	**Description**
Social Mode	
Participation Level	
Planning Stage	
Actors	
AR Functions	
Digital Infrastructure	
Participatory Infrastructure	

Figure A.13. Data Sheet Template Page 13

Opportunities

Threats

Finally, compare the “Subject Study SWOT” with the “Recommended Practices SWOT”. Do the Recommended practices effectively address the needs identified in the “Subject Study SWOT” while increasing potential participation in a substantive manner? How so?

Figure A.14. Data Sheet Template Page 14

APPENDIX B

CASE STUDY DATA SHEET SUMMARIES

Gourdarznia, Pietsch, and Krug (2017)

Citation: Goudarznia, Toomaj, Matthias Pietsch, and René Krug. 2017. "Testing the effectiveness of augmented reality in the public participation process: A case study in the city of bernburg." Journal of Digital Landscape Architecture 2: 244-251.

1. DESCRIPTION

  a. Research question

     i. How does the inclusion of AR affect public willingness to participate in land planning?

  b. Location

     i. Bernburg, Germany

  c. Summary

     i. Four pillars, collectively called "The Portico", were historic components of a former market house façade on Bernburg's riverfront, but flood damage demanded a waterfront redesign, construction of which began in 2009. As part of the project, the Portico and a portion of the connected structure were removed. The Portico was stored, and the authors conducted a study using AR to gauge public responses to a proposal that would reconstruct the Portico as a stand-alone monument in its original location. The study prepared photomontages and marker-based AR simulations for public viewing of miniaturized and 1:1 scale models of the proposed construction during an informal pop-up engagement session at the site. Facilitators provided AR-capable tablets and fixed markers for users to view the virtual objects. For the 1:1 scale mode, the marker was fixed in placed such that the virtual object appeared in the geographically correct location. Following the AR experience, subjects received a questionnaire about their knowledge and experience with AR and public participation.

2. SOCIAL MODE
    a. Social Mode
        i. Other
    b. Definition
        i. The study does not describe the social dynamics surrounding the relevant planning and design processes.
    c. What specific dynamics placed this case study with the selected category?
        i. See above.
3. ACTORS
    a. Authors of information
        i. Project Participants
    b. Recipients of information
        i. Service Users, Local Beneficiaries
    c. Who are the specific actors

i. Study authors (Project participants) surveyed passers-by (service users--in this case users of the public space-- and local beneficiaries) for their reactions.

4. PLANNING STAGE
   a. Planning stage where the tool is implemented
      i. Option Evaluation
   b. Goal of the planning stage
      i. Understanding comparative strengths and weaknesses of multiple solutions
   c. Role of representations in the planning stage
      i. Integrate diagrams and visual indicators to facilitate spatial and aesthetic comparisons. Demonstrate visual impacts. Facilitate discussion.
   d. What aspects of the case study informed this description?
      i. In the study, a developed design was being viewed and assessed by recipient actors.
5. PARTICIPATION LEVEL
   a. Key Questions
      i. Who makes the final decision regarding the proposed project's approval?
         1. Unknown
      ii. The information shared among actors meet standards for:
         1. Credibility (Factually accurate)
         2. Salience (Relevant to the recipient)
      iii. What kinds of resources are shared among actors?

1. Informative (Accurate descriptions of proposed projects)
2. Technical assistance (Supports comprehension of technical information by laypersons)

iv. What participation elements are present?

1. Opportunities for community input and feedback on proposed projects
2. One-way communication providing information on proposed projects

b. Results

i. Participation Level

1. Consultation

ii. Definition of the Participation Level

1. Decision makers inform the public and collect feedback on predetermined questions

6. AR FUNCTIONS

a. Describe the digital tool's capabilities.

i. The study provides semi-abstract renderings of in-situ and miniaturized models with representational textures applied to the models.

b. What AR capabilities are involved?

i. Markerless tracking, Abstract visualization, Textures, Scaling

7. AR INFRASTRUCTURE

a. What visualization capabilities are used?

i. Photorealistic visualizations, textures, outdoor occlusion

b. What tracking unit is used?

i. Marker-based tracking

c. What is the render unit?

    i. Local device

d. What is the monitor?

    i. Hand-held screen

e. Is the camera built-in or external?

    i. Built-in

f. Is data storage local, remote, or a hybrid?

    i. Local

g. What communication functions are facilitated?

    i. None

8. DIGITAL PARTICIPATION

a. Does the AR fall into the informing, consulting, or collaborating digital participation category?

    i. Informing

b. Describe any additional participation infrastructure used in the subject study.

    i. None

9. SUBJECT STUDY SWOT

a. Strengths

    i. Social Mode

        1. N/A

    ii. Participation Level

        1. Informs potential stakeholders about proposed changes in a credible and salient manner

    iii. Planning Stage
        1. Communicates spatial relationships between virtual and physical objects for evaluation
    iv. Actors
        1. Addresses direct landscape users
    v. AR Functions
        1. Enables basic visualization at miniature and 1:1 scales for exploration and in-situ visualization, respectively
    vi. Digital Infrastructure
        1. Requires minimal AR equipment, utilizes durable and reusable physical markers
    vii. Participatory Infrastructure
        1. Provides AR equipment to users, provides more than one viewing option, acts as a publicly accessible workshop

b. Weaknesses
    i. Social Mode
        1. N/A
    ii. Participation Level
        1. Does not document public feedback or input opportunities on the proposed development.
    iii. Planning Stage
        1. Generates participation late in the process
    iv. Actors

1. Addresses only a small portion of potential stakeholders

v. AR Functions

1. Lacks exploration of the 1:1 scale model and interactivity.

vi. Digital Infrastructure

1. N/A

vii. Participatory Infrastructure

1. N/A

c. Opportunities

i. Adoption of fixed markers for AR engagement at Key Observation Points for public visualizations

ii. Combination of marker-based miniature and 1:1 scale model enables limited exploration when hardware constraints or users' digital literacy make markerless AR unfeasible

iii. Easily incorporated into pop-up engagement scenarios

d. Threats

i. Remains low on the participation ladder

ii. Excludes many potential stakeholders

iii. Introduces visualization late in the process

iv. Does not encourage public authorship or allow for citizen influence of the planning process

10. INCREASING PARTICIPATION

a. List the identified Participation Level and Digital Participation Category

i. Participation Level: Consulting

    ii. Digital Participation Category: Informing

b. What are the next highest levels of each variable?

    i. Participation Level: Placation

    ii. Digital Participation Category: Consulting

c. Using the SWOT analysis, what aspects of the subject study are preventing the increase in participation?

    i. Description: The lack of interactivity in the AR app and opportunities for documenting feedback on the proposed development limit public input. The kiosk-based implementations limit accessibility to present participants.

d. What AR functions could overcome these limitations?

    i. Description: Introducing annotation and commenting features as well as model interactivity would provide opportunities for feedback and ideation. Providing online access to the markers could broaden public access.

e. What additional digital and participatory infrastructure will be required to achieve the increased participation level?

    i. Description: A graphic user interface for facilitating annotation and commenting, text input fields with save options, and capabilities for editing adjusting texture, placement, or components.

11. RECOMMENDED PRACTICES SWOT

a. Strengths

    i. Social Mode

        1. N/A

ii. Participation Level

1. Provides avenues to two-way communication

iii. Planning Stage

1. No change

iv. Actors

1. Expands accessibility to off-site users

v. AR Functions

1. Incorporates formal feedback channels

vi. Digital Infrastructure

1. No additional change

vii. Participatory Infrastructure

1. Expands communication channels

b. Weaknesses

i. Social Mode

1. No Change

ii. Participation Level

1. Does not provide for substantive citizen role in decision making process

iii. Planning Stage

1. Does not engage early citizen participation

iv. Actors

1. Requires digital literacy for accessibility

v. AR Functions

1. Tied to visual markers

vi. Digital Infrastructure

1. Requires server space for storing app, models, and annotations/comments pipeline and requires additional technical skills for creating GUI and model interaction scripts

vii. Participatory Infrastructure

1. Requires digital literacy for accessibility

c. Opportunities

i. Provides for citizen feedback on existing material through digital media

ii. Increases opportunities for citizens to initiate concerns

d. Threats

i. Clear citizen involvement in decision making structure is still missing

ii. Without implementing earlier participation, the digital participation strategy still remains largely reactive.

e. Final Qualitative Analysis

i. Finally, compare the "Subject Study SWOT" with the "Recommended Practices SWOT". Do the Recommended practices effectively address the needs identified in the "Subject Study SWOT" while increasing potential participation in a substantive manner? How so?

1. The recommended actions increase opportunities for public input and broaden accessibility to the app through the incorporation of feedback mechanisms and online availability of relevant resources.

Gill & Lange (2015)

Citation: Gill, Lewis, and Eckart Lange. 2015. "Getting virtual 3D landscapes out of the lab." Computers, Environment and Urban Systems 54: 356-362. https://doi.org/10.1016/j.compenvurbsys.2015.09.012. http://proxy-remote.galib.uga.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edselp&AN=S0198971515300223&site=eds-live.

1. DESCRIPTION

   a. Research question

      i. How can highly detailed 3D visualizations be provided for mobile devices in-situ?

   b. Location

      i. Sheffield, UK

   c. Summary

      i. Researchers explored methods for providing location-based 3D visualizations on-demand for mobile devices. While not necessarily AR by definition, this variant gives users possible methods for exploring credible and salient 3D models of proposed landscapes in-situ, which is a common goal of AR participation tools. The authors assess two methods for varying mobile device platforms. In one option, a tablet-based platform allows users to view a proposal plan and then select a location and viewing direction within established boundaries. The request then is processed by a remote server to render a corresponding view from a premade, detailed 3D model of the proposed landscape. The second app provides similar capabilities through a web-browser based option for smartphones, in which the device's GPS and internal compass data provide the location and orientation information

2. SOCIAL MODE
    a. Social Mode
        i. Other
    b. Definition
        i. The study does not pertain to a specific development project.
    c. What specific dynamics placed this case study with the selected category?
        i. See above.
3. ACTORS
    a. Authors of information
        i. Project Participants
    b. Recipients of information
        i. Project Participants
    c. Who are the specific actors
        i. The authors and trial subjects are simply project participants. Without a specific development project, the actor analysis is less important.
4. PLANNING STAGE
    a. Planning stage where the tool is implemented
        i. Option Evaluation
    b. Goal of the planning stage

i. Understanding comparative strengths and weaknesses of multiple solutions

c. Role of representations in the planning stage

i. Integrate diagrams and visual indicators to facilitate spatial and aesthetic comparisons. Demonstrate visual impacts. Facilitate discussion.

d. What aspects of the case study informed this description?

i. The tools provide detailed visualization options but lack input, feedback, or other interaction capabilities.

5. PARTICIPATION LEVEL

a. Key Questions

i. Who makes the final decision regarding the proposed project's approval?

1. Unknown

ii. The information shared among actors meet standards for:

1. Credibility (Factually accurate)

2. Salience (Relevant to the recipient)

iii. What kinds of resources are shared among actors?

1. Informative (Accurate descriptions of proposed projects)

iv. What participation elements are present?

1. One-way communication providing information on proposed projects

b. Results

i. Participation Level

1. Informing

ii. Definition of the Participation Level

1. Decision makers provide information to stakeholders without any means of providing feedback or negotiating

6. AR FUNCTIONS

   a. Describe the digital tool's capabilities.

      i. Both tools use geolocation to generate the selected perspective to render. Because these models are stored remotely and have minimal reliance on the mobile device's rendering capabilities, more detailed and complex models can be used for rendering, including shadows and textures. Additionally, since the most of the environment's geometry is included in the model, appropriate occlusion is each to achieve. Selecting the site also allows toggling between plan and perspective views.

   b. What AR capabilities are involved?

      i. Markerless tracking, GPS tracking, Geolocated models, photorealistic visualizations, photorealistic textures, plan view/perspective view toggle option

7. AR INFRASTRUCTURE

   a. What visualization capabilities are used?

      i. Photorealistic visualizations, textures, outdoor occlusion, plan view/perspective toggle

   b. What tracking unit is used?

      i. GPS tracking

   c. What is the render unit?

      i. Remote rendering server

d. What is the monitor?

    i. Hand-held screen

e. Is the camera built-in or external?

    i. Built-in

f. Is data storage local, remote, or a hybrid?

    i. Hybrid

g. What communication functions are facilitated?

    i. None

8. DIGITAL PARTICIPATION

    a. Does the AR fall into the informing, consulting, or collaborating digital participation category?

        i. Informing

    b. Describe any additional participation infrastructure used in the subject study.

        i. None

9. SUBJECT STUDY SWOT

    a. Strengths

        i. Social Mode

            1. N/A

        ii. Participation Level

            1. Provides on-demand visual information as requested by the user

        iii. Planning Stage

            1. Applicable for early visual analyses of spatial data or for later-stage project evaluation

iv. Actors

1. Easily accessible by a broad range of potential actors

v. AR Functions

1. High realism capabilities for credible and salient renderings

vi. Digital Infrastructure

1. Multiplatform capabilities with limited reliance on the device's technical specifications

vii. Participatory Infrastructure

1. N/A

b. Weaknesses

i. Social Mode

1. N/A

ii. Participation Level

1. Only informs viewers

iii. Planning Stage

1. Not applicable for feedback or input stages in its current form

iv. Actors

1. Requires some digital and cartographic literacy

v. AR Functions

1. No interactive capacities or real-time viewing.

vi. Digital Infrastructure

1. Requires an internet connection and reliance on a remote server

vii. Participatory Infrastructure

1. N/A

c. Opportunities

   i. On-demand, high fidelity visualizations to any user

   ii. Users can select key observation points to highlight

   iii. Users can select and generate their own renderings with high credibility

d. Threats

   i. Lacks available metadata

   ii. Renderings with greater verisimilitude can more easily abuse their credibility in the absence of transparent production of the underlying model (legitimacy)

   iii. Lacks supporting technical assistance explaining features of the visualized model

10. INCREASING PARTICIPATION

a. List the identified Participation Level and Digital Participation Category

   i. Participation Level: Informing

   ii. Digital Participation Category: Informing

b. What are the next highest levels of each variable?

   i. Participation Level: Consulting

   ii. Digital Participation Category: Consulting

c. Using the SWOT analysis, what aspects of the subject study are preventing the increase in participation?

i. Description: Lack of feedback or input capabilities. Lack of transparency for increased legitimacy

d. What AR functions could overcome these limitations?

    i. Description: Commenting, annotations, perspective origin logging, provision of metadata

e. What additional digital and participatory infrastructure will be required to achieve the increased participation level?

    i. Description: Additional digital infrastructure to support these functions will include the establishment of a feedback database, a graphic user interface for text input, and the logging and communication of model/render metadata

11. RECOMMENDED PRACTICES SWOT

    a. Strengths

        i. Social Mode

            1. N/A

        ii. Participation Level

            1. Meet consultation criteria by providing feedback mechanisms

        iii. Planning Stage

            1. Potential to expand into option evaluation and data collection

        iv. Actors

            1. Expands authorship

        v. AR Functions

1. Incorporates feedback mechanisms and enhances legitimacy

vi. Digital Infrastructure

1. Retains hardware demands

vii. Participatory Infrastructure

1. Facilitates feedback

b. Weaknesses

i. Social Mode

1. N/A

ii. Participation Level

1. Remains in "Degrees of Tokenism" participation levels

iii. Planning Stage

1. Limited interactions constrain input to text reactions

iv. Actors

1. Requires sufficient digital literacy

v. AR Functions

1. Lacks real-time interaction

vi. Digital Infrastructure

1. Increases server demands. Effective GUI can be difficult to develop.

vii. Participatory Infrastructure

1. N/A

c. Opportunities

i. Good potential for public review of VIA reports

ii. Multiplatform deployment

iii. Evaluation through discussion of specific renderings

d. Threats

i. Remains in “Degrees of Tokenism”

ii. Increased legitimacy could prop up poor credibility to uncritical users

e. Final Qualitative Analysis

i. Finally, compare the “Subject Study SWOT” with the “Recommended Practices SWOT”. Do the Recommended practices effectively address the needs identified in the “Subject Study SWOT” while increasing potential participation in a substantive manner? How so?

ii. The recommended AR functions increase the application’s participation level to meet “Consulting” criteria by incorporating feedback mechanisms. These additional functions come at the cost of developing a GUI and communications server infrastructure.

<u>Anagnostou and Panagiotis (2011)</u>

Citation: Anagnostou, Kostas, and Panagiotis Vlamos. 2011. "Square AR: Using augmented reality for urban planning." 2011 third international conference on games and virtual worlds for serious applications.

1. DESCRIPTION

a. Research question

i. Can marker-based AR allow laypersons to design public environments?

b. Location

i. Athens, Greece

c. Summary

    i. The authors investigate the feasibility of an interactive AR landscape design application with goal of facilitating design authorship by local stakeholders and laypersons. The app uses multi-marker targeting to anchor an aerial image onto which users can paint textures and place pre-defined 3D objects such as cars and vegetation. Subjects view the AR experience in a video-see-through mode using an external camera for the video production. The study details the app's demonstration at a conference.

2. SOCIAL MODE

    a. Social Mode

        i. Other

    b. Definition

        i. The study does not pertain to a specific land development project.

    c. What specific dynamics placed this case study with the selected category?

        i. See above.

3. ACTORS

    a. Authors of information

        i. Project Participants

    b. Recipients of information

        i. Project Participants

    c. Who are the specific actors

        i. In this study, the article authors and app testers are project participants

4. PLANNING STAGE
    a. Planning stage where the tool is implemented
        i. Option Creation
        ii. Option Evaluation
    b. Goal of the planning stage
        i. Generating multiple solutions for the final product
        ii. Understanding comparative strengths and weaknesses of multiple solutions
    c. Role of representations in the planning stage
        i. Demonstrate key problems. Introduce ideas early in the discussion. Development of alternative solutions.
        ii. Integrate diagrams and visual indicators to facilitate spatial and aesthetic comparisons. Demonstrate visual impacts. Facilitate discussion.
    d. What aspects of the case study informed this description?
        i. While the app does not pertain to a specific development project, the app is designed and used for subjects to create design alternatives in a given location.
5. PARTICIPATION LEVEL
    a. Key Questions
        i. Who makes the final decision regarding the proposed project's approval?
            1. Unknown
        ii. The information shared among actors meet standards for:
            1. Credibility (Factually accurate)

2. Salience (Relevant to the recipient)
3. Legitimacy (Unbiases and transparent in its production)

iii. What kinds of resources are shared among actors?

1. Informative (Accurate descriptions of proposed projects)

iv. What participation elements are present?

1. Opportunities for community input and feedback on proposed projects

b. Results

i. Participation Level

1. Placation

ii. Definition of the Participation Level

1. Decision makers add public stakeholders to advisory committees, but powerholders retain the right to judge the legitimacy of the advice and may or may not provide technical assistance to the committee. Rights and responsibilities of the committee may be ambiguous.

6. AR FUNCTIONS

a. Describe the digital tool's capabilities.

i. The app provides multi-marker based to display photo-textured 3D components in an interactive model set on top of aerial imagery. Users can select from a small library of 3D assets to place in their scene in addition to textures they can paint onto the defined ground plane. Subjects wear a video-see-through head set which uses video from an external camera on a lightweight stand near the table where the markers are laid out. The use of multi-marker tracking enables the AR session to maintain stability even when only a couple of the markers are in the field of view. This lets users explore a large model from a greater range of possible perspectives.

b. What AR capabilities are involved?

    i. Marker-based tracking, photorealistic visualizations, textures, rotating models, add/subtract models

7. AR INFRASTRUCTURE

    a. What visualization capabilities are used?

        i. Photorealistic visualizations, textures, model editing

    b. What tracking unit is used?

        i. Marker-based tracking

    c. What is the render unit?

        i. Local device

    d. What is the monitor?

        i. Video-see-through

    e. Is the camera built-in or external?

        i. External

    f. Is data storage local, remote, or a hybrid?

        i. Local

    g. What communication functions are facilitated?

        i. Graphic User Interface

8. DIGITAL PARTICIPATION

a. Does the AR fall into the informing, consulting, or collaborating digital participation category?

    i. Consulting

b. Describe any additional participation infrastructure used in the subject study.

    i. No external participation infrastructure was included in the study.

9. SUBJECT STUDY SWOT

    a. Strengths

        i. Social Mode

            1. N/A

        ii. Participation Level

            1. Facilitates 2-way communication and user-generated ideation

        iii. Planning Stage

            1. Enables the creation of alternative solutions and demonstrates limited visual impacts

        iv. Actors

            1. Broadly applicable

        v. AR Functions

            1. Facilitates interaction with and editing of the 3D model.

        vi. Digital Infrastructure

            1. All components are local to the subject. No external links required. Intuitive GUI.

        vii. Participatory Infrastructure

            1. N/A

b. Weaknesses

    i. Social Mode

        1. N/A

    ii. Participation Level

        1. Does not provide substantial resources to influence final decisions. Lacks technical support to inform designs

    iii. Planning Stage

        1. Lacks comparisons for evaluation of multiple options

    iv. Actors

        1. No change

    v. AR Functions

        1. Additional data incorporation and technical assistance can increase the credibility of user-generated content

    vi. Digital Infrastructure

        1. Increases feedback and accessibility

    vii. Participatory Infrastructure

        1. Incorporates negotiation for establishing specific goals and responsibilities

c. Opportunities

    i. Multi-marker tracking allows larger, more stable models

    ii. Input mechanisms support diversified authorship in visual discourse

    iii. Simple GUI allows quick ideation

d. Threats

i. Lacks technical assistance to inform design iterations

ii. Lacks written feedback options or record keeping

10. INCREASING PARTICIPATION

a. List the identified Participation Level and Digital Participation Category

   i. Participation Level: Placation

   ii. Digital Participation Category: Consulting

b. What are the next highest levels of each variable?

   i. Participation Level: Partnership

   ii. Digital Participation Category: Collaboration

c. Using the SWOT analysis, what aspects of the subject study are preventing the increase in participation?

   i. Description: Lack of technical assistance informing design decisions. Lack of commenting or multi-user interactions. Hardware requirements decrease accessibility.

d. What AR functions could overcome these limitations?

   i. Description: Incorporation of informative overlays or spatial data sets. Text input options and online access would increase feedback options and accessibility.

e. What additional digital and participatory infrastructure will be required to achieve the increased participation level?

   i. Description: Educational materials or tutorials could increase users' capabilities for incorporating data. Communication and user account servers would facilitate user-to-user interaction. Making the app available online with printable markers could increase the tool's accessibility. Regarding participatory infrastructure, the digital changes would need to be paired with negotiated power sharing between stakeholders in order to truly achieve partnership, and such changes cannot be achieved through adjusting the digital tools alone.

11. RECOMMENDED PRACTICES SWOT

a. Strengths

i. Social Mode

1. N/A

ii. Participation Level

1. Adds technical assistance to increase legitimacy of placation and encourages negotiation to achieve partnership

iii. Planning Stage

1. Adding data access increases the potential for use during problem analysis

iv. Actors

1. No change

v. AR Functions

1. Additional data incorporation and technical assistance can increase the credibility of user-generated content

vi. Digital Infrastructure

1. Increases feedback and accessibility

vii. Participatory Infrastructure

1. Incorporates negotiation for establishing specific goals and responsibilities

b. Weaknesses

   i. Social Mode

      1. N/A

   ii. Participation Level

      1. Requires greater commitment from participants to succeed

   iii. Planning Stage

      1. Lacks option evaluation capabilities

   iv. Actors

      1. Increased digital and technical literacy may dissuade users

   v. AR Functions

      1. Lacks in-situ visualization and cannot effectively communicate visual impacts at a table-top scale

   vi. Digital Infrastructure

      1. Increases server demands and reliance on internet connection

   vii. Participatory Infrastructure

      1. Negotiations about goals and responsibility will slow the ideation process and would require specialized training to facilitate

c. Opportunities

   i. Ideation with technical assistance increases credibility

   ii. Increased user interactions can increase saliency and transparency

d. Threats

i. Without in-situ experience, users may mis contextual factors during option creation

ii. Retains hardware requirements that limit access

iii. Poorly handled negotiations can stall the process

e. Final Qualitative Analysis

i. Finally, compare the “Subject Study SWOT” with the “Recommended Practices SWOT”. Do the Recommended practices effectively address the needs identified in the “Subject Study SWOT” while increasing potential participation in a substantive manner? How so?

1. Recommended practices increase the credibility of user-generated content by incorporating data access and tutorial materials. Facilitating written feedback increases the types of discourse in the participation strategy. By increasing users’ credibility with data and the legitimacy of their ideas through discursive evaluation, users may more confidently approach negotiations for goal setting and power sharing during decision making processes.

<u>Bishop and Stock (2010)</u>

Citation: Bishop, Ian D., and Christian Stock. 2010. "Using collaborative virtual environments to plan wind energy installations." Renewable Energy 35 (10): 2348-2355. https://doi.org/https://doi.org/10.1016/j.renene.2010.04.003. http://www.sciencedirect.com/science/article/pii/S0960148110001552.

1. DESCRIPTION

a. Research question

        i. Can collaborative virtual environments facilitate effective wind farm planning?

   b. Location

        i. Parkville, Australia

   c. Summary

        i. The authors describe a collection of virtual tools for facilitating stakeholder collaboration and assessment of wind turbines' landscape impacts. The software package, called SIEVE (Spatial Information Exploration and Visualisation Environment), consists of three components: SIEVE Builder, SIEVE Viewer, and SIEVE Direct. These pieces respectively create 3D environments from 2D spatial data, host collaborative viewing of the 3D environment, and facilitate reciprocal manipulations of the 3D environment and 2D GIS. The case study focuses on identifying turbine arrangements and visual screening methods in a collaborative VR environment.

2. SOCIAL MODE

   a. Social Mode

        i. Private Supplier

   b. Definition

        i. Privately-owned generators and suppliers provide energy to consumers through a competitive marketplace

   c. What specific dynamics placed this case study with the selected category?

i. The case study examines an existing wind farm built west of Melbourne, Australia by the private company Pacific Hydro. Since the wind farm is already built, the case study focuses on individual visual impact mitigation efforts by local community members.

3. ACTORS

   a. Authors of information

      i. Local Beneficiary, Project Participants, Technology Host

   b. Recipients of information

      i. Local Beneficiary, Project Participants, Technology Host

   c. Who are the specific actors

      i. Local landowners who may or may not be actively hosting turbines on their land are involved in the study. These stakeholders may or may not be otherwise benefiting from the turbine's presence, but they continue to participate in the case study. All actors in this case study are capable of both authoring and receiving information through the SIEVE tools.

4. PLANNING STAGE

   a. Planning stage where the tool is implemented

      i. Problem Analysis

      ii. Option Creation

      iii. Option Evaluation

      iv. Selection

      v. Decision

   b. Goal of the planning stage

i. Understanding opportunities, threats, needs, and desired outcomes

ii. Generating multiple solutions for the final product

iii. Understanding comparative strengths and weaknesses of multiple solutions

iv. Identification of the most desirable solution

v. Defining next actionable steps

c. Role of representations in the planning stage

i. Highlight aesthetic needs. Compare spatial data sets. Communicate findings.

ii. Demonstrate key problems. Introduce ideas early in the discussion. Development of alternative solutions.

iii. Integrate diagrams and visual indicators to facilitate spatial and aesthetic comparisons. Demonstrate visual impacts. Facilitate discussion.

iv. Succinctly represent alternatives.

v. Identifying action needs

d. What aspects of the case study informed this description?

i. SIEVE incorporates a broad range of capabilities into its possible workflows. SIEVE Builder allows users to construct topographically correct landscapes from geospatial data with scaled structures, turbine, and vegetation. While aerial imagery can be used, other raster data can also be used for ground plane rendering. SIEVE Viewer then allows users to take a perspective view of the 3D environment created from the GIS data. In this setting, users can rearrange structures and vegetation, scale or rotate objects, animate change over time, and assess visual and aural impacts from wind turbines. Multiple users can enter the same VR session at once and communicate via text, background voice channels in the background, and virtual avatars with body language. Users can also share their field of view to facilitate discussion of particular issues. These functions allow users to analyze data, iteratively create design alternatives, and then collaborative evaluate, select, and plan for design and implementation strategies.

5. PARTICIPATION LEVEL
    a. Key Questions
        i. Who makes the final decision regarding the proposed project's approval?
            1. Public Citizens
        ii. The information shared among actors meet standards for:
            1. Credibility (Factually accurate)
            2. Salience (Relevant to the recipient)
            3. Legitimacy (Unbiases and transparent in its production)
        iii. What kinds of resources are shared among actors?
            1. Informative (Accurate descriptions of proposed projects)
            2. Technical assistance (Supports comprehension of technical information by laypersons)
        iv. What participation elements are present?
            1. Community dominance in final decision making. Substantive community-based accountability

2. Negotiated rules and responsibilities. Substantive accountability. Technical support for community-based assessments
3. Opportunities for community input and feedback on proposed projects

b. Results

i. Participation Level

1. Placation

ii. Definition of the Participation Level

1. Decision makers add public stakeholders to advisory committees, but powerholders retain the right to judge the legitimacy of the advice and may or may not provide technical assistance to the committee. Rights and responsibilities of the committee may be ambiguous.

6. AR FUNCTIONS

a. Describe the digital tool's capabilities.

i. SIEVE primarily relies on a VR environment rather than AR environment, but the AR variant relies on markerless GPS tracking to display geolocated 3D models. The incorporation of GIS data allows for textured ground planes and spatial data displays like color-coded visual impact calculation results. Visualizations can rely on phototextures for rendering, but the verisimilitude does not strive for excessive realism. 3D components in the VR/AR session may be animated, scaled, rotated, added, or removed. Since the full environment is modeled in the VR setting, occlusion is easy. Quality of the AR occlusion is not provided.

Since users can move between GIS and VR via SIEVE Direct, users can plan in plan and perspective modes.

b. What AR capabilities are involved?

    i. Markerless tracking, GPS tracking, geolocated models, abstract visualization, photorealistic visualizations, motion, textures, occlusion, rotating models, scaling models, add/subtract models, plan view/perspective view toggle switch

7. AR INFRASTRUCTURE

    a. What visualization capabilities are used?

        i. Abstract visualization, photorealistic visualizations, animation, textures, model editing, plan view/perspective view toggle switch

    b. What tracking unit is used?

        i. Markerless tracking, GPS tracking

    c. What is the render unit?

        i. Local device

    d. What is the monitor?

        i. Video-see-through

    e. Is the camera built-in or external?

        i. Built-in

    f. Is data storage local, remote, or a hybrid?

        i. Hybrid

    g. What communication functions are facilitated?

        i. Commenting, view sharing, edit saving, graphic user interface

8. DIGITAL PARTICIPATION

   a. Does the AR fall into the informing, consulting, or collaborating digital participation category?

      i. Collaborating

   b. Describe any additional participation infrastructure used in the subject study.

      i. This case study does not provide external participation infrastructure directly related to the construction of the wind farm in question, but subjects do have direct control over their own visual impact mitigation strategies.

9. SUBJECT STUDY SWOT

   a. Strengths

      i. Social Mode

         1. For individual visual impact mitigation, each citizen has high control over planning and implementation on their property.

      ii. Participation Level

         1. Users can provide abundant and sound input to relevant planning and design processes. Two-way communication is well integrated and intuitive.

      iii. Planning Stage

         1. The SIEVE tools are broadly applicable across the planning process.

      iv. Actors

1. All involved actors are given sufficient resources to achieve credibility, salience, and legitimacy.

v. AR Functions

1. Users have a high degree of control over data and modeling. VR/AR sessions can incorporate a broad range of data types.

vi. Digital Infrastructure

1. All necessary functions are well supported, and different tools are logically integrated. Local data storage and internet connectivity can support various participation strategies.

vii. Participatory Infrastructure

1. Decision-making for visual impact mitigation efforts is strongly based in citizen control.

b. Weaknesses

i. Social Mode

1. Visual impact mitigation is a reactive after thought in this development scenario.

ii. Participation Level

1. While the tools provide citizens a high degree of input, outside factors limit their impact on the energy development itself.

iii. Planning Stage

1. This case study implements the tool after the wind farm was created.

iv. Actors

1. Energy producers are not involved.

v. AR Functions

1. Lack realistic shadows and nonspatial data displays

vi. Digital Infrastructure

1. High requirements for computational and rendering capabilities. Expensive hardware.

vii. Participatory Infrastructure

1. Lacks direct connection to energy producers.

c. Opportunities

i. Participants can design and negotiate amongst themselves to evaluate alternative solutions.

ii. Some visual impacts can be assessed.

iii. Users can generate credible, salient, and legitimate visual impact mitigation strategies.

d. Threats

i. Places burden of visual mitigation on individual land owners after the fact.

ii. Does not facilitate a relationship between the development authorities and landowners.

10. INCREASING PARTICIPATION

a. List the identified Participation Level and Digital Participation Category

i. Participation Level: Placation

ii. Digital Participation Category: Collaboration

b. What are the next highest levels of each variable?

i. Participation Level: Partnership

ii. Digital Participation Category: N/A

c. Using the SWOT analysis, what aspects of the subject study are preventing the increase in participation?

i. Description: The implementation of SIEVE tools after the wind farm construction is the biggest barrier to increasing the participation level.

d. What AR functions could overcome these limitations?

i. Description: AR functions cannot address the implementation timeline or the decision making process at this level.

e. What additional digital and participatory infrastructure will be required to achieve the increased participation level?

i. Description: While additional digital infrastructure cannot elevate the participation level for this project, these tools could facilitate negotiation of shared goals and responsibilities for a proposed wind farm in the future. Actors could use SIEVE as a foundation for assigning feasible responsibilities to community-based actors.

11. RECOMMENDED PRACTICES SWOT

a. Strengths

i. Social Mode

1. Private supplier initiates early community interactions.

ii. Participation Level

1. Negotiation of roles and objectives meet partnership criteria.

iii. Planning Stage

1. SIEVE parameters draw laypersons' attention to data in need of collecting.

iv. Actors

1. Energy producers engage with existing actors.

v. AR Functions

1. No change.

vi. Digital Infrastructure

1. No change.

vii. Participatory Infrastructure

1. Additional negotiation elevates the SIEVE tools from advisory medium to a decision-making platform.

b. Weaknesses

1. Social Mode
   a. Private suppliers may resist extensive power sharing.
2. Participation Level
   a. Negotiating roles still leaves half or most of the final decision-making power outside of the community.
3. Planning Stage
   a. N/A
4. Actors
   a. Intensive resources dedicated to SIEVE make it difficult to disseminate for broad actor inclusion.
5. AR Functions

a. No change.

6. Digital Infrastructure

   a. No change.

7. Participatory Infrastructure

   a. Additional negotiation will increase the project's timeline and necessary budget.

c. Opportunities

   i. Giving community members credible, salient, and legitimate authorship tools for equal partnerships.

   ii. Multi-faceted interactions among engaged actors in VR environment.

   iii. A consist tool for multiple planning stages can support continuity among users.

d. Threats

   i. Proper negotiation will require specialized facilitation.

   ii. Private suppliers may resist negotiation and power sharing.

   iii. Providing access to SIEVE to growing numbers of users may pose logistical challenges.

e. Final Qualitative Analysis

   i. Finally, compare the "Subject Study SWOT" with the "Recommended Practices SWOT". Do the Recommended practices effectively address the needs identified in the "Subject Study SWOT" while increasing potential participation in a substantive manner? How so?

1. The recommended practices focus on using SIEVE as-is to ground power-sharing negotiations with a private supplier. Successful negotiations would elevate SIEVE from a placatory to a partnership participation level. Since SIEVE can provide layperson actors with credible, salient, and legitimate claims to visualization and design authorship, they may more confidently rely on the private supplier less for technical decision-making, and this dynamic may provide a basis for equal negotiation.