Norwegian
University of
Life Sciences

Master's Thesis 2024 30 ECTS
Faculty of Landscape and Society

Visualizations for Sustainable Landscape Design

Julie Jebens Bakke
Master in Landscape Architecture

OVERVIEW

TITLE
Visualizations for Sustainable Landscape Design

TITTEL
Visualisering av bærekraftig landskapsdesign

THESIS TYPE
Master thesis in Landscape Architecture

AUTHOR
Julie Jebens Bakke

SUPERVISOR
Ramzi Hassan

FORMAT
Landscape A4 210 x 297 mm

NUMBER OF PAGES
55

KEYWORDS
Visualization, Sustainable landscape design, Sustainability,
Landscape architecture, Planning, Illustrations, Models, Renderings

EMNEORD
Visualisering, Bærekraftig landskapsdesign, Bærekraft,
Landskapsarkitektur, Arealplanlegging, Illustrasjoner, Modeller,
Renderinger

PREFACE

This thesis marks the end of an era, an amazing part of life, and the end of five years studying landscape architecture at the Norwegian University of Life Sciences (NMBU).

With a love for visualization and digital tools, I set out on the journey of writing this thesis. Not fully grasping the concept of sustainability, I was interrested and looking forward to learning more about it, and to help others understand how to make it more visible within our field. I belive we can make a difference, and that using the tools we are already familiar with can assist in this endeavor.

I would like to thank my supervisor, Ramzi Hassan, for good advice, valuable feedback, and interesting discussions. Thank you for believing in me and keeping me on track.

Thank you to everyone I got to interview. This thesis would not exist without you. Also thank you to all the companies who allowed me to use their illustrations as examples.

I would also like to thank all my classmates for all the cozy lunches, Cake-Thursdays, late nights with great company, and good support through the degree and thesis writing.

Lastly, I would like to thank my friends and family for enduring with me, supporting, encouraging, and procrastination opportunities.

For five incredible years, thank you!

Julie Jebens Bakke
Ås, May 12 2024

ABSTRACT

With the global issues our world is facing today, providing sustainable solutions is a universal responsibility. This includes the landscape profession. Through the profession's integrated approach, sustainable landscape design can contribute to minimizing environmental impact and provide socio-economic benefits for both nature and people. An essential tool and the main method of communication in the landscape field is visualization. Exploring ways to visualize sustainability will contribute to integrating sustainability into the landscape profession.

This thesis explores how visualization is being utilized to communicate sustainable landscape design, through the qualitative research methods of literature review and a thematic analysis of interviews with professionals.

The results indicate that the purpose, project phase, and target audience are the three main factors to consider when deciding on which visualization techniques to employ. This study also found that visualization techniques can have different attributes within the categories of Reality, Dynamicity, Interactivity, Immersion, and Dimensionality.

The findings in this study also reveal that no set definition of sustainable landscape design exists. Additionally, there is a limited amount of literature on visualizing sustainability. The existing literature mainly focuses on communication of climate change to the general public.

Moreover, the results identify renderings, diagrams, 3D models, Geographic Information Systems (GIS), photos, and manipulated photos as useful tools when visualizing sustainable landscape design. Artificial Intelligence (AI) has also been tested in the landscape field but the technology is still too immature to be an essential tool.

Synthesizing the findings from the literature and interviews identifies effective visualization techniques for communicating general landscape projects and sustainable landscape design. The chosen techniques for general projects are clearly different from those used to communicate sustainability, especially in the early stages of a project.

This study recommends further research on this topic to establish a definition and associated principles and practices of sustainable landscape design. Such a definition should encompass all aspects of sustainability, and hence further integrate sustainability in the landscape field. Further studies on the use of AI in the field of landscape architecture and design are also recommended.

SAMMENDRAG

Dagens globale utfordringer gjør bærekraftige løsninger til en felles målsetning og et universielt ansvar. Dette gjelder også landskapsprofesjonen. Gjennom profesjonens integrerte tilnærming kan bærekraftig landskapsdesign bidra til å minimere miljøpåvirkning og gi sosioøkonomiske goder til natur og mennesker. Et essensielt verktøy og hovedmetoden for kommunikasjon i landskapsprofesjonen er visualisering. Utforsking av ulike visualiseringsmetoder for å kommunisere bærekraft vil bidra til å integrere bærekraft på feltet.

Denne oppgaven utforsker hvordan visualisering blir brukt for å kommunisere bærekraftig landskapsdesign. Dette ble gjort ved bruk av to kvalitative metoder, et litteraturstudie og en tematisk analyse av intervjuer med fagpersoner.

Resultatene i denne oppgaven viser at formål, prosjektfase og målgruppe er de tre hovedfaktorene som tas i betraktning under valg av visualiseringsmetode. Studien viser også at visualiseringsmetodene har ulike egenskaper med tanke på realisme, driv, interaksjon, fordypelse og dimensjon.

Videre viser resultatene i denne oppgaven at det ikke er enighet om definisjonen av bærekraftig landskapsdesign. Det er lite litteratur som omhandler visualisering av bærekraft, og den eksisterende litteraturen fokuserer hovedsakelig på kommunisering av klimaendringer til allmuen.

Utover dette, peker resultatene på renderinger, diagrammer, 3D modeller, Grafiske Informasjonssystemer (GIS), bilder og manipulerte bilder som virkningsfulle verktøy under visualisering av bærekraftig landskapsdesign. Kunstig intelligens (KI) er også utprøvd på feltet, men teknologien er enda for lite utviklet til å regnes som et essensielt verktøy.

Gjennom analyse av funnene i denne studien identifiseres effektive visualiseringsmetoder for kommunisering av generelle landskapsprosjekter og bærekraftig landskapsdesign. De valgte metoder for generelle prosjekt er markant ulike fra metoder brukt for kommunisering av bærkraft, særlig i tidlige faser av prosjekt.

Denne studien anbefaler videre forskning rundt tema for å etablere en definisjon, og tilhørende prinsipper og praksis, for bærekraftig landskapsdesign. En slik definisjon bør omfavne alle aspekter ved bærekraft, og dermed videre integrere bærekraft i landskapsprofesjonen. Videre studier på bruk av KI på feltet for landskapsarkitektur og design er også å anbefale.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

This chapter provides an overview of the background and relevance of the study, outlining the research question, purpose, and methodology employed. This sets the stage for the following chapters by establishing the context and objectives of the research.

BACKGROUND AND RELEVANCE

CLIMATE CRISIS

The world is in a crisis, as human activity has led to a rise in the global surface temperature, affecting weather and climate all over the world. In return, this negatively impacts nature and people everywhere, even those not directly contributing to the issue (IPCC, 2023).

One response to these issues was the introduction of the 17 Sustainable Development Goals (SDGs) in 2015, creating a plan to rid the world of poverty, fight inequality, and stop climate change by 2030 (FN-Sambandet, 2024). In the report by the Intergovernmental Panel on Climate Change (IPCC) (2023) the connection between climate change and sustainable development is underlined. Mitigating and adapting to climate change is critical to sustainable development, and there are synergies between the two, according to IPCC (2023). This would mean that following the SDGs would contribute to solving the climate crisis.

THE ROLE OF THE LANDSCAPE PROFESSION

Back in 2019, The International Federation of Landscape Architects (IFLA) and the Landscape Institute declared a climate and biodiversity emergency because of the climate, nature, and societal issues that are present (IFLA, 2019; Landscape Institute, 2021). They both, together with their members, would commit to taking action and improving practices. What makes the landscape profession so essential in solving these issues, is its ability to make a difference across both mitigation and adaptation (Landscape Institute, 2021). IPCC (2023) mentions in their report that it requires a consideration of people's needs, biodiversity, and other sustainable development dimensions to be able to create context-relevant designs and implementations, which is exactly what the integrated approach of the landscape profession involves. In addition, landscape architecture and design work at all scales, from global and regional to local and even human (IFLA, 2021a).

To showcase how landscape architecture contributes, IFLA (2021b) developed a guide for landscape architects on the use of the Sustainable Development Goals (SDGs). In the guide, they discuss how the SDGs and landscape architecture align and show examples of projects. For instance, through climate-resilient urban planning landscape architects can contribute to Sustainable Development Goal 11, Sustainable cities and communities. An example project connected to this goal is the High Line in New York, which is an old railway repurposed into an urban park and a green public space.

THE ROLE OF VISUALIZATION

Consequently, landscape architects and designers can contribute to sustainability through their work, and thus the tools that are used are important to the contribution as well. An essential tool in the landscape profession is visualization, as it is the main form of communication. Visualization can for example show future scenarios or different design ideas, like how Walton and Bosomworth (2017) found that landscape architecture visualizations can assist in planning by showing potential outcomes. Concerning sustainability and climate change, Sheppard et al. (2008) emphasized how visualization contributes to making people more aware of the issues. In addition, NRK's article on interventions in Norwegian nature is also an example of how visualizations can be used to make people aware of issues that go widely unnoticed (Støstad et al., 2024). Meanwhile, Evensen et al. (2021) demonstrated how using visualizations to research people's emotional responses to specific designs can inform better design choices, showing how visualization can affect the social aspect of sustainability and assist in creating safer spaces.

The integration of sustainability into the landscape profession is an ongoing topic of debate that requires further consideration. There is a need to explore effective ways to visualize sustainability within the profession and incorporate it into practice.

RESEARCH QUESTION

PURPOSE

The purpose of this thesis is to investigate how visualization is being used in landscape architecture and design practices as a way of communicating and promoting sustainability in projects. The study aims to shed light on useful techniques and processes on what does and does not work.

RESEARCH QUESTION

How is visualization being utilized to communicate sustainable landscape design?

TARGET AUDIENCE

The thesis's main target audience includes landscape architects, designers, and urban planners looking for insights into utilizing visualization for sustainable projects. It can also be relevant to researchers, students, and academics investigating the intersection of sustainability and design visualization. Additionally, it may be of interest to environmental activists and policymakers who are interested in innovative approaches to promote sustainability.

METHODOLOGY

The study uses qualitative research methods by utilizing a literature review and interviews of practitioners from the landscape design profession to answer the research question and to achieve the goal of this study. The nature of the research question calls for qualitative methods to answer it through interpretative means, as how people do something cannot be quantified.

LITERATURE REVIEW

In this study, I conducted a literature review to find relevant sources that will help in addressing the research question. This forms the primary theoretical framework of the study and establishes the foundation for the interview questions.

To find literature, the following keywords were chosen and put into the databases Oria.no and Scopus, in different combinations and orders: “Sustainable design”, “Sustainable landscape design”, Sustainab*, Landscape, “Landscape architecture”, “Landscape design”, Visualization, Artificial Intelligence, and AI. Sometimes only one of the keywords was used, but they were usually combined with “AND” or “OR”, for instance, “Sustainable design” AND Landscape AND Visualization. From these results, the snowball method was used to find other relevant literature, and the informants were also asked if they knew of anything relevant. The relevancy of the found literature was done by me, by reading the abstract and title.

INTERVIEWS

I conducted in-depth interviews with landscape professionals to gain information and a deep understanding of the use of visualization to communicate sustainable landscapes in the current landscape design profession. Additionally, I sought to get an insight into the professionals’ thoughts on the matter.

SELECTION

I employed purposive sampling to select interviewees based on their professional background, affiliation, and potential engagement with visualization. Specifically, I targeted landscape architect practitioners and planners from medium to large firms known for their varied projects. Utilizing the Norwegian Association of Landscape Architects (NLA) directory, I identified relevant companies and individuals, ultimately conducting interviews with a total of ten participants.

CONDUCTION OF INTERVIEWS

The interviews were in Norwegian, semi-structured and followed an interview guide with standard questions created beforehand (Appendix 1). The questions were asked orally, so the exact formulation varied depending on the informant. In addition, the questions were adjusted depending on the answers of the person. Semi-structured interviews were chosen as this leads to a more relaxed conversation and makes it possible to ask clarifying and follow-up questions. This led to more in-depth answers and information on unpredictable topics.

The time and place of the interviews were adjusted to the informants and happened with the first on the 31st of January 2024 and the last on the 20th of February 2024. Most interviews were conducted in person at the informants' workplace, while three were done on video call, and two were done in person at my university. I was not strict on how long the interviews would take but told the informants it would take between 30 minutes to an hour.

To document the answers from the interviews, an assistant and I took notes of what they said. This was to keep the informants anonymous from the beginning. They were further given IDs of ID1 to ID10 to differentiate between their answers.

THEMATIC ANALYSIS

To analyze the data from the interviews, I used a method for examining qualitative data called thematic analysis. This method generates themes from the data that address the research question through data familiarisation, data coding, theme development and revision (Braun & Clarke, n.d.). As a result, the answers from the interviews were divided into three topics: Visualization and Communication, Sustainable Landscape Design and Communication, and Artificial Intelligence in Landscape Architecture. From here I looked for trends and disagreements under each topic.

LIMITATIONS

Not all keyword combinations were documented in the literature review due to the limited relevant literature in each search, and several searches ended with no results. Given that I was the sole individual responsible for reading and selecting literature, it's possible that some relevant sources were overlooked.

Ten individuals may not sufficiently represent the entire field of landscape architecture and design in Norway and their use of visualization to communicate sustainable landscape design. Still, the diversity in responses might imply this was a good selection. The processing of the data and the choice of utilizing notetaking instead of voice recording could have resulted in relevant information disappearing or being misunderstood.

STRUCTURE

The thesis will be presented through five main chapters, each contributing to exploring and debating aspects connected to the research topic, as follows:

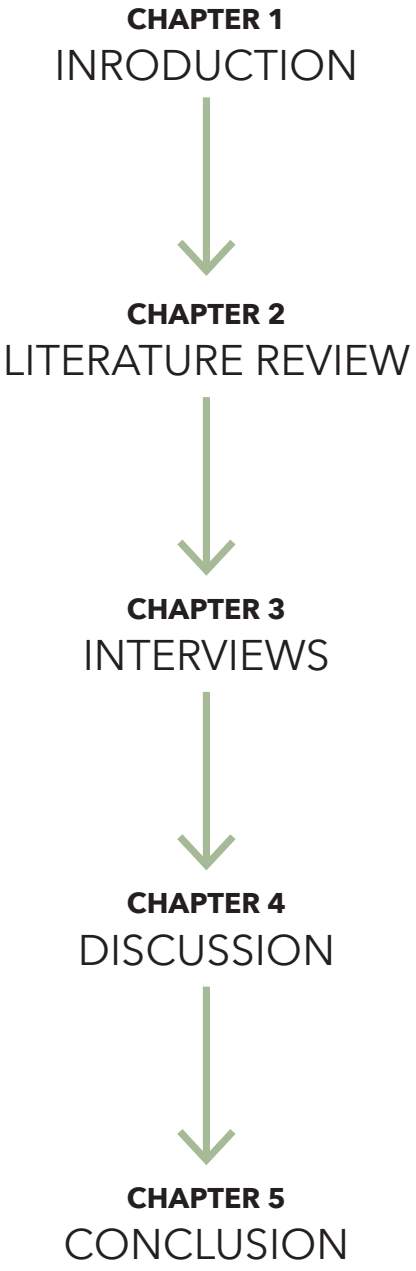
Chapter 1 Introduction
This chapter provides an overview of the background and relevance of the study, outlining the research question, purpose, and methodology employed. This sets the stage for the following chapters by establishing the context and objectives of the research.

Chapter 2 Literature Review
This chapter explores the existing literature relevant to the study, providing insights and analysis to support the investigation of the research question and to build a solid foundation for understanding the topic.

Chapter 3 Interviews
This chapter presents the results gathered from interviews with professionals in the landscape design field and provides unique insight into the topic.

Chapter 4 Discussion
In this chapter, the results and limitations of the study are discussed in relation to the research question.

Chapter 5 Conclusion
The last chapter summarizes the study through a conclusion.



CHAPTER 2

LITERATURE REVIEW

In this chapter, the findings from the literature review are presented, forming the theoretical part of this study. The chapter is divided into three parts: Part 1 examines the use of visualization. Part 2 discusses sustainable landscape design, and part 3 explores the visualization of sustainability.

1 VISUALIZATION

This subchapter looks at the development of visualization and its use as a communication tool. It will provide a historical context for the use of visualization as communication in landscape planning, providing a background for visualizing sustainability.

HISTORY OF VISUALIZATION

Visualization has always been an important part of landscape architecture and design by being the main type of communication. Through tens of thousands of years, humans have used visualizations to convey ideas and thoughts, and since gardens started representing more than necessity, hand-drawn landscape plans have been used to showcase projects (Mertens, 2010, p. 11).

When technical perspectives were invented with concepts like vanishing points in the 1400s, 3D perspectives became more commonly used to show atmospheric scenes and more technical perspectives like axonometric view were used to show the architectural aspects (Figure 1) (Bishop & Lange, 2005; Mertens, 2010). In addition to landscape plans and perspectives, visualizations from the Peterhof Palace Park project are an example of how they would add section drawings or elevations to show aspects that couldn't be seen in only 2D (Figure 2) (Mertens, 2010).

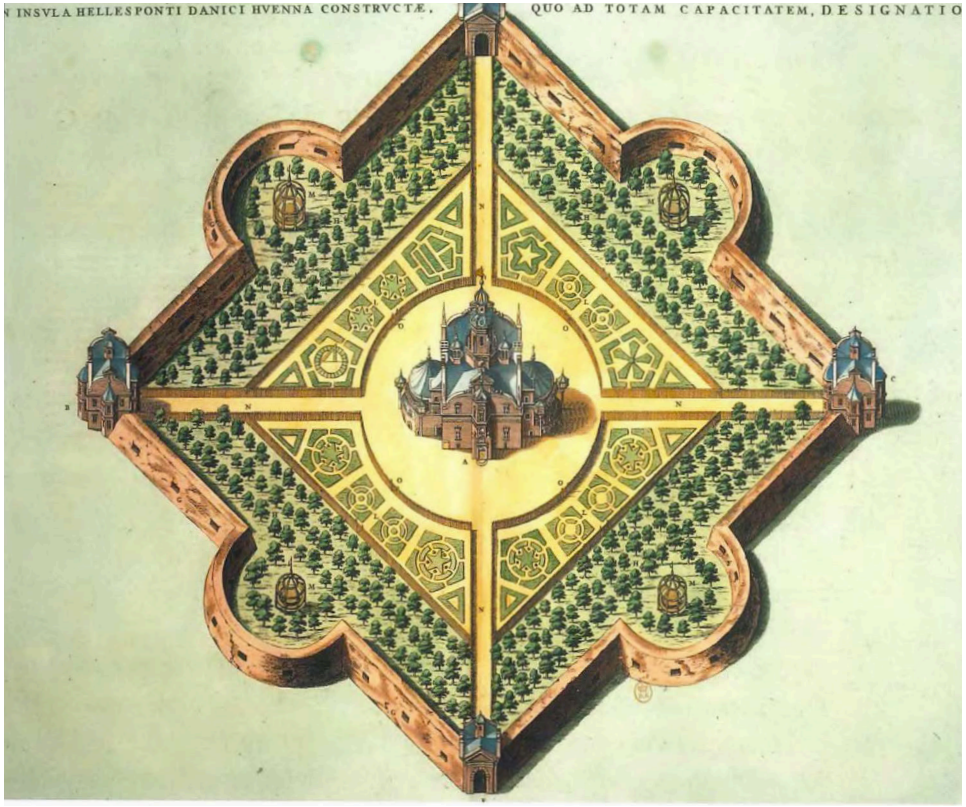


Figure 1. Copperplate engraving, axonometric view of Schloss Uraniebaum on the Island of Hveen by Joan Blaeu, 1663. From "Visualizing Landscape Architecture: Functions, Concepts, Strategies" (pp. 12), by E. Mertens, 2010, Birkhäuser.

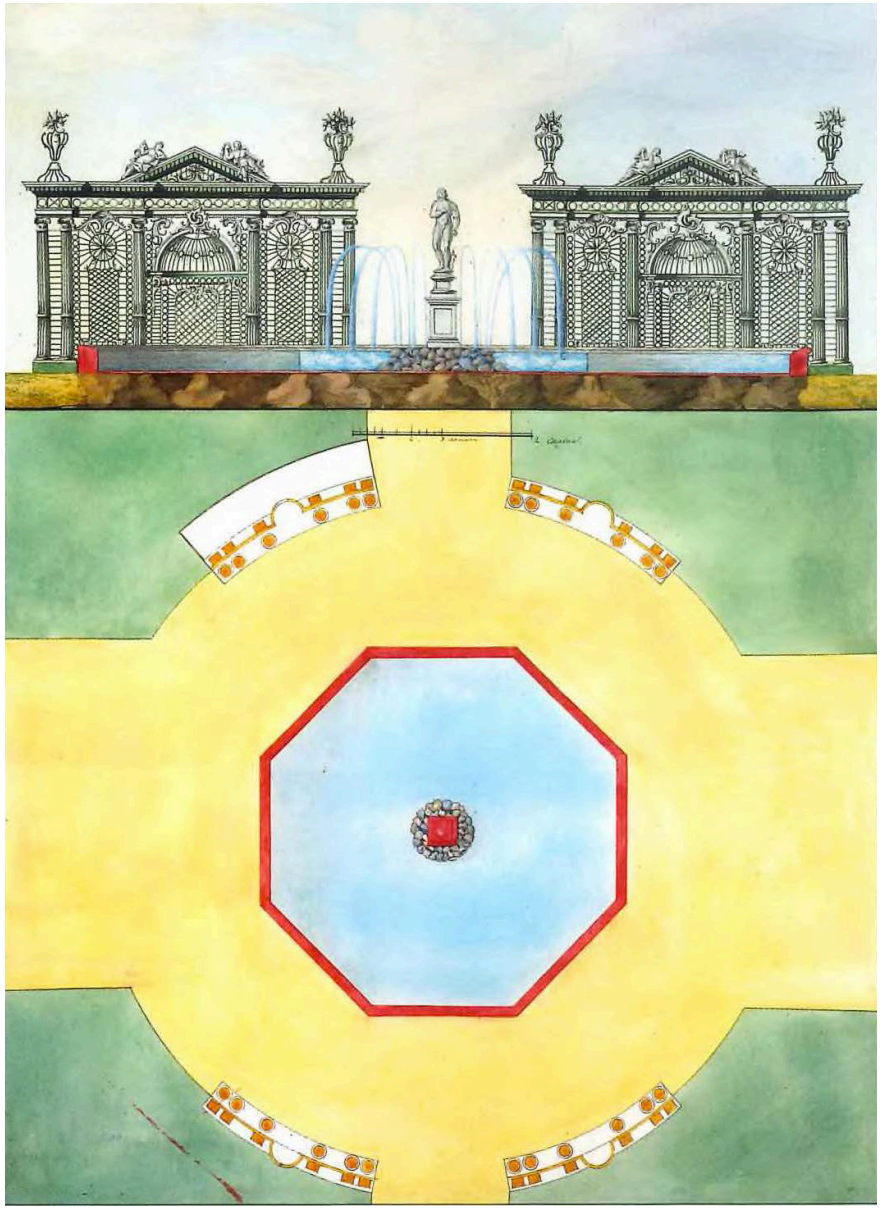


Figure 2. Watercolor of the Adam Fountain in Peterhof Palace park by Vasily Ivanovich Bajanov, 1796. From "Visualizing Landscape Architecture: Functions, Concepts, Strategies" (pp. 15), by E. Mertens, 2010, Birkhäuser.

In the 1700s, Sir Humphry Repton invented a new visualization technique to communicate his ideas. He would create 'Red Books' for each project that was filled with paintings illustrating before and after images (Figure 3 and 4). He would make one illustration of the existing situation, and then one of the proposed changes, from the same angle. He would then make it possible to fold one on top of the other to be able to compare the situations, which he would refer to as slides (Repton & Loudon, 1840). By making the future possibilities comparable to the present situation, he made it easier for his clients to imagine the proposed changes.

For a long time, hand drawings and other hand techniques, like models and engravings, were the only option for visualizing, but with the evolution of technology, new techniques emerged.

In the 1960s and 70s photographs and photomontages became common techniques, and the first Computer-Aided Design (CAD) and Geographical Information System (GIS) software appeared. Later, in the 1990s, the use of digital techniques and the possibilities for digital visualization increased, and it became possible to edit photos (Ervin, 2020; Lovett et al., 2015). While CAD and GIS evolved at this time, the Internet emerged and led to 3D visualizations and other digital tools becoming more accessible and a common tool in the profession (Ervin, 2020; Lange, 2011).

Figure 3. Existing situation with overlays up. From "The Red Book of Ferney Hall", by Humphry Repton, 1789, The Morgan Library & Museum.

Figure 4. New scenario with overlays down. From "The Red Book of Ferney Hall", by Humphry Repton, 1789, The Morgan Library & Museum.

The development continued further, and the visualizations became more realistic and possible to interact with (Lange, 2011). 3D rendering led to the possibility of creating highly realistic visualizations, and Virtual Reality (VR) and Augmented Reality (AR) created the opportunity to experience a project firsthand. With VR you can see a 3D model simulation with a special headset and feel what it's like to stand in the space, while AR makes it possible to see an overlay of the project on top of reality through a phone or tablet screen. Interestingly, AR and VR technologies in principle represent the digitalization of the Red Book concept developed by Repton.

In recent years, artificial intelligence (AI) has become more available to the public, and with the addition of picture-producing AI, this has become a potential tool for visualization. In their study, Architizer and Chaos (2023) found that 55% of their respondents were already fully embracing AI, or have at least started experimenting with it. Some researchers have investigated the use of image-generating AI in landscape architecture and found that it can be useful when creating 2D assets for a project (Fernberg et al., 2023). In addition, it can be useful when you are looking to generate or edit photos of potential scenarios in the ideation phase of a project, but it still has limited use in the profession at the level it is today (Fernberg et al., 2023; Li & Amoroso, 2023; Wang, 2021).

USE OF VISUALIZATION

With the amount of available visualization tools and techniques increasing, choosing the right tool for the job can be difficult. Still, there are some questions that can be asked and aspects that can be considered.

Lovett et al. (2015) identified three questions one should consider when using 3D visualization: When to use them, what to include in them, and how to display them.

The question of 'when' concerns the setting for the visualization and is something that changes with every project. Each project does things differently, but there's usually a general process with different purposes. As a result, the purpose of the visualization and the phase of a project are strongly linked and something to keep in mind (Lovett et al., 2015). In addition, the target audience for the visualization should be considered, as people have different experiences and backgrounds (Lovett et al., 2015; Metze, 2020), and the audience changes depending on where one is in the process.

When considering the question of 'what' and thus the content of visualizations, the aspects of realism and detail arise (Lovett et al., 2015). The evolving technology has made it easier to achieve high levels of realism and detail, but the user is still limited to the capabilities of the software that is used (Eilola et al., 2023; Lovett et al., 2015).

Lastly, how to display the visualizations involves the visualization presentation and is connected to the degree of interactivity and immersion. This factor affects how people experience the display (Lovett et al., 2015).

Though Lovett et al. (2015) speak of 3D visualizations, the questions can concern all types of visualization in the planning field.

Furthermore, looking at the visualizations themselves can aid in answering these questions and choosing the appropriate technique. Nasr-Azadani et al. (2022) found it possible to categorize visualization techniques by looking at the five attributes of Reality, Dynamicity, Interactivity, Immersion, and Dimensionality (Table 1).

Reality can be classified as abstract, semi-real, or real and demonstrates the similarity between the visualization and its equivalent in the real world, while the Dynamicity attribute looks at whether the visualization is dynamic and can change or transform, or if it is static and does not move. Similarly, Interactivity is divided into interactive and static and depicts whether it is possible to change or manipulate the visualizations. Whereas Immersion refers to the degree of being enveloped and directly involved in the display and is classified as either non-immersive or immersive. Lastly, Dimensionality has three categories, 2D, 3D, and 4D, and concerns the spatial dimensions.

Most visualization tools are a combination of these attributes. Some commonly used visualization techniques are 2D still maps, 2D and 3D panoramic views, photorealistic landscapes, section drawings, VR, AR, interactive 3D Landscapes, and GIS (Nasr-Azadani et al., 2022).

Looking at the aspects following the questions identified by Lovett et al. (2015) in addition to the attributes, some things are already connected. For instance, the question of 'what' is said to involve a degree of realism, which can be connected to the Reality attribute. Moreover, the degree of interactivity and immersion mentioned under the question of 'how' can be directly linked to the Immersion and Interactivity attributes.

By utilizing this way of categorizing the techniques and recognizing the need for them, one can start to figure out when, where, and how to use different visualization techniques to serve the needs of a project. This can be relevant when there is a need to visualize sustainability in a project for example. I will explore this further in the Discussion.

Table 1. A table showing the five attributes of visualization techniques and their classifications. Based on Nasr-Azadani et al.'s (2022) study and illustration.

REALITY			DYNAMICITY		INTERACTIVITY		IMMERSION		DIMENSIONALITY		
Abstract	Semi Real	Real	Static	Dynamic	Still	Interactive	Non-Immersive	Immersive	2D	3D	4D
The degree of familiarity with a subject and its similarity to the equivalent in the real world			Displays that alter constantly, with or without user interference		The ability to interact with, manipualte and transform a visualization		The sense of being included in or enveloped by the environment		The spatial property of having dimensions		

2 SUSTAINABLE LANDSCAPE DESIGN

This subchapter looks at the definition of sustainability in general and in a landscape context, as there exists no clear definition of sustainable landscape design. This is to help understand what is meant by visualizing sustainable landscape design.

SUSTAINABILITY

Sustainability officially became defined when the United Nations published the Brundtland Report "Our Common Future" in October 1987. This report outlines the definition of sustainability as having three dimensions (three Es): Environment, Social Equity, and Economy. Meanwhile, it also became clear that there must be a balance between the three because it won't work if one or two are neglected (United Nations, 2023). At the same time, a definition of sustainable development was given: "Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (Brundtland & Dahl, 1987, p. 41).

Since its launch in 1987, sustainability has become a significantly more commonly used word worldwide but is still mostly considered for the Environmental dimension. With the development of the United Nations Sustainable Development Goals in 2015 (Figure 5), sustainability was given clearer definitions and goals within all three dimensions. However, the meaning or the application of the word can be different depending on the context.

Figure 5. The 17 Sustainale Development Goals. From "Communication materials", by United Nations, n.d., https://www.un.org/sustainabledevelopment/news/communications-material/

SUSTAINABILITY IN LANDSCAPE ARCHITECTURE AND DESIGN

Landscape design and landscape architecture play a big part in developing the environment and society, and with sustainable development becoming more and more important, sustainable landscape design is also becoming prominent. However, exactly what sustainable landscape design entails seems to be unclear. The term does not have a universal definition or a clear history or evolution but has been explored and discussed through many years (Loehrlein, 2021, p. 2).

The American Society of Landscape Architects (ASLA) (n.d.) has a definition of sustainable landscapes. They are seen as being environmentally responsive, regenerative, and contributing actively to the development of healthy communities. These landscapes are also said to create value via economic, social, and environmental benefits. On a similar note, the Norwegian Institute for Nature Research (NINA) (n.d.) views a sustainable landscape as one that is in harmony with its surrounding environment, maintains well-functioning ecosystems, and incorporates a sustainable societal perspective. Furthermore, such a landscape must be self-sufficient over extended periods to prevent harm to its surroundings. A third similar description of a sustainable landscape describes it as a dynamic system that is characterized by its multiple trajectories and outcomes. This system is multifunctional, contributes to the provision of ecosystem services, and showcases resilience and adaptability (Musacchio, 2009).

Commonalities between these three definitions include the landscapes' ability to regenerate and be self-sufficient, to which resilience and functioning ecosystems also contribute. Secondly, it should have a societal aspect by contributing to communities or something similar. Thirdly, it should fit in with, and be responsive and in harmony with its surroundings, with adaptability also suggesting these qualities.

Meanwhile, building on the three Es of sustainability, environment, equity, and economy, Musacchio (2009) proposes three additional Es, aesthetics, experience, and ethics, when defining landscape sustainability for designed landscapes. The study discusses the limitations of the traditional definition of sustainable development because the human experience encompasses more than just these three aspects. Meyer (2008) also argues that aesthetics should be included in a sustainable landscape. However, any definition of landscape sustainability has its limitations because it must encompass more than the sum of its parts and is connected to both time and space.

On the other hand, sustainable landscaping, or sustainable landscape design as a practice, has had few attempts at a definition, but has been defined as "landscape practices that preserve our planet and our environment without depleting and damaging our air, water, and soil." (Loehrlein, 2021, p. 1). However, it is not thought of as quite the same as sustainable development, ecological design, or restoration ecology (Meyer, 2008, p. 15). Just like sustainability is more than just environmental issues, sustainable landscape design involves more than just environmental solutions. In addition to addressing ecological aspects like resources, emission of greenhouse gasses, and climate change, it should address social and cultural aspects as well, as they do in previously mentioned definitions of sustainable landscapes (Loehrlein, 2021; Meyer, 2008).

Even though they are worded a bit differently, landscape sustainability and sustainable landscapes can be thought of as the same thing. At least, the definitions seem to share the same intentions. Taking the definition of sustainable landscaping and thinking of it as being the goal of the design, it becomes possible to see it as what sustainable landscape design should be.

As the landscape is a part of our environment, this pillar of sustainability seems to be the strongest in the context of landscape design. Sustainable landscape design should be landscapes that do not damage their immediate surroundings or the rest of the world. This includes considering the causes and effects of climate change, ecology, and ecosystems. The social aspect is the second strongest, which makes sense because most landscape design and architecture are for the people. The three Es that are proposed as individual aspects can also be seen as cultural and societal aspects that is arguably important to sustainable landscape design. Finally, economy is not a clear part of any of the proposed definitions, however, the cost of a landscape project should reflect the expected environmental or societal benefits.

3 VISUALIZING SUSTAINABILITY IN LANDSCAPE ARCHITECTURE

The last subchapter will present what has been studied and written on visualizing sustainable landscape design as communication to assist in answering the research question of the thesis.

On the environmental side of sustainability, climate change is an aspect that concerns landscape design. With the changing temperatures, potential extreme weather, and other environmental issues, how landscape architects plan and design our cities and environments can affect how humans survive the changes. For example, some of the major causes of climate change are the emission of greenhouse gasses, and the release of carbon due to human activities (Loehrlein, 2021; Sheppard, 2012). This is measurable, and something the landscape architecture field can influence by making design decisions that reduce the carbon footprint of projects (Holter & Bjørgen, 2022). However, to the general public, climate change still seems like a faraway problem, and there are still many necessary actions that must be taken to change the outcome of our future (Nicholson-Cole, 2005; Sheppard, 2012). There is still a need to increase awareness, and to convince people to choose the more sustainable solutions where possible. This is where visualizing can make a difference.

Seeing is believing, so making something visual helps people understand and appeals to emotions (Sheppard, 2012, pp. 69, 285). Sheppard (2012) found that both 2D visuals like diagrams, maps and photos, and 3D visuals like models, renderings and perspectives are useful tools when communicating climate change. The 2D visuals can easily simplify the science and explain the causes, consequences, and solutions, while 3D visuals are beneficial because they can make the situations extremely clear and tangible while being informative, captivating, and emotionally engaging. Furthermore, 3D visualizations were found to be preferable over 2D visuals because of the level of realism and flexibility when it comes to tailoring the scenarios to specific areas and situations (Sheppard, 2005; 2012, p. 356).

While Sheppard (2012) mostly speaks of visualizing climate change and communicating with local communities, the principles and tools are transferable to communication with clients and stakeholders on other aspects as well (Pettit et al., 2011). A study from Denmark (Tress & Tress, 2003) found realistic scenario visualizations to be helpful when communicating potential landscape changes to stakeholders and users. Landscape visualizations showing different scenarios can help with justifying where to put the money and can function as arguments and evidence (Pettit et al., 2011). Many developers might not realize what their plans will look like before they build them and might change their minds when shown (Sheppard, 2012, p. 42).

As it has been found that sustainable landscape design has many aspects, it can be difficult to see it all in a project. Loehrlein (2021) suggests using a sustainability audit to gather information on sustainability issues at the start of a project. It covers everything from plants and the soil to the sun and air. The audit itself is in a written format, but it is recommended that one sketches the site with key features and notes. The form and drawing work together as a type of analysis that leads to recommendations that can be made to the client, after processing the problems and potential solutions. If not using this exact method, analyzing the project site and visualizing it is a way to make the clients or stakeholders aware of the potential issues and things they need to or should consider.

This review reveals that there exists literature on the use of visualization in landscape architecture, but a limited amount concerning sustainability and sustainable landscape design. The few articles and books that speak of visualizing sustainability in a landscape context, mostly cover climate change, and the audience is usually end-users or the public. In studies that have tested the usability of a tool in communicating sustainability, 3D visualization and VR are the most researched ones on the topic (Adeel et al., 2021; Atwa et al., 2019; Portman et al., 2015). Consequently, there is a lack of research on the use of other visualization techniques, on other aspects of sustainable landscape design, and with different audiences.

CHAPTER 3

INTERVIEWS

This chapter presents the results gathered from interviews with professionals in the landscape design field and provides unique insights into the thesis topic.

To explore the research question of this study, I engaged with professionals from seven different companies. The companies were of medium to large size in the field of landscape architecture in Norway, ensuring a diverse range of perspectives. This took place between the 31st of January 2024 and the 20th of February 2024.

The conversations aim to shed light on the professionals' perspectives and views regarding sustainable landscape design and the role of visualization as a communication tool within the profession. Additionally, the discussions explore their understanding of the potential integration of artificial intelligence (AI) in the field.

The interviews centered around three main themes and corresponding inquiries to guide discussions with participants:

1 - Visualization and Communication:
Subjects were asked about their practices of utilizing visualization techniques throughout project cycles and how they communicate design scenarios. Subjects explained the methods, rationale, and target audience involved.

2 - Sustainable Landscape Design and Communication:
The interviews explored the participants' perspectives on sustainable landscape design and its representation through visualizations. Subjects offered varied insights into the interpretation of sustainability within the realm of landscape architecture.

3 - Artificial Intelligence in Landscape Architecture:
The conversations explored the integration of artificial intelligence (AI) in landscape design, prompting reflections on its potential impact and adoption within the field. In addition, professionals shared their experiences and thoughts on AI technologies, providing insights into their current status and prospects within landscape architecture.

1 VISUALIZATION AND COMMUNICATION

The interviews revealed interesting insights when utilizing visualization for the communication of landscape design scenarios. A variety of visualization techniques emerged from these discussions, including hand drawings, 2D plans, 3D models, sections, photographs, diagrams, Geographic Information Systems (GIS), renderings, and Virtual Reality (VR).

Hand drawings are often on paper, with the artist using a tablet at times for a more digital approach. 2D plans illustrate a top-down perspective of the project, while 3D models offer a tangible, navigable digital representation of the design. Sections, on the other hand, provide a glimpse into the vertical cross-section of a project.

Photography plays a significant role, with inspirational photos showcasing other projects, manipulated images depicting specific scenarios, and collages merging multiple images into a single composition. Diagrams simplify ideas into schematic representations or graphical forms.

GIS comes into play with the visualization of geographic data through digital maps, while renderings offer a highly realistic digital 3D illustration based on the 3D models, often using software like Lumion (Figure 6).

Finally, VR allows for a fully immersive 3D simulation of a project. Professionals carefully weigh these visualization methods against several key factors to determine the most effective means of communication.

Figure 6. Example of a rendering or 3D illustration. Source: LINK Arkitektur, Lierstranda. (Used with permission)

Firstly, they contemplate the purpose behind the communication, aiming to discern whether they seek to persuade or inform. "The models can both be complicated and quite simple, depending on the purpose." (ID6). This distinction emerges as crucial, as interviews revealed two primary objectives: the desire to sell or advocate for a particular idea or concept, and the intention to provide informative insights into potential solutions.

Secondly, professionals consider the current phase of the project, differentiating between the preliminary stages and the post-decision implementation phase. As one informant stated, "The visualization technique depends on the purpose of the illustrations and the phase of the project" (ID10).

During the initial stages, often referred to as the concept phase, the priority is to sell the idea to clients and compelling them to invest. The techniques employed during this phase vary widely among professionals, but common tools include 2D plans, 3D models, photos, sections, and hand drawings. One such approach involves creating a 3D model or using a screenshot from a map web service, for example Google Maps, and using it as a base for hand drawn or sketch-like illustrations (Figure 7 and 8). Some professionals might opt for a combination of 2D plans and section drawings, noting, "This says a lot about the placement of a project and steepness of the terrain" (ID5). Others prefer to combine 2D plans and photos.

Figure 7. Example of a digital 3D model (above) used as a base for a hand drawing/illustration (below). Source: Bar Bakke. (Used with permission)

Figure 8. Example of a digital aerial photo (above) used as a base for a hand drawing/illustration (below). Source: Bar Bakke. (Used with permission)

As the early stages draw to a close, some professionals begin to use renderings or simpler 3D perspectives generated through software such as Lumion. VR has also been utilized by two informants to communicate their ideas, with one stating, "VR is a method that handles chaos well because you experience the depth of the model" (ID1).

However, two other informants expressed reservations about VR due to its time-consuming nature and the required equipment, which they found to be impractical in a busy work environment. They acknowledged the benefits of VR in conveying scale and spatial awareness but were constrained by its lack of efficiency. One informant explained, "There's a lot of equipment to bring, and if there's technical problems as well, it just takes too much time" (ID8).

Conversely, after the solution has been established, the focus shifts towards informing various stakeholders, including clients, other disciplines, and builders, about the technical details of the design. One informant reflected, "As you are getting closer to the construction phase, there is less focus on these kinds of illustrations [illustrations used for selling an idea], and it becomes more important with section drawings and detailed design drawings." (ID10). At this juncture, four of the ten informants would use 3D models where every discipline can add their part (Figure 9). This collaborative approach simplifies the process of identifying conflicts and potential issues. Moreover, seven informants would work with a 3D model throughout the entire process in addition to other techniques.

Figure 9. Picture showing how professionals work live in models on large screens between the different disciplines in meetings. Source: Norconsult Norge AS, Photographer: Johnny Syversen. (Used with permission)

Thirdly, the target audience considerably influences the choice of visualization method. As one informant noted, "What you need to consider is who you are communicating with and where you are in the process. What is the purpose of what you are going to show?" (ID4).

This audience spans a wide spectrum, from clients, designers, builders, and end-users to occasionally involving municipal authorities. Interviews underscored the audience's experience and field of work, as well as the level of access to visualization materials.

For instance, one informant stated, "Most people outside the planning field don't read or use 2D plans" (ID3). Those who do use 2D plans often supplement them with inspiration photos and sections to enhance clarity and comprehension (Figure 10A and 10B).

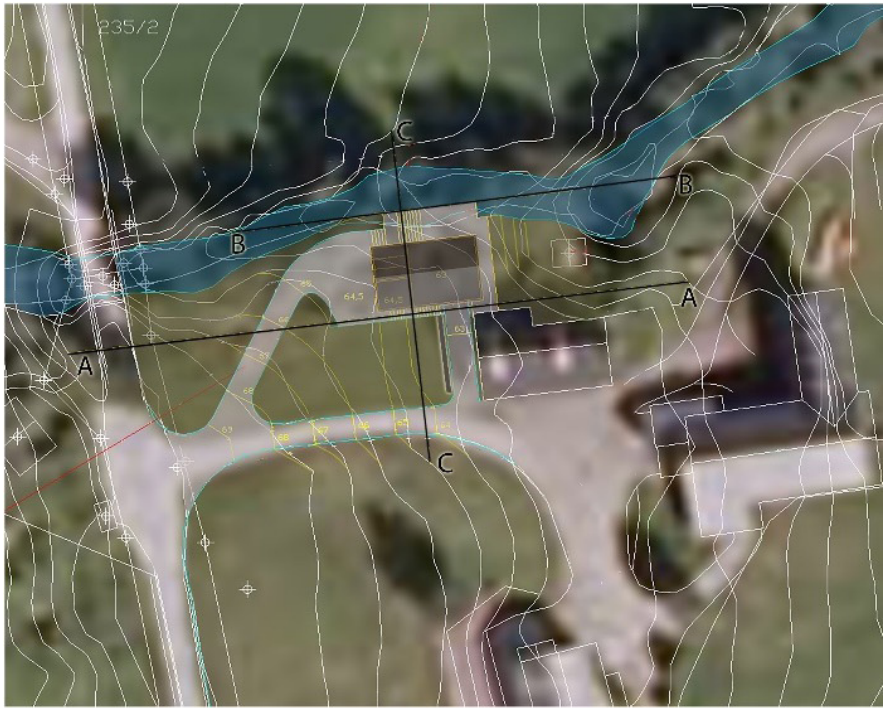


Figure 10A. Example of a 2D plan. Source: Multiconsult Norge AS. (Used with permission)

Figure 10B. Example of a section, supplementing Figure 10A. Source: Multiconsult Norge AS. (Used with permission)

As technology has evolved, many professionals have begun to favor 3D models over 2D plans, although the latter can still be useful. One informant noted, "When in the early stages, it is important to Plan- og Bygningsetaten to be able to see the borders and boundaries" (ID9).

Regarding access, three out of ten participants cautioned against granting clients and users unrestricted access to interactive models. One informant shared, "I rarely send something one can move around in. A 3D model has to look good from all angles if they are to move around on their own, while pictures show what you want to show" (ID6). Another added, "You have to be conscious of what you show, by for example not giving a client full access to an entire model. You don't always have the time to be exact with every detail and some things can be inaccurate" (ID8).

Notably, the level of realism in visualizations is closely tied to both the phase of the project and the target audience. Professionals emphasized that the degree of realism should mirror the depth of the discussion. In the early stages, visualizations often stay schematic to encourage focus on the broad design concepts rather than minute details. As one informant pointed out, "The level of realism is proportional to the level of the discussion" (ID3).

To facilitate communication with clients and users and to maintain focus on the overall design, five informants would employ illustrations with a sketch-like appearance or a toned-down 3D model. One informant observed, "A sketch communicates better that the project is not done being processed" (ID10). Another echoed this sentiment, stating, "Hand drawings make projects look less done and keep the clients from discussing the wrong things" (ID9).

As the project evolves, visualizations tend to become more detailed, aiding in informed discussions about implementation specifics. For instance, one informant mentioned that in impact assessments, visualizations must be as realistic as possible. They often use manipulated photos to demonstrate potential impact (Figure 11A and 11B). These images are also beneficial when communicating with stakeholders such as landowners, authorities, and users.

However, one informant reported using realistic visualizations throughout the entire process with both clients and users, finding this approach the most straightforward for people to comprehend. Yet, they also cautioned about the careful use of realism, especially towards end-users and the municipality.

Figure 11A. Photo of existing water levels. Source: Multiconsult Norge AS. (Used with permission)

Figure 11B. Manipulated photo showing the effect of raising the water levels. Source: Multiconsult Norge AS. (Used with permission)

2 SUSTAINABLE LANDSCAPE DESIGN AND COMMUNICATION

SUSTAINABILITY

When exploring the concept of sustainable landscape design and its communication through visualization, the interviews revealed that professionals offered varied perspectives, shaped by project scale and interdisciplinary collaboration. While some interview subjects did show a challenge in precisely defining sustainability, others emphasized its contextual nature across different project scales. One informant explained, "What sustainable landscape design means to someone depends on the scale of the project" (ID7).

Some explained that for large-scale landscape projects, sustainability entails minimizing interventions in nature while prioritizing the preservation of valuable ecosystems. Strategies include minimizing footprint and impact, such as avoiding sensitive areas like marshes and opting for vertical development over horizontal expansion. Furthermore, interventions should be reversed or restored if they're not permanent.

When questioned about sustainability, those working on smaller-scale projects highlighted the importance of biodiversity. Within the environmental dimension of sustainability, several aspects were brought up, including water management, reducing the number of impermeable surfaces, and implementing nature-based solutions. Moreover, universal and inclusive design emerged as a key consideration within the social dimension of sustainability.

Interdisciplinary collaboration was underscored as a critical element in achieving a sustainable project. As one informant stated, "You can be as talented as you want, but you need to collaborate with other disciplines to achieve sustainability" (ID8). A prime example of this collaboration is working with the water infrastructure department to devise efficient water management solutions, for example creating natural basins that can handle stormwater and floods.

Regardless of the projects' scale, an agreement surfaced on the pivotal role of material choice in sustainable design. This included an emphasis on using recycled materials and considering the lifecycle of these materials. An informant noted, "The use of materials is also an aspect and is about reuse and choosing materials with a smaller carbon footprint" (ID2).

VISUALIZING SUSTAINABILITY

Integrating sustainability into visual presentations mainly aims to support and promote sustainable ideas. This generally occurs at the beginning of a project to facilitate informed decision-making. However, the visualization methods applied may differ based on whether sustainability is the primary focus. The project's scale also influences the choice of techniques.

Most participants hadn't previously considered visualizing sustainability specifically. Three informants noted that sustainability is inherent in their work as landscape architects, and therefore their visualization methods inherently depict sustainability. One informant shared, "Sustainability is an ambition in everything" (ID4). Another added, "If you meet a client who doesn't want to think about sustainability aspects, you have to work with visualizations and get through to them so the spaces we create make the world a better place" (ID2).

Two other informants noted that visualizing sustainability is still an emerging concept, with no specific tools developed for this purpose yet. Therefore, they often employ regular techniques, supplemented with diagrams.

Four out of ten informants found diagrams useful for demonstrating sustainability. "The simple diagrams are what best communicate the intention of the project" (ID7). Diagrams can highlight key aspects, such as biodiversity or water management solutions. Some have even devised their unique approach to represent sustainability to help attain sustainability objectives within a project (Figure 12).

Photos from site inspections are crucial in large-scale projects to communicate existing natural values like biodiversity (Figure 13). These photos can later be manipulated to illustrate the potential impact of interventions. An informant explained, "The client might not be aware of the values in the area they want to develop." (ID5).

Some of the informants who generally were negative towards renderings, found them useful in a sustainable context. One informant remarked, "One positive thing about renderings is that they are pretty good at showing seasonal variations and different weather conditions when it comes to climate variations" (ID3). Renderings can narrate the story of potential sustainable solutions, making the issues and corresponding solutions feel more real (Figure 14), as an informant stated, "As soon as you can see it, it becomes tangible" (ID5). Realism can be beneficial in this context, especially when the objective is both to showcase sustainability and sell the idea.

3D models were also highlighted as effective tools for demonstrating climate change implications, such as rising water levels. The informants would often combine these models with diagrams, photos, and renderings. Combining an illustration based on a 3D model, or a rendering, with text has for example been utilized to showcase the CO2 emission in a project, and how long it would take a project to become carbon positive depending on the design (Figure 15).

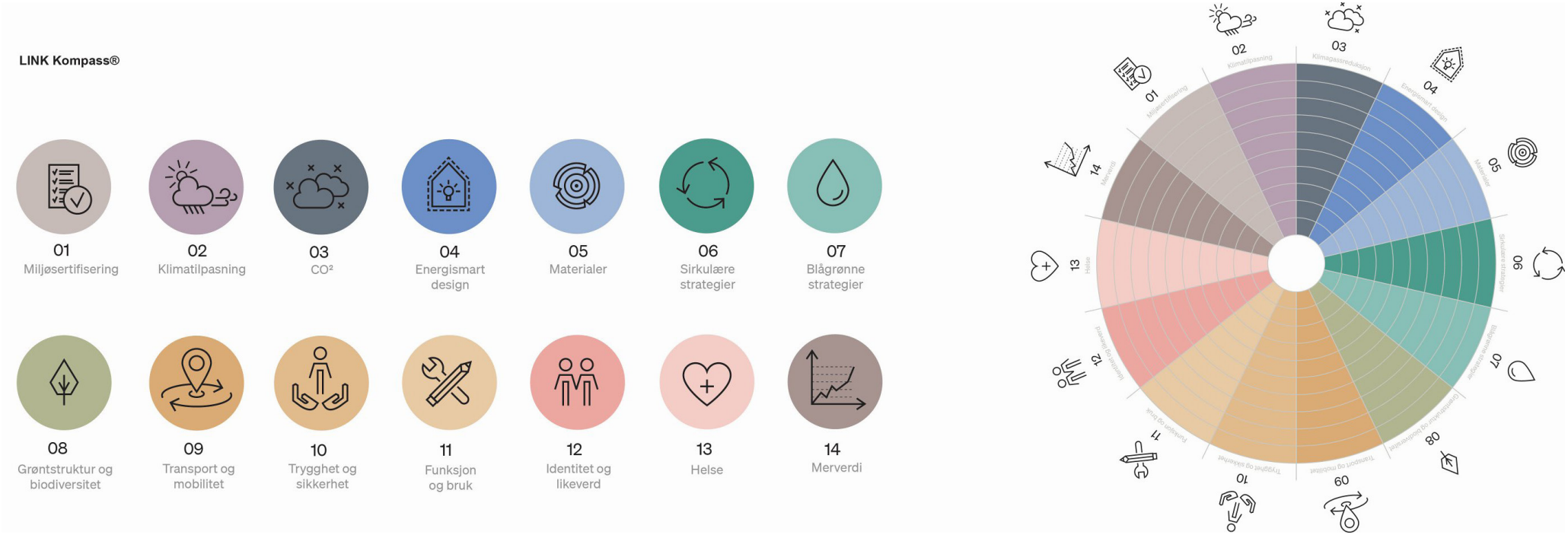


Figure 12. LINK Kompass® sustainability compass utilized to show the sustainability profile of a project. Source: LINK Arkitektur. (Used with permission)




Figure 13. Photos from site inspections. Source: Multiconsult Norge AS. (Used with permission)

Figure 14. A rendering combined with text showing nature restoration both above and below the water surface. Source: Norconsult Norge AS and Urbaniq, Buffersonen på Grønlikaia. (Used with permission)

Figure 15. Two different design scenarios and the corresponding number of years until carbon positive. Source: Norconsult Norge AS, Klimapositive byrom i Horten kommune. (Used with permission)

Geographic Information Systems (GIS) were another method employed to visualize sustainability. Participants would utilize GIS analyses and maps to present existing conditions and integrate various data. One informant noted, "The core of sustainability is to take elements like threatened species, paths and animal paths, filter them out, and see what you have left to work with" (ID8).

In the visualization process, they often incorporated a combination of 2D and 3D elements, providing a comprehensive and layered understanding of the sustainable elements within the project.

Material palettes, featuring pictures and descriptions of materials, were used to communicate the sustainability of materials. This approach offers a clear and straightforward way to showcase the material choices and their sustainable attributes.

3 ARTIFICIAL INTELLIGENCE IN LANDSCAPE ARCHITECTURE

Artificial Intelligence (AI) represents a relatively new and disruptive technology in the field of landscape architecture. The thoughts and experiences of informants with this emerging tool were explored in the interviews.

Seven out of ten informants had experimented with AI in their work. However, all ten agreed that the tool has not yet evolved enough to become an integral part of the landscape profession. One informant stated, "You have to be good at writing prompts to get what you want, and it's rare to get what you need" (ID6). AI's occasional failure to accurately understand or interpret prompts can lead to strange and inconsistent results. For instance, one informant observed, "AI doesn't understand the word 'meadow', probably because its references mostly consist of cut grass or lawns" (ID1).

Despite its current limitations, the interviews revealed that AI can presently serve as a source of inspiration and a tool for photo manipulation. Some informants speculated that AI could become more valuable in the future. "AI might take over the more quantifiable projects that have many parameters," one participant commented (ID7).

However, they expressed doubts that AI would entirely supplant human involvement or decision-making in their field. One participant noted, "It might revolutionize some tasks and make some of us more efficient, while others might become less efficient" (ID1). Parametric design, which some participants occasionally use, was cited as a precursor to AI.

CHAPTER 4

DISCUSSION

This study has provided insight into how visualization is used as a means of communication, both in general and in a sustainable context, the definition of sustainable landscape design, and the current role of AI in the landscape profession. This chapter discusses these results, and the limitations of the research process centered around the main research question: "How is visualization being utilized to communicate sustainable landscape design?"

THE USE OF VISUALIZATION

The results indicate that choosing the appropriate visualization techniques for communication necessitates an exploration of three questions: the underlying purpose of the visualization, its application stage in the design process, and the intended audience. These considerations align with insights extracted from both the literature and the interviews, for example, the significance of factors such as Reality and Interactivity, as articulated by Lovett et al. (2015) and echoed by the interviewees. Organizing these attributes into a systematic framework can aid in the strategic selection of visualization methods tailored to specific contexts.

There are multiple approaches to systematize the findings of this study, of which two examples will be provided. The first approach involves classifying visualization techniques based on attributes in one table (Table 2) while having a secondary table outlining when the different attributes are suitable (Table 3). The second approach proposes a table illustrating the appropriate times to employ different visualization techniques (Table 4).

Table 2. Different visualization techniques and their attributes.

	REALITY			DYNAMICITY		INTERACTIVITY		IMMERSION		DIMENSIONALITY		
	Abstract	Semi Real	Real	Static	Dynamic	Still	Interactive	Non-Immersive	Immersive	2D	3D	4D
2D plan	x	x		x		x		x		x		
3D model		x		x			x	x			x	
AR		x	x	x			x		x		x	x
Diagram	x			x		x		x		x		
GIS	x	x		x		x		x		x		
Hand drawings	x	x		x		x		x		x	x	
Photograph			x	x		x		x		x		
Rendering			x	x		x		x			x	
Section		x	x	x		x		x		x		
VR		x			x		x		x			x

Table 3. Preferred attributes of visualization techniques when communicating landscape design projects in general.

	Client	Disciplines	End-users	Public
Early stage, persuade	▪ Abstract or Semi real ▪ Static ▪ Still ▪ 2D or 3D		▪ Abstract or Semi real ▪ Static ▪ Still ▪ 3D	
Early stage, inform	▪ Semi real or Real ▪ Static or Dynamic ▪ Still ▪ Non-immersive or Immersive ▪ 2D, 3D or 4D	▪ Abstract or Semi real ▪ Static ▪ Still or Interactive ▪ 2D or 3D	▪ Abstract or Semi real ▪ Static or Dynamic ▪ Still ▪ Immersive ▪ 3D	
Late stage, inform	▪ Semi real or Real ▪ Static ▪ Still ▪ 2D, 3D or 4D	▪ Semi real ▪ Static ▪ Interactive ▪ 3D or 4D	▪ Semi real or Real ▪ Static ▪ Still ▪ 2D or 3D	▪ Real ▪ Static or Dynamic ▪ Still ▪ 3D

Table 4. Effective visualization techniques when communicating landscape design projects in general. Sorted by priority.

	Client	Disciplines	End-users	Public
Early stage, persuade	▪ Hand drawings/sketch-like illustrations ▪ 3D model ▪ Manipulated photos ▪ Photos ▪ 2D plan ▪ Sections		▪ Hand drawings/sketch-like illustrations	
Early stage, inform		▪ 3D model ▪ 2D plan ▪ Sections ▪ Hand drawings/ sketch-like illustrations	▪ Hand drawings/sketch-like illustrations ▪ Manipulated photos	
Late stage, inform	▪ Renderings ▪ 3D model ▪ 2D plan	▪ 3D model ▪ 2D plan ▪ Sections	▪ Renderings ▪ 2D plan	▪ Renderings ▪ Manipulated photos ▪ Photos ▪ 2D plan

The three questions, and thus factors, identified from the results can be reduced to two by combining the process stage and purpose. As the interviews indicated, there is a strong correlation between these elements, with the purpose of persuasion typically occurring in the early stages and the purpose of informing in the later stages. However, informing can also occur in the early stages, thus creating a third category when these factors are combined.

Simultaneously, it should be noted that not all stages and purposes apply to every audience, or the results may have been unclear on certain aspects. For example, the need to persuade other disciplines is usually not necessary, unlike with clients. Consequently, these tables do not encompass alternatives for all potential scenarios.

Additionally, a single technique can have different attributes depending on the execution. For instance, a section can be Semi real or Real depending on the elements used to illustrate, or how a hand drawing can be Abstract or Semi real depending on the drawing style.

Understanding why and how landscape architects and designers use visualization to communicate is a step in the direction of how to communicate sustainable landscape design, as the findings imply not much content exists on visualizing sustainability specifically.

Meanwhile, an example of how it can be important or necessary to consider visualizing sustainability separately from visualizing in general is the informants' thoughts on renderings. Many were negative towards the use of renderings in an overall context, but positive when in a sustainable context. The high level of realism can be damaging to the process of the overall design, but positively affect the target audience to think about sustainability in a project, as seen by Lovett et al. (2015) and Sheppard (2012) as well.

LANDSCAPE SUSTAINABILITY

The literature suggests that the definition of sustainable landscape design is not set and that there exist different versions with similar aspects and wording. The interviews support this in addition to bringing in the aspect of the scale of a project, which the literature does not. Moreover, a commonality between the literature and interviews is the main focus on the environmental aspect of sustainability, with the social aspect a distant second, and almost no mention of economy.

The absence of clear definitions for sustainable landscape design presents a significant challenge, as expressed by interviewees and supported by existing literature. The differences and inconsistencies between the available academic knowledge and the insights from interviews highlight the importance of, and missing, thorough understanding of the key elements of sustainable landscape design. Drawing on sources like Loehrlein's (2021) research, which discusses critical aspects such as carbon footprint, the use of different materials, and water management, is essential in addressing this challenge. A set definition of sustainable landscape design, followed by guidelines on how to create it would ease if not solve this issue.

Meanwhile, it's important to note that the results from the literature and the interviews are different because they have different angles. On one hand, the literature is academic and showcases how scholars think, while the interviews are about the profession itself and how it is being practiced. This could, for example, explain why the informants speak of sustainable landscape design in terms of measures and practices, while the literature is more theoretical with its definition.

VISUALIZING SUSTAINABILITY

The scarcity of literature focusing on visualizing sustainable landscape design highlights the reliance on insights obtained from interviews to guide this analysis. The lack of established visualization tools specifically designed for sustainability may come from the assumption that such considerations are inherent in the professional identity of landscape architects. However, this assumption may not universally hold true, calling for the development of specialized tools to seamlessly integrate sustainability principles into design processes while maintaining the essential role of landscape architects. The potential of artificial intelligence (AI) as a tool in this regard merits deeper investigation, as current testing indicates its early but promising contributions to the field.

Subsequently, examining various existing visualization techniques for visualizing sustainability reveals unique strengths and limitations with each approach. Diagrams prove effective in simplifying intricate concepts, serving as valuable tools in bridging the understanding gap among professionals, clients, and the general public. Similarly, manipulated photos can illustrate alternative scenarios, although they often require more context for proper interpretation, which applies to diagrams as well. Renderings and 3D models, distinguished by their immersive nature, elicit emotional responses, and facilitate a more detailed understanding of sustainability considerations within design contexts. Additionally, the combination of 2D and 3D visualization tools, as favored by professionals, offers a comprehensive approach to grasping the various aspects of sustainable landscape design.

Utilizing the systemization from visualization techniques in general but angling it towards sustainability can create similar tables to those presented above. Excluding attributes as a factor creates a table showing which visualization techniques according to the interviews and literature are effective when visualizing sustainable landscape design at different times with different audiences and purposes (Table 5).

The purposes listed in this table are based on the interview results. Yet, in the context of sustainability, the purpose can also involve the aspect of sustainability one aims to illustrate. As the study mainly yielded results concerning the environmental aspect, the table does not fully represent the entirety of sustainability.

As the table illustrates, several tools are effective with each audience. However, both the literature and interviews agree that the best results are achieved by using a combination of techniques. This is because a single technique cannot encompass every aspect of a project or sustainability.

This table, and the ones above, are by no means complete and would need more data to become more accurate, but they are a start in what could seem like the right direction.

For example, comparing the general communication techniques and those used specifically for communicating sustainability reveals some similarities and differences (Table 6). There is a clear contrast between choice of techniques during the early stages, while there are more similarities in the later stage. It becomes especially noticeable that renderings are utilized more frequently in a sustainability context than in general.

Table 5. Effective visualization techniques when communicating sustainable landscape design. Sorted by priority.

	Client	Disciplines	End-users	Public
Early stage, persuade	▪ Renderings ▪ Diagrams ▪ Manipulated photos ▪ Photos ▪ Sections ▪ GIS		▪ Renderings ▪ Diagrams ▪ Manipulated photos ▪ Photos	
Early stage, inform	▪ Renderings ▪ Diagrams ▪ Manipulated photos ▪ Sections ▪ GIS	▪ 3D model ▪ GIS ▪ Sections	▪ Renderings ▪ Diagrams ▪ Manipulated photos	
Late stage, inform	▪ Renderings ▪ 3D model ▪ 2D plan	▪ 3D model ▪ GIS ▪ Sections	▪ Renderings ▪ Diagrams ▪ Manipulated photos	▪ Renderings ▪ Diagrams ▪ Manipulated photos

Table 6. Effective visualization techniques when communicating sustainable landscape design compared to in general. Sorted by priority.

	Client		Disciplines		End-users		Public	
	Sustainability	**General**	**Sustainability**	**General**	**Sustainability**	**General**	**Sustainability**	**General**
Early stage, persuade	▪ Renderings ▪ Diagrams ▪ Manipulated photos ▪ Photos ▪ Sections ▪ GIS	▪ Hand drawings/ sketch- like illustrations ▪ 3D model ▪ Manipulated photos ▪ Photos ▪ 2D plan ▪ Sections			▪ Renderings ▪ Diagrams ▪ Manipulated photos ▪ Photos	▪ Hand drawings/ sketch-like illustrations		
Early stage, inform	▪ Renderings ▪ Diagrams ▪ Manipulated photos ▪ Sections ▪ GIS		▪ 3D model ▪ GIS ▪ Sections	▪ 3D model ▪ 2D plan ▪ Sections ▪ Hand drawings/ sketch-like illustrations	▪ Renderings ▪ Diagrams ▪ Manipulated photos	▪ Hand drawings/ sketch-like illustrations ▪ Manipulated photos		
Late stage, inform	▪ Renderings ▪ 3D model ▪ 2D plan	▪ Renderings ▪ 3D model ▪ 2D plan	▪ 3D model ▪ GIS ▪ Sections	▪ 3D model ▪ 2D plan ▪ Sections	▪ Renderings ▪ Diagrams ▪ Manipulated photos	▪ Renderings ▪ 2D plan	▪ Renderings ▪ Diagrams ▪ Manipulated photos	▪ Renderings ▪ Manipulated photos ▪ Photos ▪ 2D plan

ARTIFICIAL INTELLIGENCE

Artificial Intelligence is one of the newest of the technologies that are available and can be utilized in the field of landscape architecture. As such it was interesting to see if it's being used in the field today and if so, how it is being used.

The articles and informants that had tested AI agreed on its current usability of generating or editing photos for different scenarios quickly and being a source of inspiration. Furthermore, it became clear that AI at its current level is not good enough to be an essential tool.

AI was researched and discussed in this study because of its current disruptiveness of many creative professions and its ability to visualize. As it is a tool not yet integrated, its current and potential use could prove interesting when researched in later years. It is recommended that AI is continually studied and tested within the field of landscape architecture as it seems like it will be important for this profession to keep up with the times.

When studying this, it will be important to understand and establish guidelines for both how to "prompt" the AI tool to yield the best results, and to create tools and methodologies for verifying the results from the AI in a consistent manner, to ensure that it is in line with requirements and expectations.

LIMITATIONS

This thesis provides a general overview of the topic of visualizing sustainable landscape design practices and does not include specific types of visualization due to the various ways they can be employed. Instead, it focuses on techniques and processes associated with sustainability as outlined in literature and gathered from interviews.

Additionally, this study did not investigate the potential presence of strategies, laws, and guidelines, as its focus was not on their existence but rather on investigating how the landscape design profession responds to and manages the visualization of sustainability. The answers from the interviews also seem to show that there are no universal laws, specifications or guidelines on the matter as the answers were so different, and it seemed like people have just figured out what works for them. Just the fact that some believe it is a landscape architect's job to convince the clients to consider sustainability shows that it is not naturally a part of projects. Clear strategies, guidelines, and possibly even legislation could greatly benefit the profession and the advancement of sustainable landscape design, ensuring that sustainability considerations are followed without confusion.

The synthesis of findings from both the literature review and interviews sheds light on the complex relationships between visualization techniques and sustainable landscape design practices, highlighting the challenges and opportunities associated with visual communication in this field.

CHAPTER 5

CONCLUSION

The last chapter summarizes the thesis by answering the research question.

CONCLUSION

This thesis has explored how visualization is being utilized to communicate sustainable landscape design.

First, it was found that a diverse range of visualization techniques are used to facilitate effective communication with different stakeholders and that one must consider the purpose, the process stage, and the target audience when choosing a technique. This was supported by both the interviews and the existing literature.

Secondly, the results of both the literature review and the interviews suggest a missing definition of sustainable landscape design, and therefore difficulty in specifying visualization of it. This should be investigated further, and an official definition with associated principles and practices should be created.

However, some techniques were highlighted as useful when visualizing sustainable landscape design in certain sustainable contexts by the informants. While there are no tools specifically made for this purpose.

Consequently, this study identified certain tools used for visualizing sustainability in the landscape profession today. These include renderings, diagrams, 3D models, GIS, photos, and manipulated photos.

Finally, the missing literature on visualizing sustainability calls for further studies on the topic, and on all the aspects of sustainability, not just the environmental side.

REFERENCES

A

Adeel, A., Notteboom, B., Yasar, A., Scheerlinck, K., & Stevens, J. (2021). Sustainable Streetscape and Built Environment Designs around BRT Stations: A Stated Choice Experiment Using 3D Visualizations. *Sustainability, 13*(12), 6594. https://www.mdpi.com/2071-1050/13/12/6594

Architizer, & Chaos. (2023). *The Future of Architectural Visualization.* https://blog.enscape3d.com/hubfs/2023 Downloadables/Future-of-Architectural-Visualization-Report-2023.pdf

Atwa, S. M. H., Ibrahim, M. G., Saleh, A. M., & Murata, R. (2019). Development of sustainable landscape design guidelines for a green business park using virtual reality. *Sustainable Cities and Society, 48,* 101543. https://doi.org/10.1016/j.scs.2019.101543

B

Bishop, I. D., & Lange, E. (2005). *Visualization in Landscape and Environmental Planning: Technology and Applications.* Taylor & Francis.

Brundtland, G. H., & Dahl, O. (1987). *Vår felles framtid*. Tiden norsk forlag.

Braun, V., & Clarke, V. (n.d.). *Understanding TA.* Retrieved May 13 2024 from https://www.thematicanalysis.net/understanding-ta/

E

Eilola, S., Jaalama, K., Kangassalo, P., Nummi, P., Staffans, A., & Fagerholm, N. (2023). 3D visualisations for communicative urban and landscape planning: What systematic mapping of academic literature can tell us of their potential? *Landscape and urban planning, 234,* 104716. https://doi.org/10.1016/j.landurbplan.2023.104716

Ervin, S. M. (2020). A brief history and tentative taxonomy of digital landscape architecture [Article]. *Journal of Digital Landscape Architecture, 2020*(5), 2-11. https://doi.org/10.14627/537690001

Evensen, K. H., Nordh, H., Hassan, R., & Fyhri, A. (2021). Testing the Effect of Hedge Height on Perceived Safety—A Landscape Design Intervention. *Sustainability, 13*(9), 5063. https://www.mdpi.com/2071-1050/13/9/5063

F

Fernberg, P., George, B. H., & Chamberlain, B. (2023). Producing 2D Asset Libraries with AI-powered Image Generators [Article]. *Journal of Digital Landscape Architecture, 2023*(8), 186-194. https://doi.org/10.14627/537740020

FN-Sambandet. (2024, 1. February). *FNs bærekraftsmål*. Retrieved April 25 2024 from https://fn.no/om-fn/fns-baerekraftsmaal

H

Holter, K., & Bjørgen, S. (2022). *Klimasmart landskapsarkitektur : strategier for redusert klimafotavtrykk i urbane landskapsprosjekter* [Master thesis, Norwegian University of Life Sciences, Ås]. https://hdl.handle.net/11250/3012316

I

IFLA. (2019). IFLA DECLARES A CLIMATE AND BIODIVERSITY EMERGENCY. https://static1.squarespace.com/static/5d16e42a3ae2ee0001a08d34/t/5d7fa3ebf7530f4d296dc970/1568646124158/

IFLA. (2021a). *IFLA Climate Action Commitment.* https://static1.squarespace.com/static/5d16e42a3ae2ee0001a08d34/t/6177ad41ab5a092753a8a64a/1635233089919/2021+IFLA+Climate+Action+Commitment.pdf

IFLA. (2021b). A Landscape Architecture Guide to the 17 Sustainable Development Goals. https://www.iflaeurope.eu/assets/docs/SDG%2BFINAL.pdf

IPCC. (2023). *Sections. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_LongerReport.pdf

L

Landscape Institute. (2021). Landscape for 2030: How landscape practice can respond to the climate crisis. https://www.aila.org.au/common/Uploaded%20files/_AILA/Resource%20library/Climate%20Positive%20Design/12510-LANDSCAPE-2030.pdf

Lange, E. (2011). 99 volumes later: We can visualise. Now what? *Landscape and urban planning, 100*(4), 403-406. https://doi.org/10.1016/j.landurbplan.2011.02.016

Li, M., & Amoroso, N. (2023). An Early Look at Applications for Artificial Intelligence Visualization Software in Landscape Architecture [Article]. *Journal of Digital Landscape Architecture, 2023*(8), 543-553. https://doi.org/10.14627/537740057

Loehrlein, M. (2021). *Sustainable landscaping : principles and practices* (Second edition. ed.). CRC Press.

Lovett, A., Appleton, K., Warren-Kretzschmar, B., & Von Haaren, C. (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/10.1016/j.landurbplan.2015.02.021

M

Mertens, E. (2010). *Visualizing Landscape Architecture: Functions, Concepts, Strategies* (1. Aufl. ed.). Basel/Berlin/Boston: Birkhäuser.

Metze, T. (2020). Visualization in environmental policy and planning: a systematic review and research agenda. *Journal of Environmental Policy & Planning, 22*(5), 745-760. https://doi.org/10.1080/1523908X.2020.1798751

Meyer, E. K. (2008). Sustaining beauty. The performance of appearance: A manifesto in three parts [Article]. *Journal of Landscape Architecture, 3*(1), 6-23. https://doi.org/10.1080/18626033.2008.9723392

Musacchio, L. R. (2009). The scientific basis for the design of landscape sustainability: A conceptual framework for translational landscape research and practice of designed landscapes and the six Es of landscape sustainability [Article]. *Landscape Ecology, 24*(8), 993-1013. https://doi.org/10.1007/s10980-009-9396-y

N

Nasr-Azadani, E., Wardrop, D., & Brooks, R. (2022). Is the rapid development of visualization techniques enhancing the quality of public participation in natural resource policy and management? A systematic review. *Landscape and urban planning, 228,* 104586. https://doi.org/10.1016/j.landurbplan.2022.104586

Nicholson-Cole, S. A. (2005). Representing climate change futures: a critique on the use of images for visual communication. *Computers, Environment and Urban Systems, 29*(3), 255-273. https://doi.org/10.1016/j.compenvurbsys.2004.05.002

Norwegian Institute for Nature Research (NINA). (n.d.). *Bærekraftige landskap.* Norwegian Institute for Nature Research. Retrieved April 12 2024 from https://www.nina.no/B%C3%A6rekraftig-samfunn/B%C3%A6rekraftige-landskap

P

Pettit, C. J., Raymond, C. M., Bryan, B. A., & Lewis, H. (2011). Identifying strengths and weaknesses of landscape visualisation for effective communication of future alternatives. *Landscape and urban planning, 100*(3), 231-241. https://doi.org/10.1016/j.landurbplan.2011.01.001

Portman, M. E., Natapov, A., & Fisher-Gewirtzman, D. (2015). To go where no man has gone before: Virtual reality in architecture, landscape architecture and environmental planning. *Computers, Environment and Urban Systems, 54,* 376-384. https://doi.org/10.1016/j.compenvurbsys.2015.05.001

R

Repton, H., & Loudon, J. C. (1840). *The landscape gardening and landscape architecture of the late Humphry Repton, esq.* London: Printed for the Editor. https://books.google.no/books?id=wmpTAAAAMAAJ&printsec=frontcover&hl=n#v=onepage&q&f=fal

S

Sheppard, S. R. J. (2005). Landscape visualisation and climate change: The potential for influencing perceptions and behaviour. *Environmental Science and Policy, 8*(6), 637-654. https://doi.org/10.1016/j.envsci.2005.08.002

Sheppard, S. R. J. (2012). Visualizing climate change : a guide to visual communication of climate change and developing local solutions. Routledge Earthscan.

Sheppard, S., Shaw, A., Flanders, D., & Burch, S. (2008, 01/01). *Can Visualisation Save the World? - Lessons for Landscape Architects from Visualizing Local Climate Change.* Conference Proceedings, Digital Design in Landscape Architecture, 9th International Conf, https://www.researchgate.net/publication/255570495_Can_Visualisation_Save_the_World_-_Lessons_for_Landscape_Architects_from_Visualizing_Local_Climate_Change

Støstad, M. N., Mon, S. T., & Solvang, R. (2024, January 6). Norge i rødt, hvitt og grått. *NRK.* https://www.nrk.no/dokumentar/xl/nrk-avslorer_-44.000-inngrep-i-norsk-natur-pa-fem-ar-1.16573560

T

The American Society of Landscape Architects (ASLA). (n.d.). *What are sustainable landscapes?* The American Society of Landscape Architects. Retrieved April 12 2024 from https://www.asla.org/sustainablelandscapes/about.html

Tress, B., & Tress, G. (2003). Scenario visualisation for participatory landscape planning—a study from Denmark. *Landscape and urban planning, 64*(3), 161-178. https://doi.org/10.1016/S0169-2046(02)00219-0

U

United Nations. (2023, August 8). *What is Sustainable Development.* United Nations. https://www.un.org/sustainabledevelopment/blog/2023/08/what-is-sustainable-development/

W

Walton, R., & Bosomworth, K. (2017). Innovative or unrealistic: reflections on the use of landscape architecture visualisations in climate change planning. *Australian Journal of Maritime & Ocean Affairs, 9*(2), 95-106. https://doi.org/10.1080/18366503.2017.1278503

Wang, S. (2021). *Application Research of Artificial Intelligence Technology in Landscape Architectural Art Design.* 2020 International Conference on Applications and Techniques in Cyber Intelligence: Applications and Techniques in Cyber Intelligence (ATCI 2020), https://link.springer.com/chapter/10.1007/978-3-030-53980-1_51

LIST OF FIGURES AND TABLES

All non-cited figures and tables are created by the author.

APPENDIX 1 - INTERVIEW GUIDE

Intervjuguide

Løs prat

Informasjon:
- Fortell om bakgrunnen og formålet med studien
- Forklar hvordan intervjuet vil bli brukt i oppgaven
- Spør om noe er uklart og om de har noen spørsmål
- Informer om notattaking

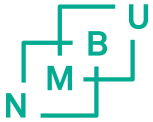
Overgangsspørsmål:
- Hvordan ville du beskrevet bærekraftig landskapsdesign?
- Hva slags erfaringer har du med bruken av visualisering i ditt arbeid?
- I hvilke stadier i prosessen bruker du visualiseringer?
- Hvilke former for visualisering bruker du?

Nøkkelspørsmål:
- Hvordan opplever du at visualiseringer bidrar til kommunikasjon av prosjektet?
- Hvilke former for visualisering opplever du at fungerer best til å kommunisere det bærekraftige i et prosjekt?
    - Hva fungerer dårlig?
- Hvordan benytter du deg av de ulike formene for visualisering? For eksempel hvordan ville du brukt VR, 3D modell, perspektivtegning etc. - interaktiv vs. Statisk visualisering
- Har du noen eksempler på prosjekter hvor visualiseringene var avgjørende i prosessen/bidro sterkt i prosessen/bidro sterkt til kommunikasjonen

Fremtid:
- Har du noen gang brukt kunstig intelligens i designprosessen?
    - Hvorfor/hvorfor ikke?
- Hvordan tror du AI kommer til å påvirke landskapsarkitekturen?

Løs diskusjon

Oppsummering:
- Er det noe du/dere vil legge til?
- Er det noen du/dere tenker jeg burde kontakte?
- Vet dere om noe relevant litteratur eller informasjon jeg burde lese?



Norges miljø- og biovitenskapelige universitet
Noregs miljø- og biovitskapelege universitet
Norwegian University of Life Sciences

Postboks 5003
NO-1432 Ås
Norway