LIVING WITH WATER

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ABSTRACT

As a result of climate change, sea levels are rising, storms are becoming more intense, and droughts are becoming more frequent. However, the Dutch built environment is not yet well prepared for these changes. At the same time, people's perceptions of water and sense of place are sceptical, making it difficult to recognise and respond to the consequences of water-related problems. This research aims to fill a critical gap in understanding human perceptions of water and to develop design guidelines that enhance technical solutions and human experience in waterfront environments. This paper presents design guidelines for integrating water into urban and architectural design through a detailed analysis of case studies. Architects can create environments that foster strong emotional connections by integrating elements that respond to personal memory, community history, physical landscape features, and emotional attachment. Incorporating water into design - through sight, sound, smell, touch and taste - reinforces these connections, promoting well-being and a sense of place. Different types of water dwellings, such as floating houses and amphibious houses, offer unique interactions with water, enriching the human experience. Material choices and sustainable practices enhance these experiences, ensuring ecological balance and resilience. Ultimately, water-resilient architecture that thoughtfully engages the human senses and emotions can create vibrant, sustainable and significant urban environments in port cities through the following design guidelines.

KEYWORDS: Water, Flood Resilience, Climate Change, Human Perception, Architectural Engineering, Sustainability, Biomimicry

I. INTRODUCTION

The global impact of climate change is undeniable, and the Netherlands is no exception. Rising sea levels are one of our country's most urgent challenges (Figure 1). Figure 2 illustrates that the historical and projected sea level rise along the Dutch coast is influenced by factors such as overall global temperature increases, as outlined in the National Delta Programme 2024. Approximately 26% of the Netherlands lies below sea level (Figure 3), with 59% of the country at risk of flooding from the sea or rivers, according to the Planbureau voor de Leefomgeving (2007). These changes are also linked to shifts in the hydrological cycle, exceptional river discharge, heavy rainfall, erosion, sedimentation, and land subsidence.

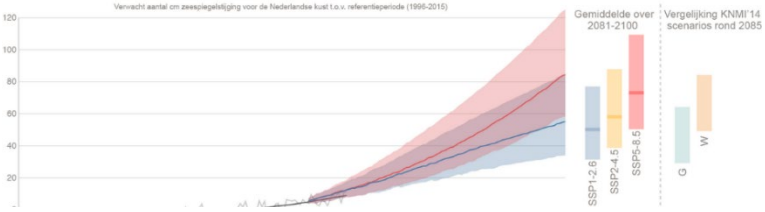


Figure 1: Sea level rise Dutch coast (Ministerie van Infrastructuur en Waterstaat, 2023).

Figure 2: Flood prone area Netherlands. (Universiteit Utrecht, 2019)

In addition to rising sea levels, climate change is increasing extreme weather events. These include periods of prolonged drought, which leads to water shortages and presents additional challenges for water management and infrastructure. Coastal settlements are among the most vulnerable areas due to the impacts of extreme climate events because they are predominantly located in vulnerable areas such as coastlines, mouths of significant rivers or low-lying areas of estuaries and deltas (Magnan et al., 2022). Rotterdam is one of those settlements in the Netherlands that belong to vulnerable areas. Rotterdam, founded around 1260 near the river Rotte, has a rich maritime history (Doolaar, 2022). A small port started at the dam, where goods were transhipped. The port provided trade, causing the city to grow. The city and harbour evolved together, resulting in a harmonious urban environment. However, during World War II, the city suffered significant damage due to the bombing (Doolaar, 2022). The post-war reconstruction introduced a new vision for Rotterdam: a clean, healthy city planned according to modernist principles. High quays with sharp lines came back. Unfortunately, this modern movement caused the city to lose its curtain connection with people and the environment (Norberg-Schulz, 1980). Over time, the port has been more associated with industrial activity and shifted westward, distancing itself from the city. Thereby the connection between the city and the harbour.

Many houses and residential areas in the Netherlands today are not sufficiently resilient to rising sea levels. Therefore, designers must focus on integrating the relationship with water into their designs to provide resilience against future water-related challenges. People's perceptions about water and the notion of a sense of place are sceptical. There has been common agreement that water is an essential element for human lives (eating, drinking) and for everything on earth, and it is summed up in the expression: "the bloodstream of the biosphere" (Ripl, 2003). About seventy per cent of the earth's surface is covered by water (Herd, 2001), which means that it is intricately involved in chemical and biological interactions. The important examples of those interactions are the hydrological and geomorphic cycles, which are critical aspects of the planet. However, there is much less discussion about the meaning of water itself, particularly how it interconnects with such dimensions of humanity as the economy, ecology, society, culture, and spirituality (Almond, 1995).

1.1 Objective

Although significant research exists on building with water, there is a gap in understanding the human perception of water. This research paper focuses on this gap. The research paper aims to create design guidelines offering a framework for designers (architects, urban planners) to conceive and implement flood-resilient buildings that contribute positively to the waterfront environment and enhance the overall urban experience, particularly from a social perspective. This will be done by comparing case studies showing different approaches and looking at specific social and technical aspects. These case studies could provide valuable insights. The design guidelines will cover aspects such as interaction with the water, closeness to the water, use of building materials, forms, urban structures, etc.

This leads to the research question: *"How can, from a human perspective, where emotions and experiences play a role, water-resilient architecture influence and enhance the perceived experience of buildings in port cities that interact with water?"*

To address the research, a literature review will be conducted from a social and technical perspective. These perspectives will be categorised into two distinct lenses. Within those lenses, different questions will be answered.

<u>Human perception lens</u>

1. Sense of Place: *What factors contribute to individuals' sense of connection and attachment to specific locations, particularly in waterfront areas?*
2. Emotional Engagement: *What emotional responses do architectural spaces evoke in individuals?*
3. Human-Water Relationship: *What cultural, historical, and socio-economic dynamics shape the relationship between people and water?*

Architectural engineering lens

4. Water typologies: *What are the different typologies of water-dwelling structures utilized in flood-prone regions, and what is the influence on human experience?*
5. Construction techniques: *What innovative construction techniques and foundation designs are suitable for building in flood-prone areas and what does this contribute to the human experience of water?*
6. Materials and water Interaction: *What materials and building technologies are best suited for withstanding the corrosive effects of water and thereby improving human interaction and experience?*
7. Case studies: *What lessons can be drawn from case studies in terms of their connection to water and adaptation to rising sea levels? Including human interaction*

II. HUMAN PERCEPTION LENS

This chapter explores the social perspective on the perception of water. First, the necessity of water in urban landscape design is explained. Then, the cultural, historical, and economic roles of water are outlined. Next, the concept of a Sense of Place is defined. Following this, the perception and emotional engagement with water is highlighted. Finally, the characteristics of water are concluded.

2.1. Water

People generally understand water through scientific perspectives. Pure water, as defined by most scientists, lacks odour, colour, or taste and boils and freezes at 100°C (212°F) and 0°C (32°F), respectively (Franks, 2000). Chemically known as H2O, water uniquely exists in liquid, solid, and vapour. In its liquid state, water has a naturally round shape and will always try to maintain this shape. As noted by the World Bank in 2014, water is one of the most basic human needs. It is a vital and elusive element necessary for the survival of the human body and all organisms. As said in the introduction, water is the bloodstream of the biosphere. Water management is essential for addressing key development challenges, impacting areas such as agriculture, education, energy, health, gender equity, and livelihoods. However, there is less discussion about the deeper meaning of water and its interconnections with various dimensions of humanity, such as economy, ecology, society, culture, and spirituality (Almond, 1995).

2.1.1 Well-being

The industry-focused urban development has a negative impact on mental health and causes stress. This necessitates a shift from a high-tech approach to nature-focused urban development (Nichols, 2020) noted that rivers significantly contribute to healing, especially with direct engagement through activities like kayaking, surfing, and canoeing. Research shows that even minimal exposure to nature reduces stress levels (Kahneman et al., 1999). People are naturally drawn to the greens of plants and blues of water, unlike the greys of concrete (Wilson, 1984). Visible blue spaces are linked to lower psychological stress (K10 scores), positively impacting urban well-being. Cities near rivers or lakes have unique characteristics and special charm (Strauss, 2002). Since the 1980s, urban planning has trended towards waterfront revitalization, emphasising blue spaces through significant planning efforts (Desfor & Jørgensen, 2004; Sandercock & Dovey, 2002).

2.1.2 Water in landscape design

Water has been a significant element of landscape design from earlier civilisations till the present day. Asakawa et al. (2003) argue that three essential components are required to create highly preferred scenery in stream corridors: water, vegetation, and a sequential experience with variety (Asakawa et al., 2003). Water has a significant general value and crucial role in ecosystems due to the positive response to water. Water will be considered to be a primary focus in design challenges (Steinwender et al.,2008). Karmanov and Hamel emphasise the necessity of water for healthy urban environments. Their definition integrates aspects of aesthetics, civilisation, and the environment (Karmanov & Hamel, 2008).

2.1.3 Water in Interior Spaces

Water has also been a prominent design element in interior spaces, prominently featured in fountains and small pools, among other applications (Mahmoud et al., 2022). The Arabs of Andalusia adorned their palaces, homes, gardens, and mosques with fountains of varying shapes and sizes, tailored to fit their specific locations. The primary purpose of these fountains was for drinking and ablution. Additionally, water served an aesthetic function, reflecting interior facades, adding dynamic movement to the empty space that may seem dismal if left with no smart and attractive treatment, and masking environmental noise. According to Feng Shui, water fountains are strategically placed within a room to enhance its aesthetic appeal while the sound of bubbling water promotes relaxation and tranquillity (Mahmoud et al., 2022).

2.2. Cultural, historical, and socio-economic dynamics of water

Historically, water has played a central role in settlement, civilisation and urbanisation, as shown along the Maas but also rivers like the Yangtze, Yellow River, Tigris, Euphrates and the Nile (Postel & Richter, 2003). However, in the urban environment, water has also been part of the Chinese gardens. In addition, water can evoke the meaning of spirituality and symbolism through histories, experiences, beliefs, rituals, and religions. "The concept of water as a 'sacred substance' is ubiquitous in religious history" (Strang, 2004), in Christianity and Islam in particular (Burmil et al., 1999; Gesler, 1996). Water forms part of essential rituals involving birth, marriage or death. For example, sacred bathing in the Ganges in India (Postel & Richter, 2003). Water also influences political power and social cooperation, especially in conflict situations (Kley & Reijerkerk, 2009). The meaning of water goes beyond scientific utility to embrace historical, economic, social, cultural, political and spiritual dimensions. A major interest here is the significance of water and how water can merge with the concept of a sense of place within a selected research site. According to Syme, Porter, Goeft and Kington (2008), "water gives a place a distinct setting and identity and features prominently in the sense of place". Yet, there has been much less discussion of what water means to people, how it connects with people's sense of place, and what that might mean for the way people interact with their surroundings.

2.3. Sense of place

In literature, the term 'place' refers to a specific geographical area or region, representing an objective concept (Kovács/Musterd, 2013). Low and Altman (1992) defined place as "space that has been given meaning through personal, group, and cultural processes". However, it does not mean that every space is a place. According to Tuan (1977), space becomes a place when people express or perceive a value in it, gained through their experience; it incorporates physical space and connects with people and societies. For example, people have experiences, memories, and feelings about a place that creates social and cultural expression. The elements of place are thus "physical attributes, activities, and conceptions" (Canter, 1977). The term place, as opposed to space, expresses a strong, effective bond between a person and a particular setting (Sime, 1986). A place is a particular space which is covered with meanings and values by the users. 'Place Attachment', 'Place Identity' and 'Sense of Place' are some concepts that could describe the quality of people's relationships with a place.

The term 'Sense of Place' emerged in architectural and urban theories during the 1960s and 1970s, influenced by scholars such as Christian Norberg-Schulz, Kevin Lynch, Edward Relph, and many others. They defined the definition from different perspectives. The definition used for this paper matches the definition of Stedman (2002) and Williams and Stewart (1998). They agreed that that sense of place is the collection of symbolic meanings, beliefs, values, feelings, attachments, and satisfactions involving a particular individual or group setting. Galliano and Loeffler (1999, p. 2), likewise, believed that this term has four essential elements as described by Ryden (1993): "personal memory, community history, physical landscape appearance, and emotional attachment".

Personal memory refers to the individual experiences and recollections associated with a specific place. These personal memories shape our perception of a place and influence our sense of connection. Therefore, it is important to consider who the user is and their specific activities. Community history pertains to the collective history of a community or neighbourhood. It encompasses historical events, traditions, stories, and cultural significance associated with a place. When designing, it is crucial to integrate with this neighbourhood's history. Physical landscape appearance refers to the visual aspects of a place, including its landscape and architecture. The physical features of a place affect the overall feeling of it. Therefore, it is essential to incorporate these aspects into a design Ryden (1993). Emotional attachment is the deeper sense of connection experienced with a place. This paper will explore the topic further as it contributes to the engagement with a specific place.

The term 'sense of place' is strongly linked to placemaking, which is understood as reshaping space to make it more attractive and usable and generate a sense of place Ryden (1993).

2.4. Perception

The term “perception” originates from the Latin word "Perceptio," which encompasses the notions of feeling, understanding, and grasping. Amos Rapoport (1977) posits that perception is fundamentally awareness through the senses. Perception is the means by which humans engage with their environment. Individuals cannot navigate life or maintain their presence without recognising the elements of their surroundings. The significance of perception lies in its role in guiding human behaviour (Soliman, 2013).

2.4.1 Perception through Senses

Human perception operates through five primary senses: sight, hearing, smell, touch, and taste Spence (2020). Yet, conventional architectural practices have predominantly favoured visual aesthetics, neglecting the importance of other sensory inputs. This oversight has contributed to various societal issues, ranging from sick-building syndrome (SBS) to seasonal affective disorder (SAD). Finnish architect Plasma noted this bias towards visual design in architecture, highlighting the need for a shift towards a more multisensory approach, combining sensory perceptions Spence (2020). Adopting Morton Heilig's concept of multisensory (see Figure 3) experience can lead to more holistic and beneficial urban spaces. This will contribute to urban environments that effectively promote our social, cognitive, and emotional development.

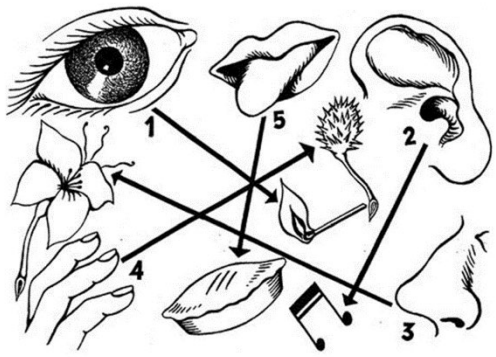


Figure 3: Schematically illustrates the hierarchy of attentional capture by each of the five senses as envisioned by Morton Heilig, the inventor of the Sensorama. (Heilig, 1992)

Visual perception of space is influenced by colour and lighting (Lam, 1992; Manav, Kutlu, & Küçükdoğu, 2010; Oberfeld, Hecht, & Gamer, 2010; von Castell, Hecht, & Oberfeld, 2018). The eye has receptors for colour and brightness, suggesting vision as two distinct senses (Sensation and Perception, 2002). Similarly, taste, smell, and touch are multidimensional, involving various sensory stimuli.

Sense	sight	hearing	smell	touch	taste
Percentage share	83%	11%	3.5%	1.5%	1%

Table 1: Comparison of the perception of the environment by individual human senses (Skaza, 2019).

2.5. Emotional engagement

Architectural spaces profoundly impact our emotions, cognitive functioning, and overall well-being. Arushi Malhotra (2020) delves into the psychological power of the built environment and its impact on the human mind. By discerning body and spatial cues, architecture can evoke a range of emotions in its users.

Emotions colour our perception of the world, influencing interactions with surroundings through sight, sound, touch, smell, and taste. These emotional responses enrich our experiences and guide our survival instincts. While psychology often focuses on emotions, architecture plays a significant role in shaping our emotional experiences of the built environment. From parks to residential and commercial areas, architectural spaces reflect the values and beliefs of the people they serve, impacting our emotions through symbolism and design. Well-planned green spaces can evoke positive emotions, while poorly designed ones can elevate stress levels. Designers have numerous methods to shape and enhance this

experience within the spaces they create. This diverse stimulation can be accomplished through the utilization or modification of the following (Malhotra, 2022):

1. **Colours:** Each colour has a unique psychological impact and evokes various emotions. Warm colours, linked with feelings of joy and passion, are well-suited for spaces where energy is desired. Colours are perceived by the sense of sight.
2. **Shapes:** Straight lines express stability and order, while curved shapes evoke a sense of naturalness and harmony. Spaces with rounded walls and feelings of comfort, safety and relaxation. Shapes will be perceived by the senses of sight, touch, and hearing.
3. **Textures:** A material's texture influences our associations and emotions. Rough surfaces evoke adventure, smooth textures suggest stability and control, and glossy finishes often signify modernity and luxury. The senses of sight, touch, and hearing perceive textures.
4. **Light:** Natural and artificial light impact people differently, with light intensity playing a crucial role. Bright natural light enhances productivity, while dim lighting promotes relaxation and the release of melatonin. This will be perceived by the sense of sight.
5. **Volume and space planning**: Altering the flow of space to enhance impact, sense of journey or arrival. This will be perceived by the senses, sight and hearing.
6. **Patterns**: This involves using patterns to create illusions in our spaces, which are perceived by the senses of sight, hearing, and touch.
7. **Sound:** From regulating noise levels to selecting music and zoning areas according to their functions and activities, all are perceived through hearing.
8. **Ventilation**: Well-lit and well-ventilated spaces enhance user comfort, thereby boosting productivity. This will be perceived through the senses: touch, smell and taste.
9. **Aesthetics**: Positive emotions can be evoked by a visually pleasing design through sight.
10. **Comfort**: Physical comfort and accommodating spaces can contribute to emotional well-being. This will be registered through touch, taste, hearing, and smell
11. **Natural Elements**: Integrating elements of nature, like greenery or natural light, can positively affect emotions. This will be perceived through sight, touch, and smell.

2.6. Perception of water

Research indicates that people's perceptions of water significantly impact their interactions with others and their environment. Tilley (2006) posited that water's constant change influences people's movement, relationships, and socialization. Water profoundly affects human emotions and perception, with sensory elements such as sound, colour, clarity, motion, and context playing crucial roles (Herzog et al., 2000; Völker & Kistemann, 2011). Designers often integrate water into spaces to evoke feelings of joy, calmness, and comfort, aligning with humans' preference for natural elements (SEÇKİN 2010; Bachelard, 1983; Nasar, 1990; Nasar & Li, 2003). Waterscape design prioritizes factors like explicitness, unity, and a sense of participation, alongside providing a feeling of attachment and pertinence toward water (Coeterier, J.F. 1996; Völker & Kistemann, 2011; Burmil et al., 1999). Viewing waterscapes can induce fascination, attention, and calmness, contributing to a sense of mental immersion and potentially positively impacting mental states (Laumann et al., 2001; White et al., 2010; Felsten, 2009). Moreover, water serves as a communal link, bringing people together in leisure activities and aiding relaxation during times of stress (Program & Fredrickson, 1999; Regan & Horn; Völker & Kistemann, 2011). Additionally, the presence of negative ions generated by water sprays, like those in waterfalls, offers numerous psychological and physical benefits, including increased serotonin levels, which can alleviate depression (Herzog et al., 2000). The atmosphere's abundance of negative ions contrasts with urban environments with significantly lower levels (Herzog et al., 2000).

2.7. Characteristics of Water

Water has the ability to evoke different sensory experiences. According to the article: 'Water as an Element of Architectural Space Desing Study Psychological Impact of Water on the Occupants of the Space' (Mahmoud et al., 2022), water has different characteristics. These will be described in the following paragraphs.

2.7.1 Sound of Water (hear)

Nature joyously announces the presence of water through its sounds. The characteristics of music are reflected in the sound of water, such as diversity in volume, softness, rhythm, intensity, and harmony. It ranges from the soft trickle of droplets to the thunderous roar of waterfalls; water's presence is frequently signalled even when unseen (Moore en Lidz , 1994). Sound emerges as a significant aspect of the human experience of water in landscape design, serving diverse functions. Water with vigorous energy and rapid flow falling from cascades or waterfalls stimulates the user. Conversely, tranquil water with a peaceful energy can soothe and calm the individual. Whether trickling or flowing, water can be manipulated to fulfil specific design objectives. Moreover, its sound informs users, providing a sense of security. This highlights water as an auditory rather than a visual element. Additionally, water's sound can mitigate surrounding noise, albeit potentially becoming intrusive itself (SEÇKİN, 2010, p. 7).

Moreover, the transmission of sound over water surfaces may magnify the proximity of neighbouring sounds, akin to comparable situations on land (Nillesen & Singelenberg, 2011). This underscores the multifaceted relationship between water and sound, influencing our environmental perception.

2.7.2 Reflection of water (see)

As a particularly natural material, water can reflect light waves through its surface, projecting detailed images of the surrounding environment. A calm water surface can show very vivid images of mountains, rocks, plants, and animals. However, when the calm water's surface is disrupted by a gust of wind or the movement of the water itself, the reflected images lose their sharpness and level of detail. This produces images resembling impressionistic scenes (Burmil et al., 1999, p. 100). Bachelard (1983) outlines that images created by water are more natural and purer than artificial mirrors. Seventy-two years earlier, Wright (1928) hypothesised the aesthetic value of reflective water, considering it "refreshing and beautifying in architecture" (Nasar & Li, 2003). Water reflection is considered an important feature. Hubbard and Hubbard claimed that harmony and enrichment could be achieved by using reflective water because it is more attractive. Small bodies of water can capture observers' attention, which has implications for design, as altering the colour of the containing surface can modify water's reflectivity (Nasar & Li, 2003). Recent landscape theorists have also recognized the aesthetic value of reflective water (Burton & Litton, 1974). From a psychological perspective, Kaplan suggests that water serves as a unifying theme in landscapes, drawing attention to itself with its sparkling texture, reflective qualities, and rippling movements (Kaplan, 1977). Reflective water is believed to possess restorative properties (Nasar & Li, 2003).

When designing waterfront homes, extra light reflected through the water towards the homes can be used. If the house is located close to the water, the reflection of the water in the house will be visible during the sunshine (Nillesen & Singelenberg, 2011).

2.7.3 Movement of Water (see, feel)

A motionless small pool of water or a vast ocean can evoke feelings of serenity and peace. Waves are created by the flow of rivers or tidal currents in seas. This gentle stimulation of the water surface can change moods depending on the water mass and speed of the waves. The term 'Blackwater' describes an undisturbed surface. Still water, with its quiet, calm and tranquil gathering, has long symbolized the reflective and pervasive spirit of nature dwelling in the forest. The pools and lakes gather the water released by flowing rivers or periodic rains (Moore & Lidz, 1994). Goethe identifies three critical qualities of still waters. First, they act as reservoirs beneath a flat surface. Second, the water reflects 'thousand twinkling stars', and thirdly, it emphasizes the 'riping fruit' of the surrounding nature.

On the other hand, the term ‘white water’ refers to dynamic forms such as cascades, waterfalls and tsunamis (Dreiseitl & Grau, 2005). Water movement can be very different from the calm environment around it (Burmil et al., 1999). Slow water movement changes can induce monotony, boredom and immobility (Burton & Litton, 1974). People are attracted to the variation and flow of water, which significantly impact the perception of landscapes (Burmil et al., 1999). Symmes (1998) emphasises that water movement can be inviting and terrifying and that each flowing water creates unique shapes and sounds.

2.7.4. Colours of Water (see)

Pure water is colourless, odourless and tasteless. However, in nature, water can take on different colours, ranging from dark grey to beautiful blue or transparent, depending on factors such as light, angle of sunlight, cloudiness and particles present (Burmil et al., 1999). Eroded materials found in the water can also play a role in the visible colour. For example, the red colour of the Colorado River comes from the mud flowing through it. Colours can also indicate what kinds of aquatic animals live there (Leopold & Davis, 1966). The colour of water has different associations: blue could be linked to coolness, while white has power and thunderous sound (Litton, 1974). Generally, blue water is preferred because of its higher clarity compared to yellow water (Smith et al., 1995). Colour and clarity are crucial in the public's perception of water quality when observing water quality. Most of the colours seen in water are a product of the environment reflected on the surface or of the visible objects underneath due to the transparency of water. That source of light is often the blue sky. The colour of water becomes deeper and darker as the light intensity decreases (Dreiseitl & Grau, 2005).

2.7.5 The Form of Water (see, feel, taste, smell)

Water has the unique property of taking on the shape of its environment, as prescribed by the laws of physics. This creates different natural appearances, ranging from wide valleys and serene lakes to meandering streams winding through arroyos (Burmil et al., 1999). Changes in the flow of water can create new forms, such as majestic waterfalls and graceful cascades, while existing forms can be altered or even disappear altogether (Burmil et al., 1999). In his research, Seçkin (2010) distinguishes between formal and informal water settings, labelling natural forms as informal and angular shapes as formal**.** In water feature design, he considers the water's edge a crucial factor for shaping the perspective that bridges people and water. He argues that weak edge design can weaken a water feature's ability to convey its message and impair its aesthetic and functional quality (SEÇKİN, 2010). Form of Water can also be seen as the physical condition of the water. Frozen water has a different perception from liquid water or vapour.

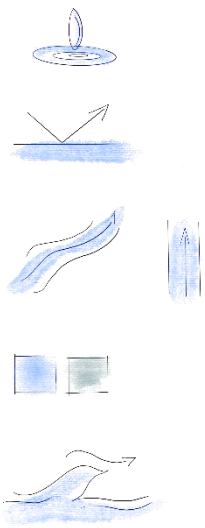
In summary, it can be concluded that people identify with a specific environment through four elements, as formulated by Ryden (1993): “personal memory, community history, physical landscape features, and emotional attachment.” The perception of a place operates through the five senses: sight, hearing, smell, touch, and taste (receptors). Stimulating multiple senses leads to a more intense experience and stronger emotional connection. Variations in characteristics such as colour, texture, light, and volume contribute to this emotional engagement.

Water holds not only scientific significance but also deeper meaning. The presence of water in landscape design as well as in interior design leads to better well-being in urban development. It connects with dimensions of humanity such as economy, ecology, society, culture, and spirituality (Almond, 1995). “Water gives a place a distinctive ambience and identity and prominently features in the sense of place.” Water profoundly influences human perception and emotions, with sensory aspects like sound, colour, clarity, motion, and context playing crucial roles (Herzog et al., 2000; Völker & Kistemann, 2011). Designers often incorporate water into spaces to evoke joy, calmness, and comfort, aligning with people’s preference for natural elements. Waterscape design emphasises clarity, unity, and participation, inducing fascination and tranquillity. Additionally, negative ions from waterfalls offer psychological and physical benefits, including increased serotonin levels. The five characteristics of water can help identify this perception of water and support design decisions. Following the design guidelines:

DESIGN PRINCIPLE

Multi-Sensory Design: Stimulating multiple senses (see, hear, taste, feel, smell) by using elements such as colour, texture, light, and volume leads to a better perception and more emotional engagement design.

GUIDELINES SENSORY



1. Sound of Water: High-energy waterfalls can stimulate users, while quiet or low-energy water forms have a calming effect.

2. Reflection of Water: Enhanced serenity and harmony will be created for users through water reflection.

    a. Light reflecting on water provides additional daylight indoors.

    b. Use façade materials that reflect water and sky.

    c. Incorporate reflection on flat water surface.

3. Movement of Water: People are attracted to variations in water flow; it can be inviting or even intimidating.

4. Colour of Water: The colour of water has different associations. Colour and brightness impact public perceptions of water quality when observing it.

5. Form of Water: Informal water shapes are considered natural, while angular forms are seen as formal.

III. ARCHITECTURAL ENGINEERING LENS

This chapter describes the technical perspective of building with water. To build for the future, it is essential to explore different dwelling typologies for living with water. The first paragraph explores these different typologies and analyses their impact on human experience. Subsequently, the critical role of material selection and construction methods is highlighted. Lastly, the importance of sustainability is highlighted.

3.1 Water Typologies

The book 'Amphibious Housing in the Netherlands: Architecture and Urbanism on the Water', discusses five typologies of water living (Nillesen & Singelenberg, 2011). These typologies will be explained in the following paragraphs.

3.1.1 Floating dwellings

In the Netherlands, floating dwellings arose from transformed ships, especially after World War II. Additionally, the typical houseboats built on a concrete base emerged as well. A significant and visible distinction between land and water dwellings is the floating body, also known as the hull. The floating body functions as the foundation for a water-dwelling, contrasting with the foundation of a land-dwelling. Various typologies exist for the floating bodies. Firstly, Steel Pipes are utilized in shipbuilding and offshore industries for buoyancy support. Secondly, a concrete box/hull can serve as a flotation device. This involves heavy construction, making buoyancy less of an issue but posing a risk of sinking. The centre of gravity is consequently lowered. Besides concrete and steel, foam and plastic products are increasingly popular as construction materials (Nillesen & Singelenberg, 2011).

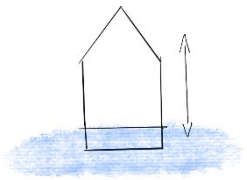


Figure 4: Floating (author)

A floating home is in direct contact with the water, resulting in the perception of water movements and sounds such as creaking ice. While this adds a certain charm, it also brings disadvantages. Fortunately, there are several technical solutions, such as guide poles, to prevent tilting and fluctuations. Though floating homes are unaffected by fluctuations in water levels, changes in water levels necessitate adjustments in the relationship with the shore, such as flexible gangways and utility lines. The design must also ensure sufficient flow and water quality by maintaining a minimum water level beneath the dwelling(Nillesen & Singelenberg, 2011).

3.1.2 Amphibious House

The amphibious house stands on land but can float at high tide, ideal for areas with lots of water and significant height differences. The flotation body remains dry when there is no water. The substructure is then image-defining and is therefore concealed in the ground or made thinner in foam or plastic. The flotation body is more robust than an ordinary floating house because it must withstand the extra pressure of the water (Nillesen & Singelenberg, 2011).

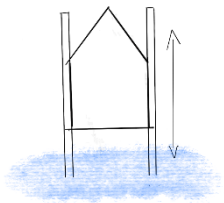


Figure 5: Amphibious (author)

The main difference between floating and amphibious houses is their connection to public infrastructure, such as roads and pipes. In the Netherlands, amphibious houses are mainly used where extreme water levels are rare but possible. Infrastructure is not adapted for these exceptional situations, leaving the house isolated when floating. To cope with significant differences in height, flexible pipes and guide piles help keep the house in the same place during high water, sometimes up to 5 metres. New designs often hide these poles in the house (Nillesen & Singelenberg, 2011).

3.1.3 Pile dwellings

Pile dwellings are mainly used in shallow water or on dry land, where any fluctuations in the water level are easily predictable. The houses rest on concrete or wooden piles, which means that the lower level of the structure is some distance above the water surface (and seems to float). The pile foundation provides a fixed and stable connection to the subsoil. The downside of the fixed connection is the lack of flexibility concerning the water level, which can cause flooding. In coastal areas, a large safety margin is included in the height of the piles. Because the water can visibly flow under the house in a pile house, the water experience is enhanced. The dwelling type is, therefore, popular in natural areas because it leaves the surroundings 'intact;'. Combined with jetties as a connection to the mainland, this can create an idyllic image (Nillesen & Singelenberg, 2011).

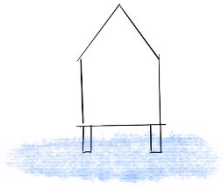


Figure 6: Pile (author)

3.1.4 Waterside living

The Waterfront house is a regular country house in close proximity to the water. The experience of the water and its panoramic view are central to this type of housing. Preferably, these houses are built at a safe distance from the water, such as on an elevated quay along a river. Some houses even have facades that extend into the water, making them appear as objects rising out of the water. To soften the boundary between home and water, terraces are often used, with the spaciousness of the water surrounding the terrace enhancing the experience. Other elements, such as boats moored near the house and visible in the water, generally have less impact on the connection between the house and the water. However, waterside houses are often vulnerable to fluctuations in water levels unless designed and built to withstand flooding (Nillesen & Singelenberg, 2011). There are two options to withstand flooding: water exclusion design and water inclusion design. Water exclusion (dry-proof building) involves waterproofing the house from the outside. This can be achieved by creating a membrane on the exterior of the building, the use of a glazed brick with a wetproof mortar, or using flood barriers, which can block water when necessary. Water inclusion (wetproof building) means that while water can flow into the building, architectural elements are added that allow the space to be still used.

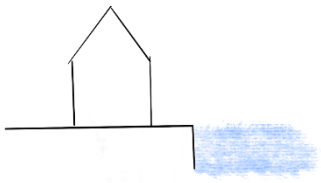


Figure 7: Waterside (author)

3.1.5 Human experience of typologies

The experience of water across different water-dwelling typologies offers a diversity of sensations and perceptions. In floating homes, water movement is directly felt as the dwelling adjusts with waves and winds, creating a dynamic and lively experience. Amphibious residences provide a unique encounter with tidal variations, where residents directly perceive changes in water levels, enhancing their sense of connection with nature and establishing a natural boundary between home and water. Pile homes offer a distinctive experience as water flows visibly beneath the structure, preserving the surrounding landscape. Lastly, waterside homes afford panoramic views of the water, with structures seemingly rising from its surface, creating a stark boundary between land and water and fostering a sense of connection and freedom. Each typology contributes to the perception and experience of water, enriching the relationship between humanity and this vital element in surprising and meaningful ways.

3.2 Construction

The construction of water-related projects plays a crucial role in building with water and people's experience. It requires robust and resilient structures, built with high-quality materials such as water-resistant metals and durable timber, to withstand the challenges of water, such as erosion and fluctuating water levels. These structures must not only be functional but also aesthetically pleasing. They should integrate seamlessly into the environment and provide a positive experience for users. Creativity and innovation play a role in designing unique water-related spaces, such as floating gardens and recreational waterfronts, that improve quality of life and contribute to sustainable and resilient wetland

communities. For example, floating structures can merge into the landscape, while pile structures rise out of the landscape. Ground-mounted foundations are designed to integrate seamlessly into the environment.

3.3 Materials

3.3.1 Technical aspects

Using suitable materials plays a crucial role when building with water. Firstly, materials must withstand corrosion and erosion caused by water, as well as the effects of saltwater in coastal regions. This calls for high-quality, water-resistant materials such as stainless steel, special coatings and durable wood that is moisture-resistant. In addition, materials contribute to the aesthetic experience of water-related architecture. Glass, for instance, can create a sense of connection with water through transparency and reflection, while natural materials such as stone and wood promote harmony with the environment and integrate seamlessly into the wetland landscape. Moreover, waterproofing materials such as waterproof concrete or a waterproofing membrane can also be used. This is 'dry proofing' the foundation, ground floor and possibly walls. A membrane or sealing strip prevents water from flowing in through cracks (Havenbedrijf Rotterdam, z.d.). Also, innovative materials offer new opportunities for building with water. Lightweight composite materials are suitable for floating structures that move with the water levels. Finally, it is essential to consider the ecological impact on wetland ecosystems when choosing materials. Using environmentally friendly and recyclable materials helps minimise the negative impacts of construction activities on water quality and biodiversity, thus preserving a healthy and resilient water environment.

3.3.2 Enhanced material experience

Materials have a physical form and texture that directly engage the user's senses of sight and touch. When multiple senses are stimulated simultaneously, the experience becomes more intense (SEÇKİN, 2010). Therefore, if a user can see, touch, and hear water, the overall experience is enhanced: the more senses involved, the deeper the connection.

Textures and finishes provide immediate information to the user about their surroundings. Polished surfaces, for example, suit formal settings, while varied textures are more stimulating. Tactile qualities of materials also inform users, such as a pool floor becoming rougher with depth to signal changing conditions and enhance safety. Preference studies suggest balancing hard materials with softer ones to reduce negative impacts. Flowing water or vegetation can soften large concrete areas, creating a more pleasant and balanced environment (SEÇKİN, 2010).

3.4 Sustainability

Sustainability plays a crucial role in building with water and directly impacts people's experience in wetland environments. First, maintaining water quality and ecological stability is essential for people and nature. Sustainable building materials and methods reduce the negative impact on water resources and ecosystems. This contributes to healthy and attractive environments, strengthening the bond between people and water. In addition, sustainability also ensures resilient infrastructure that can withstand rising sea levels. On the other hand, water-permeable paving or green roofs that retain water longer. Finally, renewable energy reduces the ecological footprint. In short, sustainability is crucial for building with water, both ecologically and for the well-being of residents. A holistic approach can ensure a sustainable future where water is a source of inspiration and well-being.

3.5 Biomorphic and Biomimicry

Biomorphic arose from the Greek words Bioic (life, living) and μορφή (form) (Snehal, 2021). It refers to creating shapes and forms inspired by nature. Biomorphic forms and patterns are integral components of biophilic design, offering an indirect connection to nature through contours, patterns, textures, or numerical arrangements found in the natural world. Integrating biomorphic in design can lead to a better water experience and evoke a deeper connection to water.

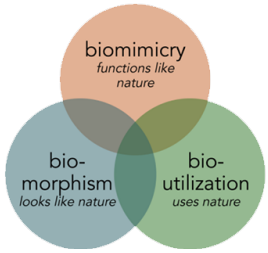


Figure 8: Differences biomicry, biomorhphism, bio-utilization. (Verma, 2024)

Biomimicry replicates the functions and processes found in nature to solve human problems (Snehal, 2021). As Snijders and Pronk (2016) outlined, it operates on three levels. Firstly, it mimics the natural forms of organisms, such as using the structure of a seashell for stronger buildings. Secondly, it replicates natural processes, like photosynthesis, to create sustainable materials. Lastly, it mimics entire ecosystems and their functional principles. Products developed through biomimicry are termed "biomimetic," encompassing form, material, construction, process, or function.

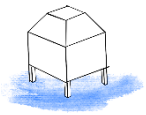
Biomimicry principles can be applied to make buildings and urban environments more resilient against water-related issues. There are various ways in which biomimicry can contribute (Snijders & Pronk, 2016). Firstly, we can examine how river deltas and wetlands naturally filter and gradually release water. Secondly, we can study how plants and animals retain and store water. Thirdly, we can explore the water-repellent properties of lotus leaves and shells, which keep themselves clean. This can be applicable in designing facades, roofs, and windows with self-cleaning coatings. Finally, there is also biomimicry inspiration in observing how reeds and bamboo use flexible materials and structures that adapt to water and wind.

It can be concluded that different typologies of water dwellings offer unique experiences and connections with water. Floating homes dynamically interact with water movements, providing a lively experience. Amphibious houses adapt to tidal variations, enhancing the natural connection. Pile dwellings, with water visibly flowing beneath, preserve the landscape and offer a distinctive experience. Waterside homes provide panoramic views, blending land and water seamlessly. Each typology enriches the relationship between humans and water. The choice of construction has a significant impact on the experience of the water. In addition, the choice of materials plays a crucial role. Materials can have different properties: resist corrosion and erosion, contribute to the aesthetic experience, be waterproof, have innovative features, consider the ecological impact, and engage with the user's senses. Lastly, sustainability is crucial for maintaining water quality and ecology, sustainable materials and methods, resilient infrastructure, and renewable energy. Besides all those technical parts, there is also an integration with biology. Biomorphic can lead to a better experience with water, while biomimicry can make buildings more resilient against water issues. Based on this conclusion, design guidelines can be established.

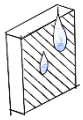
DESIGN PRINCIPLE

Select appropriate water typologies, resilient materials, and construction, implement biomimicry techniques to be water resilient, enhance the human experience, and promote sustainability in water ecosystems.

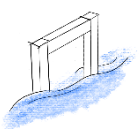
GUIDELINES ARCHITECTURAL ENGINEERING



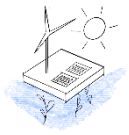
1. Water Typologies: Choose water typologies that align with and enhance the intended human experience (floating, pile, amphibious, waterside).



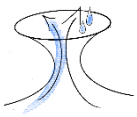
2. Materials: Select materials that resist corrosion and erosion, minimize ecological impact, and enhance the material experience through the senses (texture).



3. Construction: Water-resilient architecture requires robust and resilient structures that are also aesthetically pleasing. They should integrate seamlessly into the environment and provide a positive user experience.



4. Sustainability: Implement sustainability methods that reduce negative impacts on water resources and ecosystems, as well as for the well-being of residents, to make the building future-proof.



5. Biomimicry: Employ biomimicry techniques to enhance water resilience and create sustainable, adaptive designs.

IV. CASE STUDIES

This chapter outlines the methodology, followed by an analysis of various case studies to gain a deeper understanding of how water is perceived and experienced within architecture. Based on these insights, conclusions will be drawn to derive the design guidelines.

4.1 Methodology

The case study booklet (Appendix A) analyses various projects using both the Human Perception Lens and the Architectural Engineering Lens. Tables 2 and 3 detail the criteria used for evaluating these projects through each lens. The projects were chosen based on their focus on water as a central design element, whether through integration with the built environment or as a medium for human experience. To cover a broad spectrum of architectural types, the selection includes residential projects, public waterfront spaces, and projects in which perception is a main theme.

The analysis begins with two residential projects in port cities: Het Sluishuis and Silodam and Jonas. This is followed by analysing a waterfront project: the Oslo Opera House. Subsequently, the analysis shifts to projects centred on the perception and experience of water, using only the Human Perception Lens. These projects include Monet's Garden in Giverny, the Byodo-in Temple in Japan, Cisternerne in Copenhagen, and the Therme Vals.

The information needed for this analysis was found using architectural databases and platforms such as ArchDaily, Dezeen and other archives. For some projects, personal observations from field visits were included. Additionally, academic literature such as architectural publications provided in-depth analyses for certain case studies.

Architectural Engineering Lens	Typology	Distance and relation to water	Urban Princeples	Architectural Elements	Materialization	Construction	Sustainability
Case Study A							

Table 2: Case Studies analysed through the Architectural Engineering Lens (author).

Human Perception Lens	Sensory perception of water	Sound of Water	Reflection of Water	Colours of Water	Movement of Water	Form of Water	Human Interaction with water
Case Study A							

Table 3: Case Studies analysed through the Human Perception Lens (author).

4.1 Conclusion Case Studies

4.2.1 Het Sluishuis

The Sluishuis is an example of forward-looking urban living by seamlessly integrating architecture, water, and sustainability. Its location on the water maximises this experience through diverse housing types arranged around a central courtyard and public spaces such as promenades and terraces. These spaces engage with the water through visual and physical interactions. The design contrasts natural and abstract materials with innovative construction techniques, such as a significant cantilever construction, and incorporates sustainable features like solar panels and recycled materials. Residents and visitors experience the water on a sensory level through reflections, sounds and movements, creating a dynamic and soothing living environment that encourages direct interaction with the water.

4.2.2 Silodam

The Silodam combines innovative architecture with a unique interaction with the water landscape. Positioned above the IJ, the building offers panoramic views of the water. The construction of piles creates a visual illusion of floating and emphasises the water flow dynamics below. The mix of functions, including apartments, offices and public spaces, creates a diverse and dynamic community. The varied façade materials and styles reflect Amsterdam's multifaceted and economically diverse character. Through design elements like cantilevered balconies, large openings, and stair connections, the Silodam enhances the sensory experience of water, allowing residents and visitors to hear the lapping waves and smell the fresh sea air. Ultimately, the Silodam exemplifies how architecture can thoughtfully engage with a water environment while reflecting its urban context.

4.2.3 Oslo Opera House

The Oslo Opera House strongly emphasises the connection between land and water in a unique way. Located on the edge of the Oslofjord, it invites visitors to engage physically and visually with the water through sloping surfaces that create a seamless transition between the city and the fjord. The accessible roof offers diverse perspectives of the surroundings and allows close interaction with the water. The structure combines functionality with aesthetics, featuring white marble and granite surfaces that enhance the reflections of the water and sky and interact with the water to reveal a visible waterline, allowing the building to blend harmoniously into its surroundings. The design symbolises the meeting of nature and culture, inviting discovery.

4.2.4 Jonas

Jonas is a prominent building in IJburg Harbour, which stands out for its unique location on the headland and varied programme. It offers a mix of rental and owner-occupied housing and promotes social interaction through communal spaces and public access. The design combines privacy with a sense of community and includes unique elements such as an open indoor space, roof gardens and eco-friendly materials. Jonas is energy-neutral with a BREEAM Outstanding certification and uses sustainable solar panels and rainwater reuse technologies. The maritime influence is visible in the zinc façade and timber frame structure, contributing to the connection with the environment and providing a soothing living experience. In addition, sensory perceptions of water, such as sound, reflections and movement, are exploited to create a dynamic living environment.

4.2.5 Monet´s water garden

Monet's water garden in Giverny reflects a harmonious interaction between humans and nature, in which the colours, sounds and movements of the water stimulate the senses. The still water, which displays a spectrum of colours and reflections, creates a serene and almost dreamlike atmosphere. The combination of organic forms, such as water lilies and winding banks, and architectural elements, such as Japanese bridges, invites visitors to experience the landscape from different perspectives. This carefully designed garden connects the visual and the emotional, forming a scene highlighting the timeless beauty of water and nature.

4.2.6 Oriental Gardens and Japanese Tempels

Oriental gardens and Japanese temples show how nature and spirituality are connected, with water symbolising serenity, purification and balance. At temples such as Byodo-in, the building seems to float above the water, giving a sense of lightness and beauty. The reflections in the still water enhance this serene atmosphere. The rippling sound of water and how visitors use the ritual, such as washing hands, create a peaceful and unique experience that brings people closer to nature.

4.2.7 Cisternerne Kopenhagen

Copenhagen's Cisternerne, a former water reservoir, offers a unique experience where water and architecture come together in a mysterious underground space. The gentle sound of trickling water echoes and reflections in dark pools enhance the atmosphere and are used in art installations to play light and shadow. The water, seeping slowly through limestone walls, highlights the natural sculptures of stalactites and stalagmites. Visitors can see, hear and touch the water, creating a profound, sensory and visual experience in this unique combination of nature and art.

4.2.8 The Therme Vals

The Therme Vals is a harmonious interaction of nature and architecture that offers a unique sensory experience. Using locally mined Vals quartzite and integrating water in different forms - still, flowing and in vapour - create a soothing and mystical atmosphere. The design responds to the natural terrain, with light, shade and reflections inviting visitors to relax and explore. The baths offer a subtle balance between controlled perspectives and free exploration, where the senses are stimulated by sounds, colours and interaction with the warm, healing waters. This makes Therme Vals a unique place of tranquillity and connection with the natural elements.

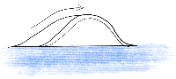
DESIGN STRATEGIES BUILDING SCALE

1. Different perspective: Design various viewpoints and multiple pathways to offer diverse and ever-changing perspectives of the water, enhancing the overall experience through different angles and perceptions.

2. Enclosure: To get a sense of enclosures, create islands in the water to get the archipelago feeling.

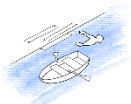
3. Awareness: Raise awareness of changes in water levels.

4. Boundary land-water: Blur the boundary between water and land through a fusion of light, colour, and shape, with vegetation along the banks blurring the transition.

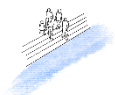


5. Biomorphic Enhancement: Utilize biomorphic forms to elevate the water experience, integrating organic shapes and patterns inspired by nature.

DESIGN STRATEGIES URBAN SCALE



8. Activities: Develop waterfronts to support leisure activities such as swimming, boating, fishing, and relaxing.



9. Social: Utilize waterfronts as social gathering spaces.

V. CONCLUSIONS AND DISCUSSION

Research has shown that people identify with a specific environment through four crucial elements: personal memories, shared history, physical landscape features and emotional involvement (Ryden, 1993). Together, this highlights the importance of detailed research on space users. The perception of a place is strongly influenced by the five senses: sight, hearing, smell, touch and taste. Stimulating multiple senses creates a more intense experience and strengthens the emotional connection to the environment, with variations in colour, texture, light and volume contributing to this engagement. Water has not only scientific significance but also a deeper symbolic value. Water contributes to improved well-being in urban development in both landscape and interior designs. It connects dimensions of humanity such as economy, ecology, society, culture and spirituality (Almond, 1995). Water creates a unique atmosphere and identity for a place, which enhances the emotional experience (Herzog et al., 2000; Völker & Kistemann, 2011). It influences human perception through sensory aspects such as sound, colour, clarity, movement and context, which can be designed to evoke joy, tranquillity and comfort. Moreover, water, through negative ions in waterfalls, provides psychological and physical benefits, such as increased serotonin levels. The five characteristics of water can support design decisions by enhancing the perception of water.

Different typologies of water dwellings offer unique experiences and connections with water. Floating homes respond dynamically to water movements, while amphibious homes adapt to tides, increasing the water connection. Pole houses, with water flowing underneath, preserve the landscape and offer a unique experience. Water villas offer panoramic views, seamlessly blending land and water. The choice of materials plays a crucial role in water experience, as they resist corrosion and erosion, contribute to aesthetics, are waterproof and consider ecological impact. Sustainability is key to maintaining water quality and ecology, focusing on sustainable materials, resilient infrastructure and renewable energy. Moreover, biomorphism can improve the water experience, while biomimicry makes buildings more resilient to water-related problems.

This thesis aims to answer the central research question: *"How can, from a human perspective, where emotions and experiences play a role, water-resilient architecture influence and enhance the perceived experience of buildings in port cities that interact with water?"*

Water-resilient architecture in port cities can significantly influence and enhance the perceived experience of buildings by harmonising human emotions and sensory interactions with water. By integrating elements that react to personal memory, community history, physical landscape features, and emotional attachment, architects can create environments that foster strong emotional connections. The inclusion of water in design—through sight, hearing, smell, touch, and taste—amplifies these connections, promoting well-being and a sense of place. Various water-dwelling typologies, such as floating homes and amphibious houses, offer unique interactions with water, enriching human experiences. Material choices and sustainable practices enhance these experiences, ensuring ecological balance and resilience. Ultimately, water-resilient architecture that thoughtfully engages with human senses and emotions can create vibrant, sustainable, and deeply meaningful urban environments in port cities through the middle of the following design guidelines.

While this conclusion strongly connects water-resilient architecture, human perception, and emotions, there remains room for further exploration of the actual perception and experience of water. Differences in cultural contexts and personal preferences may influence how emotionally attached people are. In addition, it is essential to balance multisensory stimulation without causing overstimulation. In addition, further studies are needed to test the effectiveness of the proposed design elements in different environments and to explore how sustainability and technology can be integrated on a large scale. This research provides a solid foundation and contributes to the ongoing development of architectural practices that consider human well-being and perception as well as technical solutions.

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CASE STUDIES

HARBOUR CITIES

HET SLUISHUIS (DWELLING)

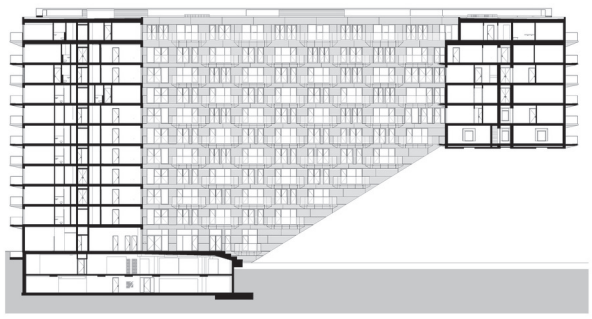
Location: IJburg, Amsterdam, Netherlands

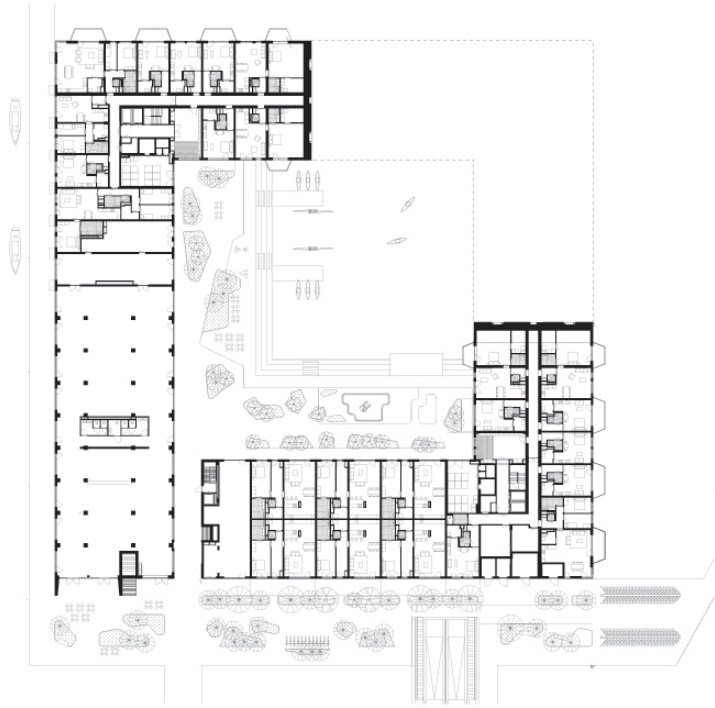
Architects: Barcode Architects , Bjarke Ingels Group

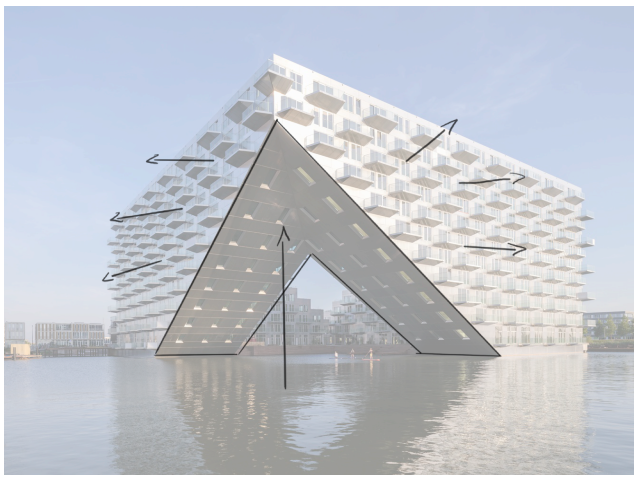
Area: 49000 m²

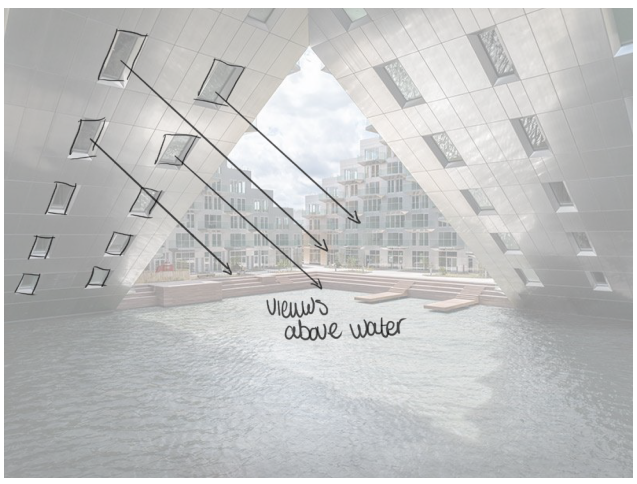
Year: 2022

Program: Residential, working, recreation









Architectural Engineering Lens	**Typology**	**Distance and relation to water**	**Urban Princeples**	**Architectural Elements**	**Materialization**	**Construction**	**Sustainability**
Het Sluishuis	Modern Amsterdam residential housing. 442 Appartments Rental and for sale.	The Sluishuis is located directly on the waterfront, minimizes the water distance. The proximity of the houses to the water varies: some are epositioned above the water, while othershave adjecent balconies. The appartments that hang over the water can see the boats sail underneath, through the window.	Island, appartments are accessible via central courtyard, which creates an enclosed feeling inside. Public plinth and jetty promenade will accomodate a varied program, a sailing school, water sports center, and a restaurant with terrace. The jetty landscape stimulates contact with the water with various mooring places, sitting decks, and floating gardens.	The volume is elevated on one side to allow water into the courtyard and stepped down on the other, creating inviting green terraces facing IJburg. From every side you expierience different volume. The public roof across the roof, children's playground in the courtyard, jetty promonade and wooden terracces stimulates sponteous encounters.	Natural materials contrast with the facade's abstract, untreated aluminum, creating a noticeable texture. The stepped roof terraces and jetty promenade, made of wood, offer a tactile appearance.	Cantileverconstrie	The landscape created on the promonade stimulates flora and fauna with local plant species and a bird island. Solar panels, a heat pump, triple glazing, and good insulation. The EPC is -0.01. Recycled and reusable materials were used during construction
Human Perception Lens	**Sensory perception of water**	**Sound of Water**	**Reflection of Water**	**Colours of Water**	**Movement of Water**	**Form of Water**	**Human Interaction with water**
Het Sluishuis	Sight, hearing, touch, smell.	The passing boats, provide the experience of rippling sound of water.	The aluminum facade reflect the surrounding water and sky, allowing the building to blend into its surroundings	The colours vary depending on the weather and time of day. From blue/ grey to deep blue or orange/pink.	Black water, undisturbed surface with rhythmic of the waves. The buidling offers a panaromic view overlooking the passing boats on the water.	The IJmeer has hardly any tides. The shape of the building is not organic.	Combining water sports and housing, the jetty promenade creates an enclosed archipelago feel and enhances water interaction.

SILODAM AMSTERDAM (DWELLING)

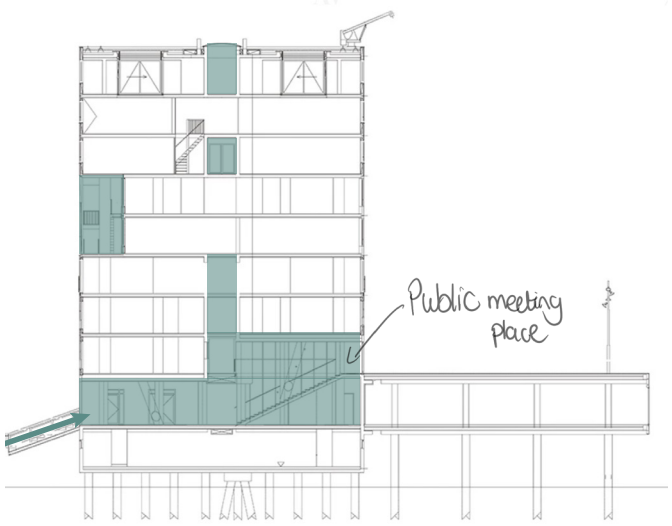
Location: IJ, Amsterdam

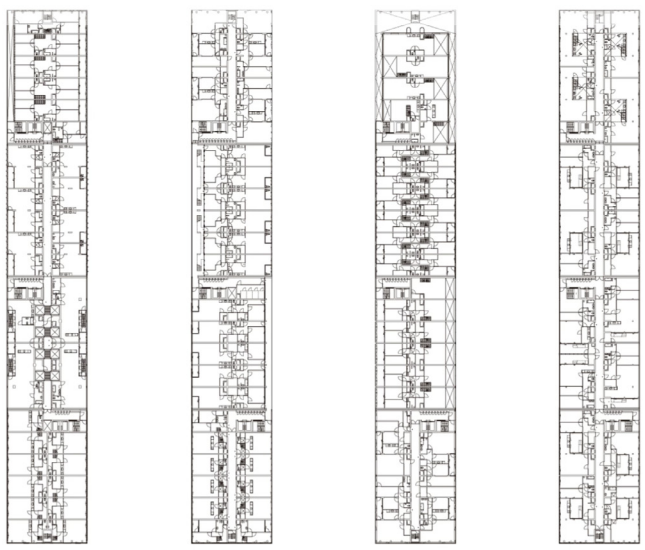
Architects: MVRDV

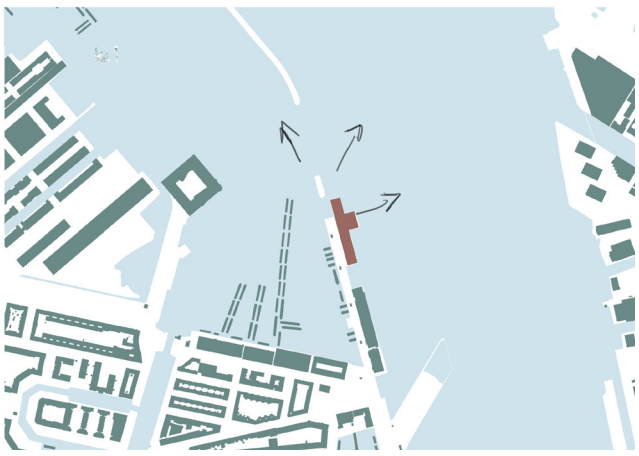
Area: 19500 m²

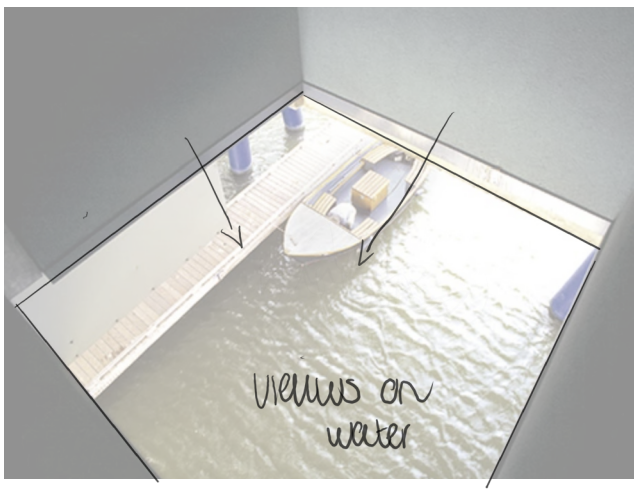
Year: 2003

Program: Mixed use, Residential









Architectural Engineering Lens	Typology	Distance and relation to water	Urban Princeples	Architectural Elements	Materialization	Construction	Sustainability
Silodam	Ten-story-high urban envolope (residential appartment). 157 Appartments Rental and for sale. Offices Work Spaces Commercial spaces Public Spaces.	Silodam is located above the water. waterfront, minimizes the water distance. Apartments have a panoramic view to the harbour, with views on both sides. Even the galleries and hallways feature views and openings to the water below.	The building is linked to the quay by stairs and walkways, which connect to galleries and corridors on both sides. Those are designed like internal streets, to meet people.	The volume of the building is simple: a big block lying in the water. A big balcony is puched outwards the volume into the water. It creates a public plaza with a panoramic view over the river. It compensates for the loss of the view at the former dam. Some parts of the building are lifted to create a collective space, the harbour under the building.	The Silo Dam uses various façade materials, such as glass, concrete and colorful panels, for visual variety. This gives the building a dynamic appearance and reflects the versatility (economic) of the city. Each cluster of houses has it's own individual facade type.	The building is constructed on stilts, making it appear to float above the water. This structure reminds of an enormous container ship docked at the wharf.	
Human Perception Lens	**Sensory perception of water**	**Sound of Water**	**Reflection of Water**	**Colours of Water**	**Movement of Water**	**Form of Water**	**Human Interaction with water**
Silodam	Sight, hearing, smell	The Silo Dam is located on the IJ, so you can hear the gentle rippling of the water against the dam. The sound varies depending on the tides and weather	The glass facades of the Silodam reflect the surface of the water. Also the water reflects, when its calm, the building.	The water of the IJ has different shades of blue and grey depending on the weather and time of day.	'White water', The Silo Dam stands on stilts above the water, making the building itself appear to move with the current. The water flows under the dam, creating a dynamic feeling.	The IJ is a natural waterway in Amsterdam, so informal water setting. It is a tidal river where fresh water from the rivers mixes with salt water from the sea.	Living above the water ensures that residents consistently have a view of and engagement with the water and harbor activities.

OSLO OPERA HOUSE (PUBLIC)

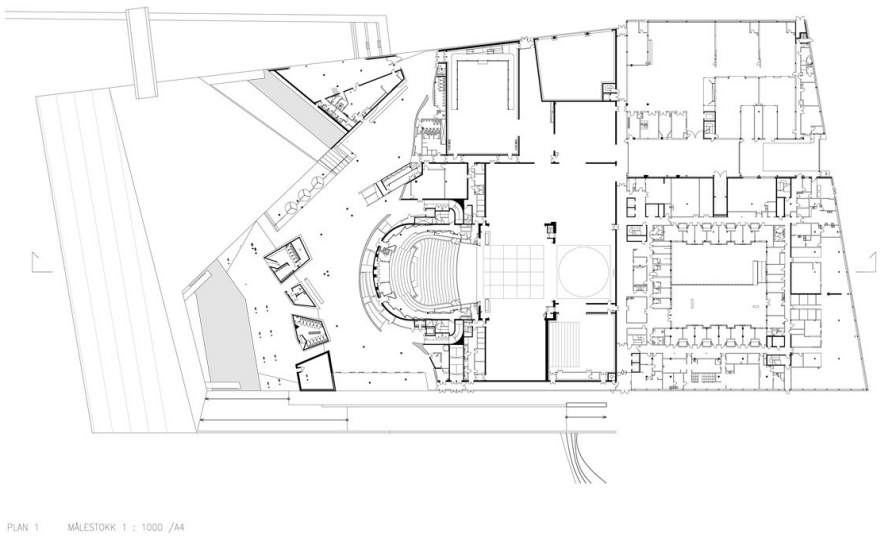
Location: Oslo, Norway

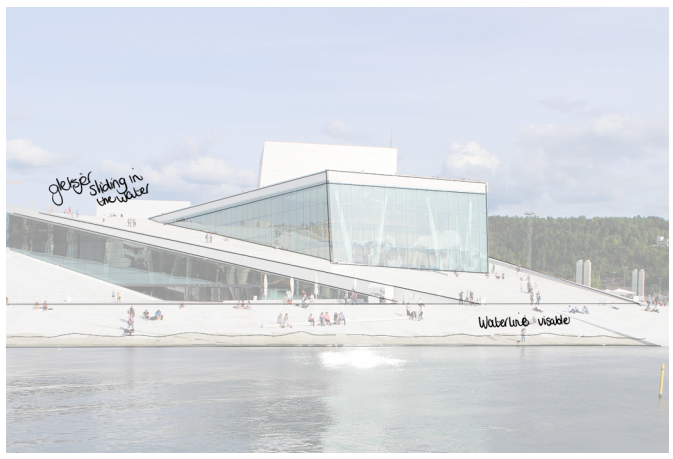
Architects: Snøhetta

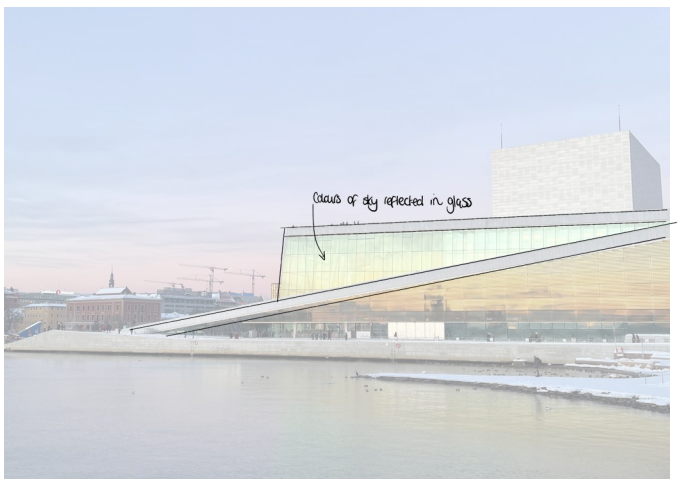
Area: 38500 m²

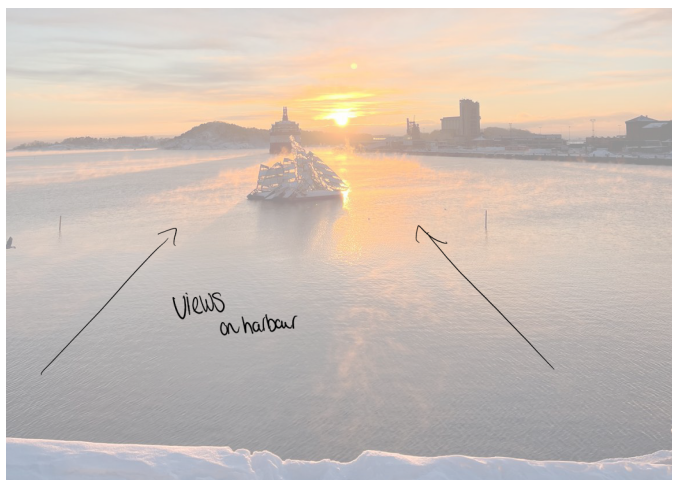
Year: 2003

Program: Public, Opera









Architectural Engineering Lens	Typology	Distance and relation to water	Urban Princeples	Architectural Elements	Materialization	Construction	Sustainability
Opera House	Public building, Opera House	The opera house is situated right on the Oslofjord's edge, offering a distinctive location. Visitors can stroll to the water's edge for a tactile experience or they can walk to the roof and enjoy stunning views of the fjord and nearby mountains.	The opera house is located at the head of the Oslofjord. It symbolises the meeting between land and sea, Norway and the world.	The sloping outer surfaces of the building making it seem to rise from the water. The opera house has a large 'wave wall' that forms the boundary between land and sea.	The surfaces are covered with marble from Carrara, Italy, and white granite.	The sloping surfaces are supported by angled columns, which do not obstruct the view.	

Human Perception Lens	Sensory perception of water	Sound of Water	Reflection of Water	Colours of Water	Movement of Water	Form of Water	Human Interaction with water
Opera House	Sight, hearing, touch, smell	The building seems to rise from the water, with the sound of waves lapping against the marble and granite surfaces creating a soothing and serene atmosphere.	The sloping exterior surface of the opera house are covered with marble and white granite. These reflect the surrounding water and sky, allowing the building to blend harmoniously into its surroundings.	The water of the Norwegian fjord around the Opera House variesw in color from dark blue to green. The combination of white marble and granite makes the building stand out, giving the impression that it rises from the water.	Black water, undisturbed surface with rhythmic of the waves. The sloping lines and design of the roof invite exploration. Visitors can walk across the roof and enjoy panoramic views of Oslo and the fjord.	The Norwegian fjord, is a natural formed water, so its a informal water setting. Tidal differences are not that big.	The inclined surfaces of the building extend into the water, facilitating easy access for swimming.

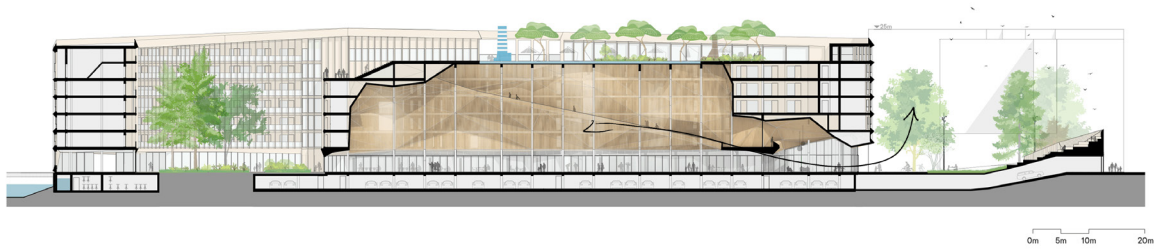
JONAS AMSTERDAM

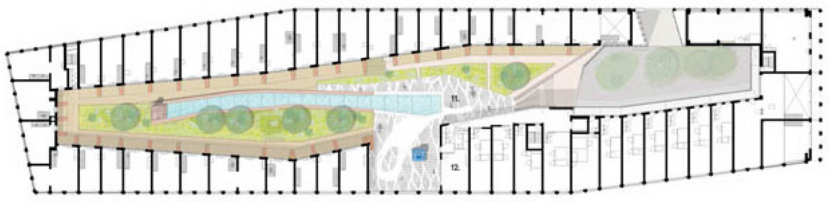
Location: IJ, Amsterdam

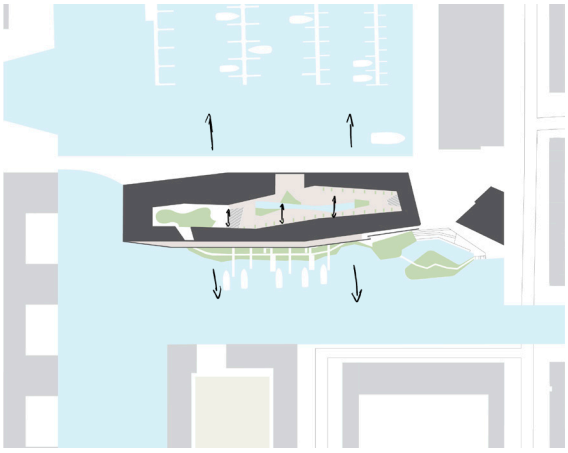
Architects: Orange Architects
Area: 29950 m²

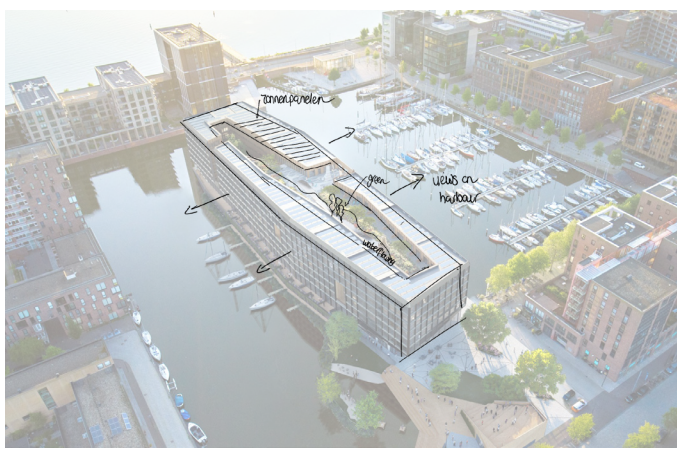
Year: 2022

Program: Residential appartments









Architectural Engineering Lens	**Typology**	**Distance and relation to water**	**Urban Princeples**	**Architectural Elements**	**Materialization**	**Construction**	**Sustainability**
Jonas	Seven-story-high urban envolope (block appartment). 190 medium-priced rental homes, 83 owner-occupied homes	Located in the middle of IJburg harbor, the building is closely surrounded by water.	Jonas distinguishes itself on IJburg due to its unique location on the headland and its varied program. The building promotes social interaction through communal areas and public access, creating a “residential landscape” that balances private homes with shared spaces. This design blends privacy with community, making it integral to the area’s social life.	The design includes unique elements such as the canyon (an open interior space with wood panels), roof gardens and spaces that promote connection to the environment.	The facade is made of zinc, inspired by shipbuilding. Additionally, sustainable materials were used, such as FSC-certified wood and biobased materials. The concrete construction consists of recycled raw materials.	The skeleton of Jonas is based on the structure of wooden shipbuilding, emphasizing the maritime character of the building.	Jonas is energy neutral with a BREEAM Outstanding certification. The building uses solar panels, rainwater harvesting, green roofs, bird habitats and Thermal Energy from Surface Water IJburg (TEO) for cooling and heating.
Human Perception Lens	**Sensory perception of water**	**Sound of Water**	**Reflection of Water**	**Colours of Water**	**Movement of Water**	**Form of Water**	**Human Interaction with water**
Jonas	Sight, hearing, smell	The building uses the tickling water sound on the glass roof, contributing to a calming experience.	The water surrounding Jonas creates reflections in the glass facades, enhancing the light and colors.	The colours vary depending on the weather and time of day.	The water on the roof flows and creates a visually dynamic element that is also functional for water drainage.	In IJburg, where tides are minimal, the building opens outward at the corners to connect with the water.	Residents can enjoy waterfront views, rooftop water features, and harbor activities, including relaxing on the rooftop beach.

WATER PERCEPTION

MONET'S GARDEN, GIVERNY

In Monet's painted world, the still water reflects the bridge hanging over it, the willow descending to it, and the irises surrounding it. Water lilies, appearing as green disks or red and purple whirls, float weightlessly on the surface. Blooming wisteria overtakes the bridge, entwining its railings with blossoms, while vegetation along the banks obscures the transition from land to water. Mirrored lilies merge with the real ones, blurring the boundary between water and land in a fusion of light, color, and form. The painted pool constantly shifts and releases light, oscillating between misted illusions and vibrant clarity (Moore & Lidz, 1994).The garden paths were carefully designed to overwhelm the senses with vibrant colors and aromatic contrasts.

Monet's paintings possess unknowable depth and an indeterminate surface. Reflections cover the pond with a mirage of solid color, concealing what lies beneath. These works are liquid seductions, relying not on fear or danger, but on the serene reflections and collections of a tranquil pool. In them, the still waters of dreams stir.

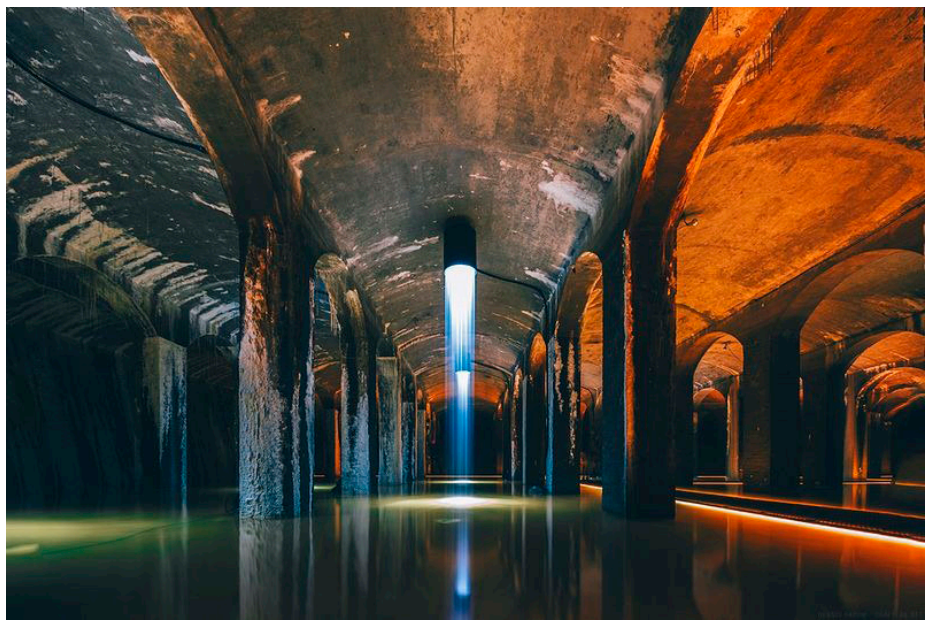
Human Perception Lens	Sensory perception of water	Sound of Water	Reflection of Water	Colours of Water	Movement of Water	Form of Water	Human Interaction with water
Monet's Garden	Sight, hearing, touch, smell	The sound of of the pond and flowing streams creates a peacheful atmosphere.	The water lilies, the overhanging tree and the Japanese bridge in the pond reflect on the calm surface of the water. Monet was fascinated by these reflections and painted them often.	The water in the pond exhibits a beatiful spectrum of colors, ranging from deep blue to bright green. Monet used these colors to capture the seasional variations and lighting effects.	The pond can be characterisezed as 'Black water'., undisturbed surface. The water lilies float slowly on the water, and the ripples caused by the wind create a dynamic pattern.	The pond has an organic, asymmetrical shape (informal). The winding banks and Japanese bridge add visual interest to the scene.	Visitors stroll along the paths beside the pond, experiencing a constantly changing perspective and view. Crossing the Japanese bridge, they feel enveloped by the water.

ORIENTAL GARDENS AND JAPANESE TEMPELS

In the Orient, the concept of nature's indwelling spirit has received the most attention. South Sung philosopher Teng Ch'ien (1963) said, "People think only men have spirit; they do not realize everything is inspirited."
Ponds and lakes in Oriental gardens symbolized the soul of the world. Unable to fit the whole world, these gardes featured miniature elements of Japanese or Chinese landscapes around the water.
The garden is an intricate world designed for exploration along winding paths, through pavilions, and over footbridges. Large islands divide the rectangular lake into smaller zones, giving each pavilion a private section of the pond and creating hidden views for visitors to discover. Zigzag bridges with tile roofs connect the mainland to the islands.

Human Perception Lens	Sensory perception of water	Sound of Water	Reflection of Water	Colours of Water	Movement of Water	Form of Water	Human Interaction with water
Byodo-in-Temple	Sight, hearing, smell, touch, taste	The smooth sound of the rippling water adds to this serene atmosphere in and around the temple.	The phoenix hall is reflected in the calm waters of the surrounding pond, this creates harmony and balance.	The clear water of the pond reflects the green shade of its natural surroundings, creating a serene atmosphere.	The lake around the temple can be characterized as 'Black water'. Het water stroomt rustig langs de paden en draagt bij aan de mystieke sfeer van de tempel. 'White water', the Otowa-waterval , staat voor de zuivering.	The phoenix hall seems to float above the water, giving it a sense of lightness and spirituality. The reflection of this imposing structure in the water emphasizes its mejsty and symbolism.	Visitors can ritually cleanse themselves upon arrival at the temple by washing their hands and mouths in the flowing water of the Otowa Waterfall. This symbolizes purification and releasing worldly concerns before entering the holy space This brings good luck and prosperity.

CISTERNERNE KOPENHAGEN



Cisternere is een voormalige waterresevoir in Kopenhagen, die is omgetoverd tot een tentoonstellingsruimte voor site-specifieke kunstprojecten.

Cisternerne forms an essential component of the Frederiksberg Museums (Frederiksbergmuseerne), its architectural uniqueness and atmospheric allure remaining central to its appeal.

Human Perception Lens	**Sensory perception of water**	**Sound of Water**	**Reflection of Water**	**Colours of Water**	**Movement of Water**	**Form of Water**	**Human Interaction with water**
Cisternerne, Kopenhagen	Sight, hearing, smell, touch	In the underground cave, visitors are surrounded by the sound of trickling water and resonant echoes. The cistern creates a sound experience in which water plays a central element.	The cave's dark pools reflect the art installations, creating a unique visual effect. Artists utilize these reflections to play with light and shadow.	The water in Cisternerne is dark and mysterious, emphasizing the contrast with the works of art. The interaction of colors creates an enchanting and visual experience.	As you explore the space, observe the subtle movements of water—droplets, flowing streams, and seepage through the limestone walls.	Over centuries, water has sculpted the cave, forming complex patterns in the limestone. The stalactite formations, comprising both stalactites and stalagmites, contribute to the distinctive character of the Cistern.	Visitors perceive the sounds, colors, and movements and can engage by walking through or touching the water puddles with boots.

THE THERME VALS

The Therme Vals, designed by Peter Zumthor, is a hotel and spa built over the only thermal springs in Graubünden Canton, Switzerland. The spa, which opened in 1996, predates the existing hotel complex. The idea was to create a form of cave or quarry like structure. Working with the natural surroundings the bath rooms lay below a grass roof structure half buried into the hillside. The Therme Vals is built from layer upon layer of locally quarried Valser Quarzite slabs. The stone's natural qualities inspired the design, creating a unique sensory experienc (Thisispaper, 2024).

The combinations of light and shade, open and enclosed spaces and linear elements make for a highly sensuous and restorative experience. The underlying informal layout of the internal space is a carefully modeled path of circulation which leads bathers to certain predetermined points but lets them explore other areas for themselves. The perspective is always controlled. It either ensures or denies a view (Thisispaper, 2024).

Human Perception Lens	**Sensory perception of water**	**Sound of Water**	**Reflection of Water**	**Colours of Water**	**Movement of Water**	**Form of Water**	**Human Interaction with water**
Therme Vals	Sight, hearing, smell, touch, taste	At the Therme, you can hear the water flowing throughout the building, creating a quiet pulsating rhythm.	The water of the thermal baths can reflect light but can also reveal glimpses of the stones underneath the surface. The reflection of the water on the dark stones creates a serene atmosphere. Visitors can enjoy the visual interplay between water and architecture.	The dark Valser quartzite slabs from which the building is constructed give the water a deep, mystical blue color. The steam creates a hazy and mysterious feeling, like a white mist spreading.	The water in the Therme flows from one pool to another through an ingenious system of natural flow. The design uses the natural slope of the terrain and gravity to move the water through the building. This creates a seamless and soothing experience for visitors.	The Therme Vals is constructed entirely from stone, comprising a total of 60,000 dark Valser quartzite slabs. These stones are influenced by the natural environment and, in turn, shape the water volumes within the baths. Additionally, the heat in the baths transforms the water into vapor and steam.	Visitors can immerse themselves in the hot springs, taking in the serene surroundings. The baths also invite swimmers, where the natural current adds an extra dimension. The varying water temperatures provide also a different experiences. Additionally, guests have the opportunity to taste the thermal waters