8 Floating developments

The next chapter in Dutch delta management?

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Introduction

Recurring catastrophic floods, intensifying hurricanes, wildfires, and other extreme weather events worldwide underscore the growing complexity and unpredictability of climate change impacts. The interconnected nature of multiple climate hazards, often occurring simultaneously and interacting with non-climatic factors, contributes to compounding and cascading risks that are challenging to manage (Intergovernmental Panel on Climate Change, 2022). These extreme events are not merely statistical anomalies; they highlight an unsettling reality: climate change is no longer an abstract risk but an immediate challenge. This challenge tests the resilience of communities, prompting a critical reassessment of how societies prepare and adapt (Birchall & Bonnett, 2021).

For low-lying countries like the Netherlands, climate change presents an existential challenge. With much of the land situated below sea level, especially in the west of the country, the Dutch have long relied on delta management systems to protect communities and agricultural land from flooding. A system of dams, dikes, canals, and pumps has kept the land dry, carefully regulating water levels. However, the accelerating pace of climate change is pushing the boundaries of these traditional solutions (Meyer et al., 2017).

Rising sea levels and more frequent extreme weather events are leading to two significant challenges: freshwater shortage and increasing flooding. According to Deltares (2024), a combination of extended dry periods, higher evaporation, and increased freshwater demand will lead to critical water shortages in summer. In winter, on the contrary, intense rainfall combined with high river discharge and higher sea levels will cause more frequent flooding. The societal impact of floods is anticipated to increase significantly in the years ahead.

As the consequences of rapid and significant sea level rise become more severe, solutions are sought by several governmental and non-governmental bodies, such as the Ministry of Infrastructure, universities, professional offices, and non-profit organisations. Deltares, the semi-governmental Dutch Delta research institute, published a report (2019) in which four major solution strategies for the future of the Netherlands were presented: *Protect-close*, *Protect-open, Advance,* and *Accommodate*. These strategies represent different extremes in how land and water might coexist in the future.

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Protect-close and *Protect-open* envision a future for the Netherlands that is in continuity with the current strategy: protect the coast with dikes, dunes, and dams. *Protect-close* and *Protect-open* differ on how water coming from the rivers is managed. *Protect-close* foresees a completely sealed system from the sea, requiring pumps to pump water out of the system. *Protect-open* considers the riverine network outside the protected system, requiring river dikes to protect the land.

Advance and *Accommodate strategies* imagine different water-land management approaches. The *Advance* strategy considers the idea of creating a series of small islands, similar to the Wadden Islands, to enclose the entire current coast, thereby forming a sort of lagoon. The outcome is an extra protection barrier for the 'old' land.

The *Accommodate* strategy envisioned accepting water into the territory by including several measures of abandoning part of the coastal urbanisation and protecting part of the historical cities, together with flood-resilient developments and floating structures. The solution strategy *Accommodate* emphasises maintaining flexibility to pursue various adaptation pathways as conditions evolve, moving away from the traditional rigid boundary between land and water and instead creating a dynamic 'fuzzy boundary'. Key recommendations include developing adaptive designs that allow projects to be expanded, elevated, or relocated, integrating climate-resilient construction practices, and exploring the 'go with the flow' strategy.

The *Accommodate* strategy aligns with a broader paradigm change currently shaping delta management in the Netherlands, as reflected in the cases discussed in this chapter. At the policy level, this shift is evident in the work of the *National Delta Programme on sea level rise* (Defacto Stedenbouw, 2021; Ministry of Infrastructure and Water Management, 2023) and in policies promoting water and soil as guiding principles in spatial planning (*Water en bodem sturend*), with an emphasis on increasing resilience (Ministerie van Algemene Zaken, 2022). *Accommodate* strategies address fluctuating water levels and the growing demand for freshwater storage during dry periods, which place significant pressure on the existing 'solid' spatial order. In this context a transition towards a *liquid perception* (Thaitakoo & Mcgrath, 2010) becomes essential. This concept calls for rethinking spatial planning to embrace the fluid relationship between land and water. A *liquid perception* facilitates the exploration of adaptive strategies to tackle current challenges while acknowledging that innovative solutions may disrupt established practices. In doing so, it creates opportunities to reshape spatial systems and redefine how society interacts with both the built and the natural environment.

Representative typologies of spatial occupation in the transitional zone between land and water include amphibious and floating developments. Amphibious developments are built on land but engineered to float temporarily when water levels rise. Floating developments, on the contrary, are designed to remain permanently afloat. While entirely located on the water, floating developments often maintain functional ties to the land, such as utilities, transportation, or governance, resulting in a hybrid spatial identity.

By embracing a *liquid perception* and establishing fuzzy boundaries, floating developments enable a closer integration of water management with urban planning, housing, and societal adaptation to climate change. This integration can influence economic trends, reshape societal values, and redefine cultural norms, underscoring the far-reaching implications of this innovative approach. Fuzzy boundaries are envisioned as interaction zones rather than fixed edges, fostering dynamic transitions and coexistence between land and water. This perspective emphasises flexibility, adaptability, and the coexistence of systems, thus reflecting the added value of ambiguity. By redefining the conventional understanding of what constitutes habitable living environments, fuzzy boundaries challenge established property rights and infrastructure development norms, encouraging a more fluid and inclusive vision. This paradigm shift produces a reciprocity between natural and built systems that enhances both resilience and spatial quality.

The shift towards a spatial order that accommodates delta dynamics and is founded in the deltaic system is not a deviation from the Dutch tradition; it continues a long history of working with water rather than against it. Historically, Dutch towns and cities were meticulously designed to accommodate water (Burke, 1956). However, technological advancements in the 20th century weakened this close relationship. There is much to be learned from past times when accommodation was more self-evident due to a lack of advanced technology.

This chapter explores both past and present water management approaches to uncover historical paradigms, highlights key projects, and explores potential pathways for scaling adaptive initiatives in response to climatic, environmental, and urban challenges. It reflects on the potential of floating development as a key manifestation of *liquid perception* and as a means for creating fuzzy boundaries within the Dutch spatial order. Floating developments represent the most tangible embodiment of *liquid perception*, offering a direct means of blurring the traditional rigid distinctions and divisions between land and water while addressing the challenges posed by climate change.

The first section establishes the foundation for understanding the evolving relationship between land and water in Dutch delta management, offering theoretical and historical perspectives concerning contemporary water management practices in the Netherlands. The second section presents key projects that highlight the paradigm shift in Dutch water management, emphasising the transition from controlling water to living with it. Following this, the potential of floating developments is examined, reflecting on how they may exemplify continuity. The conclusions present a synthesis of insights, reflecting on how floating developments could redefine land-water relationships and foster long-term climate adaptation.

Theoretical contextualisation

In this chapter, the notion of fuzzy boundaries is explored through three interconnected perspectives: (i) the ambiguous relationship between land and water, (ii) the interdisciplinary challenges of integrating ecological and urban strategies, and (iii) the paradigm shift between traditional practices and future innovations. This section focuses on the latter, exploring how the interplay between past, present, and future practices in water management demonstrates a ‘fuzzy’ transition driven by both technological advancements and societal changes. By examining this transition, this chapter contextualises how technological disruption has and continues to shape Dutch water management strategies.

Technological advancements have historically driven paradigm shifts in Dutch water management. For example, innovations such as windmills and steam engines marked transitions to more controlled and defensive water systems. More recently, near-flooding events and the growing recognition of natural processes have catalysed shifts towards approaches like *Living with Water*, which emphasise adaptability and integration with ecological systems. These perspectives collectively shed light on the trajectory of Dutch water management and its ongoing evolution.

To understand the paradigm shift in Dutch delta management, this section draws on theoretical perspectives that connect technological and societal trends with evolving practices. Hopster's theory of techno-social disruptiveness (2021) provides a framework for analysing how innovations reshape institutions, epistemic paradigms, and societal values. Complementing this, Kuhn's (2012) theory on scientific revolutions emphasises the cyclical progression from anomalies to crises, revolutions, and eventual stabilisation into a new "normal science". Together, these theories create a dual lens through which the historical evolution and future potential of Dutch delta management can be critically examined.

In the Dutch context, this approach is further supported and contextualised by Hooimeijer (2014), who delineates the major historical eras of Dutch water management, and Van der Brugge (2009), whose research on transition dynamics in socio-ecological systems highlights the roles of societal adaptation and policy shifts in driving change. Theoretical insights from Hopster (2021) and Kuhn (2012) allow us to understand how disruptions, whether driven by new technologies or natural disasters, challenge and redefine established systems, while Hooimeijer (2014) and Van der Brugge (2009) ground these theories in the specific historical and institutional framework of the Netherlands.

Techno-social disruptiveness

Since the dawn of civilisation, innovations have been central to human survival and progress, shaping not only our experiences but also our relationships with others and the environment. Technology, in particular, has a profound capacity to disrupt established practices, institutions, and belief systems (Van de Poel et al., 2023). While Bower & Christensen's theory of disruptive innovation (1995) primarily addresses market and business contexts, scholars have advocated for expanding this perspective to encompass broader societal impacts. These include disruptions to social relations, institutions, epistemic paradigms, foundational concepts, values, and even human cognition and experience. Hopster's framework (2021) introduces seven criteria for evaluating a technology's "social disruptiveness", broadening the lens through which we understand technological impacts. These criteria are (i) depth of impacts on beliefs, values, social norms and basic human capacities, (ii) range of impacts on a variety of domains, (iii) valence of impacts, which relates to the ability to trigger a strong emotional response, (iv) ethical salience of impacts,

(v) extent of uncertainty in the techno-social dynamics, (vi) pace of change and (vii) reversibility of impacts.

Significantly, technology-enabled radical innovations disrupt not only through competition but also by driving paradigm shifts that fundamentally alter worldviews (Riemer & Johnston, 2019). Drawing on Kuhn's theory on scientific revolutions (2012), as explored by Riemer and Johnston for digital disruption (2019), such paradigm-shifting potential is here used as a lens for analysing the transition within Dutch water management. In this context, technology-driven innovations challenge traditional practices and perceptions, fostering a transformative rethinking of how society interacts with and adapts to water systems.

Kuhn's framework (2012) is adapted to identify anomalies, crises, and revolutions, focusing on events such as policy shifts (e.g., the 1989 Memorandum) and engineering challenges (e.g., the 1993 and 1995 floods). Hopster's framework (2021) complements this by addressing broader societal implications, including transformations in institutions, epistemic paradigms, and values. Together, these theories provide a dual lens through which to examine the interplay between technological advancements, policy adaptations, and societal change. However, the applicability of Kuhn's framework (2012) to socio-technical systems and the operationalisation of Hopster's criteria (2021) require careful adaptation. Kuhn's framework (2012), designed for the hard sciences, assumes abrupt and irreversible paradigm shifts driven by crises, where one paradigm entirely replaces another. However, in the sciences concerned with societal study and the interactions with society and other systems, change tends to be gradual and incremental, with multiple paradigms often coexisting and influencing each other (Thomas & Suleiman, 2019). This is particularly true for areas like delta management, where new practices (e.g., *Living with Water*) integrate with, rather than dismantle, older approaches. Socio-technical transitions are also shaped by cultural, social, and political factors, which Kuhn's science-focused model does not fully address.

Historical framework: fine Dutch tradition

An important aspect of the theoretical frame involves understanding the significant technological and cultural shifts in Dutch water management and urban design. Hooimeijer (2014) identifies six distinct phases, over three periods, that are prompted by new technology, which changed the interplay between urban development and natural conditions (Table 8.1). The *Natural* (–1000), *Defensive* (1000–1500), and *Anticipative* (1500–1800) phases fall under the period of *Amphibious Culture* (Van Dam, 2017), characterised by a landscape filled with lakes and waterways, where amphibious behaviour was a self-evident part, and life took place between wet and dry environments. In this phase, each farmer was also a shipper, and during flood disasters, they could maintain the basic conditions required for a 'normal' life. The *Offensive* (1800–1880) and *Manipulative* (1880–1990) phases belong to the period of *Land Culture*. In the 19th century, new technologies and materials became available. The Industrial Revolution and the introduction of railways changed urbanisation. Water lost its importance for transportation, and humans took control over

Table 8.1 Characterisation of the Fine Dutch tradition per period and phase

Period	*Phase*	*Aspects*
Amphibious culture	Natural and defensive (- 1500) *Ditch and dike*	• Urban 'design' is the expression and the logical result of pragmatic (economic and social) and technical development with the difficult physical geographical circumstances • Urban principles established (closed water soil balance – boezem city with dam and canals) • Vulnerability was turned to profit • The dam; an urban artefact representing the technical, social, and economic conditions
	Anticipative (1500–1800) *Windmill*	• Represented by a dry core, strict control, and relation to the landscape • Consciously planning on the basis of rationality, mutual consultation, and decision-making and the absence of any idealistic expression • Efficiency • Urban plan (building-site preparation – polder city) • Urban engineering • Technological advancement allowing use of bad soil • Technology of balancing water and land is necessary to build a polder city • Urban form is reflecting the necessity for social coherence, military placement and the organisation of public works to be able to realise these plans
Land culture	Offensive (1800–1890) *Steam engine*	• Natural system as master plan • Urban engineer • Urban integral plan (building-site preparation – polder 'pumped' city) • Ability to control the water works and integrate them with other urban projects
	Manipulation, Machine power (1890–1945) *Induction and electricity*	• Start of the disconnection of the urban design from the physical geography • Division between the disciplines • Urban infra plan (building-site preparation and housing projects) • Strict control becomes the Housing Law • Scale increase in organisation, technology • Control of aesthetics
	Manipulation, Man power (1945–1970) *Technical knowledge*	• Disconnection of the urban design from the physical geography • Loss of identity of place • Urban social plan on international ideas (building-site preparation = tabula rasa) • Technocratic approach to efficiency
	Manipulation, Flower power (1970–1990) *Ecological knowledge*	• Reconnection of the urban design with the physical geography • Search for identity of place • Urban identity plan (building-site preparation and nature)
Resilient Culture	Adaptive manipulation (1990–) *Impact knowledge (IPCC)*	• Connection to the climate change projects • Urban sustainable plan (building-site preparation and climate issue) • Adaptability

Source: Hooimeijer, 2014.

nature. The most significant projects exemplifying this control-oriented approach are the Delta and Zuiderzee Works. Since the 1990s, there have not been major technological innovations; rather, there is growing knowledge about the impact of existing technologies, particularly in response to near-flood disasters, which has given rise to the Adaptive Manipulative phase. This phase introduced new paradigms such as 'Living with Water' (De Jong et al., 1995) and 'Building with Nature' (Waterman et al., 1998) to make cities resilient to climate change. The period of *Land Culture* is slowly transitioning to a *Resilient Culture*. Technologies and design are used to reduce vulnerability and improve the quality of life in cities. Interventions in the landscape increasingly embrace natural processes, allowing rivers and coastal dynamics to function more naturally.

Transition dynamics in socio-ecological systems

In the second half of the 20th century, Dutch water management underwent a paradigm shift from a sectoral and technocratic regime to an integrated and interactive one. According to Van der Brugge (2009), this transition was marked by two major policy shifts: first, the integration of water management and ecological development, and second, the alignment of river basin management with spatial planning. The first paradigm shift started during the Delta Works, when ecological concerns became integrated into engineering practices, resulting in measures to mitigate environmental impacts and preserve the ecological balance for the Zeeland estuaries. This change reached a tipping point in 1989, with the *Third Memorandum on the Water Household* (Ministerie van Verkeer en Waterstaat, 1989). Although the floods of 1993 and 1995 temporarily brought the shift back to flood protection, it became evident that natural processes and flood protection could work in synergy, strengthening one another and paving the way for the second shift. Driven by flood disasters and climate change, this shift has made water a central element for spatial planning, which led to the program *Room for the River*. The program was launched to reduce flood risks while integrating ecological restoration and spatial quality. The program sought to restore floodplains, widen riverbeds, and create overflow areas, thereby providing rivers with more natural space to manage excess water. Notable projects included the relocation of dikes, the creation of secondary channels, and the development of flood-resilient landscapes that could also serve as recreational and ecological assets. Beyond its technical achievements, the program represented a broader cultural shift, demonstrating how water management could simultaneously address safety, environmental health, and urban development. *Room for the River* exemplified the principles of the new water management paradigm, integrating water management with long-term spatial planning. This transition was formalised in the *Water Policy for the 21st Century,* introduced in 2000. According to Van der Brugge (2009), this document represents the tipping point of the second shift, establishing a long-term vision for sustainable and adaptive water management in the Netherlands, introducing the principle of 'accommodating water' as a starting point for the new water policy (Ministerie van Verkeer en Waterstaat, 2000).

Synthesis of theoretical and historical perspectives

The integration of delta management with ecology and spatial planning marks a paradigm shift, moving beyond the traditional separation of land and water as distinct and oppositional domains. Historically, land was seen as a space for habitation and production, while water was considered a force to control or exclude. This binary perspective produced traditional solutions such as dikes, polders, and land reclamation. However, the *Living with Water* approach challenges this dichotomy, emphasising the interconnectedness of land and water and proposing innovative ways of inhabiting delta landscapes.

The transitions explored further in this chapter highlight a departure from the rigid, engineered boundaries characteristic of the Delta Works era towards integrated, adaptive approaches that balance engineering, ecology, and spatial planning. These shifts have blurred traditional boundaries, promoting a holistic approach to managing the complex interplay between human settlements and natural water systems.

The theoretical perspectives – Hopster's criteria for techno-social disruptiveness (2021), Kuhn's framework of paradigm shifts (2012), Van der Brugge's transition dynamics (2009), and Hooimeijer's historical phases (2014) – provide tools to critically analyse how floating developments embody both continuity and transformation within Dutch water management traditions. While Hooimeijer's framework situates floating developments within a historical trajectory, Van der Brugge's theory provides a lens to understand the systemic transitions from sectoral, technocratic approaches to integrated and adaptive strategies. Hopster and Kuhn, on the other hand, help assess the degree of innovation and disruptiveness these developments introduce. Together, these frameworks allow floating developments to be understood not just as technical solutions but also as societal, ecological, and cultural phenomena.

The following section bridges these theoretical perspectives with contemporary practices, illustrating how current water management strategies in the Netherlands reflect this ongoing transformation. By critically engaging with these case studies, the discussion evaluates the potential role of floating developments in shaping the future of Dutch delta management.

Showcasing ongoing paradigm shift

The second part of this chapter examines contemporary examples of adaptive water management, highlighting ongoing trends in Dutch delta management. The case studies demonstrate how current approaches challenge the limitations of traditional engineering by incorporating more ecological and flexible methods to address climate change. These examples serve as a bridge, connecting lessons from historical practices to forward-looking strategies for the future.

Although delta management is coordinated at the national level, challenges differ significantly across sea, river, and polder systems, making a system-wide perspective essential. For example, the 1993 and 1995 river floods catalysed the *Room for the River* program (Van Alphen, 2020), introducing a groundbreaking approach to riverine management that extended its influence beyond the Netherlands. This program emphasised giving space back to water and nature, moving from the traditional approach of confining rivers within narrow channels. The success of *Room for the River* offers a glimpse into how working with nature can offer climate adaptive solutions. By allowing the river to flow freely in designated areas, the initiative helped reduce flood risk without building more dikes or dams. Furthermore, the environmental restoration of floodplains and wetlands brought additional biodiversity and water quality benefits, and it marked a transformative shift, paving the way for nature-inclusive strategies in Dutch landscape engineering. Initially addressing the riverine systems, these approaches gradually expanded to encompass polder systems and coastal management.

Over time, numerous projects, pilots, and test sites have emerged across the Netherlands, spanning diverse contexts from river systems to coastal areas. These initiatives exemplify the transition towards adaptive water management and align with the paradigm shift described by Van der Brugge (2009). His research on transition dynamics highlights how integrating ecological development and spatial planning is reshaping the management of land and water systems. The selected case studies showcase this transition, demonstrating the mainstream application of nature-inclusive designs that advance climate adaptation across varied landscapes.

However, these interventions have primarily focused on rural and natural settings, often leaving urban areas underrepresented. At the same time, the urgent need to build new housing and retrofit existing urban environments to improve climate resilience is becoming increasingly evident (Planbureau voor de Leefomgeving, 2009). The future vision for urban landscapes seeks to bridge this gap by integrating nature-inclusive strategies with urban development. In this context, floating structures are emerging as innovative solutions that interact with natural processes such as sedimentation and water flow. These projects reflect advancements in engineering and design but also embody the paradigm shift towards holistic, integrated approaches that blur traditional boundaries between land and water.

The analysis focuses on the following projects: multifunctional dike, double dike, wide green dike, Trintelzand and Marker Wadden, the Sand Motor, and floating developments (Figure 8.1). Together, these projects exemplify a shift from sectoral and technocratic solutions to more integrated and adaptive strategies. Each project reflects the growing emphasis on blurring the boundaries between engineering, ecology, and spatial planning. Furthermore, these initiatives are recognised as innovative and forward-thinking, often setting benchmarks for their respective approaches.

The case studies serve as more than illustrations; they act as a testing ground for the theories, allowing a critical examination of to what extent these projects align with historical trends (continuity) and the degree to which they represent a departure (disruption). Through the theoretical lens, the case studies reveal how these

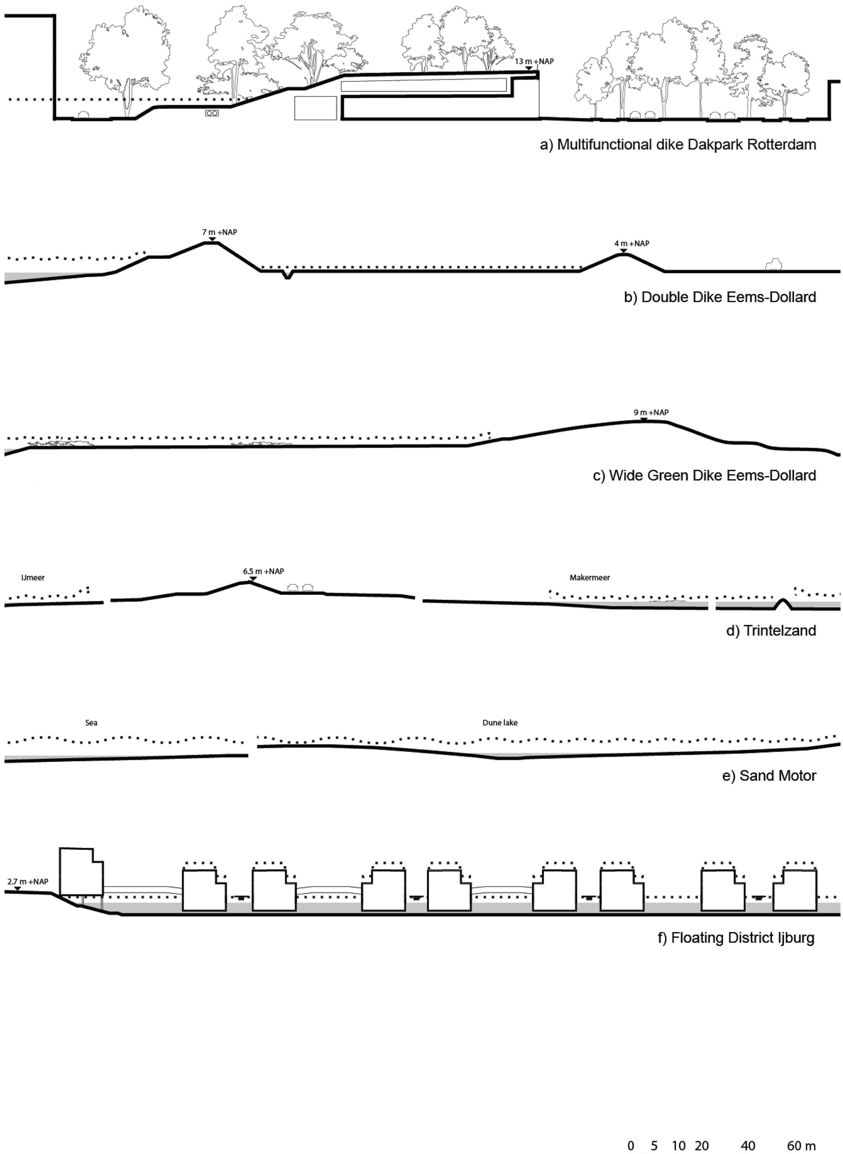

Figure 8.1 Schematic sections of the case studies discussed (a–f).

Source: Barbara Dal Bo Zanon, 2025.

initiatives reflect the paradigm shift towards integrated, adaptive approaches and provide insights into how floating developments, in particular, compare to other projects that embody the principles of *liquid perception* and fuzzy boundaries.

Multifunctional dike

Multi-purpose dikes combine urban functions with flood management infrastructures. In Rotterdam, several multi-purpose dikes have been built (Al, 2022), with the Dakpark being one of the most emblematic examples (Figure 8.1a). Dakpark integrates flood defence, recreation, and commerce into a single structure. It serves as an elevated green space providing recreational areas while simultaneously functioning as a flood barrier, a retail hub, and a parking facility. This project highlights the potential for fuzzy boundaries in urban design, where distinctions between land use categories blur to create integrated, multifunctional systems. It illustrates how green infrastructure can be seamlessly integrated into dense urban environments, supporting both climate adaptation and enhanced quality of urban life.

The Dakpark aligns with the policy shift described by Van der Brugge (2009), exemplifying the integration of water management and spatial planning. Combining flood defence with urban functions, the Dakpark reflects the principles of adaptive water management. Moreover, it shows continuity with Hooimejer's *Adaptive phase* (2014), where flood defence infrastructure is designed to coexist with urban life. While Dakpark demonstrates innovation in its multifunctionality, it represents an incremental improvement rather than a revolutionary paradigm shift. It advances traditional flood management practices by integrating additional functions, but it does not fundamentally disrupt or redefine the perception or implementation of water management.

Double dike

The second case is also a dike transformation, although with a completely different setting and program. The Double Dike project (Figure 8.1b) transforms traditional flood defence by incorporating two parallel dikes with a multifunctional in-between area. It guarantees flood protection while providing space for agriculture, recreation, and nature development. It reflects how flood protection can be combined with spatial and ecological benefits, emphasising a holistic view of water management.

Regarding pure flood protection, double dikes are not necessarily safer than single dikes (Marijnissen et al., 2021). Their value lies in the long-term benefits and multifunctionality they provide. The additional costs of constructing a second dike can be offset by the savings in reinforcing the first dike and the economic and ecological value generated in the inter-dike area over time. The inter-dike area is often used for purposes like nature restoration. Such projects reflect the shift from rigid, single-purpose flood defences to flexible, multifunctional designs that integrate ecological, social, and economic goals. By offering a range of services beyond flood protection, double dike systems embody the idea of fuzzy boundaries, blurring the line between infrastructure and the environment.

The Double Dike validates Van der Brugge's theory (2009) by showcasing integrated water management that combines flood protection with multifunctional use (agriculture, recreation, and ecological restoration). The Double Dike aligns with a past *Amphibious culture* where land and water systems were interconnected. The project challenges the rigidity of manipulative systems (e.g., single-purpose dikes) by creating a flexible space that accommodates multiple societal needs. The Double Dike represents an incremental improvement within the existing delta management rather than a disruptive innovation. It builds on established principles of integrating water management with ecological and spatial planning. While introducing multifunctionality and ecological integration, it does so within current governance and planning frameworks.

Wide green dike

The increasing need to reinforce dikes along the Dutch Wadden Sea coast and, at the same time, to preserve the ecological values of the region have spurred the search for innovative dike designs (Van Loon-Steensma & Schelfhout, 2017). One of these new designs is the Wide Green Dike (Figure 8.1c), which replaces steep, engineered slopes with a broader, gently sloping profile reinforced by vegetation and natural materials. Unlike traditional dikes, which create stark separations between land and water, the Wide Green Dike gently transitions into the surrounding salt marshes. This seamless integration supports biodiversity by mimicking natural coastal processes. The project challenges conventional engineering paradigms and explores how soft, nature-based reinforcements can contribute to long-term flood protection while maintaining the cultural and environmental character of the area.

The Wide Green Dike embodies Van der Brugge's transition dynamics (2009) by integrating flood protection with ecological restoration. Like the Double Dike, it moves beyond the single-purpose, manipulative flood defences of earlier technocratic systems and exemplifies a return to more adaptive practices. Its vegetated slopes recall the earlier *Amphibious phase* of Dutch water management, in which land and water systems were connected through gradual transitions rather than rigid separations.

Despite its innovative features, the wide green dike represents incremental progress rather than a paradigm shift. It aligns with the current paradigm of nature-inclusive projects and does not fundamentally disrupt societal norms or governance frameworks. Instead, it functions as a redefined adaptation within current socio-technical structures.

Trintelzand and Marker Wadden

Projects like Trintelzand (Figure 8.1d) and Marker Wadden, two human-made nature reserves in the Markermeer, highlight the Dutch commitment to nature creation as an integral part of water management strategies. These initiatives focus on restoring ecological balance and biodiversity by constructing artificial islands that support various ecosystems. Islands and wetlands provide habitats for birds, fish, and other wildlife, fostering an ecological network that mirrors natural systems while addressing the environmental degradation caused by past infrastructure projects, such as the construction of the Afsluitdijk (De Leeuw et al., 2024). These projects contribute to ecological restoration by using natural processes such as sediment accumulation and vegetation growth (Xiong & Visser, 2018) to stabilise shorelines and mitigate the effects of rising water levels. They serve as models of adaptive management in which engineering and ecological principles combine to create multifunctional landscapes. This multifunctionality aligns with the concept of fuzzy boundaries, where the distinction between natural and human-made spaces becomes fluid, creating integrated solutions that address both ecological and societal needs.

These projects validate Van der Brugge's theory (2009) by showcasing the integration of ecological restoration with water management. They go beyond traditional flood defences, using natural processes (e.g., sediment accumulation) to enhance resilience while restoring biodiversity. They reflect adaptive practices in which human-made interventions mimic natural systems. Their approach embodies a continuation of the tradition of working together with the parameters of the natural system (Hooimeijer, 2014). Trintelzand and Marker Wadden represent incremental innovations rather than a paradigm shift. Although they refine and expand existing practices, they do not fundamentally disrupt the current paradigm of adaptive, nature-based water management. While Trintelzand and Marker Wadden are innovative, they do not challenge societal norms or governance structures. They work within existing frameworks of ecological restoration and water management, enhancing rather than disrupting current practices.

Sand Motor

The Sand Motor (Figure 8.1e) is a pioneering coastal management project that exemplifies an innovative and sustainable approach to addressing coastal erosion and sea level rise. Instead of relying on traditional hard-engineering methods like building seawalls, the Sand Motor utilises a nature-based approach by depositing approximately 21.5 million m^3 of sand along the coast near Ter Heijde (Luijendijk & Van Oudenhoven, 2019). This large-scale sand deposition works with natural forces – such as wind, waves, and currents – to gradually redistribute the sand along the coastline, reinforcing it over time. The project serves multiple functions. Its primary goal is to enhance coastal protection by creating a dynamic buffer zone that mitigates the impacts of storm surges and rising seas. However, its benefits extend beyond safety: the project creates new habitats for biodiversity, such as dunes and intertidal zones, which support a variety of plant and animal species (De Vries et al., 2015). The Sand Motor reflects the cultural and technical shift in Dutch water management, shifting towards working with nature rather than controlling it (Van Gelder-Maas et al., 2016). It represents a paradigm shift from reactive, engineered defences to proactive, adaptive strategies that balance safety, sustainability, and landscape quality. This innovative approach blurs the traditional distinctions between engineered infrastructure and natural landscapes, creating a dynamic environment where human intervention and natural processes coexist.

The Sand Motor verifies Van der Brugge's theory (2009) by shifting from hard-engineering flood defences (e.g., seawalls) to nature-based, adaptive approaches. It works with natural processes such as sediment redistribution to enhance coastal protection while supporting biodiversity. This project demonstrates continuity with Hooimeijer's *Adaptive phase* (2014), blending engineering with natural processes to create a sustainable system.

The Sand Motor exemplifies an incremental innovation that refines existing nature-based strategies; however, its implications extend beyond immediate technical solutions. By redefining the relationship between engineering and natural processes, it has the potential to influence a paradigm shift in coastal management worldwide. The Sand Motor does not disrupt societal norms or governance structures; instead, it aligns with existing water governance frameworks.

The potential of floating development

Floating developments refer to forms of occupation that make use of buoyant structures as foundations for buildings and infrastructures. The main characteristic of these developments is that they can naturally accommodate water level variations. For this reason, they have recently been proposed as potential alternatives to ensure habitation in areas affected by rising sea levels. Examples of such areas are low-lying coastal regions and Small Island Developing States (SIDS). In these contexts, floating developments could ensure the continuation of life for affected communities. Floating developments have also been proposed for areas facing land scarcity, such as Hong Kong, Singapore, and Monaco (Ang et al., 2020; Callebaut, 2015; Zhao et al., 2024).

While living on floating structures is often regarded as an innovative solution that challenges existing urban systems, it is a practice with centuries of history. Contemporary examples include floating villages in Cambodia, Vietnam, and Peru. In the Netherlands, a country where spatial planning must address the water-rich conditions of the land, floating developments have been part of policy discussions since the early 2000s, beginning with the *Water Policy for the 21st Century* (Ministerie van Verkeer en Waterstaat, 2000). Since then, several floating projects have been implemented throughout the country, including the Floating Pavilion Rotterdam, Schoon Schip, and the floating district in Ijburg, Amsterdam (Figure 8.1f) (Moon, 2015).

Floating developments align with Van der Brugge's framework (2009), illustrating how water management seamlessly integrates with spatial planning. They also echo Van Dam's *Amphibious phase* (2017) as a modern reinterpretation of the historical tradition of accommodating water rather than reclaiming it into land.

From the perspective of Kuhn's framework (2012), floating developments represent incremental advancements within the adaptive paradigm. However, they also hold the potential to catalyse a more significant paradigm shift, depending on their scalability and widespread adoption. Although not yet fully transformative, floating developments could ultimately redefine spatial planning and governance frameworks, especially as climate change intensifies the demand for innovative, adaptive ways of living.

Regarding Hopster's framework (2021), floating developments partially disrupt existing socio-cultural norms by challenging traditional notions of land ownership, habitation, and infrastructure. However, their broader potential to fundamentally disrupt socio-technical systems may become apparent as they scale, posing challenges to governance structures and reshaping societal attitudes towards living environments and property rights.

Discussion

The projects analysed in this study – such as multifunctional dikes, the Sand Motor, Trintelzand, and wide green dikes – demonstrate an evolving trend in Dutch water management. This transformation shifts from rigid, single-purpose infrastructures to multifunctional, adaptive systems that integrate spatial, societal, ecological, and flood management goals. It reflects a shift towards fuzzy boundaries, emphasising zones of interaction rather than fixed edges, fostering resilience and spatial quality.

The examined projects validate Van der Brugge's transition dynamics framework (2009), illustrating the shift from sectoral, technocratic approaches to integrated, adaptive water management strategies. Multifunctional dikes blend flood protection with urban, recreational, and ecological functions, while the Sand Motor and wide green dikes embrace nature-based solutions that harmonise human intervention with natural processes.

These initiatives reflect the Dutch tradition of working with water rather than resisting it, extending historical practices to address contemporary challenges like climate adaptation and ecological preservation. According to Hooimeijer's framework (2014), these projects represent a potential return to adaptive practices rooted in the amphibious culture phase, where human activities coexisted with dynamic water systems. By incorporating fuzzy boundaries and multifunctionality, they deliberately move away from the rigid, manipulative systems of the 20th century. This shift signifies not a break with tradition but a renewed interpretation of earlier adaptive approaches.

Floating developments exemplify this shift, aligning with Deltares' accommodation strategy (2019) by enabling urban systems to adapt to dynamic water conditions. They build on the legacy of Dutch water management by reviving amphibious practices and adapting them to meet contemporary and future needs. By connecting the historical Dutch culture of coexistence with water to modern innovations, floating developments continue the tradition of integrating human habitats with water systems, as demonstrated in earlier Dutch urban planning. Projects like Schoon Schip further demonstrate this continuity by creating water-based communities that address housing and climate change challenges. Normalising water-based living floating developments could pave the way for a *liquid perception* of spatial planning that integrates urbanism with aquatic ecosystems.

Through the theoretical lens, floating developments reveal a nuanced relationship with historical trends in Dutch water management. Within Kuhn's framework (2012) of paradigm shifts, they represent incremental progress, enhancing existing adaptive strategies rather than introducing a revolutionary departure from current practices. However, they hold the potential to catalyse a paradigm shift over time, especially as climate change drives the need for transformative solutions. From the perspective of Hopster's framework on techno-social disruptiveness (2021), floating developments partially disrupt societal norms by challenging entrenched land-water relationships and traditional notions of property and habitation. However, they remain primarily aligned with existing governance structures, serving as a complementary innovation rather than an entirely disruptive force. Their broader potential to redefine socio-technical systems may become more apparent as their adoption scales and societal perceptions of water-based living evolve.

Final consideration

The contemporary shift in delta management emphasises the integration of water, ecology, and spatial planning, moving away from the traditional view of land and water as distinct, opposing domains separated by grey infrastructure. Historically, in the Netherlands, land and water were regarded as a fertile couple without a strict boundary: land was stabilised and drained for habitation and food production, close to water as a resource and for transport. However, as subsidence occurred, this synergy deteriorated into a rigid land-water binary, with water systems posing a threat to the land. Projects like *Room for the River* challenge this dualism by highlighting the historical interconnectedness of land and water, promoting alternative ways to inhabit delta landscapes. This change reflects the concept of *liquid perception*, where fluctuating water levels are embraced rather than resisted, creating fluid, adaptive boundaries.

The cases analysed in this chapter demonstrate how Dutch water management is evolving from rigid, engineered solutions like the Delta Works to more integrated, holistic approaches. These initiatives blur the lines between engineering, ecology, and spatial planning. They embrace a fluid, adaptive understanding of land-water interfaces, creating fuzzy boundaries that intersect with urban planning, societal adaptation, and cultural transformation.

Floating developments embody a forward-looking response to climate change, representing a shift towards urban solutions that may embrace adaptability and resilience. They relate to the historical amphibious, adaptive culture that synergised land and water but shifted to a land-centred perspective due to subsidence. Unlike conventional land reclamation or exclusionary water management, floating developments introduce a new paradigm – rooted in the concept of fuzziness – promoting integration with natural processes and encouraging fluid, adaptive relationships among social, cultural, and ecological systems. This perspective reshapes interactions between these systems by removing disciplinary barriers, encouraging collaboration, and enhancing resilience while addressing societal and ecological needs.

As floating developments gain traction as a climate adaptation strategy, several questions remain. How can these innovations be scaled equitably for diverse communities? What role can they play in addressing urban housing crises while ensuring ecological balance? Additionally, how might they reshape cultural perceptions of living environments, and how can legal and governance frameworks adapt to these new, 'liquid' spatial arrangements?

Despite these challenges, floating developments hold immense potential to redefine urbanisation. By engaging with natural processes, they offer a vision of cities that thrive alongside water and foster a renewed, amphibious relationship in the face of climate change.

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