

The Pilot Paradox in Practice

Nature-Based Pilots in the Eems-Dollard Region



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Summary

In the Eems-Dollard estuary of the northern Netherlands, urgent issues like excessive sediment, ecological decline, and the pressures of climate change have spurred the search for innovative, nature-based approaches to flood protection and land management. Several pilot projects – including the Brede Groene Dijk (Broad Green Dike), Dubbele Dijk (Double Dike), Kleirijperij (a clay ripening initiative), and a smaller offshoot called Rijpdijk – were launched to explore ways of reinforcing dikes and restoring habitats using natural processes. These pilots were motivated by the idea that sediment, traditionally seen as a problem in the turbid Eems-Dollard waters, could become a resource for building stronger, greener flood defenses. Each project tested alternative methods of dike construction, sediment reuse, or tidal habitat creation in an effort to improve climate adaptation and ecological resilience in the region. While early results from these experiments were promising, the challenge remained: how to translate one-off successes into standard practice for regional water management.

This research investigates how these nature-based pilot projects came into existence, how they evolved over time, and what obstacles they face in being scaled up or replicated elsewhere. The central question is how small, experimental projects can grow into long-term, structural solutions. To answer this, the study adopts a case study approach focusing on the four pilots in the Eems-Dollard area. A combination of qualitative methods was used: analysis of policy documents and technical reports, a review of relevant literature, semi-structured interviews with key stakeholders (such as project leaders, engineers, government officials, and local participants), and field visits to the pilot sites. Through these methods, the research pieces together a narrative of each pilot's development and the factors that influenced their trajectory.

Analytically, the study is framed by the concept of the “Pilot Paradox.” This concept highlights a fundamental tension in innovation pilots: they are intended to be experimental and temporary, yet their value often lies in their potential to shape permanent policies and infrastructure. In practice, pilots can become victims of their context – successful on their own terms but difficult to generalize or institutionalize. By applying this framework, the research examines the gap between what each pilot achieved in its local setting and the changes needed for such innovations to be adopted more broadly. In other words, it explores the contrast between short-term experimental success and long-term integration into established systems.

The findings reveal that each pilot project was shaped by a mix of technical, institutional, spatial, legal, and logistical factors. On the one hand, certain conditions enabled these projects to get off the ground. Technical creativity and flexibility in design (for example, adjusting dike designs to use locally sourced clay) proved crucial. Strong coalitions of actors – including water boards, provincial authorities, engineers, and environmental organizations – provided leadership and secured the flexible funding needed to take risks. This collaborative spirit and local enthusiasm lent legitimacy to the pilots and allowed them to proceed despite uncertainties. On the other hand, the projects encountered significant constraints. Regulatory frameworks often lagged behind the experimental approaches, meaning permits and legal approvals became complex and time-consuming. Land ownership and spatial limitations emerged as practical hurdles: for instance, identifying suitable land for sediment drying or for constructing new dike layouts required delicate negotiations with private landowners. Some pilots faced logistical challenges in handling large volumes of sediment and transporting materials, which raised questions about their feasibility at a larger scale. These technical and logistical bottlenecks, coupled with rigid standards for dike safety and environmental protection, limited how far the pilots could go under existing conditions. In short, what enabled each project – innovative engineering, committed partners, and special funding – was often matched by barriers like strict rules, space constraints, and organizational complexity.

A significant observation from the case studies is that the pilots did not follow a fixed plan but evolved through adaptive learning. Each project underwent adjustments as it confronted real-world challenges. For example, the Brede Groene Dijk project initially depended on the Kleirijperij pilot to supply clay from estuarine mud. When acquiring enough land for large-scale clay ripening proved difficult due to fragmented private ownership

and farmer concerns, the project team adapted by initiating the smaller “Rijpdijk” pilot. This sub-pilot experimented with ripening and testing clay directly on an existing dike section (land already under public management), thereby reducing the need for external farmland. Such moments of adaptation demonstrate how pilot teams responded creatively to obstacles: rather than halting the project when problems arose, they found new pathways to keep the innovation alive. These iterative changes provided additional insights and helped maintain momentum, but they also underline how context-dependent each solution was. What worked in one location or moment – like using a dike itself as a test bed – might not easily transfer elsewhere without similar special arrangements.

Despite the successes within the pilots themselves, scaling up these nature-based solutions into regular practice remains an uphill battle. The research identified several factors that make it hard for pilots to “graduate” into full-scale programs. Land ownership issues can hinder expansion; when pilot projects need more space (for instance, to extend a green foreshore or double-dike system), negotiations must reconcile public goals with private rights, often slowing down progress. Regulatory rigidity is another major barrier: environmental and safety regulations, while important for safeguarding standards, are often inflexible in the face of novel approaches. Participants found that existing laws and approval processes were not designed for hybrid infrastructure like tidal wetlands behind dikes or the reuse of dredged material in flood defenses. Securing exemptions or new guidelines required considerable effort and high-level support. Logistical and operational complexities also scale up with project size – moving thousands of cubic meters of sediment or coordinating multiple agencies across a region introduces costs and coordination challenges that were less acute in the contained pilot setting. Furthermore, the continuity of stakeholder coalitions comes into play. Pilots often benefit from a small group of champions and a project-based funding stream. To become a permanent program, these projects need long-term institutional homes, stable financing, and broader buy-in across government and community. If key supporters retire or short-term funding dries up, the transition to full scale can stall. In the cases studied, some pilots managed to secure follow-up funding and policy attention, while others remained isolated showcases with uncertain futures. A clear pattern is that scaling succeeds when there is an alignment of interests among a wide network of actors – from local farmers to national policymakers – and when there is a shared vision to integrate the pilot’s principles into mainstream policy.

In conclusion, this thesis sheds light on the delicate balance between experimentation and implementation in climate adaptation and water management. The “pilot paradox” is evident in the Eems-Dollard region: small-scale projects have demonstrated how working with nature can enhance flood protection and ecosystem health, yet bringing these innovations into the mainstream has proven difficult under existing conditions. The research shows that moving from isolated pilots to structural, long-term solutions requires more than proving a technical concept – it demands changes in institutions, regulations, and mindsets. Successful up-scaling is facilitated by flexible governance that can accommodate new ideas, adaptive legal frameworks that recognize the value of nature-based approaches, and persistent advocacy to maintain momentum beyond the initial excitement of an experiment. Ultimately, the study provides a comprehensive look at why promising pilots sometimes remain one-off successes and what can be done to bridge the gap between innovation and integration. These insights are not only relevant for the Eems-Dollard region but also offer lessons for other areas seeking to turn experimental projects into standard practice in environmental management.

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1

Introduction

The Netherlands faces a dual challenge: safeguarding water security while enhancing ecological value in a highly spatially constrained environment. Annual public investments in flood protection and nature development are substantial, ranging from €0.6 to €1.0 billion, yet they are often planned and implemented in isolation (Sweco, 2021). This fragmented approach results in missed opportunities for spatial coordination, cost-effectiveness, and long-term environmental resilience. In recent years, nature-based solutions (NbS) have gained traction as integrative strategies that work with, rather than against, natural processes to address societal challenges such as climate adaptation, biodiversity loss, and flood risk (Knecht et al., 2024; Seddon et al., 2020). These solutions focus on the protection, sustainable management, and restoration of ecosystems to deliver a wide range of benefits, from improved resilience to environmental hazards to enhanced human well-being (IUCN, 2020). Although widely promoted, NbS are not stand-alone answers; instead, they function best when embedded in broader environmental and policy frameworks. Their strength lies in their ability to integrate ecological restoration with infrastructural, regulatory, and socio-economic components (Knecht et al., 2024). In practice, the implementation of NbS often starts with pilot projects that serve as real-world laboratories. These pilots test the feasibility of theoretical concepts, support long-term monitoring, and help identify pathways for upscaling (Dunlop et al., 2024). However, moving from pilot to practice at scale remains complex. Barriers, including regulatory passivity, fragmented governance, and uncertainty about long-term effectiveness, hinder widespread adoption (Dunlop et al., 2024; Knecht et al., 2024; Vreugdenhil, Slinger, Thissen, & Rault, 2010).

This thesis examines the development and governance of NbS pilot projects in the Eems-Dollard estuary, focusing on the Dubbele Dijk and Brede Groene Dijk. These initiatives aim to address sediment management, flood protection, and ecological restoration. The research examines the factors that enable or hinder the transition from experimental pilots to mainstream environmental policy and planning, to enhance the integration of NbS into future regional strategies.

1.1. Study Area

The Eems-Dollard estuary, located in the northeastern Netherlands along the German border, is a historically dynamic estuarine system shaped by centuries of natural forces and human intervention. Once a peatland gradually cultivated from the 10th century onward, the region suffered increasing vulnerability to flooding due to soil subsidence and coastal erosion. By the 13th and 14th centuries, frequent inundations led to the abandonment of villages. While early narratives described the Dollard's formation as the result of catastrophic storm surges, recent research suggests a more gradual expansion driven by both natural disasters and anthropogenic factors (Knottnerus, 2013). A turning point occurred in the early 15th century when political rivalries prompted the deliberate destruction of dikes and sluices. These actions exacerbated flooding and permanently altered the landscape (Knottnerus, 2013). This history reflects a recurring theme: while environmental change is often framed as an external force, human agency plays a critical role. In earlier centuries, floods

were usually interpreted as divine punishment; however, decisions regarding dike maintenance, land use, and conflict directly influenced their severity.



Figure 1.1: Satellite image of the Eems-Dollard estuary between the Netherlands and Germany (NASA World Wind Landsat 7, Geocover 2000).

Today, the estuary remains a vital ecological zone and a critical interface between nature, industry, and infrastructure. It supports diverse habitats and plays an essential role in regional biodiversity. Yet the area also faces serious challenges, including land subsidence, deteriorating water quality, and sediment overload (ED2050, 2017). The region's socio-economic significance as a hub for agriculture, shipping, and industry makes these pressures even more pressing. One of the most pressing ecological concerns in the estuary is the persistently high concentration of suspended sediment. This hampers light penetration and disrupts primary productivity, with cascading effects on the food web and ecosystem stability (ED2050, 2021). At the same time, spatial demands for navigation, safety, recreation, and economic development exert competing pressures. The fact that the estuary straddles national borders further complicates governance, requiring coordination across jurisdictions and among diverse stakeholders (Brinkman, Riegman, Jacobs, Kühn, & Meijboom, 2014; Dijkstra, 2010; van der Meer, Jolink, & Veendorp, 2021). In light of these intersecting challenges, the Eems-Dollard 2050 (ED2050) program was launched in 2014 (ED2050, 2017). It brings together government bodies, industry partners, and environmental NGOs with the goal of reconciling ecological restoration with economic viability (ED2050, 2018; en Economie in Balans, 2024). Core objectives include reducing sediment loads, creating more space for natural sedimentation, and developing climate-adaptive coastal designs.

Pilot projects are central to ED2050's strategy. These interventions include the construction of a double dike system, the repurposing of dredged sediment for agricultural use, and the creation of tidal zones to promote sediment deposition. These initiatives provide valuable insights into practical constraints and opportunities and are supported by ongoing monitoring (ED2050, 2018). Nonetheless, translating promising pilot results into large-scale implementation is no straightforward task. A growing body of literature highlights persistent obstacles, ranging from institutional rigidity to financing gaps and stakeholder fragmentation, that limit the scalability of NbS (Breman et al., 2017; van Popering-Verkerk & van Buuren, 2017; Vreugdenhil & Rault, 2010). By examining how such barriers manifest in the Eems-Dollard context, this research seeks to advance our understanding of how pilot-based learning can better inform sustainable, integrated estuarine management.

1.1.1. Brede Groene Dijk, Kleirijperij and Rijpdijk

The Brede Groene Dijk, or Broad Green Dike, is an ambitious pilot project located along the northern coastline of the Netherlands, in the province of Groningen, near the Ems-Dollard estuary. It serves as a flagship example of a nature-based solution in Dutch flood risk management, aiming to reimagine the way sea dikes are reinforced by combining traditional safety requirements with ecological restoration, regional material reuse, and landscape-sensitive design. Rather than viewing dike reinforcement solely as a technical challenge, the Brede Groene Dijk embodies a broader shift in the Dutch water sector in which multifunctionality, sustainability, and regional identity take a central role. The project was initiated in response to the official disqualification of the existing sea dike along a 12-kilometre stretch between Delfzijl and the German border (bron = verwijzen naar interview). Like many dikes in the Netherlands, this structure no longer met legal standards for erosion resistance and wave overtopping. Under normal procedures, this would have triggered a conventional reinforcement trajectory, likely involving stone revetments or asphalt surfacing. However, local authorities and stakeholders including the regional water authority, the Province of Groningen, and ecological advisors expressed a shared ambition to develop an alternative. This alternative would have to meet the same safety standards while preserving the open landscape character of the region, avoiding disruptive construction materials, and ideally contributing to the solution of other regional environmental issues. The concept of a green dike, built from local clay rather than imported materials, became the central proposition.



Figure 1.2: Brede Groene Dijk from ED2050 (2021)

What made the proposal particularly compelling was its potential combination with the sediment problem in the Ems-Dollard estuary. The estuary has long struggled with excessive turbidity caused by high concentrations of suspended silt. This turbidity reduces light penetration in the water column, limits primary production, and ultimately degrades the entire estuarine food web. At the same time, dredging is an ongoing and expensive activity in the area, particularly in the harbour of Delfzijl and the Zeehavenkanaal. The logic followed quite naturally: if silt had to be removed anyway, and if dikes needed to be reinforced anyway, then perhaps one problem could be turned into part of the solution for the other (personal correspondence with interviewee 6). Dredged silt, once treated and ripened, could become the raw material for a new kind of dike. One that would be broader, greener, and grounded in the specific ecology and economy of the region. The responsible water board (Waterschap Hunze & Aa's), supported by funding from the national Flood Protection Programme (Hoogwaterbeschermingsprogramma, HWBP), launched a one-kilometre pilot to test this idea in practice. The pilot would not only explore the technical feasibility of using ripened silt for dike construction

but also assess the logistical, ecological, legal, and institutional implications of this approach. The chosen dike profile deviated significantly from conventional standards, featuring a very mild outer slope (1:7 rather than the more typical 1:3 or 1:4). This allowed it to be covered with thick layers of clay and planted with grass. This design aimed to gradually absorb wave energy and enhance long-term erosion resistance by developing natural vegetation. The use of local material was not merely symbolic; it was central to the project's promise of circularity and low-impact infrastructure.

The implementation of the pilot raised a series of practical and institutional questions, beginning with the clay itself. Several sources of silt were considered: dredged material from the harbour, sediment from the salt marshes, and material from a local ecological restoration project known as the Klutenplas. Each of these sources had different physical and chemical properties, and none of them could be used directly. To function as dike clay, the material had to be dewatered, compacted, stabilised, and matured—a process that requires space, time, and careful monitoring. To facilitate this, the project team established a parallel experimental, pilot track known as **Kleirijperij** (clay ripening facility), where silt was subjected to various ripening treatments. These experiments investigated the impact of various drainage methods, vegetative covers, and mechanical interventions on the rate and quality of clay formation. The resulting material was then transported to Deltares' Delta Flume, where full-scale wave simulations assessed its performance under extreme storm conditions. The results were mixed but promising. The ripened clay did not meet standard design criteria under conventional slope angles, but the 1:7 profile proved to be sufficiently resilient to ensure safety under a once-in-10,000-year storm scenario. This finding enabled the project to continue within legal boundaries while remaining true to its green philosophy. In this sense, the pilot demonstrated a valuable kind of adaptive innovation, one that adjusted design parameters in response to material limitations rather than forcing the material to conform to rigid technical standards. It also highlighted the importance of integrating material properties into the early design phase of flood defence infrastructure rather than treating them as downstream implementation details.



Figure 1.3: Kleirijperij from ED2050 (2021)

However, while the technical proof of concept was largely successful, the pilot also revealed serious challenges for upscaling. One major issue concerns logistics and transport. The business case for using ripened local clay hinges almost entirely on proximity. If the clay can be ripened close to the construction site, the process is feasible and cost-effective. If not, the need to transport large volumes of heavy material across weak rural roads by truck quickly becomes prohibitively expensive. In addition, it places unsustainable pressure on local

infrastructure and communities. Pipeline transport is more promising but requires dedicated spatial corridors and up-front investment. This constraint immediately raised a second issue: space. For a full-scale implementation of the green dike, ripening sites would need to be established along the entire 12-kilometre trajectory. The land behind the dike, however, is largely private, owned by roughly a dozen farmers. Negotiations to use this land revealed a range of sensitivities and complications. Three scenarios have been discussed. The first involves lease agreements with landowners, allowing the water authority to establish ripening plots temporarily. The second envisions a decentralised model in which farmers themselves take on the role of clay producers, turning the process into an additional revenue stream. This would require both technical training and a viable market perspective beyond just dike construction. The third scenario; expropriation, has been considered but is politically and legally complex. Expropriation can only be justified when it is the last and only way to meet a legally binding public safety objective. In this case, conventional grey reinforcement using imported clay or stone is still a valid, cheaper fallback option, making expropriation difficult to defend. Moreover, such a step would likely damage the trust and long-term relationships between the water board and the farming community, something all parties are keen to avoid.

Faced with these challenges, the project team initiated a new (sub-)pilot named **Rijpdijk**. This smaller experiment investigates whether clay can be ripened directly on the dike body itself, land that is already under the water authority's jurisdiction. The idea is that if ripening can be done on-site, the need for external space and transport is significantly reduced. The pilot was rapidly implemented using unspent contingency funds from the primary pilot and represents a key example of adaptive experimentation. If successful, it could remove one of the biggest bottlenecks in scaling the green dike concept and provide a more autonomous model for material integration in flood defence projects.

Despite these innovations, the Brede Groene Dijk remains a fragile success. It stands as a powerful symbol of what integrated, circular, and ecologically sensitive infrastructure could look like. But it also illustrates the complexity of moving from isolated pilots to mainstream policy. The institutional, financial, and spatial systems that govern flood protection in the Netherlands are not yet fully equipped to absorb such bottom-up innovations. The pilot benefited from exceptional conditions, including flexible funding, motivated leadership, and temporary governance arrangements that enabled experimentation. Whether these conditions can be institutionalised remains an open question. In sum, the Brede Groene Dijk represents a meaningful step toward a more holistic approach to dike reinforcement, one that integrates safety, ecology, and local identity. At the same time, it reveals the many dependencies (i.e. on land, actors, logistics, and regulation) that shape the feasibility of such innovations. As such, it is not only a case of material innovation but also institutional navigation. It provides a valuable lens through which to study the interplay between spatial design, environmental policy, and the everyday realities of flood risk management in a rapidly changing world.

1.1.2. Dubbele Dijk

The Dubbele Dijk (Double Dike) is one of the most distinctive and experimental flood protection projects ever undertaken in the Dutch coastal zone. Located along the north-eastern shoreline of the province of Groningen, near Bierum and the Eemshaven, the project comprises two parallel dike bodies enclosing a spacious intermediate zone. This middle area has been designed not merely as a buffer zone for water safety, but also as a testing ground for ecological restoration, innovative sediment use, saline agriculture, and novel land governance. While in physical form it resembles a dike reinforcement, the Dubbele Dijk is more accurately described as a multifunctional pilot landscape, intended to explore what future coastal adaptation could look like in a context of sea-level rise, sediment excess, land-use change, and policy experimentation. The project originated from the need to reinforce an ageing dike section that no longer met modern flood protection standards. However, rather than opting for a straightforward upgrade, the province (Groningen) and water board (Waterschap Noorderzijlvest) saw an opportunity to rethink the function of dike space altogether. The idea was to allow for natural sedimentation between the two dikes, enabling the coastal foreland to "grow along" with sea level rise over time. This principle of Building with Nature aimed to support long-term adaptive capacity by turning sediment, usually considered a problem, into a developmental resource. The design also allowed room for additional uses, such as aquaculture, saline crop trials, and recreational elements. As such, the Dubbele Dijk reflected a broad and ambitious logic of multifunctionality, integrating flood risk reduction, sediment management, land innovation, and ecological experimentation in a single concept.

At the technical level, the project consists of two dike bodies: an inner dike (landward side) and an outer dike (seaward side), creating a controlled in-between zone of roughly 37 hectares. This area was intentionally left lower and accessible to tidal influence through a getijdenduiker (tidal culvert), which allows brackish water and fine sediment to enter and settle. Over time, the sedimentation process would raise the elevation of the area, offering both ecological habitat and raw material for future dike maintenance or reinforcement. This approach aimed to simulate natural accretion processes under controlled and measurable conditions, providing valuable insights into the feasibility of sediment capture in artificial forelands. The ability to pilot such processes in real-world conditions was seen as a critical step toward addressing the growing challenge of sediment management in the Ems-Dollard estuary, where high turbidity has had significant ecological impacts.



Figure 1.4: Dubbele dijk from ED2050 (2021)

While the design and ambition of the Dubbele Dijk were widely praised as forward-looking, the implementation process revealed considerable complexity, especially in the legal, financial, and administrative domains. One of the most contentious aspects of the project was the land acquisition strategy. Because the land required for the dike and intermediate zone was privately owned, and because the preferred location involved a single landowner with a large, continuous parcel, negotiations focused on establishing an *erfpachtconstructie* (a long-term leasehold arrangement). The province explicitly ruled out expropriation as a tool, emphasising voluntary cooperation and stakeholder consent. This choice, while politically cautious, significantly weakened the province's negotiating position. In the absence of alternative landowners willing to participate, and with mounting time pressure to realise the pilot, the landowner was able to secure favourable conditions. No formal land valuation or taxation was conducted before the agreement. Instead, the financial arrangements were based on optimistic revenue projections for the experimental activities to be carried out in the intermediate zone, primarily aquaculture and saline agriculture. These projections, provided by interested businesses, formed the basis for the leasehold payment scheme. As later confirmed by independent evaluations, these forecasts were highly uncertain and unlikely to be realised at the projected scale or profitability. Indeed, by 2022, minimal economic activity had materialised in the area, and the expected returns had not been achieved. At the same time, the public sector had already committed substantial resources to land leasing, infrastructure development, and future obligations such as land restoration after the pilot ends in 2042. This situation raised questions about the legality and legitimacy of the financial structure, particularly in relation to EU state aid rules. Experts consulted by the Northern Audit Office (Noordelijke Rekenkamer) concluded that the arrangements likely qualified as unlawful state aid, due to the lack of market-conforming valuation and the absence of

a robust, independent assessment of expected economic benefits. The case demonstrated how experimental governance, when not paired with strong procedural safeguards, can drift into grey legal territory. It also highlighted the tension between policy innovation and legal accountability, particularly when pilots are developed under urgent conditions without a thorough exploration of alternatives.

The experimental activities within the intermediate zone also proved more complex than initially assumed. Saline agriculture and aquaculture require specific ecological and hydrological conditions, as well as market demand and logistical infrastructure. Delays in the construction of the tidal culvert meant that the sedimentation process could not start on time, thereby postponing ecological development and reducing the attractiveness for private operators. Moreover, some envisioned activities were only viable with continuous public co-financing, making the longer-term business case uncertain. These complications highlight the difficulty of designing multifunctional land use in practice, particularly when ecological dynamics and commercial feasibility are deeply intertwined. Despite these complications, the Dubbele Dijk has achieved several important outcomes. First, it provided a concrete example of how space for sedimentation and ecological development can be integrated into flood protection infrastructure. Second, it facilitated learning across sectors (i.e. engineering, agriculture, and environmental planning) on the conditions under which multifunctionality can be effective. Third, it prompted a discussion about governance models for adaptive coastal management, particularly in contexts where spatial claims and policy ambitions intersect in complex ways.

In summary, the Dubbele Dijk represents both a bold experiment and a cautionary tale. It pushed the boundaries of what flood protection can entail, showcasing the potential of combining physical infrastructure with ecosystem services and innovative land use. At the same time, it revealed the institutional vulnerabilities of such approaches, including legal uncertainty, overreliance on optimistic projections, and insufficient integration into existing governance frameworks. Like many pilots, it flourished under conditions of temporary flexibility and exceptional support, but whether those conditions can be scaled or sustained remains an open question. As with the Brede Groene Dijk, the Dubbele Dijk raises fundamental issues about how spatial innovation is initiated, governed, and legitimised in a context of increasing environmental urgency.

1.1.3. Regional impact

A key focus of this research is not only to examine the two selected case studies, analyzing their scaling strategies and implementation plans, but also to assess the cumulative impact of multiple pilot projects. This broader perspective aims to determine how deploying numerous pilots contributes to the overarching regional objective of balancing economic and ecological interests. Key questions include whether these individual projects already generate significant improvements, the extent and nature of scaling required, and whether their integration within the ED2050 program follows a deliberate strategy or has emerged more organically. Additionally, it is crucial to explore whether the substantial upscaling of specific initiatives, such as DD, is necessary to achieve the intended regional goals.

1.2. Stakeholders & institutions

A multi-actor perspective is essential to analysing the complex policy problem of integrating locally sourced sediment into dike reinforcement strategies in the Eems-Dollard estuary. Following [Enserink et al. \(2010\)](#), relevant stakeholders have been identified and characterised according to their perceptions, values, and resources. These stakeholders represent a diverse mix of governmental bodies, expert consortia, research institutes, and civil society actors, each contributing their framings and priorities to the policy arena.

Among the primary actors are the regional water boards, **Waterschap Hunze en Aa's** and **Waterschap Noorderzijlvest**, which lead the Brede Groene Dijk and Dubbele Dijk pilots, respectively. These actors possess both high power/influence and high interest as they are directly responsible for flood safety in the region and are committed to innovative, sustainable dike concepts. Their framing combines technical reliability with ecological opportunity, particularly by reusing sediment from the Eems-Dollard estuary. **POV-DGG (Project Overstijgende Verkenning - Dijkversterkingen met Gebiedseigen Grond)** functions as an innovation and knowledge-sharing platform. While not directly implementing projects, its coordinating role and access to national innovation agendas give it substantial influence. **Rijkswaterstaat** and the **Ministry of Infrastructuur & Water Management** are critical institutional players due to their role in regulatory approval and alignment

with *Natura 2000* and *PAGW* (Programma Aanpak Grote Wateren) policies.

Other stakeholders include the **EcoShape** consortium, a public-private partnership promoting 'Building with Nature' principles, and technical consultancies such as **Arcadis**, **RPS**, and **Deltares**, which provide essential data and design support. **The Province of Groningen** also holds significant influence as a spatial planning authority, seeking to balance economic decline, land use, and ecological restoration. Civil society organisations and NGOs, particularly those involved in environmental advocacy, such as *Natura 2000* stakeholders, are less powerful but still hold significant influence. Residents and farmers represent actors with lower institutional power but potentially high interest, especially concerning land use change, transport impacts, and involvement in pilot areas.

The institutional context surrounding the Eems-Dollard pilots is characterised by an interplay of formal rules, procedural frameworks, and informal norms that govern how decisions are made and by whom. The starting point is the classification into three institutional dimensions as discussed by (Enserink et al., 2010).

1. Regulatory and Legal Frameworks

Projects such as the *Brede Groene Dijk* and the *Dubbele Dijk* must comply with strict national safety standards for flood protection (e.g. WBI 2017), *Natura 2000* regulations, and environmental permit procedures. Using non-standard materials (e.g. ripened clay from estuarine sediment) challenges these frameworks, prompting negotiations with Rijkswaterstaat, the Ministry of I&W, and sometimes the European Commission. Procedures like the MIRT-Verkenning and Environmental Impact Assessment (EIA) are also key in developing projects.

2. Organisational Structures and Competencies

Multiple layers of government, national (e.g. Rijk, Rijkswaterstaat), regional (provincie), and local (waterschappen, gemeenten) share responsibility over spatial planning, flood protection, and ecological restoration. Institutional overlap often leads to coordination challenges and opportunities for integrative governance. The *waterschappen*, although highly competent in technical water management, must collaborate closely with provinces and ministries when projects touch upon spatial development or *Natura 2000* areas.

3. Informal Institutions and Decision Cultures

Dutch water governance is shaped by a *polder model* tradition emphasising consensus, deliberation, and participation. Platforms such as POV-DGG and ED2050 embody this culture by bringing together stakeholders in a semi-formal learning and decision environment. However, institutional innovation (e.g. including ripened clay in safety models) often requires "policy entrepreneurship" to bridge formal rigidity and informal willingness to innovate.

Pilot Paradox

Despite their ambition and potential, these pilots also highlight a persistent governance dilemma: the so-called "pilot paradox" (Bremner et al., 2017). While pilots are praised for their experimental value and learning potential, they often struggle to translate localised success into structural, system-wide change (Vreugdenhil, Frantzeskaki, Taljaard, Rault, and Slinger (2009)). The *Brede Groene Dijk* and *Dubbele Dijk* are exemplary in this regard. Both pilots are spatially innovative, ecologically ambitious, and well-supported by public-private coalitions. Yet their replication or embedding into broader water management and spatial planning systems remains uncertain. One key issue lies in the institutional environment in which pilots operate. Because these projects are often initiated under temporary frameworks, exceptional funding conditions, and with limited procedural constraints, they risk becoming isolated showcases rather than catalysts for structural change. The *Kleirijperij*, for instance, presents a compelling example of circular material reuse, yet the structural integration of its clay production model into national dike reinforcement policy is still uncertain. Similarly, the *Dubbele Dijk* demonstrates how multifunctional land use can be aligned with flood defence, but follow-up investments and institutional alignment remain vulnerable to shifts in political will and funding cycles. This disconnect is amplified by the short-term nature of political and administrative planning horizons, often shaped by four-year electoral cycles, while sediment processes and ecological recovery span decades. Furthermore, scaling nature-based solutions like those tested in the Eems-Dollard region requires not only technical feasibility but also long-term policy commitment, regulatory adaptation, and stable financing mechanisms.

This research therefore examines not only how these pilot projects are designed and implemented, but also under what conditions they can be scaled or institutionalised. Understanding these enabling or constraining factors is crucial for turning isolated innovations into lasting strategies for climate adaptation and ecological resilience.

1.3. Scope and Objective

This research explores the steps taken in developing the ED2050 program, assessing the practical measures implemented to address the key challenges of the time. Rather than examining current processes or challenges within the program, the study focuses on the historical trajectory that led to its present state, with particular attention to three to four pilots in the region: Dubbele Dijk, Brede Groene Dijk, Kleirijperij, and Rijpdijk. In doing so, it does not engage with current or ongoing policy and governance discussions related to the pilot projects. Instead, it analyzes the role of various pilot project initiatives in shaping the ED2050 program as it stands today, offering insights into its evolution and development. Although ongoing governance discussions are not the primary focus of this research, this study aims to contribute to them. Current governance debates centre on strategies for scaling up various pilot projects. The final chapter will identify potential dilemmas related to the upscaling process and provide insights into the challenges that must be addressed in developing effective scaling strategies.

Scientific Relevance

Pilot projects have become a central instrument in sustainability transitions, particularly within sectors that are technically conservative and institutionally rigid, such as flood risk management. In academic literature, pilots are understood not only as sites of technical experimentation but also as arenas in which actors negotiate new ideas, build coalitions, manage uncertainties, and challenge existing norms (SOURCE). However, the assumptions surrounding pilots as neutral, learnable, and scalable are increasingly questioned, leading to the notion of the “pilot paradox” (Vreugdenhil & Rault, 2010). This paradox refers to the tension between the ambition to experiment and the systemic barriers that keep pilots context-dependent, non-replicable, and politically bounded. This study contributes to this growing body of work by offering an in-depth empirical exploration of two Dutch pilot projects: the Brede Groene Dijk and the Dubbele Dijk. Both are developed within the Eems-Dollard 2050 programme and aim to test the feasibility of using locally sourced, non-standard soil in dike reinforcement. Rather than evaluating their outcomes in terms of technical success alone, this research investigates the broader social, institutional, and procedural dynamics that shaped their development: What conditions enabled these pilots to emerge? What ideas, actors, and uncertainties influenced their trajectories? And which factors contributed to, or hindered, their perceived success?

Through this focus, the thesis takes up recent calls in the literature for more grounded, case-based studies that move beyond idealized narratives of experimentation. It engages directly with the inner workings of pilot governance: the emergence of legitimacy, the management of risk, the formation of temporary alliances, and the translation of local learning into institutional change. In doing so, it also reflects on the role of contextual specificity, e.g. the sediment issues in the Eems-Dollard estuary, or the institutional culture of Dutch water authorities, in shaping what a pilot can become. By identifying cross-cutting themes, such as uncertainty tolerance, leadership, technical flexibility, or narrative framing, that appear to influence the development paths of the Brede Groene Dijk and Dubbele Dijk, this research seeks to contribute to the refinement of pilot theory. It complements transition studies and policy science by asking not only what pilots do, but what makes them possible in the first place. The scientific relevance thus lies in the empirical unpacking of the pilot-as-process rather than pilot-as-instrument, advancing our understanding of experimentation as a dynamic and contested practice within real-world governance settings.

EPA relevance

The development and implementation of pilot projects in the Ems-Dollard estuary are deeply embedded in the core themes of Engineering and Policy Analysis (EPA). This region represents a highly complex socio-ecological system where hydromorphological dynamics, ecological degradation, economic interests, and regulatory frameworks intersect in unpredictable ways. Understanding how innovative pilots like the Brede Groene Dijk and Dubbele Dijk emerge, evolve, and (sometimes) scale requires integrated thinking across technical, in-

stitutional, and behavioral dimensions, which is a hallmark of the EPA approach. This thesis engages directly with EPA-relevant methods and perspectives by analyzing how pilot projects function as interventions within a dynamic system under deep uncertainty. The study takes a systems perspective by tracing the feedback loops between technical innovation, actor coalitions, institutional norms, and environmental targets. It also emphasizes the role of governance processes, stakeholder framing, and decision-making under ambiguity, thereby aligning with core EPA concepts such as multi-actor modeling, transition governance, and policy learning. Moreover, by focusing on why certain pilots gained traction while others stalled, the research contributes to a better understanding of experimentation as a tool for adaptive governance, a challenge central to contemporary environmental policy design. The findings aim to inform decision-makers not only about the technical feasibility of such projects, but about the procedural and political conditions that make successful upscaling possible. In this way, the thesis provides insights with broad relevance for complex, multi-actor transition processes far beyond the Dutch delta, resonating with EPA's interdisciplinary mission to bridge engineering analysis and strategic policy advice.

1.4. Research Question

As discussed, pilot projects are widely used to explore and demonstrate innovative responses to complex environmental and governance challenges. Within the field of Nature-based Solutions (NbS), pilots are increasingly promoted as a way to experiment with adaptive strategies in response to climate change, ecological degradation, and land-use transitions. However, despite their strategic role in innovation, the function of pilot projects within long-term governance processes remains ambiguous. The literature has highlighted a persistent tension known as the Pilot Paradox: pilots are intended to be temporary and experimental, yet their success often depends on their ability to influence or become embedded within permanent policy frameworks. While much attention has been given to the outcomes or impacts of pilot projects, comparatively little is known about the processes through which they are initiated, how they evolve over time, which actors shape them, and what barriers or enablers affect their trajectories. As a result, questions remain about how and why certain pilots transition into structural solutions, while others remain isolated or stall. To address these gaps, this thesis examines four NbS pilot projects in the Eems-Dollard estuary region; the Brede Groene Dijk, Dubbele Dijk, Kleirijperij and Rijpdijk as in-depth case studies. Rather than evaluating their technical success alone, the research focuses on the conditions under which these pilots were developed, the governance dynamics that shaped them, and the dilemmas they encountered in attempts to scale or institutionalize their results. This leads to the following research question:

How did the pilot projects in the Eems-Dollard region come into existence, evolve over time, and what challenges do they face in upscaling?

Sub-questions:

1. How did the design and implementation of these pilots evolve over time?
2. What barriers and enablers influenced the initiation and progression of these pilots?
3. What governance dilemmas are emerging in the upscaling of these pilots?

This thesis is conducted in collaboration with Deltares as part of an internship within the NL2120 project. NL2120 is a long-term initiative that has brought together governments, nature organisations, engineering firms, dredging companies, and knowledge institutions over the past decade to advance nature-based solutions for climate adaptation, nature-inclusive agriculture, biodiversity restoration, and sustainable housing. The pilot projects studied in this research (Brede Groene Dijk, Dubbele Dijk, Kleirijperij and Rijpdijk) are all examples of nature-based solutions to enhance ecological and socio-economic sustainability in the Eems-Dollard region. By analysing how these pilots emerged, evolved, and faced challenges in scaling up, this research can contribute valuable insights to NL2120.

Changing policy

During the research process, significant new developments emerged that are not fully integrated into the main text. These relate to recent changes in European policy, which strongly affect the legislative and governance

context of the case studies in this thesis. To provide clarity, the implications of these policy changes are assessed separately in Appendix A. Importantly, this does not render the current research outdated: the research questions and methods remain valid and highly relevant. Instead, the additional analysis highlights the evolving nature of the governance context and underlines the complexity in which these topics must be understood.

2

Literature Review

Pilot projects are widely used in water management and climate adaptation as small-scale experiments to test innovative ideas in a controlled setting (Buuren et al., 2016; Vreugdenhil & Rault, 2010). They allow practitioners to try out new approaches, for example, novel flood defences or freshwater management techniques, on a limited scale before implementing them more broadly. In the Netherlands, pilot projects have been adopted as a means to address complex challenges such as sea-level rise, salinisation, and increased rainfall (Vreugdenhil & Rault, 2010). It is common for studies on water and climate issues to recommend launching a pilot before rolling out a full policy or project. For instance, in the province of Zeeland, pilots have been set up to combat agricultural drought by testing innovative drainage and water storage techniques in “Living Labs” (Beirnaert, Locker, Ooms, & Vervelde, 2025). These pilots generate practical insights in collaboration with farmers, researchers, and authorities, with the hope that successful innovations can later be scaled up across the region (Beirnaert et al., 2025).

Given their promise, pilot projects are often accompanied by high expectations. Policymakers and engineers view pilots as “safe spaces” to learn about an innovation’s real-world performance and to build stakeholder support, all while mitigating the risks associated with immediate full-scale implementation (Buuren et al., 2016). Pilots are typically set up somewhat at arm’s length from formal policies, granting freedom to experiment with fewer bureaucratic constraints (Buuren et al., 2016). They also tend to receive extra resources (i.e. time, funding, and expertise) to maximise their chances of success (Buuren et al., 2016). The underlying hope is that a successful pilot will produce valuable knowledge and demonstrate the value of an innovation, thereby paving the way for broader adoption in policy and practice.

2.1. Roles and uses of pilot projects

What exactly is a “pilot project”? In practice, the term can mean different things to different people (Vreugdenhil & Rault, 2010). Generally, a pilot is a temporary, controlled implementation of an innovation, whether a new technology, policy measure, or management approach, intended primarily for learning and demonstration rather than for delivering long-term outcomes. Vreugdenhil and Rault (2010) note that pilots are used for many purposes: from truly experimenting to simply showcasing a concept, or even as a political delay tactic. In their study of Dutch water management pilots, Vreugdenhil and Rault (2010) identified multiple roles and types of pilots, introducing a framework to capture the diverse objectives that pilots can serve. For example, some pilots are set up to generate evidence for decision-making, while others are designed to build networks and capacity. Yet, others are tasked with providing a proof-of-concept for a novel approach.

Despite this diversity, a common thread is that pilot projects are intended as learning instruments. They operate in a “real-world laboratory” style: implementing an intervention in a confined setting to observe the innovation–context interaction and glean lessons for improvement (Vreugdenhil & Rault, 2010). In water management, pilots often involve multiple stakeholders (engineers, water authorities, local communities, researchers) working together in a multi-actor context. Such collaboration can facilitate social learning (e.g. stakeholders

jointly interpreting results and learning about each other's perspectives), which is crucial for complex water issues. Ideally, a pilot yields not only technical data but also insights into governance, stakeholder acceptance, and practical implementation challenges.

Over time, enthusiasm for pilot projects has been tempered by more critical evaluations. While pilots are expected to produce learning and drive policy innovation, studies have found that they often fall short of influencing mainstream policy (Vreugdenhil & Rault, 2010). In some cases, pilots generate interesting results and even positive outcomes locally, but these outcomes do not translate into any lasting change beyond the pilot itself. A telling (and slightly cynical) adage in international development circles captures this disconnect: "*pilots never fail, but they never scale*" (Buuren et al., 2016). In other words, almost every pilot can be proclaimed a success on its terms, yet many are never replicated or institutionalised.

Academic evaluations echo this concern. For instance, a review by De Groen et al. (2004) concluded that many pilot projects amount to nothing more than learning from failure – valuable lessons, perhaps, but ineffective as instruments for policy innovation (Vreugdenhil & Rault, 2010). Similarly, Sanderson (2002) found "no policy learning took place" in the pilots they studied; they were treated as one-off demonstrations or even as distractions rather than steps toward the new policy. Sanderson warned that the pilot project label could be abused, giving a false appearance of progress while deferring real change (Sanderson (2002); Vreugdenhil and Rault (2010)). Also, (Nair & Howlett, 2014) stresses that pilot projects can be used for political gain, either to enhance political legitimacy or, on the other hand, to be abandoned as failures if the political climate turns unfavourable. These critiques highlight a gap between the high hopes placed on pilots and their often modest real-world impact on policy and practice. The disparity suggests that running a good pilot is not enough; what matters is what happens after the pilot. This realisation has led researchers to examine more closely how pilot results can be transferred, scaled up, or embedded into broader governance.

Notably, Dutch water management experts observed that the effectiveness of pilot projects is hindered by a range of barriers that prevent their lessons from diffusing. Vreugdenhil and Rault (2010) identified five major hurdles that commonly limit the impact of pilots

1. **Limited Representativeness:** Pilot conditions and results may not be fully applicable to other sites or the "real world." By design, pilots often use confined scales (to reduce risks) or extra resources, which can make their outcomes appear too context-specific or idealised compared to standard projects. Stakeholders may doubt whether the innovation would work under normal budget, scale, or complexity conditions. In short, what works in a carefully supported pilot might not work in a typical implementation, undermining the pilot's persuasive value.
2. **Limited Learning:** Sometimes, the knowledge gained in a pilot doesn't effectively reach those outside the pilot team. Causes include short pilot durations, inadequate monitoring, or difficulty attributing outcomes to the intervention. Essential lessons may remain tacit or siloed among pilot participants. Vreugdenhil and Rault (2010) found cases where pilot teams grew enthusiastic and knowledgeable but failed to transfer that enthusiasm or know-how to other decision-makers. Without mechanisms for broader social learning or knowledge dissemination, a pilot's insights can be lost in reports rather than informing future projects.
3. **Lack of Institutionalisation:** Innovations tested in pilots often lack a path into the standard "toolbox" of policies or measures. Agencies tend to stick to approved solutions; if the pilot's approach hasn't been officially accepted (e.g. added to regulations, design codes, or funding schemes), it won't be adopted. In water management, for example, a new dike design piloted by one regional water board may not be adopted elsewhere unless it receives formal approval or is included in national guidelines. Without institutional embedding, pilots risk remaining curiosities.
4. **Poor Timing:** A pilot might miss its window of opportunity. By the time the pilot finishes, the policy climate may have shifted, so there is no appetite to use its results. For instance, an innovation could become irrelevant if regulations or priorities changed while the pilot was running. This "poor timing" hurdle means pilots need to align with policy cycles; otherwise, even a technically successful pilot might arrive too late to influence decisions. Conversely, a pilot that comes too early, before a felt need is evident, might also be ignored.

5. **Wait-and-See Attitude:** Finally, diffusion often falters due to a passive approach by those who ran the pilot. Some pilots operate under the assumption that if the results are promising, adoption will naturally follow. In reality, active efforts are needed to champion the pilot's outcomes. If pilot organisers only start thinking about scaling after the pilot ends (a common practice), it might be too little, too late. This "wait-and-see" mindset can lead to missed opportunities, as no one takes ownership of driving the innovation forward.

These challenges show that moving from a one-off pilot to widespread change is not automatic. The very features that make pilots attractive for internal success (i.e. their flexibility, protection, and singular focus) may set them up for external failure. This central tension has been dubbed the "Pilot Paradox." (Vreugdenhil & Rault, 2010).

2.2. The Pilot Paradox: Internal vs. External Success

The Pilot Paradox refers to the ironic observation that "the conditions required to achieve internal success run counter to the conditions required to achieve external success." (van Popering-Verkerk et al., 2020). In other words, the factors that help a pilot project succeed on its terms often hinder its adoption in the broader policy regime. Vreugdenhil and colleagues articulated this concept, and it is now a key focus of research on climate governance experiments (Buuren et al., 2016; Vreugdenhil & Rault, 2010). As one researcher put it, the pilot paradox explains "why it is complicated to implement the results of pilots that have been set up to achieve great internal success."

Several examples illustrate these opposing conditions. A pilot project typically thrives with creative, entrepreneurial staff who think outside the box, whereas implementing a new approach at scale may require persistent, bureaucratic savvy staff who work within established rules (van Popering-Verkerk et al., 2020). During a pilot project, teams are given plenty of "room for experimentation". They can deviate from standard procedures and regulations to try something new (Buuren et al., 2016). But when scaling up, that innovation must "tie in with existing rules and views," fitting the norms of the wider organisation and regulatory framework (van Popering-Verkerk et al., 2020). Likewise, pilots deliberately start small to stay manageable and minimise risk, whereas full implementation must eventually occur at large scales to have a real impact. These contrasts mean that a pilot optimised for internal success (novelty, freedom, sufficient resources, a tight-knit team) may produce results that are mismatched with the realities outside the pilot.

Internal success refers to the effective execution of the pilot itself—achieving intended outcomes, gaining new knowledge, and fostering innovation. In contrast, external success refers to how pilot outcomes are adopted, scaled, and integrated into broader policy and practice. The literature identifies key conditions influencing this dynamic (Breman et al., 2017; Buuren et al., 2016; van Popering-Verkerk et al., 2020; Vreugdenhil et al., n.d.). For instance, organisational distance allows pilots to innovate by operating independently of formal structures, yet external success requires embedding within these organisations to facilitate adoption. Similarly, while small, like-minded coalitions promote rapid learning within the pilot, broader, representative stakeholder involvement is essential to legitimise outcomes for scaling. The relationship to policy follows a comparable pattern: distancing from existing policy frameworks enables experimentation, but alignment with policy is crucial for institutional uptake. Other conditions, such as scope, resource allocation, leadership, and ownership, also exhibit this tension. Pilots often benefit from a narrow scope, targeted resources, strong directive leadership, and clear team ownership to ensure success. However, external success demands engagement with real-world complexity, reliance on regular resources, distributed leadership, and shared ownership to ensure legitimacy, continuity, and long-term integration. In the figure below, the conditions for internal and external success for pilots are visualised.

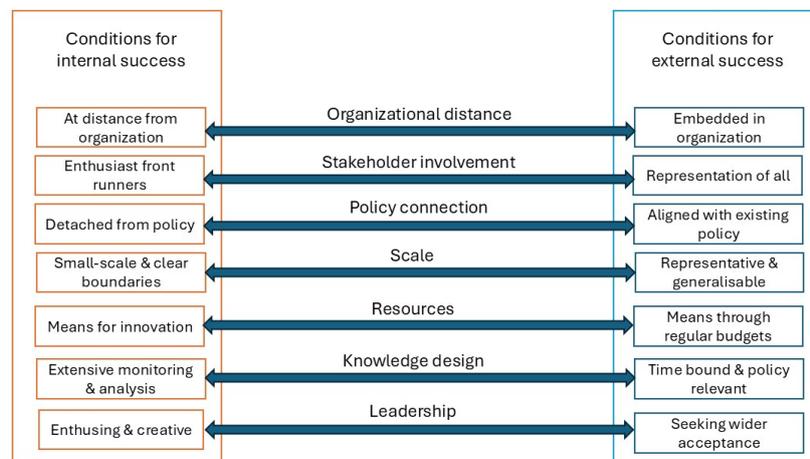


Figure 2.1: Conditions for internal and external success for pilots (Adapted from (Breman et al., 2017; van Popering-Verkerk et al., 2020; Vreugdenhil et al., n.d.)

This inherent tension explains why so many pilots stop at the “proof-of-concept” stage. Researchers examining Dutch climate adaptation pilots between 2010 and 2016 found that in the majority of cases, “a high score on the conditions for internal success goes along with low scores on conditions for wider uptake.” (Buuren et al., 2016). In other words, the more a pilot was optimised to succeed in its bubble, the less its outcomes were adopted outside that bubble. For example, a Zeeland pilot known as Water Farming Walcheren (aimed at improving freshwater availability for farmers on the island of Walcheren) was very successful on its terms; it had a custom process, engaged eager local stakeholders, and showed positive results. Yet it exemplified the pilot paradox: “organised at a far distance from water authorities”, with a process wholly tailored to the pilot, it struggled to embed its innovations into the standard practices of those authorities (Buuren et al., 2016). The pilot’s distance from the dominant values and norms of the water management regime became a “weakness,” limiting broader uptake. In this case and others, the pilot’s internal triumph contained the seeds of external difficulty.

It is important to note that the pilot paradox is not inevitable – it’s a tendency, not a universal law. Some pilots manage to navigate the tension. Success tends to occur when a pilot deliberately balances internal experimentation with external alignment. For instance, the Marken flood safety pilot in the Netherlands was an experimental project aimed at implementing a new flood risk strategy on the island of Marken (Buuren et al., 2016). Unlike many isolated pilots, the Marken project was closely tied to a national policy shift: the Netherlands was then embracing a new multi-layer safety concept for flood management. The pilot was conducted by the national water agency in collaboration with local authorities and had strong strategic backing (Buuren et al., 2016). As a result, it succeeded in developing an innovative dike design that fit the new policy principles, and importantly, “the results of the pilot will be used for other delicate water safety situations in other regions in the Netherlands.” (Buuren et al., 2016). In this case, external uptake was part of the plan from the start, and the pilot’s outcomes were scaled into at least some broader applications. Such examples show that overcoming the pilot paradox is possible, but it requires conscious effort to bridge the gap between the pilot and the regime.

2.3. Overcoming the Paradox

Recognising the pilot paradox, researchers and practitioners have proposed various strategies to improve the up-scaling and embedding of pilot innovations (Buuren et al., 2016; van Popering-Verkerk et al., 2020). A key insight is that one should design a pilot with its eventual diffusion in mind. Rather than treating scaling as an afterthought, successful cases, such as the Marken pilot or recent “living labs,” have integrated scaling considerations from the outset. According to Nair and Howlett (2014), the successful scaling of pilot projects depends

on key factors such as sustained political commitment, coherence with current policies and programs, and the establishment of continuous monitoring and evaluation processes. In the water sector, policies and programs are highly politically sensitive, especially when the resource spans multiple regions and jurisdictions. As a result, political support becomes a key factor in scaling water-related pilot projects (Vivekanandan & Nair, 2009). Zhou, Quitzau, Hoffmann, and Arnbjerg-Nielsen (2013) thereby stress the importance of collaboration between key stakeholders when pilot projects challenge established management practices, particularly when introducing alternative approaches to resource management. Nair and Howlett (2014) add that such an approach is crucial for breaking the resistance that often keeps systems stuck in traditional, inflexible practices. Some recommended strategies include:

1. **Ensure early involvement of important institutions:** Even if a pilot operates at the fringe, maintain links to the mainstream organisations (ministries, water boards, municipalities) that would implement the innovation later. This might involve including their representatives in the pilot steering group, or regular reporting to higher-level managers about pilot progress (Buuren et al., 2016). The goal is to achieve normative congruence: aligning the pilot's objectives and values with those of the home institutions so they feel ownership of the results. In the Walcheren water farming case, for example, hindsight suggests closer engagement with regional water authorities might have improved the "organisational appropriateness" of the pilot's outcomes (Buuren et al., 2016).
2. **Plan for diffusion:** Right from the start, pilots should have a clear implementation pathway for their findings. This means formulating how the innovation could be adopted if the pilot is successful, e.g., identifying what policies, budgets, or regulations would need to change and working on those in parallel. In a recent Climate Adaptation Living Lab in Dordrecht, the project team explicitly asked, "How will we secure the implementation of these pilots if they succeed?" at the design stage (van Popering-Verkerk et al., 2020). They involved researchers from Erasmus University and Deltares to help with a learning evaluation and to advise on upscalability throughout the pilot's life. By treating upscaling as part of the pilot's deliverables, one increases the chances that results won't languish on a shelf.
3. **Balance "Freedom to Fail" with demonstrating feasibility:** Pilots need some freedom to fail, but not to the point that their context is seen as completely unreal. Strategies can include conducting multiple pilots of a similar innovation in different contexts to validate robustness, or running a pilot in phases (starting with experimental conditions, then gradually conforming to more real-world conditions) (Vreugdenhil, Janssen, Hermans, & Slinger, 2022). The idea is to produce results that are both innovative and credible to sceptics. For instance, running the same pilot concept in several regions (with publications of results) can build confidence that the innovation is broadly applicable (Vreugdenhil et al., 2022).
4. **Embed social learning and networks:** Actively facilitate learning not just within the pilot team but among outsiders who will carry the work forward. This can be done by holding workshops with future end-users, creating peer networks of practitioners, or hosting open demonstration days. Vreugdenhil et al. (2022) emphasises that social learning (getting more people to understand and "own" the knowledge) helps prevent the limited learning hurdle. In the Dordrecht Living Lab, an overarching network was established across four pilots, enabling the sharing of experiences and lessons beyond each project (van Popering-Verkerk et al., 2020). Such networking ensures the pilot's knowledge does not remain isolated.
5. **Secure institutional endorsement:** To address the institutionalisation barrier, pilots should seek early approvals or inclusion of the innovation in formal processes. This might mean working with standard-setting bodies to develop guidelines based on the pilot, or getting the innovation on an "approved list" for funding. One strategy is to identify a champion within a government agency who will push for adopting the pilot outcomes. Another approach is to align the pilot with ongoing policy programs, so that if it is successful, it naturally integrates into something already in motion (as the Marken pilot aligned with the new national flood risk strategy).
6. **Windows of opportunity:** It's crucial to tie pilots to current policy questions or urgent needs. A pilot launched as part of a broader program (e.g., the Dutch Delta Programme for climate adaptation) stands a better chance of uptake because stakeholders are already seeking solutions. If a pilot's results are ready exactly when policymakers need input for a new plan or funding cycle, they are far more likely to be

adopted. This suggests pilot planners should be strategic about timing, perhaps accelerating certain aspects or keeping decision-makers informed so that a positive result can be seized upon quickly.

The Climate Adaptation Living Lab Dordrecht provides a concrete example of many of these strategies in action. Its aim was explicitly to create “pilots with a lasting impact” by avoiding the pilot paradox (van Popering-Verkerk et al., 2020). Researchers involved in the project reported both successes and remaining challenges. On one hand, they managed to run pilots that pursued internal and external success concurrently. Two neighbourhood-level pilots (Waterkraan and Vogelbuurt) not only tested green-blue climate measures but also fed their approaches into new municipal plans and even spurred follow-up projects. Non-traditional partners (like community groups and different municipal departments) were brought in to broaden support. On the other hand, even with this proactive approach, the Living Lab found that “sustainable embedment of innovation is no sinecure,” meaning it’s still hard work. They observed a familiar tendency for focus to gravitate back to the pilots themselves, with less time for cross-pilot learning than hoped due to busy schedules. And integrating pilot lessons into regular procedures (e.g. standard financing and decision-making processes) remained “not a matter of course yet”. This experience reinforces that overcoming the pilot paradox requires continuous effort: keeping the broader vision in view even as one tackles day-to-day pilot tasks.

To support future pilots, van Popering-Verkerk et al. (2020) distilled five success factors for bridging the gap.

1. **Inspiring and Framing:** Give the pilot an identity or “brand” associated with innovation and excitement, to inspire both participants and outsiders. In Dordrecht, the Living Lab itself became a brand that signalled an open, experimental culture, helping to bring others on board while staying sensitive to the existing organisational culture.
2. **Deliberate Scheduling:** Be selective and strategic in launching pilots, with clear expectations and a development path mapped out in advance. Essentially, don’t start a pilot without knowing what you will do if it succeeds (and even if it fails)
3. **Networking Beyond the Pilot:** In addition to the pilot’s project team network, create an overarching network (e.g., a living lab consortium) where progress and lessons from all pilots are shared. This prevents isolation and fosters a community of practice that can sustain and carry forward its outcomes.
4. **Mobilising Resources:** Recognise that implementation at scale needs a broad set of resources. Use the pilot as a platform to attract funding, political support, knowledge, and partners for the next steps. In other words, leverage the pilot’s momentum to line up what’s needed for full implementation.
5. **Organising Learning:** Treat learning as a core part of the pilot by formulating explicit learning questions, enabling exchanges among pilots, and disseminating lessons internally in the organisations from day one. This ensures the pilot generates not just a technical result but also a prepared audience ready to use that result.

These factors echo many of the academic recommendations and underscore a practical point: pilots must be nurtured both as experiments and as precursors to change. By balancing these dual roles, pilot projects in water and climate governance can better fulfil their promise. They can move from being one-off trials to becoming true catalysts for innovation.

2.4. Upscaling and diffusion

Researchers have examined how pilots can diffuse beyond their original context. Diffusion refers to the broader application of elements of the pilot innovation (i.e its ideas, practices, or artefacts) beyond the pilot’s boundaries. Diffusion can occur through several pathways. One mechanism is horizontal spreading or dissemination, meaning the replication of the pilot in new locations or organisations at a similar scale and complexity (often also called “broadening” of experiments). For example, a successful pilot in one neighbourhood or department might inspire similar projects in other neighbourhoods. Another mechanism is vertical growth or scaling up, which involves expanding the pilot’s scope or integrating it into higher-level structures so that the problem is addressed on a larger, often more complex scale. Scaling up typically entails institutional change; influencing policies, regulations, or organisational frameworks so that the innovation becomes embedded in the mainstream system (Moore, Riddell, & Vocisano, 2015)). In essence, scaling up seeks to “change the rules of

the game” by impacting laws, rules or resource flows, thereby anchoring the pilot’s approach in formal structures (Moore et al., 2015). A third dimension highlighted in literature is scaling deep, which focuses on cultural and mindset shifts. Scaling deep recognises that enduring change happens when “people’s hearts and minds, their values and cultural practices, and the quality of relationships” are transformed in support of the innovation’s aims (Moore et al., 2015). In other words, beyond numbers and policies, diffusion can mean instilling new norms and learning into the social fabric of an organisation or community. Scholars argue that successful transitions from pilot to broader impact often require a combination of these scaling mechanisms. (Moore et al., 2015) note that expanding an innovation’s impact is a multifaceted process: it is not achieved simply by copying a pilot elsewhere or “spreading a product” alone, but also by working to adjust institutional structures and cultivate supportive cultural conditions. For instance, a pilot program might be scaled out by launching it in additional communities to reach more people, while simultaneously scaling up by changing municipal policy to support its long-term funding, and scaling deep by influencing the organisational culture or public attitudes to embrace the new approach. Literature on policy innovation diffusion similarly emphasises that what gets diffused can vary. It may be the concrete solution or technology (the artefact), the underlying idea or principle, or an institutional model (e.g. a new partnership or protocol) that travels from the pilot into wider use (Vreugdenhil et al., 2010). Recognising these different “subjects of diffusion” helps in crafting strategies for upscaling, as each may require different support (for example, diffusing a technical tool vs. diffusing a new regulatory approach involves distinct challenges).

Actor roles and learning processes are crucial in enabling (or hindering) the scaling up of pilots. Pilot projects are often driven by passionate individuals or small teams (pilot leaders or champions) whose enthusiasm and flexibility can spark initial success (van Popering-Verkerk et al., 2020). Indeed, having an enthusiastic champion with the freedom to innovate is linked to short-term pilot success and even the spread of inspiration to others. Yet, moving from inspiration to institutionalisation requires additional capacities. Studies have found that diffusion beyond the pilot phase benefits from more persistent, connective leadership – individuals who can effectively link the pilot with other departments, stakeholders, and decision-making processes over the longer term. In Rotterdam’s pilot evaluations, for example, pilots that achieved follow-up were often those where leaders invested in networking and had “a long breath” (i.e. long-term commitment) to embed the innovation internally. Another important factor is ownership and stakeholder involvement. When a pilot is overly “owned” by its initiating team alone, it may not diffuse. The team might guard it too closely. Too much protective ownership can impede the transfer of the innovation into the regular organisational domain (e.g. if the pilot team fails to hand off the project or knowledge, others cannot champion it). By contrast, if multiple parties are involved early on, they share a sense of ownership and can act as ambassadors for the pilot outcomes, thereby easing the diffusion process. This relates to the concept of embedding: pilots that are embedded in the real organisational context, aligned with existing structures or needs, and that involve end-users or other departments tend to have a smoother path to upscaling (van Popering-Verkerk et al., 2020). If a pilot is executed in a “safe sandbox” completely isolated from the usual rules, it may achieve a one-time success under special conditions, but then struggle to translate into the normal system where those conditions don’t exist. Thus, a balance is needed between granting pilots flexibility and ensuring relevance to the broader context.

Institutional learning mechanisms are also highlighted for scaling up innovations from pilots. One observation is that many pilots lack clearly defined learning goals or knowledge dissemination plans. They often do not specify what questions the pilot is meant to answer and who should use that knowledge (van Popering-Verkerk & van Buuren, 2017; van Popering-Verkerk et al., 2020). This can lead to valuable insights being lost or remaining tacit, especially since pilot teams are typically busy and may not prioritise formal lesson-sharing (e.g. writing reports, updating colleagues). To counter this, organisations need structures that capture and transfer pilot learnings. The idea of a learning organisation is relevant here: a learning organisation “facilitates the learning of its members and continuously transforms itself” to integrate new knowledge. In the context of upscaling pilots, this means having processes to reflect on pilot outcomes, repositories or knowledge platforms to share lessons, and feedback loops to inform policy or strategy (van Popering-Verkerk et al., 2020). For example, Rotterdam’s approach suggests dedicating pilot coaches or facilitators who help project teams draw out lessons and connect them to the right stakeholders, as well as creating pilot databases or forums to make insights accessible across the organisation (van Popering-Verkerk et al., 2020; Vreugdenhil et al., n.d.). These mechanisms ensure that when a pilot ends, it does not simply “end” but feeds into new projects, adjustments

in practice, or even formal policy revision if appropriate (Vreugdenhil & Rault, 2010). Despite these supportive measures, challenges remain in translating pilot initiatives into broader application. A common challenge is that pilot projects may only achieve partial diffusion. Studies find that often the easiest outcome to spread is an intangible one (inspiration or new ideas) rather than concrete adoption of the pilot's product or policy reform. In Rotterdam, most pilots resulted mainly in "inspiration being scaled up," an inherently "not very tangible form of upscaling." In contrast, substantive institutional changes ("vertical upscaling" such as new regulations or structural funding) were rare. When upscaling did occur, it was usually internal and horizontal. For instance, a pilot's practices might be applied in another city department or lead to a follow-up project. Expansion beyond the organisation to external partners or city-wide policy was limited (van Popering-Verkerk et al., 2020; Vreugdenhil et al., n.d.). This suggests a tendency for pilot outcomes to stay local. Furthermore, even when a pilot is successful, scaling it out or up can encounter resistance: other departments or municipalities might view the pilot as context-specific and be hesitant to replicate it, or political support may disappear after the pilot hype passes. There are also practical issues like securing long-term funding (a pilot might be funded from a one-time budget "potje", but scaling usually requires sustained resources), and aligning the innovation with existing policy frameworks or regulations (an innovative pilot might not fit neatly into current rules, necessitating changes at the policy level to accommodate it). These barriers underscore that moving from a pilot to a mainstream program is not automatic; it requires deliberate strategy and often institutional change.

3

Research Design

This chapter outlines the research design and methods used to investigate how pilot projects in the Eems-Dollard region were initiated, how they evolved, and what challenges arose in scaling them up. It details the qualitative case study approach, the use of relevant conceptual frameworks, data collection procedures (primarily interviews and document analysis), and the analytical strategy. The study is guided by one main research question (how the pilot projects came into existence, evolved, and faced upscaling challenges) and three specific sub-questions:

1. How did the design and implementation of these pilots evolve over time?
2. What barriers and enablers influenced the progression of these pilots?
3. What governance dilemmas are emerging in the upscaling of these pilots?

By addressing these sub-questions, the research aims to build a comprehensive narrative of each pilot project's lifecycle from inception to upscaling efforts. The following sections outline the methodological choices made to rigorously and transparently address these questions.

3.1. Research Design and Approach

This research adopts a qualitative and strongly empirical case study design. The overarching aim is not only to document how the pilot projects in the Eems-Dollard region developed, but to actively interpret their evolution through the analytical lens of the pilot paradox (introduced briefly above and discussed in more detail in chapter 2). In other words, the study does not treat the pilot paradox as a hypothesis to be tested, but as a guiding framework for analysing and judging how the pilots were initiated, how they functioned under specific conditions, and how these conditions shaped opportunities and barriers for upscaling.

The case study approach is appropriate because the focus lies on complex and context-bound processes. The Eems-Dollard region provides the broader context, within which two pilot projects are examined in detail: the Brede Groene Dijk (including its sub-pilots Kleirijperij and Rijpdijk) and the Dubbele Dijk. These projects were chosen because they are emblematic examples of experimentation in regional water management and climate adaptation, and because they have reached a stage where questions of scaling and institutionalisation are highly relevant. Analysing two cases also allows for a degree of comparison, while keeping space for in-depth attention to the unique trajectory of each pilot.

The research is explicitly interpretive. It relies on the judgment of the analyst, who positions the pilots against the key dimensions of the pilot paradox framework. This means that the study does not aim to produce a neutral or objective mapping of facts, but rather a carefully reasoned interpretation of empirical material in relation to theory. In this sense, the pilots are treated as empirical instances through which the dynamics of the pilot paradox can be understood in practice. The emphasis is therefore on building a narrative of each pilot

project's life cycle, and on assessing how conditions that supported the pilots internally later became enablers or barriers when scaling was considered.

To construct this analysis, the study draws on three main types of empirical material:

1. **Interviews** with stakeholders directly involved in the design, implementation, and governance of the pilots.
2. **Document analysis**, including policy papers, project reports, and secondary literature that provide context and trace the projects' institutional embedding.
3. **Field visits and informal conversations** with local residents and actors in the region, which helped situate the pilots in their social and geographical environment.

Together, these sources provide a rich empirical basis. By triangulating them, the research enhances credibility and ensures that the analysis is not based on a single perspective. Still, the final step of the research is an interpretive one: the analyst's assessment of how the pilots relate to the paradoxical dynamics of success and scaling, as described in the conceptual framework. In this way, the methodology is both empirical and interpretive: grounded in data, but always directed towards understanding the pilots through the lens of the pilot paradox.

3.2. Conceptual Framework

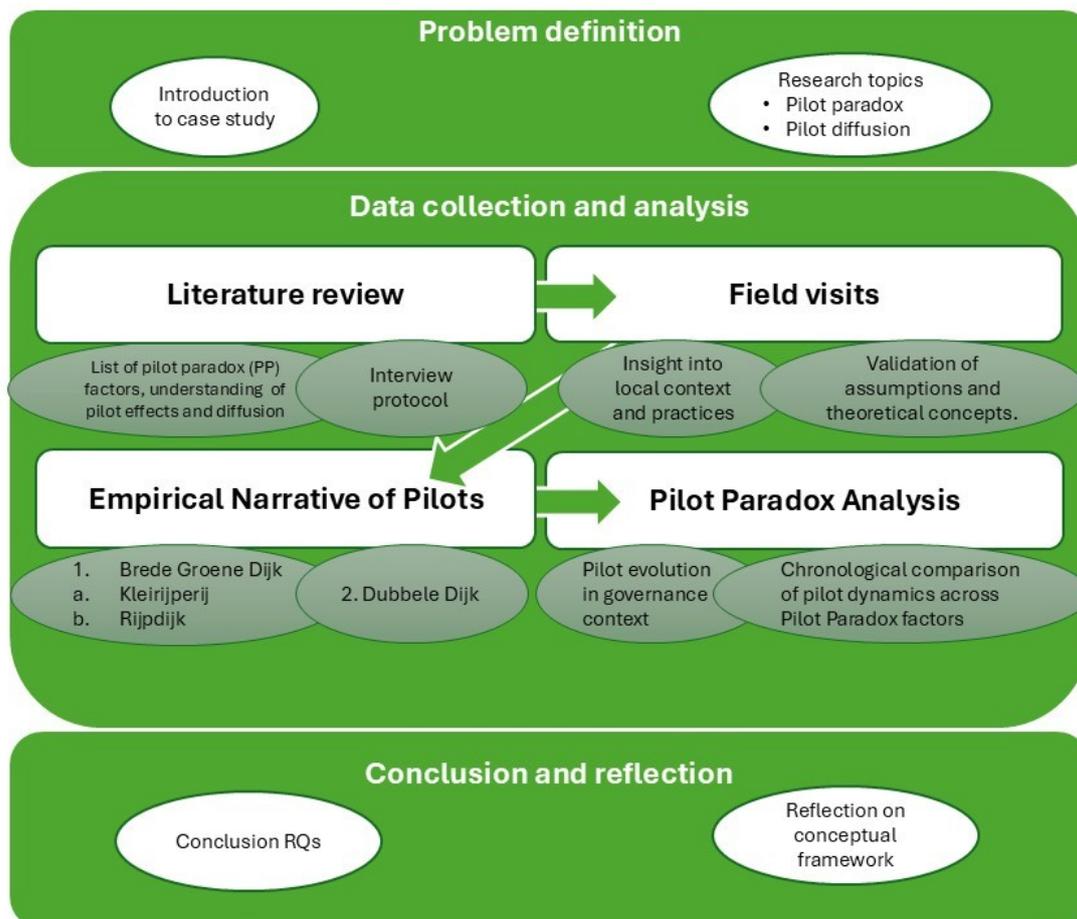


Figure 3.1: Research flow diagram

The conceptual framework (figure 3.1) structures the research in three main stages. It begins with the problem definition, where the case study is introduced and the central research topics of the pilot paradox and pilot

diffusion are identified. The second stage focuses on data collection and analysis, combining insights from a literature review and field visits. The literature review provides an overview of pilot paradox factors and informs the interview protocol, while field visits offer understanding of the local context and allow validation of theoretical assumptions. These strands come together in the empirical narrative of pilots, which documents cases such as the Brede Groene Dijk (including Kleirijperij and Rijpdijk) and the Dubbele Dijk. Building on these narratives, the pilot paradox analysis explores the evolution of pilots in their governance context and compares pilot dynamics across paradox factors over time. The framework concludes with conclusion and reflection, addressing the research questions and evaluating the conceptual framework itself.

3.3. Data Collection Methods

3.3.1. Semi-Structured Narrative Interviews

The core of the data collection is a series of semi-structured, narrative-based interviews with stakeholders involved in the selected pilot projects. Semi-structured interviews were chosen to balance flexibility (allowing interviewees to tell the story of the pilot in their own words) with consistency (ensuring key topics are covered across interviews). An interview guide was developed around major themes derived from the conceptual framework, but interviewees were encouraged to elaborate freely and chronologically on their experiences. This narrative approach helps capture the processual nature of each pilot – the sequence of events, decisions, and turning points over time – and provides insight into the subjective perspectives of those directly involved.

Interview Participants: A purposive sampling strategy was used to select interview participants who had direct knowledge of the pilots. These included project initiators and managers, representatives of organisations responsible for or sponsoring the pilots (e.g. regional water boards, provincial agencies, environmental programs), technical experts or researchers involved in monitoring the pilots, and other key stakeholders, such as local community or NGO representatives, if applicable. By interviewing a diverse range of actors, the study captures multiple viewpoints on each pilot, enabling the identification of both shared narratives and points of divergence. All participants were approached with informed consent procedures, where they were briefed on the research purpose and how their input would be used. Their consent (along with their preference for attribution or anonymity) was obtained before the interview. In total, the study conducted seven interviews, each typically lasting between 60 and 90 minutes. A list of interviewees is provided below.

ID	Occupation	Stakeholder	Date	Location
Interviewee 1	Project Manager Brede Groene Dijk	Waterschap Hunze & Aa's	18-06-2025	Rijpdijk
Interviewee 2	Program Manager Dubbele Dijk	Provincie Groningen	07-07-2025	Online
Interviewee 3	(Ex-) omgevingsmanager Dubbele Dijk	(Ex-) Noorderzijlvest & Provincie Groningen	21-05-2025	Online
Interviewee 4	Project leader Kleirijperij	Provincie Groningen	22-05-2025	Online
Interviewee 5	Projectleader	Provincie Groningen	28-05-2025	Online
Interviewee 6	Omgevingsmanager Dubbele Dijk	Provincie Groningen	04-06-2025	Online
Interviewee 7	Project Manager	Provincie Groningen	22-01-2025	Online

Table 3.1: Overview of interviewees: occupation, stakeholder, date, and location

Interview Protocol: Interviews were organised to cover the three chronological phases of each pilot's lifecycle – design (inception and planning), implementation (execution and any adjustments), and completion/upscaling (conclusion of pilot and efforts to continue or scale it). Participants were first invited to recount how the pilot project came into existence: what motivated it, who championed it, and what initial goals and designs were set (addressing sub-question one on key drivers and the early design choices). They were then asked to describe how the pilot unfolded over time: how implementation proceeded, how the design or approach might have evolved through the pilot's duration, and what challenges or changes occurred (addressing sub-question two on evolution of design/implementation). Next, interviewees reflected on the outcomes and effects of the

pilot: what the pilot was intended to achieve (e.g. technical outcomes, learning objectives, policy influence) versus what was observed or accomplished, including any unexpected results (informing sub-question three on intended vs. experienced effects). Finally, the discussion moved to the pilot's aftermath and prospects for upscaling: what happened after the pilot's formal completion, what barriers or enablers affected whether the pilot's approach was continued or replicated elsewhere, and what governance dilemmas (if any) emerged in trying to embed the pilot's lessons into broader practice (addressing sub-questions 2 and 3 on barriers/enablers and upscaling dilemmas).

Throughout the interview, the interviewer used probing questions tied to analytical themes that stem from the frameworks. In particular, five themes were emphasised to ensure comprehensive coverage:

- **Policy Connection:** How and to what extent was the pilot connected to formal policy processes or existing regulatory frameworks? (Or conversely, was it deliberately kept at arm's length – an experimental “niche” – and how did that influence its operation and scaling? (van Popering-Verkerk et al., 2020))
- **Stakeholder Involvement:** Who were the key actors involved in the pilot (government, experts, businesses, community), and how were they engaged? What roles and interactions characterised the collaboration? This relates to the multi-actor aspect of socio-technical experiments (van Popering-Verkerk et al., 2020).
- **Organisational Distance:** What was the institutional positioning of the pilot? For instance, was it part of an official program or more of an ad-hoc project? Did it operate within the existing organisational hierarchy or in a semi-autonomous space? This theme examines the “bounded” nature of the experiment and any protective distance from routine operations
- **Resources:** What resources (funding, expertise, manpower) were available for the pilot, and how did they affect its progress? Were special resources provided that would not be available under normal circumstances? Adequacy of resources and their continuity are considered critical factors for pilot success and potential upscaling.
- **Knowledge Orientation:** How was learning pursued and captured in the pilot? For example, did the pilot have formal learning objectives, monitoring programs, or evaluation moments? How were findings and experiences documented or communicated, and did participants view the pilot as a learning experiment or merely a one-off implementation?

By structuring the interviews around both a timeline (design → implementation → completion/upscaling) and these thematic lenses, the research elicited rich narratives that touch on all aspects of the research questions. The semi-structured format allowed interviewees to introduce additional relevant issues, while the interviewer ensured that each of the above themes was discussed if not raised spontaneously by the participant. All interviews were conducted in English or Dutch (depending on the interviewee's preference; Dutch interviews were later translated where necessary). They were audio-recorded with permission and later transcribed verbatim. This produced a substantial qualitative dataset of textual transcripts for analysis. The interview process also fostered trust and openness by adopting a conversational tone – respondents were encouraged to share stories and examples, rather than just brief answers, which aligns with the narrative interview approach.

3.3.2. Document Analysis & Grey Literature

In addition to interviews, the study incorporated an analysis of documents and grey literature related to the pilot projects. This served two purposes: (1) to contextualise and triangulate the interview findings, and (2) to gather factual details (dates, figures, formal outcomes) that interviewees might not recall with precision. The documents reviewed included: policy papers and plans that led to or mention the pilots (e.g. the Eems-Dollard 2050 program documents), project proposals and design reports for the Brede Groene Dijk and Dubbele Dijk, progress reports and technical evaluations of these pilots, and any available project completion reports or knowledge dissemination materials (such as brochures or presentations by the organizations involved). Additionally, media articles and press releases were reviewed when relevant to assess how the pilots were portrayed publicly and whether any stated intentions aligned with the insider perspectives.

Notably, project evaluation reports and internal memos were valuable as they often explicitly discuss what

worked well and what barriers were encountered in the pilot, offering a written account that can be compared with interviewees' oral accounts. Grey literature (unpublished reports, consultancy studies, etc.) provided insight into the practical lessons and operational details of the pilots. For example, technical reports on the Kleirijperij (the clay ripening experiment) document the process of transforming dredged sediment into dike-quality clay, providing valuable details that help verify and enrich the narrative of how the Brede Groene Dijk pilot was implemented. Policy documents, on the other hand, illuminated the intentional side of the story, why authorities pursued these pilots and how they envisioned scaling or learning from them.

The document analysis was conducted in parallel with the interviews. Before and during the interviewing phase, documents were reviewed to generate background knowledge and to formulate informed questions. After the interviews, relevant documents were revisited to cross-check specific information (e.g., timelines, stakeholder roles, outcomes) mentioned by the interviewees. This triangulation enhances the reliability of the findings: if both interview narratives and written records point to the same drivers or obstacles, confidence in those findings increases. Conversely, if there were discrepancies (for instance, an interviewee recalling a different rationale for the pilot than the one stated in an official document), those became points for interpretation and further probing (sometimes prompting a follow-up question or clarification with the source). All documents used were catalogued and referenced in the analysis to ensure traceability. When using information from documents in the thesis, the source is cited appropriately. In some cases, excerpts from policy documents or reports are quoted in the results (with permission, if not publicly available).

3.3.3. Field Visits and Local Conversations

In addition to interviews and document analysis, this research also includes field visits in the Eems-Dollard region. The purpose of these visits was not only to observe the physical setting of the pilots, but also to get a sense of the social environment in which they are embedded. Walking through towns, villages, and rural areas, speaking with people in everyday situations. These were not formal interviews, but spontaneous conversations with a wide range of individuals: builders working near the dikes, restaurant owners, residents walking their dogs, or visitors spending a day on the beach.

Such encounters were important because they offered a feeling for the region and its people. They provided insights into what local communities consider important, what worries them, and how they perceive ongoing changes in the landscape. These perspectives do not necessarily produce hard data, but they add depth to the analysis by colouring the broader context in which the pilot projects take place. Understanding local values and priorities helps to make sense of why certain approaches gain support while others face resistance. It also supports the interpretation of the pilot paradox in each case, by situating the pilots within the lived experience of the communities around them.

In this way, the field visits contributed to building a richer and more grounded understanding of the region. They offered a human dimension to the research that complements the official narratives found in documents and the targeted perspectives collected in formal interviews.

A list of most important encounters with contact persons from the area is provided in the appendices.

3.4. Data Analysis

The analysis of the qualitative data followed a thematic analysis approach, moving from raw data to coded themes and then to synthesised findings. Based on the sub-questions and the conceptual lens (pilot paradox factors), an initial list was developed. Top-level codes corresponded to major themes such as "Initiation Drivers," "Pilot Design/Changes," "Intended Effects," "Experienced Effects," "Barriers," "Enablers," "Upscaling Dilemmas," "Stakeholder Roles," "Resource Use," "Learning processes," etc. Many of these were directly tied to the interview themes and research questions. For example, any mention of difficulties in scaling up the pilot would be coded under something like "Upscaling Challenges," reflecting the pilot paradox idea, while discussions about how the pilot was set up or adjusted would fall under "Design and Implementation Evolution." This deductive framework ensured that each sub-question would be addressed in the coding process.

After coding, **within-case analysis** was performed for each pilot project. This involved aggregating all data (interview quotes, document evidence) related to a single pilot and constructing a coherent narrative and analysis

for that case. Chronological charts or timelines were used to map key events and decisions in the design, implementation, and completion phases of each pilot, annotated with notes on drivers, changes, and outcomes. This helped in understanding the sequence and causality within each case. It also allowed an assessment of each sub-question for the individual pilot – for example, summarising the main drivers of initiation for Brede Groene Dijk, or listing the main barriers encountered during Dubbele Dijk's progression.

Next, a **cross-case analysis** was conducted to identify patterns and differences between the two pilot cases. Here, the coded themes served as comparative categories. The researcher compared, for instance, what drivers were common to both pilots and what drivers were unique to one, how the implementation challenges differed or aligned, and whether similar upscaling dilemmas were reported in both cases. This comparative step strengthened the findings by seeing which insights were case-specific and which might be more general to pilot projects in this context. Where differences were found, the analysis sought to explain them (e.g. perhaps the governance context of one pilot differed from the other, leading to different experiences).

Throughout the analysis, the conceptual frameworks were used as a sense-making tool. For example, when a theme related to “distance from policy” emerged, it was interpreted in light of the pilot paradox literature – is a certain degree of distance helping the pilot (providing freedom to innovate) or hindering its diffusion (causing isolation)? Similarly, instances of learning or lack thereof were examined in terms of pilots as experiments – was there evidence of single-loop or double-loop learning, and were insights fed back into policy? The frameworks thus provided an explanatory context for the raw observations.

Finally, the results of this analysis are presented (in the subsequent chapter) structured around the research sub-questions. By organising the findings according to the three sub-questions, the thesis directly addresses each aspect of the main research question in turn. Within those sections, evidence from interviews and documents is woven together, with illustrative quotes and examples, to substantiate the claims. Every effort was made to let the voices of participants be heard (through quotations) while also synthesising their inputs analytically. Contradictory evidence or minority viewpoints are also acknowledged to provide a nuanced account.

3.5. Validity, Reliability, and Ethics

Ensuring the trustworthiness of the research was a priority in the methodology. Several strategies were employed to enhance validity and reliability:

1. **Triangulation:** As described, data from multiple sources (interviews, documents, literature) were cross-checked. Whenever a significant claim is made (for example, “Pilot X was mainly driven by ecological objectives”), it is typically supported by more than one source of evidence (e.g. an interviewee's statement and a policy document's stated goals). Triangulation reduces the likelihood of relying on a single informant's potentially biased view and provides a more robust confirmation of facts and interpretations.
2. **Member Checking:** After conducting interviews and drafting case narratives, the researcher conducted informal member checks by reaching out to a few key interviewees to verify factual details or to clarify ambiguous points. In some cases, summary findings or specific quotes were sent back to participants to ensure their views were captured accurately and in context. This feedback loop with participants helped correct any misunderstandings and bolstered the credibility of the qualitative analysis.
3. **Transparency in Analysis:** A clear chain of evidence was maintained from raw data to conclusions. All transcripts and documents were stored and organized so that any finding in the thesis can be traced back to its source. Excerpts in the results chapter are annotated with who said them or which document they came from. By being transparent about how interpretations were derived, the study allows readers (and examiners) to judge the soundness of the conclusions. Moreover, the use of established frameworks lends construct validity: the study is explicit about the concepts it is measuring (e.g. “barriers” as defined in pilot paradox theory, or “learning” as per experimental pilot literature) and sticks to those constructs in analysis.
4. **Reliability in Data Collection:** The interview protocol, while flexible, was consistently applied across interviews. All interviews were conducted by the same researcher, using the same guiding questions, which

improves reliability (consistency) in how data were elicited. The use of a recording and verbatim transcription process avoids reliance on memory or selective note-taking. Coding reliability was addressed through cross-checking code applications and refining the codebook to resolve ambiguities.

5. **Limitations Acknowledged:** The methodology acknowledges that, as a qualitative case study, the findings are context-specific and not automatically generalizable to all pilots or regions. The goal is analytical generalisation (to theory) rather than statistical generalisation. Nonetheless, by relating the findings to the pilot paradox framework, the study can discuss how the insights might be applied to similar situations. Any limitations in the data (such as a limited number of interviewees for a particular pilot or missing documentation) are reported in the thesis to ensure transparency in qualifying the confidence in specific results.

4

Results

In this chapter, the results are presented. First, an empirical narrative is presented. Here, the story of the pilots is told. Next, this narrative is further assessed using the frameworks as mentioned in earlier chapters.

4.1. Empirical Narratives

4.1.1. The Eems-Dollard through the eyes of the residents

The Eems-Dollard region, located in the far northeast of the Netherlands, is a remote and sparsely populated area where land, water, and infrastructure have long been in a state of negotiation. This estuarine landscape, situated on the border between the Wadden Sea and the German border, has been shaped by centuries of dike building, land reclamation, and ecological changes. Historically, the Dollard Bay was created by storm surges in the Middle Ages, after which generations of dikes and polders reshaped the coastal edge into its current form. The region continues to face challenges linked to land subsidence, sea level rise, and shifting economic conditions.

Spatially, the landscape is defined by its openness: vast, flat lands dominated by agriculture, small roads, and scattered villages with names that evoke a certain surrealism, such as *Hongerige Wolf* (“*Hungry Wolf*”) and *Nooitgedacht* (“*Never Imagined*”). Yet, daily life tends to unfold at its own rhythm, often quietly and with limited engagement in national policy developments. In conversations with residents and newcomers to the area, a recurring theme seems to emerge: a general distance from and disinterest in the large-scale infrastructural projects occurring nearby. For example, near the Dubbele Dijk pilot project, a resident living less than 100 metres from the new structure reported no involvement in or knowledge of its planning or purpose (contact person 2). Although he was aware of some controversy concerning land ownership relating to a prominent neighbouring farmer who also sold land to a nearby Google data centre, he expressed little concern about water safety or climate adaptation. When asked about local risks, his attention turned to more anecdotal concerns, including humorous references to drug-smuggling stories and family histories.

A similar tone was observed in encounters with other residents and visitors. A man walking his dog along the dike (contact person 3) described the region’s landscape as so flat that it was “*almost enough to believe the earth is flat.*” Figure 4.1 shows this vast landscape, with the Dollarddyke in the background. He, too, had recently moved to the area and noted that most neighbours tended to “keep to themselves” and were not engaged in discussions about dike reinforcement or climate resilience. Restaurant owners in the area (contact person 4), despite being surrounded by historical photographs of flood events and land development, also reported that issues such as dike safety were not a primary concern among locals. Instead, the main topic of anxiety remained the ongoing effects of gas extraction and the resulting earthquakes, a persistent and deeply felt issue in the province of Groningen.



Figure 4.1: Vast landscape of the Eems-Dollard region, with Dollard dike in the background

Further west, near the Brede Groene Dijk pilot, small-scale rural dynamics add another layer to the regional context. The owners of a local bed and breakfast (contactperson 5), located in a restored farm, spoke more about the condition of the building and the quiet disappearance of many traditional farmhouses than about the nearby pilot project. Their experience reflects a broader pattern in the region, where demographic shifts, economic contraction, and agricultural transitions leave behind not only buildings but also institutional gaps and uncertainties about the future of rural life.

Together, these observations highlight a central characteristic of the Eems-Dollard region: while it is often the focus of long-term national and provincial policy interventions, local attention and engagement may be limited or absent. At first glance, at least. Large-scale pilots, such as the Dubbele Dijk and Brede Groene Dijk, are introduced into a social landscape that is not necessarily hostile, but perhaps indifferent. This disconnect between formal innovation and informal reality is a key aspect of the context in which these projects must operate. What follows is a closer examination of how these pilots emerged, their development, and what their stories reveal about the broader dynamics of innovation, governance, and scale in this unique region.

4.1.2. Brede Groene Dijk

Initiation (2012-2016)

The concept of the “Brede Groene Dijk” (Broad Green Dike) began taking shape over a decade ago. Around 2012, during discussions in the Dutch Delta Programme for the Wadden Sea area, innovators proposed a novel idea: strengthen the Dollard sea dike in Groningen using nature-based methods and local materials. “*The seed for this demonstration project was planted... in the Deltaprogramma Waddenzeegebied,*” recalls a water board

project manager. The water board Hunze en Aa's was enthusiastic about a "natuurdijk" (nature-based dike) along the Dollard estuary, especially if it could use the estuary's excess silt as building material. This led to the simple yet radical idea of harvesting local muddy sediment, drying it into clay, and using that clay to reinforce and widen the existing seawall. Such an approach promised a win-win: improving the Eems-Dollard's water quality by removing sediment contributing to excess turbidity, and yielding a sustainable source of clay nearby for dike improvement. Early feasibility studies (e.g., a 2014 pilot study by Wageningen University) explored the viability of a broad, grass-covered sea dike with gentle seaward slopes and a salt marsh foreland in this location, thereby providing scientific grounding for the concept. From the start, institutional support gathered around the idea. The concept aligned with a growing vision of integrating flood safety and ecosystem restoration in the region. It quickly drew interest from regional and national bodies. The Province of Groningen and Rijkswaterstaat recognised an opportunity to address multiple issues simultaneously, and the concept received attention in the Delta Programme's innovation tracks. Around 2015-2016, the initiative gained a formal platform with the launch of the Eems-Dollard 2050 program, a multi-year adaptive program aimed at ecological improvement of the estuary. Within this new collaboration, the Broad Green Dike idea was adopted as a flagship pilot. In mid-2016, a coalition of government agencies and local stakeholders formally set up the Eems-Dollard 2050 program. "*There were more initiatives in the area – like the 'Dubbele Dijk' and the Marconi salt marsh – to improve nature; that's why the Eems-Dollard 2050 program was established*", according to a program manager at the Province. Within this program, the dike concept evolved into a comprehensive area development project, supported by nine partners across what they termed the "silt chain" (including Rijkswaterstaat, the Province, municipality, Groningen Seaports, the regional nature NGO Het Groninger Landschap, neighbouring water boards, and knowledge organisations). This broad coalition provided the pilot with a strong institutional foundation and a sense of shared ownership. As one project leader noted, having so many parties involved, even regulators, meant "*everyone feels a part of it,*" an aspect that is crucial when navigating rules and innovative practices.

Kleirijperij (2016–2021)

With the concept endorsed, attention turned to the practical challenge at its core: turning wet Dollard mud into solid dike-worthy clay. In 2016, a dedicated project team was established, comprising engineers, ecologists, and policymakers. Remarkably, the team remained consistent over the years, a continuity that is "*basically unbelievable in our business,*" according to one technical manager, and which helped the project maintain momentum and trust. The water board partnered early on with engineering consultants (such as Sweco) and the EcoShape consortium to design and execute pilot experiments. Together, they secured funding from innovative sources. The Wadden Fund (Waddenfonds) and the national High Water Protection Program provided financial backing, since the project promised both ecological gains and improved flood safety. By 2017, plans were at a stage to 'break ground' on a "Kleirijperij" (a clay ripening field) and to start producing clay from dredged sludge.

Beginning in 2018, the team constructed silt depots on a site near the Dollard dike (close to Delfzijl). These are large experimental basins where dredged sediment could be laid out and left to dewater and oxidise. The first depot was filled in 2018 with silty material dredged from the Delfzijl harbour channel (Havenkanaal). In 2019, a second depot was filled, this time with sediment taken from the nearby Breebaart polder salt marshes. Each section of the ripening site tested different methods to accelerate the natural clay-forming process, varying drainage techniques, sediment layer thickness, vegetation, and other factors. Over the next few years, the sun, wind, and even plant growth slowly performed their magic on the mud. Key processes, such as dewatering (removing water), desalination (removing salt), and oxidation (breaking down organic matter), gradually transformed the sticky estuarine sludge into firmer clay soil. Throughout this period, researchers and engineers closely monitored the changes, tweaking the approach to find what worked best. By 2021, after approximately three years, the pilot had produced its first batches of usable clay, which were sufficiently dry and cohesive to meet the basic needs for dike building. This was a significant milestone: tests in June 2022 confirmed that the locally "ripened" clay had the strength to be applied in a real dike section.

This experimental phase was not without challenges. Technically, one of the biggest questions was whether clay made from salty, organic mud would meet the traditional standards for dike material. In the Netherlands, clay used in dike reinforcement typically must have low organic content, low salinity, and specific grain size

characteristics, criteria developed for inland or naturally deposited clay. The Dollard sediment, however, initially contained high levels of organic matter and salt from the sea. *“We first tried to make the clay fit into the requirements,”* an engineer recounted, *“but along the way we discovered we weren’t able to get the organic content and salt levels down enough”*. Realising this, the team took an innovative approach: instead of forcing the clay to meet the old standards, they adjusted the dike design to work with the clay. They opted for a broad profile dike with gentler slopes and a thicker clay layer, so that slightly unconventional clay could still perform safely. In essence, they decided to *“design the dike to the clay”*, a reversal of the usual practice of only using clay that fits strict specifications. This required close cooperation with safety experts and regulators to ensure the dike would continue to meet flood protection standards in practice. To build confidence, the team conducted large-scale Delta Flume tests at the Deltares research facility, utilising the ripened clay on a gentle slope mock-up. These wave tests provided unique data on how this clay and dike geometry would withstand storm conditions. The flume trials, along with extensive lab testing, demonstrated that the locally sourced clay, if kept within an optimal moisture range, could indeed serve its purpose on a shallow-sloped green dike. This technical pivot, from changing the material to changing the design, was possible only because all stakeholders were on board in rethinking the rules. As one participant noted, *“what we are doing is not new, but what is new is the attention and the research. . . To change rules and regulations, it needs to be done this way, involving everyone”*. Regulators, normally cautious, were part of the pilot’s working group and saw the evidence firsthand, which helped them grant permits and make the necessary exceptions. Throughout 2018–2021, local community interactions also shaped the project’s evolution. The clay ripening site was located in a rural area near farms and villages, which meant the team had to manage practical concerns such as truck traffic, odours, and landscape changes. *“One challenge was working with the local community during the clay transport,”* remembered a project team member. In fact, when it came time to move the ripened clay to the dike, planners carefully coordinated trucking routes and timing in consultation with residents and authorities. The site itself became something of a regional attraction and point of pride: the water board organised open days and even bus tours to the Kleirijperij, so that farmers, villagers, and visiting experts could walk on the drying mud flats and feel the clay between their fingers. This transparency and outreach built local support. People could see with their own eyes the emerging solution; *“when people visit, they can see how the clay is changing. . . it is tangible,”* an engineer noted. In addition, the very process of obtaining sediment created a benefit for nature: when sediment was dug from a degraded marsh, it formed a new pool with an island (nicknamed the “Klutenplas”) that immediately became a prime breeding habitat for avocets and other wading birds. Such co-benefits helped convince sceptics that the pilot was not only about dikes, but also about enriching the environment.

Natura 2000

Institutionally, the period up to 2021 was primarily focused on maintaining the coalition and addressing problems. The Province of Groningen appointed a program manager to coordinate the broader coastal development agenda, while the water board’s project manager focused on implementing the pilot on the ground. There were moments when partners had to step out of their comfort zones. *“In such a collaboration, you must regularly step over your own shadow,”* as the provincial lead put it. For example, sorting out roles and funding between the province, water board, and Rijkswaterstaat led to *“pretty tough discussions”*. Who would do what, and who would pay for what, in this unorthodox project. Trust and a shared vision carried them through these negotiations. Another hurdle was regulatory: normally, excavating salt marshes for clay would be forbidden in a protected Natura 2000 area. Early on, the project encountered this obstacle; on paper, what they proposed was not allowed. The solution was unprecedented: *“all parties wrote a letter saying they still found this a good method to create nature gains and they support the alternative procedure.”* In other words, every stakeholder, from government agencies to environmental groups, jointly petitioned for an exception, arguing that the ecological benefits outweighed the negatives. This unified front helped secure regulatory approval for the responsible harvesting of marsh sediment. Everyone needed to support one another when rules needed to be bent. The multi-party alliance, with its shared sense of ownership, thus proved its worth in these tense moments by unlocking doors that a single entity could not open alone.

Construction (2022)

By early 2022, all pieces were in place to finally build the pilot dike section. This resulted in a 750-meter stretch of Broad Green Dike on the Dollard coast. In April 2022, the water board and EcoShape gave the green light

to start construction near the Carel Coenraadpolder, a segment of the Dollard sea wall identified for testing. The plan was to widen and raise the existing dike over this 750 m length using the newly matured clay from the Kleirijperij, mixed with some locally won salt-marsh soil for good measure. Over the spring and summer, trucks hauled approximately 40,000–50,000 cubic meters of clay from the ripening site (located at Delfzijl) to the dike section. Care was taken to minimise disruption: the team had only a short window outside the wet winter season, and they coordinated closely with residents on transport timing. By late July 2022, the major earthworks were completed. The once-uniform narrow dike profile was transformed, now featuring a much broader seaward base and a gentle slope that tapered out toward the tidal flats. What had been a steep, armoured levee was reimagined as a broad green buffer blending into the landscape. Contractors then seeded and stabilised the new dike surface with a grass mix. In September 2022, the first section of the Brede Groene Dijk was officially delivered and inaugurated. “*The dike lies there beautifully*,” said the project manager proudly at the completion, pointing out how natural it looks next to the salt marshes. This achievement marked the world’s first sea dike reinforced with clay made from salty, dredged sediment—a milestone celebrated by the partners and closely watched by experts nationwide.

The demonstration dike immediately entered a phase of intensive monitoring and evaluation. From the outset, this pilot was designed not just as a one-off structure but as a learning project. Over the next three years (2022–2025), EcoShape and scientific institutes tracked how the dike performs and matures under real conditions. They set up instruments and surveys to observe settlement, strength, and erosion behaviour of the new clay, the development of a robust grass cover on the dike, the effectiveness of drainage measures within the dike body, and how the whole system interacts with the adjacent salt marsh foreland. These data are vital for proving the concept’s viability at scale. Early signs were positive: by late 2022, the clay-borrow pits had naturally evolved into new wetlands, the dike’s grass was taking root, and the structure easily withstood high tides and storms. The Delta Commissioner visited and hailed the project as “*A good example of innovative Dutch hydraulic engineering... done smarter and more sustainably*”, noting how it fits elegantly in a Natura 2000 area and avoids the CO emissions of hauling clay long distances. He also highlighted a longer-term benefit: the adaptive potential of a clay dike. If sea levels rise faster than expected, one can simply lay more local clay on top to raise the dike in the future, with a flexibility much greater than that of a traditional dike with asphalt revetments.

According to those interviewed about the pilot project, local reception of the completed pilot has been enthusiastic. During construction, the water board made efforts to engage locals, for example, by holding informational meetings in nearby villages and keeping farmers informed when moving equipment down narrow dike roads. After completion, they organised site visits for residents, policymakers, and even international delegations. The 750 m stretch became a showcase where one could stand on a grassy slope and gaze over both the newly greened dike and the Dollard estuary it is meant to protect. This visible success helped shift mindsets. What was once a somewhat abstract concept was now literally set in the earth and grass. According to those involved, “*seeing was believing*”. The pilot made it easier for people to imagine scaling this approach to the entire coastline. EcoShape’s technical manager mentioned: “*by doing this physical pilot, people can imagine how this can work in even bigger projects... it offers something real*”. The Broad Green Dike, although now just a short segment, is starting to be viewed as part of a larger climate adaptation story for the region.

Next Steps (2023–now)

With the pilot dike in place, the focus has shifted to long-term dynamics and upscaling plans. Throughout 2023–2025, the project partners are continuing to study and learn from the pilot. They regularly share findings in reports and workshops, feeding the knowledge back into design considerations for the full 12+ km Dollard dike. For instance, the monitoring is examining how the clay further consolidates over multiple seasons (does it develop cracks in summer drought or soften in winter rains?) and how well various grass and herb species establish a durable cover. These insights will determine what refinements are needed when building the rest of the dike. Importantly, the pilot has so far validated that locally ripened clay can perform comparably to “normal” clay on a dike, provided the dike is designed appropriately. This finding is groundbreaking, suggesting that many coastal dikes in soft-soil areas could be made more sustainable by sourcing sediment from their own environment rather than importing material.

Encouraged by the pilot’s success, the water board and its partners are already planning the next phase: rein-

forcing the remaining 11–12 km of the Dollard seawall in the same green manner. The tentative plan (subject to final approvals and financing) is to start this full-scale project around 2025. Lessons from the pilot are being applied to make the roll-out more efficient. For example, rather than one centralised clay ripening farm, they envision building a series of clay ripening depots along the dike itself. In that way, sediment can be collected and matured right next to where it will be used, eliminating most of the truck transport. The aim is to continuously extract around 1 million tonnes of fine silt from the Eems-Dollard estuary per year in the coming years, converting that into dike clay and simultaneously improving water clarity and ecology. If achieved, this would represent a massive scale-up, effectively turning a coastal defence project into an ongoing environmental restoration operation. Stakeholders emphasise that scaling up will only happen if it's cost-effective and safe, but they are optimistic. *“We already know this is our preferred alternative,”* the project manager says about the full Dollard dike reinforcement, *“but it must also be affordable”*. Cost analyses are underway, weighing the savings from local materials against the expense of the ripening process. There is confidence that, with minor adjustments, the method can compete with traditional dike strengthening budgets, especially when factoring in the environmental benefits and avoided costs of land subsidence elsewhere (since clay will not be dug from inland fields).

The Brede Groene Dijk pilot has also begun to influence policy and institutional thinking. The partners view it as a template for breaking down silos between sectors. Instead of separate projects for flood safety, nature development, climate adaptation, and soil management, this pilot combines them. The provincial program manager advocates for a “comprehensive plan” to reinforce the Dollard coast in a way that optimises all these goals together. He notes that it requires innovation in procedures and funding streams, including pooling budgets and aligning the requirements of programs such as the Flood Protection Program (HWBP) and ecosystem restoration programs. The success of the pilot bolsters arguments for adjusting regulations that previously made such integrated projects difficult. The pilot received national recognition for its innovative approach; the Delta Commissioner's office even awarded it a “Zonnetje” award as a shining example of adaptive, nature-based flood protection. This has raised the project's profile and is helping to secure political support for the next steps. Locally, the water board has learned to take on a new role beyond its conventional remit. *“Traditionally, provinces are the area directors, but a water board can also be the connector,”* says the project manager, referring to how Hunze en Aa's stepped up to unite different parties around a shared vision. His advice to fellow water managers tackling big dike projects is to engage others early: *“Go outside in time, seek the connection. . . Shake people awake and say: ‘listen, you can join.’”* This proactive, collaborative spirit has been a hallmark of the Broad Green Dike project's development.

In summary, the Brede Groene Dijk pilot project evolved from an innovative idea in 2012 into a real-world demonstration by 2022, thanks to a combination of technical ingenuity, community engagement, and institutional collaboration. It was born from the recognition that the challenges of the Eems-Dollard region (i.e. turbid waters, sinking land, and the need for stronger dikes) could be addressed more sustainably if tackled together. Over time, the project evolved: initial studies and lobbying led to a multi-partner program; experimental clay ripening trials yielded new engineering solutions and regulatory adaptations; and the successful 750 m pilot dike paved the way for plans for full-scale implementation. Along the way, technical decisions (like redesigning the dike to suit local clay), local interactions (from engaging residents to creating bird habitats), and institutional influences (joint funding, regulatory support, and cross-sector partnerships) each shaped its trajectory. Notably, a coalition of institutional actors was able to overcome the rigorous Natura 2000 legislation. The pilot's story is one of learning by doing, where each phase built confidence for the next. As of 2025, the Broad Green Dike stands as a celebrated example of climate adaptation in the Netherlands, demonstrating how a regionally grounded solution can emerge when engineers, ecologists, governments, and communities collaborate. With the knowledge gained and trust built, the region is poised to turn this one green dike section into an entire climate-resilient coastline, securing both people and nature for decades to come.

4.1.3. Dubbele dijk

Initiation (2014-2015)

The concept of the “Dubbele Dijk” (Double Dike) arose in the mid-2010s as an innovative answer to multiple converging challenges. The primary sea dike along the Eems estuary had been found inadequate. It would fail to meet height and stability norms in the future and urgently needs reinforcement. At the same time,

the ecological decline of the Eems-Dollard had been noticed. The water had become excessively turbid from suspended silt, reducing light penetration and stifling primary production (algae growth), with cascading effects on fish and bird populations. Past land reclamations had eliminated natural salt marshes and mudflats where sediment would normally settle, so the silt just kept swirling in the water. The region's economy was also struggling; this corner of Northeast Groningen faced population decline and needed new economic impulses. Rather than tackle each problem in isolation, local leaders began envisioning a single intervention that could address flood safety, ecological restoration, and economic development in an integrated manner. The Province of Groningen initiated explorations into a multifunctional "double dike". Essentially, two dikes with a strip of land or water between them as a feasible solution to achieve "*three goals: improved safety, new economic drivers, and more biodiversity*". In other words, a second dike could be added to strengthen flood protection, and the area between the old and new dike could serve ecological and economic purposes. It was a bold idea, reimagining a dike not just as a barrier but as part of a broader landscape strategy.

The double dike concept gained traction rapidly through collaborative studies and workshops conducted in 2014 and 2015. The Province and the local water board (Noorderzijlvest) convened meetings with landowners and experts to test the waters for this idea. In late 2014, work sessions (werkateliers) were held to discuss the "dubbele dijk" concept with farmers and other stakeholders. By early 2015, a follow-up meeting with nearby farmers took place to gauge support. Stakeholder engagement from the beginning was critical because implementing a double dike would require using privately owned farmland in the coastal zone and altering its use to a tidal nature zone. Provincial officials made it clear at the outset that they would only proceed if landowners were willing participants; "*the pilot would only start based on voluntary cooperation of the landowners; no expropriation would take place*". This assurance set a collaborative tone (and a significant constraint) for the project's development.

Meanwhile, a series of studies in 2015 fleshed out the double dike idea from different angles. Wageningen Marine Research (IMARES) examined the potential for aquaculture within a double dike, considering whether saltwater farming of shellfish or seaweed could thrive in the semi-enclosed zone. Landscape architects and engineers (Bosch Slabbers and Alterra Wageningen UR) produced a feasibility study (WadLab) with conceptual designs for a "multifunctional double flood defence zone" between Eemshaven and Delfzijl. At the same time, economists looked at a business case: consultants Kieft Noord and AMJ Advies delivered a report on an exploitation model for the double dike area. These reports with titles like "Economic and ecological perspectives of a double dike along the Eems-Dollard" envisioned how the in-between space could be put to productive use. One early analysis even suggested that introducing aquaculture could transform local agriculture and that "*from an economic perspective, three aquaculture types appear very profitable*". Such optimism added momentum to the project. By September 2015, provincial representatives were meeting one-on-one with potentially affected landowners to discuss technical aspects and plan future talks about making land available. There was a sense that the concept was not only technically intriguing but also generating local interest. Indeed, by the end of 2015, the Province noted that, "*given the interest of landowners,*" it decided to proceed with developing the double dike as a formal pilot project.

What helped turn this daring idea into reality was its alignment with broader agendas at both regional and national levels. Around the same time, the Dutch government and regional authorities launched the ED2050 program. As mentioned earlier, this is a long-term adaptive initiative aimed at restoring the estuary's ecology while strengthening the local economy. The Eems-Dollard had been identified as a problem area in a 2015 "Ecology and Economy in Balance" study, and ED2050 was the collaborative response, emphasising "leren door doen" ("learning by doing") through pilots and adaptive management. Like the Brede Groene Dijk, the double dike concept fits this like a glove: it promised to create new intertidal habitats to trap silt (addressing turbidity and water quality) and to explore innovative land use, such as saline agriculture, which was precisely the kind of integrated solution ED2050 was looking for. Likewise, at the national level, the Programmatic Approach to Large Waters (Programmatie Aanpak Grote Wateren, PAGW) had just been initiated to fund projects that combine water safety with ecological improvement. The proposed double dike was embraced under these umbrellas. In fact, when the Ministry of Infrastructure and Water drafted the official Start Decision for a "Pilot Buitendijkse Slibsedimentatie Eems-Dollard" in March 2019, it explicitly listed the Dubbele Dijk as one of the innovative projects in the region to give the area "a new impetus". The pilot double dike thus became anchored in a multi-level policy framework: it was part of the ED2050 program and counted as

a PAGW project from the start. This ensured political and financial support from both the central government and the province, framing the project not as a quirky local experiment but as a pathfinder for climate-adaptive, nature-based water management.

Crucially, the double dike idea was folded into the ongoing dike reinforcement project that the water board Noorderzijlvest was already obliged to carry out. The primary sea wall, from Eemshaven to Delfzijl, had been marked for upgrading in the national Flood Protection Program (HWBP) after failing a safety assessment conducted between 2006 and 2011. Typically, the water board would simply raise and armour the existing dike. However, the Province and water board saw an opportunity to do things differently by initiating the pilot. By late 2015, they agreed to pursue the double dike as an alternative approach within the Eemshaven-Delfzijl dike improvement. In early 2016, the project entered formal planning, which involved designing a second “back” dike inland and a tidal zone between them. This required changes to spatial plans. In September 2016, the Provincial Council approved a zoning change for the affected lands (re-designating about 60 hectares of farmland to “Agriculture with values – Nature and landscape”). The double dike would thus be codified in the official Provincial Integration Plan for the dike upgrade, cementing it as the chosen alternative to raising the old dike.

One of the first real tests of the project’s governance was securing the land for the area between the dikes. The envisioned pilot site encompassed approximately 50–55 hectares of low-lying farmland located at the toe of the existing sea dike. Since the province had vowed not to expropriate land for this pilot forcibly, they had to negotiate with the landowners. In practice, much of the needed area belonged to a single large farmer. Initially, provincial authorities hoped to buy the plots or arrange a land swap for alternate fields. However, by May 2016, that landowner flatly refused to sell or trade his land. He did not want to permanently lose ownership of his property for this experiment. Instead, he was willing to consider leasing it out. This put the province in a bind: either drop the pilot site, try a lengthy expropriation process despite earlier promises, or accept a creative land arrangement. They chose the last option. In mid-2016, the Provincial Executive (Gedeputeerde Staten) made a political decision to forgo expropriation, arguing that it wasn’t legally viable anyway, as a conventional dike strengthening could always be done as an alternative to meet safety standards. They pursued a leasehold deal or “erfpacht” with the owner. By July 2016, the province agreed in principle to lease the required Fifty-odd hectares for the project. The terms were generous: a long-term lease of approximately 51–52 hectares for 26 years, in exchange for a one-time upfront payment that ultimately amounted to roughly €8 million. Essentially, the province paid nearly the full land value (as if buying the land), but the farmer would retain ownership and, after 26 years, could reclaim his land. An official lease contract was signed in December 2016, and the notarial deed was executed in March 2017 to formalise the arrangement. This “erfpachtconstructie” was highly unusual for a flood safety project and later became a subject of scrutiny and debate. It exposed the province to financial risks (they invested millions in land they wouldn’t own permanently) and legal complexities (questions of state aid and fair compensation arose), but at the time, it was seen as the only practical way to keep the pilot on track under the self-imposed conditions. Notably, the pressure of time was a big factor here: the water board’s dike improvements needed to stay on schedule, and officials worried that fighting a court battle to expropriate land would take too long. In internal discussions, “*the province regularly stated that ‘time pressure’ played a major role*” in the decision-making. The regional Audit Office later pointed out that this urgency was in part self-inflicted. Had authorities initiated the legal procedures earlier or been willing to delay the pilot, they might have managed a normal land acquisition process. But in 2016, all parties were eager to start building without delay, so they accepted the lease arrangement despite its drawbacks. The deal was finalised by the end of 2016, clearing the last major hurdle before construction began.

Construction (2017–2019)

With land secured and plans approved, the project moved into implementation. Construction of the new inner dike (the second line of defence) began in late 2017 as part of the broader Eemshaven-Delfzijl dike strengthening works. Over the next two years, a 2-kilometre stretch of new embankment was built inland of the old sea dike, roughly parallel to it. Notably, the engineers made a point of using locally sourced materials in this process, embodying the “building with nature” philosophy. The top layer of soil from the in-between area (which had been cropland) was excavated and repurposed to construct the core of the new dike. By doing so, the project avoided importing vast quantities of clay from elsewhere. It simultaneously tested how this local

clay, somewhat unconventional by standard dike norms due to its salt and organic content, would perform. (This approach was shared with the Brede Groene Dijk.) The result was a broad, gently sloped embankment landward of the original dike, built to be climate-resilient and earthquake-resistant, but deliberately not as high as a standalone primary dike would need to be. Instead, the safety concept relied on the two dikes working in tandem: the old seaward dike, still facing the open water, taking the first impact of waves, and the new landward dike acting as a second barrier to catch any overtopping water that might wash over the old dike in extreme storms. As one project engineer explained, this meant “*the sea dike doesn't have to be raised [further], because the [new] dike behind it catches the excess water*”. The space between them, around 50 hectares of low-lying terrain enclosed by the two dikes, was envisaged to function as a controlled flood zone and ecological experiment.

By December 2019, the Dubbele Dijk pilot infrastructure was complete: a double line of flood defences with an enclosed intermediate basin was in place. The new inner dike fulfilled the water board's obligation of securing the coast against high water, thereby achieving the primary goal of flood safety. From the outside, the landscape didn't look like a typical dike upgrade; it was more like a shallow polder flanked by twin dikes. However, at the moment of physical completion, the pilot's full functionality was not yet realised. In particular, the design called for installing a tidal inlet (*getijdenduiker*) in the old outer dike to allow salt water from the estuary to flow in and out of the between-dike area with the tides. This feature was key to the ecological and sedimentation ambitions: letting tides in would gradually deposit silt in the area (helping to clear the estuary water) and create salt-marsh habitat, and it would enable possible aquaculture or saline crop farming by providing seawater. Yet, due to budget constraints and planning choices, the tidal culvert was not installed by 2019. The area between the dikes initially remained cut off from the daily tides, essentially a brackish wetland waiting to be activated. The phasing of the project was a conscious decision. The authorities initially focused on building the dikes (to meet the flood safety deadline) and left the finer points of tidal exchange and site utilisation for a second phase. A hindsight critique was that delaying the tidal inlet slowed down the ecological benefits and made it harder to attract entrepreneurs, but at the time, it was seen as prudent given the experimental nature of breaching a sea dike. The water board wanted to carefully design the culvert to ensure it wouldn't undermine the dike's integrity. They also anticipated higher maintenance demands once the sea infiltrated: the inner dike would have one side constantly exposed to salt water, a new scenario for dike managers, so they planned to monitor how this affects the dike's condition and upkeep costs. In short, as 2019 drew to a close, the Double Dike pilot had demonstrated that an alternative dike reinforcement could be constructed successfully; however, the project was only at the starting point of an ecological and economic experiment.

Getijdenduiker & realisation (2020–2022)

The next challenge was to utilise the in-between area in line with the pilot's ambitions. With the physical infrastructure in place, the province and its partners hoped that private or public parties would step forward to develop aquaculture ponds, cultivate saline crops, or otherwise utilise the new land-and-water zone. However, this turned out to be more difficult than expected. In 2019, a call for tenders to find entrepreneurs to invest in and manage the *tussengebied* (intermediate area) attracted little enthusiasm. The attempt to award development rights failed. Potential operators found the proposition “too uncertain” to commit to. This was a reality check: although studies had painted an exciting picture of cultivating salt-loving crops or farming shellfish behind the dike, in reality, no one wanted to risk money on it without the evidence that it would work. The economic feasibility was still an open question. Some of the earlier projections of profit had been optimistic and based on laboratory or theoretical scenarios; for instance, one report had projected earnings using best-case prices and even suggested using waste heat from a nearby Google data centre to boost greenhouse production of saline vegetables. As the provincial auditors later drily noted, the “*hard figures supporting the revenue increase were thin*” and heavily dependent on experimental techniques. A more sober analysis by the marine research institute NIOZ in 2018 estimated that actual revenues from aquaculture (like seaweed or shellfish) might only be in the order of €6,000 per hectare per year, far lower than early optimistic forecasts. In short, the ecological ambitions were high, but the economic business case was unproven.

Faced with hesitation from the market, the Province of Groningen and other public stakeholders chose to take a more active role. In 2020, the provincial government decided to invest further in the pilot area's realisation: they allocated funding to construct the tidal sluice in the outer dike and to begin some pilot-scale land use

themselves. This effectively meant doubling down on the project despite the setbacks, a recognition that the pilot, to demonstrate its value, needed a push from the public authority first. Engineers returned to the drawing board to design a gated culvert that would allow seawater to flow into the area at high tide and out at low tide. By late 2021, preparations were underway to finally install this tidal connection (it would only be built in 2023, after a few years' delay). In the meantime, the province initiated a couple of small-scale trials in the area to start gathering experience. By mid-2021, two experimental leases were awarded to test saline farming on small plots (less than 0.1 ha each) for a few months. These were more like research demonstrations than commercial operations, but they allowed practitioners to “get their boots muddy” in the new terrain and see what might grow or thrive. In essence, the pilot entered a phase of cautious trial and error, very much in the spirit of ED2050's adaptive learning. Officials involved remained optimistic that, as knowledge improved and the tidal exchange was established, more entrepreneurs would be willing to step in. After all, the long-term vision was that the in-between zone could gradually build up into a higher elevation through silt deposition and potentially become valuable land, perhaps even fertile pasture or arable land, or support a sustainable aquaculture industry. But reaching that point requires patience and continued support.

Throughout 2021 and 2022, the Dubbele Dijk project also underwent evaluation. The Northern Netherlands Audit Office (Noordelijke Rekenkamer) conducted a thorough review focused on the unusual erfpacht land deal and whether decisions had been efficient and lawful. Their final report, titled “Dijkbezwaren,” published in late 2022, candidly highlighted some of the tensions and lessons of the project. They noted, for example, that “time pressure” had been a dominant theme driving decision-making, sometimes at the expense of exploring alternatives. The report questioned whether the perceived rush, due to the water safety deadline and fear of losing subsidies, had constrained the province to a suboptimal approach to land acquisition. It also pointed out that the province partly created its own time pressure by insisting on the pilot's inclusion so late in the dike improvement schedule and then feeling bound to the voluntary-only land policy. In response, provincial officials argued that the urgency was real. The water board had a firm deadline to deliver a safe dike, and they did not want to jeopardise that. This back-and-forth illustrates the balancing act inherent to the project: it had to mesh an experimental, iterative initiative with the rigid timelines of flood safety regulations and funding cycles. The Rekenkamer's report also revisited the economic viability of the pilot's envisioned uses. It noted that the business case presented to decision-makers had been overly optimistic, relying on yield scenarios provided by interested businesses, whereas other studies were far less optimistic. For instance, one analysis foresaw high yields by factoring in ideal market prices and even additional income from utilising warm water effluent, whereas NIOZ and other independent reports foresaw slim profits or even losses under realistic conditions. The gap between ambition and reality was evident. To the province's credit, it had commissioned updated studies in 2022 to reassess the business case and examine alternatives, such as outright buying the land or whether state aid rules were implicated. These reflections were part of treating the pilot as a learning exercise. In fact, true to its pilot character, by 2022, the Double Dike had yielded as much institutional learning and debate as it had on-the-ground results. It put new forms of governance under the microscope, examining public-private interaction, flexibility in regulations, and how to value co-benefits, such as ecosystem services, alongside traditional cost-benefit calculations.

Next steps (2025-)

Even if it faced challenges, the Dubbele Dijk project remains a symbol of innovation in Dutch water management. It demonstrated a novel way to integrate water safety with ecology. Instead of fortifying the coast with only concrete and asphalt, the pilot adopted a more adaptive approach: creating a safe hinterland by breaking the single line of defence into two and utilising the space between for nature and experimentation. In doing so, it is anticipated that sediment can be captured, water quality improved, and eventually new land or economic activity can be gained, a win-win for both the environment and the community. The project is explicitly a learning pilot under the ED2050, meaning its success is not only measured by immediate outputs but also by the knowledge gained for the future. Already, the insights from the Dubbele Dijk are feeding into other initiatives. For example, lessons about using locally sourced clay and managing saline seepage are being shared with other coastal projects (the Brede Groene Dijk trial, for one, and even national discussions on “building with nature” techniques). The Dubbele Dijk also reinforced the idea that tackling issues like sea-level rise will require creative, multifunctional solutions. The pilot's first objective was explicitly a “*sustainable and climate-proof coastal defence, one that can grow with sea level rise*”. Through a controlled flooding area,

the double dike concept provides room for the sea in a manageable way, potentially allowing sediment to accumulate and tidal action to occur at higher levels as the sea rises, something a traditional dike cannot do. This approach aligns with long-term adaptation thinking, and if successful, could be scaled up for application elsewhere along muddy coasts.

Now, in 2025, the Dubbele Dijk represents a young transformed landscape; two parallel dikes enclosing an embryonic salt marsh and experimental fields. Only a small portion of the 50-hectare zone has been used actively so far, but this is expected to change as the tidal gate operation commences and confidence builds among users. The next few years will reveal how quickly the area silts up and whether it can indeed support viable aquaculture or agriculture. For now, the project remains in pilot mode, with government support and monitoring. It embodies a certain tension inherent to innovation, balancing bold ecological ambitions with economic reality and doing so under the watchful eye of public accountability. The land lease construction, for example, was a creative solution to a stakeholder deadlock; however, it meant that the province essentially became a temporary landlord in pursuit of environmental gains, an unconventional role that drew criticism. Likewise, the project's timeline was compressed by the need to dovetail with a scheduled dike upgrade, forcing decisions that a standalone project might have handled differently. These frictions have provided valuable lessons in governance: the importance of clear legal frameworks for pilot projects, the need for flexibility in timelines when experimenting, and the benefit of early and transparent communication with stakeholders (especially landowners and local communities) to maintain trust.

In narrative terms, the story of the Dubbele Dijk is one of a pioneering spirit in the face of urgency. It began with a grand idea to turn a problem (excessive silt in the water) into a solution (utilising that silt to strengthen dikes and enrich soils). It was spearheaded by a coalition of government agencies, researchers, and locals united under the vision of Eems-Dollard 2050, who were willing to try something new to revive their region. Along the way, there were obstacles (e.g., reluctant landowners, sceptical financiers, regulatory puzzles) that required compromise and creativity to overcome. The initiative's pilot status was both a blessing and a curse; it allowed freedom to innovate and draw on special funding for innovative measures, but it also meant venturing into the unknown, with higher uncertainty and risk than a standard project. One local water manager reflecting on the project summed it up by saying that with the Dubbele Dijk, they were "*generating new knowledge*" for the future. Indeed, the Double Dike has already fulfilled that role: it has taught lessons about sediment behaviour, farming in brackish conditions, inter-agency cooperation, and even the public perception of novel climate adaptations. As a chapter in the region's history, it transformed a stretch of Groningen's coast into a living laboratory. And as a chapter in the Netherlands' adaptation story, it provided an empirical narrative of how big ideas are translated into practice on the ground, not in a linear fashion, but through negotiation, iteration, and learning by doing. The Dubbele Dijk's development and origins thus illustrate the messy, yet hopeful, process of innovation in delta management, where water safety, ecology, and economy are not opposing forces but rather parts of one integrated vision for a sustainable future.

4.2. Pilot Paradox Analysis

To understand how the Brede Groene Dijk and Dubbele Dijk pilots evolved and functioned within their institutional contexts, this section applies the pilot paradox framework as discussed in sections x&y. The pilot paradox captures how pilots must remain exceptional to be innovative, yet connected enough to be influential. Each pilot is assessed chronologically using seven key factors: organisational distance, stakeholder involvement, policy connection, scale, resources, knowledge design, and leadership. This approach enables the tracing of how the pilots' positions shifted across these dimensions during phases of development. This enables the identification of structural constraints and enabling conditions that shaped their trajectories. The analysis begins with the Brede Groene Dijk and is followed by the Dubbele Dijk. This section concludes with additional dynamics that fall outside the framework, but significantly influenced the pilots, and are noted separately.

4.2.1. Brede Groene Dijk

Initiation (2010-2016)

1. **Organisational distance:** Initially, the project lived within the vision of Waterschap Hunze en Aa's. It was a departure from standard practice, so it sat outside normal processes. While the idea aligned with

a long-standing ambition for green dikes, it was conceived as an innovative project rather than routine maintenance. *“Our dike was rejected in 2011, but not with high urgency. That gave us time to think about alternatives, like a greener, clay-based approach inspired by Germany.”* - Interviewee 1. (Later, a national innovation program (POV-DGG) would formally recognise it as a “quick win.”)

2. **Stakeholder involvement:** At this stage, participants were primarily internal, comprising water board engineers, planners, and a small group of expert advisors. Key actors included an influential project manager (Interviewee 1) and his team, as well as consultants (e.g., Arcadis) and RPS researchers. There were only initial contacts with broader stakeholders (e.g. Rijkswaterstaat’s flood program), so the diversity of involvement was modest.
3. **Policy connection:** The pilot was loosely connected to higher-level policies. It supported national goals of sustainable dike management (HWBP targets) but deliberately violated some existing technical rules (e.g. using nonstandard clay). This tension was acknowledged: using local sediment was seen as “daring” because it did not meet design standards. In effect, the project was only slightly aligned with flood safety and environmental agendas (combining water safety with Natura 2000 protection), but it required renegotiating existing norms; *“We wanted a dike that fits the environment. We aimed for a natural solution. Natura 2000 was a point of attention”*, Interviewee 1 mentioned.
4. **Scale:** In concept, the pilot was modest, initially just planning rather than construction. The full-scale need for 1km (later built) was recognised, but at this point, the idea was still a proposal. Its scope was large in ambition (solving two big problems), but small in execution (a single experiment rather than the whole dike).
5. **Resources:** Resource planning was just taking shape. Funding was uncertain but anticipated through the Hoogwaterbeschermingsprogramma. No significant construction budgets had yet been committed, though the partners knew they would have to invest significantly if the idea moved forward. Local material was plentiful; *“The estuary is full of silt, why not bring it to land and try to build a safe dike with it?”* (Interviewee 1). However, it had to be stockpiled and “ripened,” a process requiring extensive testing and monitoring. This led to the planning of a new pilot (Kleirijperij).
6. **Knowledge design:** Early on, the project was envisioned as a learning exercise. The team formulated research questions (e.g. how the local clay would behave over time) and proposed extensive monitoring from the outset; *“We started to see new chapters being added to the story of the green dike research, monitoring, trials.”* (Interviewee 1) However, formal knowledge structures (data collection protocols, partnerships with research institutes) were only in draft form. The design emphasised the need to understand new soil properties rather than impose them blindly.
7. **Leadership:** Ambitious champions drove the idea. Leadership was entrepreneurial: project engineers and the water board’s technical manager pressed the innovation, even before institutional support was clear. These leaders showed initiative and courage, willing to accept uncertainty to “link area challenges” and achieve sustainability gains. Interviewee 1 exemplified, *“We didn’t want to call it a pilot. We wanted to demonstrate it works.”*

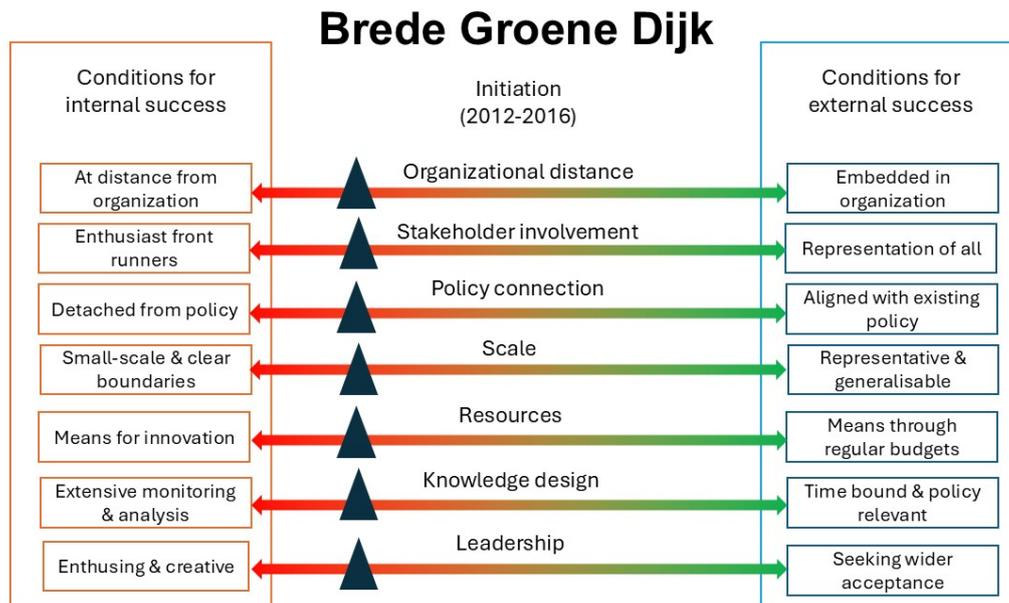


Figure 4.2: Assessment of Brede Groene Dijk between 2012 and 2016 in terms of pilot paradox factors, represented as filled triangles.

4.2.2. Kleirijperij pilot (2016-2021)

1. **Organisational distance:** The POV-DGG program provided the pilot with an official framework (a “quick win” demonstration), thereby reducing its isolation. Yet it remained somewhat of a side project within the broader Eemshaven–Delfzijl dike stabilisation. In other words, distance decreased slightly: the project began to straddle the line between a grassroots innovation and a formal demonstration track. Interviewee 1: “*We consciously invited Heleen Vreugdenhil to explain the ‘pilot paradox’ before we even started writing the plan.*”. By formally embedding the project in the national innovation track (POV-DGG) and inviting external experts, the pilot reduced its isolation and moved closer to mainstream institutional frameworks.
2. **Stakeholder involvement:** The stakeholder set broadened sharply. In addition to Hunze en Aa’s and Noorderzijlvest (partner board), the consortium EcoShape (contractors/knowledge institutes), Rijkswaterstaat experts (HWBP), NGOs, and Deltares became involved in the test. The “quick win” workshop brought together engineers, geotechnical experts, ecologists and authorities. Interviewee 4 mentioned: “*A cooperation agreement was signed between the province, Rijkswaterstaat, Hunze Aa’s, EcoShape, and others; that helped us resolve difficulties together.*”. The pilots more and more became a representation of important stakeholders (illustrated in figure 4.3)
3. **Policy connection:** Interviewee 1: “*The slib is the problem—remove it and make a safe dike. That became part of the HWBP innovation program.*” With the POV-DGG label, the pilot gained clear policy ties. It was now an official innovation under the HWBP. The test dike was explicitly justified as research: its design and monitoring aligned with HWBP’s goals of adaptive learning. Nonetheless, the pilot still operated on the fringe of existing regulations; for example, planners had to seek waivers or special design methods because standard slope/soil criteria did not cover this case. This phase demonstrated mixed alignment, being supported by policy objectives but requiring exceptions in technical rules.
4. **Scale:** The project grew in ambition. The one-kilometre pilot plan was finalised: to be built within the next few years and monitored over three years. The scope of preparatory work expanded, including geotechnical tests on depot soils and larger surveys of estuary sediment. Interviewee 1 explained: “*We built depots at two sites, one at Seaports and one on the dike itself.*” Still, only a small physical structure existed (the short proefdijk), but it represented a clear step toward the full-scale pilot.

5. **Resources:** Funding solidified around research rather than construction. HWBP and the water boards budgeted for soil testing, monitoring equipment, and building the test pad. In-kind resources (sand, labour) came from partners like EcoShape. The land for the depots was prepared: in 2018, a series of kleirijperijen was constructed using marsh dredge to allow local clays to harden. These efforts demonstrated a commitment to material and labour well before the main build. Interviewee 4 mentioned: “*We had to deliver 100,000 m³ of clay to the Brede Groene Dijk. That was written in the cooperation agreement.*” Financially, the project still depended on innovation grants rather than capital expenditure from infrastructure budgets. In the figure, an empty triangle is shown. This represents the step of introducing the kleirijperij. It shows a shift towards incorporating new methods/materials (i.e. ripened local clay) through regular processes.
6. **Knowledge design:** Formal research planning has matured. The team defined detailed testing programs for the test dike and depot soils. Monitoring sensors and lab analyses were arranged. Knowledge generation was structured: the test trial aimed to calibrate models and assess the constructability of each local soil type. Here as well, a triangle is used to represent a slight shift towards the conditions for external success. By creating new knowledge (introducing a 'sub'- pilot), possibilities for scaling the BGD increase.
7. **Leadership:** The leadership became more collaborative. The board's project manager worked closely with POV-DGG's technical manager and consultants, sharing responsibilities. Decisions were still proactive, but the “engine” of the pilot was now a team effort. This network leadership helped secure buy-in; for example, the HWBP officials publicly endorsed the experiment, indicating institutional approval.

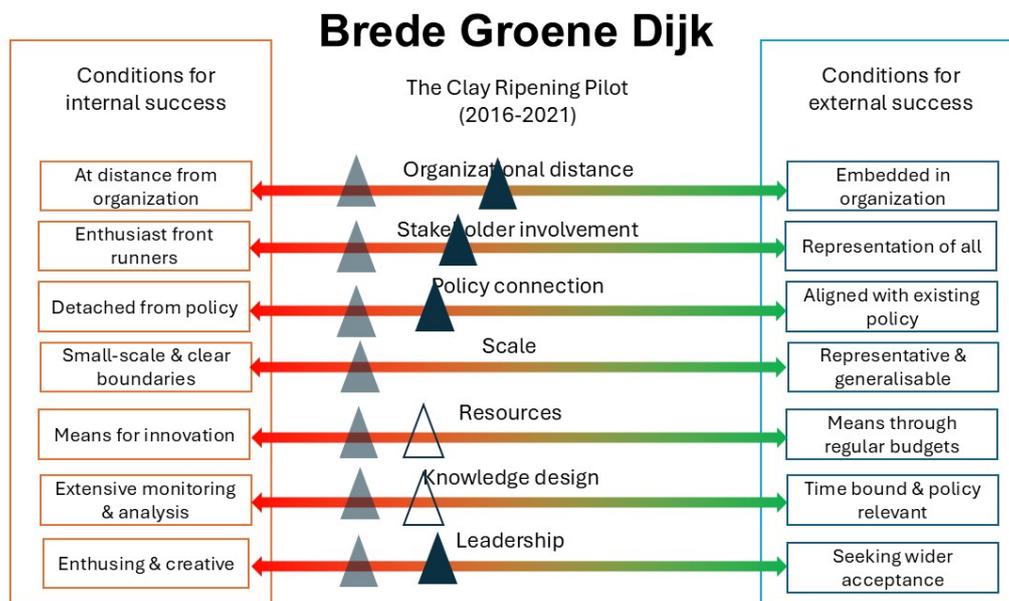


Figure 4.3: Assessment of Brede Groene Dijk between 2016 and 2020 in terms of pilot paradox factors, represented as filled triangles.
*Empty triangle represents pilot kleirijperij

4.2.3. Construction (2022)

1. **Organisational distance:** The pilot was now closely tied to the ongoing dike-strengthening program. Although still labelled a demonstration, it effectively became part of the official project at that location. Its proximity to mainstream work increased: construction was carried out under the water board's jurisdiction, using contracted crews and inspectors. The pilot retained some special status (extra data collection), but it was no longer an isolated experiment. Interviewee 1: “*For HWBP projects we decided to adopt the same project management structure, even though we normally worked differently.*” By using the

same structures as conventional HWBP dike projects, the demonstration became closely tied to main-stream execution rather than an isolated pilot. Organisational distance decreased further, integrating the pilot into the standard execution phase.

2. **Stakeholder involvement:** Many more participants came on board. Construction contractors and site supervisors joined the team, and external supervisors (from Deltares, TNO, etc.) visited the site for inspections. Local interest groups (farmers, environmental NGOs) became aware of the work, and the water board organized site tours for stakeholders. The POV-DGG working group continued to meet. Overall, stakeholder diversity peaked: engineers, ecologists, regulators and community actors were all kept informed, even if day-to-day construction was handled by a core team. Contactperson 6 (independent researcher) mentioned: *“I sat in the Kwelder advisory group with the water board, the province, NGOs, and landowners; it was a pleasant and responsive group.”*
3. **Policy connection:** At this stage, the project had to comply with formal safety oversight even as it tested new methods. Regulators allowed the variant design under an experimental permit or assessment path. The demonstration effectively operated within a “sandbox” of the policy framework, following the high-level goal of water safety while temporarily relaxing prescriptive criteria. The pilot also aligned with environmental policy: for example, the clay depots and dike construction were carried out in tandem with creating a breeding lagoon (“klutenplas”) for shorebirds, thereby preserving Natura 2000 values. Thus, the pilot straddled two policy streams (flood safety and nature management), maintaining alignment on broad objectives while bending some technical rules. The project operated under experimental permits, but its outcomes started to influence national design rules by challenging outdated clay standards (Interviewee 1)
4. **Scale:** This was the pilot’s largest physical footprint. At 750m length and full dike thickness (built up to 6–8m high), it represented a significant civil works project (comparable to a mid-sized dam fill). However, relative to the total dike length (tens of kilometres), it remained a slice. The scope was deliberately limited to allow learning: the project team emphasised it was a test segment, not yet the full reconstruction. In summary, the scale was large in terms of effort and visibility, but still a fraction of the ultimate strengthening.
5. **Resources:** Major resources were deployed. The local boards and HWBP research funds paid for construction, instrumentation, and heavy equipment. The needed material (1.7Mm³ of clay) had been accumulating in nearby depots for years, so soil supply was ready (though managing the logistics of excavation, transport, and compaction was nontrivial). Engineers noted that building with wet, heterogeneous soil required careful handling (sometimes more clay had to be placed to reach the same stability as standard clay). Financially, this phase was largely covered by a mix of project funds (e.g. HWBP funding for monitoring). Overall, resources were ample but also budgeted as part of the pilot mandate.
6. **Knowledge design:** The knowledge program was in full swing. Instrumentation (piezometers, settlement markers, vegetation plots) was installed during construction, and measurement schedules were defined. Designers built in provisions for observation (e.g. inspection corridors, extra sounding points). In effect, the construction itself became a “moving experiment” following the blueprint from earlier stages. Learning objectives were carefully tracked: each layer placement and compaction was documented for future analysis, and baseline lab tests on soil samples had been completed. The knowledge process was highly structured, reflecting the heavy emphasis on research in this demonstration.
7. **Leadership:** Implementation was guided by hands-on leadership. The water board’s project manager had to balance innovation with safety; he led site meetings and worked with contractors to adapt standard methods (for example, using special moisture-control during compaction). This phase still saw shared leadership – the boards consulted experts frequently, but the authority remained with the local engineering team. Notably, the original champions remained visible: they used progress as an opportunity to engage higher-level patrons (e.g. inviting HWBP representatives to inspect the site), securing continuing support.

“For me, there is only one real success of a pilot: upscaling.”

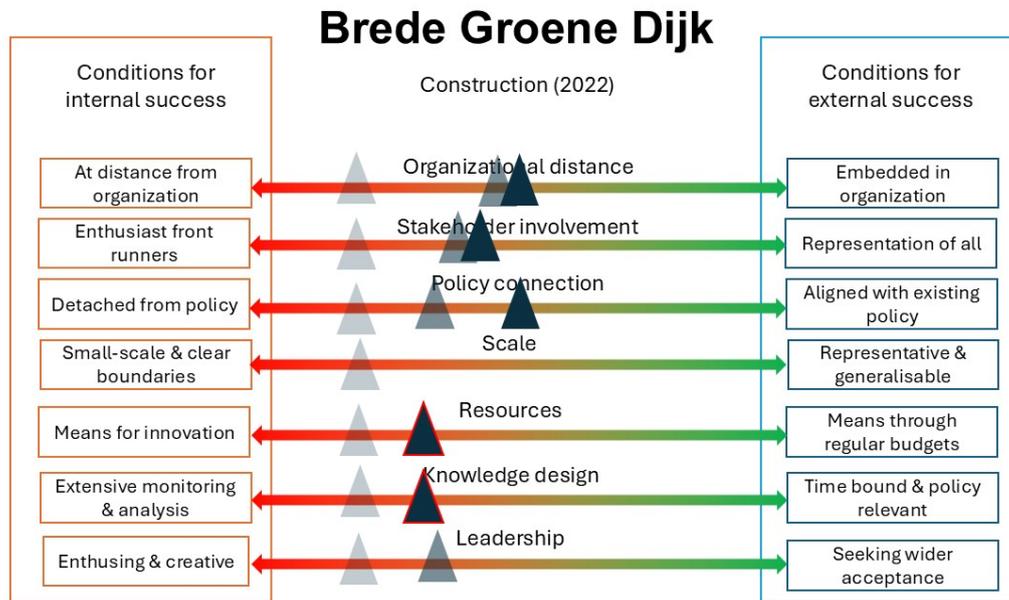


Figure 4.4: Assessment of Brede Groene Dijk during construction in 2020 in terms of pilot paradox factors, represented as filled triangles. *The red triangle outline represents pilot kleirijperij, here the output of this pilot has been incorporated into the Brede Groene Dijk project

4.2.4. Next steps (2023-)

1. **Organizational distance:** During monitoring, the pilot functioned in a hybrid mode. It remained under the water board's maintenance department (since the site was now an asset to be cared for), but it still had a "pilot identity" in that data collection and analysis were overseen by the original innovation team. The organizational ties were now two-way: the routine maintenance branch had to incorporate the unusual structure, but it did so in collaboration with the research group. Thus, organizational distance stayed low: the pilot was essentially embedded in the system, though flagged for special treatment.
2. **Stakeholder involvement:** This phase saw continued broad engagement. Research partners (e.g. universities, consultancy labs) stayed active, processing samples and contributing reports. The HWBP community followed the project through newsletters and field meetings. Even project neighbors (such as local residents and fisheries authorities) were kept informed of water-level data and ecological impacts. However, no new major stakeholders were added; the effort shifted from expanding parties to deepening involvement of the existing ones.
3. **Policy connection:** By now, the pilot was well-known to policymakers. Its findings began to influence discussions on design regulations. For example, the project team argued for updating design models to include local clay parameters, and policymakers showed interest (as noted by the POV-DGG team). The grant application to HWBP's KIA (knowledge agenda) implied formal integration into national R&D plans. In this sense, the alignment with policy strengthened: the pilot outcomes were explicitly meant to feed back into standards and future programs. It had begun as an exception and was moving toward becoming a test case for new rules.
4. **Scale:** The physical scale was fixed, but the knowledge scale grew. Although no new dike length was built, the project's influence effectively expanded: data from the single kilometer were being considered for application elsewhere. Internally, planners started contemplating how the full ~20 km dike might be reconstructed if the pilot succeeded. So, while the on-the-ground scale remained one segment, the conceptual scale broadened to region-wide implications.
5. **Resources:** The focus of resources shifted to analysis. Significant funding was allocated for monitoring

equipment upkeep, lab tests, and planned experiments (e.g. the Deltagoot wave flume). The HWBP and Dutch Deltafonds provided research grants. Operationally, the board invested in *nazorg* (aftercare) activities: extra ballast or drainage adjustments where required. Overall, budgets for this phase were smaller than for construction but guaranteed by the pilot's research mandate. Resource tension was low, partly because the uncertain costs of long-term maintenance were now understood to be part of the value proposition: building with local clay might cost more on maintenance but save on transport and ecosystem health.

6. **Knowledge design:** The learning system reached full maturity. A well-defined feedback loop was in place: field data were continually compared to model predictions, and periodic reports were produced (often shared publicly). The team remained conscious of trade-offs: for instance, they planned to count “clean water” as a benefit against extra maintenance expense

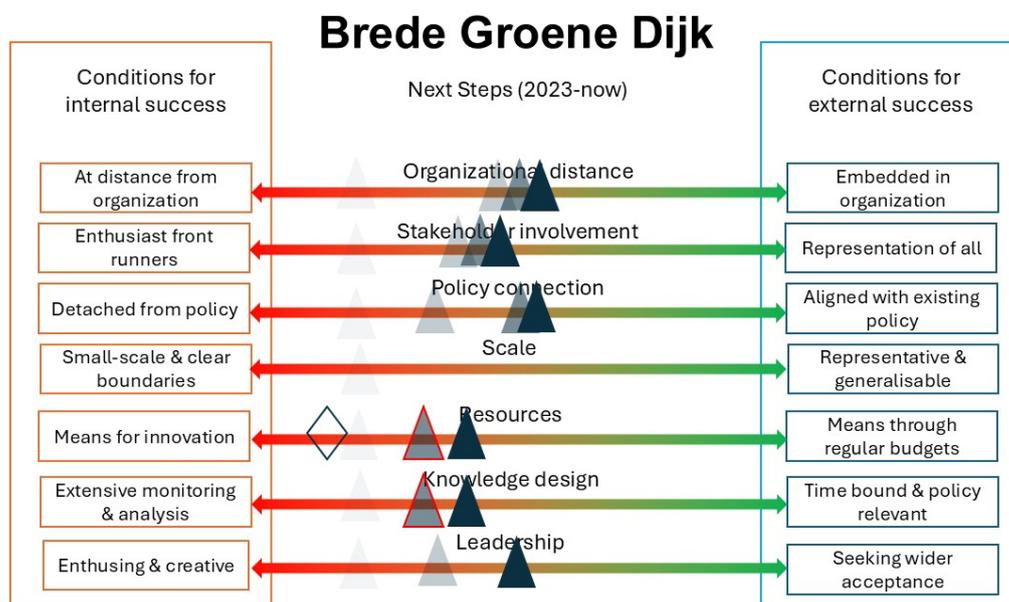


Figure 4.5: Assessment of Brede Groene Dijk between 2023 and 2025 in terms of pilot paradox factors, represented as filled triangles. *The red triangle outline represents pilot kleirijperij, here the output of this pilot has been incorporated into the Brede Groene Dijk project. **The 'diamond' represents the new pilot Rijpdijk

4.3. Dubbele Dijk

4.3.1. Initiation (2014–2016)

By late 2016 the design was complete and formal decision processes had begun. The pilot had moved from informal concept to an official MIRT project (with a published “Startbeslissing”). This transition marked a shift from creative innovation to bureaucratic implementation.

1. **Organisational distance:** The idea originated with regional authorities, the Province of Groningen and Waterschap Noorderzijlvest. They collaborated with consultants (BoschSlabbers, Alterra, Deltares). At this stage the pilot was largely driven by local actors, apart from routine national programs. However, planners embedded the concept into broader plans early on. For example, the pilot was to be formally placed under the HWBP from the outset, and was adopted into the Eems-Dollard 2050 climate program (ED2050). This dual positioning meant the pilot was not an isolated experiment but connected to policy agendas (HWBP for flood safety, ED2050 for regional development), reducing its “distance” from established programmes. Interviewee 3 mentioned: “*The Double Dike originated partly from a local municipal vision, but especially from the cross-project exploration (POV Wadden) where new dike concepts were studied. Embedding it in both HWBP and ED2050 ensured it was never just a local experiment.*”

2. **Stakeholder involvement:** From the start the pilot engaged a wide set of players. The project was jointly led by the province and the water board, with technical studies by universities and engineering firms (Alterra, Deltares, BoschSlabbers). Local farmers, aquaculturists and nature interests were already involved in design workshops (e.g. two public “ontwerpateliers” with stakeholders in 2014–2015). Land use planning was coordinated with municipal authorities. In short, the feasibility phase saw broad participation: regional governments, technical experts and intended end-users (e.g. pilot farmers in the salt-water polders) all shaped the concept. *“Farmers, NGOs, and even aquaculture entrepreneurs were consulted early on. Design workshops (‘ontwerpateliers’) ensured local users shaped the pilot concept”* (Interviewee 4).
3. **Policy connection:** Early on, this pilot was framed to fit several policies. It responded to new Dutch climate adaptation and water-safety goals (the HWBP needed innovative solutions), and to regional development policy in the Eems-Dollard area. A 2013 cooperative declaration already committed local actors to integrated goals of safety, economy and nature. The double-dike idea was explicitly aligned with that “triple bottom line.” By 2015 the Province formally included the Dubbele Dijk concept in plans for the Eemsdelta dike reinforcement. While innovative (building a lower second dike is not standard practice), it was woven into the legal/regulatory process via the national MIRT framework and the ED2050 program. *“The Province of Groningen fully financed the pilot, integrating it with HWBP reinforcement needs and ED2050’s climate adaptation agenda. This was a deliberate policy link”* (Interviewee 3).
4. **Scale:** In design, the pilot was deliberately modest. The concept covered about 50 hectares of hinterland between two dikes (roughly 11–12 km of dike line). It was a single-site demonstration for one coastal segment. The scale was small enough to be manageable, but large enough to test multiple goals. Crucially, planners intended this to be a demonstration with lessons for larger application: *“If this pilot works well for safety, economy and ecology, then this dike concept can be applied elsewhere along the coast.”* So the scale was narrow (pilot scope), but envisaged for broad transfer. *“The project covered about 55 hectares, secured via voluntary land contribution. It was just one site, but chosen to test multiple purposes with potential broader use”* (Interviewee 3).
5. **Resources:** Funding at this phase came from a mix of local and special innovation budgets. The national Ministry (RWS) set aside 10 million for related pilot projects in the region. Within that, 6 million was specifically earmarked (in 2018) for the ED2050 “raising farmland” pilot (the Dubbele Dijk’s inland polder). The water board and province also committed in-kind staff and planning budgets, but much of the project relied on these earmarked innovation funds. In effect, the pilot ran on special program money (PAGW/ED2050) rather than normal maintenance budgets, giving it the financial latitude of an R&D project. Interviewee 3 mentioned: *“The project was fully financed by the Province, with additional contributions from ED2050 and the Waddenfonds. It relied heavily on earmarked innovation funds rather than standard budgets.”*
6. **Knowledge design:** From the start the pilot was planned as a learning project. A feasibility study laid out clear research questions (stakeholder processes, social acceptance, safety impacts, costs). The province and water board jointly managed a research consortium. Proposed methods included literature review, interviews, and (later) hands-on monitoring of the pilot during construction and operation. In the design phase they already sketched how to monitor the dike and test salt-tolerant crops. For example, planners anticipated testing a clay-processing marsh (kleirijperij) and aquaculture in the intermediate zone. In short, knowledge goals were built in: the pilot was to produce policy-relevant results on feasibility, not just engineering drawings. Interviewee 2 told: *“From the beginning, experiments with saline crops and aquaculture were planned, alongside monitoring of soil behaviour. Universities like Hanzehogeschool were directly involved.”*
7. **Leadership:** Leadership was dynamic and multi-level. The Province of Groningen played a visionary role, pushing the triple-goal concept. The water authority (Noorderzijlvest) took a pragmatic implementation lead. Both showed enthusiasm and “entrepreneurial” flair – they championed a novel idea. They also sought legitimacy by linking the project to national climate and flood programs (a strategic move to broaden acceptance). In practice, regional leaders drove the project forward, but with an eye on national co-sponsorship. In hindsight, observers note that ambition and risk-taking by these local

decision-makers opened doors (though it also meant decisions were made with limited precedent). Interviewee 3 pointed out that “*the Province took the lead and bore all financing risks, while Noorderzijlvest handled water safety. Success depended strongly on personal trust between leaders.*”

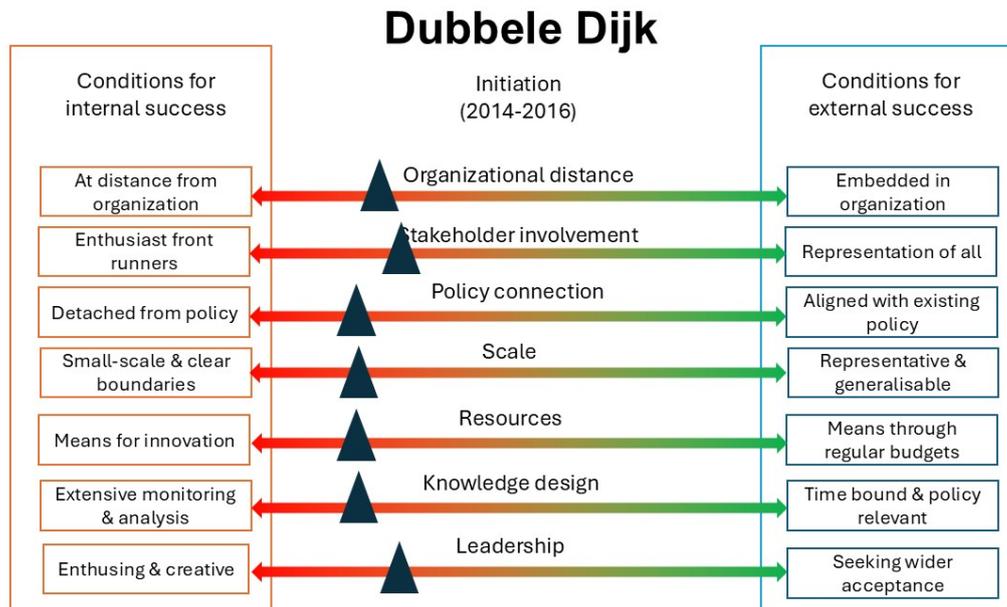


Figure 4.6: Assessment of the dubbele dijk between 2014 and 2016 in terms of pilot paradox factors, represented as filled triangles

4.3.2. Construction (2017–2019)

1. **Organisational distance:** Once construction started (early 2018), the project became more embedded. The water board Noorderzijlvest issued tenders and oversaw building of the new dike (as part of its HWBP contract), while the province arranged the polders behind it. In effect, the pilot became part of the standard dike-reinforcement program. Its leadership now included mainstream actors (i.e. public works contractors (Boskalis, KWS) and national regulators). The organisational distance narrowed. Interviewee 6 mentioned that “*when construction began, Noorderzijlvest issued tenders and supervised contractors, embedding the pilot into the regular HWBP structure.*”
2. **Stakeholder involvement:** During construction, stakeholders stayed involved but the process became more technical. Formal permits were obtained through standard channels, and local stakeholders were informed through public consultations. The intermediate polders were planned in consultation with farmers and nature groups. Nevertheless, the core partnerships remained: provincial planners coordinated with the water board’s contractors, and consultants monitored construction. The broad coalition from Phase 1 (authorities, experts, NGOs and businesses) largely persisted, but focus shifted to execution. “*Even during construction, farmers and NGOs were engaged, but the process became more technical and focused on contractors*”, Interviewee 6 mentioned.
3. **Policy connection:** This phase saw the pilot explicitly put into policy practice. The new dike segment became the “Ommelander Dijk” project within the national HWBP (note that it also had to meet new earthquake and tidal standards). The intermediate zone design had to comply with environmental rules (e.g. tidal sluice permissions). Importantly, the ED2050 program governance was active: from 2019 the Province began “shaping the intermediate area” under the Eems-Dollard agenda. By mid-2019 the project had firm footing in both water management and spatial-planning policies (natural reserve management, agricultural zoning). “*The dike had to meet both earthquake safety and Natura 2000 rules. This dual compliance shows how policy integration shaped construction*”, according to Interviewee 6.

4. **Scale:** The physical scale expanded slightly as work progressed. In practice, the pilot covered 11.7 km of coastline and about 50 ha of land. This was modest even during construction. However, the visibility of the project grew – it was by now a full-scale construction site. It remained a one-off: no other sections were built the same way in that period. Planners took care to keep the pilot contained, conducting detailed soil tests only for this section. *“The project covered around 12 km of coastline and 50 hectares. It remained just one pilot stretch, deliberately kept contained”* (Interviewee 3).
5. **Resources:** Construction budgets became concrete. The water board drew on its HWBP budget (with some input from national climate funds). The province used its ED2050 allocation for preparing the polder (dike breaches, clay-ripening ponds). Because this work was integrated into larger programs, precise numbers are complex, but all signs point to ample funding. Interviewee 6 also noted that national agencies made 10–16 million available for related initiatives. There was no serious funding shortfall reported in the empirical accounts.
6. **Knowledge design:** The pilot’s learning regime kicked into high gear in this phase. Engineers and scientists installed sensors and surveys as the new dike was built. By 2019, measurements of settlement and stability were collected. Farmers were selected to run pilot salt-agriculture plots in the polder. The consortium (Alterra, Deltares, etc.) held regular workshops to interpret results. For example, a profile of the new dike was deliberately “flatter” (gentler slope) than usual, to test performance under overtopping. The intermediate clay pond was filled and sampled. In short, every aspect of the concept was instrumented. Progress reports and fact sheets (e.g. Veendorp 2019) were produced. Interviewee 2 stressed this; *“Farmers began salt-crop trials, while sensors monitored dike settlement and overtopping. Knowledge generation was embedded in construction.”*
7. **Leadership:** *“Leadership depended on coordination between Province and Water Board. Despite tensions, local champions pushed innovation through”* (Interviewee 3). Implementation required strong coordination. The water board’s project managers handled day-to-day control, while the province ensured the pilot’s multi-purpose goals were honored. Throughout, leadership remained energetic. The same local champions from Phase 1 guided contractors. At the national level, RWS inspectors provided oversight. The project was a showcase for “innovative dike” ambition. There were some tensions, but leaders maintained alignment of the technical team with the broader vision.

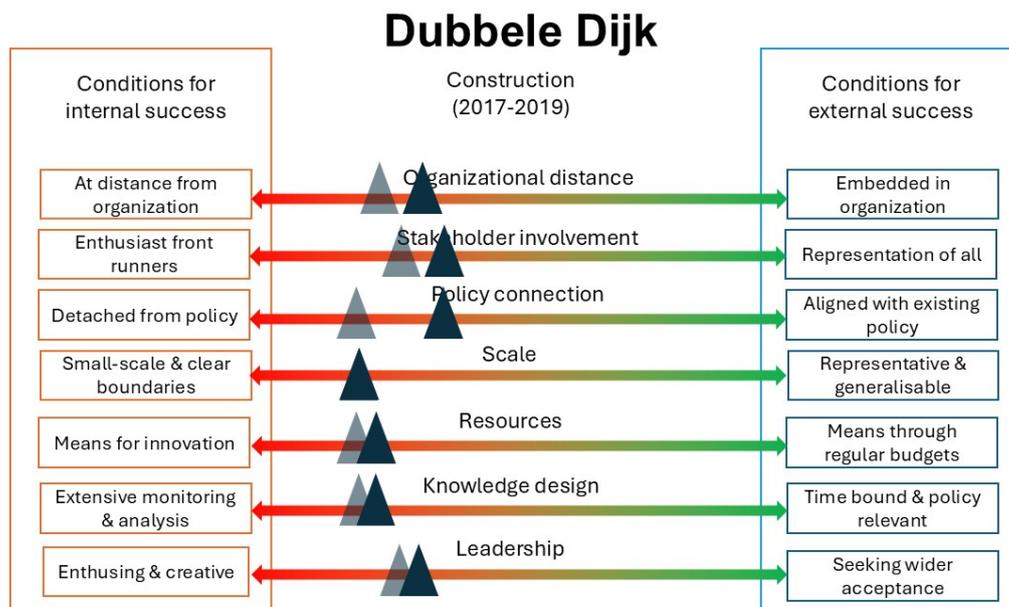


Figure 4.7: Assessment of the dubbele dijk between 2017 and 2019 in terms of pilot paradox factors, represented as filled triangles

4.3.3. Getijdenduiker (2020–2022)

1. **Organisational distance:** In operation the pilot remained part of the standard structure but with an advisory twist. Operational control of the dikes stayed with Noorderzijlvest, and land use with the province. However, a special governance channel (the ED2050 program's steering groups) continued to monitor the pilot as one project among many. Over time it became increasingly "mainstreamed," with maintenance of the new inner dike planned as part of normal HWBP procedures. According to Interviewee 6, *operational responsibility clearly rested with Noorderzijlvest, while ED2050 steering groups kept the project under review, making it simultaneously mainstream and exceptional.*
2. **Stakeholder involvement:** Stakeholder roles became hands-on as farmers and aquaculture entrepreneurs began working in the polder, while academic partners tracked ecological outcomes. Public interest also remained high, with NGOs such as the Groningen Landscape participating in annual reviews. Interviewee 3 mentioned that *entrepreneurs like the Seaweed Company and Hanzehogeschool experiments directly shaped the polder's design and use, turning the pilot into a quasi-operational partnership rather than a closed experiment.*
3. **Policy connection:** By this stage, the pilot's results started feeding into policy discussions. Early data on wave run-up and soil stability were reported to national regulators, helping to update design guidelines. The idea of "inundation polders" behind dikes began to gain traction in other policy forums. *As stated by a policy advisor, monitoring results were shared nationally, ensuring that the inundation polder concept entered broader discussions as a viable approach.*
4. **Scale:** The physical scale of the pilot remained fixed (50 ha, 12 km), but its perceived importance grew. Planners started to consider what might happen if this concept were applied across the Wadden coast, and related projects were initiated to test further possibilities. *According to interviewee 2, although the site itself was limited, it was increasingly treated as a "proof of concept" with clear potential for larger application.*
5. **Resources:** After the capital works were completed, resource intensity leveled off. Ongoing efforts focused mainly on monitoring and maintenance, funded by ED2050 and supplemented by regular HWBP budgets. *As Interviewee 6 observed, after construction the costs largely shifted to ecological studies, with ED2050 and Ecoshape providing targeted funding for continued testing.*
6. **Knowledge design:** Knowledge structures became more systematic in this phase. Monitoring included flows, salinity, and ecological impacts, with farmers and researchers directly involved in data collection. Annual workshops ensured that results were interpreted collectively. *According to a policy advisor, design choices such as using ringsloten and sensors to track salinisation impacts on agriculture were central to ensuring that findings informed both local practice and provincial policy.*
7. **Leadership:** Leadership shifted from implementation to reflection. Annual review meetings with scientists, officials, and local representatives guided adjustments, while external scrutiny through audits added accountability. *As highlighted by a policy advisor, by 2022 provincial and water board leaders focused less on construction and more on evaluating replication potential, marking a deliberate transition from "getting it built" to "learning and deciding next steps."*

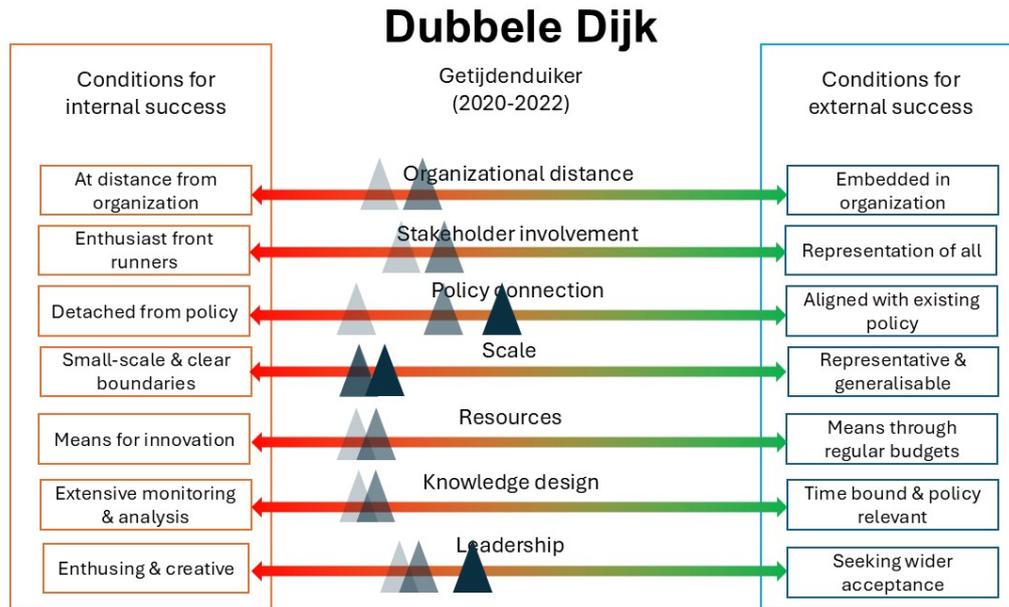


Figure 4.8: Assessment of the dubbele dijk between 2020 and 2022 in terms of pilot paradox factors, represented as filled triangles

4.4. Beyond the Pilot Paradox Framework

In addition to the factor-by-factor analysis of each pilot, several broader dynamics emerged from the cases that are not fully captured by the existing pilot paradox framework. The pilot paradox concept – as articulated by Vreugdenhil and colleagues – focuses on internal versus external success conditions within a single pilot. It outlines how factors that foster a pilot's internal success (e.g. flexibility, dedicated resources, a small creative team) can hinder its wider adoption (which demands standardization, alignment with rules, and broad support). While this framework's seven dimensions provided a useful lens for our analysis, the empirical findings revealed additional dynamics that cut across or lie outside these defined factors. These dynamics – described below with examples – help explain how the pilots were shaped and why certain aspects fell through the cracks of the original framework:

First, both the Brede Groene Dijk and Dubbele Dijk pilots demonstrated instances of strategic governance framing that influenced their trajectory in ways the framework does not explicitly consider. Key actors actively shaped the urgency, timing, and narrative of the pilots to seize political opportunities. For example, in the Dubbele Dijk case the project initiation was deliberately accelerated to align with external funding windows, not because the pilot was technically ready sooner but to take advantage of a narrow subsidy opportunity. This kind of political timing – framing the pilot as urgent to fit a budget cycle – created a path dependency in the project's development. It meant that certain design and implementation choices were driven by the need to meet external deadlines rather than purely by internal project logic. Such cross-cutting strategic maneuvers affected multiple pilot paradox dimensions at once (from resource allocation to stakeholder engagement), yet the current framework has no dedicated category for framing and timing strategies. In other words, the original model partially touches on leadership or organisational culture, but it misses the structural role of strategic timing and narrative. These findings suggest that how a pilot is politically framed and timed can be just as critical as its technical setup – a factor that the existing framework fails to capture well.

Second, the analysis uncovered significant cross-pilot interactions: the two pilots evolved in tandem and often reinforced one another's progress. Developments in one pilot project directly supported or validated the other, indicating a mutually reinforcing relationship beyond individual project boundaries. For instance, the Dubbele Dijk's early success in constructing an inland embankment using locally ripened clay lent credibility to the Brede Groene Dijk's plan to build a full-scale green dike with local sediment. Conversely, lessons from

the Brede Groene Dijk – such as its rigorous monitoring approach and insights into saline soil behavior – informed the operational plans for the Dubbele Dijk's intertidal polder zone. These exchanges were facilitated by overlapping actors, shared platforms (both pilots were part of the Eems-Dollard 2050 program), and a regional narrative that linked the two experiments. In effect, the pilots functioned not in isolation but as a network of experiments, where one pilot's "win" bolstered the momentum and legitimacy of the other. The pilot paradox framework, however, treats each pilot as an independent unit of analysis (focusing on conditions within one pilot and its interface with the broader regime). It does not account for this meso-level dynamic between parallel pilots. The mutual reinforcement and knowledge transfer observed here fall outside the original seven dimensions. This implies that any comprehensive analysis of pilot projects should look not only at one pilot in a vacuum, but also at how multiple pilots can interact and collectively influence change – a nuance the existing framework fails to address.

Third, both pilots were embedded in broader programmatic structures – notably the regional Eems-Dollard 2050 (ED2050) initiative and the national Flood Protection Program (HWBP) – which shaped their development in ways not fully captured by the pilot paradox framework's individual factors. These umbrella programs provided more than just funding or coordination; they acted as strategic containers that legitimized the pilots and linked them to long-term policy goals. For example, being part of ED2050 allowed each pilot to position itself not as a one-off experiment, but as a piece of a larger regional adaptation strategy. This programmatic embedding conferred narrative coherence and institutional backing that helped the pilots survive political and administrative transitions. It also facilitated cross-project learning: successes or insights from one ED2050 pilot were communicated and taken up by others under the same program umbrella, amplifying their overall impact. While some aspects of this influence appear in the original framework (e.g. the "policy connection" dimension touches on aligning pilots with policy goals), the full effect of program-level context is beyond its scope. The framework does not explicitly account for how a higher-level program or coalition can define acceptable pilot objectives, provide sustained support, or shape expectations across multiple experiments. Our cases show that this integrated program context had a decisive role in how pilots were framed, resourced, and interpreted, yet the pilot paradox model has a blind spot here. In summary, the multi-level governance setting – with pilots nested in a larger policy program – introduced dynamics (such as shared vision, inter-pilot learning, and added legitimacy) that the existing framework does not adequately include.

Finally, the Brede Groene Dijk case revealed a recursive innovation pattern where new sub-pilots were launched to enable the main pilot, challenging the framework's assumptions about resources. Two auxiliary pilots – de Kleirijperij (a clay ripening facility) and de Rijpdijk (a small on-dike clay maturation trial) – were set up explicitly to generate inputs and conditions needed for the Brede Groene Dijk. In effect, the project team created additional pilots to produce the resources and knowledge that the primary pilot lacked initially. For instance, de Kleirijperij was used to produce and test locally sourced clay under controlled conditions so that the main dike experiment would have a supply of proven material. Similarly, de Rijpdijk was a quick trial on an existing dike section to explore in-situ clay ripening, which informed the larger design. Without these sub-experiments, the core pilot could not have proceeded to full implementation. This dynamic goes beyond the pilot paradox framework's resource dimension, which tends to treat resources as a static input (either available or not, depending on institutional constraints or special budgets). Here we see resources had to be actively built through further experimentation, highlighting a limitation of the current framework. It doesn't anticipate that practitioners might respond to resource or knowledge gaps by nesting one pilot within another. In other words, the framework assumes a linear scenario where a pilot either has the required means or fails due to external barriers, whereas our findings show a feedback loop: pilots can spawn sub-pilots to overcome barriers. This iterative, "pilot-within-a-pilot" approach is not captured by the existing model, which means analysts using the framework might overlook how innovative teams dynamically create enabling conditions. Recognizing this pattern is important, as it shows that pilot projects can evolve in a non-linear fashion, assembling their own building blocks through additional trials – a reality that the original pilot paradox concept does not address.

In summary, these observed patterns – strategic framing, cross-pilot synergy, programmatic embedding, and recursive sub-pilots – lie outside the scope of the classic pilot paradox factors, yet they played a significant role in the evolution and outcomes of our case studies. Each of these dynamics underscores ways in which real-world pilot projects operate in a more complex landscape than the framework assumes. By identifying these gaps, we set the stage for a deeper discussion on how the pilot paradox perspective was applied in this

study and how the framework might be refined to account for such phenomena. (These points will be further examined in the discussion chapter.)

5

Discussion

5.1. Reflection on Conceptual Framework

This research employed the pilot paradox framework as a guiding perspective to examine the two pilot projects, as outlined in the methodology. Rather than treating the “pilot paradox” as a strict hypothesis to be tested, it was used as an analytical lens – a way to interpret the cases by looking at tensions between achieving success within the pilot versus scaling that success beyond it. It is important to clarify that this approach constitutes an assessment based on the analyst’s judgement. In practice, applying the pilot paradox meant qualitatively evaluating how each pilot measured up against a set of theoretically derived dimensions (like stakeholder engagement, flexibility, or policy alignment) that literature suggests can paradoxically impede broader uptake. For example, this study looked at whether each pilot had the “protective” conditions for internal success (e.g. dedicated funding, freedom to deviate from rules) and then assessed if those very conditions left it disconnected from mainstream processes (potentially hindering external success). However, this evaluation is not a formulaic output – it relies on our interpretation of interview statements, project documents, and observed outcomes in light of the paradox concepts. In other words, calling something a manifestation of the pilot paradox (or claiming a factor is “misaligned”) involves a degree of subjective judgment. Another researcher might weigh certain evidence differently or interpret a pilot’s outcome through a different theoretical lens altogether.

Recognizing the subjective element in this analysis is crucial. The pilot paradox perspective provided a structured way to reflect on the cases, but it did not yield binary answers (e.g. “pilot successful” vs “pilot failed”). Instead, it guided an interpretive discussion of where each project stood in relation to expected paradoxical tensions. This means the findings – such as noting that Brede Groene Dijk benefited from flexibility yet struggled with institutional integration – are shaped by how we applied the framework. They are context-dependent insights rather than universally measurable facts. Had we chosen a different framework or if another analyst with a different background applied the same pilot paradox lens, the emphasis and conclusions might vary. This reflexive understanding situates our discussion: we are effectively assessing the pilots through one particular conceptual filter.

Despite this interpretive nature, using the pilot paradox framework proved valuable. It helped surface the often overlooked factors that influence a pilot’s journey from idea to impact. It also allowed us to systematically compare the two cases along common dimensions. Yet, the exercise highlighted that the framework in its current form has limitations (as detailed in section 4.3.4). Some dynamics we observed required stepping outside the given categories. This suggests that while the pilot paradox is a powerful heuristic for analysis, it may need adaptation or expansion to more fully capture complex cases. In the following, we discuss what these findings imply for the framework itself and propose recommendations to refine it, so that future researchers can apply it more effectively and consistently.

5.2. Adjusting the Pilot Paradox Framework

This study's insights point to concrete ways the pilot paradox framework could be adjusted to improve its analytical reach and utility. By refining the framework to include the dynamics identified above, other scholars and practitioners would be better equipped to assess pilot projects in different settings without relying as heavily on ad-hoc judgement. Key recommendations include:

Incorporate Cross-Pilot and Program-Level Dynamics: The original framework focuses on a single pilot's internal vs. external alignment, but this study's findings underscore that pilots often exist in a network or ecosystem of experiments. It is recommended to extend the framework to account for inter-pilot interactions and programmatic context as explicit considerations. For example, an added dimension could examine whether a pilot is part of a larger innovation program or has sister projects, and how these connections influence its success. This would guide researchers to ask questions about knowledge exchange between pilots, shared resources, or collective scaling strategies – areas that the current framework overlooks. By including a “contextual integration” dimension (encompassing both cross-pilot reinforcement and embedding in broader programs), analyses can capture the meso-level factors that affect a pilot's trajectory. This adjustment would make the framework more applicable in real-world situations where pilots rarely operate in isolation.

Acknowledge Strategic Framing and Timing: The two cases illustrated that political and strategic considerations (how a pilot is framed to decision-makers, timing decisions to align with external opportunities or crises) have major impacts on pilot outcomes. The existing pilot paradox model touches on elements like leadership and organisational culture, but it does not explicitly prompt analysis of deliberate framing or timing moves. Adding a component or sub-dimension for strategic governance actions, assessing how actors manage the narrative and schedule of a pilot to navigate institutional landscapes, would be recommended. This would encourage future researchers to document, for instance, if a pilot was fast-tracked (or delayed) due to political windows, or if its goals were reframed to garner support. Making this an explicit part of the framework ensures that such cross-cutting influences are not treated as an afterthought. It would reduce the chance that analysts miss these nuances or write them off as unrelated, and instead integrate them into the evaluation of pilot success conditions.

Reconceptualise the Resource Dimension to Allow Iterative Innovation: The pilot paradox framework currently treats resources as an input condition, but as seen in the Brede Groene Dijk, pilots may generate their own resources and knowledge through iterative sub-pilots. This study suggests the framework be refined to account for this adaptive resource generation. Practically, this could mean encouraging analysts to look for instances of pilots spawning additional experiments or partnerships to overcome barriers. The resource dimension could be broadened beyond a snapshot (“were sufficient funds/skills available or not?”) to a process view (“how did the pilot team address resource gaps over time?”). By doing so, the framework would guide a more dynamic assessment, capturing creative problem-solving strategies like launching sub-pilots or forming new collaborations. Future users of the framework could then systematically identify whether a pilot's internal success was enabled by such recursive steps, something not obvious if one only checks whether initial conditions were favourable. This change would make comparative studies more robust, as it standardises the recognition of non-linear innovation pathways across different pilot cases.

Develop Clearer Indicators and Tools for Assessment: To make the pilot paradox lens more accessible for other researchers, the framework could benefit from operationalising its dimensions into clearer indicators or even a structured evaluation tool. Currently, using the framework demands interpretive work (as we experienced), because one must translate qualitative evidence into judgements on broad categories. Providing a set of guiding questions or a rubric for each dimension would standardise this process. For instance, under each paradox dimension (and any new ones added), the framework could list observable signs of internal success and corresponding challenges for upscaling. Future analysts could then systematically check these signs in their case and score or describe the extent to which each paradox aspect is present. This would not eliminate the need for qualitative judgement – which is inherent in complex social research – but it would make the assessment more transparent and replicable. If multiple researchers apply the framework in different cases using the same guiding indicators, it will also become easier to compare results and refine theory across studies. Essentially, this recommendation calls for transforming the pilot paradox from a primarily conceptual lens into a more practitioner-friendly analytic toolkit.

By implementing these recommendations, the pilot paradox framework (Vreugdenhil et al.) can evolve from a descriptive notion of “internal vs. external success tension” into a more comprehensive and user-guided framework for evaluating pilot projects. This study’s insights would then serve a dual purpose: illustrating the paradox in action and directly informing improvements to the conceptual model. Future scholars examining pilots – be it in climate adaptation, urban innovation, or other fields – would have a richer framework at hand, one that captures not only the classic paradox dimensions but also the interactive, strategic, and iterative elements that we found to be crucial. In sum, this experience using the pilot paradox perspective highlights the importance of continually refining theoretical frameworks with on-the-ground evidence. By adjusting the pilot paradox framework as suggested, other researchers and practitioners are enabled to conduct a similar assessment of pilots elsewhere with greater nuance, consistency, and confidence in their findings.

5.3. Reflection on Contradictory Local Involvement

An important tension emerged between the empirical observations and the representations found in grey literature and expert interviews regarding local involvement. In the early phases of fieldwork, the local population appeared largely indifferent to the pilot activities; direct engagement was limited, and few residents seemed to identify actively with the goals or progress of the project. This contrasts sharply with project documentation and statements from pilot proponents, which consistently emphasise strong public support and broad regional commitment. Rather than dismissing one source in favour of the other, this contradiction highlights the layered nature of perceived involvement. While formal stakeholder processes and public communications may have created an image of alignment and enthusiasm, this perception was constructed mainly and circulated by those directly invested in the pilot’s success. Their framing of “local support” often referred to procedural compliance or absence of protest, rather than to substantive community engagement or co-ownership. This underscores the importance of critically examining who defines involvement, and through which lenses. It also suggests that successful pilot embedding (especially in regionally sensitive contexts) may depend as much on symbolic alignment and narrative legitimacy as on active grassroots participation. Recognising these nuances adds necessary depth to the stakeholder involvement dimension of the pilot paradox framework.

5.4. Limitations

It is essential to reflect critically on the methodological limitations of this research. A key limitation lies in the relatively small number of interviews conducted. Due to time and scope constraints, the interview component of the study primarily focused on a select group of institutional actors, including representatives from the Province of Groningen and regional water authorities.

While these actors play a crucial role in the design and implementation of the pilots, this focus inevitably shaped the lens through which the projects were assessed. This limitation does not invalidate the findings of this study, but it does mean that certain perspectives (particularly those of local residents, non-governmental organisations, or national-level stakeholders) remain underrepresented. As a result, the analysis may have captured only part of the broader spectrum of views on the pilot projects. Moreover, the relatively homogenous group of interviewees may have influenced the observation of contradictory attitudes toward the pilots from actors in Groningen, as described above. The nuanced tensions between enthusiasm for innovation and concern over risks or legal uncertainty, as expressed in the interviews, could partially stem from the positionality and institutional interests of the interviewed stakeholders. A more diverse respondent base might have further contextualised or complemented these findings. Acknowledging these limitations is essential not to frame them as methodological flaws, but rather to recognise them as inherent boundaries of a qualitative, exploratory study within a complex and evolving policy domain. Future research could benefit from expanding the range of interviewees to include a broader array of voices, which would help compare institutional perspectives with those of other actor groups in the region.

5.5. Reflection on AI Use

During the drafting of my research proposal, I used AI to improve, clarify, and make my text more concise. Throughout the research process, I consistently utilised AI for language refinement and to assist in structuring my arguments. The most commonly used prompts included:

- Make this more concise
- Improve grammar
- Restructure the following text

Beyond linguistic refinement, I also used AI to support the collection and analysis of information from scientific literature. I uploaded scientific articles into the language model to extract a clear overview of their research objectives and conclusions. The primary prompt used for this purpose was:

- Analyse this scientific paper and provide a detailed summary, identifying the research objective and conclusions

To validate the generated output and ensure academic integrity, I systematically verified the AI-generated summaries. This involved closely reviewing the original scientific articles and using the search function (Ctrl + F) to locate key terms and sections that corresponded to the information analysed by AI. This allowed me to efficiently assess whether the AI's summaries matched the source material, without having to reread every article in full. Regarding research integrity and data ethics, it is important to note that no interview data (such as transcripts, quotes, or the names of interviewees) were ever shared with or processed through AI tools. All empirical data were handled confidentially and analysed independently by me. This approach enabled me to work efficiently while also ensuring the quality and reliability of my research proposal. AI helped me make my writing clearer and more concise, but I take full responsibility for the content and validation of the sources used.

6

Conclusion

This thesis set out to examine two pilot projects in the Eems-Dollard estuary: the Brede Groene Dijk and the Dubbele Dijk. The aim was to understand how they originated, how they evolved, and what challenges they now face in scaling up. A qualitative case study approach was used, combining field visits, document analysis, and semi-structured interviews. The pilot paradox framework guided the analysis, but the study also identified dynamics beyond the framework.

Sub-question 1: How did the design and implementation of these pilots evolve over time?

Both pilots emerged from long-standing regional debates about silt, flood safety, and nature restoration. The Brede Groene Dijk began with technical trials that tested whether dredged silt could be matured into usable clay. Over time, it expanded into a full dike reinforcement project, supported by experimental sub-pilots such as the Kleirijperij and the Rijpdijk. The Dubbele Dijk followed a different trajectory: it was conceived from the outset as a multifunctional landscape intervention. Its design combined flood safety with ecological restoration and saline agriculture, making it broader in scope but also less fixed in form.

Sub-question 2: What barriers and enablers influenced the progression of these pilots?

Key enablers were strong local leadership, programmatic support from ED2050 and HWBP, and funding opportunities that gave political urgency to act. The pilots also benefited from flexibility in design and from knowledge exchange between the two projects. At the same time, barriers appeared. Both projects struggled with fragmented responsibilities, unclear long-term financing, and the difficulty of aligning diverse stakeholder interests. In the Brede Groene Dijk, resource gaps had to be solved through sub-pilots. In the Dubbele Dijk, broad ambitions made it hard to agree on concrete next steps. These tensions confirm but also extend the paradoxes identified in the analytical framework.

Sub-question 3: What governance dilemmas are emerging in the upscaling of these pilots?

For the Brede Groene Dijk, the dilemma lies in securing land and finance for clay ripening. Farmers are reluctant to make land available, and expropriation is politically unfeasible. Alternative methods, such as clay maturation on the dike itself, may reduce the problem, but they remain unproven and require additional funding. Moreover, many potential beneficiaries, such as conservation NGOs, are unwilling to invest because they are not formally responsible for flood safety. For the Dubbele Dijk, the central challenge is strategic ambiguity. It is unclear whether scaling should mean replicating the double-dike structure, expanding saline agriculture, or both. Without clarity, mobilizing stakeholders and resources for the next step remains difficult.

Main Research Question: How did the pilot projects in the Eems-Dollard region come into existence, evolve over time, and what challenges do they face in upscaling?

The pilots arose from a regional search for innovative, nature-based responses to intertwined problems of safety and ecology. They developed through iterative experimentation, political timing, and programmatic support, with each project reinforcing the other. Their progression was enabled by visionary actors and favorable funding, but also constrained by fragmented responsibilities and contested resource availability. Today,

the main challenge is not whether the pilots are technically feasible, but whether they can be scaled up in a contested governance landscape. The Brede Groene Dijk illustrates the difficulty of securing land and shared investment, while the Dubbele Dijk shows how unclear goals can stall momentum. Together, they reveal that the transition from pilot to mainstream depends less on technical proof and more on resolving governance dilemmas around land, funding, and strategic direction.

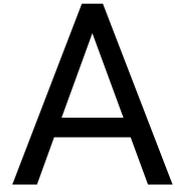
These findings highlight both the value and the limits of the pilot paradox perspective. The framework helped to structure the analysis, but the cases also revealed dynamics beyond its scope, such as strategic framing, cross-pilot interactions, and recursive sub-pilots. Recognizing these patterns is essential for future research and practice. Pilots in complex environments rarely follow linear paths. Their success in upscaling will depend on adaptive governance that can align diverse actors, clarify goals, and create resource conditions for lasting implementation.

It should also be noted that during the course of this research, recent changes in European policy began to reshape the legislative and governance context of the case studies. While these developments were not fully incorporated into the main analysis, their implications are discussed in Appendix A. The findings presented in this thesis remain valid, yet the policy changes underline that governance contexts are not static but evolving. This reinforces the need for continuous reflection on how pilot projects are assessed and interpreted within a dynamic policy environment.

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EU Nature Restoration Law

As discussed in this thesis, scaling up nature-based pilots, such as the Brede Groene Dijk and Dubbele Dijk, faces significant legal hurdles under the current Natura 2000 regime. Natura 2000 (established by the EU Birds and Habitats Directives) imposes strict protection on habitats and species, possibly limiting large-scale interventions even when they aim to improve ecosystem quality. At the same time, a new European Nature Restoration Law (Regulation (EU) 2024/1991) has been adopted, introducing binding restoration targets and a more proactive legal framework (European Union, 2024; of the European Communities, 1992). This supplement compares Natura 2000 and the Nature Restoration Law, outlining their objectives, mechanisms, and legal flexibility, and discusses how the Restoration Law creates new opportunities to upscale ED2050 pilot projects.

A.1. Natura 2000

The Natura 2000 framework (under the Birds Directive (1979) and Habitats Directive (1992)) aims to stop biodiversity loss by preserving valuable species and habitats (European Commission, 2020). Its core objective is to ensure that listed habitats and species are maintained or restored to a “favourable conservation status” in their natural range (European Commission, 2020). To achieve this, member states designate protected sites (Special Areas of Conservation and Special Protection Areas) forming the Natura 2000 network, and must implement necessary management measures to maintain or improve the ecological condition of those sites. Crucially, the Habitats Directive establishes a strict safeguarding regime: any plan or project likely to affect a Natura 2000 site undergoes an appropriate assessment (Habitats Directive Article 6(3)). Approval is only possible if it will not adversely affect the site’s integrity. If damage is unavoidable, the project must prove that no feasible alternatives exist and serve an imperative public interest, with all compensatory measures taken (Article 6(4)) (European Union, 2024). This rigorous no-deterioration rule generally prohibits activities that could degrade protected habitats or harm the conditions of species.

While Natura 2000’s strict protections are ecologically justified, they can impede innovative nature-based projects at larger scales. The Eems-Dollard estuary is part of the Wadden Sea Natura 2000 area, meaning ED2050 interventions occur in a highly regulated environment. Small pilot projects have been permitted under carefully controlled conditions, but scaling them up introduces legal complexity. For example, the Brede Groene Dijk had to navigate nature protection rules despite its environmental benefits. The pilot was explicitly designed to “fit nicely” into the surrounding Natura 2000 habitat. Yet, it required a nature permit (Wet natuurbescherming) with strict conditions and monitoring to ensure no significant harm to the salt-marsh and mudflat ecosystem. Implementation was phased and combined with ecological enhancements (e.g. creating the Klutenplasp (a temporary bird breeding island)) to satisfy conservation objectives while extracting clay. Scaling this approach to the remaining 12 km of sea dike, as envisioned by the water authority, means potentially affecting a much larger area of protected habitat. A process likely to trigger extensive assessments and possible objections under current law. Similarly, the Dubbele Dijk encountered the need for additional permits and careful design to avoid Natura 2000 violations. In practice, Dutch water managers note that multi-functional

dike concepts, such as broad or double dikes, often face additional permitting hurdles (e.g., Natura 2000 approvals), which can deter their adoption (Rekenkamer, 2022). Indeed, building with nature inside or adjacent to protected areas has been identified as problematic: regulations are “making building more difficult or halting it unintentionally” in such zones (Interviewee 2&3). The static, precautionary character of the Natura 2000 regime (preventing deterioration above all) can conflict with the dynamic restoration needed in places like the Eems estuary, where some short-term disturbance may be necessary for long-term ecological gains. This legal rigidity often limits pilot projects to a small scale or experimental status; any upscaling demands extensive justification that the intervention won’t undermine conservation targets. In short, under Natura 2000, the default legal stance is to avoid change in protected areas unless proven absolutely necessary, which poses a high bar for large-scale nature-based innovations even if they aim to improve the ecosystem.

A.2. EU Nature Restoration Law

The European Nature Restoration Law (Nature Restoration Regulation, EU 2024/1991) represents a shift from protection to proactive restoration. The law has been adopted in 2024 as part of the EU Biodiversity Strategy. It is the first EU-wide law to set binding targets for ecosystem restoration (European Union, 2024). The overarching objective is to realize the long-term recovery of biodiverse and resilient nature across all member states, while contributing to climate change mitigation and adaptation goals (European Union, 2024). Unlike Natura 2000 (which focuses on specific protected sites and species), the Restoration Law applies across broader landscapes, targeting at least 20% of EU land and sea areas to be restored by 2030 and all ecosystems in need of restoration by 2050 (European Union, 2024). This includes forests, peatlands, agricultural lands, urban green spaces, rivers, wetlands, and coastal and marine habitats. By design, it complements the Habitats and Birds Directives: it does not replace existing protections but builds on them by requiring active improvements even outside current protected areas. The law mandates each member state to develop a National Restoration Plan (within two years of entry into force) outlining how it will meet the targets, and to monitor and report progress regularly (European Union, 2024). In essence, the Restoration Law shifts EU nature policy from a reactive stance (preventing damage) to a forward-looking one of recovering degraded ecosystems at large scale.

To drive restoration, the Regulation sets a series of quantitative, time-bound targets. These include, for example: increasing the area of habitat types in “good” condition (with a goal of 90% of such habitats in good status per country), reversing pollinator declines by 2030, restoring free-flowing rivers by removing barriers (25,000 km by 2030), expanding urban green spaces, and enhancing marine habitats such as seagrass beds (European Union, 2024). Each target is underpinned by specific indicators. Critically, the law imposes a “continuous improvement and non-deterioration” obligation for areas under restoration: once measures are in place, habitats should show improving trends and, after reaching good condition, must not significantly deteriorate again (European Union, 2024). However, the Regulation introduces flexibility in how this no-deterioration rule is applied compared to Natura 2000’s absolute stance. Article 6 of the Habitats Directive remains in force for Natura 2000 sites (plans still require Article 6(4) justification if they harm a site) (European Union, 2024). But the Restoration Law explicitly acknowledges that achieving restoration may involve transformative actions and offers new legal tools to accommodate them. Notably, it clarifies that if a restoration measure intentionally converts one habitat type into another (both of EU interest), this is not deemed a deterioration (European Union, 2024). In other words, ecological change for the sake of restoration is legally distinguished from harmful degradation. This is a crucial innovation: under the Habitats Directive alone, converting (for example) an open mudflat into a vegetated salt marsh could be seen as a loss of the mudflat habitat. Under the Restoration Regulation, such a conversion can be allowed (even within a Natura 2000 site) if it is a desired outcome of a restoration project that overall benefits biodiversity and resilience (European Union, 2024).

Additionally, the law allows some regional flexibility in meeting targets: member states, “in the absence of alternatives,” may apply the non-deterioration requirement at a biogeographic region level rather than strictly per site, provided compensatory measures are taken for any localised habitat losses (European Union, 2024). This effectively permits a strategic view; a minor negative impact in one area could be offset by larger gains elsewhere, as long as the overall conservation status in the region improves. Such provisions introduce a degree of legal tolerance for well-planned interventions that may initially disrupt current conditions to achieve net ecological benefits.

The Restoration Law also emphasises climate adaptation and disaster prevention. Healthy ecosystems are seen as natural buffers, so restoring wetlands, salt marshes, and other habitats is explicitly linked to reducing flood and erosion risks (European Union, 2024). The Regulation's recitals stress building up resilience to climate impacts as a key driver for restoration measures (European Union, 2024). This framing can elevate the status of nature-based solutions for coastal protection (such as those in ED2050) as national priorities, not just for biodiversity, but also for climate safety. Indeed, certain activities beneficial to climate goals receive special legal facilitation: for example, projects related to renewable energy are declared "of overriding public interest" to prevent restoration requirements from unduly hindering them (European Union, 2024). While that specific clause pertains to energy projects, it highlights the Regulation's overall approach of striking a balance between ecological restoration and other societal interests through carefully defined exceptions and presumptions of public interest (European Union, 2024).

In summary, the Nature Restoration Law creates a more enabling legal environment for proactive ecosystem engineering: it mandates countries to undertake restoration (turning what was previously optional into a legal duty) and provides mechanisms to reconcile those restoration actions with existing conservation rules.

A.3. Implications for Eems-Dollard

The Eems-Dollard estuary is an example of the tension between static protection and dynamic restoration. Under Natura 2000 rules, ED2050's ambitions to improve tidal wetlands, water quality, and sediment balance must operate in a way that avoids impacts on existing protected features. This has meant that pilot projects like the Brede Groene Dijk and Dubbele Dijk were initially limited in scope and closely scrutinised for ecological side-effects. Each required meticulous design to align with conservation objectives (e.g. using local dredged sediment to strengthen the dike in an ecologically friendly way, thereby reducing waste and improving water quality simultaneously). Despite being designed "good for people and nature," these projects underwent extensive monitoring to ensure they did not inadvertently violate habitat protections (Interviewee 1). For instance, the Brede Groene Dijk pilot monitoring program examined the effects on the adjacent salt-marsh and mudflat communities, and its permit mandated adaptive management in the event of unforeseen ecological responses (Interviewee 1). Such precautions, while necessary under current law, illustrate how time-consuming and uncertain scaling up can be. A full 12 km green dike reinforcement will require a comprehensive Appropriate Assessment and possibly an Article 6(4) derogation if it cannot be demonstrated to be neutral to all protected features.

The new Nature Restoration Law has the potential to reframe these interventions from regulatory exceptions to encouraged actions. Firstly, the legal mandate to restore ecosystems by 2030–2050 gives ED2050 projects a supportive policy context. The Dutch government will need to include the Eems-Dollard in its National Restoration Plan, as the estuary's habitats (e.g. turbidity-impaired waters, reduced intertidal habitat) are known to be in degraded condition. The ED2050 program's own goals (i.e., achieving Natura 2000 and Water Framework Directive targets by 2050) align directly with the timeline of the EU Restoration Law (ED2050). What was previously an aspirational regional goal now carries the weight of EU law. This means that scaling up pilot measures (like marsh creation, sediment reuse, or nature-friendly dike designs) is not only permitted but arguably required to meet the binding restoration outcomes. Nature-based solutions can shift from being viewed as experimental to being recognised as essential tools for compliance with EU targets on habitat recovery and climate adaptation.

Moreover, the Restoration Law's flexibility provisions remove some legal roadblocks that ED2050 faced. For example, consider the case of expanding the Brede Groene Dijk concept, where converting portions of existing mudflats or subtidal zones into a semi-natural grassy foreshore could previously be interpreted as deterioration of mudflat habitats. Under the new law, if this conversion is part of a restoration strategy to increase coastal resilience and create new salt-marsh habitat, it "should not be considered to have deteriorated" the site (European Union, 2024). This explicitly legitimises the kind of trade-off inherent in building with nature: a short-term alteration of one habitat to achieve a long-term net gain in overall ecosystem function and biodiversity. Additionally, if some loss of habitat area is unavoidable locally, the requirement to offset it within the biogeographical region provides a clear legal pathway (through compensatory restoration elsewhere) rather than an outright prohibition (European Union, 2024). The Restoration Regulation essentially gives authorities

a green light to approve scaled-up projects provided they are part of an overarching restoration plan and yield verifiable ecological improvements. The emphasis on climate resilience in the law also strengthens the argument that these pilots serve the public interest. Restoring natural dynamics in the Eems-Dollard (e.g. reconnecting tidal flows or expanding marshes) not only benefits biodiversity but also helps buffer storm surges and sequester carbon. The law's intent to prevent and reduce natural disasters indicates that measures enhancing coastal protection via nature are aligned with EU priorities (European Union, 2024). This could make it easier to classify large ED2050 projects as having "imperative reasons" of public interest (e.g. climate adaptation), smoothing the legal justification under both Article 6(4) of the Habitats Directive and national permitting.

The ED2050 pilots themselves demonstrate how policy evolution can facilitate upscaling. The Brede Groene Dijk pilot was recently recognised nationally for its innovative approach to flood safety and sustainability, precisely because it works with natural processes. It shows that nature-based designs can be effective and "climate-proof" (e.g. easily adaptable to sea-level rise by adding more clay later). With the Restoration Law in force, the remaining 11.75 km of dike reinforcement using this green method is more defensible legally, as it directly contributes to restoring the estuarine sediment balance (trapping excess silt to improve water quality) and enhancing the ecological structure of a Natura 2000 site (a gentle foreshore for species habitat). Likewise, the Dubbele Dijk has created a new 30 ha tidal wetland behind the primary seawall. Scaling such "double-dike" concepts along more of the coast could help the Netherlands meet habitat expansion targets, since it actively creates intertidal nature while improving flood defence. Under the previous regime, each extension of this concept would face questions of habitat loss (due to enclosing part of the Dollard) and disturbance; under the Restoration Law, it can be reframed as a restorative measure – increasing the total area of salt-marsh and transitional habitat, which is something the law calls for. Importantly, the Dutch water authorities and the Hoogwaterbeschermingsprogramma (Flood Protection Program) have already begun studying how to overcome regulatory barriers for building with nature in protected areas.

In conclusion, Natura 2000 and the new European Restoration Law provide contrasting legal lenses through which to view large-scale nature-based interventions, such as those in Eems-Dollard 2050. The Natura 2000 framework, while vital for halting harmful activities, has historically constrained the upscaling of pilots due to its strict "no harm" ethos and procedural hurdles. ED2050's experience highlights these challenges – innovative projects had to tiptoe around regulations designed for static conservation. The Nature Restoration Law (2024) marks a significant shift to a restoration and resilience ethos, introducing legal mandates and flexibilities that can transform such pilots into mainstream practices. By setting explicit restoration targets (including for coastal and estuarine habitats) and allowing adaptive management (habitat transformations and compensated impacts), the law provides legal room to grow for initiatives like the Brede Groene Dijk and Dubbele Dijk. This proactive legislation effectively supports ED2050's vision: it aligns regulatory imperatives with ecological innovation, ensuring that scaling up nature-based solutions is not seen as an infringement on protection rules, but rather as a fulfilment of new restoration obligations. For coastal regions like the Eems-Dollard, at the intersection of climate adaptation and ecosystem recovery, the European Restoration Law thus serves as a timely enabling instrument – bridging the legal-ecological gap and empowering practitioners to upscale pilots into transformative, landscape-scale actions that benefit both nature and society. The coming years will test how these legal opportunities are implemented in practice. Still, the direction is clear: Europe's environmental law is evolving not just to defend the status quo of nature, but to rebuild it actively, opening the door for ED2050's pioneering projects to become a blueprint for sustainable estuarine management across the EU.

B

Contactpersons

ID	Occupation or situation
Contactperson 1	Program Manager
Contactperson 2	Resident near Dubbele Dijk
Contactperson 3	Person walking dog on dike
Contactperson 4	Restaurant owners near Dubbele Dijk
Contactperson 4	Owners B&B near Brede Groene Dijk
Contactperson 5	Owners local shop Delfzijl
Contactperson 6	Independent researcher connected to Brede Groene Dijk
Contactperson 7	Workplanner Rijpdijk
Contactperson 8	Employee & Guide from Hunze & Aa's
Contactperson 9	Owner small coffee stand in Nieuw Statenzijl
Contactperson 10	Elderly couple walking in Nieuw Statenzijl
Contactperson 11	Waitress restaurant in Termunterzijl
Contactperson 12	Man sunbathing/swimming at beach Termunterzijl
Contactperson 13	Receptionist Hotel Delfzijl
Contactperson 14	Employee Noorderzijlvest (phone conversation)
Contactperson 15	Birdwatchers on top of Brede Groene Dijk
Contactperson 16	Mother and young son at Zeehondenkijkwand
Contactperson 17	Worker at Dubbele Dijk
Contactperson 18	Hikers on Dollarddijk
Contactperson 19	Woman walking dog near Dollarddijk
Contactperson 20	Family mowing sheep on/next to Brede Groene Dijk
Contactperson 21	Resident of Finsterwolde next to supermarket
Contactperson 22	Resident of Spijk
Contactperson 23	Cycling elderly couple having a break near the Ambonezenbosje
Contactperson 24	German couple in 'De Kiekkaaste'
Contactperson 25	Man walking in Polder Breebaart
Contactperson 26	Owners kibbelingkraam Bad Nieuweschans

Table B.1: Overview of contact persons with description of the situation or their occupation