

## Organizing resilient infrastructure initiatives

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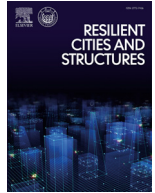
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## Full Length Article

# Organizing resilient infrastructure initiatives: A study on conceptualization, motivation, and operation of ten initiatives in the Netherlands

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## ABSTRACT

Resilient infrastructure is critical to a sustainable and functioning society. Infrastructure management and (re)development are highly complex processes encompassing various stakeholders' interests while they are pressured by the uncertainty of climate change and social transition. In response to these challenges, various resilience initiatives emerged with different motivations and approaches. The purpose of this research is to understand the interplay between motivations and organizational approaches as well as resilience conceptualization. This can provide insights into which domains of resilience have been focused on and what needs to be improved in their organizational approaches to realize motivations. This research specifically investigates ten resilient infrastructure initiatives in the Netherlands. By using scoping review and content analysis, our results highlight that resilience initiatives conceptualize resilience in different ways, mainly focusing on built and organizational resilience with a focus on long-term and wider geographic scope. Each initiative had several motivations, including 1) creating innovative solutions, 2) sharing knowledge, 3) promoting commitment and cooperation, and 4) promoting resilience. These motivations are reflected in the organizational approach. For example, there was a strong link between the motivation 'creating shared knowledge' and the organizational approach 'research collaboration.' Generic motivation such as 'promoting resilience' does not have one mainstreaming approach, which shows promoting resilience in practice is still in the exploration stage. This research provides major motivations and organizational approaches and their link within the resilient infrastructure initiatives which can contribute to better organizing similar initiatives aiming for resilient infrastructure.

## 1. Introduction

The infrastructure sector is the backbone of socioeconomic and technological development and critical for a sustainable future [1]. However, current infrastructures in advanced countries are facing the end of their technical and functional life cycle, becoming obsolete due to their ageing and changes in social needs. At the same time, the infrastructure sector is getting pressure from societal challenges such as climate change and sustainability. The decision to maintain, renew, or replace those infrastructures can be an opportunity to improve the infrastructure sector more resilient and sustainable in the future. In other words, infrastructure projects play a key role in multiple transitions and can contribute to the sustainability of society [2].

Naturally, infrastructure projects involve various stakeholders with different motivations, agendas, and values. To overcome the barriers between different sectors and disciplines, an 'initiative' can enable collaboration for a common goal [3]. Especially, there are many infrastructure project initiatives advocating resilience. Resilience can be a useful concept as a holistic approach to understanding a system's performance

in times of disturbance under complexity [4]. The resilience initiatives pursue long-term investment in resilience which can generate low opportunity costs and high returns in the long run [5], and contribute to changing the culture, understanding, and approaches in organizations toward more resilient thinking.

There are several studies on monitoring resilience initiatives' performance (e.g., [6]). Evaluating initiatives' performance is important as performance legitimizes the investment of resources from their mother organizations and promotes continuous improvements of initiatives in their missions, goals, and activities [7]. However, there is less attention to why and how these initiatives are organized. Understanding motivation and approaches of resilience initiatives can identify knowledge gaps (which areas have less focus?) and room for improvement (how can resilience initiatives perform better?). Motivations and approaches define initiatives' activities and performances, which in turn legitimize the existence of the initiatives.

Therefore, the purpose of this paper is to find the common motivation and organizational approaches of resilience initiatives in the infrastructure sector and contribute to better organization of such initiatives.

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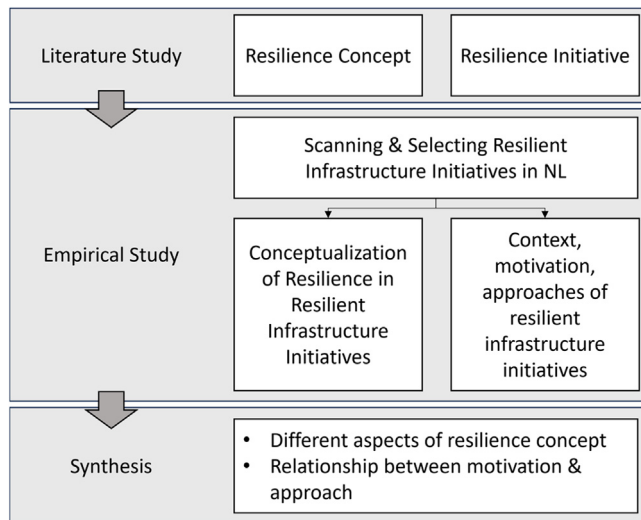


Fig. 1. Flow of the Research.

The research questions are; 1) how do resilience initiatives conceptualize and operationalize resilience?; and 2) what are the motivations and organizational approaches of these initiatives and how those are related?

To answer these questions, ten exemplary resilient infrastructure initiatives in the Netherlands are selected. The Netherlands is one of the countries with various infrastructures dealing with uncertainties and complexity in the decision of maintenance, renewal, and replacement. There are multiple inter-organizational initiatives and programmes in the Netherlands to manage and/or renew infrastructure to prepare for the future, considering sea-level rise and social change [8]. Understanding the resilience initiatives in the Dutch infrastructure sector can bring insights into organizational collaboration and in turn, enhance the resilience and sustainability of the infrastructure sector.

The remainder of this paper is organized as the following (see Fig. 1). The literature review first introduces the resilience concept including definitions and characteristics (domains). Then it explores resilience initiatives as an inter-organizational collaboration in the infrastructure sector. Then, the research method section describes data collection and analysis methods, including screening of Dutch resilient infrastructure initiatives. After briefly introducing each initiative, the findings section summarizes and synthesizes resilience conceptualization, contexts, motivations and organizational approaches of these initiatives. Finally, the conclusion section highlights the practical implication of this research, the limitations and opportunities for future research.

## 2. Literature review

### 2.1. Conceptualizing and operationalizing resilience

The original resilience concept by C.S. Holling was defined in two different approaches: static ‘engineering’ resilience and dynamic ‘ecological’ resilience, in which the former is recovering back to the original state while the latter is maintaining the system’s function during disturbances [9]. Since then, the resilient concept has become prevalent in various fields of study, including ecology, disaster and risk management, climate change adaptation, international development, engineering, energy, and planning [10,11]. Broadly speaking, resilience means a system’s ability to withstand, absorb, and adapt to shocks and transform into a better system [12]. In social science, resilience is more than bouncing back to normal [13], instead, it is the ability to adapt to various challenges since the system is never stable [10]. In that sense, the concept aligns with that of socio-ecological system studies, which refers to resilience as the capacity of a system to maintain its function

while absorbing the impact of disturbance, to self-organize, adapt and learn [14]. The resilience of a system is critical for a sustainable society [15]. Meerow et al. [10] provide a comprehensive definition of urban resilience as “the ability of an urban system-and all its constituent socio-ecological and socio-technical networks across temporal and spatial scale- to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity (p. 45, author’s highlight).” Although there is no agreement on the degree or speed of change, the commonly recognized phases in the resilience concept are absorption, recovery, and adaptation [11].

Adding to the laxly defined resilience concept, operationalizing resilience in practice is also challenging. Different initiatives interpret resilience according to their goals, which makes it challenging to activate broader engagement in the resilience movement due to a lack of awareness or incentives [16]. The Resilient City Approach perceives resilience as a set of tools for cities (or city governments) to deal with existing or foreseen problems [17]. Four components consist of system resilience: technical, organizational, social, and economic [18]. Technical resilience means providing a certain level of service during and after the crisis while organizational resilience reflects timely and informed decision-making. Social resilience is the preparedness of the community or neighbourhood for the crisis and the level of help people can get from their neighbours. Finally, economic resilience is having financial means to recover from a disaster.

Resilience can be operationalized in three different ways: 1) capital or assets, 2) capacity and 3) quality of the system’s component [6]. Resilience as capital is an asset or existing trait of a city that can be utilized in absorbing/recovering/adapting to shock, including built, human, social, economic and natural capital. Resilience as capacity is the ability of a city (or system) which is adaptive, anticipatory, and absorptive capacities. Finally, existing resilience evaluation frameworks provide dimensions and drivers of resilient cities/systems and identify the quality or requirement of their components. It defines the quality of system components as reflective, resourceful, robust, redundant, flexible, inclusive, and integrative. One observation from these conceptualizations is that it seems the system’s resilience is achieved when the system’s components are resilient (e.g., [18] and [11]). In other words, making a resilient system entails equipping each component of the system with certain assets or qualities. The components are sectoral domains such as built and natural environment, governance (organization), human and social capital, and economy (economic resilience). When these domains are ‘reflective’, ‘resourceful’, ‘robust’, ‘redundant’, ‘flexible’, ‘inclusive’ and ‘integrative,’ the system can be considered as resilient.

As mentioned above in the definition of Meerow et al. [10], resilience entails scale boundaries. Resilience can be urban, regional, or national, concerning specific geographical areas. At the same time, there are temporal elements in resilience, focusing on the short-term, medium-term and long-term resilience of the system [10,19]. This relates to how much change is desirable to pursue resilience, whether it’s step-by-step change transitory, incremental or radical transformation [11].

As summarized in Table 1, there are various studies on the understanding of the resilience concept. Different focuses show the complexity of the resilience concept, which has multiple layers and characteristics. The complexity of conceptualization and operationalization challenges various organizations that pursue resilience in their domains as well as collaboration between the organizations.

### 2.2. Resilience initiatives and inter-organizational collaboration

According to the Cambridge Dictionary, an initiative is “a new plan or action to improve something or solve a problem.” Initiatives can assist the project’s success and bring about broader change in culture, perception, and way of working within the organization [20]. Moreover, initiatives are not bounded by the boundary of a single organization. They can be organized between different organizations depending on

**Table 1**  
Overview of conceptualizing and operationalization of resilience.

Focus	Concept	Source
Phases	System's capacity to absorb, recover, and adapt to the shock	[11]
State of the system after the recovery phase	Bouncing back to normal vs. recovering and adapting to the shock	[13]
Resilient system has...	<ul style="list-style-type: none"> <li>• Technical resilience: built &amp; natural capitals</li> <li>• Organizational resilience: organizational capital</li> <li>• Social resilience: human &amp; social capital</li> <li>• Economic resilience: economic capital</li> </ul>	[11,18]
Resilience as ...	<ul style="list-style-type: none"> <li>• Capital: built, human, social, economic &amp; natural capitals</li> <li>• Capacity: adaptive, anticipatory, &amp; absorptive capacities</li> <li>• Quality of systems' components: reflective, resourceful, robust, redundant, flexible, inclusive &amp; integrative</li> </ul>	[6]
Scale	<ul style="list-style-type: none"> <li>• Geographical scale (urban, metropolitan, regional, ...)</li> <li>• Time scale (short-term, long-term)</li> </ul>	[10,19]
Degree of change	Transitory, incremental or transformational	[11]

Source: author's summarization.

the scope of the problem [3]. For example, there is a consensus that climate change cannot be solved by one agency and collaborative efforts are needed. Collaboration is “a cooperative relationship amongst organizations that relies on neither market nor hierarchical mechanisms of control [3; p. 24]”

In that sense, resilience initiatives can be understood as inter-organizational collaboration. Inter-organizational collaboration occurs to share and complement resources, skills, and knowledge to overcome challenges that an entity cannot deal with alone [21]. Resilience initiatives promote resilience concepts and mobilize the resources and capacity of various organizations to tackle societal issues. Organizations include (local) government, businesses, universities and knowledge institutes to community organizations. Collaboration is the core of such initiatives, working together to achieve a shared goal. However, there are many forms of collaboration, showing different dynamics in goals, processes (organizational structure), interaction, and decision-making processes [22].

Especially, inter-organizational collaboration creates new roles and responsibilities (work division/specialization) and new governance (controlling and coordinating organizational processes) [23]. In the context of resilient infrastructure, inter-organizational cooperation is desirable as an integrated approach can save resources (human, material, and financial) and create more sustainable infrastructure [24]. However, inter-organizational collaboration in infrastructure projects is often hindered by a lack of incentives to cooperate [25], a lack of clear data-sharing practice [24] and limited operational mechanisms bounded by rules and regulations instead of trust and reciprocity [26]. Interorganizational collaboration in infrastructure projects can navigate different values and interests of organizations, effectively use limited resources and capacity, and enable dealing with the complexity of infrastructure projects [27].

The values and interests of organizations are reflected in their motivation [28]. Moreover, motivation shapes goals, approaches, and activities in collaboration. Motivation or work motivation is “a set of energetic forces that originate both within as well as beyond an individual's being, to initiate work-related behaviour, and to determine its form, direction, intensity, and duration [29: p.11]”. To understand how resilience initiatives are organized, we need to first look into their motivation and how it is related to their activities. Hence, this research seeks to study ten resilient infrastructure initiatives in the Netherlands, mapping their resilience concept, motivation and operational approach to theorize their relationships.

### 3. Methodology

We first highlight the ‘why’ we made certain research choices and then the ‘what’ we did as part of the data collection and analysis [30]. This research aims to explore the motivations and approaches of different infrastructure resilience initiatives. Specifically, the focus is on the interplay between those motivations and organizational approaches. For this exploratory research, qualitative inductive research is apt because it allows the researcher to start with instances, construct patterns from these using inferences from appropriate conceptual frameworks and create a theory on this basis. Especially, the focus of this study, the motivation and organizational approaches of resilient infrastructure initiatives are descriptive and qualitative. Bansal et al. [31] highlight that inductive theorizing grounded in data can broaden the researchers' epistemological frame, yielding completely novel ideas. Analysing narratives in the text is a well-accepted research method to study motivations [32]. We particularly use the narrative scoping approach, which involves navigating a wide range of literature to present conceptual clarification or evidence [33,34]. Various narratives of motivations of the resilient infrastructure initiatives and their approaches are studied to answer the research questions.

The focus of the analysis is the Netherlands. The Netherlands has been exploring the concept of resilience, publishing ‘The Netherlands' Recovery and Resilience Plan’ responding to the crisis of the pandemic, including green transition, digital transition, and ensuring socioeconomic resilience. The special focus is on the infrastructure sector. Infrastructures are critical for social prosperity and they are directly influenced by climate change. In the Dutch context, asset managers (e.g., Rijkswaterstaat) and municipalities are facing challenges: infrastructures are ageing; maintenance costs are increasing; and other uncertainties threaten the planning [35]. However, all these challenges can be an opportunity for a resilient infrastructure renewal [8] with collaborative governance. There are multiple initiatives which seek to push the envelope in developing resilient infrastructure.

The scope of resilient initiatives and programmes includes initiatives or programmes initiated by any entities, including public, and private actors, civil society, universities, and knowledge institutes. Initiatives that use the word ‘resilience’ in their aim, objectives, or their programme are included. First, we conducted a quick online search on resilient infrastructure initiatives in the Netherlands using the search terms resilient initiative, resilient infrastructure initiative, infrastructure renewal, resilient programme, resilient infrastructure renewal pro-

gramme, and resilient cities to retrieve 25 initiatives in the Netherlands. Second, using a snow-balling approach we identified five more initiatives arriving at 30 resilient infrastructure initiatives in the Netherlands. Third, we collected preliminary data on these 30 initiatives and selected ten relevant resilient initiatives and programmes focusing on infrastructure renewal in the Netherlands. The preliminary data includes title, initiator and related organizations, duration (year), funding sources, focus area (domain), general goals and aims, methodology, resilience concept, and regional scopes of initiatives. To select the most relevant initiatives, the following exclusion criteria are considered: 1) the focus area is not infrastructure (e.g., general climate research or resilience); 2) inter-organizational collaboration (e.g., partnership, network, research consortium, etc.) is not explicitly defined; and 3) there is no specific action points. After the screening, ten initiatives were selected with a clear focus on infrastructure (maintenance, renewal, or replacement) and resilience, and have organizational approaches. Finally, we gathered statements regarding mission, vision, goals, resilience concepts, activities and approaches from annual and interim reports, websites, and other publicly available documents of the selected initiatives to understand the context (challenges), motivations, and organizational approaches as well as resilience conceptualization.

We then used a grounded theory approach by Strauss and Corbin [36] to analyse the data collected. Grounded theory is an inductive research process that is effective in transforming raw data into theoretical concepts [37]. It is a theory building based on evidence (data) to help understand similar phenomena and cases and to provide a framework for future research. Open coding, axial coding, and selective coding are the major steps of grounded theory. First, we open-coded the data (various statements regarding resilience, motivation, and organizational approaches) compiled from the ten resilient infrastructure initiatives to extract instances of different motivations. For motivation, the statement in future tense or subjunctive structure is considered. For example, the RED&BLUE states that “Our shared purpose is to create a common language, shift understandings, build collective governance capacity, and promote systems-changing spatial strategies that guide urban re/development and investment in Dutch delta settings”. From this statement, we extracted ‘to create a common language,’ ‘to shift understanding,’ ‘to build collective governance capacity,’ and ‘to promote systems-changing spatial strategies.’ These ‘raw’ data are later compared with motivations of other initiatives and grouped by similarity to create categories. ‘to create a common language’ is categorized as ‘to create and share knowledge.’ Thus, open coding involved breaking down, examining and categorizing the data into open categories [36] and we created multiple categories for challenges, motivations, and approaches from these ten resilient infrastructure initiatives. Second, we used axial coding to find the relation between motivation categories and approach categories. Axial coding involves putting categories back together in new ways to provide new insights [36]. While open coding fractures the data, axial coding allows theory to emerge from data as the researcher investigates “what is really going on” in the data [38]. Then finally, we carried out a selective coding to synthesize the challenges, motivations and organizational approaches to generate a theory. The theory aims to explain how different motivations resulted in various organizational approaches.

## 4. Findings

### 4.1. Ten Dutch resilient infrastructure initiatives

This section introduces a brief overview of resilient infrastructure initiatives in the Netherlands. The overview includes context and challenges which initiatives are focusing on, why the initiative was started and how it is organized.

- (1) RED&BLUE (Real Estate Development & Building in Low Urban Environments).

RED&BLUE is a research programme (2022–2027) under Resilient Delta, a consortium between TU Delft, Erasmus University, Rotterdam, and Erasmus MC. The focus area of RED&BLUE is real estate development and infrastructure investments in the Netherlands. Dutch real estate development and infrastructure sector are under fragmented structures, fighting for limited resources and space. There is an urgent need to “co-develop adaptive and equitable climate strategies for the Netherlands”. Their aim is to combine the worlds of climate risk management, real estate, finance, asset management, spatial planning, and water management. The consortium wants to change the business case in the real estate market through joint learning. Their main activities are trans-disciplinary research and networking through 1) regular (inter)national cross-disciplinary meetings, 2) science-practice exchange focused on use cases within the Greater Amsterdam and Rotterdam regions, 3) public events and 4) online and physical interventions.

- (2) Programme Next Generation Infrastructures (NGinfra).

NGinfra is a long-standing cooperation between large-scale infra-developers in The Netherlands such as transportation, drinking water, electricity, and flood protection, amongst others. NGinfra highlights the uncertainty of executing long-term strategies. There are nine dilemmas including 1) new vs. existing business models; 2) collaboration; 3) innovation; 4) engaging stakeholders; 5) responsiveness; 6) value; 7) flexibility and robustness; 8) digitalization and resilience; and 9) long-term vs. short-term resilience. The initiative aims to bring cooperation between large-scale infrastructure developers in the Netherlands, with six thematic areas: 1) infrastructure managers for safe use of the subsurface in the Netherlands (SIVOON), 2) exploring the future, 3) value of infrastructure, 4) infrastructure data, 5) security and 6) availability (of infrastructure). The NGinfra presents itself as a knowledge centre, and its main activities include joint research and knowledge sharing.

- (3) Redesigning Deltas.

Redesigning Deltas is a 5-year research programme aiming to build knowledge and promote commitment and cooperation for integrated management for the resilience of the Dutch Delta area. The collaboration involves the Delta Urbanism group and various faculties of the TU Delft, the Delta program, Deltares, Resilient Delta, Erasmus University, Wageningen University and PBL. The main activities include 1) joint fact-finding, 2) design study, 3) academic synthesis, and 4) cross-boundaries exchange. These four activities construct a feedback loop to define the education and research program that focuses on implementation. The main methodological approach is research by design.

- (4) Delft Deltas, Infrastructures & Mobility Initiative (DIMI).

DIMI is part of TU Delft’s research and education programme which aims to solve interdependent and complex social issues by developing integrated solutions for vital infrastructure facilities for flood risk management and smart mobility. DIMI specializes in design solutions to create adaptable and multifunctional technical solutions. They aim to train people, disseminate knowledge, and collaborate to make innovative solutions for urban deltas. DIMI provides multi- and interdisciplinary research and education. Highlighting research by design as an innovative methodology, their three major themes are Future-proof Built Environments & Urban Infrastructures, Resilient & Adaptive Urban Delta, and Innovation Airport.

- (5) Resilient Rotterdam.

Resilient Rotterdam is initiated by Rotterdam municipality to make Rotterdam a resilient living community of people by ensuring the quality of development, knowledge sharing, and leadership. The focus areas include 1) cyber port city, 2) infrastructure, 3) climate resistance, 4) clean and reliable energy, 5) society in balance, 6) network city, and 7) resilience thinking. The municipality supports any initiatives under these focus areas and coordinates networking events for knowledge sharing.

## (6) City Deals (Agenda Stad).

City Deals is a network of the central government, municipalities, and social agencies in the Netherlands to build commitment and collaboration to promote growth, quality of life and innovation. The main focus is on economic growth and competitiveness, however, resilience is also included in the ‘deals.’ These public agencies make ‘deals’ to work together in the following areas: 1) circular city, 2) data infrastructure, 3) energy transition, 4) health and quality of life, 5) cross-border economy, 6) climate adaptation, 7) next economy, 8) social arrangement, 9) urban transformation, and 10) top campuses and innovation environments. The city deals are making shared ambition and cooperation to develop innovative solutions for social challenges with various public and private agencies. This is a highly innovative approach for the Netherlands by working together multisector, multilevel and multidomain. It is highly reflective of the governance of innovations and their scaling-up.

## (7) 4TU.RE Centre and DeSIRE programme.

4TU Centre for Resilience Engineering (4TU.RE Centre) is a research consortium amongst four universities of technology in the Netherlands, including the Delft University of Technology, Eindhoven University of Technology, University of Twente and Wageningen University and Research. The centre focuses on engineering solutions (technical solutions and system designs) in interaction with social-ecological systems. The centre initiated DeSIRE (Designing Systems for Informed Resilience Engineering) funding programme to generate awareness of resilience and build a professional community in resilience engineering. The programme focuses on 1) resilience thinking in engineering, 2) measuring the resilience of social-technology-ecology systems, and 3) resilience governance in systems such as agriculture, decision-making, energy, cyber, supply chain, transport networks, cities, and water.

## (8) Dutch Resilience Hub (Netherlands Water Partnership).

The Dutch Resilience Hub was initiated by the Netherlands Water Partnership to establish the Dutch Resilience Ecosystem. It provides networking opportunities for public, private and non-governmental agencies working around resilience in cities, coastal communities, or rural areas through various events including round table sessions, webinars, and conferences. It also has a large international network in Asia, North and South America, Europe and the Middle East, providing opportunities for international cooperation. It highlights collaboration for new knowledge, technologies and tools for resilience.

## (9) NWA call - Urbiquay (Urban Bridges and Quay Walls).

NWA call - Urbiquay is a research funding program initiated by the Dutch Research Agenda (NWA) to make resilient urban bridges and quay walls. There are many bridges and quay walls in the historic centres of cities in the Netherlands such as Amsterdam. Since these bridges and quay walls face the end of their life cycle, this research funding program seeks to find resilient and sustainable ways to maintain and/or renew infrastructure. Three research projects are awarded for the funding: LiveQuay; live insights for bridges and quay walls, STABILITY: sustainable circular life extension strategies for inner-city bridges and quay walls, and Logiquay: adaptive multi-actor multi-modal closed-loop planning and logistics for renewal and renovation of urban bridges and quay walls. This initiative looks for new approaches for renovation to contribute to benefits other than their direct function

## (10) Infra Administrator Network.

The Infra Administrator Network (Bestuurders Netwerk INFRA) includes 35 Dutch asset managers and public organizations in charge of various infrastructures (e.g., bridges, locks, and quay walls). The Dutch infrastructures are facing their end-of-life cycle and need maintenance, renewal or replacement. This poses a great opportunity to seek sustainable and resilient infrastructure. By organizing Infra5daagse, a 5-day

meeting with decision-makers of participating organizations, this initiative provides opportunity for networking to co-create solutions for future proof infrastructure.

## 4.2. Focus area and domains of resilience in resilience initiatives

Before diving into the motivation and approaches of resilience initiatives, it is first necessary to understand how those initiatives are identifying resilience concepts. The analysis focused on the domains of resilience such as capital or assets that the resilient system has rather than the quality or capacity of the system or the system’s components. The main goal is to reveal the initiatives’ focus areas and emphasized resilience domains. From the statements regarding resilience from each initiative, the 13 defined codes (see the title row of Table 2) for resilience domains are checked.

The comparison between the ten resilient infrastructure initiatives reveals three important points. First, there is a relationship between the focus area and resilience domains. The initiatives focusing on a specific sector (e.g., RED&BLUE, Urbiquay) emphasize specific resilience domains such as built and organizational capital. On the other hand, initiatives focusing on cities (e.g., Resilient Rotterdam, Agenda Stad) or networks (e.g., Dutch Resilience Hub, Infra Administrator Network) encompass all domains of resilience.

Second, all initiatives checked built and organizational capital in the resilience domain. Since this study targets the infrastructure sector, it is natural to see check marks in the built capital. Interestingly, check marks are also found in organizational capital. Infrastructure management and operation are highly relevant for organizational capital, which reflects stakeholders’ management and decision-making. On the other hand, there is less attention to natural, social, and economic domains. Only three initiatives mention natural capital and five mention social and economic capital.

Finally, for time and geographic scale, most of the resilience initiatives show gradual plans toward long-term and broader geographical scale. For example, Redesigning Deltas, Urbiquay and Infra Administrator Network primarily target infrastructure with a narrow geographical scale, but they recognize a wider impact on urban, regional, and even national scope. It suggests resilience infrastructure initiatives not only focus on the resilience of infrastructure itself but also consider the wider impact of the infrastructure on society.

## 4.3. Motivation and approach of resilience initiatives

The different contexts, motivations and approaches of the ten resilient infrastructure initiatives in the Netherlands are summarized in Table 3. RED&BLUE, NGinfra, Redesigning Deltas and DIMI, and 4TU.RE Centre are knowledge institutes initiated by universities. Similarly, Urbiquay is a national research program to make infrastructure climate-resilient and future-proof. These research initiatives all recognize the uncertainty and complexity of the infrastructure sector and the need for an integrated approach. Therefore their motivation is to create knowledge and mobilize people to promote commitment and cooperation toward a more integrative and resilient infrastructure. To do so, these initiatives take research collaboration, education, and networking as the main organizational approaches.

RED&BLUE, focusing on real estate development and infrastructure, has the motivation to create a common language through “transdisciplinary knowledge and collaboration” and “co-creation process.” NGinfra’s major motivation is to build knowledge together. They believe “tackling issues together is not only cheaper but also yields more.” With the knowledge, NGinfra wants to promote commitment and cooperation amongst public, private, and knowledge organizations for resilient Dutch infrastructure. Their main activities are through research collaboration and networking with knowledge sharing. The main goal of Redesigning Deltas is “to build the knowledge and collective commitment in the Delta community” which shows their motivation in creat-

**Table 2**  
Scope of Resilience in Resilience Initiatives.

Initiatives	Focus area	Resilience Domains														
		Capital				Time scale			Geographic Scale							
		Human	Social	Natural	Built	Organizational	Economic	Short-term	Mid-term	Long-term	Infrastructure	City (urban)	Regional	National/EU		
Red&Blue	Real estate & infrastructure investment	v	v		v	v		v			v			v		
NGinfra	Public space management	v	v		v			v						v		v
Redesigning Deltas	Dutch infrastructure	v			v	v		v			v					v
DIMI	Delta management	v			v	v		v						v		v
Resilient Rotterdam	Rotterdam	v			v	v		v						v		v
Agenda stad	Dutch cities	v			v	v		v						v		v
4TU.RE Centre	Engineering	v			v	v			v					v		v
Dutch Resilience Hub	Dutch Resilience Hub Network	v			v	v		v						v		v
Urbiquay	Infrastructure	v			v	v		v						v		v
Infra Administrator Network	Dutch infrastructure	v			v	v		v						v		v

ing knowledge and promoting commitment. DIMI wants to contribute to “sustainable social welfare and economic prosperity” through an “integrated approach with interdisciplinary research and education.” 4TU.RE Centre also has the motivation of building knowledge and promoting commitment and cooperation, as their mission statement writes “to develop, apply and disseminate knowledge, methods and tools for making societies more resilient.” Their activities include research collaboration and education.

Resilient Rotterdam, Agenda Stad, Dutch Resilience Hub and Infra Administrator Network are mainly a network amongst cities or public and private organizations that are interested in resilience. These initiatives aim for broader resilience not limited to infrastructures, but building resilient infrastructure is one of their core goals. Initiated by public organizations, these initiatives foster networking amongst experts to create knowledge and solutions in a collaborative way. For example, the Dutch Resilience Hub states “to promote our resilience strengths as a whole,” “to connect you to matching opportunities,” and “to form a Dutch Resilience Ecosystem” as motivation while the Infra Administrator Network promotes “integrated and future-proof” infrastructure sector by “jointly formulate an approach.”

4.4. Synthesis of the findings

The purpose of organizing resilient initiatives is to improve critical infrastructure [6]. From our data, we saw that resilient infrastructure initiatives focused on addressing three challenges and these are also the context around which the initiatives are proposed. These are: 1) external threats such as climate change, for example, the RED&BLUE and Dutch Resilience Hub are focused on addressing climate change; 2) societal change such as sustainable future, energy transition, digitalisation, and globalization, for example, DIMI is focused on social issues and Agenda Stad is focused on energy transition; and 3) specific infrastructure challenges such as the need for renewal, for example, the Storm Surge Barrier Programme is aimed at renewing existing infrastructure. We see from the context and challenges these resilient infrastructure initiatives focus on are intertwined and complex which is why the resilience concept is useful. For example, the Resilient Rotterdam initiative focuses on climate change and societal change such as digitalization.

Recognizing these challenges, the motivations of the resilient initiatives can be categorized into four: 1) to create innovative solutions such as in the case of Urbiquay, 2) to create and share knowledge as with 4TU.RE Centre, 3) to promote commitment and cooperation such as in the case of Agenda Stad, and 4) to promote resilience as with Dutch Resilience Hub. Creating innovative solutions is a specific motivation targeting innovation in infrastructure renewal while creating and sharing knowledge to build knowledge around the resilience concept in the infrastructure sector. Promoting commitment and cooperation means mobilizing people and creating a common language to create connections and networks so that people have a shared understanding and bring systematic change. Finally, promoting resilience means making something resilient, including infrastructure, Rotterdam (a city), the Dutch Delta (a region), or society. These motivations are also related to each other.

Based on these motivations, the initiatives have different approaches. Their main approaches can be broadly categorized into four: 1) research collaboration similar to NGinfra, 2) education as in Redesigning Deltas, 3) networking as in Resilient Rotterdam, and 4) co-creating solutions as in Urbiquay. Research activities are mentioned along with collaborative, inter- and transdisciplinary which highlights the co-creation of knowledge. Education and training programmes are often accompanied by the results of collaborative research. Education and training are to generate awareness of resilience and increase the capacity of individuals or organizations in terms of adaptability and flexibility. Networking is creating an arena to make connections and find shared interests and opportunities to collaborate. The networking

**Table 3**  
Context, Motivations and Approaches of Resilient Infrastructure Initiatives.

No.	Initiatives	Context (Challenges)	WHY: Motivations	HOW: Approach
1	RED&BLUE	<ul style="list-style-type: none"> <li>• Fight for space</li> <li>• Fragmented structure</li> </ul>	<ul style="list-style-type: none"> <li>• To create a common language (knowledge)</li> </ul>	<ul style="list-style-type: none"> <li>Research collaboration</li> <li>Networking</li> </ul>
2	NGinfra	<ul style="list-style-type: none"> <li>• Climate change risk</li> <li>• Uncertainty, dilemmas</li> </ul>	<ul style="list-style-type: none"> <li>• To promote systemic change</li> <li>• To mobilize people</li> </ul>	<ul style="list-style-type: none"> <li>Research collaboration</li> <li>Networking (knowledge sharing)</li> </ul>
3	Redesigning Deltas	<ul style="list-style-type: none"> <li>• Environmental crisis, fragmented practice</li> </ul>	<ul style="list-style-type: none"> <li>• To promote commitment &amp; cooperation</li> <li>• To build knowledge</li> </ul>	<ul style="list-style-type: none"> <li>Research collaboration</li> <li>Education</li> </ul>
4	DIMI	<ul style="list-style-type: none"> <li>• Social issues, interdependence &amp; complexity</li> </ul>	<ul style="list-style-type: none"> <li>• To promote commitment &amp; cooperation</li> <li>• To create knowledge and educate people</li> </ul>	<ul style="list-style-type: none"> <li>Research collaboration</li> <li>Education</li> </ul>
5	Resilient Rotterdam	<ul style="list-style-type: none"> <li>• Climate change, digitalisation, new economy &amp; globalization are growth opportunities</li> </ul>	<ul style="list-style-type: none"> <li>• To make Rotterdam resilient</li> <li>• To initiate movement (mobilize people)</li> </ul>	<ul style="list-style-type: none"> <li>Support initiatives (co-create solutions)</li> <li>Networking</li> </ul>
6	Agenda Stad	<ul style="list-style-type: none"> <li>• Energy transition, climate change</li> </ul>	<ul style="list-style-type: none"> <li>• To promote commitment &amp; cooperation</li> </ul>	<ul style="list-style-type: none"> <li>Collaboration (shared goal, &amp; agreements amongst cities): co-create solution</li> <li>Networking</li> <li>Research &amp; education (knowledge centre)</li> </ul>
7	4TU.RE Centre	<ul style="list-style-type: none"> <li>• Dealing with rapid changes, incidents, disasters and stressful situations</li> </ul>	<ul style="list-style-type: none"> <li>• To make society more resilient</li> <li>• To create knowledge</li> </ul>	<ul style="list-style-type: none"> <li>Networking</li> <li>Research &amp; education (knowledge centre)</li> </ul>
8	Dutch Resilience Hub	<ul style="list-style-type: none"> <li>• Resilience in cities, coastal communities, or rural areas</li> </ul>	<ul style="list-style-type: none"> <li>• To promote resilience</li> <li>• To connect people with opportunities</li> </ul>	<ul style="list-style-type: none"> <li>Networking</li> </ul>
9	Urbiquay	<ul style="list-style-type: none"> <li>• Climate change</li> <li>• Infrastructure under pressure and need for sustainable solutions for civil infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>• To develop sustainable solutions in managing, restoring, and replacing civil infrastructure</li> <li>• To create knowledge about future-resilient bridges and quay walls</li> </ul>	<ul style="list-style-type: none"> <li>Research collaboration</li> <li>Co-creating solutions</li> </ul>
10	Infra Administrator Network	<ul style="list-style-type: none"> <li>• End of life cycle of Dutch infrastructure</li> <li>• Need for integrated and future-proof infrastructure sector</li> </ul>	<ul style="list-style-type: none"> <li>• To renovate Dutch infrastructure integrated &amp; future-proof</li> <li>• To promote commitment</li> <li>• To create vision</li> </ul>	<ul style="list-style-type: none"> <li>Networking</li> <li>Co-creating solutions</li> </ul>

**Table 4**  
Synthesis of motivation and approaches of resilient infrastructure initiatives.

Motivation/approach	Collaborative research	Education	Networking	Co-creating Solutions
To create innovative solutions	<ul style="list-style-type: none"> <li>• Programme</li> <li>• RED&amp;BLUE</li> <li>• 4TU.RE Centre</li> </ul>		<ul style="list-style-type: none"> <li>• RED&amp;BLUE</li> <li>• Resilient Rotterdam</li> <li>• Infra Administrator Network</li> </ul>	<ul style="list-style-type: none"> <li>• Infra Administrator Network</li> <li>• Urbiquay</li> </ul>
To create and share knowledge	<ul style="list-style-type: none"> <li>• Urbiquay</li> <li>• Redesigning Deltas</li> <li>• DIMI</li> <li>• 4TU.RE Centre</li> </ul>	<ul style="list-style-type: none"> <li>• Redesigning Deltas</li> <li>• DIMI</li> <li>• 4TU.RE Centre</li> </ul>		
To promote commitment & cooperation	<ul style="list-style-type: none"> <li>• RED&amp;BLUE</li> <li>• Nginfra</li> <li>• Redesigning Deltas</li> </ul>	<ul style="list-style-type: none"> <li>• Redesigning Deltas</li> </ul>	<ul style="list-style-type: none"> <li>• RED&amp;BLUE</li> <li>• Nginfra</li> <li>• Resilient Rotterdam</li> <li>• Agenda stad</li> <li>• Dutch Resilience Hub</li> <li>• Infra Administrator Network</li> </ul>	<ul style="list-style-type: none"> <li>• Agenda stad</li> </ul>
To promote resilience	<ul style="list-style-type: none"> <li>• 4TU.RE Centre</li> </ul>	<ul style="list-style-type: none"> <li>• 4TU.RE Centre</li> </ul>	<ul style="list-style-type: none"> <li>• Dutch Resilience Hub</li> </ul>	<ul style="list-style-type: none"> <li>• Resilient Rotterdam</li> </ul>

can be organized with knowledge-sharing events such as conferences, workshops, and seminars. Finally, the co-creating solution is a specific effort to make technical solutions.

As shown in Table 4, the majority of the initiatives are located in cross-sections between motivation ‘to create and share knowledge’ and approach ‘collaborative research.’ Since the motivation is to create new knowledge, it is natural to have collaborative research as an approach. At the same time, some initiatives also choose ‘education.’ Another noticeable relationship is the motivation ‘to promote commitment and cooperation’ and approach ‘networking.’ Mobilizing people and creating shared language can enhance commitment and collaborative efforts. The motivation ‘to promote resilience’ is linked with all four approaches as this motivation is more generic and normative and can be the overall goal for the initiatives. Finally, the motivation ‘to create innovative solutions’ is highly related to ‘research collaboration’ and ‘co-creating solutions.’

Finally, Fig. 2 shows the relationship between the motivations and approaches of resilient infrastructure initiatives. The initial coding of

each motivation is linked to an organizational approach. Based on this ‘set’ of open coding, four categories of motivation and four categories of organizational approaches are identified. With axial coding, each set was positioned in motivation-organizational approach categories to accumulate the links. Each arrow represents which motivation is related to which approach. The thickness and colour (red) of the arrow represent the stronger relationship, based on how frequently the link was made by different initiatives. The arrow with a dotted line means an indirect relationship, in which the relationship between the motivation and approach is not explicit but has implicit relations.

All motivations are linked to all approaches but some of the motivations have a stronger relationship with certain approaches. This once again confirms Pinder’s definition of motivation that shapes the organizational approach [29]. The strongest relationship was found between the motivation ‘to promote commitment and cooperation’ and the organizational approach ‘networking,’ showing eight occurrences. Networking is a common way to mobilize people to promote cooperation providing opportunities to understand different organizations [24]. Network-



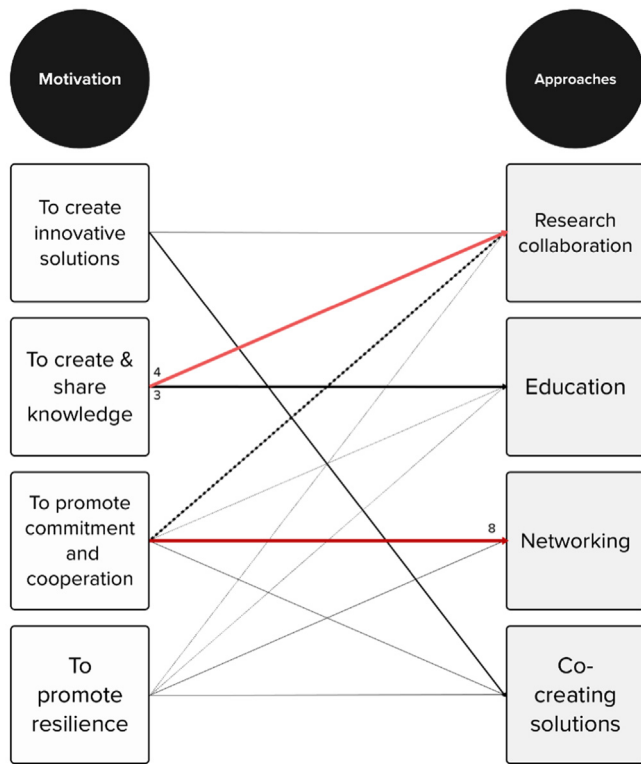


Fig. 2. Relationship between motivations and approaches in Resilience Initiatives.

ing is important for the infrastructure sector as resilience in the sector depends not just on the ability of a single organization, but on different organizations that come together as a system to collectively provide key services [39]. Another strong relationship is ‘to create & share knowledge’ and ‘research collaboration’ and ‘education.’ This is a natural result as many of the initiatives are research consortiums, aiming to create knowledge and provide education. There was also an indirect but strong relationship between ‘to promote commitment and cooperation’ and ‘research collaboration.’ Sharing knowledge and information amongst stakeholders can create collaborative governance and flexibility which in turn can improve the resilience of the system [40]. Also, research collaboration is one way to engage people and commit to resilience. Another interesting observation is that the generic motivation ‘to promote resilience’, although linked with all four approaches, does not have a mainstreaming approach, compared to ‘to create & share knowledge’ which is also a somewhat generic motivation. Perhaps it is because there are different interpretations and definitions of the resilience concept, which makes it difficult to have one mainstreaming approach. Also, this could mean we are still in the exploring stage of achieving ‘resilience.’

5. Conclusion

Climate change and societal issues pushed organizations and governments to operate differently over the past years. Moreover, the social need for a more sustainable and liveable environment is increasing, accelerating the urgency for changes. Dutch infrastructures were built 50 to 60 years ago and are facing the end of their functional life. At the same time, climate change and changing societal need increases uncertainty and complexity in the infrastructure sector. Therefore, asset managers seek optimal ways to deal with these ‘wicked problems.’ Ensuring system-wise resilience is important to reduce disaster risk and it depends on the system component’s resilience and available resources to mobilize during recovery and adaptation [41]. Resilience initiatives

emerged in various organizations, including government, universities, and public agencies, to collaborate and build capacity to organize infrastructure management, development, and renewals in coherence with social needs while avoiding climate change risks and disasters.

This study aims to provide an overview of resilience initiatives focusing on the infrastructure sector in the Netherlands. By using a scoping review approach, this study identified ten representative resilient infrastructure initiatives and analysed their motivation and organizational characteristics as well as their conceptualization of resilience. The findings can provide practical implications for policymakers, practitioners, and researchers in resilient infrastructure sectors. First, there needs to be a comprehensive understanding of resilience concept. The conceptualization shows resilience initiatives in Dutch infrastructure sectors are emphasizing built and organizational resilience, while less attention is given to natural, social, and economic resilience. Considering the nature of the infrastructure sector, it is natural, however, as critical infrastructure can provide opportunities for overcoming societal issues, future initiatives can pay attention to natural, social, and economic domains. Pay attention to these domains. Second, to create and share knowledge, research collaboration is mainstreaming methods. In the analysis of the motivations and approaches of resilience initiatives, a strong relationship was found between the motivation ‘to create & share knowledge.’ New insights and knowledge can be achieved with transdisciplinary research, including public, private, research, and civil organizations. Universities and knowledge institutes play an important role in sharing and disseminating knowledge through ‘education.’ Third, networking is an ideal way to mobilize people and ‘promote commitment and cooperation.’ Through networking, different organizations can understand each other’s interests and come up with integrated budgets and projects. Networking is a stage for co-creating solutions.

There are several limitations of this study. First, this research only selected 10 initiatives which were prevalent. There were more initiatives such as Partners for Resilience (<https://www.partnersforresilience.nl>) or the National Delta program whose boundaries go beyond infrastructure or resilience. However, this did not affect the findings because the focus was on the motivations and operationalization of resilient initiatives rather than on the landscape of resilient infrastructure initiatives in the Netherlands. Second, the analysis relies on secondary data available to the public which sometimes does not reflect the whole story behind the organization of resilient initiatives. However, official statements in written form represent approved messages from the initiatives and therefore provide typicality. Finally, the research focuses on the Netherlands, where water infrastructures are very important. For this reason, it may be difficult to apply resilient infrastructure initiatives organizational approach to other countries whose infrastructure needs are different from the Netherlands. Despite these limits, this study theorizes organizational collaboration, motivations and activities of resilient infrastructure initiatives. This brings implications for future resilient initiatives, more focus is needed on natural, social, and economic domains.

Further research is needed to confirm the findings and further develop how the motivation and organizational approaches are translated into activities and performance. Future research directions can be analysing the performance of resilient initiatives concerning their activities and overall contribution to the resilience of the target domain, how different initiatives’ contributions make synergies, and how these efforts (knowledge development, networking, etc.) come down to a practical application.

Relevance to resilience

This paper investigates ten resilient infrastructure initiatives in the Netherlands and reports different conceptualization, motivation and organizational approaches. We found the resilience concept in Dutch infrastructure initiatives focuses on built and organizational resilience and less attention to natural, social, and economic resilience. We identified

four motivations to organize resilience initiatives which are ‘to create innovative solutions,’ ‘to create and share knowledge,’ ‘to promote commitment,’ and ‘to promote resilience.’ Four organizational approaches are ‘research collaboration,’ ‘education,’ ‘networking’ and ‘co-creating solutions.’ There was a strong relationship between specific motivation and approach, for example, ‘to create and share knowledge’ and ‘research collaboration’ and ‘education.’ However, the generic motivation ‘to promote resilience’ does not have a main approach which suggests promoting resilience in practice is still in the exploratory stage.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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