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Nature-based climate adaptation projects, their governance and transitional potential-cases from Copenhagen

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This paper investigates and broadens the discussion of nature-based climate adaptation for storm water management and coastal flooding. Based on three Copenhagen cases of locally initiated innovative flagship projects and framed by governance and transition theory, we investigate how nature-based solutions can be understood in a real-life context, and how hybrid projects joining technical and nature-based solutions might work; the governance methods of such projects; and their transitional potential. The cases underscore the importance of nature perception for the design of the project, and the role of daily recreational users as crucial for project legitimacy. Innovative projects might seem local, but often they are embedded in larger strategies and serve to flesh out such strategies and might even change them in a longer perspective. New problems and projects foster a need for new types of partnerships, which can challenge co-operation. Finally, it is questioned how – and if – experiences from flagship projects can be anchored and mainstreamed into a new normal for climate adaptation.

KEYWORDS

climate adaptation, nature-based, governance, transition theory, storm water, sea level rise, Copenhagen

Introduction

In Denmark, climate adaptation relates mainly to increasing problems of managing "unruly" waters: an increase in frequency of heavy rain events calls for improved urban storm water management (Madsen et al., 2009; Gregersen et al., 2021) and coastal flooding is expected to increase due to sea level rise (Kirezci et al., 2020). In coastal areas, the combination of the two can create even more severe flooding problems.

Cloudbursts are relatively frequent, occurring locally and sometimes with considerable material damage, especially in hard-paved urban environments. A specific event in 2011 with severe effects in the capital region of Copenhagen marked the start of a "new normal" regarding climate change induced hazards. It fueled first

an acknowledgment that adaptation is necessary, and secondly a discussion about how to adapt: *via* nature based and site-specific infiltration projects, or by technical solutions such as larger sewers to lead off the storm water? Though still a minor part of the total adaptation schemes, nature-based solutions with their aesthetic, environmental and multi-functional values have gained momentum, and some experiences have already been harvested (Backhaus and Fryd, 2012; Liu et al., 2019).

Danish coasts are prone to storm surges, which happen regularly, not only in the South-western marshlands along the North Sea, but also occasionally, and with severe effects, in the inner parts of the Danish archipelago. A major flooding event in 2006 on these, normally well protected, coasts spurred the awareness of this risk. Dikes and seawalls are the preferred coastal protection measures in Denmark but expected sea level rise and growing awareness of coastal nature qualities has fostered a willingness to explore new types of multifunctional and nature-based solutions for coastal protection (Farago et al., 2018).

In Denmark, municipalities have considerable budgets and responsibilities toward climate adaptation. Every municipality is obliged to make a climate adaptation plan in which they designate areas that are prone to flooding or erosion (Erhvervsstyrelsen., 2020), and often they are main actors in the development of innovative climate adaptation projects, carried out in meta-governance setups also including citizens, private businesses, semi-public water utility companies, and other actors (Engberg, 2018).

Thus, both freshwater and seawater management take place in an increasingly complex governance situation involving many actors. In this paper, we investigate decentral, nature-based, and site-specific climate solutions that also boast an added value relating to recreation, biodiversity, or aesthetics. We base our analysis on three projects at different scales and from different times, which will serve as micro-cases to cast light on:

(1) How does local, nature-based climate adaptation manifest itself in a Danish/Copenhagen context and what functions do adaptation projects provide?
(2) How are such projects governed and implemented and what makes success or failure?
(3) What is the learning and transitional potential of innovative flagship projects?

Analytical framework

In this paper we investigate the role of decentralized climate adaptation projects. By this we understand projects which are conceived and initiated at a local level with local and non-local partners (i.e., not through direct implementation of a national plan), and which are site-specific (i.e., designed for a specific natural, social, and political context). As our research questions regard 1) what nature-based climate solutions are, 2) how they are (or should be) governed, and 3) what learning potential they can have, our analytical framework covers these three themes.

Nature based solutions and the urban blue-green infrastructure

The green and natural spaces in an otherwise built-up urban fabric have been recognized as essential for urban quality of life, almost since the start of modern city planning (e.g., Olmsted, 1871). The notion of cities as landscapes encompassing both built-up and green areas and the need to understand cities as an integrated part of nature comes later with the climate and biodiversity crises in the form of landscape or ecological urbanism (Corner, 2006; Mostafavi and, 2010; Ahern, 2012; Beatley and Newman, 2013; Spirn, 2014; Sijmons, 2020). With this comes also an understanding of nature in cities not only as "green" spaces, but also as a blue-green infrastructure which fosters natural processes that are just as important for the functioning of cities as sewers or transport systems (Gill et al., 2007; Brears, 2018; Liu et al., 2019; Gomes Sant"Anna et al., 2021). Existence, production, or enhancement of the urban blue-green infrastructure is a prerequisite for nature-based climate adaptation – or nature-based solutions (NBS), first coined so by the World Bank in 2008 (Hanson et al., 2020). Nature-based solutions are embraced by the European Commission as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience [and] bring more, and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient and systemic interventions" (European Commission and Directorate-General for Research and (European Commission Directorate-General for Research Innovation., 2021 p. 6). Thus, besides the "nature-base", NBS are multifunctional projects, in which the primary goal (which could be climate adaptation) is not a sole aim, but where also other "added values" are given attention, such as biodiversity, aesthetics, recreational features, social benefits or general place attractiveness (Pauleit et al., 2011; Raymond et al., 2017; Frantzeskaki, 2019). Nature-based projects are often site-specific or "locally attuned to societal contexts" (Frantzeskaki, 2019 p. 101) and the complexity of NBS that bridges ecosystems and social systems requires both landscape planning and governance as critical knowledge fields (Albert et al., 2019). The elements of NBS range from coastal resilience, water management and air quality to health and urban regeneration, requiring participatory planning and a high degree of trust between partners (Raymond et al., 2017).

Franzeskaki (2019) lists seven lessons or prerequisites for successful nature-based solutions. Among these are the need for NBS projects to be aesthetically pleasing (without saying what that specifically entails). This theme was investigated

more in-depth by Suppakittpaisarn et al. (2019), who in a US photo-based survey found that green infrastructure looking like forests, landscape constructions including flowers, and "neat" storm water installations were the most preferred by both laypeople and professionals, while Hofmann et al. (2012) in a similar German based study found differences between these two groups, the lay persons being more biased toward the "neat", while professionals preferred a "wilder" look.

Different perceptions of the aesthetics of urban nature are obviously closely tied to different fundamental views on nature. A Danish sociologist highlighted four different archetypical views on nature: The utilitarian, the romantic, the functionalistic and the ecological (Hansen, 1989). The utilitarian view of nature is anthropocentric, rooted in an agricultural interaction with nature, while the romantic view praises the wild and untouched as for instance found in the English picturesque garden culture. The functionalistic view on nature emerged in the 20th century and concerns the human need of light, air and green recreational areas and forms the basis for the modernist welfare park landscapes. Finally, the ecological view on nature represents a more holistic and eco-centric perspective, in which humans are an embedded part of nature, much in line with the later concept of ecological urbanism. Priego et al. (2008), in a cross-national study likewise found that there are different perceptions and opinions about what is the "good" urban nature depending on cultural background, but still most residents felt that urban nature is important, and it is worth noticing that there is no difference between groups of different socioeconomic status in this regard. Nature-based solutions seem to lean heavily upon the ecological view on nature (Hansen, 1989), but is also influenced by a romantic view (the neat and pretty) as noted by Hofmann et al. (2012) and by utilitarian and functionalistic views in asking "what nature can do for us humans".

Governance and implementation of NBS adaptation projects

By generating multiple benefits, NBS projects have the potential to focus on coordinated efforts that span over several policy areas (Raymond et al., 2017; European Commission Directorate-General for Research Innovation., 2021). This means that different stakeholders need to be involved to unfold the full potential of the projects. Especially the collaborative element is important (Buijs et al., 2016; Engberg, 2018; Frantzeskaki, 2019) and should be taken into a new level of co-creation, an even more problem-based, dynamic, and actor-centered process, requiring leadership and conflict mediation between actors with different values and preferences for green transition tools (Hofstad et al., 2021). This involves the basic question of how "nature" and nature aesthetics is understood by different actors and whether NBS will always contribute to sustainability? To ensure sustainability, Nesshöver et al. (2017) recommend using an adaptive approach for involvement of multiple stakeholders, and the use of several knowledge types to develop a common understanding of solutions and trade-offs. Evaluating for future learning is also essential. Frantzeskaki (2019) underscores the need for trust among diverse actors as a prerequisite for true co-creation. This is not easy, however. Hanson et al. (2020) state that constraints for the implementation of NBS include lack of methods for stakeholder involvement, lack of guidance for how to balance multiple benefits and lack of knowledge regarding the different stages of the project.

Based on an understanding of NBS as a vehicle to obtain co-benefits of different fields such as climate, biodiversity and socio-cultural value, Raymond et al. (2017) propose seven steps the in assessment of benefits, which can, in our opinion, be interpreted as checkpoints for choosing pathways in an implementation process. These include identifying the multidimensionality of the problem, choosing interventions, and relating them to "grey" solution types, engaging stakeholders (including the possibly negative ones), investigating if the project can be upscaled, and choosing which indicators and methods to use for long time monitoring (Raymond et al., 2017). In a recent case study of 17 German NBS cases, Zingraff-Hamed et al. (2021) discuss the financial implications and the question of property rights, stating that "linking of on-the-ground actors with the city government to implement long-term and large-scale measures aimed at hazard exposure reduction is crucial to ensure implementation" (Zingraff-Hamed et al., 2021 p. 1619). Hence, it is important to understand how different stakeholders benefit from the solution and how that in turn impact their sense of responsibility and willingness to be part of the NBS project (Albert et al., 2019; Zingraff-Hamed et al., 2021).

The scales of urban green spaces and projects differ widely, and therefore local and bottom-up projects are not necessarily "the best". On the contrary, "a more fruitful approach may be to adopt principles from strategic planning to facilitate upscaling and enhancing the ecological output of active citizenship" (Buijs et al., 2016 p 52). The strategic planning approach combines strategic visions based on broad stakeholder participation and comprehensive analyses, while strategic projects steer development in the envisioned direction, address selected local areas (and needs) and generate immediate results for the actors involved (Oosterlynck et al., 2011).

Frantzeskaki (2019) points out that many studies are carried out as single case studies looking for multiple benefits, but there is little research on their implications for policy, planning and governance – so we need multiple case-study research to draw findings that are relevant for governance. In such a cross-national case study of green infrastructure, di Marino and Lapintie (2018) conclude that fragmented administrative units also influence the interpretation and purposes of green infrastructure, making the specification of scales important:

what should be dealt with on regional, city or local level? Also in a global south case study, Herslund et al. (2018) conclude that there is a need to understand the potential of green infrastructure as a basis for climate adaptation and to develop coping strategies that include residents.

Learning and transformation potential of NBS climate adaptation projects

When thinking about the learning and transformational potentials of nature-based climate adaptation projects, transition theory is a relevant framework, the main point being that existing socio-technical systems (regimes) tend to preserve themselves, but that smaller innovative projects (niches) over time might induce change in a whole socio-technical system (Geels, 2002; Hodson et al., 2017). In line with this, Markard et al. (2012) observe that sustainability challenges seem to be coupled with strong path-dependencies and lock-ins, in which established technologies (such as adaptation based on sewers, dikes and seawalls) are supported by existing business models, institutional structures, and legal systems, and that this does not support broader and profound changes in technology or governance. In this context, nature-based adaptation projects might be seen as "niches" that make "cracks" in the regime, which in the long run may allow for transition of the regime and mainstreaming of a more nature-based thinking. Therefore, learning from projects is essential for innovation (Raven et al., 2012), both related to the performance of new practices, but also to a broader rethinking of the values underlying the status quo (Smith, 2007; Farrelly and Brown, 2011).

Transformational learning includes creation of new knowledge on governance and business models derived from the single projects. In addition, if the project is broadly founded, with multiple stakeholders in a collaborative process, it has better chances of leading to new ways of seeing the world and learning collectively how to deal with complex issues (Dóci et al., 2022). In general, the building of broad social networks that include regime outsiders (e.g., citizens) helps to facilitate stakeholder engagement, mobilization of resources, and institutional learning (Schot and Geels, 2008; Shove and Walker, 2010; Raven et al., 2012). However, this is not a well-paved road, and it can be questioned whether experimentation and ordinary urban planning need to be seen as two differing processes and if experiments actually lead to learning (Mukhtarov et al., 2019).

Methods and cases

The study is carried out as a descriptive case study (Gerring and Cojocaru, 2016) of nature-based responses to climate change in Denmark. Three examples in the Copenhagen region were chosen as cases. The three cases are part of a common regional context and planning tradition, including the regional "Five-finger-plan" for urban growth management, as well as climate mitigation and adaptation plans at regional and municipal levels. They represent a diversity (Gerring and Cojocaru, 2016) regarding scale, time, place in the regional structure, actors, and which multifunctionality themes were addressed in each case.

The three cases comprise a small-scale, climate sensitive courtyard renovation completed in 2021 (case 1); a medium-scale storm water management and river restoration project adjacent to a social housing area initiated in 2010 and inaugurated in 2017 (case 2); and a large-scale cross-municipal coastal protection project from the late 1970'ies (case 3) (see Figure 1).

All cases were state-of-the-art projects, both technologically and governance-wise at the time of their completion. Each case contributes to answer our research questions: 1) how nature-based climate adaptation is conceived and what forms it can take, 2) how projects can be governed and implemented, and 3) how learning (and possibly transition) might happen from such avant-garde projects.

Nature based solutions

In which way is the project nature-based? How is it part of the city's green-blue infrastructure? What technologies/nature-based solutions are used? In which way is the project multifunctional: Which added values are part of the project? In which way is the project site specific and "attuned" to its context? How does it contribute (or is expected to contribute) to biodiversity, outdoor recreation, human health, economy, and in a broader perspective to urban regeneration and the status of the surrounding urban area?

Governance and implementation

Which actors were involved, what was each actor's role and how did they cooperate? How can the project be placed on a scale from hierarchical management to co-creation? Was trust built between the actors and how? What happened after the project construction phase (if relevant), how was/is the project financed in the project planning and construction phase and after? Was the project part of a larger strategic vision, and if yes, how was the project important for the overall strategy?

Transformational capacity

How innovative is the project? Is it far from the existing socio-technical system? Or partly? Was a learning perspective included in the project? How were the experiences disseminated? Has learning occurred and to which context?

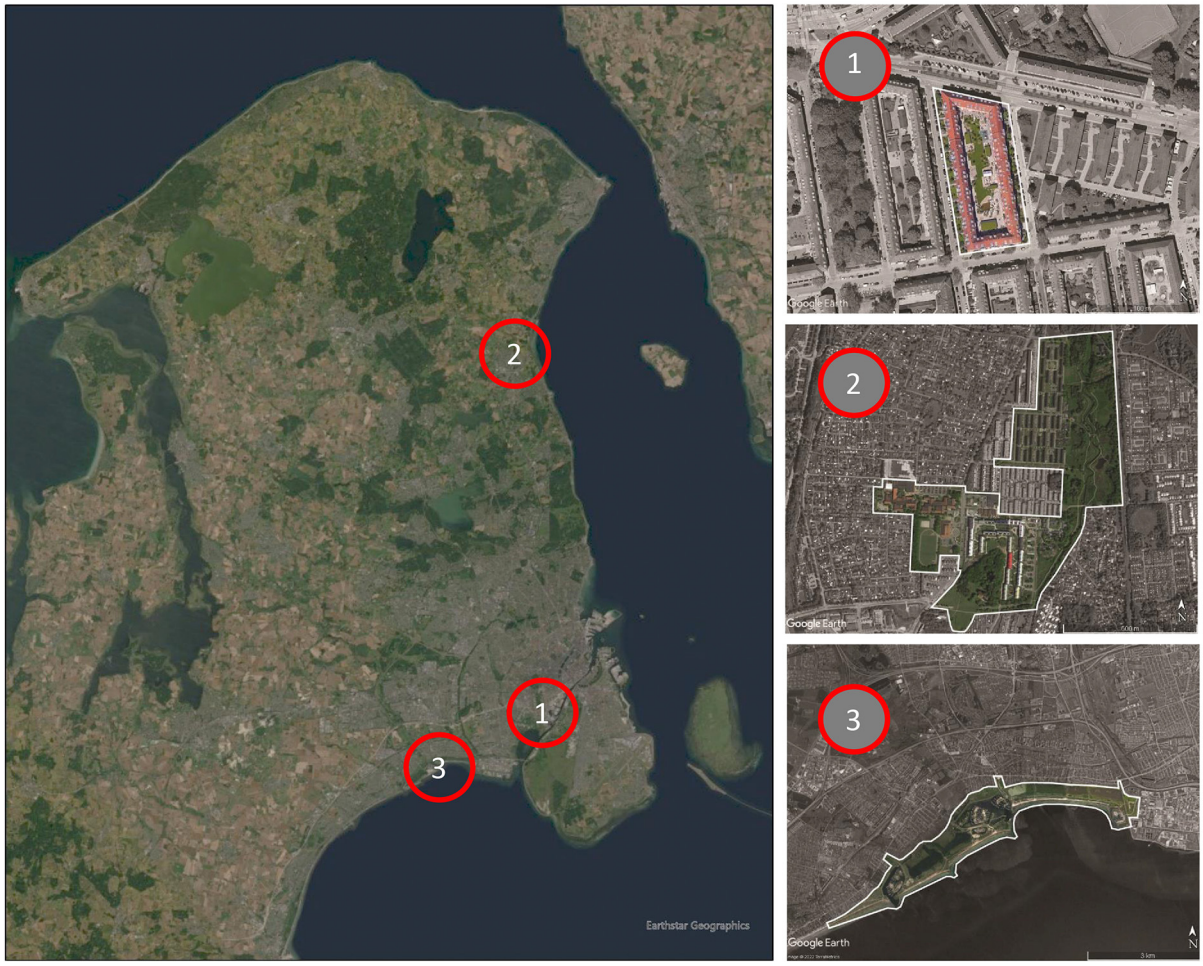

FIGURE 1
Overview map of cases in Copenhagen's regional structure. Case 1: Straussvej – local NBS storm water management in a residential courtyard in the City of Copenhagen. Small scale, 2020. Case 2: Kokkedal – district level NBS storm water management in a suburban area north of Copenhagen. Medium scale, 2010-2017. Case 3: Køge Bay Beach Park – regional coastal protection project along a metropolitan growth corridor south of Copenhagen. Large scale, 1970'ies. Sources: Overview (base map by Cowi-Hexagon, 2020). Image 1, 2 and 3 to the right. Orthographic photos of the three case sites. Outlines and greyscales are alterations of original Google Earth imagery made by Ole Fryd. © Google Earth.

Data and documentation

To our knowledge, case 1 has not previously been investigated and documented in a scientific publication. For documentation of this case, we used document studies including a very comprehensive webpage including technical and governance documentation (City of Copenhagen., 2022), combined with site visits and interviews with the project manager and the leading landscape architect.

Case 2 is thoroughly documented (in Danish) in three evaluation reports concerning technical solutions (Fryd and Jensen, 2018), governance (Lund, 2018), and public urban spaces (Kiib and Marling, 2020). One of the authors of the present paper was part of the evaluation process and authored the technical report. The reports are used for documentation, while updated information on the management was collected through a phone-interview with the director of the water utility company and supported by updated ground truthing.

Case 3 is documented in a recent study by three of the authors of the present paper (Lund et al., 2021, 2022). The study was based on site visits, document analyses, and interviews with one of the original designers, officers from the cross municipal management company, the designers of an upcoming redevelopment project, and staff from one local municipality.

All interviews were carried out during 2021 and 2022. Information obtained from interviews are referred to as (interview with "relevant informant").

Case results

Size S: Courtyard renovation in the dense city, Courtyard of the future, Straussvej

In the past few decades, the City of Copenhagen has slowly but surely renovated courtyards in urban blocks from around 1880 to 1940. This is part of the general urban regeneration of Copenhagen and has immensely lifted the quality of housing and urban life. The "Courtyard of the Future" project, 2016-2021, has brought these efforts to a new level and a new era, where nature-based climate adaptation is going hand in hand with the recreational needs of the residents. The project at Straussvej, completed in June 2021, boasts to be the first example in the City of Copenhagen of a bio-cleansed storm water retention basin ("rainwater lake"). Moreover, the courtyard is built from recycled materials, and it is the first fossil and emission free construction site within the city boundary. The composition of actors is unique as it is the first larger scale storm water management project built on private land, in which the regional water utility company participated (City of Copenhagen., 2022; interview with project manager) (see Figure 2).

Nature-based solutions

There is a specific challenge of handling storm water in the low-lying urban area where this residential block is located. Due to the high groundwater level, storm water cannot be infiltrated (interview with project manager). Therefore, a hybrid solution was used. Rain gardens provide a pre-filtering of the stormwater, based on pebbles and sand-enriched humus with plantings. The main solution, however, is a pumping and retention system, partly subterranean, partly covered by vegetation and partly with the water day lighted in a concrete water element. Water in the final retention basin (the pond) is continuously recirculated and cleansed to a level where the water can be used for play (Sindby-Larsen and Nielsen, 2021). Being situated within an urban perimeter block, the project has a strong focus on multi-functionality, as it combines water retention with daily recreational use and biodiversity. Many smaller spaces for staying and playing were established, a greenhouse was built, and utilities such as waste management and bicycle parking were integrated in the design. Many different species were planted, and the hope is that more plants and animals will migrate to the courtyard and the artificial lake (interview with landscape architect).

Governance and implementation

The project was initiated by the City of Copenhagen as a strategic project. It acts as a focal point for several of the city's strategies: the Climate adaptation plan of 2011, the Cloudburst plan of 2012, the general urban renewal policy and as mentioned before, the courtyard renovation effort, in which every year a few courtyards are renovated with public funding (interview with project manager). Residents participated in the project development; they did not invest money but agreed to undertake the future management of their new "garden". A comprehensive co-creation process including interviews and workshops with input from residents started the project, and notably residents were involved in creating the brief for the professional advisors (City of Copenhagen., 2022). The project also involved the regional water utility company who joined in when it was justified that retaining water in a courtyard would save capacity in the public sewer system. The project was financed mainly by the city (12 mill DKK), with a financial contribution by the utility company (4 mill DKK) (interview with project manager). This, according to the project manager, is double the normal investment in courtyard renovation projects in Copenhagen, yet it was accepted as the project was regarded a pilot project with learning perspectives.

Working with the technically advanced water system may pose challenges in terms of management. Normally, residents will manage the courtyard in the post-project phase. This will be described in a document of agreement between the city administration and a coalition of the different owners of the courtyard. In this case, however, it was discussed how the facility manager(s) and the residents' courtyard group could take over this task (interview with project manager). The long-term success of the project is still to be seen.

Transformational capacity

The project is clearly seen as a highly innovative pilot project, so how was learning from the projects carried on further? According to the project manager, first and foremost, it has contributed to changing practices and guidelines in the city administration. As part of the general strategies, a geographical prioritization tool has now been made, in which climate adaptation needs are combined with urban renewal needs to make a sequence plan for investments in courtyard renovation. Hitherto, this was based on applications from residents. The courtyard renovations have a long tradition of participation. The city makes the monetary investments in areas which are privately owned by the residents, so agreement from all sides is necessary for success. This specific project has sparked a change in the way co-creation with residents is being carried out. The advisors (often designers) would hitherto have the responsibility for participatory processes, but in the project this task is "taken back" by the city, to ensure good communication, clear messages, and clarity as to who owns the project. Likewise, the standard agreements with advisors (designers) will include exact measures for water retention, and demand for engineering capacity in the team.

The designers have learned through the project and bring this learning into other projects. Technical aspects of cleansing

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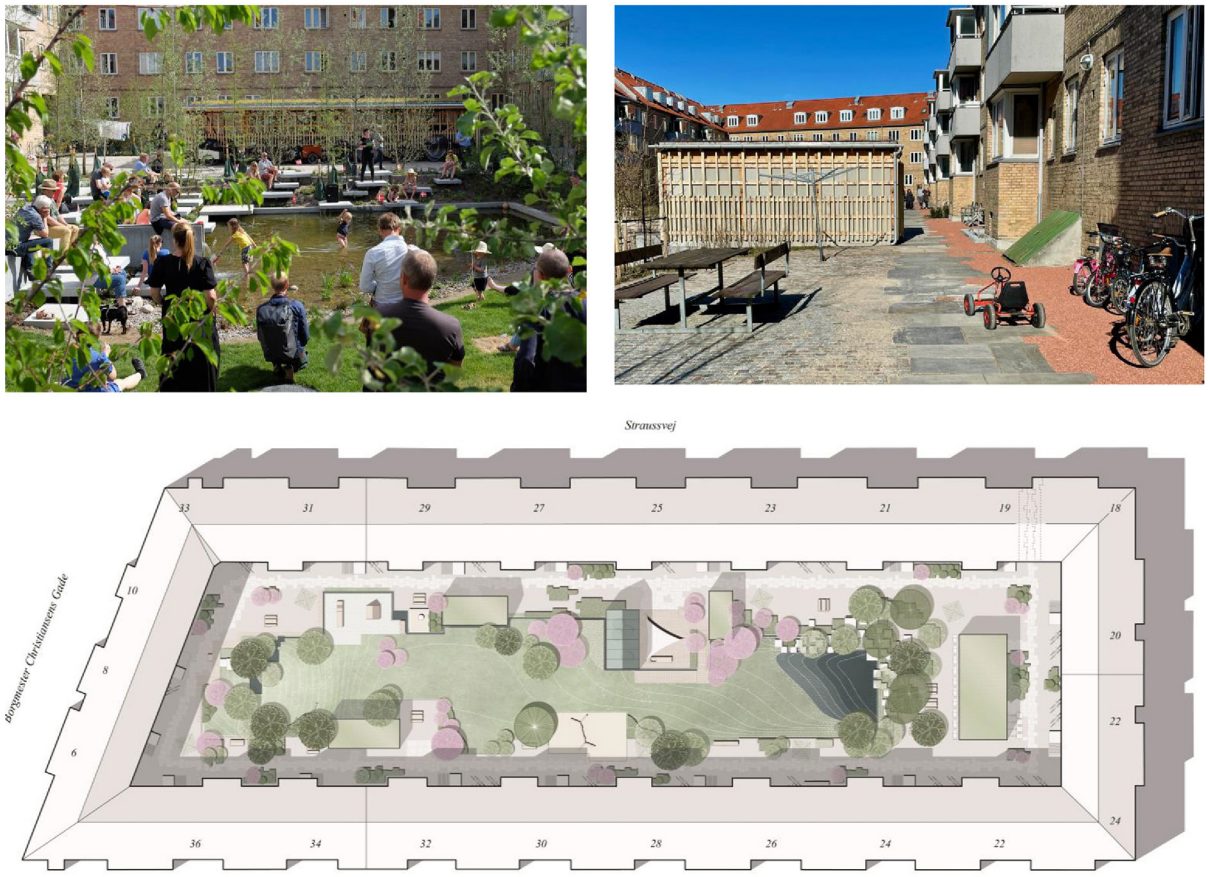

FIGURE 2
Master plan and photos from straussvej courtyard adaptation. **(Left)** Photo from inauguration 10th June 2021 (City of Copenhagen). **(Right)** Reuse of slabs and cobblestones are part of the sustainability concept. **(Bottom)** Landscape plan for the project (BOGL landscape architects).

are important, but the lead designer also stresses that they used a new design approach which starts with the given (e.g., available re-useable materials) and take the design from there, as opposite to making the design up front and look for materials to suit it (interview with landscape architect).

The project is thoroughly documented at a website (City of Copenhagen., 2022) to be inspirational for other projects in and outside Copenhagen. It is a comprehensive site, including a technical evaluation report and documentation of the co-creation process. The project is labeled a "demonstration and visiting garden", which means that many professional and lay groups visit the project site on guided tours (interview with project manager).

Size M: Climate adaption Kokkedal and Usserød river 2011-2017

The project site covers an area of 69 ha in the North of Zealand. The area contains two large-scale, subsidized housing associations, a local retail park, public schools and parklands. It borders Usserød river which caused severe flooding of the area in 2007 and 2010. The challenge of the project was to develop a climate adaptation project that could also promote an improved urban life: connect the fragmented (sub)urban areas, create new attractive meeting points, and overall bring nature closer to the residents (see Figure 3).

During the 19th century, Usserød River was straightened, and the water flow became strictly regulated. To enhance the water quality and recreational qualities, it was re-meandered in 1999-2002, and in 2012, the capacity of the river was increased by widening the waterway and flood protection was increased by establishing a dike along the riverbed.

The Kokkedal adaptation project used as a case here was implemented from 2012-2017. With a budget of 145 million DKK and 40 construction sites across the city district, the Kokkedal climate adaptation project is one of the largest and most complex in Denmark to date, both regarding partners and technical solutions.

FIGURE 3
Masterplan and photos from Kokkedal river restoration and storm water adaptation project. **(Left)** Master plan (SCHÖNHERR landscape architects). **(Top Right)** The Moroccan Garden (Ole Fryd). **(Middle Right)** New integrated play space and retention (Realdania/Ingemann Ørnstrup). **(Bottom (Right)** New access to riverine nature (Realdania/Ingemann Ørnstrup).

Nature-based solutions

The Kokkedal project contains an extensive catalog of solutions for climate adaptation and storm water management methods. While storm water was formerly hidden underground in pipes, storm water management is now made visible in a way that offers new urban and green recreational possibilities. The main idea of the technical solutions is detention. Decentralized detention basins in the urban environment are designed to manage runoff from a 5-year rain-event. Additional detention basins located in the river valley can detain runoff up to a 20-year event. It was found prudent not to go for a solution entirely based on aboveground water management with infiltration and evapotranspiration, but to keep the existing pipes and underground solutions and supplement them with detention basins in the urban landscape, doubling as public urban spaces, playgrounds or large greenspaces or wetlands. It makes this hybrid system robust at a lower price, which freed finances to heighten the quality of the surface solutions, e.g., the quality of the urban public spaces doubling as storm water detention basins when needed. However, the full project now relies on the existing sewer system which is subject to renewal within the next 10–20 years. The estimated replacement cost in the project area is (an additional) 70 million DKK which would have been omitted if the project had gone all in on NBS (Fryd and Jensen, 2018).

The residents already ascertain that the project has improved the sense of security as planned. The new recreational areas are popular and have driven out the shifty activities which used to dominate the area. Storm water is managed satisfactorily up to a 20-year rain event. Rain events larger than this can still be managed without any serious damage occurring (Fryd and Jensen, 2018).

Governance and implementation

The project organization comprised the municipality of Fredensborg, two affordable-housing associations, two charitable organizations, and later also the water utility

company. A team of advisors (engineers and architects) won the competition and carried out the design and construction management as well as the participation process. An evaluation (Lund, 2018) stresses that this complex project with many partners demands a network approach, where all partners are considered equal, and cooperation is based on mutual confidence and an open exchange of knowledge. This approach clashed with other more conventional public leadership and management forms, municipal bureaucracy and law enforced new public management in the water utility company. Much time and an open mind from all partners was needed to sort out these conflicts, and legal assistance helped the partners to feel secure in the project organization (Lund, 2018).

Residents were involved in the project, but only in the form of several public meetings where it was possible to comment on ideas and concrete projects and sub-projects. In one of the social housing estates the formal handover of the project for ongoing operations and maintenance from the contractor to the owner was unsuccessful. Formal contracts on the transfer of responsibility and money had not been effectuated and as a result five detention basins within the premises of the housing estate remain dry in year 2022, do not contribute to storm water management and have not been maintained for a period of 3–4 years (personal communication: water utility manager).

Transformational capacity

In this case, the involvement of two large charitable funding bodies meant that resources were set aside for a thorough evaluation of technical solutions (Fryd and Jensen, 2018), governance (Lund, 2018), and the impact on public life (Kiib and Marling, 2020). These evaluations are publicly available online. Although they all state that the project had challenges, not least in the relation to governance, they also acknowledge that the project was innovative regarding technical and governance aspects and that it has provided the area with new public spaces, of which many focused on much needed high-quality space for children.

The large scale and the level of complexity in the Kokkedal project provided a platform for learning for other projects with or without charity funding.

Size L: Køge Bay beach park and coastal protection

Køge Bay Beach Park is located approximately 10 kilometers south of Copenhagen and covers a seven kilometer long artificial barrier island along the shoreline. The beach park was inaugurated in 1980 and is one of the few realized examples of large-scale landscape-based coastal protection in a Danish context (see Figure 4).

Nature-based solutions

Køge Bay Beach Park is a man-made coastal landscape, which both functions as coastal protection (crest height at 3–4 meters above sea level) and as a recreational area. The beach park consists of two larger barrier islands, built upon existing longshore bars. Sand nourishment, construction of piers, and deepening of the waters behind the beach created new barrier islands with sand dunes, salty marches, lagoons, recreational pathways, and marinas. The dunes of the beach park were gradually formed by the wind, animals, and humans; hence the processes of nature was an integral part of the landscape design (interview with original designer; Lund et al., 2021). Sand was pumped in from far out in the sea to get the right grain size, the water level and circulation in the lagoons were closely regulated by overflow structures, piers were built with boulders from Scania, and the new barrier islands were connected to the hinterland by bridges (Valgreen and Front, 1986). The project is hybrid but qualifies as an NBS project due to its multi-functionality. It was – and is - mainly perceived as a recreational landscape with varied spaces that support leisure activities such as sea bathing and beach life, cycling, water sports, sailing, bird watching and foraging. The marinas include buildings for various hobby associations. The project was originally branded as a largely recreational landscape, but over the years a stronger focus on ecological values has emerged (Lund et al., 2022).

Governance and implementation

The foundation for a beach park in Køge Bay was laid in the 1936 seminal plan, "Green Areas of Greater Copenhagen" (Forchammer, 1936), when the landscape south of Copenhagen was still mainly farmland. In the 1960s and 1970s, the huge urban development project of Køge Bay was built as a 22 km long linear city along the bay, planned for around 150.000 people. This paved the way for the construction of a structural coastal protection measure, which at the same time should improve the recreational quality of the coast of the shallow bay and brand the new southern expansion of Copenhagen as an attractive place to live. In 1975, seven partner municipalities and two regional authorities formed Køge Bugt I/S as a decentral, formal partnership to realize the Beach Park "as it seemed clear that the partnership had to take over the initiative [from the national state] if the project should be realized after all these years of considerations and planning" (Jorno, 1986 p. 26). The broad range of initiators underlined the regional importance of the new recreational landscape. In 1977 the construction started, and the project was inaugurated in 1980 (Valgreen and Front, 1986). Citizens' participation in the planning phase was restricted to meetings with the homeowners along the coastline and, during the construction phase, negotiating detailed solutions when residents obstructed the construction work to state their case (Valgreen and Front, 1986; p 39–40).

FIGURE 4
Køge Bay Beach Park, barrier islands for coastal protection **(Top left)** Marina, boathouses at lagoon (Anna Lund). **(Top right)** Recreational beach (Anna Lund). **(Bottom)** Barrier Island seen towards the south with urban settlement in the background (Drone image by Henrik Hedelund, Ishøj Municipality).

As of 2022, the formal partnership is jointly owned by the five municipalities at the coast, namely Hvidovre, Brøndby, Vallensbæk, Ishøj and Greve, with a common secretariat and maintenance section. The board comprises one representative from each municipality and the financial contribution by each municipality reflects their length of the coastline within the beach park. A legal statement specifies the judicial mandate of the partnership, which is to maintain the area. However, in 2021, the partnership launched a new vision for bringing the park up to date, both in relation to climate adaptation and recreational facilities (Norrøn, 2021). The vision plan runs in parallel with a national vision for greener cities and a decision to propose a national by-law that specifically will enable future construction works in the beach park. Some of the local partners experience much time pressure and decisions being forced through to be included in the legal document which is to be agreed on by the Danish parliament, rather than allowing the beach park to grow more incrementally and to secure a more thorough and long-term public engagement process (interview with municipal officer).

Transformational capacity

The beach park is part of Copenhagen's "five-finger-plan" and the project is therefore an element in a larger regional strategy for urban growth corridors and the provision of green

space in the Danish capital region. The project can be seen as a unique example of landscape-based coastal adaptation that integrates added values such as biodiversity, recreational qualities, and social activities. Even though it is more than 40 years ago since the project was realized and around 90 years ago since the project idea was first developed, Køge Bay Beach Park still constitutes an important best-practice case of a holistic approach to nature-based coastal adaptation. According to one of the lead designers and technical experts on the project back in the 1970s, it would be almost impossible to develop a similar project today due to legal and political constraints, bureaucracy, and potential conflicts at the local government level (interview with original designer). This might be the reason why surprisingly little transformational learning has occurred from this project. The main landscape architect of Køge Bay has since made beach and harbor designs his field of expertise and he has designed the other large beach project in Copenhagen, Amager Strandpark, which shows the same features, but without the flood protection aspect.

Also surprisingly, little systematic monitoring of use and ecological development has taken place. An ongoing monitoring system for the development of coastal vegetation is in place in certain parts of the area, but there is no monitoring of human recreational use (interview with management organization). As coastal protection the project has functioned well so far.

Eight cross-case results and discussion

Together, the three cases demonstrate some aspects of the theoretical themes of decentralized nature-based climate adaptations, their governance, and their transitional potential.

Nature perception forms the projects

The perception of nature and of landscape (Hansen, 1989) plays a major role in how projects are conceived of and constructed, and this is changing over time. The 40-year-old project of Køge Bay beach park was clearly based on a utilitarian and functionalistic view of nature as a playground for humans. But it also included a romantic perspective. The flood protection function was totally absent from the initial narrative which only branded the beach park as "a Danish Riviera and Beach Paradise" (Valgreen and Front, 1986). The view of nature and landscape clearly changed, both within the Køge Bay project and from Køge Bay to the newer projects. The utilitarian perspective is still in front – it is after all about nature-based solutions to human problems – but there is a much more intricate understanding of how natural processes work and that a multi-user perspective should also include non-human species, and in Straussvej – the newest project – biodiversity is one pronounced goal of the project.

Nature-based are often hybrid

Natural processes do not appear to be feasible standalone options for water management in an urban context. Although all three projects are essentially nature-based, it was necessary to let technology "help" the processes for economic or practical reasons. In the Straussvej courtyard project, technology plays a major role in the solution, while nature seems to be an extra value to be gained from the project. In Kokkedal, the nature-based solution (detention basins) supplemented the existing below-ground technical pipe solutions, and in Køge Bay beach park the (semi)natural solutions are also supported by constructions and water regulation systems. From a technical viewpoint, the projects are hybrids. But when looking into the multi-user perspective, also part of the NBS definition, the projects all come out with other values and multiple user groups in addition to the pure flood prevention.

Daily recreational use is crucial for legitimacy

In all projects the social values connected to the residents play the largest role as added values in a multifunctional perspective. Projects that enhance the quality of public urban or green spaces as well as the facilities for recreational activities lend local legitimacy to the climate adaptation projects. Aesthetics, nature perception and local preferences for use are important elements, in which the importance of participation or co-creation is essential for the acceptance of the physical changes which the projects cause.

Local projects are strategic projects

Local or decentral projects, if they are innovative, are often in reality strategic projects – i.e., they form part of larger plans or strategies, which they "flesh out", and in some cases they also spark a development or change in the overall strategy. In the three cases this meant that they were initiated by public authorities or otherwise had a strong public involvement, but it does not necessarily mean that they are initiated top-down from the national state level. Larger strategies and visions can be inspiring for the decision to make a project, how to phrase the aim and content, and who to involve. The projects results can also spark new, larger policies. The Straussvej courtyard project was part of the Copenhagen city cloudburst plan, but also resulted in more widely used standards for how to deal

with climate adaptive courtyards and how to prioritize among such projects. The Kokkedal project was a combination of social challenges, housing renewal, revitalization of public urban spaces and enhancing the sense of security in public open spaces along with an expansion of the urban storm water management system as a climate adaptation strategy. Hence the project had a wide agenda that was tied together in an integrated, large scale strategic flagship project. Køge Bay beach park was born out of the Copenhagen five-finger-plan and the urban development along the coast to which it contributes livability and a brand.

New problems require new partnerships

All projects include new types of partnerships and an increasing degree of complexity in the interaction among partners. In the Køge Bay project, the partnership included public authorities and only little public participation. Notably, the Kokkedal and Straussvej projects involved the water utility companies, in Kokkedal first as a minor partner, later as full partner, and in the most recent project, Straussvej, as a full and important partner from the start. In relation to local and decentralized climate solutions, Kokkedal highlights the necessity to delegate power and responsibility from the formal public agencies to local landowners and residents – but it also shows that this is not an easy task. The governance evaluation of the Kokkedal project designated the clash between bureaucracy, new public management, and network leadership as the biggest challenge in the project and building trust between the different partners as crucial for success (Lund, 2018). While this was not equally clear in the two other projects, still partnerships between actors who are not used to work together is stated as a challenge in all three projects.

Participation is crucial and changing over time

The involvement of residents or users in project development was important in all the projects, but participation seems to become increasingly complex, from neighbor-hearings in 1976, over serious public meetings in Kokkedal, to a profound interview and workshop-based co-creation process with substantial inputs from residents in the recent Straussvej project. The differences may also reflect the scale of the project: it is considerably easier to give input to a courtyard garden than to a regional beach park stretching over several municipalities. Likewise, it seems that the drivers for wanting participation from residents are developing. In the late 1970'ies it was mainly about avoiding problems and protests, while in the newest Straussvej courtyard project there was an interest in including knowledge from residents about how the courtyard was used before and what they would like to preserve or change.

Long-term management should be foreseen and prepared

Specific issues concern the future management and perceived ownership over time. In the courtyard renovation project, specific concerns were raised by the project manager about the future maintenance of the water handling system, which is technically more complex than residents and caretakers are used to. Will they be able to maintain the system? Or will it decay, and the investment have been in vain? The large-scale project of Køge Bay beach park is maintained by a professional organization and is thus secured continuous co-funding from the five municipalities whose residents have immediate benefits from its presence. This ensures stability but seems to have lifted responsibility away from the main owners (the municipalities) and put the park in a beauty sleep, from which it only now is getting out of with the new development plan that might release its further potentials. Kokkedal makes the shortcomings of an unresolved maintenance plan explicit as part of the system remains out of operation 4 years after the construction work was completed. The setup of a monitoring program (recreation, nature) could be a vital part of supporting an appropriate long-term management.

From flagship to new normal?

Flagship projects such as these: Innovative, well-financed and well-branded have the potential to put new themes, solutions, and values on the agenda. They can help mobilize stakeholders and innovators around a certain problem, contribute with new ideas, and demonstrate solutions. Hence, in a transition theory perspective they qualify as "niche projects" which may in time change the socio-technical "regime". But it can be questioned how experiences from such projects can in practice be mainstreamed into a new normal in everyday urban development with less money and less attention. The three cases illustrate this dilemma. The two most recent projects are clearly conceived of as demonstration projects for new nature-based solutions and new types of organization. At the same time, they are not revolutionary in their technical design or organizational setup. They are pragmatic in that they use hybrid technologies and thus they do not turn over the existing socio-technical regime, but rather pushes the limits toward a more holistic and integrated, hybrid climate adaptation. However, as demonstration projects, they had a considerably larger budget than a mainstream project would have. In Straussvej the budget was double of a normal courtyard renovation, and in Kokkedal two charitable funding bodies put in a considerable amount to lift the project. On the one hand, this is a blessing, on the other hand it puts a "project logic" over the efforts that makes a hard line between the project and

the later maintenance phase. The status as flagship projects meant that great efforts were made to disseminate results and experiences. The older, large-scale project of coastal protection in Køge Bay was not thought of as a demonstration project at all. It was a solution to local or regional needs. There was an awareness, however, that the project was groundbreaking, so it was documented in a book at an early stage (Valgreen and Front, 1986). In at least two projects an important learning was based on how the single entrepreneurs or designers who were involved in the flagship project could carry experiences further in their professional life (interview with designers of beach park and courtyard). This does not constitute a change in the "regime" as such, but it contributes to developing the field of nature-based climate adaptation.

Conclusion

An increasing number of nature-based climate adaptation projects exist in Denmark. They manifest themselves at various spatial scales, from the plot and neighborhood level to the larger city district and regional level. Projects are predominantly retrofitting designs of the existing urban fabric, but occasionally also tabula rasa projects reflecting blue-green infrastructure planning. In a transition perspective, most initial or precedent-setting multifunctional climate adaptation projects can be seen as "niche experiments". They are often promoted and branded as flagship projects with larger budgets and more professional and administrative efforts invested in the projects than normal, hence challenging ordinary practices and the status quo of the socio-technical "regime". In particular, the level of participation and the delegation of power to local stakeholders continuously prove challenging. Further, the scale of technological innovation is generally small, incremental, and pragmatic, yet relevant for gradual and continuous learning loops. The well-documented projects, where money is set aside for monitoring and evaluation of the level of success or failure, have a particular potential to serve as a cornerstone for wider sustainability transitions.

Nature-based climate adaptation projects are strongly acknowledged and promoted by the European Commission. Yet, the systematic review of implemented cases and the extraction of lessons learned remains scant. This paper provides new insights and perspectives on the role of decentralized NBS projects in a Danish context, however with a limited scope and scale of analysis. It is recommended that wider city-wide, nation-wide, inter-regional and global analyses are conducted and compared for a closer understanding of dynamics and defining variables across geographies.

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The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

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