Kok, S.; Bisaro, A.; De Bel, M.; Hinkel, J.; Bouwer, L.:

The potential of nature-based flood defences to leverage public investment in coastal adaptation: Cases from the Netherlands, Indonesia and Georgia.

In: Ecological Economics. Vol. 179 (2021) 106828.

First published online by Elsevier: 29.08.2020

https://dx.doi.org/10.1016/j.ecolecon.2020.106828

The potential of nature-based flood defences to leverage public investment in coastal adaptation: cases from the Netherlands, Indonesia and Georgia

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Declarations of interest: none

Abstract

Nature-based flood defences (NBFD) are receiving considerable attention in the coastal adaptation field. Advocates of NBFD point to their cost-effectiveness, flexibility and the range of co-benefits they produce beside flood risk reduction. However, NBFD are not yet common practice. One reason for this may be found in financial barriers. To date, there has been little attention for financial aspects of NBFD, as the literature has focused on design, effectiveness and socio-economic impact of such projects. We address this gap by analysing the financial attractiveness of real-world NBFD from the perspective of the public actor. We address the following research questions: through which mechanisms can public investments in NBFD projects be leveraged? and ii) what are the enabling conditions for these mechanisms? We find two types of revenue generating mechanisms: value capture, in which the public actor generates revenues from private beneficiaries through taxes; and co-investment, in which the project attracts in-kind or cash contributions from other actors. We illustrate the potential of these leveraging mechanisms in four case studies and find that NBFD can generate significant tax revenues in locations with high demand for certain co-benefits, whereas project size, type, timing and beneficiaries of co-benefits determine the potential for co-investment.

Keywords: NBFD, coast, climate adaptation, value capture, co-investment

Acknowledgements
This study is part of the GREEN-WIN project, supported by the Horizon 2020 programme of the European Commission (Grant Agreement 642018). We thank all our colleagues from the GREEN-WIN project for supporting us with their insights and expertise, and Bregje van Wesenbeeck and her colleagues from the Building with Nature Indonesia project for sharing documents and insights. Furthermore, special thanks go out to interviewees and participants to the workshop 'Bridging the Finance gap: Attracting Non-Public Finance to Coastal Adaptation', held in Delft on 30 November and 1 December 2017.

1 Introduction

Nature-based flood defences (NBFD), measures based on natural processes that often generate ecological benefits, are receiving considerable attention in coastal climate change adaptation. Advocates of NBFD in infrastructure planning point to their cost-effectiveness, flexibility to cope with climate change and the range of co-benefits they produce beyond flood risk reduction (Browder et al., 2019).

Yet to date there has been little implementation of NBFD by governments responsible for coastal risk management around the world. Current NBFD projects that do exist often have a strong innovative or pilot character (Van Wesenbeeck et al., 2014), with corresponding non-mainstream infrastructure funding coming from e.g. innovation budgets. Moreover, NBFD are in most cases not explicitly supported in national or sub-national regulatory or planning frameworks and guidelines for coastal risk management (Jongman et al., 2018), with exceptions such as the living Shoreline Protection Act in Maryland, USA (Maryland General Assembly, 2008) and the coastal strategy as outlined in the Dutch Delta Program (Ministry of Infrastructure and Water et al., 2018) which shift the playing field in favor of NBFD.

At the same time, an emerging literature has enumerated a multitude of barriers that impede coastal adaptation in general, pointing out that the barriers that arise are often financial or social, rather than technical or economic (Moser and Ekstrom 2014, Hinkel et al 2018). The thrust of this literature is that technically feasible flood defence measures that produce social welfare gains exist for many coastal locations (Hinkel et al., 2018). However, they are often not implemented as (local) public budget constraints complicate the raising of sufficient funds to cover the often high upfront investment costs of coastal adaptation (Bisaro and Hinkel, 2018; Shipman and Stojanovic, 2007).

NBFD have the potential to overcome these financial barriers because they often provide co-benefits beyond flood risk reduction in the form of ecosystem services (Renaud et al. 2016). Where flood risk protection benefits are typically stochastic and long-term and may not always be reflected in a market (e.g. insurance, property prices), these co-benefits may provide new opportunities to attract additional investors or generate revenues for the public actor, thereby reducing the financial barriers for investment in such projects.

To date, research on NBFD has largely focused on technical, cost-effectiveness and economic aspects in order to establish the viability and desirability of NBFD as a flood risk reduction and adaptation measure (Barbier, 2016). There has been relatively little attention for this financial dimension in research– with the exception of e.g. Colgan et al. (2017) who explore financial tools for investment in NBFD projects. Furthermore, there is some evidence in literature that NBFD hold potential to generate revenues for the public actor, as investments in reducing coastal erosion in the eastern US are capitalised in coastal real estate values (McNamara et al., 2015). Initial studies show that land value capture, i.e. instruments for recovering value generated by public infrastructure investments, can be effective to attract funding for beach nourishment (Mullin et al., 2018).

In the related field of Payments for Ecosystem Services (PES), which entails a market-based approach to conservation finance based on the user-pays principle (Redford and Adams, 2009), an extensive literature has emerged for over more than a decade. This has produced relevant insights on the financial dimensions and willingness to pay of beneficiaries for ecosystem services, particularly in the context of watersheds (Gómez-Baggethun et al., 2010a; Porras et al., 2008). Although the initiating actor and incentives differ, certain principles or experiences from PES may be applicable in the context of investment in NBFD.

In short, few studies have so far explored whether financial revenues can be generated from NBFD projects and through which mechanisms this can be done. Consequently, there is as yet a relative lack of case studies empirically analysing financial flows from NBFD. Such questions are salient because of the above mentioned prominence of financial barriers to coastal adaptation (Hinkel et al., 2018).

This paper aims to address this gap by exploring the financial dimension of NBFD in four cases, explicitly addressing the following research questions:

- Through which mechanisms can public investment in NBFD projects be leveraged?
- What are the enabling conditions for these leveraging mechanisms?

In this context, we define 'leveraging[1] public investment' in coastal adaptation as a public actor reducing net expenditures by attracting additional investments or generating revenues, compared to a baseline in which the public actor covers all costs and does not generate revenues.

This paper is organised as follows. The next section (2) describes the theoretical framework, including an introduction of NBFD, the relation to PES and potential mechanisms for leveraging public investment, based on literature review and an expert workshop (see also Supplementary Materials 1). Section 3 describes the methodology for identifying these mechanisms in four cases; results are presented in section 4. We discuss

1 The term 'leveraging' is typically used in the context of using public investments to leverage additional investments from private actors in e.g. climate action (Griffiths, 2012).

enabling conditions or these mechanisms and directions of further research in section 5. Section 6 concludes.

2 Analytical framework

2.1 *NBFD*

Nature-based flood defence (NBFD) can be defined as 'measures that use natural dynamics and ecosystem services to reduce flood risk' (Van Wesenbeeck and Penning, 2018). Typical ecosystems that provide coastal flood risk mitigation benefits through reducing wave height and/or forming natural barriers include coral reefs, mangroves, salt marshes and oyster/shellfish bank ecosystems and beach/ dune systems. The design of such NBFD, which entails integrating, preserving or restoring features of these natural systems and ecosystems, is often more location-specific than conventional engineered solutions and requires a good understanding of the local natural system. Aside from flood risk mitigation, NBFD often deliver various co-benefits, including e.g. recreation and tourism, habitat creation, drinking water provision, (sea)food production, carbon storage and fish nursery (E. Cooper et al., 2009; Gittman et al., 2016; Schueler, 2017; van Wesenbeeck et al., 2016). These co-benefits can render a NBFD more attractive from socio-economic perspective. This is demonstrated in an increasing number of studies that comparing the socio-economic rationale of NBFD against hybrid or conventional alternatives (e.g. Browder et al., 2019; Renaud et al., 2016; Salgado and Martinez, 2017). Peer-reviewed literature regarding among other things socio-economic outcomes of NBS are collected in the Nature-Based Solutions Evidence Platform hosted by the University of Oxford (University of Oxford, 2020).

2.2 *Financial perspective on flood risk protection*

Coastal adaptation is a typical example of a public good: in most cases, benefits of flood risk protection are non-excludable and non-rivalrous. In practice the initiator for providing coastal protection is often a public actor and projects are almost exclusively funded with public money (Bisaro and Hinkel, 2018). When public good investments (e.g. roads or parks) have a reflection in a real market e.g. real estate, it may be possible for the public investor to capitalize these benefits, i.e. convert to a cash flow or capital, in order to leverage limited public infrastructure budgets.

In the context of flood risk reduction however, this is difficult as flood risk benefits are not consistently reflected in coastal real estate markets[2] (Beltrán et al. 2018), and investments in coastal infrastructure may even have a negative effect on real estate and tourism markets as they decrease coastal amenity values e.g. accessibility of beach or landscape quality (Jin et al., 2015; Rangel-Buitrago et al., 2018). NBFD can resolve this opposition between flood risk and amenity value by providing flood risk reduction while maintaining or increasing amenity value. In such cases, the higher amenity value and/ or coastal protection benefits is expected to be reflected in property values and this value may be captured by the public actor (McNamara et al. 2015).

2.3 *Relation to PES*

Payments for Ecosystem Services (PES) aim to create market-based mechanisms based on principles of ecosystem service users paying service providers. Although the initiating actor and incentives differ, certain principles or experiences from PES may be applicable in the context of investment in NBFD in which co-benefits in the form of ecosystem services are produced.

The concept of PES has been developed in the context of the classic problem where actors affecting an ecosystem have no incentive to take off-site externalities into account. PES is typically based on mutual self-interest between parties, and therefore expected to be sustainable and efficient (Pagiola, 2008). Particularly of interest in the context of NBFD are experiences with PES in a watershed context, in which a group of public or private beneficiaries takes the initiative pay upstream actors to conserve or provide ecosystem services.

In this case, investment stems from direct demand from users for specific services, in the former these services are provided as secondary benefits beyond the primary public goal of coastal protection. These experiences demonstrate that that there can be incentives for a wide array of beneficiaries to co-invest in a project if it delivers specific ecosystem services. This may also be the case for ecosystem services beyond flood risk protection provided through NBFD. For example, coastal tourism operators might be willing to invest in conservation or restoration of coral reefs nearby (Cooper et al., 2009), or preservation and increase of beach width. Figure 1 compares the concepts of PES in a watershed context and leveraging of public investment through coastal NBFD.

[2] There are exceptions where flood risk benefits do positively affect property prices – particularly in more sophisticated segments of the markets (Beltrán et al., 2019) and in areas with a particularly high flood hazard and lacking protection (like Miami; McAlpine and Porter, 2018).

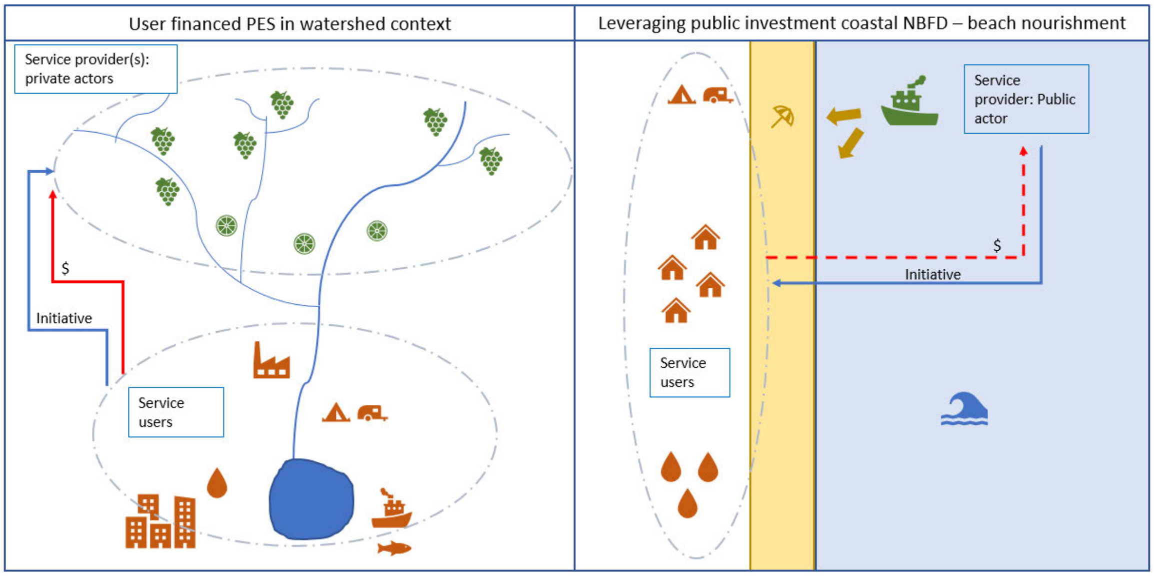

Figure 1 Schematic depiction of the way a user-financed PES in a watershed context compares to leveraging public investment in NBFD in a beach nourishment project. The blue arrow shows the initiative, the red arrow the (desired) cash flow.

If and to what degree a co-benefit can be capitalized depends on the local setting, and especially on the type and timing of a co-benefit. It will be easier to develop mechanisms that redirect cash flows resulting from a NBFD project back to the public actor for co-benefits that are reflected in a functioning (local) market in the short term. This may include benefits such as enabling or improving recreation and tourism opportunities, increasing property values, food and drinking water production, and possibly carbon storage. Other benefits such as spatial quality or biodiversity may be capitalized on a voluntary basis if actors are willing to pay for conservation benefits. For example, Conway et al. (2013) and Wollenberg et al. (2018) discuss how saltmarsh restoration could attract investments through respectively carbon sequestration and habitat banking markets.

2.4 Mechanisms for leveraging public investment in NBFD

The previous section discussed the relation of NBFD to PES – the latter has increasing evidence of users of ecosystem services (co)investing in their production or preservation. Such co-investment schemes might be an attractive mechanism to leverage public investing in NBFD, in relation to NBFD co-benefits beyond flood protection. Land value capture is another promising mechanism for leveraging public investments in NBFD.

Land value capture

“Land value capture” describes a set of instruments applied to capture value generated by public infrastructure investments, initially developed in urban and transport infrastructure sectors (Suzuki et al. 2015; Connolly and Wall 2016; Walters 2012). Direct value capture instruments include, e.g. the selling of public land after public infrastructure investments have increased its value (Bisaro et al., 2019; Van Der Krabben and Needham, 2008). Indirect value capture mechanisms include property tax or special levies on land or property that have similarly increased in value due to public infrastructure investments (Root et al., 2015).

Land value capture is potentially applicable in coastal flood risk management, as evidence from the eastern US shows that investments reducing coastal erosion through beach nourishment are capitalised in coastal real estate values – increasing beach width is a key factor in this (McNamara et al., 2015). Moreover, experiences with differential property taxes – imposing heaviest costs on residents that benefit most – used to fund beach nourishment show that such indirect value capture instruments can be effective (Mullin et al., 2018).

Co-investment

Co-investment refers to a group of public or private actors covering part of the investment and/or operation and maintenance costs for a project. We define investment in this context as an in-kind or cash contribution to a NBFD project, from actors other than the public actor responsible to organize flood risk protection, such as private beneficiaries, NGO's or donors or other public actors, who are willing to co-invest for profit or mandate-oriented reasons.

Key mechanisms for leveraging public investment in NBFD

In the course of this paper, we formalise three mechanisms for leveraging public investment in NBFD projects:

i. *Public actor capturing revenues from private beneficiaries of NBFD co-benefits (value capture)*

Value for private actors generated by NBFD co-benefits is captured either directly through market transactions where an output of the NBFD project is sold to create a return cash flow, e.g. the sale of (increased-value) real estate development projects, land or materials (like sand, wood, oysters), or indirectly through taxes e.g. property tax for adjacent or benefiting properties, or visiting fees for natural areas protected or created in the NBFD project.

ii. *Cash contributions stimulated by NBFD co-benefits (co-investment)*

Cash contributions to NBFD projects can be either mandate-oriented or profit-oriented. NBFD co-benefits may create new business opportunities, or protect existing business activities, which provides incentives for companies to (co-)invest *(profit-oriented*). Additionally, co-benefits such as habitat restoration or improvement of local livelihoods may elicit co-investment on philanthropic grounds, e.g. from development funds, NGO's, philanthropic organisations or from companies' corporate social responsibility (CSR) budget (*mandate-oriented*).

iii. In-kind contributions by private sector contributions stimulated by NBFD co-benefits (co-investment)

Other than cash, companies might invest time and resources in adaptation-related activities coupled with, or in exchange for, the rights to exploit the co-benefits (*profit-oriented*). Furthermore, nature or landscape organisations might be willing to take over management of the project area after implementation *(mandate-oriented)*.

3 Methodology

3.1 Case study selection

To illustrate how the mechanisms discussed in section 2.3 could work in practice, we discuss four NBFD cases in this light. As the scope of this paper lies in analysing financial flows, we selected cases which i) have been financed and reached the implementation stage, ii) demonstrate at least one of the mechanisms for leveraging the public investment and of which iii) we had access to information, data and stakeholders involved in design and implementation. The selected cases include one mangrove restoration project (Demak, in Indonesia), and three sand nourishment projects (Prins Hendrikdijk and Sophiastrand, in the Netherlands and Batumi, in Georgia).

3.2 Case study analysis

To analyse how the mechanisms for leveraging public investment work, we describe each case in terms of i) project set-up, ii) costs and cost-effectiveness, iii) relevant stakeholders and analyse iv) mechanisms that leverage public investment in coastal adaptation and iv) corresponding cash flow in relation to (co)-benefits of the NBFD and v) leveraging potential in relation to project costs. The cases have been developed using document analysis including e.g. feasibility studies, reports and contracts. To increase the understanding of the cases in terms of project goals and implementation process, as well as key factors influencing decisions and underlying motivations of stakeholders, one or two semi-structured interviews per case were conducted with key stakeholders such as project managers. See Supplementary Materials for a list of interviewees and interview questions, and more elaborate case descriptions.

3.3 Scope and limitations

We are aware of concerns relating to the degree to which NBFD and in particular sand nourishment actually benefit nature (Peterson et al., 2000), and the issue of commodification of ecosystem services (Gómez-Baggethun et al., 2010b), but do not address these in the course of this paper.

The analysis of the cases focuses on describing how the NBFD co-benefits in each case may leverage public investment in coastal adaptation and understanding underlying incentives and institutional-set up. As such, and because most cases have not been implemented long enough, we do not analyse the effectiveness of the solutions themselves regarding adaptation benefits, potential trade-offs of the design and the sustainability of financial and institutional arrangements. We also do not explicitly address the socio-economic rationale of investing in NBFD over conventional or hybrid alternatives as part of our analysis; we depart from the assumption this has been analyzed sufficiently in the decision-making process during project design and selection, and focus our analysis on the financial dimensions.

4 Results from the cases

This section presents the results from the analysis of the cases. Table 1 summarises their main characteristics. The details are discussed in the following sections.

4.1 Sophiastrand (Netherlands)

As of 2010, a 1 km section of the dike near Sophiastrand in the Dutch province Zeeland no longer met the required safety standard and had to be reinforced by the implementing agency of the Ministry of Infrastructure and Water Management, Rijkswaterstaat. As a small dune strip had formed naturally on top of the dike in past decades, an alternative beach nourishment project was proposed and compared to conventional dike reinforcement in a cost-benefit analysis (CBA) (Schasfoort et al., 2014). The CBA found that the beach nourishment project (costs estimated at €1.25m) would be cheaper than dike reinforcement (€1.6m) and generate significant co-benefits related to tourism and recreation: in the close vicinity of the beach there is a large commercial holiday park (Roompot) and adjacent marina. The project was executed in 2013. A qualitative ex-post analysis showed implementation costs were €0.2m lower than expected due to innovation in procurement practices: furthermore, the project has increased opportunities for sport fishing and water sports, and new accommodation was developed on the widened beach as projected in the

CBA. As a result, local tourism operators have seen a significant increase in visitor numbers and revenue (De Visser 2017).

Co-investment: profit-oriented in-kind contribution

In the design stage of the project, the non-profit public-private organisation Ecoshape provided free advisory services. This organisation aims to develop and share knowledge on NBFD: the incentive for its private partners, including contractors and engineering companies, consists of achieving a competitive advantage through experience and knowledge on NBFD. Furthermore, in exchange for the permission to build a number of holiday houses on the beach (Leeuwen et al., 2014) – which is usually restricted in the Netherlands on account of landscape quality - Roompot takes on maintenance activities such as reprofiling the beach after storm events in consultation with the local Water Authority.

Value capture

The attractiveness of the area for recreation increased as the beach nourishment project increased beach width and landscape quality. The projects' CBA calculates the impulse to the recreation/ tourism industry (accounting for the substitution effect; expressed in present value – PV - discounted at 5,5% for 50 years): existing holiday homes increase in value (€2.6m); new holiday houses are built on the beach (€5m); and the increase in visitors leads to more expenditures in the food, beverage and leisure industry in the area (€0.9m). Based on current Dutch tax legislation, these benefits generate revenue to the public actor through the 21% VAT on accommodation (€0.55m), food & beverage industry and other recreational services (€0.15m); property and property transfer tax as the newly constructed holiday homes on the beach are purchased by private individuals (€1.1m); and the tourism tax raised by the municipality on overnight stays (€0.3m). As such, the potential value capture in this case amounts up to more than 100% of the initial investment costs. Ex-post analysis of tourism tax records from the municipality indeed showed an increase after project implementation, but within the margins of longer-term volatility. Other tax records were not available at the required local level to discern project effects.

Table 1 Summary table of key characteristics of NBFD cases and results in terms of demonstrated public investment leveraging mechanisms. Timing of co-benefits is expressed in the time it takes before they become available: short term (ST) 0-5 years, medium (MT) 5-10 years and long (LT) > 10 years. Reported project costs include capital and operational expenditures and is based on document analysis. Cost-effectiveness is in relation to a more conventional engineering approach. *Capex & opex: capital and operational expenses

	Sophiastrand (Netherlands)	**Batumi** (Georgia)	**Demak** (Indonesia)	**Prins Hendrikdijk** (Netherlands)
Spatial scale	1 km	6 km	20 km	3 km
Project Status	Finished in 2013	Implementation phase	Implementation phase	Implementation phase
Ecosystem	Tidal salt marshes/ beaches and dunes	Beaches and dunes	Mangroves	Tidal salt marshes / beaches and dunes
Project goals	Meet flood safety standards, whilst protecting and enhancing spatial quality	Prevent significant erosion	Reduce coastal erosion by mangrove restoration whilst reducing local adverse incentives by supporting sustainable livelihoods	Meet safety standards whilst protecting and enhancing spatial quality and create valuable habitats
Socio-economic context	Rural area close to small village: key economic activities include tourism and recreation, including large holiday park adjacent to project.	Coastal strip in highly developed urban area with well-developed tourism and recreation industry.	Rural coastal area with local communities practicing fishing and aquaculture.	Rural island location with significant natural value and tourism
Co Benefits & timing	Habitat creation (MT); Recreation/ tourism (ST);	Recreation/ tourism (ST)	Habitat creation (MT); fish nursery (MT/LT); wood production (LT)	Habitat creation (ST/MT); Recreation/ Tourism (ST)
A: Project costs	€1,25m (capex & opex*)	€ 23.1m (capex & opex)	€5m (capex)	€45m (capex & opex)
Cost-effectiveness	More cost-effective than alternative	N/A: engineering solution not feasible	More cost-effective than alternative	Less cost-effective than alternative
B: Revenues				
Value capture public actor	*€2,1m*: • Property tax revenues €1.7m • VAT tax revenues: € 0.1m • Tourism tax: € 0.3m	*€2-2,2 m* • Income tax revenues: €0.2 m • Property tax revenues: € 0.4-0.6 m • VAT tax: €1.4 m	N/A	N/A
Co-investment	Profit-oriented in-kind contribution to O&M by private actor: *€ unknown*		In-kind contribution private actor: € *value unknown* Mandate-oriented cash contributions: *€5m*	Mandate-oriented cash contribution private actor: *€12.2m*
Leverage ratio (B/A)	~ 168 %	8-9%	100%	27%

4.2 *Batumi (Georgia)*

Batumi is a port city in Georgia on the coast of the Black Sea, with a thriving tourism sector with many hotels and apartment buildings along the coastline. In recent years, coastal erosion and consequent flooding has damaged the 5 km boulevard and adjacent properties – including apartment buildings, offices and large hotels. In the process of developing a solution, conventional measures such as large breakwaters in front of the coastline were deemed undesirable due the negative landscape impact (Giardino et al., 2014), expected to reduce the attractiveness of the area for tourists and property owners. In the end, a hybrid beach nourishment solution in combination with revetments to capture sediment was selected, with costs estimated at $23m (Technital SpA et al. 2015). The Batumi Coastal Protection Project is ongoing and has been financed mainly by the Asian Development Bank (as a loan to government) and executed by the Georgian Municipal Development Fund. Key benefits of the project include the protection of the coastline, boulevard and adjacent properties from erosion and consequent loss of income/revenues, an increased attractiveness of the area for tourism due to increased beach width, and an improved investment climate for the tourism industry. Non-market effects include improved health and safety by reducing flooding damage and nuisance and preserving ecological functions (Giardino et al. 2014; Technital SpA et al. 2015). Key stakeholders of the project include the local government, property owners and the tourism industry.

Value capture

The main rationale for the project lies in protecting existing infrastructure and property and consequent tourism revenues. The projects' CBA estimates avoided damage at respectively € 40-64 m and € 32 m (expressed in PV, discounted at 12% for 30 years) (Technital SpA et al., 2015). By avoiding damage and loss of private revenues, revenue streams from private beneficiaries to the government through property tax, income tax and the VAT tax on tourism expenditures are protected as well. The revenues from property tax are estimated at € 0.4-0.6m. Income generated by the tourism industry - 25 % of turnover (Technital SpA 2015) - is taxed at 20% (PWC, 2013): hence, 5 % of the tourism revenues are captured through the income tax, €1.6m. The revenues from the VAT tax (18%) on sales of products are estimated at € 1.4m. As such, the value capture potential mounts up to approximately 8-9 % of the investment costs.

4.3 *Demak (Indonesia)*

The northern coast of Java is subject to continuous and increasing coastal erosion and flooding: in the long run 30 million people living in the coastal zones may be exposed. Protecting this long, low-lying and muddy coastline with engineered solutions would not be cost-effective. Along a 20 km coastline section in Demak (Central Java) – hosting 70.000 people and 6000 ha aquaculture ponds - the Building With Nature project (2015-

2019) aims to showcase large-scale application of NBFD techniques that restore mangroves, such as permeable dams that trap sediments: implementation costs are estimated at €5 m. The engineering alternative, which consists of hard structures such as aquaculture pond bunds and breakwaters, would exacerbate erosion problems by disturbing the sediment balance and reflecting and strengthening waves (Tonneijck and Van Eijk, 2008). The project involves local communities in the construction and maintenance of the NBFD and aims to enhance their livelihoods to promote longevity of the project. The latter involves supporting the communities in moving from extensive low-productive shrimp production, which through its impact on the water system contributes to subsidence which in turn aggravates erosion and flood risk, to more diversified, productive and environmentally friendly aquaculture via a Farmer Field School Program in the sister-project PASMI. The Building With Nature project aims to counteract loss of land and reduce flood risk. Co-benefits of the restored mangroves in the long term will include brushwood production and increased profits from fishing (among others due to fish nursery function) (Hakim, 2017). Key stakeholders of the project include the local population and aquaculture owners and fishermen.

Co-investment: cash-contribution

The project is co-funded by a development grant (FDW[3]: €3 m), a knowledge development subsidy (NWO[4]: €0.6 m) and a public-private organisation (Ecoshape: €1 m). Additionally, the German Climate Fund IKI invested €3 m in a later phase of the project to aid upscaling and replication of the project, among others by initiating a training programme and help desk facility. Motivation for these contributions are mandate-oriented: development funds like FDW aim to contribute to specific SDGs; the private actors in Ecoshape aim to obtain a competitive advantage through investing in innovative approaches. The contributions by Ecoshape and IKI demonstrate that NBFD may attract different funding streams whilst still in innovative phase as compared to 'mainstream' or proven technology phase.

Co-investment: in-kind contribution

The project introduces an innovative financing mechanism in the area, called Bio-Rights: in return for active engagement of the community in implementing and maintaining mangrove conservation and restoration measures, communities are supported financially and through capacity building to move from extensive shrimp farming to more sustainable and profitable aquaculture. This exchange is conditional – financial support is only delivered if coastal restoration is successful. The main reason to introduce this scheme is to create a local incentive to prevent over-exploitation or destruction of newly created mangroves and to ensure local capacity building. Conditional grants of €10.000 are issued to community groups (Tonneijck et al., 2015). The project thus externalises part of

[3] FDW: Fonds Duurzaam Water, former Dutch fund supporting collaboration for sustainability in the water sector

[4] NWO: Dutch organization providing grants for scientific research

construction and maintenance activities on the permeable dams and building local capacity to do so, while reducing local adverse incentives that may harm the project.

4.4 *Prins Hendrikdijk (Netherlands)*

The dike on the eastern side of Dutch Wadden Sea island Texel (Prins Hendrikdijk) required reinforcement to meet the safety standard defined by law. In a 2 km long section of this dike, a NBFD in the form of a dune strip and lagoon in front of the dike (costs €45 m) was selected over the alternative, a conventional reinforcement of the existing dike (costs €30 m). The NBFD offers various co-benefits such as preserving agricultural land and historical features which would have been lost in the dike reinforcement project, increasing the aesthetical value of the landscape and contributing to conservation goals in this Natura 2000 Wadden Sea area (Hoogheemraadschap Hollands Noorderkwartier, 2017). The project was implemented in 2019. After implementation ownership and management of the area will be transferred to a nature conservation organisation.

Co-investment: mandate-oriented cash contributions

Traditionally, coastal adaptation measures in the Netherlands are initiated and implemented by the local Water Authority: the least-cost alternative is funded by the Flood Protection Programme (HWBP) in which state and local resources are pooled. If a more expensive alternative is chosen such as in the case of the Prins Hendrikdijk, additional co-funding is required to make up the difference. The 'Waddenfonds' contributed €12.2 m to the project. This fund was initiated in 2007 by the state to compensate for the adverse effects of natural gas extraction in the region such as subsidence and damage to nature, subsidizes projects that contribute to nature, heritage, tourism and recreation and innovation in the Wadden Sea area.

5 Discussion

In this section, the enabling conditions for value capture (Section 5.1) and co-investment (Section 5.2 and 5.3) in the context of NBFD are discussed, followed by a review of potential trade-offs between these mechanisms and nature and equity (Section 5.3), and limitations and directions for further research (Section 5.4).

5.1 *Enabling conditions for value capture*

Key enabling conditions for value capture from NBFD as illustrated in the cases relate to the socio-economic setting, institutional design and timing of benefits of the project.

Socio-economic setting: demand for co-benefits & infrastructure for capturing value

Whether and which co-benefits occur depends on the type of NBFD, as well as the socio-economic setting: to what degree is there demand for the co-benefits provided in the project? Is there an infrastructure for value capture, or can this be developed? In the Batumi and Sophiastrand case there is a clear demand for recreation and tourism and corresponding tourism infrastructure which enables capture of revenues through taxes. Furthermore, there are properties close to the project location; the property markets in these locations do not reflect flood risk directly but are influenced by coastal amenity value which will be increased by NBFD rather than harmed by hard protection infrastructure. In the case of Prins Hendrikdijk, the demand for additional recreational opportunities in the area is limited, and there are no tourism operators or properties nearby whose value could increase with additional spatial quality. In the case of Demak, biomass production from the mangrove and increasing fish stocks will benefit local population and businesses, but these benefits will be smaller and develop over a longer time span. Therefore, the additional tax revenues will be limited in comparison to the project costs.

Suitable tax system/ institutional design

Generally, economic benefits derived from infrastructure projects are captured though the regular tax system. In the Sophiastrand and Batumi cases, the added value of the projects for the tourism and recreation sector is captured through VAT, income -, tourism - and property tax. These tax revenues are pooled in the general public budget at national and municipal level. This means the revenues do not flow back to the public entity or to the budget targeting coastal adaptation. In order to ease the coastal adaptation investment burden for public actors, redirecting tax revenues from NBFD measures to coastal adaptation would be valuable.

Particularly in Georgia, the pressure on public budgets is high and there might be an incentive to capture revenues for adaptation purposes. In the Netherlands (Sophiastrand) as an exception to the general rule, there is mostly sufficient funding available for coastal adaptation. The cases demonstrate that NBFD indeed lead to benefits for local actors which can be taxed, for example with value capture instruments such as tax increment financing schemes (TIF), which earmark the expected increase in revenue from existing taxes in a local district. However, critics of such taxes point to the complications and expenses in administering TIFs (Terrill and Emslie, 2017). A first step could be to analyse whether and which type of value capture mechanism would be desirable and feasible depending on a countries' institutional design and coastal adaptation funding needs.

Timing of co-benefits and revenues

Aside from recreation benefits resulting from sand nourishment where benefits are immediate, the time frame in which co-benefits of NBFD are delivered is typically long-term. A mangrove, coral reef or shellfish bank may take decades to fully develop and deliver co-benefits such as a fish nursery function or tourism. For capturing project revenues though tax collection this is not necessarily a problem, as long as the added value in a certain sector can be clearly attributed to the projects' outcome.

We find that NBFD projects in locations with high recreation demand, existing tourism and housing infrastructure, and significant benefits that are clearly attributable to project outcomes are attractive for value capture. An important additional requirement is a system for earmarking taxes, designed to ensure the money flows back to coastal adaptation, with proportionate transaction costs.

5.2 *Enabling conditions for co-investment from private actors*

To determine if a case is viable for attracting private co-investment, key enabling conditions include the size of the project and the time scale in which the benefits work.

Project size

Key enabling conditions vary with project size. As is often the case in coastal adaptation projects, the NBFD project costs in the cases are medium to large, with initial investments ranging from €1.2 m – €45 m. Especially in the larger projects, co-benefits such as livelihood improvement, climate resilience and nature development may be attractive for mandate-oriented climate, development or philanthropic funds. This potential of NBFD projects to attract additional funding streams towards coastal adaptation projects is illustrated in the Demak and Prins Hendrikdijk cases, with respectively climate funds FDW and IKI and the regional environmental fund Waddenfonds co-funding these projects.

In smaller-scale NBFD projects with clear benefits for local private actors, such as the tourism industry or private property owners, an in-kind or cash contribution might be raised from these actors. Although this option was not explored during the Sophiastrand project, this case does fit in this picture: the Roompot holiday park is a local, sizeable private actor with short-term benefits from the project. Outside of our study, another example of this includes a recently established fund for reef protection in Mexico, which consists of contributions from large, established local tourism operators (Kellett and Way, 2018).

Especially in such small-scale NBFD projects the potential contribution must be sizable in relation to the projects' costs to be worthwhile the potentially significant transaction costs of arranging such contributions. With benefits spread over the longer term, private actor contribution to the maintenance phase may be more feasible. E.g. in the Sophiastrand case, the local tourism operator does beach maintenance. Lessons learned from this case indicate that if final responsibility for coastal adaptation lies with the public actor, clear terms of agreement are needed on what efforts are to be expected under various circumstances, as well as regular coordination between public and private parties, in order to enable private in-kind contributions.

Timing of co-benefits

Small-scale NBFD projects that have a limited amount of private beneficiaries and produce benefits on a short time scale are the most suitable for attracting cash or in-kind co-investment from private actors. Such benefits include tourism benefits in an area with a limited number of established operators. The predictability of co-benefits is high at this scale, and the limited group of beneficiaries reduces the risk of free-riding behaviour. Larger projects with long-term benefits and a wide array of beneficiaries are more suitable to attract local private actor co-investment in the operation and maintenance phase, or mandate-oriented co-investment from impact investors. As predictability of co-benefits is more difficult at this scale, co-investment may be conditional on environmental and social impact assessment studies and post-implementation monitoring requirements, as seen in the Prins Hendrik case.

In the Demak case, where the benefits of mangrove restoration occur on a long timescale and where there is a wide array of beneficiaries, the benefits have a stronger public good character than in the small-scale Sophiastrand case with relatively short-term benefits. The lack of a short-term incentive for local private actors to take on adaptation activities is addressed in Demak by offering a temporary financial incentive to promote local knowledge and support of the adaptation measure, to stimulate in-kind contribution in maintenance in the future. A potential weakness of this approach is its long-term sustainability: it is unknown whether the knowledge and support created survives after the financial incentive ends after 10 years.

5.3 Finance and governance issues for NBFD

Finance

To capitalize on the potential of NBFD to leverage public investment, coastal risk managers would have to consider during the design phase which co-benefits can be expected from the project and identify if there is potential for value capture or co-investment. The potential for value capture depends on how the co-benefits translate into local private revenues, to which extent these are captured through existing tax revenues and the feasibility of applying the value capture instruments discussed in Section 2.3. To identify the potential for cash or in-kind co-investment in the implementation or operation and maintenance phase, an analysis on the type and timing of co-benefits, and number and wealth of benefiting local private actors is needed. In case of long-term benefits and/or large numbers or less wealthy beneficiaries, an analysis how co-benefits match with mandate-oriented investors' impact goals can help identify potential sources for co-investment.

Equity, nature and public perception

To leverage public funding through value capture or profit-oriented co-investment in the context of NBFD, creating or increasing the value of private co-benefits is necessary – e.g. housing and (exploitation rights of) recreation opportunities. Through co-investment a private actor can gain influence in decisions on the project design or obtain certain privileges: economic activities such as harvesting biomass, fishing, or recreation and tourism may cancel out any benefits the project has for common or public goods such as landscape quality or habitat provision. This may lead to public opposition: when ecosystems are created or enhanced in the public, the public may not want them (privately) exploited through special privileges, although to what extent this is the case is likely culturally driven.

The Sophiastrand case illustrates this: the permission for holiday house construction on the beach raised protests from lobby groups promoting environmental quality and preservation of a pristine coastline. In the Prins Hendrikdijk project, it was explicitly chosen not to allow any visitors in the project area so as to preserve its value for nature. Although such trade-offs may affect public perception and support for NBFD projects, the first hurdle regarding public support for NBFD around the world is to convince local stakeholders of the validity of NBFD as alternative to conventional approaches to coastal protection – in this context, The Netherlands have a progressive position with public opinion very accommodating to NBFD.

If at some point the potential of NBFD projects to leverage public investment in coastal protection would become a criterion in prioritizing investments, this might skew investments towards richer areas: tax revenues are likely to be higher in a rich than a poor area, as well as the potential for contributions from local private actors.

5.4 Directions for further research

The cases used in this study to illustrate how NBFD co-benefits may render such projects more attractive from a financial point of view are all relatively recent or ongoing. Therefore, we were not able to evaluate the cases ex-post on the i) effectiveness in terms of coastal protection; ii) potential trade-offs of the mechanisms to nature, equity or public perception; and iii) effectiveness and sustainability of newly born actor constellations and the projects' impact on collected tax revenues. Further research analysing trade-offs between financial attractiveness, equity and nature would be valuable, as well as evaluation of effectiveness and sustainability of leveraging mechanisms after completion. Additionally, further research analysing the mechanisms for leveraging public investment in a larger sample of cases, in various ecosystems and under various institutional (e.g.

capacity of public budget, institutional arrangements for coastal protection) and socio-economic settings (e.g. supply and demand for co-benefits) around the world would promote insights in their applicability and sustainability under various circumstances.

6 Conclusions

In the context of persisting financial barriers for public entities to implement coastal flood protection, attracting additional funds or capturing created value can help overcome these barriers. As flood risk protection is not consistently reflected in all coastal real estate markets, capturing direct flood risk benefits e.g. through property taxes is not always feasible. We illustrated in four cases how the co-benefits provided by NBFD create opportunities to leverage public investment in coastal protection. Depending on i) project size, ii) the type of good provided by the co-benefits and their timing, and iii) the number, type and wealth of beneficiaries, NBFD co-benefits create opportunities to capture private revenues through direct or indirect taxes, and by attracting cash or in-kind co-investment from mandate – or profit-oriented private actors.

Value capture instruments such as tax increment financing might be applicable in order to recoup part of the investment and earmark it for re-investment in similar projects. The cases show such indirect value capture can have a significant leveraging potential in relation to project costs, although there are limited real-life applications of this concept in the context of coastal protection at present. As value capture entails capturing value of (co)benefits that appear after project implementation, this mechanism cannot be used to raise up-front investment capital at the project level, and additionally has too high transaction costs to apply at a project basis: it would therefore be most valuable if applied in the context of a wider coastal risk management strategy.

At the project level, co-investment from non-public actors can help reduce net expenditure for the public actor. Particularly in a context with a limited number of private beneficiaries and co-benefits in the short term, cash co-investment in the implementation phase may be feasible, although it must be significant in relation to project costs to justify the high transaction costs. With longer-term co-benefits and/or more and more variable beneficiaries (i.e. due to larger project scale) cash or in-kind co-investment may be possible in the maintenance phase, or alternatively, the (co)benefits may match with mandate-oriented investors' impact goals.

Despite the small sample of cases and limited scope of this study, the findings indicate that NBFD co-benefits indeed can be more attractive from a financial point of view than conventional measures, as the co-benefits lead to opportunities for leveraging public investment in coastal adaptation through value capture or attracting co-investment. To capitalize on the potential of NBFD to leverage public investment, coastal risk managers should consider in the projects' design phase which co-benefits the project is expected to deliver and identify if there is potential for value capture or co-investment. This is particularly relevant in a context where public budget constraints prevent sufficient investment in coastal protection and raising up-front capital for such projects is difficult. Further research could address potential trade-offs, effectiveness and sustainability of these leveraging mechanisms ex-post and in a larger sample of cases situated in various physical, socio-economic and institutional contexts.

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