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Stakeholders' Perception on the Contribution and Challenges of Nature-Based Solution for Flood Risk Reduction in Rotterdam, the Netherlands

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Abstract

Nature-Based Solution (NBS) helps to reduce the sole reliance on grey infrastructure for urban flood reduction. This study aimed to understand stakeholders' perceptions of the contribution of NBS projects to flood risk reduction. It also explored respondents' knowledge on and co-benefits of NBS, and the challenges. Data for this study were collected through 100 questionnaire surveys and eight key informant interviews from two flood-related NBS projects in Rotterdam, the Netherlands. Results showed that the selected NBS projects have had moderate to low contributions to flood risk reduction in Rotterdam. Although the majority of the respondents had very limited knowledge of the NBS concept, they reported several co-benefits of the studied projects. Key informants reported several challenges such as 'uncertainty of benefits or effectiveness' and 'lack of people's familiarity with the NBS concept' that the authority experienced while planning and implementing these NBS projects. There was no provision for a maintenance budget for NBS projects, which might threaten their sustainability. Suggestions are made to create awareness of people on NBS approaches and allocation of budget for regular maintenance of projects' infrastructure.

Keywords: *Nature-Based Solutions, Co-benefits, Challenges, Flood Reduction, Rotterdam*

Introduction

Nature-Based Solution (NBS) provides new and effective alternatives to infrastructural development that can deal with cities' numerous problems in a cost-effective manner (Fink, 2016; Frantzeskaki, 2019). NBS is an idea that directly relates to or supports the concept of ecosystem-related approaches, services, or adaptation (European Commission, 2015; Eggermont et al., 2015; Faivre et al., 2017). Particularly, NBS focuses on adaptation to climate change, ecosystem benefits and green set-up (Kabisch et al., 2016a, b). On the other hand, NBS is designed to deal with diverse societal challenges through the effective use of resources to safeguard social, economic and environmental benefits simultaneously (European Commission, 2015; Faivre et al., 2017; Cohen-Shacham et al., 2016; Maes and Jacobs, 2017;

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Albert et al., 2017; Fini et al., 2017; Raymond et al., 2017a) and this characteristic of NBS is referred as "multifunctionality" (Kabisch et al., 2016a). Besides, some other features of NBS comprise cost-effectiveness (European Commission, 2015, Keesstra et al., 2018), adaptableness (Cohen-Shacham et al., 2016), dependence on a transdisciplinary perspective and evidence-based approaches (Nature, 2017).

Nature-based solutions' has been taken into account as an umbrella concept encompassing diverse approaches with a wide range of applications (Cohen-Shacham et al., 2016). NBS combines different traditional ecosystem-based approaches, like "ecosystem services", “green-blue infrastructure”, “ecological engineering”, “ecosystem-based management” and “natural capital” (Nesshöver et al., 2017, Nature Editorial, 2017) alongside evaluating the socio-economic advantages of resource-effective and systemic solutions (European Commission, 2015; Raymond et al., 2017a,b). It was argued that the notion of NBS is not confined to natural elements only; relatively soft engineering approaches are also considered part of NBS (Marton-Lefèvre, 2012; van Wesenbeeck et al., 2014). These solutions might entirely be ‘green’ or a combination of ecosystem elements and ‘grey’ infrastructures (World Bank, 2017).
The application of NBS has various challenges too. The most significant challenges that are related to the application of NBS include but are not limited to the uncertainty about future benefits or value (Kabisch et al., 2016a, b; Raymond et al., 2017a,b; Nesshöver et al., 2017), lack of established implementation guidelines for NBS (Pontee et al., 2016), “disconnection between short-term actions and long-term goals” (Kabisch et al., 2016a), assuring the participation of related stakeholders, the unfamiliarity of NBS concept to the broader public (Kabisch et al., 2016b), lack of political and economic will (Balian et al., 2016) and financial constraints of the individual municipality (Droste et al., 2017). Additionally, NBS might not be feasible for all urban areas because these require more space than traditional grey interventions (Boelee et al., 2017). Furthermore, health problems might also result from NBS, like allergies to pollen grains or the spread of any infectious ailments to nearby residents (Keune et al., 2013).

This study focuses on the application of NBS toward flood risk reduction. The traditional ways to manage floods are becoming insufficient to deal with their frequent occurrence and devastating impacts (Jabed, 2019). Traditional responses and interventions have focused on grey infrastructure approaches (hard, conventional, or engineering solutions) such as pipes, canals, tunnels, dikes, embankments, and flood walls, and there is evidence that such infrastructures have not been effective in achieving adequate flood protection, cost-effectiveness, and environmental sustainability (World Bank, 2017; Brink et al., 2016; Kourkoulis, 2018; Vojinovic et al., 2021). Recently the concept of “nature-based solutions”, “ecosystem-based adaptation”, “eco-DRR” or “green infrastructure” has emerged as a good alternative or complement to traditional grey approaches (World Bank, 2017; Vojinovic et al., 2021). These interventions can be completely “green” (i.e. consisting of only ecosystem elements) or “hybrid” (i.e. a combination of ecosystem elements and hard engineering approaches). Researchers (e.g., Vojinovic et al., 2021; Zölch et al., 2017; Versini et al., 2018; Kong et al., 2017) reported the effectiveness of NBS in flood risk reduction. However, too

often the role that nature can play in reducing flood risks is overlooked or undervalued (The Nature Conservancy, 2020).

The distinct criteria of NBS are that they become better with the elapse of time while the effectiveness of traditional grey infrastructures often declines over time (OpenNESS, 2015). Moreover, it can enhance green economies and jobs by involving stakeholders and ensuring co-benefits, eventually linking social and economic interests (Kabisch et al., 2016a; Marton-Lefèvre, 2012; Raymond et al., 2017a,b). Alongside addressing a targeted problem, NBS offers co-benefits like ecosystem services and human welfare (Cohen-Shacham et al., 2016; Hartig et al., 2014) which are notable advantages of these solutions compared to the grey infrastructures (Pontee et al., 2016). For instance, NBS that are designed for flood reduction can help to increase coastal resilience, promote the urban living environment (Larson and Perrings, 2013) reduce an urban heat island effect, expansion of biodiversity (McFarland et al., 2019), improve physical and mental health (Hartig et al., 2014; Keniger et al., 2013), strengthening social cohesion among citizens (Birch et al., 2013; Xiang et al., 2017), creating opportunities for recreation (IUCN, 2019; Lafortezza and Sanesi, 2019) and upgrading urban aesthetic beauty can consequently raise the property value through upgrading the environmental quality of an area (Raymond et al., 2017b).

In the Netherlands, about 60% of the country's land is prone to flooding (European Commission, 2015). To reduce flood risks in Rotterdam, several "Nature-Based Solutions" projects have been implemented including restoration of the local park, roof garden, rain gardens, etc. (Frantzeskaki, 2019). However, there is a lack of evidence on the effectiveness of these projects. The objectives of this study were to explore the stakeholders' perception of the contribution of NBS in addressing flood risk in urban neighbourhoods, to unveil the co-benefits of the NBS projects in Rotterdam and their impacts, and to identify the challenges of planning and implementing NBS projects.

Methodology

Description of the Study Projects

This study was carried out in two NBS projects namely Water Square and ZOHO Raingarden located in the *Agniesebuurt* neighbourhood (Figure 1) of Rotterdam municipality. This 19th-century neighbourhood is located in the Rotterdam Noord (HHSK, 2019). This urban area is characterized by less greenery space and a more stony environment, creating a high risk of flooding. However, the municipal authorities have undertaken several initiatives to make the area climate-proof in the coming days (ibid). Water Square and ZOHO Raingarden are two climate adaptation initiatives implemented to minimize the flood risk in the *Agniesebuurt* area.

Water Square: Water Square or Benthem Square is a floodable multifunctional square considered an iconic water management structure constructed to hold considerable rainwater during extreme rain events. It can help to remedy the flooding condition of its nearby areas. The construction of this project was started in 2010 and realized by 2014. Benthem square is the first water square in the world of its type that also provides numerous benefits to its users

alongside flood management (Bassolino, 2019). This project's primary purpose is to retain water that ultimately helps in the flood management of Rotterdam. Besides, it is widely used as a recreational and relaxation space for people of different ages.

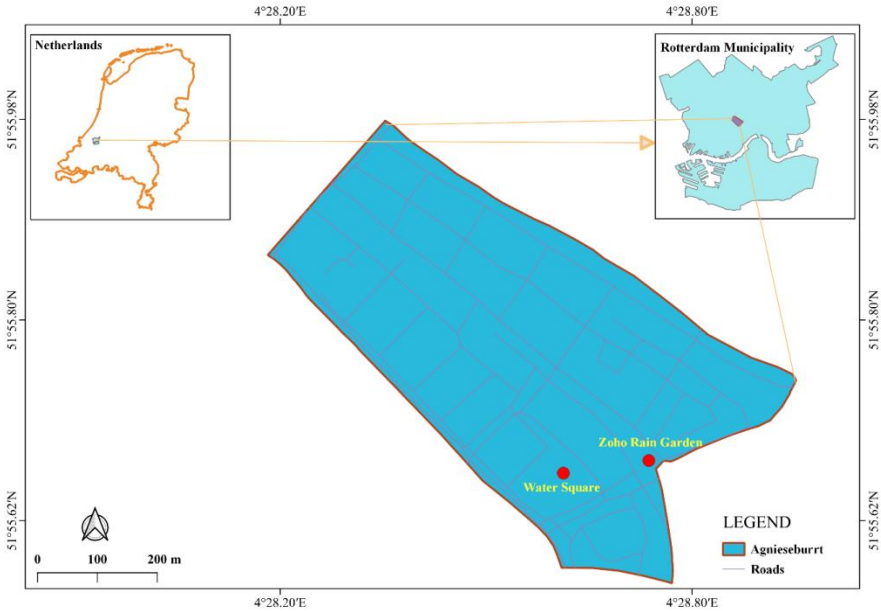

Figure 1: Location map of the Study area. (Source: Prepared from Google Maps 2022)

ZOHO Raingarden

ZOHO Raingarden is a unique public garden with a water-holding capacity during excessive rainfalls. This project was initiated to modify a monotonous parking space to a greenish and unpaved surface. This project was accomplished through two different phases where Urbanisten initiated the 1st phase, and the latter phase was done by Rotterdam municipality. This garden receives rainwater from around 3000 sq. meters of the surface area alongside other benefits to the local community or its users (De Urbanisten, 2016).

Research Approach and Data Collection

This study adopted a mixed research approach consisting of questionnaire surveys and key informant interviews. A simple random sampling strategy was applied to conduct the questionnaire surveys. A semi-structured questionnaire was developed to collect quantitative data and narratives. The questions were related to respondents' demography (gender, education, occupation and residence), knowledge and co-benefits of NBS projects, and contribution of NBS projects to flood reduction. The respondents were the people who often visited the study project sites (Water Square and ZOHO Raingarden). We randomly approached the people but only considered those older than 18 years. A total of 100 questionnaire interviews were conducted in both study sites (50 in each project).

The key informants of this study were chosen using the purposive sampling method. We interviewed only those involved with either implementing or maintaining both projects (i.e., Water Square and ZOHO Raingarden). A total of eight key informant interviews (4 for each project) were held, including the Project Manager, Urban Planner, Architect, and Maintainer. These interviews highlighted mainly the challenges of NBS projects.

Data Analysis

We followed descriptive analysis (frequencies and percentages) for quantitative data. Qualitative information is presented using narratives.

Results

Demographic characteristics of respondents

The majority of respondents for both study projects were male (Table 1). More than 70% of the respondents in both study sites either graduated or hold a post-graduate degree. About 50% of the respondents from Water Square were job holders and in Raingarden 40% of respondents had a job. Among the respondents of Water Square, about 66% were found to live in the neighbourhood of the project, while 40% of respondents from Raingarden were living around the project. The rest of the respondents were living in different neighbourhoods of Rotterdam, however, they had an idea about the projects as they often visited these project areas or their workplace was close to Water Square or Raingarden.

Table 1: Demographic profile of the respondents.

Variables	Study projects	
	Water Square	Raingarden
Gender (%)		
Male	90	70
Female	10	30
Educational Qualification (%)		
Higher Secondary	22	30
Honours/Degree/Bachelor	54	38
Master	24	30
Occupation of Respondents (%)		
Student	30	20
Job Holder	48	40
Part-time service	12	20
Business	10	8
Jobless	-	10
Resident Status (%)		
Living in the project's neighbourhood	66	40
Living away from project location	34	60

Respondent's knowledge of the NBS concept

Table 2 presents respondents' responses regarding the level of their familiarity with the NBS concept. About one-third of respondents (32%) who were found to visit Water Square regularly do not possess any idea about NBS. Contrariwise, almost 60% of respondents from Raingarden were not familiar with the notion of NBS at all. Even though Raingarden is a public space that is green enough and solely based on natural elements, many people who often visit the place don't know that it's an NBS for flood risk reduction in this neighbourhood. An older person passing through the Raingarden stated that she walks in the garden almost every day, but she thought that it was a public garden like many others located in Rotterdam. She also added that there was no such widespread discussion of NBS that could make people more aware of it. On the Raingarden site, 28% of respondents stated that they heard about the concept of NBS somehow but do not have detailed knowledge about it. In the case of Water Square, about 34% of the respondents heard the term 'Nature-Based Solution', though they had no idea of how it works (Table 2). While one-fifth of the respondents in Water Square possessed some ideas about the NBS, only 8% of respondents in the Raingarden stated that they heard about this term. In both cases, respondents with some ideas about NBS were either students or professionals like teachers.

Table 2: People's knowledge of NBS projects.

Variables	Study Projects		Both projects
	Water Square	Raingarden	
Familiarity with NBS Concept (%)			
Not Familiar at all	32	60	41
Heard about the concept but have no idea	34	28	31
Heard about the concept and have some ideas	20	8	14
Familiar but never got involved	10	4	7
Very familiar and already involved with NBS	4	-	

On the other hand, a few respondents in both NBS projects said that they understood the NBS concept well but never participated in any NBS projects as a stakeholder. However, only one respondent from Water Square was identified among 50 respondents who participated in a different NBS project and possessed a good understanding of this concept. He stated,

> *"I didn't participate in the planning or implementation of Water Square because it's been a long time since the project was realized and I do not live in this neighbourhood; I visit this square as I work nearby. However, last year I was involved in a workshop on a Nature-Based project which is mainly about developing a green roof in my neighbourhood. I was enthusiastic to be part of that project and I would like to join in such nature-based initiatives if there's an opportunity in the coming days".*

Contribution of NBS projects to flood reduction

Less than 30% of respondents in both study sites expressed that both Water Square and Raingarden had contributed to flooding risk reduction with some limitations (Table 3). They commented that these two projects can retain a significant volume of water during rainfall. As the *Agniesebuurt* neighbourhood has fewer green spaces than those of other areas in Rotterdam, respondents think that Water Square and Raingarden were making the neighbourhood secure from getting flooded. One respondent from Water Square said that even though it has enough capacity to hold a substantial amount of water, he never saw it fulfilled. He also added that Water Square might receive much water from the bigger area as it has a substantial retention capacity. However, it stores the rainwater from the roof of surrounding buildings and the square itself. Therefore, it has some limitations instead of contributing to reducing flood risk. At the same time, 12% of respondents in Raingarden stated that the project contributed enough to lessen the flood risk in their area. Being the only green public space in this neighbourhood, it can ease excessive water infiltration during rainfall. However, almost one-third of Water Square's respondents (32%) considered the project to contribute sufficiently to lessen the flood impacts.

Table 3: Contribution of the NBS projects to flood reduction.

Variables	Study Projects	
	Water Square	Raingarden
Contribution of the project to flood reduction (%)		
No contribution at all	-	22
Very little contribution so far	44	38
Contributed to flood reduction with some limitations	24	28
Contributed enough	32	12

On the other hand, 22% people of Raingarden also assumed no contribution from the project so far. A key informant from Rotterdam municipality said that people mostly judge a project's contribution depending on its visible effect. Moreover, it was said that the underlying contribution of a project like increasing the infiltration capacity of an area or performing like a sponge might not be perceived by the people. However, some of the respondents who possess a good understanding of NBS considered the projects as having little contribution. Though few people expressed that more NBS projects like Water Square and Raingarden in the neighbourhood can contribute significantly to minimizing the flood risk in that area.

Perceived co-benefits of NBS projects

Even though the NBS projects (Water Square and Raingarden) were undertaken toward flood risk reduction, they also provided additional co-benefits. Respondents identified several co-benefits of these two projects (Table 4). The vast majority of the respondents (78%) from Water Square mentioned the sports facilities as the prominent co-benefit of the NBS project. The design of Water Square included a basketball court and a skating ground. Many young

people were seen skating over the square, though the researcher had rarely seen someone playing basketball. Some respondents said that the sports center sometimes uses the basketball court, while some other reported that they often play soccer there. Furthermore, some students were observed practicing dance over the basketball court. In addition, about 58% of respondents said that the square is a nice playground for children. As opposed to, no sports facility was provided by Raingarden and none of the respondents mentioned such co-benefit from this project, though children were seen to play in Raingarden as the design allowed the kids to do some interesting tasks like jumping over smaller-sized concrete blocks. Moreover, one-fourth of respondents from Raingarden mentioned that the facility of the children's playground was a benefit of this project.

Table 4: Perceived co-benefits from the NBS projects.

Variables	Study Projects	
	Water Square	Raingarden
Co-benefits from the projects (%)		
Recreation	20	-
Relaxation	12	48
Community Gathering	32	20
Social interaction	34	28
Ecological benefits	-	58
Good environment	10	50
Scenic beauty	42	44
Sports	78	-
Green environment	-	70
Children's playground	58	24

(Multiple responses are considered)

About one-third of the respondents said about the scope of community gathering (32%) and a nice place that facilitated social interaction (34%) as co-benefits of Water Square. Such get-together opportunities somehow helped to improve social cohesion as said by many of the respondents. Respondents from both projects expressed that these places are suitable for relaxation while few of them see indirect health benefits from these NBS projects. One of the key informants (from De Urbanisten) uttered that Water Square provides sports and relaxation facilities while Raingarden positively impacts people's minds with its green environment; both projects indirectly offer health benefits to the people. Again, more than 40% of respondents of both projects mentioned aesthetic beauty as an advantage of these NBS projects. A coordinator (from Rotterdam Municipality) of the Water Square project said that the unique design of this project was attracting many people to visit the place regularly, even many professionals from other countries often come to have a look at this.

On the other hand, respondents who expressed aesthetic beauty as a co-benefit from Raingarden mostly said that natural beauty attracts them to walk through this garden. About

71% of respondents stated that Raingarden created a green environment in the neighbourhood. A respondent added that as the *Agniesebuurt* neighbourhood has very few greeneries, Raingarden is a green place where people feel better walking through and spending leisure time. A key informant (from Stadskwekerij De Kas) of the Raingarden project stated,

> *"It has health benefits as it provides a nice environment for the citizen and nature can somehow affect people's happiness. And the entrepreneurs of the area are really pleased with this garden. People love to walk through the garden; mostly residents with pets prefer to walk through this Raingarden. Some people also told me that they love the place since it was changed".*

To 58% of respondents, ecological benefits were important co-benefits of the Raingarden project. A key informant, who is also a biological expert said that this garden also benefited the tiny animals, sheltering them and helping to maintain the ecological balance of that area.

Challenges in implementing NBS projects

Through key informants' interviews, this research identified several challenges that emerged during the planning and implementation of NBS projects. Some of those challenges were common in both Water Square and Raingarden. It was revealed that in the planning or initial stage of implementation of both projects, there were challenges like 'uncertainty of benefits or effectiveness' and "lack of people's familiarity with the NBS concept", which hindered the projects somehow. On the other hand, "people's unfamiliarity with NBS" was considered a significant barrier to implementation; this issue was also identified in the respondents' survey (Table 2). Moreover, there was a challenge of 'integrating the ideas of stakeholders' because different people came with different ideas, which was a tough task to develop a design considering everyone's expectations. Even though stakeholders from different levels came up with different ideas, most of them had 'contributed enough' as said by the key informants of both projects. A key informant of Water Squarer (from De Urbanisten) stated that three workshops were organized to obtain and integrate ideas from stakeholders. All of them had positively contributed to the workshops and subsequently developed the design. "Participants had contributed even more than our expectation", the key informant added.

At the same time, both projects experienced some technical challenges. In Water Square, technical difficulties were faced while designing and implementing the design. The main challenge was to re-adjust the design many times. An expert from Rotterdam Municipality uttered that they needed to combine a lot of disciplines to make an effective design, which was a technical challenge indeed. It was also a challenge to make sure that everything is working well. Again, there was a requirement to bring about the changes in design consistently because people wanted it differently and due to the technical challenges afterward the design was changed as well. Because for collecting the rainwater, the design needed to use the roof of schools, but they hadn't permitted them to use; so, the designers made a few changes in the design.

However, the technical problem that affected the Raingarden design was the existing underground facilities of that area; which made the implementation difficult and imposed

some changes in the design. Furthermore, the authority brought a technical change for rapid infiltration of water because if the water remains in Raingarden for more than a day, it could result in the growth of mosquitoes. Some respondents also reported the prevalence of mosquitoes in this project. This is a current challenge from the Raingarden as it might result in 'negative health effects' on the residents of this area. Again, the complicated design of Water Square created some challenges in the maintenance of the project. Moreover, it was known that the design of Water Square has very little possibility to allow any modification in the future, which is indeed a future challenge that might affect the project. On the other hand, it was expressed by the key informants (from Rotterdam municipality and De Urbanisten), that there was no budget allocation for both projects for their future maintenance, which might result in uncertainty of maintaining the projects effectively. These iconic projects might fail due to the shortage of maintenance budget in the coming days.

Discussion

The concept of NBS is still being refined and it has not been widely materialized yet. In the Netherlands, there are a few projects of NBS, but only two of them were chosen for this study. It was unveiled from this study that people living around these NBS projects have very limited knowledge of NBS. Even after an endeavor by policymakers (EC, 2016; UN, 2013) and practitioners (Cohen-Shacham et al., 2016; Rizvi et al., 2015) to disseminate the aim and usefulness of NBS, the concept remains unacquainted with the mass people (Faivre et al., 2017; Nesshöver et al., 2017). Therefore, the issue of NBS acceptability to the residents remains a question.

Both NBS projects have contributed to flooding risk reductions with some limitations. People often expressed the localized impacts of both projects. Some key informants expressed that NBS cannot be compared with the traditional grey infrastructure in terms of effectiveness; rather NBS can work as a complementary solution. The distinct criteria of NBS are that they become better with the elapse of time, while the effectiveness of traditional grey infrastructures often declines over time (OpenNESS, 2015). Both Water Square and Raingarden have ensured several co-benefits in addition to their main purpose of rain water retention to eventually reduce flood risk in the area. Though the number of benefits provided by either project is different, they have some similar co-benefits for the people. Relaxation, community gathering, and increased social interaction are some common benefits of both projects. People often visit these projects and spend their quality time considering these as nice places. It was reported that NBS projects have had a greater impact on creating social cohesion in the community by creating public commons (Birch et al., 2013; Xiang et al., 2017). Frantzeskaki (2018) also reported the benefits of NBS in creating urban commons. However, Water Square provides some recreation and sports facilities that Raingarden does not offer. Research works (e.g. IUCN, 2019; Lafortezza and Sanesi, 2019) have also stated that NBS ensures different recreation and relaxation facilities for the people. In addition, the most notable benefit of Raingarden is that it has made the area green and ensured a good environment for the people living nearby. Furthermore, Raingarden is ensuring ecological benefits and has improved the aesthetic view of the area, and a similar observation was reported by researchers (Cohen-Shacham et al., 2016; Hartig et al., 2014; McFarland et al., 2019) elsewhere.

Key informants identified several challenges experienced by the authority during the planning and implementation of NBS projects. Among these 'uncertainty of benefits or effectiveness' and "lack of people's familiarity with the NBS concept" were the major hindrances stumbling the implementation during the initial phase of the projects. Kabisch and his colleagues defined such uncertainties of benefits and effectiveness as "fear of the unknowns" (Kabisch et al., 2016a,b). On the other hand, some other researchers have considered the 'peoples' unfamiliarity with NBS' as a significant barrier to its implementation (Kabisch et al., 2016b, Balian et al., 2016), which is also the major concern found in this research. As different groups of people came up with different ideas, the challenge of 'integrating the ideas of stakeholders' came to a discussion, so developing the design became even more arduous. It is quite challenging to manage the stakeholders' perceptions about the long-term and short-term benefits that will be offered by the chosen NBS compared to the estimated expenditures (Raymond et al., 2017 a,b). Additionally, both projects had no budget provision for maintenance. Droste et al. (2017) reported that the lack of financial provision for maintenance is a significant challenge in sustaining the benefits of NBS projects.

Conclusion

The findings of this study revealed that the NBS concept is still not well understood by the respondents although they could identify several co-benefits of the studied projects. The majority of the respondents stated little or moderate contribution of NBS projects to flood risk reduction, which might be due to their limited knowledge of NBS. People's knowledge of NBS approaches could be enhanced through awareness creation and participation in projects. Although both studied NBS projects experienced some challenges, the most important one is the lack of a maintenance budget. The authority needs to allocate a sufficient budget for regular maintenance of the NBS infrastructure to ensure the sustainable supply of ecosystem benefits. This research would be useful for policymakers to understand the limitations of the projects and take measures for designing future NBS projects.

Study Limitation

One of the major limitations of this study is the low number of respondents. Due to time constraints, we could not collect more responses. In future research, care should be taken to ensure sufficient time for collecting data with a statistically valid number of samples.

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Declaration

This article has been prepared from the first author's Master's thesis pursued at IHS, Erasmus University Rotterdam, the Netherlands. Other than the online submission of the thesis in the university portal, no part of this research has been published elsewhere.

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