Environmental Science and Policy 145 (2023) 164–174

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Social housing as focus area for Nature-based Solutions to strengthen urban resilience and justice: Lessons from practice in the Netherlands

Robbert P.H. Snep [a,*], Judith Klostermann [a], Mathias Lehner [b,c], Ineke Weppelman [a]

[a] Wageningen University & Research, P.O. Box 47, 6700 AA Wageningen, the Netherlands
[b] Zaanstad Municipality, PO Box 2000, 1500 GA Zaandam, the Netherlands
[c] Nextcity.nl, Bankastraat 3H, 1094 CZ Amsterdam, the Netherlands

ARTICLE INFO

Keywords:
Social housing
Nature-based Solutions
Environmental justice
Climate adaptation
Urban green
Biodiversity

ABSTRACT

Social housing typically encompasses neighbourhoods with low social-economic status. Here, environmental problems like climate change and biodiversity loss have a higher impact than in other neighbourhoods. Applying Nature-based Solutions (NbS) may enhance the resilience of social housing neighbourhoods and as such make cities more just. In this article we explore to what extent NbS can be applied, given the physical, social and financial limitations that define Dutch social housing practice, and - by doing so – what NbS can contribute to environmental justice. Based upon several Living Lab experiences and dialogues with numerous housing corporations, ten NbS measures have been identified that likely will match with current practices in social housing. Implementing NbS contributes to all aspects of environmental justice, with distributional justice as the most straightforward one (more NbS means more environmental benefits). Procedural and recognitional justice were found to be of crucial importance to make greenspaces worthwhile for the residents. Our study draws attention to the fact that NbS knowledge is key but currently still insufficient, both within housing corporations as within the key partners (local authorities, landscaping firms). This means that there is a growing demand to increase NbS knowledge in the social housing sector. We finalize this article with recommendations on how to meet this demand.

1. Introduction

Neighbourhoods with low social-economic status (SES) tend to suffer more from environmental problems than other neighbourhoods (Allen and Balfour, 2014). For example, Chakraborty et al. (2019) found that heat waves disproportionally affect low-income urban neighbourhoods worldwide. The residents of such neighbourhoods will be exposed to weather extremes more than average. This means that the resilience of their neighbourhoods is low, e.g. the ability of the system to cope with hazardous events (IPCC, 2012). An environmental asset that may mitigate the negative impact of heat waves and contribute to liveability, health and well-being (Markevych et al., 2017) by means of ecosystem services, is the presence of natural elements (e.g., greenspace or green infrastructure). However, this presence tends to be lower in low SES neighbourhoods (Schüle et al., 2019). Although this has been studied less, also the quality of the natural elements (relating e.g. to use, aesthetic quality, comfort and safety), tends to be poorer in low SES neighbourhoods (Hoffimann et al., 2017; Baka and Mabon, 2022). This is especially unfortunate because the presence of natural elements (of at least reasonable quality) seems more beneficially associated with the health of inhabitants of low SES neighbourhoods than with that of those living in high SES neighbourhoods, especially in Europe (Rigolon et al., 2021).

There is a need for solutions that tackle the environmental problems that low SES neighbourhoods are confronted with. Nature-based Solutions offer a way forward, as they are 'actions that work with and enhance nature to restore and protect ecosystems and to help society adapt to the impacts of climate change and slow further warming, while providing multiple additional benefits (environmental, social and economic)' (EEA, 2021). In other words, next to increasing and/or maintaining biodiversity, Nature-based Solutions (NbS) can provide a variety of ecosystem services, such as climate adaptation and health improvement (Hartig and Kahn, 2016; Kabisch et al., 2016; Bai et al., 2018). NbS can take different shapes. They may consist of upgrading public and private greenspaces ('green infrastructure') such as parks and (shared) gardens, but also of integrating natural elements into architecture, such

* Corresponding author.
E-mail address: Robbert.snep@wur.nl (R.P.H. Snep).

https://doi.org/10.1016/j.envsci.2023.02.022
Received 30 September 2021; Received in revised form 12 January 2023; Accepted 28 February 2023
Available online 18 April 2023

as in green roofs or walls.

By applying NbS where they are needed most and/or may be expected to result in the greatest benefits, i.e., in low SES neighbourhoods, also the spatial distribution of environmental assets and liabilities within a city may become more equal. In this way, they will contribute to environmental justice (EJ), or more precisely, to the distributional justice dimension of EJ. Besides this distributional dimension, usually (at least) two other dimensions are distinguished: a procedural dimension and a recognitional dimension. Procedural justice refers to participatory and inclusive decision-making processes and it is linked to transparent and meaningful citizen involvement ((Schlosberg, 2013). Recognitional justice is about interpersonal interactions that allow people to express themselves in their own way, provision and access to information, and respect for different needs, values, preferences and identities (Langemeyer and Connolly, 2020). During the process of developing and implementing a NbS, it is important to take these other two dimensions into account too. They are not only important in their own right, but respecting them is likely to contribute to the successful implementation of the NbS. This is especially important when the appreciation and the use that the inhabitants make of what the NbS provides is essential for achieving its full benefits (Frantzeskaki, 2019).

Calderón-Argelich et al. (2021) have assessed how the three EJ dimensions have been addressed in relation to different types of ecosystem services in an urban context. They conclude that there is a focus on the distributional dimension of EJ, as well as on regulating and cultural ecosystem services. As for the type of ecological structure involved, they conclude that parks and urban forests have received the most attention thus far and call for studying other types of structures. In our study, we explored if and under which conditions it was possible to implement NbS in social housing estates, focusing on the shared gardens in such estates. We did so in the Dutch context.

1.1. Social housing in the Netherlands

In the Netherlands, social housing is a task of housing corporations: non-profit organizations that operate within the legal framework of the Housing Act. Dutch housing corporations are – different from other countries – the only providers of social housing. A total of 267 housing corporations manage 2.4 million dwellings, constituting 32% of the total Dutch housing stock today and offering a home to 4 million tenants. Social housing estates have become more vulnerable over the past decade. Since 2015, the corporations are no longer allowed to build for and rent to middle income families (Aedes, 2017). Given that nowadays only low income groups are eligible for social housing, the overrepresentation of families with a non-Western migrant background, single parents, people coming out of jail or psychiatric institutions has increased (Aedes, 2017; BZK/CBS, WoON, 2018, 2018; Kooiker and Marangos, 2018; Wittebrood and Permentier, 2011).

Social housing tenants are generally least satisfied with the quality of their living environment (Kullberg and Ras, 2018). Thus, there is clearly room for improvement. However, the vulnerable position of residents brings along social limitations for the implementation of NbS. E.g. the joint use of recreational spots within the living environment easily leads to conflicts. In socially stronger neighbourhoods, with a mix of higher and lower incomes, and less people with a difficult past, an initial investment by local authorities may result in a self-sustaining social system in which residents take care of their residential environment, such as their private or shared garden. In poorer neighbourhoods, with also often a more transient population, this is less likely to be the case (Mattijssen et al., 2016).

Social housing practice can also imply physical limitations for NbS implementation. Social housing districts are often characterized by a high population density and limited space for green infrastructure (Aalbers et al., 2014; De Haas, 2017; De Vries et al., 2020). Especially in 19th century neighbourhoods, the greenspace can be very limited. In some periods during the 20th century, more greenspace was realised in social housing neighbourhoods (Hop, 2008; Wamsteker, 2012; Feddes, 2012; Steenhuis, 2016). However, even if there is a lot of public greenspace, apartment dwellers usually will not have a private garden; they may have a shared garden, with its quality and joint use being a potential issue.

A third issue are financial limitations. Social housing corporations have seen a sharp decline in their investment budget: since 2013 they have to pay around 1,7 billion euro of tax to the national government, amounting to 1/6th of their yearly rental income (Aedes, 2017), increasing to over 2 billion euro in 2018. This means that they already struggle to build new houses and maintain their assets. Any activity outside these main priorities, like upgrading their greenspaces, has been low on the list of priorities. Landscaping is often outsourced, with landscaping companies competing mostly on price. Greenspace is designed to be 'low maintenance' and as a consequence, the diversity and maintenance level in the present greenspace is low (Feddes, 2012; Westra et al., 2014).

We are confronted with the wicked problem that (i) at present social housing areas often have limited or no well-functioning greenspaces, (ii) such greenspaces are needed in these neighbourhoods more than anywhere else, and creating or upgrading them may contribute to (distributional) environmental justice at the same time, but (iii) due to financial, spatial and social limitations, NbS prove difficult to realize in these areas. In our project Pleasant Green Living (2019–2021), we wanted to tackle this wicked problem, resulting in the following research question:

- ***How can NbS successfully be implemented in social housing areas, contributing to distributional justice, given the physical, financial and social limitations commonly encountered in the Dutch social housing context?***

We aimed to answer the research question by using a Living Labs methodology (explained below). Three Living Labs were executed in the Dutch city of The Hague. The Hague is the third biggest city of the Netherlands, after Amsterdam and Rotterdam. These three cities have the highest percentage of poor people, a little over 10% (SCP, 2019). We choose to focus on The Hague as here low SES districts are abundant, and all key stakeholders were willing to collaborate in Living Labs: three housing corporations (Staedion, Haag Wonen, Vestia), the municipality of The Hague, sector organizations on urban green (VHG - Royal association for gardeners and landscapers, The Green city – knowledge & partner network, Dutch association for rose growers), NbS education (Yuverta, Van Hall Larenstein University of Applied Sciences) and NbS research (WUR: Wageningen University & Research). Each housing corporation was asked to bring in a case study location where they experienced problems with their green areas (often private or shared gardens). WUR coordinated the project. Together with students from a polytechnic institution 'Van Hall Larenstein' and an institution for secondary education 'Yuverta' in Rijswijk, the problems at these locations were investigated.

Sections 2 to 4 of this article describes the Living Lab methodology and the three Living Labs carried out for this project. Since the Living Labs were conducted consecutively, largely as separate studies, they are also described and reported on in this order. Section 5 describes the NbS course for housing corporations, which was deployed to disseminate, and to some extent validate, the lessons learned from the Living Labs among a wider group of housing corporations in the Province of South-Holland. In Section 6, the results of the Living Labs and NbS course for housing corporations are discussed. Section 7 formulates the conclusions of this 'learning by doing' approach. Based on this discussion, we formulate recommendations for NbS implementation in social housing estates.

2. The living labs

Living Labs are a relatively new research method in which a multidisciplinary approach is used to develop and investigate ideas in 'real life'-situations with 'real people'. The users are aware that they participate in the project and actively contribute their knowledge of the situation. Knowledge is developed within the context of the users in a continuous interaction between the users and the scientists. The advantages of this approach are that knowledge from different disciplines is integrated to address complex problems, and the findings can be applied directly by the users (Dell'Era and Landoni, 2014). We considered the Living Labs method to be especially suited for addressing urban problems because this indeed is a complex environment, since the needs and aims of many different stakeholders must be accommodated in a limited amount of space.

In a Living Lab, there is no rigid research design. There is only an informed problem description as a starting point, an outline of the methods that will be followed, and a description of the research outputs that are expected. Within the time frame of the project, the research is shaped further in a step-by-step process, in a dialogue with the users. New problems that emerge during the project can be addressed in tailored sub-projects. The output of a Living Lab typically consists of case study descriptions and concrete designs, but also guidelines for other stakeholders on how they can improve their situation, based on the evidence in the Living Lab. The validity of the results and the applicability in other situations then needs further testing in follow up research (Dell'Era and Landoni, 2014).

Living Lab 1 had an emphasis on social limitations & opportunities, Living Lab 2 had an emphasis on financial limitations & opportunities and Living Lab 3 had an emphasis on physical limitations & opportunities. As the Living Labs followed each other in time, each emphasis was chosen based on the experiences in the previous Living Lab and the needs as expressed by the housing corporation that 'owned' the case study. A second step was to find out if, despite all these barriers, improvement of the greenspaces in both physical and social functioning was attainable. In interviews, surveys and group discussions, information about the conditions for implementing NbS was gathered. The schools for housing corporations further assisted in validating garden designs and approaches that might solve the practical problems. From case study reports and meeting notes we drew the lessons that are reported below.

2.1. Living Lab 1: social limitations and opportunities

2.1.1. Case description

The first Living Lab case (2019) was provided by housing corporation 'Staedion'. Staedion owns 37,000 homes in different areas of The Hague. For the Living Lab, a location was chosen of three apartment blocks with shared inner gardens. The three gardens had different problems; one suffered from water logging; another had recently been renovated, but was still of low quality urban green; and all of them were rarely used by the residents. The corporation had already put some thought into improving the collective gardens, but they struggled with involving the residents in the redesign process. In the past, residents did not show up at all for meetings. As was already explained in the introduction, residents of social housing often belong to groups with a low socioeconomic status with a lot of worries on their minds. At the same time, successful garden redesign requires their direct involvement to make sure the new design meets their needs and desires. Therefore, the emphasis in the first Living Lab was on activating the residents. This Living Lab needed to answer the question to what engaging methods residents would respond. If none of the methods worked, the further design of the gardens potentially would need to follow a different path compared to affluent neighbourhoods, whose residents are more inclined to become involved.

2.1.2. Methods

A process was developed in which residents living around the three gardens were approached several times. Students from the two schools were involved and executed a part of the work as a learning project: five higher education students in environmental management (Van Hall Larenstein) and nine secondary education students in horticulture (Yuverta). First, the residents received an official letter from the corporation that we were about to start a redesign process. Then door-to-door interviews were held. Then posters, an invitation card, and a Facebook page were made to invite them to a meeting. The number of interested people was allowed to grow over time. In the final meeting, 42 residents came and discussed each garden in three groups using mood boards (Fig. 1). There was a market with several preliminary student designs for each inner garden. The residents could express their ambitions and needs regarding garden use on posters on the wall. All information was noted down and used to develop more detailed, 3D student designs for each garden. Due to the Covid-19 pandemic, the process came to a halt; but in June 2021, three designs for one garden were presented to the residents, and they could vote which one they preferred.

2.1.3. Results

The main result consisted of a guideline for housing corporations how to involve their residents in a process towards the design for a new garden. The guideline emphasizes a step-by-step approach to allow trust to grow and to allow more people to become involved in every step. The guideline is published on a website together with other products to help housing corporations improve their green infrastructure. Next to this, a series of 3D garden designs was produced of which three were put before

Fig. 1. Mood board on developing a set of NbS in an inner garden, as discussed with residents of the surrounding social housing apartment buildings. The mood board mainly addresses climate change impacts in and adaptation measures for gardens.

the residents so they could vote. The housing corporation had set a budget aside to realize the garden that was chosen and in December 2021 this garden design was implemented in practice.

Lessons learned in Living Lab 1:

- People in social housing have little choice where they live; they feel lucky to have a roof over their head at acceptable costs. Their (shared) garden does not have a priority for them.
- We first needed to win the trust of the housing corporations that we would not encroach on the privacy of their population, and then also the trust of the residents themselves to respond to surveys and show up in meetings. Their relation with official institutions is often problematic, so their trust needs to be won before they are willing to give their opinion on the green environment.
- The fact that we worked with students who were involved in the project as part of their training helped to achieve this, because they were seen as innocent of any previous frictions between the residents and the housing corporation.
- The population in social housing blocks is diverse and residents can have different needs for the greenspaces: some seek peace and quiet, while others want their children to have a playground. Integrating these different needs in a limited amount of space is a design challenge.
- If the housing corporation wants to upgrade the gardens and pay for this by raising the service fee, they legally need the consent of 70% of the residents. However, the residents in social housing have a low income and are likely to oppose any kind of raise in the monthly rent.
- Because of financial restrictions, investment as well as maintenance costs of NbS must be low. For this reason, housing corporations hesitate to implement green roofs, since these are rather costly. Advanced water infiltration methods may also be too expensive, but natural infiltration is possible.
- Knowledge on how to realise effective greenspace (e.g. for water retention) was lacking among the housing corporations we worked with. For the green design, they relied on the landscaping companies to which they had outsourced the garden maintenance. To address this problem, we decided to organize training sessions for housing corporations, which will be described below (3. NbS course).
- The housing corporations face a dilemma between a private garden for each (ground floor) apartment versus a shared garden for all. Residents at the ground floor are often disabled persons that may experience difficulties in maintaining their garden. Also, varied and badly maintained fencing and garden sheds can become an aesthetic problem. Housing corporations need flexible design solutions so they can change the partitioning depending on the wishes of the residents over time.

2.2. Living Lab 2: financial limitations and opportunities

2.2.1. Case description

Living Lab case 2 (2020) was provided by the housing corporation ‘Vestia’. Vestia is a relatively large corporation with more than 80.000 homes in Rotterdam, The Hague, Delft and Zoetermeer. This corporation still suffered from financial mismanagement in 2012 in which the management gambled and lost millions of euro’s. Because of this, their financial options were even smaller than for other corporations. The case study for the second housing corporation Vestia was again about inner gardens that needed to be redesigned to fit the user needs better. Three gardens surrounded by housing blocks from Vestia served as inspiration for redesign, located in the south-western part of The Hague, in between Tesselschadelaan, Roemer-Visscherstraat, and Jan Luykenlaan (For an example see Fig. 2). At the time, the gardens consisted mainly of lawns with some mature trees, some shrubs like Hortensia, and some playground equipment. The gardens had fences and gates that could be closed, but in the daytime they were usually open to anyone. The idea was to collect more information on what residents in social housing generally want to see in gardens in terms of hard infrastructure and plant material. The financial background problems of Vestia were felt in a high turnover of personnel (we had four contact persons in six months) and a higher level of distrust between the residents and the corporation, apparently because the housing quality was often beneath the required level. On top of this, our project suffered from the Covid-19 pandemic. Contacts between partners were difficult, while contact with residents was virtually impossible.

Fig. 2. A typical greenspace in a social housing block of Vestia in The Hague, before redesign.

2.2.2. Methods

Although a written survey was not ideal for our target group we saw no other options due to the Covid-19 crisis. The survey included questions how they wanted to use their garden and what their visual preferences were. We also asked if they felt safe in the garden and how their contacts with the neighbours were. To overcome any language problems the survey was using pictures and this was distributed on paper in one of the housing blocks surrounding the gardens (about 42 households). We also decided to focus on how to deal with the limited financial resources in Living Lab 2. Information on what the expenses for the gardens were and how this was financed was collected in Teams meetings with Vestia personnel.

2.2.3. Results

The Covid-19 pandemic made all contacts difficult, which had been so important in Living Lab 1: contacts between project partners, between student groups, and between researchers and residents of the housing block. Only six completed survey forms were returned out of 42. In the survey results, the users specified as their requirements colourful flowers, playing opportunities for children and meeting spaces. The students solved further design requirements (such as how to address climate adaptation, biodiversity increase and increase of social cohesion) based on studying the literature and on discussions with supervisors and project partners. Based on this information, three different levels for one garden were designed, starting from a basic cost level with mostly indigenous species and then introducing upgrades in the same garden with little destruction of capital. The idea was that this model would allow for gradual investments in gardens. The basic level showed that even at low costs, an attractive garden could be realized, focusing on biodiversity. Next to support for biodiversity, the basic garden offered natural playing facilities such as paths mown in higher grass. The second level had more varied vegetation and some more meeting spaces for the residents. The third level with the highest costs involved more trees, perennial plants and more luxurious meeting spaces. This three level model enables housing corporations to find cheap options, and

upgrade a design if financially possible.

Climate adaptation measures may provide opportunities to also improve the greenspaces in social housing areas. Possibly Dutch water boards are willing to subsidize investments in better drainage, such as infiltration of rainwater in a garden (Van Hattum et al., 2016). Water boards are regional governments that take care of water management. Improvement of local drainage or slower runoff from green roofs will lower the costs of water management for water boards. When a housing corporation experiences water logging problems, they often lack the expertise how to solve it. A landscaping firm may offer technical options, but the analysis if and how this will solve the problem is still lacking, while the housing corporation can only spend its limited budget once. A basic analysis can already help to assess if a given technical option matches with the expected amount of water. In a sub-project of Living Lab 2, a hydrological tool was developed with which the demand for water storage in a garden could be calculated. With this tool the water storage measures in a design, such as infiltration crates, a vegetated swale or green roofs can be judged on effectiveness. A requirement was that the tool does not need many data and few modelling capabilities.

Lessons learned:

- A functional garden design that is inviting for children to play at low cost can also support biodiversity. With the three garden designs that increase the implementation costs stepwise housing corporations have the possibility to upgrade the garden gradually, based on their financial possibilities.
- In water-rich areas like The Hague, rats are normally present. When a lot of household waste is available, they will multiply and instead of only being active at night, they will also show themselves by day. Next to the potential of health problems such as Weil's disease, this can also become a barrier for better greenspaces. In an effort to control the rats, housing corporations sometimes hesitate to plant shrubs or perennials. However, changed behaviour of the residents with their waste seems the most important solution to reduce the rat overpopulation.
- A simple hydrological tool can help to assess the validity of a garden design for a specific location. This is important for choosing realistic dimensions for the water retention facilities. It may also help to acquire additional funding from the municipality or the Water Board to implement the NbS.
- In Living Lab 2, social safety was an important issue: the presence of a maze of small sheds and back alleys caused people to not feel safe in their shared garden. From this, we deduced the need for a garden design with a high level of transparency.

Living Lab 2 provided a solution for the financial restrictions and also produced a tool for tailoring a design to the hydrological conditions. However, other physical aspects such as heat stress and biodiversity were not sufficiently addressed yet. These aspects became the focus of the third Living Lab.

2.3. Living Lab 3: physical limitations and opportunities

2.3.1. Case description

The third Living Lab (2021) was with housing corporation 'Haag Wonen'. Haag Wonen owns 22.000 dwellings, of which an important part is located in The Hague Southwest, a garden city district (Batchelor, 1969). Despite the large amount of greenspace in this district, there are numerous problems related to climate adaptation (e.g. pluvial flooding, heat stress), health & wellbeing (e.g. lack of social cohesion) and biodiversity conservation (e.g., low habitat value). In this case, we focused on three similar inner gardens (each 25 m x 190 m) located between gallery flat buildings. In their original state, they represented a low functionality for the residents, mainly as aesthetical green. Haag Wonen, as well as their landscaping firm ' Engelsman hoveniers', The Hague municipality and the regional waterboard Delfland had the ambition to develop the inner gardens in such a way that a better contribution is made to the mentioned environmental challenges. This needed to be done within the financial, organizational and spatial limitations of the real estate locations.

2.3.2. Methods

A working group was set up in which we directly collaborated with the housing corporation, the landscaping firm and the local and regional authorities. In a number of sessions, this group defined the program of requirements of the inner gardens, discussed the pros and cons of different NbS that could be applied and provided input for a garden design. A sketch design was made by the landscaping firm and finetuned based on the comments from the working group. Comments were related to the functional requirements of the proposed green-blue garden elements, regarding e.g. balancing maximal water retention with avoiding nuisance by mosquitos. Lessons learned were identified and discussed during the course of the different working group sessions.

2.3.3. Results

The product of this third Living Lab was a renewed greenspace design, developed by the landscaping firm, with a functional vegetated swale. Its capacity was checked by the local water board so that it could effectively deal with the runoff from the roofs and match with the connected water management system. Other features of the design were coolspots, vegetation that was attractive for pollinators, good aesthetic quality for surrounding social housing apartments and room for real estate maintenance (e.g. scaffolds) (Fig. 3).

Lessons learned:

- In the city of The Hague, more affluent neighbourhoods are built on sandy soils, while social housing is located in former peat areas. In the peat areas, water problems occur much more often, such as flooded basements and flooded gardens. This provides a strong argument for the local authorities to provide help to housing corporations in an active way.

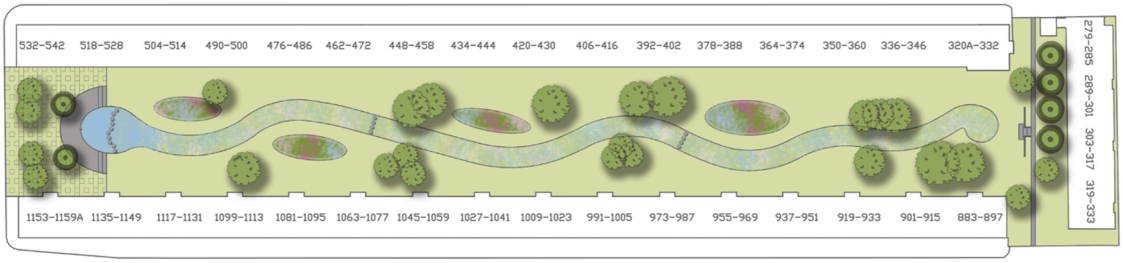


Fig. 3. Redesign for an inner garden in a social housing block in The Hague. The redesign includes a series of NbS: a vegetated swale, pockets with flowers for pollinators, and trees as cool spots, matching the financial, physical and social space available.
Source: Engelsman Landscaping.

- The knowledge base of landscaping firms regarding conditions for NbS performance is critical for good NbS plans, and even among frontrunner landscaping firms there is still a need to improve basic and applied NbS knowledge.
- The garden design of this case shows that functional NbS elements can be integrated in the plan; climate-proofing and biodiversity support is possible and can be combined with the financial and physical conditions of social housing practices. There is little cooperation between housing corporations, municipalities, and water boards at the scale of neighbourhoods. A close collaboration between these organisations as well as the landscaping firm may pave the way for NbS practices that are new in social housing (e.g. vegetated swales). Due to the collaboration, it is safeguarded that the design will be functional and accepted as an cost-effective alternative to traditional stormwater engineering.

2.4. NbS course: upscaling the lessons learned

2.4.1. Methods

In the Living Labs in the city of The Hague several interesting lessons were collected. To disseminate these lessons beyond the Living Labs, an interactive course 'NbS implementation in social housing' was developed for housing corporation staff. The content and the communication style of this online course was developed in close cooperation with the contact persons of the housing corporations involved in the Living Labs. In a try-out phase, the course was offered to staff from the three involved corporations. Later this was expanded to all (interested) corporations in the province of South-Holland. The course consisted of three sessions of 2 h each, distributed over a full day (part 1 & 2) and a half day 3 weeks later (part 3). Part 1 addressed basic knowledge on the societal challenges of climate change, biodiversity loss and human health, and NbS as a general solution (beyond the shared gardens, so also include e.g. greenblue roofs) for these challenges. Recent scientific insights in NbS performance were presented (see e.g. Snep et al., 2020). Part 2 addressed a range of action perspectives for implementing NbS in real estate (e.g. green roofs, green walls) and outdoor space (e.g. private & shared gardens) in social housing, while including resident participation in the design process. For part 3, course participants were given the task to prepare and present a NbS implementation case in their social housing practice, applying the lessons from the course. Also, they were asked to explore their own role and the current policy and practice within their housing corporation regarding implementing NbS. By doing so, participants were challenged to use the course information for their own daily practice.

2.4.2. Results

With the goal of upscaling the lessons learned from the Living Labs, an online NbS course was offered three times in the period January-April 2021. A total of 50 participants from housing corporations in the Dutch province of South Holland (including The Hague) participated in the course, representing different roles within the housing corporations: departments for sustainability, finance, real estate management, outdoor space management, and social issues were represented. Results from the evaluation, in which 29 participants participated, showed on average a high satisfaction about the content and the opportunities for interaction on specific issues with the course supervisors and other participants. Frequently, terms like 'inspiring' and 'eye-opener' were used by the respondents. During part 3 of the course, some participants gave the feedback that they – based on the first course day - already had inspired their management to prioritize NbS actions for climate adaptation and biodiversity conservation. In one case budgets were already raised. Also, several participants returned the message that the course informed them on new priorities for their residents, like the impact of heat stress and the need to provide indoor cooling during heat waves using blue-green roofs and walls, and cool outdoor spaces.

During the courses it also became clear that social housing practice still has a long way to go before NbS implementation will be mainstream. Participants saw many NbS solutions are available, but wondered which ones were applicable in social housing real estate. During and after the courses participants provided feedback on a number of concrete options for NbS implementation. In Table 1, we present the options as they were discussed with the corporations.

The NbS implementation course can be considered successful, as not only the current participants got motivated, but also because a growing interest was noticed from housing corporations in other Dutch regions to participate in such a course. As an additional spin-off of this part of the project, a series of meetings was planned in which the NbS-course developers have discussed with directors of housing corporations and the Dutch Ministry of the Interior and Kingdom Relations (that includes Housing Affairs) how NbS can be mainstreamed in social housing at a national level.

3. Discussion

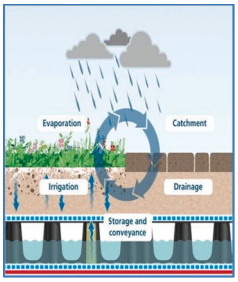
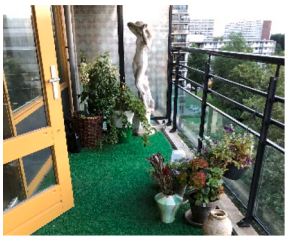
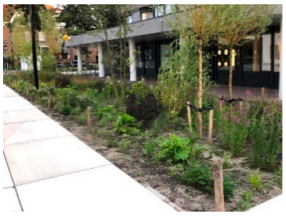
3.1. Reflecting on the results of the study

Although there are numerous publications on NbS applications in urban environments as well as on environmental justice (e.g. De Vries et al., 2020, Calderón-Argelich et al., 2021, Pineda-Pinto et al., 2021), studies focusing on greenspace in social housing estates thus far have been missing (Ordóñez et al., 2022; Calderón-Argelich et al., 2021). In this paper, we identified which specific NbS would fit within the context of the Dutch social housing, given the social, financial and physical barriers for applying NbS in social housing estates.

Obviously, social housing in itself is a contribution to *distributional* justice, providing poorer people with adequate housing. NbS have the potential to increase distributional justice further, as the improvements that they provide (e.g. in climate adaptation) are likely to make social housing estates more at par with wealthier neighbourhoods. However, social housing corporations struggle with providing better green space on their properties, among others due to financial restrictions imposed by the national government. Regarding financial limitations, there are several relatively unexpensive options. For example, the garden design of Living Lab 3 contributes to storm water retention, biodiversity conservation and recreation benefits at low maintenance costs. An important condition for NbS implementation is that there is sufficient space. If buildings are too close together and open space is needed for roads and parking spaces, only more engineered NbS are applicable, such as smart green roofs (https://en.projectsmartroof.nl/). In new social housing developments, NbS can already be integrated in the phases of planning and design.

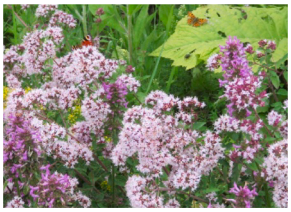
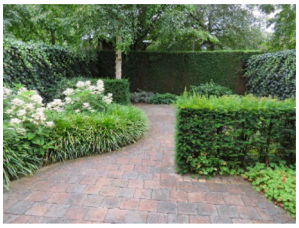
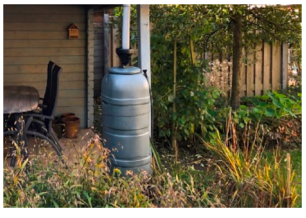
The project explicitly aimed to respect *recognitional* justice considerations by reaching out to the residents of social housing. Lower income groups hesitate to trust others and political organisations, which may lead to difficulties in communication with housing corporations and the municipality (Kullberg and Ras, 2018). Inhabitants of low SES neighbourhoods are also likely to have other priorities than the quality of the public greenspaces, like acquiring sufficient income, proper housing,

Table 1
Overview of NbS solutions applicable in social housing, a result from both the Living Labs and the interactive NbS course. Illustrations: Permavoid (1), Robbert Snep (2) and Ineke Weppelman (3–10).

nr	*NbS type and application area*	*Benefits*	*Conditions & remarks from corporations*
1	Blue-green roofs (e.g. https://en.projectsmartroof.nl/: Smart Roof 2.0)  Application: Flat roofs at apartment buildings. Especially relevant in densely built-up areas (with little outdoor greenspace) and areas with severe climate impacts.	Indoor building cooling (mainly top floor), stormwater retention, biodiversity, recreation	Corporations do consider green roofs, particularly for new developments or during roof renewal, to limit additional costs. Corporations have signed agreements with municipalities with targets for implementing green roofs, often linked with stormwater subsidies from local municipality or waterboard. Recreational use of green roofs is often considered 'not suitable', to avoid safety and nuisance issues. Blue-green roofs and their specific performance on the mentioned benefits are mostly unknown by corporations. This requires more active dissemination.
2	Green facades with climbing plants  [Corporation Rochdale, Amsterdam] Application: (blind) facades of apartment buildings and sheds Especially relevant in areas with little greenspace and indoor heat stress issues	Indoor building cooling, relaxing view (linked with mental health) from surrounding buildings, aesthetics, biodiversity	Corporations are hesitant to apply green facades, to avoid building damage or intensive maintenance. However, a few first practices appear (e.g. Rochdale, Amsterdam). Specific technical information needs to be disseminated to provide asset management departments with realistic expectations. Corporations may combine green facades with nesting opportunities for birds and bats.
3	Built-in nesting opportunities for swifts, house sparrows and bats.  Application: single family-houses, apartment flats	Biodiversity, mosquito control	(Built-in) nesting opportunities for birds and bats become more common at corporations thanks to 10 + years of extensive campaigns by conservation NGOs (e.g. Birdlife Netherlands). Application is restricted to new developments. Corporations still lack the insight that built-in nesting opportunities are only half of the story, and greenspace with more extensive ecological value is needed in the same area before animals can make a living there. More communication is required to make these NbS functional.
4	Green balconies with perennials and climbing plants  Application: apartment buildings with galleries and balconies	Relaxing view (linked with mental health) and aesthetics	Corporations explore opportunities to add plants in highly urbanized settings, but hesitate if such high maintenance green will be manageable in a social housing setting (e.g. irrigation need).
5	Vegetated swales & rain gardens  Application: corporate greenspace (e.g. shared gardens, front yards) See Fig. 3	Stormwater retention, biodiversity	Corporations have very limited experience yet with vegetated swales and rain gardens, though the first practical application has been implemented (Haag Wonen, The Hague) with a technical design that has been approved by the local water board. Vegetated swales enable corporations to capture stormwater and avoid flooding issues, particularly at inner gardens (where they are solely responsible).

(*continued on next page*)

Table 1 (*continued*)

nr	*NbS type and application area*	*Benefits*	*Conditions & remarks from corporations*
6	Pollinator gardens, bee hotels  Application: corporation greenspace See Fig. 3	Biodiversity, aesthetics, pollination at corporate allotment gardens.	With the increasing global concern regarding pollinator decline, corporations want to make a contribution to their conservation too. Pollinator gardens become more popular, although more communication about their value (focus group: residents) and good maintenance guidelines (focus group: corporations, gardeners) is still needed.
7	Cool spots: canopy cover by groups of trees or vegetated pergola system  Application: corporate greenspace See Fig. 3	Outdoor cooling spot during heat waves, social cohesion, mental health, biodiversity, aesthetics	Corporations may offer sufficient outdoor cooling places for their residents, but this insight is not yet part of their liveability approach. More communication is needed here. For effective cooling, sufficient canopy cover is required, which means mature trees. This means corporations should include this in their green asset management.
8	Allotment garden plots  Application: corporate greenspace	Social cohesion	Corporations may offer space and material for their residents to develop allotment gardens. As such they facilitate not only use but also stewardship of the corporate greenspace and stimulate residents to be active and to meet each other.
9	Greening gardens (minimal 60% green, unpaved surface)  Application: Private gardens on rental properties	Stormwater infiltration, cooling, biodiversity	Corporations can demand a minimum percentage of the private gardens at their rental properties to be unpaved/green, to be more resilient to e.g. climate change. Such a rule is drawn up to avoid paving the whole garden plot, which is often preferred by social housing residents in order to have little maintenance. Corporations can collaborate with gardeners, garden centres and volunteers to provide their residents with practical support in greening their gardens. Municipalities can offer maintenance services for residents and corporations to lower the threshold for greening outdoor spaces.
10	Rain barrels  Application: Private gardens on rental properties	Irrigation of garden plants	Corporations plan to provide their residents with rain barrels, to capture and store rainwater. As such, rainwater can be used during dry periods to irrigate garden plants. As rain barrels have a limited capacity (200–300 litre), this action is only a first step in stimulating awareness about saving water.

and a safe neighbourhood. This is especially troublesome from a *procedural* justice perspective, since it adds to the difficulty of motivating inhabitants to participate in the planning, designing and implementation of a NbS in their neighbourhood (Buijs et al., 2016). Therefore, we put a lot of effort to win the trust of the residents in Living Lab 1. The fact that we worked with students helped to achieve this. Unfortunately, the outbreak of Covid-19 severely limited any further interaction with the residents in Living Labs 2 and 3. In those Labs, we could only make a first step in the inventory of what residents want and need in their shared gardens. Also, we were unable to explore the diversity among those residents, which is more salient in social housing neighbourhoods than in wealthier neighbourhoods, because here the cultural diversity is the highest of all Dutch neighbourhoods.

When we look at the type of ecosystem services that NbS provide, we see that, as in previous research, in our Living Lab areas regulating and cultural services are the most important ones (cf. Calderón-Argelich et al., 2021). Regulating climate change is an absolute necessity given the urban heat island effect. Cultural services like offering space for rest, play and recreation and meeting others are also much needed in social housing, where people often live together in small houses. Provisioning food is a nice idea that can serve a cultural purpose of bringing people together, but the space often is too limited to provide a substantial amount of food for the large social housing population. Also, it is not clear yet if these residents are interested, even though vegetable gardens are a proven practice in more affluent neighborhoods. Regarding biodiversity, the planet obviously needs this, but it is unclear if and how the residents of social housing want this in *their* garden, and it is not advisable to impose it top down as long as this is not clear, as this would violate recognitional justice principles.

3.2. Reflecting on the approach in this study

The Living Lab method helped us to collaborate with all parties involved and to align the research with their needs. A first result of the project is that it shows the array of topics that is relevant for addressing greenery in social housing neighbourhoods. There are indeed significant barriers for the development of well-functioning greenspaces such as private or shared gardens in social housing areas. The lack of financial resources of housing corporations, and the lack of trust and resilience among the tenants seem to be the main problems. At the same time, there is a high potential benefit of improving the gardens, such as increases in their recreational value and effectiveness for climate change adaptation. One of the conclusions is that social and economic issues tend to outweigh the physical ones in these neighbourhoods. It is not enough to construct and maintain a well-designed garden. Projects may come down to 50% social management (i.e., investing time in the residents) and 50% 'real' garden management (investing time in the plants). The lack of trust and resilience among residents imply that improvement of the gardens will seldom be a self-initiated process by the residents. Support is needed for active involvement of the households and for development of a functional design.

The project had an explorative and applied character. The outcomes of Living Labs are case-specific, but for the Dutch situation we consider the issues encountered quite representative, as during the NbS course cases that were presented by the participants from outside The Hague confirmed and elaborated the issues that we focussed on in the Living Labs. However, they may not be representative for social housing in other countries. As for the implementation of solutions, this is less clear as well. In a pilot project, much expertise and time is available, but this will not be the case when the concepts are applied on a large scale.

3.3. How can the results be interpreted for environmental justice in general?

Through implementing Nature-based Solutions in social housing estates, residents may profit from ecosystem services derived from the functional greening of their living environment. In most cases, NbS will be implemented in existing built-up areas. Although the quality of the green and blue NbS elements on corporation property will then increase, the overall urban design of the residential area will not change. This means that distance to and availability of large public greenspaces will remain the same, and as studied by De Vries et al. (2020) this is still lower for low income neighbourhoods than for high income neighbourhoods. Location is an important factor in exposure to environmental challenges (Braubach and Fairburn, 2010). Implementing NbS by housing corporations can, therefore, contribute to distributional justice, but is unable to solve all environmental inequities. Also other stakeholders than housing corporations should take care of providing sufficient functional greenspace in deprived neighbourhoods.

We recommend the following topics for further research:

The role of residents in NbS implementation in social housing
- their perceptions and experiences on local biodiversity and on the prevention of climate and health issues,
- their involvement in the local decision-making processes, including the relations between tenants and the housing corporation: power and trust issues
- effective ways to support them in social cohesion and physical maintenance regarding the use of (shared) gardens

The involvement and support of municipal and other authorities in NbS implementation in social housing
- Their perceptions and experiences with social housing as a target area for biodiversity conservation, and the prevention of climate and health issues
- Their ability to support both housing corporations and tenants in implementing effective NbS

The development, implementation and monitoring of effective NbS that fit the physical, social, financial and organizational limitations of social housing

4. Conclusions

This study explored if and how NbS can fit within the limitations that define Dutch social housing practice. It illustrates the potential of nature to improve the liveability of the urban environment for low socio-economic status (SES) citizens by providing different types of ecosystem services, thus working effectively towards just cities. The interest of housing corporations in NbS for social housing is growing. Ten NbS measures were identified that could be incorporated in social housing practices if supported by municipalities and waterboards. The study also indicates how NbS implementation can enhance environmental justice, with distributional justice being the most straightforward one. Applying NbS in social housing areas means more environmental assets, contributing to a more equal distribution at the city level. Regarding procedural and recognitional justice, a process is needed that involves the residents so that their views and values are included in the design of their green infrastructure. Finally, this study highlights several other lessons: NbS knowledge is key, but currently still is insufficient, both within housing corporations as well as within the key partners (local authorities, landscaping firms). There is a growing demand to

upgrade NbS knowledge within the social housing sector. Finally, a continued support in the social and physical maintenance stage is likely needed to consolidate the effects of an NbS design after its implementation.

CRediT authorship contribution statement

Robbert Snep: Conceptualization, Formal analysis, Funding acquisition, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Judith Klostermann:** Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Mathias Lehner:** Writing – original draft. **Ineke Weppelman:** Visualization, Writing – review & editing.

Declaration of Competing Interest

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

Data Availability

The authors are unable or have chosen not to specify which data has been used.

Acknowledgements

This publication is funded by the Dutch Foundation TKI Horticulture and its partners, and the Wageningen Knowledge Base program: KB36 Biodiversity in a Nature Inclusive Society (project number KB36-003-008)—that is supported by finance from the Dutch Ministry of Agriculture, Nature and Food Quality. The paper builds upon earlier work on water smart cities, Nature-based Solutions and urban ecosystems in the Green Climate Solutions and Green Cities programs at Wageningen University & Research (WUR). As part of the Pleasant Green Living project an online course on NbS implementation in social housing (see article) was developed with help of the Dutch province of South-Holland, the Dutch network Together ClimateProof and the Green Housing Providers. We thank WUR-colleague Sjerp de Vries for his constructive support during the revision phase of the manuscript.

References

Aalbers, C., de Vries, S., Swart, R., Betgen, C., van Eupen, M., 2014. Socioecological inequalities in European urban areas. A first exploration of incidences, causes, consequences and assessment methods. Wageningen UR. Environmental Sciences Group (ESG), Wageningen.

Aedes, 2017 Nederlandse bouwopgave, Bijdrage Aedes t.b.v. rondetafelgesprek Tweede Kamer 6 december 2017.

Allen, J., and Balfour, R., 2014. Natural Solutions for Tackling Health Inequalities. London. Available online at: https://www.instituteofhealthequity.org/projects/natural-solutions-to-tackling-health-inequalities/natural-solutions-to-tackling-health-inequalities.pdf.

Bai, X., Dawson, R.J., Ürge-Vorsatz, D., Delgado, G.C., Salisu Barau, A., Dhakal, S., Dodman, D., Leonardsen, L., Masson-Delmotte, V., Roberts, D., Schultz, S., 2018. Six research priorities for cities and climate change. NATURE 555, 23–25.

Baka, A., Mabon, L., 2022. Assessing equality in neighbourhood availability of quality greenspace in Glasgow, Scotland, United Kingdom. Landsc. Res. 1–14.

Batchelor, P., 1969. The origin of the garden city concept of urban form. J. Soc. Archit. Hist. (28.3), 184–200.

Braubach, Matthias, Jon, Fairburn, 2010. Social inequities in environmental risks associated with housing and residential location—a review of evidence. February 2010, Pages Eur. J. Public Health Volume 20 (Issue 1), 36–42. https://doi.org/10.1093/eurpub/ckp221.

Buijs, A.E., Mattijssen, T.J., Van der Jagt, A.P., Ambrose-Oji, B., Andersson, E., Elands, B. H., Møller, M.S., 2016. Active citizenship for urban green infrastructure: fostering the diversity and dynamics of citizen contributions through mosaic governance. Curr. Opin. Environ. Sustain. 22, 1–6.

BZK/CBS, WoON2018, 2018. Kerncijfers over Wonen 2018, Nederland. https://www.woononderzoek.nl/.

Calderón-Argelich, A., Benetti, S., Anguelovski, I., Connolly, J.J.T., Langemeyer, J., Baró, F., 2021. Tracing and building up environmental justice considerations in the urban ecosystem service literature: a systematic review. Land. Urban Plan 214, 104130. https://doi.org/10.1016/j.landurbplan.2021.104130.

Chakraborty, T., Hsu, A., Manya, D., Sheriff, G., 2019. Disproportionately higher exposure to urban heat in lower-income neighborhoods: a multi-city perspective. Environ. Res. Lett. 14 (10), 105003.

De Vries, S., Buijs, A.E., Snep, R.P.H., 2020. Environmental justice in the Netherlands: presence and quality of greenspace differ by socioeconomic status of neighbourhoods. Sustainability 2020 (12), 5889. https://doi.org/10.3390/su12155889.

Dell'Era, Claudio, Paolo, Landoni, 2014. Living lab: a methodology between user-centred design and participatory design. Creat. Innov. Manag. Vol. 23 (No. 2), 137–154 (DOI: 10.1111/caim.12061).

EEA 2021. Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction. European Environmental Agency, report 1/2021.

Feddes, Ytje, 2012. Het groene kapitaal van tuinsteden. Agora 14–16, 2012-2 p.

Frantzeskaki, 2019. Seven lessons for planning nature-based solutions in cities. Environ. Sci. Pol. 93, 101–111.

Haas, Wim de, 2017. Groen, gelijk en eerlijk. Verkenning naar de relatie tussen sociale uitsluiting en de natuurlijke omgeving. Wageningen, Wageningen Environmental Research. http://edepot.wur.nl/422983.

Hartig, T., Kahn, P.H., 2016. Living in cities, naturally. Science 352 (6288), 938–940.

Hattum, T., van, Blauw, M., Bergen Jensen, M., de Bruin, K., 2016. Towards Water Smart Cities - Climate Adaptation Is a Huge Opportunity to Improve the Quality of Life in Cities. Wageningen University & Research, Wageningen.

Hoffimann, E., Barros, H., Ribeiro, A.I., 2017. Socioeconomic inequalities in green space quality and accessibility—evidence from a Southern European city. Int. J. Environ. Res. Public Health 14 (8), 916.

Hop, Margareth E.C.M., 2008. Vaste planten in Nederlands openbaar groen. Extensief beheer in de praktijk. Praktijkonderzoek Plant & Omgeving B.V., PPO nr. 425, Wageningen, www.ppo.wur.nl.

IPCC - Intergovernmental Panel on Climate Change. (2012). Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of working groups I and II of the intergovernmental panel on climate change. Cambridge: Cambridge University Press.

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K., 2016. Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecol. Soc. 21 (2), 39. https://doi.org/10.5751/ES-08373-210239.

Kooiker, S. en A.M. Marangos, 2018. Gezondheid. In: De sociale staat van Nederland 2018. https://digitaal.scp.nl/ssn2018/gezondheid.

Kullberg, J. en M.Ras, 2018. Wonen. In: De sociale staat van Nederland 2018. https://digitaal.scp.nl/ssn2018/wonen.

Langemeyer, J., Connolly, J.J.T., 2020. Weaving notion of justice into urban ecosystem service research and practice. Environ. Sci. Policy 109, 1–14.

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A.M., de Vries, S., Triguero-Mas, M., Brauer, M., Nieuwenhuijsen, M.J., Lupp, G., Richardson, E.A., Astell-Burt, T., Dimitrova, D., Feng, X., Sadeh, M., Standl, M., Heinrich, J., Fuertes, E., 2017. Exploring pathways linking greenspace to health: theoretical and methodological guidance. Environ. Res. 158, 301–317.

Mattijssen, T.J.M., A.E. Buijs, B.H.M. Elands & R.I. van Dam, 2016. De betekenis van groene burgerinitiatieven. Analyse van kenmerken en effecten van 264 initiatieven in Nederland. WOt-rapport 127, Wageningen.

Ordóñez, C., Wheeler, M.A., Raynor, K., Panza, L., Seely, H., Adamovic, M., 2022. Advancing research on urban greenspace experiences and perceptions in disadvantaged communities: a social housing perspective. Urban For. Urban Green. https://doi.org/10.1016/j.ufug.2022.127754.

Pineda-Pinto, M., Frantzeskaki, N., Nygaard, C.A., 2021. The potential of nature-based solutions to deliver ecologically just cities: lessons for research and urban planning from a systematic literature review. Ambio. https://doi.org/10.1007/s13280-021-01553-7.

Rigolon, A., Browning, M.H., McAnirlin, O., Yoon, H., 2021. Green space and health equity: a systematic review on the potential of green space to reduce health disparities. Int. J. Environ. Res. Public Health 18 (5), 2563.

Schlosberg, D., 2013. Theorising environmental justice: the expanding sphere of a discourse. Environ. politics 22 (1), 37–55.

Schüle, S.A., Hilz, L.K., Dreger, S., Bolte, G., 2019. Social inequalities in environmental resources of green and blue spaces: A review of evidence in the WHO European region. Int. J. Environ. Res. Public Health 16 (7), 1216.

SCP, 2019. https://digitaal.scp.nl/armoedeinkaart2019/waar-wonen-de-armen-in-nederland/.

Snep, R.P.H., JGWF, Voeten, Mol, G., Van Hattum, T., 2020. Nature based solutions for urban resilience: a distinction between no-tech, low-tech and high-tech solutions. Front. Environ. Sci. 8, 599060 https://doi.org/10.3389/fenvs.2020.599060.

Steenhuis, Marinke, Joost Emmerik, Hank van Tilborg, Marieke Brouwer-te Molder, Hilde Bloemers, 2016. Onderzoek naoorlogs groen – een nieuwe tijdslaag. Den Haag, woonwijk Nieuw Waldeck. 'Herstel van samenhang in de chaos als gevolg van goede

bedoelingen van de kleinschaligheid.' Casus Nieuw Waldeck – eindrapportage (5/6). H+N+S Landschapsarchitecten bv, Amersfoort / SteenhuisMeurs BV, Paterswolde – Rotterdam.

Wamsteker, 2012. De ideale duurzame stad. Profielwerkstuk OSG Erasmus, Almelo https://issuu.com/thomaswamsteker/docs/pws-de-ideale-duurzame-stad.

Westra, S.H.J.Fowler, Evans, J.P., Alexander, L.V., Berg, P., Johnson, F., Kendon, E.J., Lenderink, G., Roberts, N.M., 2014. Future changes to the intensity and frequency of short-duration extreme rainfall. Rev. Geophys. 52, 522–555. https://doi.org/10.1002/2014RG000464.

Wittebrood, Karin en Matthieu Permentier, 2011. Wonen, wijken & interventies. Krachtwijkenbeleid in perspectief. Sociaal en Cultureel Planbureau, Den Haag https://www.scp.nl/Publicaties/Alle_publicaties/Publicaties_2011/Wonen_wijken_en_interventies.