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Nature based solutions in cities of the global South—The ‘where, who and how’ of implementation

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Nature based solutions in cities of the global South—The ‘where, who and how’ of implementation

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Abstract

Nature-based solutions have gained popularity as an approach to reduce the impacts of climate and environmental change, providing multi-fold and multi-sectoral benefits especially in cities. Yet there has been growing concern about their utility for cities of the Global South, a concern fuelled by the paucity of studies, including scientific peer reviewed and gray literature. In this paper, we contribute to this knowledge gap, based on an analysis of 120 case studies of NBS in Global South cities, documented in two databases (Urban Natural Atlas and Oppla). These cases fall largely under categories of blue and green infrastructure, with a few cases also focusing on grey infrastructure (in buildings or campuses). While most cases are in Asia, several have also been documented in Africa and Central/South America. Two-third of documented NBS cases are aligned towards either national, or lower-level (regional and local) policies indicating the importance of policy mechanisms for driving their implementation. Institutional arrangements are usually non-government, government or collaborative arrangements, with the goal of climate resilience, biodiversity support and ecosystem restoration—along with social goals of creating public spaces. However, when private players take on the mandate for NBS, they focus primarily on grey infrastructure (in buildings and campuses), primarily meant for private or employee benefits, and not for the public. In cases where public engagement is a stated priority, we find tokenistic approaches deployed, primarily seeking engagement through information dissemination and consultation predominate. Despite the stated importance for participation and engagement, only a few cases focused on empowerment and co-creation of NBS with local communities. We suggest that there is a greater need for documentation regarding the modes of participation especially on roles and levels of actors involved, to enrich our understanding of the impact of NBS on values of justice and equity in the cities of the global South.

1. Introduction

We are living in a world where the average global temperature has risen by at least 1.1 °C, with the last nine years being the warmest years recorded since modern recordkeeping started in 1880 [1]. Cities have been a dominant contributor to climate change and global warming, contributing 75% of global CO₂ emissions and consuming nearly 80% of the global energy generated [2]. Urban growth has led to an eight-fold increase in global material consumption over the last century, and is projected to triple by 2050 [2, 3]. This increased consumption of global resources in cities has led to an increasing scarcity of natural resources such as land, clean water and air [4]. Rapid urban expansion of cities in the global South has increased the exposure of people and material assets to climate change risk from extreme events [5], amplified by depletion of resources and ecosystem degradation [2].

Nature-based solutions (NBS) are increasingly proposed to adapt and sustain cities in the face of ongoing climate crisis. NBS draws on the benefits offered by local ecosystems to enhance human well-being and protect biodiversity [5, 6]. There have, of course, been various definitions of NBS since the term was first

mentioned by the World Bank in 2008. In this paper we follow the definition provided by the International Union for Conservation of Nature (IUCN), as ‘actions to protect, sustainably manage, and restore natural or modified ecosystems that address environmental, social and economic challenges simultaneously by maximising the benefits provided by nature (...) inspired by, supported by, or copied from nature’.

NBS are often viewed as systemic solutions of working with nature and ecosystems, ‘integrative, synergistic and interdependent solutions’ [7] which can help achieve sustainable development goals [8] by connecting social, ecological and economic factors in an integrated manner to address urban challenges [9, 10]. The current research on NBS, specifically from the lens of urban planning and sustainability stems from urban centres of the global North and there is a lack of understanding the economic, social and environmental contexts from emerging urban areas of the global South, though they comprise increasingly vulnerable populations with limited access to resources [8]. The same is highlighted in the case of the African continent as well, where there is limited references to NBS in national adaptation plans attributed to ‘political unwillingness to fund and enforce natural resource conservation’ [11]

Previous research suggests that NBS as a multifunctional approach which produces co-benefits [7, 12] and can help to strengthen nature-human relations, especially in urban areas [13] to achieve urban resilience agendas [7, 14]. Thus, for instance, Sedon *et al* [15] demonstrate that NBS foster partnerships among people and nature with a view to address societal goals. Turner *et al* [16] point to the potential for NBS to provide positive outcomes for people and nature at the local scale, but also emphasise the need for further research to understand how to avoid such interventions leading to maladaptation for people and nature [15–17]. Scholars such as Ferrerira *et al* [18] and Frantzeskaki *et al* [19] highlight the importance of multi-sectoral approaches and multi-actor engagement for governing NBS. Nyika and Dinka [20, 21] in their review of NBS in Africa, suggest the need for a multi-stakeholder approach to ensure NBS co-benefits such as enhancing resilience, safeguarding people and property, and ensuring the well-being of both humans and nature. Kiss *et al* [20], in their analysis of NBS cases across 21 cities highlight that multi-stakeholder engagement approaches do not confirm effective implementation of NBS.

Participation seems to play a key role in shaping the likelihood of positive or negative societal outcomes for NBS [18]. Yet, as Puskas *et al* [21] highlight, the focus on understanding the relation between participation and NBS is fairly recent. Most previous literature has focused on types of benefits provided by NBS [22] and the challenges to [23] NBS implementation. A large scholarship on participation have demonstrated the importance and need of participatory approaches, mainly through theoretical discussions, there is an unequal representation of empirical data and real-world case studies [21]. Despite the increasing consensus that citizen participation is crucial in implementation of NBS [21], there is limited research on the different categories of participation (table 2 provides detailed categorisation of participation) that are adopted, and their importance in ensuring successful outcomes, as highlighted by Ferreira *et al* [18].

The large and growing body of work documenting the implementation of NBS, peer reviewed [17] and gray literature [5], has now made it possible to conduct systematic reviews to address some of these questions. Johnson *et al* [5] undertake a systematic review of the systematic reviews of NBS, highlighting a major gap—most previous systematic reviews focus on peer-reviewed literature alone, with only 26% considering gray literature besides peer-reviewed literature. Yet relying only on peer reviewed literature is problematic, as academic studies are often concise and limited to specific locations, while gray literature may be better distributed spatially, and provide additional in-depth background information on aspects such as participation and governance processes. Seddon *et al* [15] further point to the severe lack of documentation of NBS implementation in the global South, an area where gray literature can be helpful in expanding coverage. They also provide a wider critique of the limitations of NBS as applied to under-capacitated cities in these regions. Specifically, regarding multi-stakeholder partnerships, while there are a few studies assessing structural and institutional barriers and enablers of NBS [18, 24, 25], there has been limited focus on the role of different actors, including governments, corporates and citizen groups.

In summary, three major gaps emerge in our understanding. First, there is a lack of literature that specifically documents the experiences of NBS implementation in global South cities, largely because of the exclusion of gray literature from most analyses. Second, critiques highlight the need for multi-stakeholder implementations of NBS in cities—we need to assess if this is so in global South cities, which are often under-capacitated. Third, participation is key for successful implementation of NBS, there is a need to understand the different modes and the role of different actors in shaping NBS outcomes.

The objectives of this paper are consequently three-fold. First, we map out various cases documented in gray literature across the global South to understand the geographical spread of NBS in the global South and identify the main sectors under which NBS is implemented. Second, we identify the main actors involved in leading NBS implementation, to assess if there is multi-stakeholder involvement. Third, we delve into identification of the various participatory approaches followed to implement NBS in addition to

investigating the role of different actors and examining aspects of participation and their relation to governance arrangements deployed to implement NBS.

2. Methodology

2.1. Data and data sources

Gray literature is often referred to as ‘fugitive literature’ because it is may not easily accessible to reviewers [5] and other stakeholders. Yet, gray literature can play a very important role in improving our understanding in key areas such as NBS implementation in cities of the global South, where the availability of academic peer reviewed literature remains limited.

We focused on two databases namely, Urban Nature Atlas (UNA) (www.naturvation.eu/atlas) (around 1200 cases), Oppla (<https://oppla.eu/>) (around 500 cases), well known for their documentation of NBS.

UNA, a knowledge base dedicated to documenting and highlighting NBS, with an aim to inform, inspire and enable individuals and organisations interested in NBS and cities. Developed in 2017, as part of the Naturvation project, under the Horizon 2020, the atlas was initiated with the collation of NBS data from 100 European cities. In 2021, the atlas was made available to the global public, attracting case-studies from around 70 countries across all continents. The British Academy funded the collection of these cases in preparing for COP26. The database is open source—anyone can submit a NBS to the Atlas upon registration, but the submitted case study is thoroughly reviewed by the team before it is published on the atlas [26]. The database documents the case overview in terms of challenges addressed, objectives and main beneficiaries. Further, the duration of the project, governance aspects such as management set-up, type of initiating actor and community involvement in addition to documenting sources of funding and the impacts of the project. Oppla, the second database considered, is also funded by the EU. This is a broader platform designed for people with diverse needs and interests, from science, policy, and practice. It is a community platform, which not just documents NBS, but enables networking with like-minded actors to gain insights and access other useful resources for promotion of NBS [27]. Oppla documents cases with a focus on the main objectives, actors involved, financial support, and potential benefits in addition to the SDG covered.

2.1.1. Collation of cases

The two data sources followed different formats of data collation. The UNA had a more concise and standardised mode of reporting, while case studies from Oppla, though very detailed, had varying levels of information provided for each of the cases. We adopted specific classifications from the UNA and classified Oppla cases using the same codes. For example, we used this approach to categorize organizations involved, mentioned in Oppla, into a standard set of categories.

2.2. Selection of cases: eligibility and exclusion criteria

A search of the two databases on NBS in Asia, Africa and Central and South America (including the Caribbean islands) yielded 208 cases. There were no limitations on the year of the cases, which ranged from 1999 to 2023. As our focus was on NBS in urban areas, we excluded NBS, which were in non-urban areas. We also excluded projects that were not implemented and/or were awaiting release of funds or approvals, focusing only on cases completed by June 2023. Thus, the cases were excluded only based on their spatial focus (urban) and whether they were ongoing (being implemented). Applying these two criteria, the number reduced from 208 to 120 cases, which were checked to ensure there were no repetitions. Figure 1 represents the eligibility and exclusion criteria.

2.2.1. Classification of urban—non-urban and global North—global South

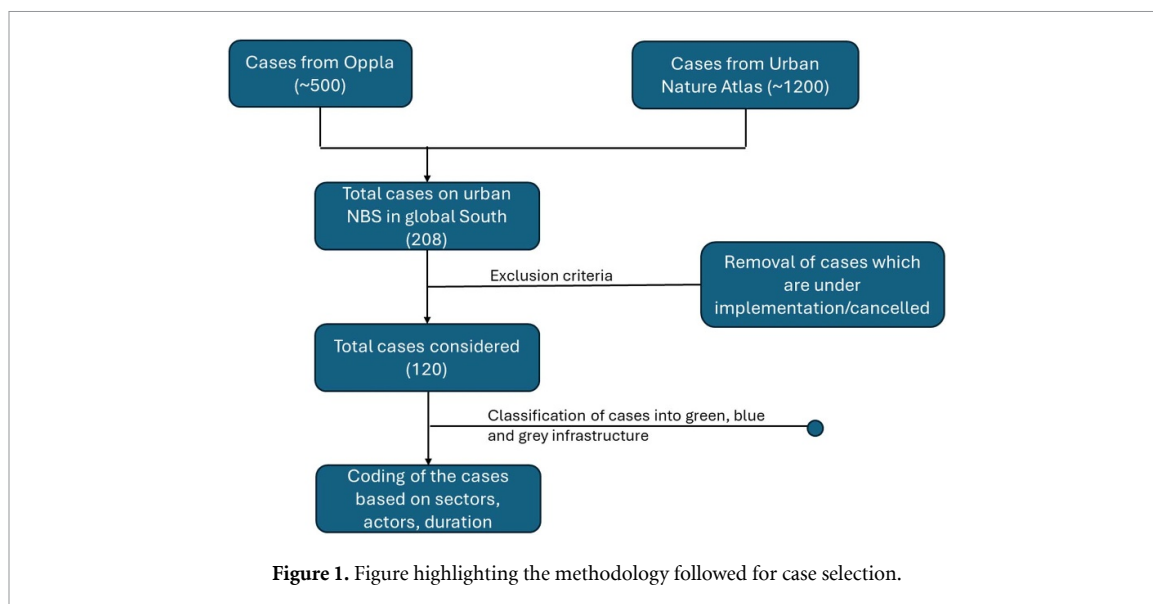
The UNA focused only on urban NBS—we random checked this manually for several cases to confirm this as well. Oppla cases were manually assessed to select urban cases, by examining keywords, objectives, and case abstracts. Further selection of cases from the global South was done by referring to the country index in the World Population Review.

2.3. Coding of data and extraction of results

Information extracted from the cases included in our analysis were coded based on the year they were initiated, geographical context, NBS sectors of focus, stated objectives, governance arrangement (government-led; non-government led and co-governed), lead and supporting actors, links to national or local policies and finally participatory approaches they followed in NBS as stated in table 1.

2.3.1. NBS types

The NBS cases were classified as Green, Blue and Grey Infrastructure, based on their objectives. Green infrastructure referred to projects where there has been an emphasis on increasing green cover through



various methods. This included but was not limited to Urban Forests, gardens and so on. Blue infrastructure as the name suggests referred to projects focusing on water bodies and other projects that focused on improving water resources. Grey Infrastructure is primarily vertical gardens and other vegetation that was incorporated into buildings. This classification within the NBS projects helped understand the spread of cases across the implemented projects, giving us an idea of focus areas of documented cases of NBS in the Global South.

2.3.2. Actors

Cases were coded based on the lead actor and supporting actors, into three main categories: government led, non-government led and co-managed cases. This was based on a classification system used in the UNA. Cases in Oppla were later classified under the same headings, by reading cases and qualitatively assigning them to one of these categories based on the information provided in the text.

2.3.3. Types of participation

We understand participation to be an ‘interaction between institutions and people, the different governance arrangements, and forms and methods which moderate these’ [20]. As categorised by Kiss *et al* [20], we categorise participation into co-creating, empowering, collaborating, consulting and informing, which are embedded in the governance arrangement. Based on Arnstein’s [28] ladder of participation, we consider consultation and informing as tokenism while empowerment, collaboration and co-creation are considered to be higher degrees of citizen power. We classified the selected cases, different modes of participation indicated under the categories identified above (table 2). The data for the mode of participation were listed in both the databases. It should be noted that there were multiple modes of participation listed under each NBS, but there was no coherent information on the process of its implementation.

3. Results

3.1. Where—geographical extent and sectors of NBS

On mapping the 120 NBS cases, we found that the majority—92—were implemented in Asia, followed by 17 in Africa and 11 in Central and South America (figure 2). India (with 13 cases) and China (with nine cases) were the countries with the highest number of documented NBS. Tanzania (with three cases) had the highest documented number of NBS cases in Africa, closely followed by Mozambique and Senegal and South Africa (with two cases each).

NBS, was predominantly implemented through ‘green’ infrastructure—such as parks and urban forests—and ‘blue’ infrastructure consisting mainly of wetlands and waterbodies (figure 3). Most cases were observed to cover more than one type of NBS sector (refer table 1). NBS were implemented through a series of smaller initiatives over a pre-defined space leading to the coverage of multiple sectors of NBS. For example, the case of Misheel botanical garden, along the Tuul River in Ulaanbaatar, Mongolia containing a combination of green-blue infrastructure, aims to restore the ecological balance and increase the flow of the Tuul river basin by planting trees. Similarly, the Green urban infrastructure project in the municipality of

Table 1. Example data coding for documented NBS.

Sl no.	Name of project	Country	Lead actor	Supporting actor	Participatory approaches/community involvement	From	To	Sector
1	Redevelopment of Rasulbagh Children's Park	Bangladesh	Dhaka South city corporation	SHATOTTO-Architecture for Green Living and JPZ Consulting (Bangladesh) Ltd.	1. Co-management/joint management, 2. Citizen oversight (e.g. boards, advisory), 3. Citizen monitoring and review	2018	2021	Green infrastructure Grey infrastructure
2	Guyana's Mangrove Restoration Project	Guyana	National agricultural research and extension institute	EU	1. Dissemination of information and education 2. Consultation (e.g. workshop, surveys) 3. Joint implementation (e.g. tree planting) 4. Co-management/joint management/citizen oversight (e.g. boards, advisory)	2009	2014	Blue infrastructure Green infrastructure
3	Revitalization of Tebet Eco Park	Indonesia	DKI Jakarta	Citizens	1. Dissemination of information and education 2. Consultation (e.g. workshop, surveys) 3. Citizen science	2021	2022	Blue infrastructure Grey infrastructure Green infrastructure

Table 2. The different categories of participation based on literature Arnstein [28], Ferreira et al [18], Kiss et al [20].

	Categories of participation	Types of participatory approaches listed in the selected cases	Activities included
Tokenism	Informing	Dissemination	Includes information dissemination and awareness campaigns Workshops, surveys and other modes of consultation
	Consulting	Consultation	
Higher modes of participation	Collaboration	Joint implementation; co-management; citizen engagement	Inclusion of citizens in managing projects such as volunteers. Involving local community in undertaking activities such as tree plants, cleaning and maintenance Inclusion of citizens in boards or advisory roles Crowd sourcing of ideas, funding, and participatory budgets Cases that have not mentioned any participatory approach
	Empowering	Citizen oversight and task force groups	
	Co-creation	Co-planning, crowd sourcing	
	Unknown	Unknown	

Beira, Mozambique is implemented in two phases, which focuses on rehabilitating the Chiveve River (completed in 2016) and construction of a public park along the banks of the river (completed in 2020), which serves as a catchment and flood control area and fulfilling needs of urban recreation.

Objectives: We identified 18 key words, based on the stated objectives of the documented NBS in the database and cross-verified it with the classifications in Ferreira et al [18] and mapped these across different sectors. Most of the NBS had diverse focus areas. Here, we present results for nine keywords which had more than two NBS cases (table 3). Numerous NBS were implemented with an aim of improving the environment, focusing on biodiversity, conservation and reducing the impacts of climate change, by building resilience. In terms of social benefits, NBS in cities are primarily focused on providing recreation and well-being. NBS under green and blue infrastructure had a greater focus on the environmental benefits as compared to social benefits. The data also highlighted that most NBS under green infrastructures were designed to provide not just a recreation space, but also improve the well-being of cities.

3.2. Who—actors and governance arrangements

Two major groups of actors were involved in leading and initiating NBS. The non-government actors, in the form of citizens, community associations, civil society organisations and for-profit organisations, including private companies and industries (table 4). Secondly, there are government actors working at multiple levels-national, regional and local and diverse departments such as forest, tourism and municipal planning.

Non-Government led (Non-Gov): 43 of the 121 documented NBS were led by non-governmental actors, including civil-society organisations, private companies, research institutes and universities (table 4). It was interesting to note that among the non-government actors, the private sector and corporates had the highest number of NBS (with 20 cases). They had a very specific focus on built spaces, implementing projects of ‘nature on and in buildings’ under grey infrastructure. These included vertical and roof gardens (example, the construction of the largest vertical garden in Uruguay, comprising of over 6000 plants which are endemic, intended to reduce temperature, produce oxygen and offset greenhouse gas emissions) and greening of residential and commercial complexes (for example, the urban farm office building, a vertical farm of vegetables, fruits and herbs in Vietnam with an intended objective of restoring vegetation to urban structures). NBS led by non-governmental actors such as research institutes and universities focused on green infrastructure such as the pilot Miyawaki forest established by the urban living lab project in Jordan, and the creation of the Chulalongkorn University centenary park, an urban forest within Bangkok.

Government led (Gov led): 33 NBS were led by government actors, of these, most NBS (24 cases) were led by local and regional governments, whereas only nine were led by national governments (table 4). As expected, government led NBS were largely implemented through government departments and agencies. For example: for the construction of the Jamburi urban park in Bangladesh, the national government led the project which was implemented by the public works division within the Ministry of Housing and Public Works, creating a park and a lake to provide citizens with access to a social space. Most government led NBS fall within the categories of green and blue infrastructure (figure 4). Green infrastructure, encompass projects for restoration and conservation of parks and forest areas, mainly to combat desertification, improve

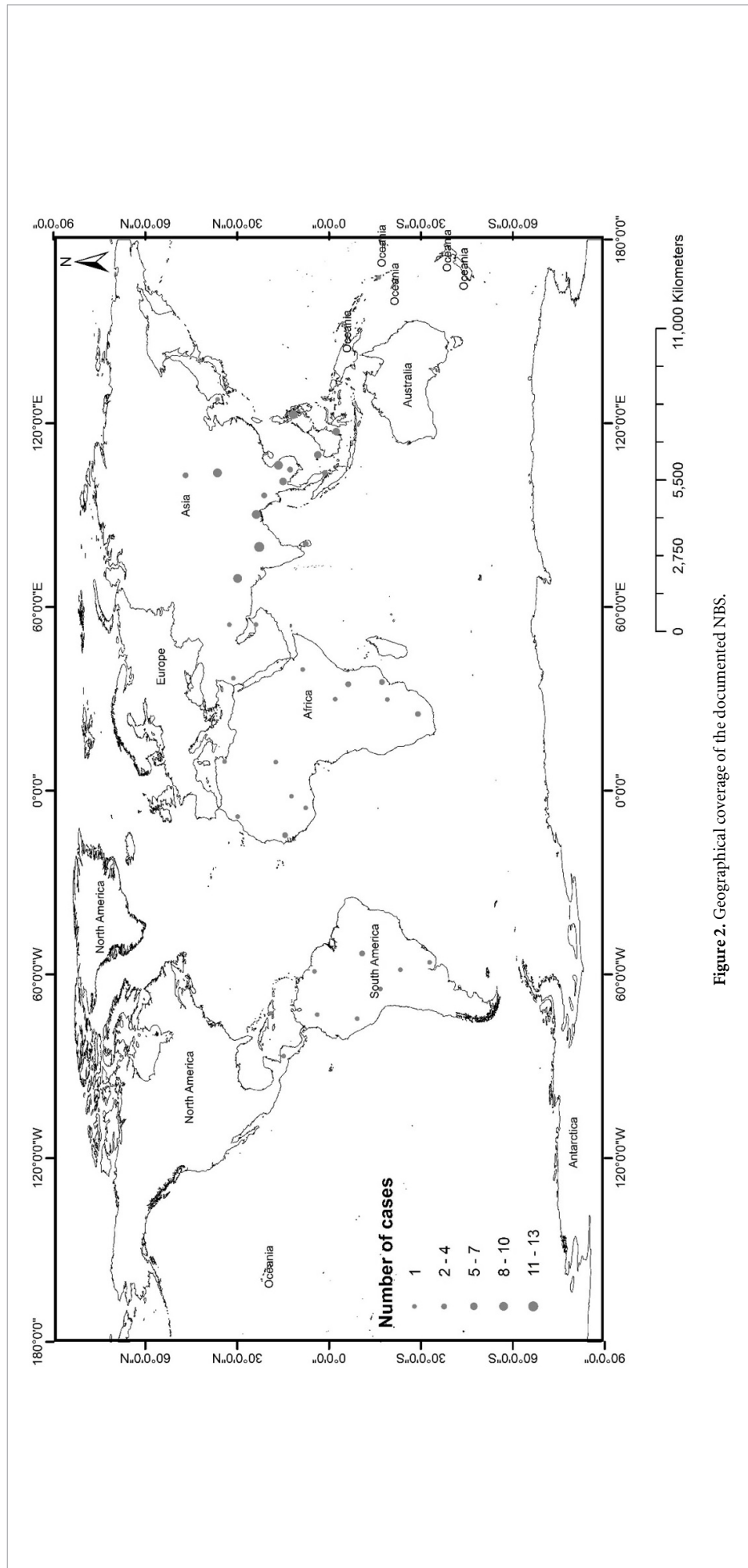


Figure 2. Geographical coverage of the documented NBS.

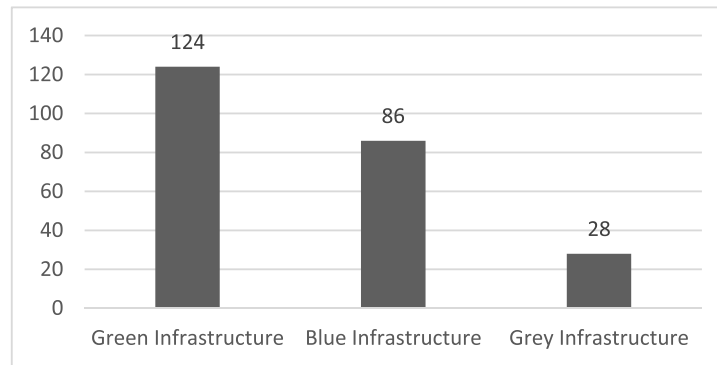


Figure 3. Graph highlighting sector-wise NBS cases documented.

Table 3. Stated objectives and associated NBS (sector wise).

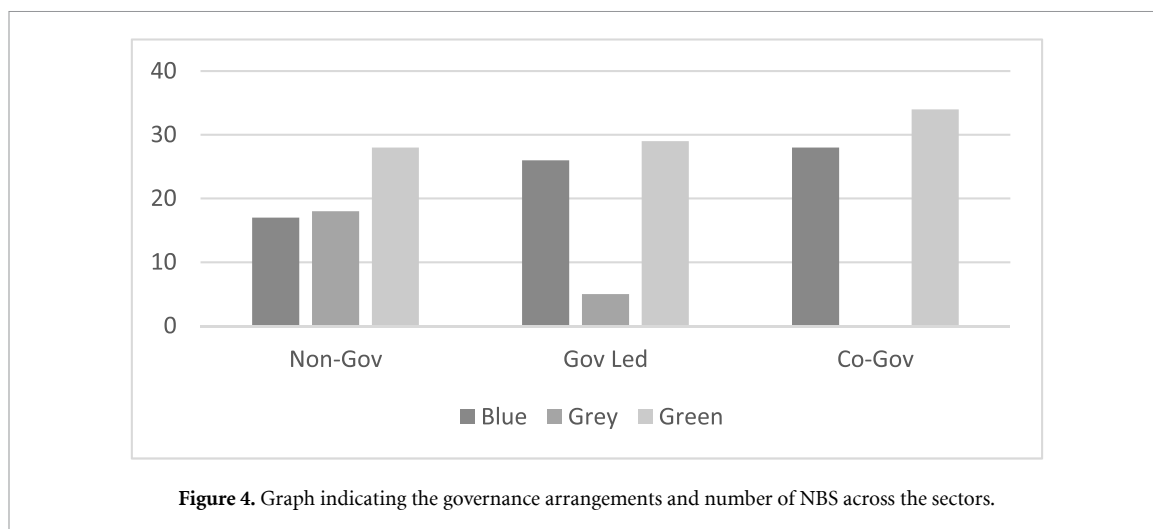
Benefits	Key words from stated objectives	NBS sectors		
		Blue infra	Green infra	Grey infra
Environmental benefits	Biodiversity	29	28	6
	Climate resilience	16	23	2
	Conservation	18	11	0
	Wildlife	8	6	1
	Air quality	2	4	4
Social benefits	Recreation	20	23	4
	Restoration	12	6	0
	Quality of life	5	8	1
	Well-being	7	11	3
	Food security	2	4	2

Table 4. Types of actors leading and/or initiating NBS.

Government-led	National	9
	Regional and local	24
Non-government led	Citizens and community associations	3
	Business and social enterprise	2
	NGO	9
	Research organisations and universities	9
	Private sector and corporates	20
Co-governed		44
Total NBS		120

carbon sinks and mitigate climate impacts. Blue infrastructure focuses largely on conserving wetlands, and restoration of lakes and waterbodies to reduce urban flooding. NBS under grey infrastructure included creation of ‘forests in an airport’ and ‘airport in a forest’ as stated in an example from Malaysia, where a jungle boardwalk replicating elements of a tropical forest was constructed within Kuala Lumpur International Airport between 2004 and 2009.

Co-governed (Co-Gov): this refers to NBS which were led with the involvement of both government and non-government actors. 44 of 120 documented NBS were identified to be led under this governance arrangement. NBS under green infrastructure such as parks, urban forests, community gardens were predominant NBS implemented with co-governance—for example, in Indonesia, where the national government, in collaboration with UNEP and local government actors, started a peri-urban farming program, where 15 urban farms and gardens were created using vacant land to grow horticultural crops, spices, medicines and herbs. Blue infrastructure was also a crucial NBS, which had an element of waterbodies covering blue infrastructure. For example, the government of Peru under the glaciers project collaborated with a Swiss consortium led by the University of Zurich to reduce the impact of glacial melt and flash floods. This program-initiated management of more than 200 new lakes, created due glacial melt, directly impacting



population in different cities—thus not just benefiting communities but protecting high-altitude freshwater ecosystems.

Relation to National and Local Policy: 80 cases implemented were designed in line with a local or national policy. There was a higher prominence given to local policies over national policy, while implementing NBS under green and blue infrastructure.

3.3. Assessing participation

Most NBS claimed to include a component of participation, either be it engagement, consultation, or just information dissemination (table 2 details the categories of participation) across sectors and governance arrangements. NBS employing co-governance model provided greater emphasis on participation, and listed at least one form of participation, with only five cases (out of 44 cases) not mentioning a mode of participation. 21 NBS led by government and 17 NBS led by non-government actors did not indicate the form of participation followed. NBS, which did not indicate a form of participation were cases such as the development of the Ankor Botanical Garden in Cambodia and the establishment of ‘green factory’ projects, such as a factory in Rangpur, Bangladesh where in plants were grown on the façade of the factory. However, we found limited information regarding the level and scale of actual participation both in the planning and post implementation phase.

Tokenism: Among those NBS, where participatory approaches were documented, tokenistic types of participation, i.e. of informing and consultation (figure 5 and table 5) were the most common and recurring forms of participation. Tokenistic categories of participation such as consultations and informing (39 cases each) were the preferred form, with numerous these NBS cases led by non-government actors and under co-governance (table 5). ‘Awareness creation’ and workshops to bring the community on board were the main forms of participation. For instance, the creation of the Uulin Noor Park in Ulaanbaatar, where an individual converted an abandoned quarry into a green garden in the middle of the ger. The park had a method, where visitors could plant trees and take care of it, leading to a change in community attitudes and awareness creation on the importance of nature for both well-being and sustainability of the society. Another case focused on establishing a multi-purpose greening, implemented by a multilateral organisation in collaboration with the local government in Sri Lanka. This involved restoration of mangroves to increase resilience of coastal cities to disasters and focused on developing awareness among communities and understanding community needs before implementation of the NBS.

Higher levels of participation: Among the higher levels of participation, we observed that collaboration between actors was the predominant form of participation (figure 5, table 5). We discuss only those modes which have a high number of cases, as most of the cases documented that they follow multiple forms of participation such as joint implementation, co-management, co-planning. As five cases highlighted empowerment of citizens through citizen oversight and task forces as a mode of participation, we discuss these as well.

Joint implementation (45 cases) to be the predominant form of collaboration. This was mainly for NBS under green infrastructure. This can be attributed mainly to tree plantation drives, such as planting 1000 trees within the campus of Sidi Mohammed Benabdellah University, in Fez, Morocco, jointly with students, faculty and NGO representatives, leading to the creation of green areas on campus. Or individual led NBS, as

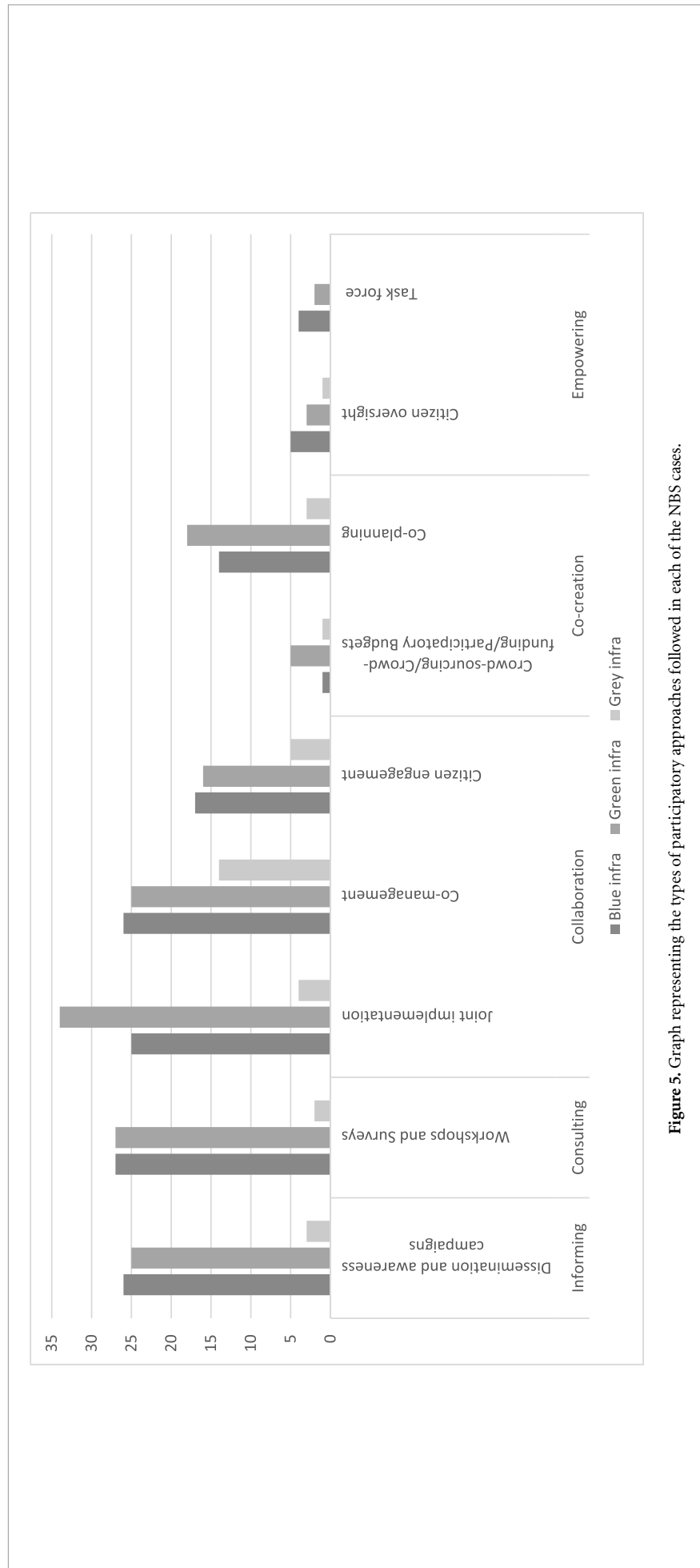


Figure 5. Graph representing the types of participatory approaches followed in each of the NBS cases.

Table 5. Categories of participation across sectors of NBS.

NBS sectors	Categories of participation									
	Informing Dissemination and awareness campaigns	Consulting Workshops and surveys	Joint implementation	Collaboration Co-management	Citizen engagement	Crowd-sourcing/participatory budgets	Co-creation Co-planning	Co-creation Crowd-sourcing/participatory budgets	Citizen oversight	Empowering Task force groups
Blue infra	26	27	25	26	17	1	14	1	5	4
Green infra	25	27	34	25	16	5	18	5	3	2
Grey infra	3	2	4	14	5	1	3	1	1	0

seen in the case of the Miyawaki forest driven by a civic officer of the Navi Mumbai city jointly with a local NGO, converting a dump yard into a healthy and dense forest.

Co-management was predominant in NBS under blue infrastructure (26 cases), and green infrastructure (25 cases) (refer figure 6 and table 6). This involved NBS which involved both implementation and management, as is seen in the case of floating gardens (Baira), a traditional practice of crop cultivation in the wetlands of Bangladesh. The NBS involved local communities in construction of these ingenious floating islands and management of the gardens which has benefited approximately 2000 families. Similarly, an example of NBS in India, focusing on lake rejuvenation and conservation, was documented to involve a stakeholder-managed process for improving the quality of water, and involved generating interest among multiple stakeholders to conserve more lakes. Co-management is also the preferred form of participatory approaches listed under grey infrastructure, which is limited. These are predominantly cases of urban farming and vertical gardens, as seen in the case of Nigeria, where three vertical gardens were implemented in the local community for the purpose of alleviating heat and enhancing biodiversity with support of community leaders and participation of the local community. As noted previously, NBS under grey infrastructure was primarily led by private companies acting alone, including roof gardens and vertical gardens within campuses and on buildings.

Co-planning was a major source of participation under co-creation (figure 5 and table 5), implemented under co-governance (ten cases) and non-government actors (nine cases). NBS under green and blue infrastructure had greater involvement of communities in the planning phase, mainly in cases focusing on lake rejuvenation, conservation and tree planting drives. One case which highlights the citizen oversight is of rehabilitation of a peat swamp into a thriving forest reserve (Raja Musa Forest reserve) in Malaysia, wherein a network of community groups manages the forest and its resource use in close linkage with the forest department and other government agencies since 2010. A rehabilitation project was initiated by a local NGO in collaboration with governmental and non-governmental actors. The uniqueness of this project lay in enhancing and strengthening the capacity of the local community in water management and forest rehabilitation. This included reforestation, creation of demonstration models, dissemination and awareness programmes leading to documenting a 'model of low-cost hydrologic restoration of peat swamp' which has been replicated in multiple locations. This also led to the creation of an annual forum for community-based exchange of successful experiences.

Empowerment (five cases), mainly in the form of citizen oversight and citizens in task force as a mode of participation. Cases include redevelopment of a children's park in Bangladesh, led by the city corporation of Dhaka by creating a green space for interaction as well as improve flood protection of the area. The city government involved both residential and business community and other local actors sharing the plans and other project details at a public hearing and making sure everyone was on board with the plans. Further, respected members of the community were involved in monitoring and review in addition to being on advisory boards. Another example led by non-government actors and implemented with community members and authorities was the alley garden project in Yangon. This involved conversion of trash alleys in CBD into gardens, street markets and playgrounds. The project employed a user-centric participatory approach where, citizens were encouraged to form committees for project administration and management in addition to participate in meetings and design workshops.

A large number of NBS (21 cases, refer table 6) have not mentioned any form of participatory approaches. This includes cases such as the redevelopment of Iloilo River esplanade in the Philippines, which involved the conversion of a dyke road into a linear park. Similarly, there are projects such as construction of rain gardens under Begumpet flyover in Hyderabad India, and construction of bioswales and rain garden in central Jakarta, Indonesia to reduce inundation and flood protection. These NBS were initiated by local city governments to overcome ecological degradation and build adaptive capacity of cities.

4. Discussion and way forward

In this paper, we undertook a review of gray literature to understand the main sectors of NBS, identified the main actors, different governance arrangements and different modes of participation engaged by actors working on NBS in the global South. The main findings are, (a) there is a greater need for documentation of NBS from the global South, especially outside Asia, where the documentation is thin; (b) most of the documented NBS are linked to a policy, mainly at the regional level or the national level; (c) majority of NBS are implemented under co-governance or by non-governmental actors; (d) while there is a lot of discussion on community engagement, tokenistic approaches of participation are the main modes of such engagement across sectors.

The number of cases documented from the global South, especially from urban areas, are severely limited compared to the global North [29]. Out of around 1800 documented NBS across both the databases, only

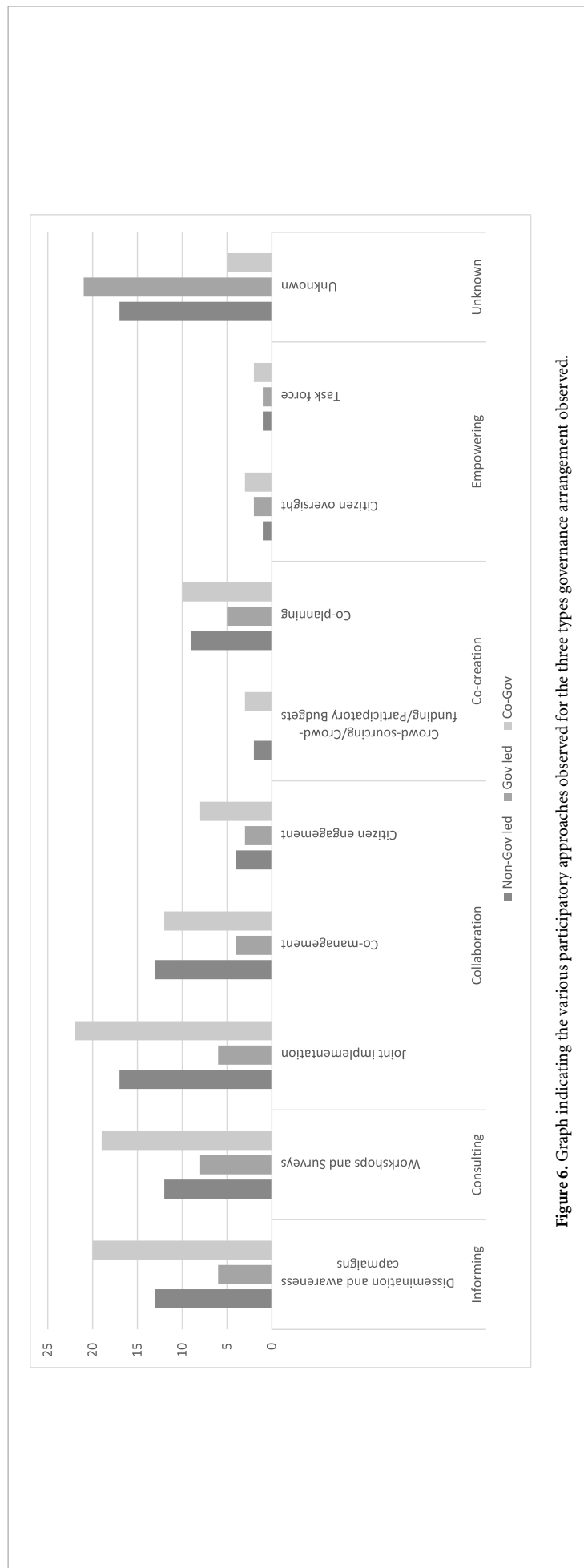


Figure 6. Graph indicating the various participatory approaches observed for the three types governance arrangement observed.

Table 6. Categories of participation across the three identified governance arrangement leading NBS.

Governance arrangement	Categories of participation									
	Informing Dissemination and awareness campaign	Consulting Workshops and surveys	Joint implementation	Collaboration Co-management	Citizen engagement	Co-creation Crowd-sourcing/crowd- funding/participatory budgets	Co-planning	Citizen oversight	Empowering Task force	Unknown
Non-gov led	13	12	17	13	4	2	9	1	1	17
Gov led	6	8	6	4	3	0	5	2	1	21
Co-gov	20	19	22	12	8	3	10	3	2	5

120 completed cases from the global South were documented. Of the 120 selected cases, most were from Asia, mainly India and China, followed by countries in Africa. Most documented cases were spread across more than one type of NBS (green, blue or grey). This was mainly attributed to the temporal scale of implementation of NBS, as small projects over pre-defined spaces, connected and expanded over years. This also showed that NBS is a long-term action, which is holistic and can address problems jointly rather than individually, thus promoting multi-disciplinary and systemic engagement, as stated by Adams *et al* [7], Lin *et al* [8] and other scholars. Such engagement helps to further stated goals of building climate resilience and improving biodiversity, along with the creation of urban social spaces for recreation, as highlighted by Ferreira [18].

There appears to be an increased focus on achieving environmental benefits such as biodiversity conservation followed by social benefits of recreation. This can be attributed to the changing ecosystem services in urban areas, as well as the role of biodiversity and local ecosystems in building sustainable cities, as highlighted by Nyika and Dinka [11]. We also note, a predominance of NBS focusing on green (parks) and blue (lakes) infrastructure, which provide additional societal benefits including the creation of social and community spaces, enhancing the well-being of communities—besides environmental benefits such as flood zones and air pollution mitigation as highlighted by Ferreira [18].

Two-third of documented NBS cases are aligned towards either national, or lower-level (regional and local) policies indicating the importance of policy mechanisms for driving their implementation. Local, regional policies played a dominant role in developing a large number of NBS, corroborating Carmin *et al* [30]. This can be attributed to the practicality of NBS at the local level, as indicated by Dorst *et al* [24] helping in overcoming institutional barriers, as highlighted by Kiss *et al* [20]. Institutional arrangements are usually non-government, government or joint (collaborative) arrangements, with the goal of climate resilience, biodiversity support and ecosystem restoration—along with social goals of creating public spaces. However, when private players take on the mandate for NBS, they focus primarily on grey infrastructure (in buildings and campuses), primarily meant for private or employee benefits, and not for the public. In NBS where public engagement is a stated priority, we find tokenistic approaches deployed, primarily seeking engagement through information dissemination and consultation predominate. However, where higher forms of participation are deployed, joint implementation is most frequently seen. Despite the importance, few cases focus on empowerment and co-creation of NBS with local communities.

Such a predominance of tokenistic approaches, has also been noted by other scholars such as Puskas *et al* [21] and Ferreira *et al* [18]. Tokenistic approaches to participation focus on aspects such as information dissemination, joint implementation (mainly for tree plantation and lake restoration) and consultation, corroborating Kiss *et al* [20]. Of the NBS considered, only six showed a higher level of participation, including aspects such as citizen oversight and participation in task forces. This corroborates Dennis and James [31], as stated in the review undertaken by Puskas *et al* [21] that though there is a greater emphasis on higher levels of participation in theory, its practical implementation remains low. This lack of implementation can be attributed to the pronounced disparities between and within actor groups, access to decision-making by communities, influence and political power [29], raising questions of environmental justice [32]. Kiss *et al* [20], list a set of limiting conditions highlight that participation is inherently bounded by existing institutional structures and power relations, lack of trust and accountability, as well as the political agenda among actors involved. As indicated by van der Jagt *et al* [33], we also highlight that the form of participation depends on the aim of the project. Most of the NBS projects were designed to produce solutions, with a limited role for collaborative research agenda and may not include initiation of a long-term engagement process. We also found that the levels of participation were higher in NBS implemented under co-governance as compared to non-government led and government led NBS. Thus an NBS which was designed on the principles of co-governance had a greater chance to be more inclusive of citizens as compared to those which were led by governments, as also observed by Kiss *et al* [20].

The ongoing climate crisis impact cities across the globe, but cities in the global South are likely to be hit the hardest because of multiple risk factors, including high population densities, rapid growth, and limited financial and administrative capacities. Thus, it is essential to understand how these cities in the global South will benefit from the concepts of NBS to reduce the environmental injustices. There is a need for further research and documentation of urban NBS from the global South, calling for a greater push for documenting NBS both as peer-reviewed publications and gray literature. This requires a common framework for documenting diverse NBS practices across cities, to ensure comparability and drive learnings. Further, research needs to understand the NBS-policy interconnect, if NBS is to be widely accepted as a means of adaptation in cities across all policy scales. This requires not just greater understanding of policies at multiple scales, it also calls for better and detailed documentation of the NBS cases being implemented. It is equally critical to document NBS through the concepts of justice and equity. This is important, as conservation and social benefits, such as recreation, are often stated as key reasons for NBS (refer table 3). These benefits from

urban NBS are increasingly derived by the privileged communities, at the expense of vulnerable social classes, as indicated by Anguelovski and Corbera [32] and Sekulova *et al* [34]. This raises challenges regarding participation, where without wider support from both the citizens and policies, NBS initiatives might not be sustainable in the long-run, as described by Kotsila *et al* [35].

A key question that is raised in peer-reviewed literature is about who decides on what urban challenge to address using NBS, who is the beneficiary of the implemented NBS and so on [34]. In gray literature, we especially find that these questions are not clearly documented. Also missing is information on the levels and scale of participation, and there is a real need for better documentation of the modes of participation focusing on the roles and levels of participation of every actor involved, to enrich our understanding of the challenges and gaps of NBS and its implementation, especially from the perspective of gender dynamics, and to better understand the impact of their implementation on perceptions, values and outcomes of justice and equity in cities of the global South.

Data availability statement

The data that support the findings of this study are available on Urban Nature Atlas (<https://una.city/>) and Oppla (<https://oppla.eu>).

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Author contributions

All authors contributed to the study conception and design. Arvind Lakshmisha and Harini Nagendra conceptualised the paper. Arvind Lakshmisha wrote the first draft of the manuscript and Harini Nagendra provided comments and edited the manuscript. Abdul Fathah Nazar was involved in collating and coding the cases and analysis of the data. All authors have read and approved the final manuscript.

Conflict of interest

The authors declare no competing interests.

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