

Assessing the benefits of nature-based solutions in the Barcelona metropolitan area based on citizen perceptions

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ABSTRACT

Nature-based solutions (NBS) address societal challenges, such as risk vulnerability and climate resilience, and provide a potential for local adaptation. Other green conceptualizations besides NBS, such as green infrastructures (GI) and ecosystem services (ES), seem to be useful for indicating the potential of nature in urban climate resilience through the provision of a multifunctional landscape, simultaneous services and benefits and stakeholder participation. The extent to which user insight into usual experiences and practices can contribute to NBS management to improve locally adapted solutions could be further explored as part of the NBS concept. Here, we aim to provide empirical evidence about the usual experiences and practices of citizens with respect to NBS. Further, we will address how this insight contributes to NBS management. This study investigated user perceptions based on a public perception survey, to gain information that can be used for (among other things) locally adapted NBS management. To collect evidence, 114 surveys were conducted with users of the Besòs riverside park, an NBS in the Barcelona metropolitan area. The results show that the NBS users are the citizens living near the area who visit the area frequently, mainly for social, cultural, recreational benefits and for health-related purposes. These findings suggest that conducting surveys at the local level is beneficial for gathering evidence on user experiences, perceptions, and practices with respect to NBS, and that this insight could contribute both to NBS monitoring as well as to increasing user awareness and knowledge about an NBS. Stakeholder participation complements the aim of officially recognizing the Besòs area as a key GI for the water cycle in the upcoming Barcelona metropolitan master plan. User insight and NBS management could thus interact to promote a more localized, decentralized, and bottom-up management strategy.

1. Introduction

Nature-based solutions (NBS) belong to an overarching green concept that refers to the innovative use of nature for addressing societal challenges [17]. A core idea behind the NBS concept is that, as a place-based intervention, NBS solve different issues through nature-based processes, thereby providing multi-solutions that require the participation of different stakeholders as well as local adaptation for a context-specific response [18]. NBS implementations address a variety of challenges, including risk vulnerability and climate resilience to events such as floods, droughts, heatwaves, and rising sea levels. In peri-urban areas, NBS are used for water challenges as a way of addressing the pressures related to climate, risks, and urbanization [34]. NBS provide context-specific results in simultaneous and different dimensions, such as land use planning to support biodiversity [5] and

social benefits via positive human well-being outcomes [6].

Previous research has established NBS as a comprehensive concept, or "umbrella", for other green concepts [1, 35]. In fact, a close link between NBS with the terms of green infrastructure (GI) and ecosystem services (ES) is frequently documented in the literature [18, 20, 22]. The relationship between these "green concepts" is interpreted by the role of nature in different processes. For instance, NBS promote the use of nature as a way of providing solutions; GI is a strategically planned network for a multifunctional landscape that delivers ES; and in turn, ES refers to the simultaneous provision of benefits and services of nature for various beneficiaries, including non-human.

Previous research differentiates these concepts by promoting their distinctiveness. Dorst et al. [18] expose how NBS is characterized by core ideas: i) nature-based; ii) solution-orientation and multi-functionality; iii) integrative implementation; and iv) adaptation to the

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context. Escobedo et al. [20] describe GI as a strategically planned network that delivers a wide range of ecosystem services (ES), supported by how the European Union (EU) and the Food and Agriculture Organization (FAO) have defined GI. The authors explain that these organizations consider GI to be a strategically planned network of natural areas (as high-quality areas), as well as semi-natural and cultivated areas, with other environmental features. These features are designed and managed to deliver ES such as to protect biodiversity in urban and peri-urban settings. Belmeziti et al. [9] refer to ES as the simultaneous benefits and services, in which nature serves to address various issues, such as those related to water, climate, urban, fauna and flora, and social well-being.

Specifically, the literature on innovation based on nature focuses on the link between the NBS concept and the green infrastructure (GI) and ecosystem services (ES) concepts [7, 22, 29, 36, 37]. Research presents the linkage of NBS–ES by emphasizing climate change ([12, 13]; Pedersen [31]), while links with GI (e.g., GI–NBS and GI–ES) accentuate the spatial aspects of the "infrastructure" in its spatial context, such as land use changes and urban planning ([14, 16, 25, 30, 38, [47] 48], 2019; [49]).

Implementation performance is a central aspect of these green concepts as approaches that help to reduce context-specific vulnerability through co-benefits, multifunctionality, and stakeholder participation, which are considered as simultaneous and key features. The co-benefits, which are mainly associated with the ES term, provide services for climate, urban, social, and fauna; multifunctionality, which is derived from the GI concept, is associated with urban systems intersections; and stakeholder participation, which operates primarily through NBS, is a key feature indicating the purpose of active integration of the multiple actors.

The co-benefits term identifies the benefits and services of nature through the ecological, social, and economic dimensions of sustainability, which are usually assessed through ES. The role of nature is differentiated through ES categorization, which distinguishes the provisioning, regulating, cultural, and supporting services [41]. For instance, co-benefits related to water issues can limit pollution, retain peak flow, recharge groundwater, reduce the volume of water exported from the space, and/or receive and manage water from another space; co-benefits for fauna include providing food and serving as a corridor, habitat, temporary refuges, and resting areas during migration [9].

GI, in particular, plays an important role in maximizing the environmental, social, and economic potential of natural capital through multifunctional use, which contributes to resilience. Multifunctionality, especially through GI, is a key advantage for urban life quality [3, 19, 40]. GI and its multifunctional use help to benefit from the environmental, social, and economic potential of natural capital [8]. In addition, multifunctionality contributes to the potential of synergies and intersections of nature with urban systems in peri-urban landscapes [33]. Multifunctional GI facilitates human interactions with nature and its multiple values (e.g., human well-being); for daily experiences, this supports conceptualization such as biophilic cities, for frequent and qualitative contacts with nature [6].

The multi-actor dynamics behind implementation processes, such as the participation of different stakeholders, are considered key for NBS mainstreaming and learning. Stakeholder participation relates to the high involvement in NBS of public authorities, followed by civil society, sector-related actors (such as water actors), and business and private representatives (as the least involved actors) [34]. Citizen perceptions aid a wider uptake of NBS, as a transitional path towards its technological adoption [15]. Citizen involvement and stakeholder networks are significant for localized learning processes [17]. Teaching interventions can effectively promote knowledge of the territory, thereby increasing the participants' social resilience and their ability to adapt to adversity [11].

Previous research has revealed that surveys are an effective way to gather, analyze, and present the perceptions of different social actors on the use of nature, as well as specific aspects of GI, NBS, and ES. For

instance, Balázsi et al. [4] developed an expert survey to better understand cultural ES related to farmlands in Europe. Ferreira et al. [21] implemented citizen surveys to assess the coherence of the policies emerging from stakeholder perceptions of urban climate challenges and their preferred NBS, to tackle them in two cities in Portugal.

However, how insight into the usual experiences and practices of users can contribute to NBS management for locally adapted solutions needs to be further explored. The present study uses citizen perception surveys to provide empirical evidence for potential local support, in order to answer two key questions: i) What are usual experiences and practices of citizens with NBS? and ii) How can this insight contribute to NBS management? We present a qualitative analysis of citizen perceptions at the site of the Besòs river restoration in the Barcelona metropolitan area. Through their participation in the survey, respondents have provided a descriptive input to answer the guiding questions of this study.

This intervention is examined from the standpoint of NBS; however, the Besòs restoration was a ten-year process (from 1996 to 2006), in which constructed wetlands and a riverside park were implemented to address mainly water challenges [42]. As a first step, we use the survey results to describe the Barcelona case, based on the citizens' usual experiences and practices and their perceptions of NBS in terms of services and benefits, as well as on characterization of various user profiles. In a second step, we discuss the citizens' usual experiences, perceptions, and practices as contributions to NBS management, as it could complement the aim of officially recognizing the Besòs area as a key GI for the water cycle in the upcoming Barcelona metropolitan master plan [2]. In a third step, we consider how NBS management could be beneficial for users.

This study of user perceptions is relevant for NBS management, urban planning, and local adaptation strategies, all of which contribute to climate resilience [19]. This research aims for a better understanding of user perceptions by providing evidence that validates their insight into NBS adoption as shaped by local conditions, as a transitional pathway for what has been named "community-empowered placemaking combined with 'ecosystem literacy'" [15]. Surveys, among many other tools, could facilitate the purpose of adding value to the information gathered for NBS management—for example, for facilitating citizens involvement and informed acceptance (or contestation) for wider uptake and learning.

2. Materials and methods

The study used surveys to better understand public perception of a specific NBS case in the Barcelona metropolitan area. User insight is key to learn about several aspects for NBS implementation, such as its acceptability, contestation, and involvement as a transformational pathway. Previous studies have shown that surveys are useful for presenting perceptions on specific nature-based aspects. Initially, the case study is briefly presented as a context-specific intervention, using territorial and socioeconomic indicators based on the proposal for Green City Indicators [10]. Descriptions from the historical background were then used to explain the circumstances of the intervention (from 1996 to 2006) and the problem-solving feature. Surveys were used to collect the public perception of the intervention, which provides various benefits from natural solutions along the course of the Besòs river in the Barcelona metropolitan area (Fig. 1).

2.1. Case study

In terms of territory, the Barcelona metropolitan area (*Àrea Metropolitana de Barcelona*, AMB) has 636 km², with a population of 3,247,281 inhabitants and a population density of 5093 inhabitants per square kilometer in 2017. Barcelona city (BCN) has an area of 101.35 km², and holds nearly half of the metropolitan population, with 1,660,314 residents as of the beginning of 2021, and a population density of 16,149.3 inhabitants per square kilometer. In contrast, Sant Adrià de Besòs, which

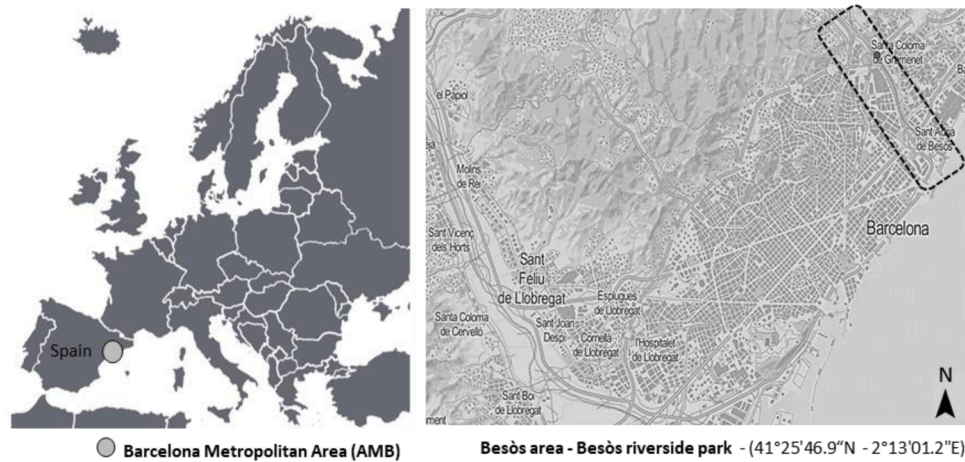


Fig. 1. Location of the Besòs riverside park in Barcelona metropolitan area.

is the location of our case study, is a municipality of 3.82 km² and 37,282 inhabitants, and a population density of 9760 inhabitants per square kilometer (Table 1).

For the socioeconomic dimension, several differences between Catalonia, Barcelona, and SAB were identified. In particular, SAB has a lower overall income (expressed in GDP per capita), GDHI, and a significant number of unemployed inhabitants. No specific data were found for BCN and SAB to reveal differences compared to Catalonia for life expectancy or the Gini index. In this sense, as a general perspective, SAB is a more socially vulnerable area (Table 2).

It is important to place the problem-solving feature behind this NBS into context. At the end of the 20th century, the challenges for the Besòs river were related to mitigating the poor water quality and the relatively high risks of flooding [39]. A Besòs river intervention was needed to address the environmental degradation of water resources caused by heavy pollution from industrialization-related activities that were performed in the area. To respond to this, a river restoration project began in 1996 that lasted until 2006, with the goal of improving the riverbed’s environmental conditions, including its hydrology as a natural system, and to allow recreational use of the river banks [32, 39]. This intervention was mainly supported by European funds, resulting in a significant investment in the Besòs river and the metropolitan area [28].

Here, the nature-based solutions were implemented by: i) constructing wetlands, as a first section, around the Montcada i Reixac wastewater treatment plant (WWTP); this was completed in 2003; and ii) creating a 22-hectare, 9-km-long riverside park (of which 5-km-long is a public use area) as a second section, completed in 2006. Currently, the intervention of the river’s delta is a pending action (2022), which will correspond to a third section (Fig. 2).

This characterization of the Besòs sections and supported activities (Fig. 3) reveals how the NBS has effects at the scale of the metropolitan area of Barcelona, as the river’s right bank corresponds administratively to Barcelona (BCN), while the river’s left bank connects the municipalities of Montcada i Reixac (MiR), Santa Coloma de Gramenet (SCG), and Sant Adrià de Besòs (SAB) as a continuum (MiR/SC/SAB).

Research in the area has established that this intervention addressed the challenges that motivated its implementation, with steps towards a more sustainable peri-urban area. Key advances in the river water

quality and the biodiversity of the area have been documented, for instance by an academic initiative (termed the Barcelonarius) that has been consistently monitoring its environmental progress and establishing the overall balance status of the river [44]. From an NBS standpoint, the intervention has helped to regenerate natural capital and keep resources in use, contributing to more sustainable urban water management; however, further efforts should be made to endorse the circularity paradigm and avoid waste externalities [33].

2.2. Survey content and approach

Data used in this study were collected through detailed surveys during six campaigns in June 2021. Participants were asked to complete a 15-question survey (Q1–15) divided into three sections: (I) to describe their experience and their visiting practices; (II) to examine their perception of NBS services – benefits; and (III) to characterize the user profiles.

In Section I, the questionnaire aimed to identify the types of visits, visit habits/patterns, and changes in these habits due to the COVID-19 quarantine “of each user surveyed”. The general-aspects question (Q1) asked about frequency of visits, usual day(s) of visitation, usual schedules, and time spent in the area. The questions on visiting habits/patterns identified: i) how participants usually access/arrive to the area (Q2), by giving them the option to choose from four transport modes, or to add another response; ii) whether they came alone or accompanied during the visit (Q3); and iii) the date they first visited the park (Q4). Two questions addressed changes in their visits because of the COVID-19 pandemic (Q5), and their observation of changes in park visitation during 2020 (Q6).

In Section II, the questionnaire aimed to examine the users’ ideas related to NBS services and benefits as ES and disservices. Participants were asked to select three reasons for their personal motivation/benefits for visiting the area, from ten options. The options given were based on the most typical activities that can take place in an urban park. However, the option of “other” was available for another type of motivation/benefit (Q7). They were then asked about their level of agreement with the ten statements framed in the sentence: “For neighbors, an important aspect of the river park is that it improves...”, including NBS services and

Table 1

Basic territory indicators. Data source: INE, Idescat.

Dimension	Indicator name	Definitions	AMB	BCN	SAB
Territory	Administrative area	Geographical (surface) area of the city in km ²	636	101.35	3.82
	Total population	Number of inhabitants in administrative area (2021)	3247,281	1660,314	37,283
	Population density	Number of inhabitants per km ²	9760	16,149.3	9600

AMB, Àrea Metropolitana de Barcelona (Barcelona metropolitan area); BCN, Barcelona; SAB, Sant Adrià de Besòs.

Table 2
Socioeconomic indicators. Data source: INE, Idescat.

Dimension	Indicator Name	Definitions	CAT	BCN	SAB
Socio-economic	Population growth	Total growth (annual average) (rate per 1000 inhabitants 2001–2011)	16.98 (CAT)	7.33	6.88
	GDP per capita	GDP per capita (thousands of euros €)	29.11 (2020)	42.6 (2020)	27.7 (2019)
	GDHI	Gross disposable household income per inhabitant (thousands of euros €) – (Based on 2019 Benchmark revision. 2018)	17.6	21.5	14.8
	Unemployment registered	Number of inhabitants registered as unemployed. (Annual averages, 2021,% on total population)	437,165 (10.4%)	81,103.7	3113.2
	Life expectancy	Life expectancy at birth. (2018) (Years, women (w), men (m))	86 (w) 80.4 (m)	–	–
	Gini index	0 to 100 Inequality indicators of the distribution of income.	31.7	–	–

CAT, Catalonia; BCN, Barcelona; SAB, Sant Adrià de Besòs.

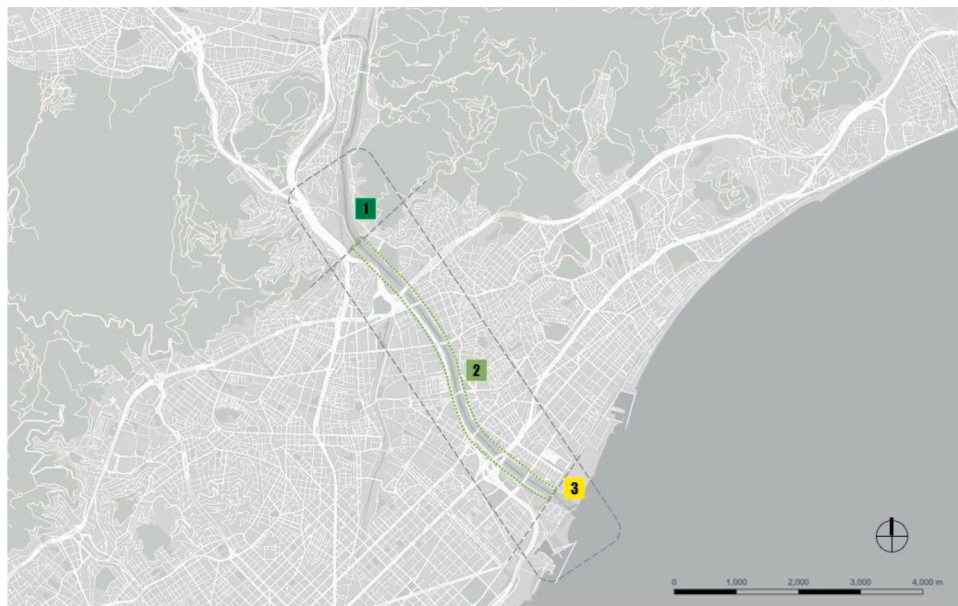


Fig. 2. Sections along the Besòs River intervention. Section 1, location of the constructed wetlands; Section 2, Besòs riverside park; Section 3, restricted area.

benefits (Q8). Users were then asked to subjectively rate how important they considered the previous ten aspects to be (Q9). The final question aimed to identify the disservices, based on a selection of three (out of five) options of the most problematic aspects for the neighbors (Q10).

Section III characterized the user profiles based on gender identity, age, birthplace, postcode, and current employment situation (Q11–15), respectively. Despite the fact that the surveys did not include open-ended questions, some participants indicated specific aspects of their visit, which were noted by the interviewers, included as field observations in the results.

2.3. Data collection and analysis

The aim of this study was to survey as many people as possible, and of any profile, in order to have a representative sample for the user perception analysis. The survey was conducted from a Thursday to a Sunday in June 2021, during both the mornings (9 AM to 11 AM) and the evenings (5 PM to 7 PM), to include groups of people who visit the park at different times during the day. Thursday and Friday were chosen to represent the group of users who visit the riverside park on weekdays, while the two weekend days, to represent users who visit it on weekends/public holidays. The survey was carried out at the end of spring/beginning of summer when the weather in Barcelona is typically pleasant and sunny, with people probably more inclined to be outdoors. It should be noted that social life had not returned to normal following

the COVID-19 pandemic restrictions in the Barcelona metropolitan area; for example, there were still mobility restrictions and nighttime curfews (from 10 PM to 6 AM).

Data were analyzed following the questionnaire order as empirical evidence for user perceptions of the Besòs riverside park as an NBS implementation. The first section was analyzed to identify user experiences and practices in the park; the second section, to examine the perception of the NBS services, benefits, and disservices; and the third section, to characterize the user profile based on their gender, age, birthplace, postcode, and employment situation.

All user responses were classified, and graphed using Microsoft Excel. We obtained 114 responses from users, 37 of whom identified as women, 76 as men, and 1 did not respond. Once all data had been processed, the results were represented in pie charts, as a visual tool for effective understanding of the survey responses. The surveyors (who are the co-authors NR, MB, and ER) played an active observer/listener role on-site during the survey campaigns, which aided in better understanding the citizen insights. The additional notes taken during the surveys based on the participants' comments were used for the Results and Discussion as complementary information (presented in italicized text).



Fig. 3. Characterization of the Besòs sections and supported activities along the riverside park.

3. Results: user perceptions and profiles

3.1. User experiences and practices

The first section of the questionnaire identified the citizens' usual experiences and practices (Fig. 4). For the general aspects of the visits (Q1), most respondents were frequent users, visiting the riverside park three or more times per week (70%), and their visits were comparable on weekdays and weekends. Almost half of those surveyed (47%) reported that the best time to visit the riverside park is in the mid-afternoon (around 6 pm), with the vast majority spending 1 to 2 h there (61%). In response to the questions about habits/patterns during their visits, most of the participants responded that they usually walk to the area (81%; Q2), and almost half of them visit the area alone (47%; Q3). Interestingly, the time since their first visit to the Besòs riverside park varied (Q4): a large proportion first visited the riverside park within the last 5 years, with 34% from 1 to 5 years ago, and 16% within the past year. However, 21% visited it for the first time nearly 20 years ago, and some even stated "when the park opened".

The responses to the two questions concerning changes in their

visiting habits revealed that a significant majority of citizens (79%) visited the park with the same frequency (45%) or even more frequently (34%) during the COVID-19 pandemic (Q5 and Q6; Fig. 5). In addition, most of them (71%) observed changes in the park's influx during the 2020 pandemic, and their perception is that "people were drawn to the park as soon as the stay-home confinement ended".

3.2. Users insight to the NBS services, benefits, and disservices

In Section II, the questionnaire examined the user perceptions related to NBS services and benefits as ES, as well as to its disservices. When asked to select three reasons for their personal motivation/benefits for visiting the area (Q7), the participants' most common responses were: to go for a walk; for health-related reasons; to be in a wide, open space; and to relax and reduce stress. The survey question about NBS services and benefits was problematic for respondents. When asked about their agreement with statements framed under the sentence: "For neighbors, an important aspect of the river park is that it improves...", their responses seem to express that all the output measures of the river park were equally important to them (Q8; Fig. 6).

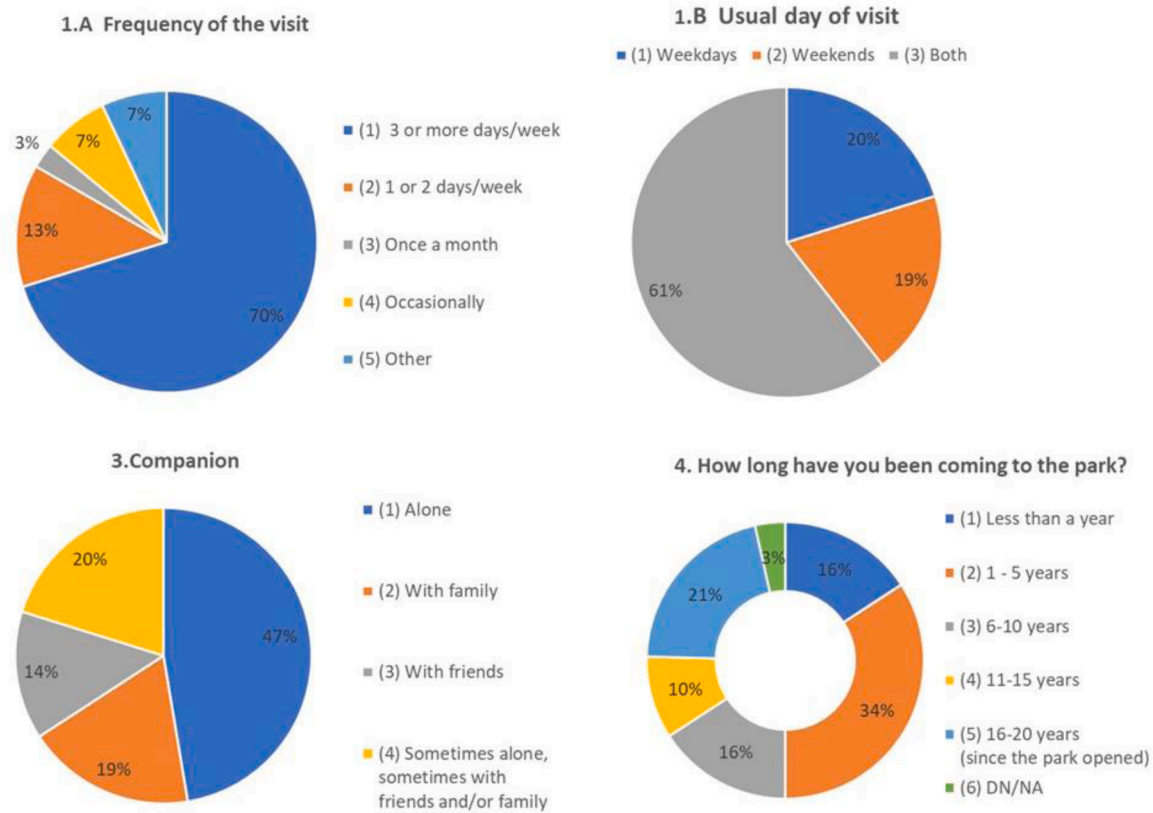


Fig. 4. Responses to citizens' usual experiences and practices – section I (Q1–4).

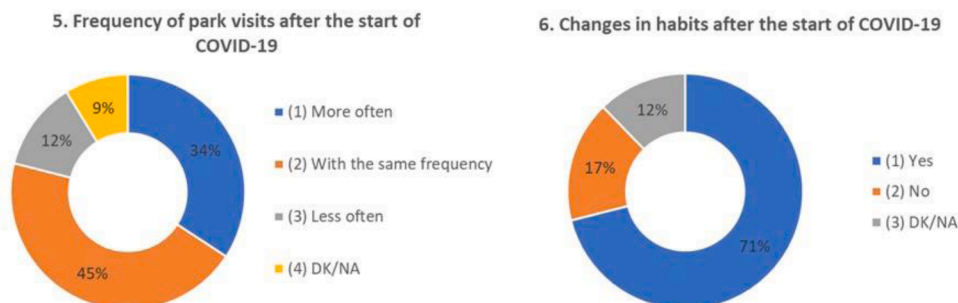


Fig. 5. Responses concerning the COVID-19 pandemic – section I (Q5 and 6).

Thus, responses about the importance of the services and benefits (Q9) were difficult to assess. Also, as the park is mostly visited by neighbors, especially older people commented on how it used to be: *“the park is much better than before—they take care of the green area and the smells”*, revealing their knowledge and interest in the presence of biodiversity. The question about disservices was quickly answered (Q10): more than half of the respondents considered that none of the aspects asked were problematic for the riverside park; in contrast, they indicated that mosquitoes, rodents, trash, dog excrement, and too few services in the park (e.g., toilets, beach bar, equipment) were considered to be the most problematic. For the latter, the neighbors surveyed frequently expressed that the need for bins, benches, water fountains, and toilets was *“urgent!”*

3.3. User profiles

In Section III, the analysis of the profile of those surveyed showed that the park is mostly used by neighbors, who according to their

postcode are residents of Sant Adrià del Besòs, Santa Coloma de Gramenet, Badalona, and Barcelona. They represent various ages, but mainly older than 30 years (74%) (Q12; Fig. 7). The survey was completed by both men and women, but as a result of a random sampling strategy, these results show a gender disparity (with more men participants than women).

Two-thirds of users were born in Spain, and the remaining one-third were born in Bangladesh, Bolivia, Chile, Colombia, Ecuador, France, Italy, Morocco, Pakistan, Paraguay, Peru, Dominican Republic, United States, or Venezuela (Q13; Fig. 8). The sample of the 114 respondents was significantly heterogeneous in terms of origin-of-birth and age.

4. Discussion: citizen insight and NBS management

These findings indicate that the use of citizen perception surveys is useful for two central purposes: first, it gathers evidence about how users perceive the NBS, and second, it identifies how this citizen insight could contribute to NBS management, which is the focus of this discussion.

8. For residents, an important aspect of the riverside park is that it improves...

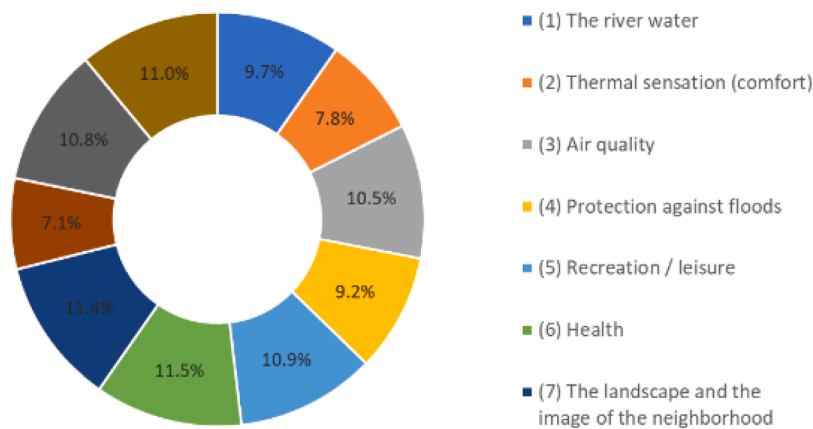


Fig. 6. Responses to services and benefits perceived – section II (Q8).

12. Age

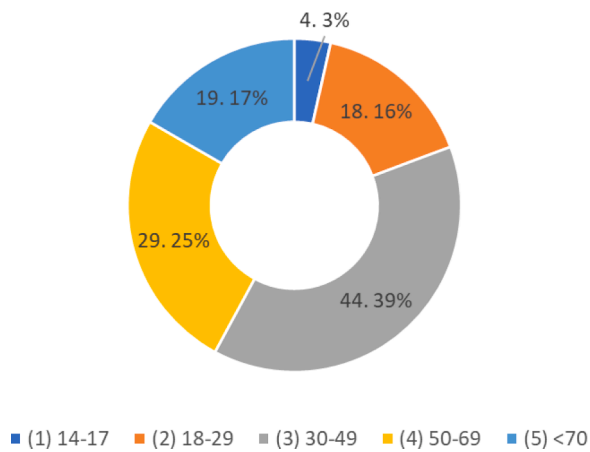


Fig. 7. Responses to users age – section III (Q12).

4.1. Citizen insight as contributions to NBS management

The frequent use of the area by citizens is driven by various uses and motives to visit the riverside park, highlighting the importance of the NBS in its context—here, as a multifunctional green infrastructure that has the form and the (spatial) conditions for recreational, social, and cultural purposes. In addition, users seemed to be informed about the risk vulnerabilities of the area, especially the ones who were long-term users, as they could provide a ‘before-and-after’ perspective. However, users seemed mostly unaware of the operationalization conditions established in NBS management to reconcile the area as an urban park, in particular as the precaution and adaptation measures follow (non-human) priorities, i.e. access restrictions, lack of furniture, lack of shade (from trees), etc. Awareness and knowledge about the delivery of co-benefits seem to depend on the users’ recognition of how the NBS addresses risk vulnerabilities, which will probably be a central feature for using the citizen insight to support NBS monitoring. This identification of awareness and knowledge is considered a reference of the experiential learning on the problem and solution orientation of NBS [18].

During the survey’s campaigns, we observed that riverside park use is concentrated on one bank at a given time—for instance, by people seeking sunlight exposure in the mornings (right side bank–BCN) and protective shade in the afternoons (left side bank–MIR/SC/SAB). Also,

respondents commented that the right bank (BCN side) is affected by the proximity to the highway B-10 (*Ronda litoral*), and that the left bank of the river (MIR/SC/SAB) was preferable: “it’s better in terms of the infrastructure”. The left bank has a pathway that is divided into a bike lane, as a fast-moving corridor between the municipalities, and a pedestrian lane. However, conflict can emerge in this open and wide space, because bikes cross or turn faster than they should; several respondents commented that the bike lane should be better marked with signposts, as “many cyclists do not respect the lanes”.

The spaces beneath the bridges crossing the river serve as climate refuges in this search for thermal comfort. In particular, the interaction of thermal sensation with spatial conditions, such as a shadow from sunlight or exposure to it, enhances the experience of users and creates routines in the use of the riverside park as GI. These spaces, for example, provide shade for a variety of activities, such as salsa dancing classes, teaching children to ride a bike, and social gatherings. This finding shows that the riverside park provides thermal comfort through its multifunctionality and infrastructure hybridization, as the delivery of ES through GI. This recognition reinforces the argument of a previous study about green roofs as urban GI, in which thermal regulation was highlighted as a main ES for Barcelona city [25].

One of these climate protected spaces, in particular, is used for extended meetings of a specific social group. Interestingly, when surveyed, some participants of this specific group responded that they were visiting the park for the first time; for this reason; their responses could be the most indicative of a lack of awareness of the intervention. Consequently, a participatory approach for increasing awareness of NBS to its users may be an advantage, because in contrast to its multifunctionality, the problem-solving feature behind the NBS is not implicit knowledge gained via experience.

Users are aware of the influence of the user behavior and park use, as well as the differences that are likely to cause conflict among different user groups. For instance, participants described conflict related to other’s behavior and the use of the park, such as alcohol bottles and similar acts of incivility, and the lack of police action. It could seem contradictory that many neighbors are aware of the flood risk, control access, and warning alarm system, yet respond to the disservice question by stating that “the park’s timetable is inconvenient,” and that the lack of urban furniture is unjustified (Fig. 9). Users also seem unaware of the river bank management and differential lawn treatments, for which citizens have expressed how its “lack of maintenance” interferes with their occupation of the space, or how it could be improved because “the irrigation schedule is out of control... and they should water the lawn when the park is closed to avoid puddles”.

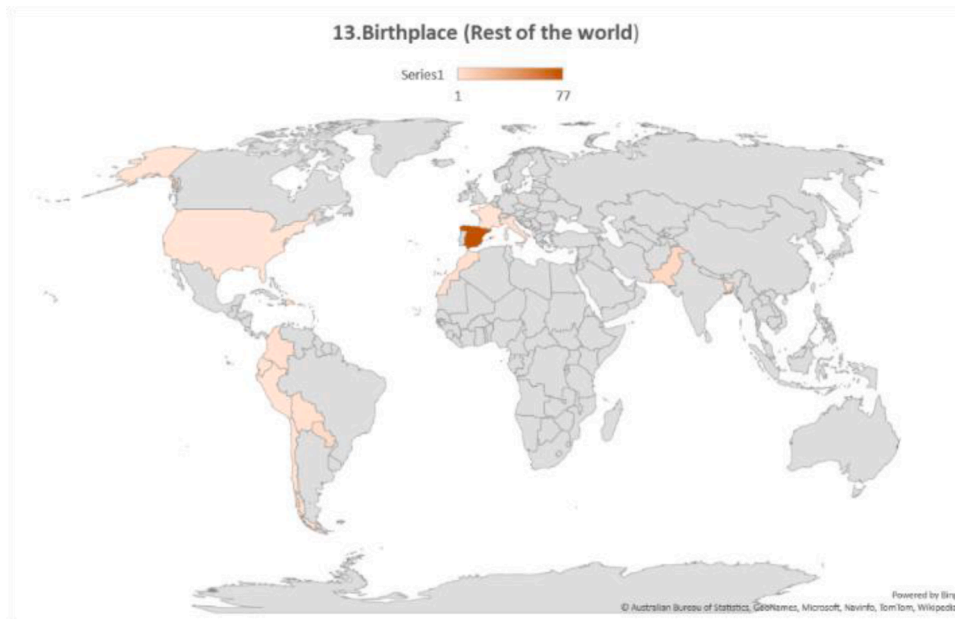


Fig. 8. Responses about countries of citizen’s birthplaces – section III (Q 13 - 15).



Fig. 9. Besòs riverside park in Barcelona metropolitan area. (A) Access control and the alarm system; (B) the right river bank, which corresponds to Barcelona (BCN); and (C) the left river bank as a continuum (MiR/SC/SAB).

The river’s intervention has advanced in the recognition of the multiple actors involved and in specific efforts for integrating various stakeholders, which are central for an NBS standpoint. In particular, stakeholder participation, and especially that of citizens, could be beneficial for a more coherent development of NBS, as citizen

participation was not considered an input during the river restoration design [42]. The Besòs Consortium, which is the organization in charge of the NBS management at the local level (<https://consorcibesos.cat/>), has implemented different actions that have enhanced the NBS in terms of its management and its innovation development. These actions have

benefitted from the multi-actor dynamics supporting NBS, and in particular, from surveys that highlight user perceptions, communication campaigns for knowledge and learning, and plans for coordinated action and stakeholder networks.

In 2015, surveys were carried out at the riverside park to determine public perception on management conditions, which gathered evidence to confirm maintenance acceptability as well as inputs for its enhancement. Because it is a canalized river, different expositions, such as knowledge- and innovation-related activities, have been implemented along the riverside 'walls' in order to enhance the user experiences and recreational needs with knowledge and learning. For instance, in 2018, the 'The Besòs 2017: a photographic uprising' presented a photography exposition on the river's transformation, while the 2019 exhibit on 'Biodiversity of the Besòs: birds of the river' was seen as an effort to raise awareness about the process of change and the co-benefits of biodiversity (e.g., as bird watching activities) that highlight the benefits of teaching and learning activities in-place [11].

In 2021, an innovation advance was developed through a pilot for other NBS types, such as the construction of a green-wall pilot along the riverside, implying the resolution of several challenges for further NBS adoption. Because the area is prone to flash flooding, the green-wall elements were designed as fixed to ensure a risk-free implementation, and the use of nature called for the need to be creative about watering a wall, as well as the users' acceptance of the species used expressed in their willingness and behaviors for conserving it. In the same year, the promotion of the Besòs peri-urban experiences was implemented, as an action in the '48 h of agriculture and urban greenery' as part of Barcelona's activities as the World Capital of Sustainable Food 2021, which may benefit the area from the (future) support of different stakeholder networks [17].

For this purpose, increased commitment to citizen participation could stem from urban experimentation and/or social innovation practices, in which active users and beneficiaries promote "the right to shape the city using human initiative" [24]. Similar innovative experiences in other contexts have shown the development of tools to help cities and their urban residents meet their recreational needs through better-informed decision-making, such as Bremen's *meingrün* application (<https://app.meingruen.org/>) [26]. The Web app was developed to provide citizens with solid information regarding the location of green areas within the city, their quality and amenities, as well as their reachability, within the 'meinGrün project' (Leibniz-Institut für ökologische Raumentwicklung (IÖER), 2020).

4.2. Management for increasing user awareness and knowledge about NBS

The findings show that, in the Besòs, the NBS endorses the availability of a multifunctional landscape that supports concurrent activities (planned or informal) carried out regularly during the late spring-early summer (June as the period surveyed). This multifunctional landscape corresponds to the users' interest in active mobility (co-benefit) as one of their primary motivations is walking, emphasizing their motivation to visit the area for physical and mental health benefits [45]. Because access to use the riverside park is restricted at night, in order to control flooding risks and security issues, the citizens' daily use of NBS add to the 'multifunctional landscape by operating on a timetable' as a feature that could be monitored for its management. Our findings suggest that, at the local level, the interaction between users and NBS could be considered as an information-supported routine, allowing for a closer interaction, as a two-way information exchange, between users' insight and the NBS management.

This interaction is useful for facilitating NBS management with input by citizens, as it can support the efforts for precaution and adaptation to a changing environment. In addition, a multidisciplinary integration at a local level could further consider citizens as part of the expert users. User insight could contribute to NBS monitoring, for example, with key

information on daily maintenance needs, which could be used for informing about risk vulnerability and/or for contrasting user experiences, perceptions, and practices, with the priorities established for precaution and adaptation. Alternatively, NBS monitoring could provide useful information to different stakeholders, including citizens, about the biotic conditions shaping NBS conservation and maintenance. This interaction could be facilitated by a variety of on-ground tools, such as urban experimentation and/or social innovation, which will most likely transform the existing and dominant practices of NBS [27].

An approach to NBS management that interacts with user perceptions about the waterfront renaturalization could lead towards its recognition as an actor playing a role for a more local, decentralized, and bottom-up implementation. Thus, urban experimentation and/or social innovation can be used as means of recognizing how this interaction may have significant implications for a just and a hybrid NBS governance [43].

In the Besòs case, an increased participation is required to ensure its acceptability, as citizen insight has disclosed concerns along NBS implementations related to management activities. For instance, monitoring user perceptions can facilitate collaborations, and avoid contestations, about priorities in daily practices, e.g., bike mobility vs. walking for health and recreation, and/or wetlands management for biodiversity conservation and water quality. Also, the Besòs riverside park receives nearly a million visits per year [45]; here, the citizen insight that we obtained may be representative of these visitors and provide information that reveals gained knowledge, which gradually enhances the role of citizens as expert users of the intervention.

This promotion is likely to raise public awareness and knowledge that support nature in urban planning, such as the integration of NBS management (including ecosystem services) as the non-human priorities and disservices. Awareness about this prioritization could reconcile the ecological purposes and social expectations for a coherent management and services delivery. Overall, this will aid to scale up GI and to broaden NBS adoption, as a transitional pathway in which its capacity is community-supported, to 'rival, replace or combine' gray infrastructure [15]. Accordingly, stakeholder participation should be further endorsed in light of an upcoming update of the Barcelona metropolitan master plan, which aims to officially recognize the Besòs area as a key GI at the metropolitan level, primarily for the water cycle [2].

Further research is needed to determine whether the information used for decision-making in NBS management is consistent with the information available to users, as well as the various stakeholders. This could validate, for example, how specific informative actions aimed to increase their awareness and knowledge on NBS benefit user perceptions. For this purpose, studies could make use of various methods to gather evidence on users' perception, including traditional survey campaigns with qualitative or quantitative orientations [21], or more sophisticated approaches for real-time evidence, such as citizen science, serious games, or experimentation for education and training through urban living labs [46]. Evidence for tools that facilitate the resolution of climate adaptation concerns is relevant and urgent for the local level, particularly for the information exchange on experiences, perceptions, and practices, especially in light of controversies and uncertainties, such as the mediation of 'sustainability accounts' for urban reconfigurations [23].

5. Conclusions

This analysis characterized the case of the Besòs river in the Barcelona metropolitan area based on citizen perception surveys to identify the citizen experiences and practices, their user profiles, the user perceptions of the NBS, as well as how this information could contribute to NBS management. The survey results show that the area is mainly used by citizens living near the area, who visit the area frequently, mainly for social, cultural, and recreational benefits related to health-related purposes—thus profiting from the simultaneous benefits and services

provided by the multifunctional landscape and infrastructure hybridization. However, increased interactions based on user insight can facilitate awareness of the NBS features and biotic management. Further endorsement of stakeholder participation could better highlight to the general public how an NBS can help to ease ecological, social, climate risks, and urban-related vulnerabilities.

This analysis underscored the idea of interactions, as user insight is important not only for identifying the experiences, perceptions, and practices of beneficiaries, but also for NBS management. As a transformative governance approach, tools and practices can support a more participatory structure to integrate NBS into urban planning, and collectively shape a more resilient city. Limitations of this study include only taking surveys during June, which corresponds to the late spring/early summer, which is arguably the nicest season in the region and could introduce a bias into respondents' opinions. Therefore, additional campaigns during other months/other seasons could be conducted to determine whether there is seasonal variability in responses. In addition, follow-up studies could make use of an improved version of the survey or another method of gathering citizen insights, with qualitative orientations for including non-categorical questions, or quantitative to measure the users' impact.

Tools that enable citizen participation by integrating citizen insight into urban planning are important, and are urgently needed, considering the changes in climate and the net-zero strategies for local adaptation deployments. However, monitoring citizen perception remains an open topic for urban climate challenges, as both short- and long-term processes can facilitate NBS management. Urban experimentation and/or social innovation approaches could also be used in implementing NBS to establish greater commitment and trust, to determine who should be involved, when, and in which positions, and to create a more local, decentralized, and bottom-up management strategy.

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