



Justice in urban nature-based solutions: A systematic review of distributive, recognition, and procedural dimensions

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ABSTRACT

Nature-based Solutions (NbS) have become central to urban climate adaptation agendas, yet their capacity to advance environmental justice remains underexplored. While justice has emerged as a key concern in NbS debates, no systematic synthesis has examined how its three dimensions, distributive, recognition, and procedural, are empirically addressed in urban research. This review analyzes 72 peer-reviewed studies published between 2016 and 2025, mapping how justice is framed, referenced, and translated across diverse methodologies and contexts. Findings reveal that NbS scholarship remains dominated by biophysical indicators and ecological performance metrics, while justice is often invoked but unevenly integrated into analytical frameworks. Distributive justice appears mainly through spatial proxies of access and benefit allocation; recognition justice surfaces in critiques of technocratic framings and epistemic exclusion; and procedural justice is typically confined to participation narratives without co-decision. Our synthesis identifies three structural tensions - technocratic, epistemic, and participatory - that constrain the transformative capacity of NbS, revealing how ecological bias and power asymmetries persist in research and practice. For policy and planning realm, embedding justice as a guiding criterion for diagnosis, design, and monitoring is essential to align NbS with socially sustainable urban transitions. By bridging debates, this review reframes justice as a precondition for legitimacy and effectiveness in nature-based urban transformations.

1. Introduction

As urbanization rates and climate change intensify, public managers face growing challenges in delivering innovative solutions that simultaneously address climate impacts and risks while ensuring the quality of life for urban populations. In this context, cities have increasingly turned to nature-based solutions (NbS) as a means of tackling these challenges [1,9]. By providing ecosystem services NbS can generate multiple benefits for people and address diverse issues simultaneously, positioning themselves as both alternatives and complements to traditional gray infrastructure [2,11,19]. However, despite their potential, the implementation of NbS is not without risks and limitations. When they extend beyond governmental spheres and reach the private sector, these solutions may be appropriated through market-driven logics, prioritizing economic returns over socio-environmental equity [1,3].

When driven by profit, this process may benefit only wealthier social groups or sectors such as real estate, fostering greenwashing practices,

understood here as the strategic use of environmental narratives to legitimize projects or investments without addressing underlying socio-environmental inequalities or power asymmetries [14]. Phenomena such as population displacement resulting from green gentrification and the widening of inequalities in the distribution of green spaces, illustrate how environmental interventions that are poorly integrated into fair and inclusive decision-making processes may deepen injustices [3–5]. To prevent such distortions, it is essential to adopt principles of inclusion and empowerment for all stakeholders [3,5], ensuring that transitions through NbS address the three dimensions of environmental justice, distributive, procedural, and recognition [6].

Within these dimensions, distributive justice focuses on the spatial and social allocation of benefits and burdens, as well as the quality and functionality of NbS; recognition justice examines whether certain identities and knowledge systems are devalued due to the imposition of dominant or authoritarian values; and procedural justice concerns how environmental decisions are made, prioritizing the active and ongoing

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participation of individuals and communities [5,6]. The relationship between NbS and environmental justice is central to the debate on urban planning for climate resilience [3,5]. Although the scientific literature has advanced in characterizing the benefits and risks of these solutions [7–10], a significant gap remains: the need for further studies examining how NbS interact with existing structures and asymmetries of power, as well as with social participation. Issues such as the degree of community involvement, how conflicts are addressed, and the urban territorial distribution of these solutions still lack comprehensive and critical syntheses [5].

Although studies acknowledge injustices associated with urban NbS, these issues are often identified descriptively or critically rather than examined as integrated analytical dimensions [8,14,16]. In distributive terms, many studies acknowledge unequal access or exposure, yet they predominantly rely on spatial or biophysical proxies without systematically engaging with the underlying social asymmetries [17,18,35–37]. From a recognition perspective, epistemic exclusions and the marginalization of local knowledge are frequently acknowledged, but seldom operationalized as core analytical criteria [17,38–40]. Procedurally, participation is discussed, yet often treated as an attribute or normative principle rather than critically examined in terms of influence, continuity, and power redistribution [9,27,39]. As a result, the degree of community involvement, the handling of conflicts, and the territorial distribution of NbS remain unevenly and fragmentarily addressed across the three dimensions of environmental justice [30].

Accordingly, this study conducts a systematic literature review to answer the question: how has environmental justice been addressed in the literature on NbS in urban contexts? Building on recent global syntheses of NbS research, which have underscored justice and equity as central yet insufficiently developed dimensions for mainstreaming NbS [11], This review advances existing work by moving beyond normative calls for justice and systematically examining how distributive, recognition, and procedural justice are explicitly or implicitly translated into analytical approaches, indicators, and evaluative frameworks across urban NbS studies. Specifically, we (i) analyze distributive justice, assessing how benefits and burdens of NbS are allocated across territories and social groups; (ii) investigate recognition justice, identifying whether and how local knowledge systems, cultural values, and marginalized communities are acknowledged or excluded; and (iii) assess procedural justice, evaluating the extent and quality of public participation in NbS planning and implementation through the IAP2 spectrum, a framework that categorizes public involvement from information to empowerment, reflecting increasing degrees of potential influence over decision-making outcomes [43]. Examining scientific production across diverse geographical contexts in cities of both the Global North and South, while maintaining an explicit focus on urban NbS studies as the unit of analysis, this review synthesizes the current state of knowledge and reveals systematic biases and critical gaps, thereby offering pathways for embedding justice more effectively in urban NbS research and practice.

By tracing where distributive, recognition, and procedural justice are present, absent, or addressed only superficially, this review seeks to build a clearer picture of how justice is currently embedded in urban NbS research. In doing so, it not only informs ongoing academic debates but also provides an evidence base with direct relevance for planning and policy, strengthening the capacity of NbS to serve as genuinely transformative instruments for more just and inclusive urban futures. We adopt an environmental justice framework focused on distributive, recognition, and procedural dimensions as they relate to human communities. This analytical choice reflects both the objectives of the study and the dominant orientation of the reviewed literature, which operationalizes justice primarily through social, institutional, and governance-related dimensions of urban NbS. While ecological systems are central to NbS outcomes, they are considered here insofar as they mediate socio-ecological trade-offs and condition justice claims, rather than being treated as independent subjects of justice.

2. Methods

2.1. Type of review and protocol

This study adopts a thematic systematic review design to examine how environmental justice has been addressed in the literature on NbS, guided by the central research question: How has environmental justice been addressed in the literature on NbS in urban contexts? We adopt the tripartite framework of environmental justice not only as a theoretical lens but as a structuring axis guiding the interpretation and discussion of results. We also followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol, adapted for reviews in the social sciences [41]. The protocol incorporated strategies to ensure transparency and reproducibility at all stages, including the selection, screening, and synthesis of studies.

The articles were published between January 2016 and March 2025 and indexed in the Web of Science and Scopus databases. This temporal scope was chosen to reflect the consolidation of the term “Nature-Based Solutions” in the scientific literature, particularly after its formal inclusion in key documents of the European Union and international agencies from 2015 onward, as well as to capture the most recent production related to environmental justice in urban contexts. The Web of Science and Scopus databases were selected due to their relevance as multidisciplinary indexing platforms that cover a broad spectrum of fields and provide robust search refinement tools. This choice aimed to ensure broad international coverage while guaranteeing the inclusion of high-quality, peer-reviewed studies.

The search employed combinations of descriptors and Boolean operators covering terms related to NbS and environmental justice, with an emphasis on urban contexts. Searches were conducted across the title, abstract, and keywords fields of the indexed documents in both databases. The search strings used are presented in Table 1:

The restriction of the search to studies engaging with environmental justice reflects a deliberate choice aligned with the objectives of this review. Rather than mapping the full body of urban NbS research, the focus is on examining how justice considerations are explicitly or implicitly conceptualized and translated into approaches within the literature. This strategy prioritizes analytical depth, enabling a systematic assessment of distributive, recognition, and procedural dimensions in urban NbS research. By restricting the search to studies explicitly engaging with the term “nature-based solutions”, this review may have led to the underrepresentation of relevant research conducted under alternative terminologies, particularly in non-European contexts, a pattern also reflected in the geographic concentration of studies identified in the results.

On March 8, 2025, searches were conducted in the Web of Science (230 records) and Scopus (111 records) databases, identifying a total of 341 documents. After deduplication in Zotero, 161 unique records remained and were subjected to blind, paired screening using Rayyan, a web-based platform designed to support systematic reviews by enabling

Table 1
Search strings and filters applied in Web of Science and Scopus.

Database	Search string (literal)
Web of Science	((TS=(nature based solution* OR nature-based solution* OR nbs)) AND TS=(justice OR equit* OR fair* OR environmental justice)) AND TS=(urban))
Scopus	((TITLE-ABS-KEY (nature AND based AND solution* OR nature-based AND solution* OR nbs) AND TITLE-ABS-KEY (equit* OR fair* OR justice OR environmental AND justice) AND TITLE-ABS-KEY (urban)) AND (LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2024) OR LIMIT-TO (PUBYEAR , 2025)) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")))

independent and blinded screening of records [42]. In this process, two reviewers independently assessed titles and abstracts without access to each other's decisions, reducing selection bias. At this stage, articles were considered eligible if they addressed, even implicitly, both urban Nature-Based Solutions and environmental justice, resulting in 125 records retained for full-text screening. Disagreements between reviewers were resolved through discussion and consensus, ensuring consistency in the application of the inclusion criteria.

The final selection was conducted in two exclusion stages. At the first exclusion stage, studies were excluded when they did not engage, either explicitly or implicitly, with NbS or environmental justice in urban contexts. Implicit engagement was identified when NbS-related interventions or justice-related concerns were substantively examined through discussions of green infrastructure, ecosystem-based approaches, governance arrangements, or socio-spatial inequalities, even if the terminology of NbS or environmental justice was not explicitly adopted. Studies were also excluded at this stage if they focused exclusively on rural contexts or did not correspond to research articles or perspective articles.

At the second exclusion stage, review-type publications (including systematic, scoping, narrative, or conceptual reviews) were excluded to avoid overlap with existing syntheses. In addition, studies were excluded when they lacked an empirical basis and did not offer a critical analytical perspective, defined here as the absence of interpretative analysis linking NbS to social, spatial, or institutional dynamics. Purely

documentary or descriptive works were excluded when they limited their contribution to inventories of plans, policies, or projects without analytical problematization of their implications for justice.

This ensured that the final corpus consisted of studies with direct relevance to urban planning practices and policies. After both exclusion stages were applied, 75 articles remained for full-text review, of which three could not be retrieved in full, resulting in 72 articles analyzed. The complete flow is presented in Fig. 1 (PRISMA flow diagram). The studies categorized as Document Analysis that were retained employed a structured empirical methodology grounded in the systematic examination of urban plans and the critical interpretation of site selection criteria for NbS.

2.2. Extraction and analytical variables

All data were extracted into a structured spreadsheet (see Supplementary material, Table S1) containing the following columns: type of study; country/region (classified into six geographic categories: Latin America, North America, Europe, Asia, Africa, and Oceania, plus a "Not applicable" category for studies without a defined location); public participation (level of engagement according to the IAP2 Spectrum of Public Participation, 2018 version); criteria for site selection for NbS implementation; types of conflicts identified (classified into seven pre-defined macro-categories); and environmental justice dimensions (distributive, recognition, and procedural). The analytical categories

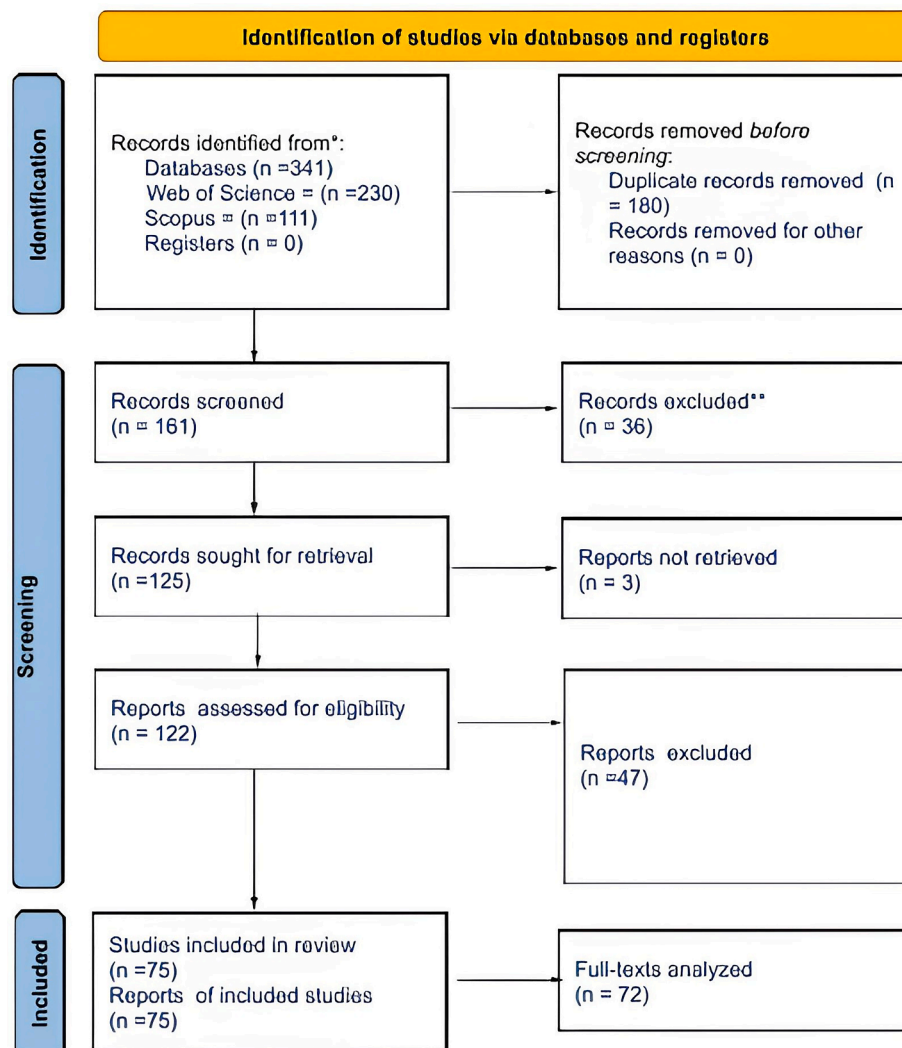


Fig. 1. PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only.

presented in Sections 2.2–2.4 are grounded in established frameworks but are here operationalized as coding instruments to guide the analysis of the reviewed literature.

These analytical categories were applied through a qualitative coding process conducted during full-text review. The selection of variables and coding categories was informed by established environmental justice and NbS governance literature and directly aligned with the research question guiding this review. This approach enabled the analysis to assess how justice-related dimensions were addressed, problematized, or overlooked across the reviewed studies, without imposing rigid classifications before analysis.

The classification of study type (Table 2) followed a tailored typology adapted to capture different methodological approaches, distinguishing between quantitative, qualitative, and mixed-method investigations, case studies, comparative studies, documentary analyses, and theoretical-critical perspectives. The public participation variable was coded using the IAP2 Spectrum framework (Inform, Consult, Involve, Collaborate, Empower), which will be explained later in the text. Anchor terms were drawn from the methodology section of each article to ensure that the classification reflected practices actually implemented, rather than those presented merely as rhetorical claims.

The coding of conflicts (Table 3) employed seven predefined macro-categories: Distributional Conflicts, Recognition Conflicts, Procedural Conflicts, Governance & Institutional Conflicts, Ecological Trade-offs, Social-Ecological Tensions, and No Conflict Identified. Each macro-category included subcategories and associated keywords, established in advance to ensure consistency and replicability throughout the analysis.

Both data extraction and classification followed a pre-defined protocol, and the coders independently reviewed a sample of articles to resolve any discrepancies through consensus, thereby enhancing the reliability and consistency of the dataset. We acknowledge that the heterogeneity in definitions of NbS and environmental justice may lead to interpretative variations, as well as the language restriction (English) and indexing criteria (Web of Science and Scopus), which may introduce biases by underrepresenting relevant studies published in other languages or not indexed in these databases, risks that are inherent to systematic reviews in general.

Table 2
Typology of study designs in the reviewed literature.

Type of Study	Definition	Primary Method (Examples)
Quantitative Empirical	Studies primarily employing statistical or quantitative analyses to test hypotheses or measure variables.	Survey; Field inventory; GIS/spatial analysis; Modeling
Qualitative Empirical	Studies primarily using qualitative methods to explore meanings, perceptions or contextual factors.	Interviews; Focus groups; Ethnography; Content analysis
Mixed-methods Empirical	Studies explicitly combining qualitative and quantitative methods in an integrated design.	Survey + Interviews; Participatory mapping + Statistics
Document Analysis	Studies exclusively based on systematic analysis of secondary textual sources (policies, plans, reports).	Policy review; Content analysis of urban plans
Case Study	In-depth empirical studies focused on a single case or specific local context.	Case illustration; Field observation
Comparative Study	Empirical studies explicitly comparing two or more cases, contexts or regions.	Cross-case analysis; Multi-site survey
Theoretical/Critical Perspective	Conceptual or argumentative papers offering critical reflection without primary data collection.	Theoretical essay; Conceptual framework

Table 3

Conflict macro categories in NbS planning and implementation: definitions and examples.

Macro Category	Definition	Example Keywords	Allowed Subcategories
Distributional Conflicts	Inequities in the distribution of benefits and costs of NbS	gentrification; displacement; unequal access; infrastructure	Green Gentrification; Access Inequity; Benefit–Cost Mismatch
Recognition Conflicts	Exclusion of local knowledge and cultures; imposition of external narratives	epistemic; culture; narrative; misrepresentation	Epistemic Exclusion; Cultural Misrepresentation
Procedural Conflicts	Failures or tokenism in participation and decision-making processes	tokenism; participation; deception; broken promise	Tokenism; Participation Failure; Procedural Barrier
Governance & Institutional Conflicts	Incoherence or dispute between policies, agencies, or levels of government	incoherence; overlap; dispute; mandate	Policy Incoherence; Jurisdiction Dispute; Resource Barrier
Ecological Trade-offs	Tensions between disparate ecological objectives (conservation vs. use)	conservation; degradation; trade-off; ecosystem vs. use	Conservation vs Use; Habitat vs Infrastructure
Social–Ecological Tensions	Conflicts that cross social and ecological spheres (when social and environmental values clash)	social-environmental conflict; balance; “nature vs city”	Recreational vs Conservation; Health vs Ecosystem Integrity
No Conflict Identified	Study does not report any conflicts	none	None

2.3. Participation assessment (IAP2)

Public participation was analyzed using the *International Association for Public Participation (IAP2) Spectrum of Public Participation* in its 2018 version (Fig. 2), as it is widely recognized as a robust framework for classifying different levels of citizen engagement in decision-making processes. Each article was examined for the presence of participation linked to the planning or implementation of NbS, distinguishing between *Applied*, when the study described or evaluated participation practices effectively implemented and aligned with one or more levels of the IAP2 Spectrum and *Critique-only* when the study addressed participation solely in theoretical or critical terms, without empirical evidence of implemented practices.

The classification of the predominant participation level followed the five categories of the IAP2 Spectrum *Inform, Consult, Involve, Collaborate, and Empower* (Table 4). The assignment of each level was based on anchor terms identified in the methodology or results sections of the articles (Table 5), ensuring that the coding reflected the actual degree of involvement rather than mere intentions or participatory rhetoric. Studies that described NbS implementation without specifying the IAP2 level of engagement were coded as 'Applied - Not identified'. This category was retained to ensure consistency in the coding process and to make the dataset comprehensive, allowing both identified and non-identified cases of participation to be systematically compared. The IAP2 level “Inform” was classified as “critique-only” when it appeared without empirical evidence of deliberation, co-decision, or power-

Increasing impact on the decision



Fig. 2. Participation approach vs. IAP2 predominant level. Source: International Association for Public Participation (IAP2). (2018).

Table 4

Participation approach vs. IAP2 predominant level (Critique only vs. Applied).

Approach Type	IAP2 Level
Critique-only	Inform
Applied	Consult
Applied	Involve
Applied	Collaborate
Applied	Empower
Applied	Not identified

Table 5

AP2 levels: definitions and anchor terms used for coding.

IAP2 Level	Definition	Anchor Terms / Indicators (merged)
Inform	One-way communication of information to the public, without invitation for input or feedback.	newsletter, leaflet, broadcast, report, update, announce*, publish*, post, communicate*, information session*, press release*, flyer
Consult	Obtaining public feedback or opinions, but decision-making power remains with project owners.	survey*, questionnaire, public consultation, request for comments, feedback, poll*, comment*, input, public hearing*, stakeholder feedback
Involve	Active engagement of the community in specific stages, but without full co-decision authority.	participatory workshop*, community workshop*, focus group, roundtable, participatory mapping*, interactive mapping*, engage*, participat*, interview*, stakeholder meeting*, public forum*, town hall meeting*
Collaborate	Formal partnership where community and researchers share decision-making in defined phases.	co-design, steering committee, working group, advisory board, partnership, joint decision-making, co-development workshop*, joint committee, co-produce*, joint planning*
Empower	Transfer of final decision-making authority to the community or stakeholders.	empower*, referendum, vote, delegated authority, autonomy, transfer authority, citizen jury, community vote, self-determination, community control

sharing mechanisms.

2.4. Environmental justice and nature-based solutions: an analytical lens

Environmental justice provides a conceptual framework for critically assessing who benefits, who bears the burdens, and who makes decisions about NbS in cities, addressing the unequal distribution of environmental goods and harms and advocating for the right of affected people to participate in environmental decision-making. When applied to urban NbS, this perspective examines how their planning and implementation shape human well-being across different contexts [12]. For this study, we adopted the tripartite environmental justice framework widely used in the literature [5,13–16] which comprises three dimensions:

1. Distributive justice: operationalized by identifying, within the analyzed articles, evidence of who receives the benefits and who bears the impacts or costs associated with NbS, including aspects of spatial allocation, physical accessibility, and the quality and functionality of interventions.
2. Recognition justice: operationalized by analyzing excerpts indicating the devaluation, invisibilization, or marginalization of certain social groups, knowledges, and identities, as well as the imposition of

hegemonic values or priorities. We also considered cases in which

the studies pointed to a lack of recognition as a limiting factor for the effectiveness of NbS.

3. Procedural justice: operationalized by assessing how decisions related to NbS are made, including mechanisms for active, continuous, and inclusive participation of individuals and communities, transparency, access to information, and deliberative processes. This dimension includes both effective inclusion practices and critiques of symbolic or limited involvement.

3. Results and discussion

3.1. Distributive justice

Fig. 3 presents the number of studies by geographic region, two studies included in the review did not analyze a specific city or region, but rather proposed a conceptual framework for the participatory assessment of NbS. As it does not report empirical evidence tied to a geographical context, it was coded as Not applicable in the column Geographical Region. Of the 36 European studies, 33 were conducted in Global North contexts and 3 addressed cases across both North and South. Although these studies did not focus on a specific city or region, they were not excluded because they are not purely conceptual. Both are grounded in empirical material and in critical analyses of documented NbS practices, and therefore meet the inclusion criteria for analytical or documentary studies with a justice-oriented perspective, as defined in the Methods section.

The geographic distribution of the studies analyzed reveals a strong concentration of justice-oriented NbS research in Europe and North America [9,15,17,26,25,27,37], while regions of the Global South remain underrepresented [24,33,34]. This imbalance reflects structural asymmetries in research capacity, funding access, and international visibility, which shape how justice is conceptualized and operationalized. As dominant analytical lenses tend to mirror the socio-institutional contexts in which research is produced, distributive challenges rooted in vulnerability and deprivation remain less visible in underrepresented regions.

Fig. 4 shows a predominance of quantitative empirical studies (43%) within the reviewed literature. This pattern indicates that distributive aspects of urban NbS are most frequently examined through biophysical and spatial proxies, such as vegetation cover, cooling effects, water retention, or exposure metrics [17,27,35]. In this context, distributive justice is most often addressed indirectly, inferred from spatial inequalities in access, exposure, or benefit distribution, rather than being explicitly operationalized as an analytical dimension guiding research design, indicator selection, or evaluative criteria. This tendency can be explained by the methodological structure of the field itself, in which quantitative and comparative studies, being more numerous, seek to

translate the distribution of environmental benefits into indirect quantitative indicators [17,40,46,47]. Examples include research that provides robust ecological evidence, yet operationalizes justice primarily through indirect bio-physical proxies rather than through explicit distributive, procedural, or recognition-based analyses [17,40].

In contrast, qualitative, documentary, and mixed-method approaches, representing around 25% of the studies, are those that reveal the social and territorial dynamics behind the distribution of costs and benefits, examining perceptions, governance arrangements, and redistributive effects such as displacement, rising property values, and unequal access to green areas [8,26,30]. This methodological asymmetry does not indicate an absence of justice in quantitative research but rather illustrates how the field tends to privilege certain types of evidence over others. While most studies acknowledge the importance of the distributive dimension, few quantify or explore it in depth. Consequently, distributive justice is widely mentioned, either directly or indirectly, across the studies but is rarely examined in depth, remaining more of a critical diagnosis than a guiding principle for the design and evaluation of urban NbS.

In distributional terms, the reviewed literature shows increasing conceptual clarity in how distributive justice is integrated into the field of NbS. Across the studies examined, socio-environmental equity is consistently recognized as a prerequisite for both the effectiveness and legitimacy of NbS, moving the debate beyond a purely ecological rationale toward a socially grounded perspective. Several articles [4,28,29] engage substantively with distributive justice, rather than merely referencing the term, through critical analyses or methodological approaches. They address issues such as the unequal allocation of benefits and costs, and the socio-spatial vulnerabilities shaping who gains or loses from NbS interventions. Others [4,9,30] reveal that the lack of distributive criteria within urban policies and planning frameworks often leads to technocratic approaches that reproduce spatial injustices. Some studies [17,25] also demonstrate that inequalities in green infrastructure coverage are closely linked to distributive justice, reflecting historical legacies of segregation and exclusion from decision-making. Vulnerable areas tend to have less green space and experience higher temperatures, while other research [18] highlights the need to develop spatial indices and prioritization metrics to guide the implementation of NbS in less-privileged areas.

Another finding concerns studies focused on the practical redistribution of environmental benefits in vulnerable settings or social housing, where territorial equity is combined with co-production approaches [20,21]. In this view, an ecological transition must proceed without leaving anyone behind, prioritizing marginalized, poor, and vulnerable communities [22] with co-production serving as a structuring methodological axis through co-design, co-implementation, and co-monitoring [23,30].

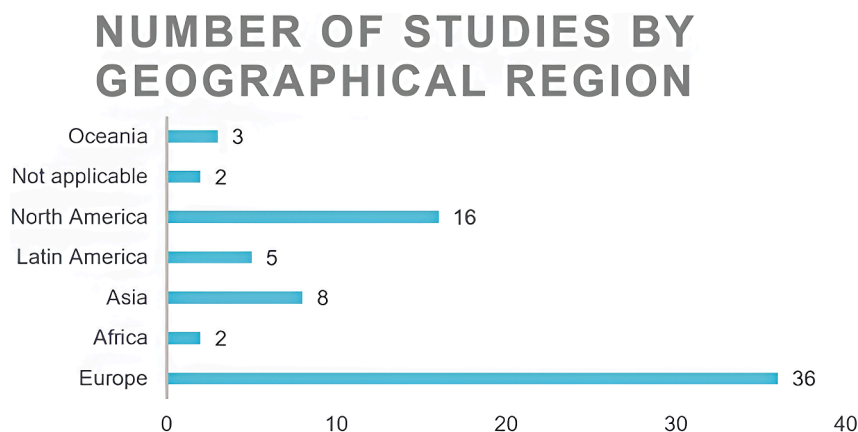


Fig. 3. Number of studies by geographical region. Author's own elaboration (2025).

TYPES OF STUDY

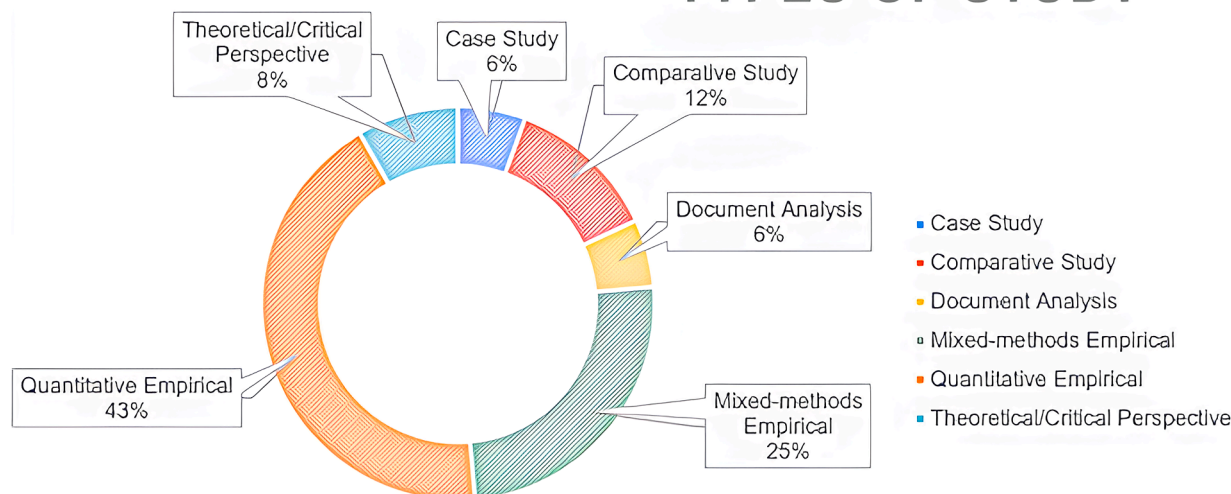


Fig. 4. Types of study. Author's own elaboration (2025).

A recurring misalignment is evident in urban planning that, although they often invoke multifunctional benefits ranging from social cohesion to biodiversity, base their siting criteria primarily on ecological considerations such as hydrology, space availability, and logistical factors, reflecting technocratic priorities [9]. Fragmented institutional arrangements and sectoral perspectives further hinder the integration of green infrastructure with equity, as institutional coordination and knowledge translation are frequently absent from planning processes, reinforcing technocratic and sectoral approaches [8,29,30]. Moreover, reliance on standardized metrics, such as square meters of green space, average temperature, or CO₂ captured, tends to narrow what is formally

recognized as a benefit of NbS [8].

Several studies argue that, for NbS to fulfill their objectives of urban sustainability, it is necessary to move beyond governance gaps such as the absence of mechanisms for distributive equity [12,14,29,30]. This includes addressing unforeseen trade-offs, such as green gentrification, rising property values, and the displacement of vulnerable groups, as well as ensuring distributive equity throughout the entire life cycle of NbS, rather than only at the moment of implementation [19,30]. It is also noted that global NbS frameworks often treat justice as a functional component, without addressing the structural roots of distributive inequalities. In such cases, justice becomes absorbed into planning

TYPES OF STUDIES X CONFLICT



Fig. 5. Types of study X Conflict. Author's own elaboration (2025).

instruments without questioning who makes decisions and who ultimately benefits [14]. These patterns are linked to where research is conducted, distributive conflicts rooted in vulnerability and deprivation remain less visible in underrepresented regions.

Distributional conflicts most commonly constrain access to green spaces, exposure to climate-related risks, and the allocation of ecosystem services, with benefits frequently accruing to areas or social groups that are already relatively privileged [15,17,30]. These unequal distributions undermine the transformative potential of NbS by reinforcing existing socio-spatial inequalities, limiting risk reduction for vulnerable populations, and eroding the legitimacy of NbS as justice-oriented interventions [4,14,30].

3.2. Recognition justice

The analysis of Fig. 5 shows that the most recurrent conflicts identified in the reviewed studies are related to governance, participatory processes, and recognition, indicating that the literature understands NbS as arenas of contestation over who decides, who participates, and who is heard. In quantitative studies, distributive, procedural, and institutional conflicts predominate, demonstrating that current scientific production acknowledges territorial inequalities in the distribution of NbS benefits and costs. However, such conflicts are generally identified through spatial and environmental indicators rather than through the direct voices of affected groups, which limits a deeper understanding of the social and political roots of these inequalities.

Qualitative empirical studies are not presented as a standalone category in Fig. 5, as qualitative approaches are embedded across case studies, document analyses, comparative studies, and mixed-methods designs, following the study typology defined in Section 2.2.

Mixed-method studies [21,24,31] capture more accurately the interdependence among the three dimensions of justice. In these works, procedural and institutional failures emerge as structural causes of distributive inequalities, revealing that participatory exclusion and fragmented governance are central mechanisms in the production of injustice within urban NbS. They also expose recognition gaps linked to the limited valuing of local perceptions and knowledge. Although recognition-related conflicts remain less frequent, they appear transversally across all study types.

Across the reviewed literature, recognition-related issues are acknowledged through references to ignored voices and the limited incorporation of local knowledge and perspectives [8,12,41,30]. However, compared to distributive and procedural conflicts, recognition is less frequently operationalized as a core analytical dimension [39,44,45]. As a result, recognition-related concerns recur across different study types, yet remain subordinate to institutional and distributive explanations. Recognition is frequently acknowledged at the level of discourse, with studies citing epistemic exclusion or the limited valuing of local knowledge, yet without translating these concerns into analytical choices that shape research design. In such cases, remains a contextual diagnosis rather than a dimension that informs variables, indicators, or evaluative criteria [44,45].

Ecological trade-offs and socio-ecological tensions, in turn, are rarely explored, indicating that the debate on conflicts prioritizes social and institutional dimensions over the environmental contradictions internal to NbS. Taken together, the findings show that the field is advancing in mapping these tensions [11,30] but still lacks approaches that analytically integrate them into the design and evaluation of urban NbS.

In general, the literature argues that genuine recognition requires identifying and legitimizing the multiple ways people relate to nature, without reducing them to technocratic logics of efficiency or conservation [8,14]. It emphasizes the cultural and historical value of local practices, calling for the confrontation of long-standing colonial and racial relations that have shaped the exclusion of minority groups [15,30]. Recognition justice should not be limited to the inclusion of voices but must also question the very frameworks that define what counts as

knowledge [8,14,30].

Transitions must include local and traditional knowledge in the design of NbS, recognizing Indigenous peoples and rural communities as holders of adaptive knowledge essential for restoring degraded ecosystems. This demonstrates that symbolic recognition alone is insufficient and must be accompanied by territorial protection, benefit sharing, and decision-making participation [24,30].

This is where studies show that, despite discourses of “inclusion” and “participation,” the NbS field remains dominated by expert communities that determine the language, indicators, and legitimacy of knowledge. Expanding participation is insufficient when it takes place only after technical framing, as local governments and international consultants continue to monopolize what is considered valid knowledge [8,30]. Recognition justice requires opening decision-making arenas to those who live with climate risks, not only to scientists and planners. Epistemic injustice occurs where local and community knowledge remains subordinated to technocratic forms [8,12,14,30]. Moreover, it is not enough to acknowledge technical or cultural knowledge; it is also necessary to recognize the emotional and symbolic bonds between people and their territory, as the failure to acknowledge the subjective and affective meanings of nature often leads to social resistance [25]. This pattern aligns with evidence showing that NbS research remains heavily concentrated in the Global North, where dominant epistemic frameworks are often reproduced with limited engagement with context-specific knowledge from the Global South [30]. As a result, locally grounded perspectives and alternative ways of relating to nature are less likely to be recognised within mainstream NbS studies.

3.3. Procedural justice

The analysis of procedural justice presented is grounded in the internal distribution of participation levels and approaches identified across the reviewed studies. The assessment examines how decision-making processes in NbS planning and implementation are described and evaluated through participatory arrangements, with attention to influence, continuity, and decision-making power. Fig. 6 shows that many of the studies reviewed fall under the Involve level (43%), indicating that public participation is recognized as a relevant component of NbS but is generally confined to specific stages of the decision-making process, without necessarily corresponding to co-decision practices.

In approximately one-third of the articles (31%), it was not possible to identify the level of engagement, as participation is mentioned in a generic or normative manner, without details on methods, actors, or stages involved. In these cases, the coding protocol did not allow classification within the IAP2 spectrum due to insufficient reporting of actors, stages, or participatory mechanisms. This recurring pattern suggests that participation is often invoked as a discursive principle of inclusion rather than specified as an analytically traceable dimension. Fig. 7 further indicates that both applied and critique-only studies are predominantly concentrated in the Involve and Not identified categories, reinforcing that participation is more often referenced as a normative or contextual element than translated into analytically traceable decision-making arrangements.

Across the reviewed studies, procedural justice failures are most often linked to the absence of active listening and co-planning processes, particularly when users' perceptions and lived experiences are not integrated into NbS design and implementation [6,8,28,30]. Procedural justice requires listening and co-production from the diagnostic stage, as planning detached from an understanding of who is being excluded becomes an unjust process [8,14,31]. It extends beyond formal consultation and calls for democratic institutions and practices capable of ensuring that affected groups can meaningfully influence decision-making processes, aligning procedural justice with participatory governance approaches in NbS. However, the literature cautions that participatory or co-creative practices may be mobilized without critically interrogating underlying power relations, institutional

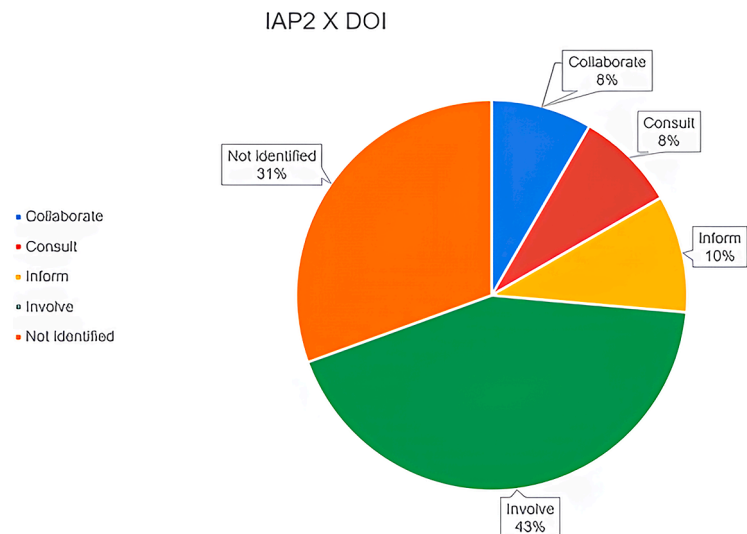


Fig. 6. IAP2 X DOI. Author’s own elaboration (2025).

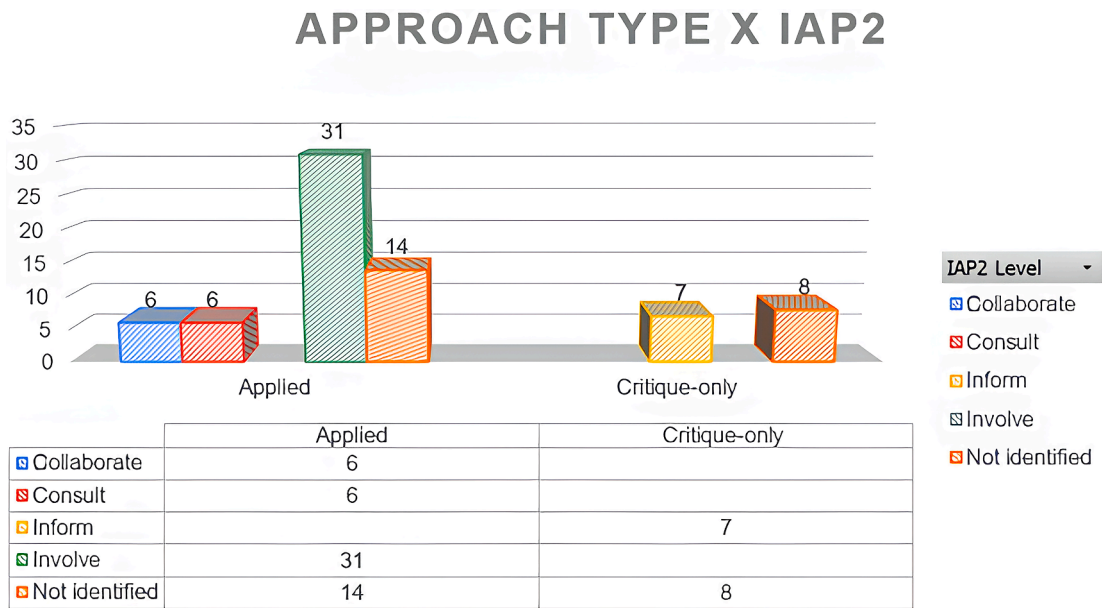


Fig. 7. Approach type X IAP2 level. Author’s own elaboration (2025).

arrangements, or the actual scope of influence afforded to participants. In such cases, decision-making arenas remain constrained by technocratic frameworks, limiting whose knowledge informs planning processes and potentially rendering certain social groups, experiences, and forms of marginalization invisible [6,8,14].

Fair procedural processes have transformative effects on individuals, shaping bonds, behaviors, and senses of belonging. Active listening to the perceptions and preferences of groups historically absent from decision-making forums is essential to ensure representation and to strengthen social ties and collective experiences of engagement. Excluding certain groups from the co-production stages means depriving them of the participatory experience itself, one that fosters belonging and collective awareness [26,30].

Beyond the creation of participatory arenas, institutional capacity itself must be transformed, a process that requires organizational reflexivity, whereby public institutions are able to continuously review their own procedures as new actors, values, and forms of knowledge enter the decision-making arena [14,30]. Continuous negotiation,

cultural adaptation, and critical revision of the norms and instruments guiding resource management are essential. When such institutional transformation does not occur, exclusion can be reproduced within administrative mechanisms themselves, causing even so-called participatory policies to preserve power asymmetries and technocratic control [15,30]. This helps explain why procedural justice may be reduced to formal participation narratives when governance models are transferred or replicated across contexts without sufficient adaptation to local institutional, social, and political conditions. As highlighted in the literature, some governance models circulate internationally and have been developed within Global North policy and research settings, a pattern that reflects the uneven global production and dissemination of planning frameworks rather than inherent limitations of specific regions [14].

3.4. Why justice matters for urban NbS?

Linking the findings to the global debate on urban nature-based

solutions within climate adaptation and sustainability research, NbS have been increasingly promoted as instruments to address climate challenges while enhancing the quality of life in cities [1,5]. However, the growing interest in their implementation does not exempt them from reproducing socio-spatial inequalities [8,9,14,30,32]. The evidence gathered shows that these solutions may, in fact, reinforce the very exclusions they aim to overcome. In this context, justice ceases to be a normative component and becomes a condition for legitimacy and effectiveness, only interventions that recognize and confront structural inequalities can generate long-lasting and widely shared benefits. When justice is not considered from planning through implementation, NbS become detached from the needs of vulnerable populations, undermining both their social and environmental sustainability.

The geographic concentration of justice-oriented NbS research is a structuring condition that shapes how environmental justice is conceptualized and operationalized. Studies produced predominantly in Global North contexts tend to privilege analytical lenses, indicators, and governance models aligned with those socio-institutional settings, which influences how distributive, recognition, and procedural dimensions are framed, measured, and interpreted. As a result, justice claims emerging from more vulnerable and underrepresented contexts remain less visible, not due to their absence, but because of asymmetries in research capacity, funding access, and knowledge production that condition whose experiences and priorities enter the academic debate.

The three structural tensions identified in this review emerge from the synthesis of recurrent critiques within the environmental justice and urban governance literature [6–8,12,14,19,30]. Studies have highlighted the dominance of technocratic rationalities [26,33,30,36], the marginalization of situated knowledge [8,12,14,26], and the prevalence of participatory arrangements with limited decision-making power in NbS processes [8,15,28,30]. By integrating these strands, we show how such tensions operate across contexts and constrain the justice-oriented and transformative potential of urban NbS.

The review revealed that although environmental justice is widely invoked in the discourse on NbS, its practical incorporation remains uneven and fragmented across the distributive, recognition, and procedural dimensions. The observed patterns indicate that the gaps in integrating justice stem not only from methodological or conceptual shortcomings but from structural tensions inherent to the NbS field itself. The first of these is the technocratization of approaches, which transforms social and political challenges into issues of ecological engineering, reducing the role of justice to a functional component of efficiency rather than a normative principle of redistribution and recognition. This instrumental rationality helps explain why so many implementations prioritize biophysical indicators over socio-spatial inequalities.

The second tension is epistemic universalism, in which global justice frameworks are uncritically transposed onto local contexts, erasing specific histories of exclusion and inequality. This lack of contextualization is particularly evident in studies from the Global South [11,24,30,32] where NbS are often presented as neutral solutions without considering colonial or racial legacies. The third tension concerns symbolic participation in consultation and co-creation processes that preserve decision-making asymmetries and fail to transform institutional power structures.

The three tensions identified operate as interdependent dynamics that shape how problems are framed, which forms of knowledge are legitimized, and who is effectively able to influence decision-making in the field of NbS. Technocratic tensions reveal the dominance of performance-oriented approaches, in which NbS are primarily assessed through technical or environmental metrics detached from social dynamics and governance arrangements that produce inequality. Recognition tensions expose how restrictive definitions of what counts as valid knowledge limit the incorporation of local experiences and situated knowledges, even in contexts where participation is formally acknowledged. Participatory tensions indicate that consultative and symbolic

forms of engagement continue to prevail, constraining the capacity of decision-making processes to redistribute power or to substantively challenge existing institutional arrangements.

Taken together, these findings suggest that addressing the barriers that constrain the transformative potential of NbS does not depend solely on expanding the number of implemented interventions, but rather on transforming the governance processes through which these solutions are conceived, prioritized, and evaluated. The reviewed literature indicates that integrating social and distributive criteria alongside ecological performance metrics, broadening epistemic foundations to include local and experiential knowledge, and strengthening participatory mechanisms beyond symbolic engagement constitute central conditions for reorienting NbS toward more just transitions. In the absence of such conditions, NbS tend to lose their transformative potential, reproducing pre-existing asymmetries and limiting public legitimacy by failing to promote effective redistribution of power within urban governance models.

4. Conclusions

We examined how distributive, recognition, and procedural dimensions of environmental justice have been addressed in urban nature-based solutions research. The analysis identified three interrelated structural tensions, technocratic, epistemic, and participatory, that constrain the transformative potential of NbS across diverse urban contexts. These tensions help explain why justice is widely invoked in NbS discourse, yet remains unevenly and fragmentarily integrated into analytical frameworks, governance arrangements, and decision-making processes.

Within the reviewed literature, mixed-methods studies were more effective in capturing the interrelations among distributive, procedural, and recognition dimensions of environmental justice, as they combine institutional, spatial, and experiential perspectives. However, these approaches still represent a relatively small share of the overall production of urban NbS. Nonetheless, the presence of all three dimensions of justice in most analyzed studies indicates a growing theoretical maturity within the field. At the same time, the strong concentration of justice-oriented NbS research in Global North contexts constitutes a manifestation of the epistemic and institutional tensions identified in this review, shaping which justice claims, priorities, and forms of knowledge become visible in the literature. As a result, justice dynamics rooted in vulnerability and deprivation in many Global South urban contexts remain underrepresented, not due to their absence, but because of asymmetries in research capacity, funding access, and knowledge production. Moving forward requires transforming the three dimensions of justice into guiding criteria for the diagnosis, planning, and monitoring of NbS.

Promoting justice is not merely an ethical aspiration but a condition for sustainability, essential for NbS to become truly effective instruments of urban transformation. We hope that researchers, practitioners, and policymakers recognize that their legitimacy depends not only on ecological effectiveness but, above all, on social coherence.

By bridging debates on environmental justice, urban governance, and nature-based solutions, the three structural tensions identified in this review point to the types of institutional, epistemic, and participatory capacities required to overcome them. Addressing technocratic tensions depends on strengthening governance arrangements capable of integrating social and distributive criteria alongside ecological performance metrics. Overcoming epistemic tensions requires expanding institutional and analytical capacities to recognize and incorporate local, experiential, and situated knowledge in NbS planning and evaluation. Finally, confronting participatory tensions entails moving beyond symbolic engagement toward decision-making processes that enable meaningful influence and redistribution of power. While these capacities will necessarily vary across socio-spatial contexts, particularly between the Global North and South, we underscore that the

transformative potential of NbS is inseparable from the institutional, epistemic, and participatory conditions through which they are governed.

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AI tools were used only for minor language editing under the full control and responsibility of the authors. All ideas, structure, arguments, and conclusions are entirely the authors' own.

CRediT authorship contribution statement

Luana Braz Villanova: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Bruno Peregrina Puga:** Writing – review & editing, Validation, Supervision, Methodology. **Marcus J. Collier:** Writing – review & editing, Validation, Supervision.

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.

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Supplementary materials

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Data availability

No data was used for the research described in the article.

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