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Pathways for mainstreaming nature-based solutions for climate adaptation: grounding, capitalising, embedding and anticipating across 12 Mediterranean cities



Erich Wolff[✉], Katharina Hölscher & Niki Frantzeskaki

The implementation of urban nature-based solutions (NbS) is gaining momentum, with significant efforts to advance the use of green walls, constructed wetlands, raingardens and other solutions in Europe. We examine nine case studies across the Mediterranean to analyse different mechanisms that contribute to institutional mainstreaming of NbS for climate resilience in urban and peri-urban areas. Drawing on targeted interviews and workshops with representatives of academia, governments and project managers, we offer insights into how these solutions can gain scale through different pathways that account for both disruptive and anchoring mechanisms by (i) adapting existing processes and gradually changing institutions (embedding), (ii) leveraging gaps in institutions and finding opportunities to build momentum from previous initiatives (capitalising), (iii) convincing actors and proving the effectiveness of NbS (grounding), and (iv) creating knowledge to respond to future demands (anticipating). Responding to unique policy landscapes and geo-climatic and cultural contexts, the cases offer insights into how different pathways can create institutional space for climate adaptation or leverage existing institutions to consolidate transformative change for implementing NbS in the Mediterranean and beyond.

The implementation of nature-based solutions (NbS) in cities, such as green walls, constructed wetlands and green corridors, is gaining traction globally^{1,2}. Generally understood as ‘actions to protect, conserve, restore, sustainably use and manage’ natural or modified ecosystems to address societal challenges (e.g. climate adaptation, environmental degradation, food production, water security), NbS are expected to support biodiversity, increase resilience and operate adaptively³. For this reason, urban NbS are part of a broader context in which society has been turning to nature in an effort to make cities more liveable, resilient and healthy environments for both humans and other species⁴. Growing concerns with the intertwined crises (i.e. interconnections between biodiversity loss, climate change, other planetary boundaries and their effects to human health and wellbeing) are contributing to a renewed interest in experimenting with NbS in cities in different contexts^{5–7}.

Our current knowledge on urban NbS for climate adaptation relies on learning from demonstration projects as means of exploring how to adopt NbS in cities^{8,9}. While this creates a strong evidence base from real-life projects, the ways in which these demonstration projects instigate change in planning practice and urban governance remain underexplored^{10,11,12}. Despite a decade of experimentation and investments in the development of guidelines, indicators and technologies, many gaps remain in our understanding of how these solutions can become mainstream practice. Major barriers relate to the institutional structures and organisational routines of how urban governance takes place: departmental siloes, rigid and narrow funding procedures, and expert-oriented decision-making, amongst others^{13–15}. This has led to a more recent focus on studies examining the process of ‘institutional mainstreaming’ of NbS in urban governance, which has been defined as ‘an ongoing, incremental process of creating and re-

Faculty of Geosciences, Human Geography and Spatial Planning, Utrecht University, Utrecht, The Netherlands. ✉ e-mail: e.meirawolff@uu.nl

Fig. 1 | Location of the 9 case studies (referred internally as demonstration sites or DEMOs) and examples of nature-based solutions being implemented in CARDIMED (updated to February 2026). Source: CARDIMED, Alexandra Tsatsou. **a** Raingardens and trees planted at the Saint Gerome campus of Aix Marseille University (France). Source: CARDIMED, Erich Wolff. **b** Green walls installed in a school in Ferla (Italy). Source: CARDIMED, Niki Frantzeskaki. **c** Example of naturalised school backyard in the region of Aragon (Spain) Source: CARDIMED, Erich Wolff. **d** Agroforestry system in the island of Lesbos (Greece). Source: CARDIMED, NTUA.



forming the institutional order of existing governance arrangements that determine how planning takes place¹⁶.

Mainstreaming NbS depends on gathering support within existing institutions or transforming institutions to accelerate their uptake. These topics are central to an emerging body of knowledge examining the mainstreaming of NbS through in-depth case studies^{13,17,18},

interrogating and applying concepts from sustainability transitions, such as the frameworks of amplification processes¹⁹ and strategies for scaling innovations²⁰. We contribute to this literature by drawing on the experiences from twelve locations (across nine different case studies illustrated in Fig. 1), implementing NbS across the Mediterranean region as part of the Climate Adaptation and Resilience Demonstrated

in the Mediterranean project (from here onwards referred to as CARDIMED).

Each of these case studies offers opportunities to observe how mainstreaming occurs, each shaped by a combination of different mechanisms that can include opportunities for making NbS knowledge accessible to new audiences and efforts to integrate NbS into local policies²¹. Considering the influence of the various mechanisms in mainstreaming, we ask:

What are the pathways advancing the mainstreaming of nature-based solutions in cities during and post-implementation? To answer this question, we introduce ‘pathways for mainstreaming’ as a bridging typology that emphasises the interrelations between mainstreaming mechanisms (conceptualised in the next section). We understand ‘pathways for mainstreaming’ within urban governance as the ongoing interplay between different mechanisms conducted by actors across jurisdictions, disciplines and institutions contributing to the uptake of NbS in practice.

Considering the lessons from real projects implementing NbS allows us to observe the complex reality of institutionalisation, overcoming the simplistic assumption that niche experiments are automatically reproduced, expanded, or integrated into policy. Instead, we propose a more nuanced examination of actors and actions in the process of mainstreaming NbS as a response to calls for more research on institutionalisation. Aligned with previous investigations^{4,22,23}, our study of mainstreaming NbS in urban governance is based on a close observation of ‘institutions in the making’ to examine, for instance, the flexibility allowed in existing regulations and the willingness of local actors to embrace reflexivity.

Examining the mainstreaming of nature-based solutions

The literature exploring efforts to mainstream NbS indicates that how these solutions are institutionalized depends on how willing professionals are to change their practices and on how influential innovators are in the creation of new policies. In this sense, understanding mainstreaming as a pathway and not as an outcome is useful to acknowledge that actors continually interact in multiple ways that circumvent, challenge or transform institutions to support the uptake of NbS. In this text, we understand *actors* as the organisations or stakeholders who are directly or indirectly engaged in the reproduction or change of current processes, which can include representatives of government, civil society, non-governmental organisations, as well as members of academia and the private sector^{24,25}.

We situate the experiences from CARDIMED in relation to other works that have examined the uptake of NbS in different contexts^{13,17,18} to position the pathways to mainstreaming NbS as an integrative typology to study the institutionalisation of these solutions. A growing body of knowledge suggests that it is critical to examine the interplay between different actors in specific contexts to understand the processes that lead to the adoption of innovations from an institutional perspective²⁶. These actors and interactions shaping urban governance should, therefore, be carefully considered by implementers developing strategies for mainstreaming NbS within institutions, here defined as the ‘regulative, normative and cultural-cognitive structures that guide the behaviour of actors, such as laws, policies, standards, norms, values or cultural expectations’²⁵.

Looking at different actors and at how they can change to support the implementation of NbS is central to understanding how mainstreaming takes place in different contexts. Current scholarship indicates that the institutional mainstreaming of NbS depends not only on gradually including these solutions into existing policies, but also on transforming existing governance processes^{27–29}. The study of institutional changes, therefore, comprises investigations on how able institutions are to embrace collaborative and inclusive governance mechanisms and how willing actors are to operate in a more reflexive way^{10,30,31}. This is the object of study of the growing field of studies on NbS institutionalization^{11,32} and institutional structuration¹⁶, whereby actors experimenting with NbS may promote transformative changes to urban governance through different processes supporting the implementation of NbS on broader scales or different contexts.

Mainstreaming NbS refers, therefore, to how processes led by different actors can support transformative change, such as influencing policy to foster NbS or encouraging the replication of a successful demonstration project in another city¹⁹. Based on this understanding, this section reviews how the current literature on NbS conceptualises the different ways in which mainstreaming can take place through (i) mainstreaming mechanisms and (ii) amplification processes.

Theoretical frameworks for understanding mainstreaming

Mainstreaming NbS is critical to support cities in the process of accelerating transformative change towards a more sustainable future. In this context, we understand mainstreaming more broadly as ‘a transformative governance and planning process to inform urban planning practitioners and research for further uptake and adoption of NBS in cities globally’²¹. Examples from the literature offer insights into how different actors can both change existing institutions (including their rules, norms and procedures) and circumvent barriers preventing the adoption of NbS^{14,33,34}. As a result, reviewing this literature provides a useful reference to examine the various pathways through which the adoption of NbS is taking place in the case studies.

Lessons from other case studies across different contexts in Europe highlight that the processes through which NbS can be mainstreamed are often context-specific and complex^{9,18,35}. However, some mechanisms such as learning (e.g. dedicating efforts to embed lessons learnt into practices and policies) and experimentation (e.g. trying new forms of engagement, collaboration and co-production) have been observed widely²¹. Studying the mechanisms that contribute to the uptake of NbS requires, therefore, a deep examination of institutions, including legislation, professional practices and rules.

Understanding mainstreaming is often framed as an investigation into how institutions enable or prevent the large-scale implementation of innovations^{11,15,36} and into how these same institutions can be circumvented or transformed to allow for the uptake of NbS^{23,37}. In this sense, the processes through which NbS gain currency through the transformation, adaptation and challenge of institutions can be studied through various disruptive and anchoring mechanisms. The typology of ‘pathways for mainstreaming’ is used here to acknowledge the various actors advancing the implementation of NbS and how their actions create interplays between different mainstreaming mechanisms, often through a ‘learning by doing’ practice.

The examination of mainstreaming as multi-actor processes that unfold according to various mechanisms is aligned with other studies that investigated the uptake of NbS in Europe^{10,16,17,38}. The fields of social innovation and sustainability transitions, similarly, show that studying mainstreaming requires a careful consideration of how projects can gain traction across scales through processes that are led by various actors^{39–41}. This literature indicates that NbS can be promoted in different ways, including by fostering systematic transformative change, by investing in the expansion of landmark projects, or by successfully replicating promising small-scale initiatives^{16,42,43}.

Mechanisms for mainstreaming NbS. Studies that have looked at amplification processes and innovation diffusion within the specific field of NbS indicate that mainstreaming of these solutions depends on different actions and processes that allow for institutional change or adaptation. Adams et al.²¹ argue that mainstreaming mechanisms might involve ‘anchoring’ NbS within existing procedures or ‘disrupting’ them to promote transformation. These changes relate to how institutions engage in different processes and how they enable or prevent the implementation of NbS: while anchoring depends on integrating and creating learning opportunities to embed NbS into existing processes and policies, it can also be valuable to disrupt existing rules, practices and institutions to make space for NbS, replacing existing alternatives such as grey infrastructure or allowing for hybrid options. As a result, the shift towards a future in which NbS are considered mainstream in cities requires the recognition of the multiple ways in which existing

institutions can be dismantled, circumvented, adapted or leveraged to promote transformation^{16,22}.

Using an approach that anchors NbS within existing processes can be a powerful strategy to institutionalise change^{10,11}. Mainstreaming mechanisms that depend on integration and learning are well documented in the literature through case studies that explore how to anchor NbS into other policies^{33,44} or that address conflicting regulations that slow down the implementation of NbS. Mainstreaming NbS through learning differs from the business-as-usual approach by adopting an iterative and reflexive attitude that takes note of failures and builds new knowledge⁴⁵. When established, reflexive monitoring and evaluation practices create opportunities for learning and serve as an important way 'to evaluate day-to-day activities, decisions and progress' as well as to continuously reflect on long-term goals and examine whether they are being achieved and what changes 'on the go' can positively affect the project outcomes¹⁶. While a reflexive practice that promotes learning is critical for supporting the gradual adoption of NbS in supportive environments, a disruptive approach might be unavoidable in other contexts.

Mainstreaming can be slowed down when actors lack 'experience, knowledge and skills about design and facilitation' or encounter 'barriers due to existing planning routines and cultures'¹⁶, so the disruption of existing practices and institutions can also be a valuable opportunity for experimentation to emerge. Disruption can be a key force for mainstreaming NbS, for example, when stakeholders experiment with new technologies or when challenges to the status quo make space for more inclusive decision-making processes^{28,46}. Situating techniques developed in other contexts through experiments and trialling innovative governance systems is critical to ensure that NbS are appropriate to each context and relate to the specific needs of communities^{47,48}. Disseminating knowledge about NbS to unfamiliar actors and translating it into local practices depends on a collaborative institutional environment that is open for disruptions and can benefit from a flexible governance model that prioritises the co-development of local NbS.

Mainstreaming through experimentation and scaling are considered disruptive because they might depend on making space for NbS by circumventing existing restrictions or expanding existing practices to account for other perspectives⁴⁹. Examples of integration as a mainstreaming mechanism show that the implementation of NbS might require regulations 'to either open up narrow tendering procedures or avoid specific planning rules or land ownership problems'¹⁶. Disruptive mechanisms of mainstreaming should also account for the multiple values that mediate people's experiences with nature and the various social, ecological and cultural benefits of urban ecosystems³⁴.

While many efforts have been made to examine the uptake of NbS in cities^{2,12,50}, the terminology used varies significantly, leading to theoretical gaps, the conflation of different concepts and challenges in knowledge communication¹⁹. In this context, discussing NbS mainstreaming through an integrative typology that considers both mechanisms and their interactions is particularly relevant. By understanding mainstreaming through ongoing practices on the ground, we draw on the experiences from CARDIMED to outline a typology of different pathways for mainstreaming NbS. With this typology, we seek to facilitate the documentation of lessons and capture the interplay of the various actors and mechanisms that contribute to mainstreaming NbS.

Relevance of mainstreaming nature-based solutions in the Mediterranean

NbS in the Mediterranean region are expected to play important roles in the process of adapting cities to climate change⁵¹. The unique geo-climatic and cultural context of the Mediterranean means that the implementation of NbS in the region requires the development or experimentation with NbS that can address the unique challenges in the region and that can be aligned with local governance systems^{52,53}.

The use of NbS in densely populated areas in the Mediterranean faces a set of environmental and institutional challenges that are not yet well

studied in the literature. These challenges include local environmental conditions, such as an increased risk for water stress and substantial spatial constraints in densely populated cities⁵⁴. These challenges are further aggravated in some contexts by other factors specific to islands, reported in the global literature, such as increased costs, logistical barriers, and higher exposure to climate hazards^{55–57}. In the Mediterranean region, these factors intersect with various environmental, cultural and economic forces such as the growth of tourism and intensification of agriculture⁵⁸. While these forces can create new opportunities for NbS and sustainable development, they can also aggravate existing challenges by competing for valuable land and increasing the demand for water in drought-prone areas.

From an institutional perspective, previous studies reveal that epistemological, regulatory and participatory barriers are currently slowing down the uptake of NbS in the Mediterranean^{51,53,59}. Previous studies in CARDIMED showed that authorities and professionals in the region are not yet contributing to the creation of databases that can serve to inspire and share knowledge between different actors in the region, preventing collaboration and more inclusive practices⁵⁹. Other barriers identified in this study also indicate that technocratic approaches to NbS in the region at times marginalise other ways of relating to nature (such as affective memory, stewardship and cultural connections with fauna and flora) and frame community engagement as a burden to practitioners, instead of leveraging cultural bonds, local knowledge and community mobilisation to promote sustainable practices⁶⁰.

Well-documented barriers to NbS uptake in Europe are particularly relevant in the Mediterranean, including limited policy integration across scales, lack of expertise in some regions and an insufficient involvement of communities in the process of implementing NbS⁶¹. Narratives used to describe NbS in the region are still dominated by technocratic language, which fuels distrust between professionals, communities and governmental actors⁵⁹. The distrust between different actors is aggravated by insufficient monitoring and challenges to quantify and monetise the wide co-benefits of NbS (e.g. contributing to human wellbeing, promoting cultural connection or mitigating soil degradation), which when ignored can distort economic consideration (e.g. return-on-investment analysis by local authorities).

The Mediterranean also faces implementation challenges observed globally, such as institutional misalignments and governance barriers that can slow down the uptake of NbS^{2,14}. Fragmented governance mechanisms, institutional inertia, business-as-usual regulatory procedures, disciplinary silos, lack of continuity in implementation knowledge and a disconnection between long-term goals and immediate interests are some of the factors that have been observed in the Mediterranean, undermining efforts to mainstream NbS in cities^{52,58}.

Methods and case studies

In this study, we employed a qualitative, mixed-methods approach to uncover different ways of conducting mainstreaming within the teams involved in CARDIMED. We adopted a reflexive and iterative approach to conduct the research activities listed in Table 1 with the teams responsible for the case studies. The preparatory stages of this investigation included a series of activities to provide a conceptual framework and support the research activities:

- (i) Review existing literature and policies on NBS-related planning practices and governance approaches by identifying relevant reports, scientific papers, and policy documents that investigated the implementation of NbS in the Mediterranean region. This review provided the foundations for the theoretical framework used in this work.
- (ii) Identify key stakeholders involved in the implementation of NbS. Building upon the relationships established in the research consortium and on earlier mapping activities⁵⁹, we identified key actors (including urban planners, designers, and governance bodies) working within each case study. This step was important to book the initial interviews, which were later expanded to capture a broader set of participants representing the various organisations involved in CARDIMED.

Table 1 | Activities that supported the findings in this report

Activity	Engagement model	Goal	Number and group of participants
Section on Mainstreaming in Demo Action Plan (DAP)	Remote engagement: Each of the teams implementing NbS was asked to provide ideas of promising mainstreaming strategies	Identify initial understandings of mainstreaming based on the experiences of each team	The section discussing mainstreaming strategies was included in the reports for each of the 9 case studies
Interviews with CARDIMED actors (between March 2025 and January 2026)	Virtual/ in person interviews (for selected teams): Representatives of firms, governments, academia and other actors were invited to discuss their experiences	Document tacit knowledge and explore possible mainstreaming mechanisms in a 90-min interview	35 participants (from different sectors: academia, NGOs, private practice, and government) including all team leaders and representing all case studies
Validation workshop during the 2025 CARDIMED annual meeting in Zaragoza (Spain)	In person workshop (focus group format) with representatives of all teams, particularly team leaders	Validate findings and identify gaps in the knowledge from the previous stages	24 participants from different organizations present at the consortium meeting representing all case studies

(iii) Design interview guides and workshop material, building on existing literature and the specific context of CARDIMED, considering also documents produced in previous work packages and action plans. The interview guide and workshop material were designed to allow us to interrogate how the various actors understand mainstreaming and which mechanisms are being used.

Table 1 provides an overview of the main sources of data and activities that contributed to the findings in this report. The justification and explanation of the methodology used are provided in the following sections.

Early discussions in action plans

The starting point for our investigation was part of the text contained within the Demonstration Action Plan (DAP), submitted by each of the implementation teams in 2024. In this document, the teams were asked to reflect on their experiences and relationships to outline possible strategies for expanding their projects in the future. The teams received support on how to respond to this prompt, but no specific discussions were conducted to elaborate on the topic of mainstreaming, which allowed teams to openly envision possible mainstreaming options.

This analysis offered insights into the various pathways for mainstreaming NbS that could be envisioned across the region, showcasing the ways in which effective mainstreaming can take place based on the everyday practice of professionals. The ideas included by the teams in the DAPs were later brought to discussions in interviews, emphasising an interactive and reflexive process that allowed teams to continue exploring possible mainstreaming strategies over time. Reflexivity in qualitative research is valued for its potential to uncover tacit knowledge, allowing participants to explore ideas by critically reflecting on their own positionality (the recognition of one's own philosophical position, cultural perspective and personal background with regard to a particular subject) and experiences⁶². This was a central aspect of our investigation as we aimed to reveal understandings, experiences and habits that are often implicit and considered part of professional practice.

Interviews about mainstreaming

At the centre of our investigation, we conducted a series of interviews with various actors in CARDIMED ($n = 35$) to interrogate the different mechanisms and strategies that can lead to the expansion of the projects beyond the project funding period. Most interviews were conducted virtually due to logistical constraints, with a few exceptions when it was possible to align different activities within a single visit. The interviews took place between March 2025 and January 2026 and followed a guide (Appendix A) that encouraged participants to describe their work, the relationships and institutions involved in the implementation process, as well as the mechanisms that are currently informing mainstreaming plans.

The interviews were mainly conducted in English (primary language used for communication within the CARDIMED consortium) with exceptions when participants preferred to use local languages (including Greek, Portuguese, Spanish and Italian). The interviews were recorded and later transcribed (following oral consent from participants) to reduce the loss of data during the analysis⁶³. Using a semi-structured interview guide

was important to allow participants to steer the open-ended discussions, recognising that the various actors have different visions and unique expertise in their fields when planning and implementing NbS⁶⁴. The interviews also offered participants an opportunity to provide material on the financial, knowledge-based, and digital tools used by the teams through project documents or site reports.

The interviewees were selected using a snowball and purposive approach⁶⁵ that acknowledged the professional relationships between the different actors in the project. A full anonymised list of the interviewees and their profiles is presented in Appendix D. Some of the interviews were organised with more than one participant at a time, particularly when participants worked regularly together and felt that it made more sense to discuss the project as a group. In some cases, interviewees were not available for the interview simultaneously but had the opportunity to recommend other actors who could provide a different perspective on the implementation of each of the CARDIMED initiatives at another moment. Recruiting participants using this approach served as a platform to start broader conversations about mainstreaming in CARDIMED, allowing us to collect a diverse set of responses from actors in different roles, including professionals often underrepresented in the official narratives.

The experiences shared during the interviews allowed us to develop a typology of pathways for mainstreaming NbS (presented in the results) that emerged through the coding of the material. The coding process entailed the identification of key mechanisms relevant for each case study, which was then followed by the comparison with the experiences from other teams to synthesise the pathways. The findings were interpreted using an iterative process that aggregated the different experiences within similar groups based on the actors and strategies adopted locally. Other works interpreting the ways in which innovations emerge and gain currency have used similar methods, demonstrating the value of investigating mainstreaming using a multi-actor, iterative and qualitative approach^{19,20,66}.

Validation workshop at in-person meeting

The workshop, conducted to discuss the initial ideas from the DAPs and the findings of the interviews during the annual consortium meeting in Zaragoza, was critical to ensure that actors from different backgrounds within CARDIMED could express and collectively reflect on their experiences. This activity, conducted as a focus group workshop⁶⁷, was important to validate the findings and document how different actors interpreted the same process from their different perspectives.

The validation process during the workshop was based on a table (reproduced as Table 3 in Appendix B) that contained examples of mainstreaming strategies that were validated by the participants through discussions. The participants were then given the opportunity to continue populating the table with examples from their own experiences, as shown in Fig. 2. The table was then discussed collectively to ensure that the examples were reviewed and agreed upon by the group, promoting intercultural dialogues and accuracy in our work. The choice for this approach is useful to uncover not only strategies being adopted in CARDIMED, but also how they are understood and valued by those involved in different roles (including scholars, project managers, implementors and policymakers).

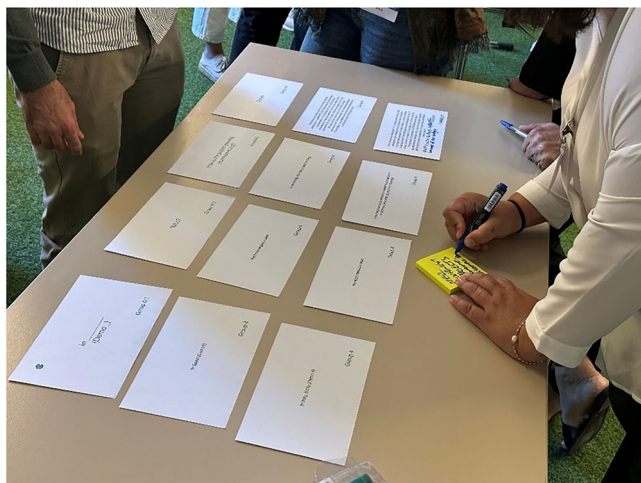


Fig. 2 | Photos from the workshop conducted in the consortium meeting in Zaragoza (Spain) in 2025. The examples discussed during this activity are shown in Table 3 (Appendix B). Source: CARDIMED, BIOAZUL, David Salaberri.

During this workshop, participants were divided into groups and had the opportunity to discuss their experiences with teams from other countries using their own words, which led to the identification of novel mainstreaming strategies not foreseen by the organisers. The use of this mixed-methods approach employing a series of reflexive activities to understand the mainstreaming of NbS is useful to account for different perspectives, and for this reason has also been used in other projects investigating the institutionalisation of NbS in different contexts^{16,17,68}.

The analysis and synthesis of the material, including data collected from the DAPs, the interviews and the workshop, used an abductive thematic model⁶⁹, which combines an inductive approach to account for novel types of mainstreaming and a deductive approach that used concepts from different frameworks, including the mainstreaming mechanisms and amplification processes. This approach, that accounts for categories described in the literature while also making space for new ideas⁷⁰, was particularly valuable to uncover new ways of conceptualising mainstreaming within the specific context of actors implementing NbS in the Mediterranean.

Context of the CARDIMED project

CARDIMED is a Horizon Europe action-research initiative implementing, documenting lessons and evaluating the use of NbS in the Mediterranean region. CARDIMED is a consortium of partners examining different types of NbS and drawing on the experiences from twelve locations across nine case studies (referred internally as demonstration sites): Quinta do Carmo (Portugal), Marseille (France), Catania and Ferla (Sicily, Italy), Alghero (Sardinia, Italy), Lesbos, Mykonos and Sifnos (Aegean Islands, Greece), Oinofyta (Central Greece), Nicosia (Cyprus), Zaragoza (Spain) and Izmir (Türkiye). The geographical location of the case studies is illustrated in Fig. 1. Through CARDIMED, researchers, government officers and practitioners are testing a variety of NbS tailored to local environmental, social and institutional contexts, including the construction of green walls, the restoration of riverine ecosystems, and the installation of raingardens. The full list of implementation partners and the types of NbS implemented in each of the case studies is listed in Table 4 (Appendix C).

CARDIMED is embedded in the context of growing concerns with water scarcity and increasing exposure to environmental hazards, such as heatwaves and floods, in the Mediterranean region. Alongside other projects funded by the European Union, CARDIMED is pioneering the development, implementation and evaluation of innovative strategies to improve water security and environmental conditions in the region and beyond. As a result, the project's case studies are valuable 'living labs'⁷¹ for testing new

approaches that can directly support the achievement of climate adaptation, resilience and biodiversity goals established in the European Union (EU) Climate Adaptation Strategy, the Water Resilience Strategy⁷² and the EU Nature Restoration Law⁷³.

The implementation activities in CARDIMED are overseen by researchers from various institutions with local coordination led by academic partners, private companies and regional or municipal authorities. The pilot projects are intended to generate knowledge, build local capacity and offer examples that can inspire local actors to learn from and potentially replicate successful NbS in new initiatives first within the demonstration sites (listed in Fig. 1) and later beyond CARDIMED.

Results and discussion: pathways for mainstreaming nature-based solutions

The interviews indicate that the various case studies in CARDIMED are mainstreaming NbS in the region through different pathways, relying on different mainstreaming mechanisms. The four main pathways, and the corresponding mainstreaming mechanisms that underpin them, are illustrated in Fig. 3.

The experiences shared by the implementation teams demonstrate that the mainstreaming process is deeply connected to local actors and their potential to embrace or resist change. The capitalising and embedding pathways for mainstreaming settle the institutional space, including by (changing frames and narratives, regulations, procedures and rules) to anchor NbS. The anticipating and grounding pathways, in turn, create new institutional space(s) and, in doing so, generate new institutions for the adoption of NbS. They serve as precursors to mainstreaming and signal an early-stage effort to promote the widespread adoption of NbS. Table 2 offers examples of how different mainstreaming mechanisms, both anchoring NbS and disrupting existing systems, are taking place within the case studies.

This section elaborates on these and other examples to further illustrate how actors are mainstreaming NbS in the Mediterranean by grounding in the local context to demonstrate efficacy, capitalising on existing opportunities and embedding solutions within existing systems.

Mainstreaming by grounding (experimentation + translation)

This pathway relies on visible, successful pilot projects serving as experimentation grounds and examples to inspire and promote further initiatives in the region. Using a 'show and tell' or 'leading by example' approach, projects grounding NbS in a specific context are underpinned by the notion that implemented examples are powerful platforms for convincing sceptical actors of what is possible to achieve. Actors engaging with this pathway believe that innovative projects capable of testing ideas and techniques on the ground are valuable strategies for mainstreaming NbS, as they play a central role in translating knowledge to the local context.

Experimentation is an important component in these projects, because many of them depend on testing technology developed elsewhere in a new context. Examples of how experimentation can lead the process of mainstreaming by grounding can be found in several CARDIMED case studies, particularly in *Cyprus* (case study 9). While the Gardens of the Future initiative in Nicosia has an established reputation for urban gardening, it has recently started an experiment with an aquaponic system using a system manufactured and installed by an Italian company. This experiment involved testing both the technology in place as well as new forms of maintenance and use of the system for educational activities regularly undertaken in the gardens. Despite initial challenges, actors involved believe that this pilot could be an important demonstrator of how this system could be adopted in other cities beyond the context where it was initially developed.

Projects grounding NbS in context also seek to change values and priorities within institutions, whether by convincing planners and engineers about the potential of NbS or by generating enthusiasm among communities and politicians. This was observed in the project in *Catania, Sicily* (case study 4), where scholars involved in the project brought their experiences of planning and designing NbS to debates with professional circles and local

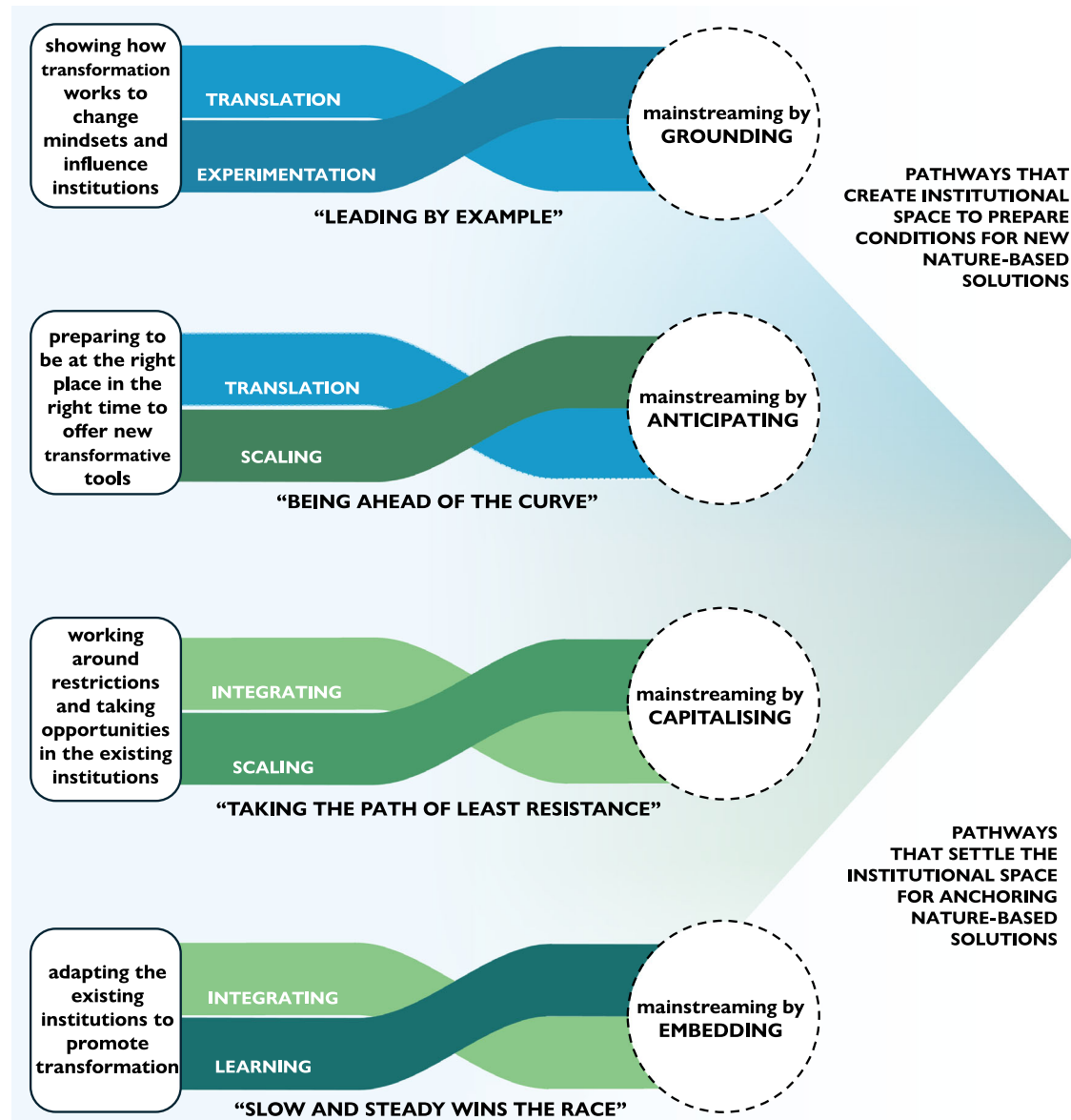


Fig. 3 | Four main pathways for mainstreaming nature-based solutions in urban governance (mainstreaming by capitalising, mainstreaming by anticipating, mainstreaming by embedding and mainstreaming by anticipating). Source: Elaborated by the authors.

government officials. This was facilitated by the ‘*Consulta del Verdi*’, a working group hosted by the municipality of Catania to discuss greening initiatives and their implications for the city. These strategies are aligned with efforts described in the literature as scaling deep or amplifying beyond, as they target changes in values and preferences among various actors involved with urban nature. This strategy is aligned with experiences with NbS in other contexts that advanced mainstreaming through approaches such as placemaking and co-design for NbS^{22,74,75}.

This pathway is at the centre of discussions in CARDIMED and was often mentioned in interviews. This is not surprising, as this pathway is the result of narratives arguing for the direct replication of successful initiatives that demonstrate the feasibility of innovations. This was observed, for instance, in the *Greek islands (case study 1)*, which is testing NbS in the islands of Mykonos, Lesbos and Sifnos to show how water retention systems, circular wastewater irrigation and agroforestry practices (shown in Fig. 1d) can be applied to the context of the Aegean Islands. The experiment of rebuilding traditional stone dams is particularly relevant as an example of locally developed techniques with cultural roots that can inform approaches for implementing NbS in the Mediterranean.

These examples ground the techniques in the context and have inspired neighbouring islands to seek resources to implement similar projects, creating a ripple effect through regional government partnerships. This outreach strategy, described as ‘replication through inspiration’, has been observed in other documented cases, as innovations gain traction when ‘individuals pick up ideas from media and get stimulated to start a similar initiative’⁶⁶.

Mainstreaming by capitalising (scaling + integrating)

This pathway involves gaining scale by capitalising on projects that are already established or seen as more feasible by key actors. By ‘taking the path of least resistance’, they find opportunities in existing networks, integrate with existing practices that are more palatable to risk-averse actors and avoid misalignments with existing regulations to accelerate the adoption of NbS. These strategies are aligned with approaches described as scaling deep by building upon existing relationships that can lead to broader acceptance of NbS, and scaling out by strategically finding ways to expand the number of people or places benefitted. Efforts to gain scale by capitalising are also recognised within the ideas of amplifying out, particularly when actors use

Table 2 | Examples from the interviews

Pathway	Main mechanism	Strategy	Strategy description	Location
Grounding	Translation	Using pilot projects as an opportunity to illustrate the potential of NbS within technical and policymaker circles	Case study 1 has created an example in the region that has attracted attention from other municipalities. As the NbS is implemented and monitored, this project is revealing how other cities in the region could adopt a similar approach. The team coordinating implementation activities with the municipalities has received multiple requests from other cities that are now interested in the project because of the precedent that was created in CARDIMED.	Greek Islands
Grounding	Experimentation	Approaching the implementation of NbS as an opportunity to inform procedures and innovate in the engagement with other actors	Case study 4 was developed in a context where many local institutions did not understand nature-based solutions and how they worked. The team used the Consulta del Verdi (local working group hosted by the municipality) to introduce the concept. This process means that CARDIMED served as an opportunity for the team to experiment with communication and to take part in discussions about the regulation of urban NbS in this location.	Sicily
Embedding	Integration	Engaging with multiple actors proactively by proposing ways in which procedures can be standardised across different government levels	Case study 5 brings together funding from multiple sources across the municipality, province, and national governments. The management of the project has started integrating accountability by connecting with these different stakeholders to ensure that they use similar metrics, indicators and processes, such as budget reporting procedures.	France
Embedding	Learning	Learning how different institutions can work together to facilitate the implementation of NbS that require approval and maintenance from multiple actors	Case study 8 had to work with different teams of the local municipality to learn how to embed CARDIMED with the operations of the city. This is important because different parts of the government have different roles, and the maintenance of the project will require funds and coordination of operations from the parks' authority. This has led to lessons on how different governmental institutions can work together to accelerate future projects.	Türkiye
Capitalising	Scaling	Expanding the benefits of the project by strategically joining forces with other initiatives to gain scale	Case study 7 leverages existing regional projects such as repurposed railway corridors to maximise the ecological connectivity of the restoration of rivers in the Montado ecosystem. The project also leverages CARDIMED to align local funds with EU nature restoration goals, leveraging ongoing initiatives to increase spatial connectivity and scale.	Portugal
Capitalising	Integration	Building momentum for NbS by integrating it to ongoing initiatives with established networks and knowledge bases	Case study 6 is connecting the interventions being developed in CARDIMED with other projects that already existed before. In particular, the team already has knowledge on the local partners and on the needs of the community through a project that had engaged with local schools and how they relate to climate change adaptation and climate action (Pacios por el Clima). This integration allows the project to grow quickly and communities to be continually involved through time.	Spain
Anticipating (hypothetical)	Translation	Building knowledge about how NbS could be economically valuable to spearhead innovative practices	Case study 2 is currently preparing the strategy to monitor the effects of the NbS implemented by CARDIMED. In doing so, it had to understand the existing effects of their operations, map how the current environmental conditions and learn about the possible outcomes that the intervention can have in the future. This process might have commercial value to partners and other companies, which could make NbS seem more desirable for other businesses.	Central Greece

their knowledge to spread the benefits of NbS to other projects, which was documented across different case studies.

The river restoration project in the region of Alentejo, Portugal (*case study 7*) is striving to maximise its ecological gains by leveraging synergies with other projects managed by the regional authority. The team involved in the project is also responsible for the conversion of abandoned railway lines in the region into cycling infrastructure, which intersect with the rivers and riparian areas being restored in CARDIMED. Recognising the ecological potential of integrating both projects to form a broad network of ecological corridors, the team is positioning this project as a strategic choice for achieving environmental goals in the region following debates about the application of the EU Nature Restoration Law⁷³. Building upon connected areas in the landscape is recognised in the literature as a promising strategy to mainstream NbS within a given region. This approach is aligned with recommendations for enhancing the potential benefits of NbS, gaining scale by connecting isolated projects to broader corridors within the same catchment⁷⁶.

The project in Spain (*case study 6*) is implementing NbS in school patios, capitalising on a growing interest in projects to mitigate heatwaves and their effects on children. Presenting NbS as heat-resilient solutions reduces resistance to NbS and capitalizes on existing greening projects in schools by integrating the NbS into the '*Patios por el Clima*' project that previously engaged communities in climate adaptation activities in educational contexts. The project builds upon the existing initiatives and offers new avenues for renaturalising school patios (illustrated in Fig. 1c), capitalising on existing expertise and public support while also contributing to ongoing debates about the governance and techniques used in this context⁷⁷. The governance of these projects, however, depends on careful integration with other policies such as the regional climate adaptation strategy⁷⁸, encompassing debates that range from how to incorporate these spaces into school curriculum to how to raise funding to maintain nature in educational environments⁷⁹.

The implementation of NbS in Turkey (Türkiye) (*case study 8*) exemplifies how projects mainstreamed by capitalising can strategically integrate with other policies to avoid restrictive procedures. The project planned to advance conservation efforts in an area of ecological relevance by building NbS that improve water quality and support educational activities in the area. Due to the ecological status of the location, considered a Ramsar Convention protected wetland, the permits for installation were delayed and only were able to proceed due to a strategic decision to use an adjacent area that was not considered part of the wetlands and was zoned for urban use. This example illustrates how actors with a deep knowledge of the system can integrate NbS into the existing regulatory framework to further facilitate their implementation.

Initiatives mainstreaming NbS by capitalising on existing relationships and institutions can also significantly benefit from engagement with communities through approaches that acknowledge diverse ways of knowing and experiences. Connecting personal experiences in the landscape with ecological knowledge is also a promising strategy to mainstream NbS, as it can foster a sense of belonging and improve awareness of environmental stressors in the long-term. This is a valuable strategy because increased interest in nature and awareness has been linked to improved conservation results and stronger environmental policies in the Mediterranean⁶⁰.

Mainstreaming by embedding (learning + integrating)

Mainstreaming by embedding leverages gradual change as the main strategy to adapt existing institutional arrangements through efforts to work within existing procedures and regulations. Adopting an approach of 'slow and steady wins the race', actors using this pathway believe that integrating NbS into existing regulation requires learning how procedures could be adapted and applying this knowledge to create integration. Building upon the ambition to change regulations and procedures, these NbS projects find ways to accelerate change by gradually modifying practices and accommodating innovations to facilitate growth and replication in the long term.

The removal of car parks to create rain gardens in the Marseille case study (*case study 5*) is advancing NbS in the region by coordinating multi-source funding. The policy team is currently advocating for more integration between different funding actors as a key strategy for mainstreaming solutions locally. The policy actors in the project have proposed a standardised reporting format, simplifying administration across diverse funders and contributing to the development of procedures that facilitate the implementation of innovative solutions beyond the project. Tackling bureaucratic barriers, this innovation reveals how to promote the uptake of NbS through integrative procedures that promote institutional change and facilitate the everyday work of teams implementing innovations. The institutional changes observed in Marseille are also taking place at different levels through an iterative learning process, transforming the relationship between actors that are not directly involved in policy.

The construction of naturalised rain gardens in the Aix-Marseille University campus in Marseille (*case study 5*) is being conducted in partnership with local actors, so standard procurement and contracting procedures established by the university apply. This means that the installation of the NbS had to be undertaken by contractors that were initially selected to provide conventional gardening, paving and landscaping services. These contractors had no previous experience with the construction of naturalised rain gardens, resulting in a process of 'learning by doing' in which staff had to practice new techniques to replace conventional procedures (e.g. slopes that direct water into concrete drains, weed-removal practices during the maintenance of gardens). While this has led to challenges during the implementation, it reveals the opportunities for learning that come with the implementation of pilot projects.

The use of integration as a mechanism to promote the uptake of NbS is also being observed in the case study in Ferla, Sicily (*case study 4*). This project is installing green walls in schools that serve as opportunities to familiarise the community with urban NbS. This is helping to shift local perceptions, but has encountered challenges to overcome restrictive professional guidelines that discourage the use of greenery attached to facades. The team is championing NbS in this context by acting as a knowledge translator that shows how the know-how of NbS can be applied in practice, in places that require new solutions to deal with water reuse and heat resilience. Beyond its potential to operate as an example (discussed in mainstreaming by grounding), the team has been actively engaged in providing contributions to revise local regulations through a report that provides practical advice to engineers and architects interested in green walls⁸⁰. Building upon lessons learnt from CARDIMED and previous research projects, these contributions are direct responses to building codes and explain how these solutions can safely be implemented using systems illustrated in Fig. 1b while complying with existing regulations and professional guidelines.

These examples reveal the critical importance of learning from the implementation of NbS pilots and then integrating lessons into existing policies and procedures, facilitating the adoption of these solutions in specific governance and professional contexts.

Mainstreaming by anticipating (scaling + translation)

While mainstreaming by grounding, capitalising and embedding have already been observed in practice, it is also worth noting that, at least theoretically, NbS can be mainstreamed through proactive strategies that account for possible policy changes, as represented in Fig. 3. The interviews reveal that actors in CARDIMED believe that NbS in the Mediterranean can be mainstreamed by anticipating changes, building upon emerging demands or 'being ahead of the curve'. The examples in Sardinia (*case study 3*) and central Greece (*case study 2*) illustrate how this pathway could accelerate the adoption of NbS in the region by catering to the demands of an emerging market that is looking for solutions for a growing concern with water scarcity.

The mainstreaming of NbS by anticipating the pathway involves translating knowledge between academia and practice and finding ways to scale transitions catering to emerging needs from businesses and regulators.

This pathway brings forward types and models of NbS developed elsewhere to ambitious actors and assesses economic feasibility and interest from local stakeholders, building expertise, adapting approaches that can be financed locally and adapting techniques to local contexts through learning and relationship-building. Backgrounding this pathway, the demand for new techniques and processes capable of repurposing wastewater is expected to play an important role within the context of the European Commission's Water Resilience Strategy published in June 2025⁷².

In Sardinia (*case study 3*), the translation of knowledge on how to treat water using NbS can be particularly valuable as there is an expectation that water reclamation will be encouraged in agricultural practices in the coming decade. Similarly, in Central Greece (*case study 2*), HALCOR's experiences with NbS in CARDIMED, if proven successful, can be economically advantageous for a whole industrial sector, setting a new standard for water treatment in industrial operations. These examples illustrate the need to further examine 'mainstreaming by anticipating' as a powerful potential pathway for supporting the uptake and financing of NbS in the region.

These experiences show that implementors willing to use these pathways see it as a disruptive strategy, since it responds to a demand that does not yet exist. Developing projects to respond to possible future needs requires actors to carefully reflect on who would be interested in the innovations developed, how they can overcome possible challenges and how this knowledge can be translated into different contexts.

Conclusions

The interviews show that the case studies are engaging different actors, changing institutions and pioneering new strategies to mainstream NbS (Table 5 in Appendix D contains a list with the roles of the interviewees and their institutional background). The four pathways for mainstreaming NbS are not mutually exclusive and often overlap within and across case studies, reflecting the complex, relational nature of scaling NbS in diverse Mediterranean contexts. The CARDIMED experience highlights the importance of both anchoring and disruptive mechanisms in the process of expanding the reach and removing barriers for the adoption of NbS. These strategies include institutional innovation, capacity building, and contextual adaptation as complementary efforts to mainstream innovative solutions.

The case studies offer new insights into ongoing debates about scaling NbS in Europe^{16,17,81} by bringing nuance to our understanding of how anchoring and disruptive mainstreaming mechanisms unfold. Many initiatives (such as in Portugal and Spain *case studies 6 and 7*) can only be successful when leveraging the knowledge and support of local actors, particularly communities living in the area. In France (*case study 5*), illustrated in Fig. 1a, the interviews showed that the removal of parking lots to make space for naturalised rain gardens in the university campus requires a careful consideration of the ways in which students and staff frame nature and how these framings inform maintenance operations (such as weeding and vegetation trimming). The teams have shown that mainstreaming requires reaching out to residents to discuss the projects, building support and creating momentum for growth through practices such as community workshops, citizen science and participatory mapping. The interviews indicate that all pathways can benefit from collaborations and connections with citizens, who share memories and experiences with nature, which are valuable starting points for building knowledge for NbS implementation.

The case studies provide useful insights into how various actors can build upon or adapt institutions in ways that can inform future initiatives embarking on the adoption of NbS at large. Expanding projects to promote integration with other policies and activities is critical for mainstreaming and currently shapes mainstreaming strategies, particularly in projects mainstreaming by embedding and capitalising. These examples show that NbS implementation when strategically aligned with other activities, such as low-intensity agricultural practices, can contribute to landscape diversity and community participation. These rich landscapes, shaped by cultural connections with the land, have been proven to support biodiversity and protect endangered species in the Mediterranean⁸².

While the case studies in Spain and Portugal (*case studies 6 and 7*) show the potential of mainstreaming by capitalising on existing initiatives and priorities, the experiences in the Greek Islands (*case study 1*) illustrate the influence that powerful examples can have grounding knowledge about NbS across networks. In several case studies, the teams involved in the project found synergies between the data collected and the demand for information to inform other local initiatives. Projects mapping urban heat islands (e.g. Patios por el Clima in Spain) and raising awareness of water scarcity (e.g. Drop of Dew short film in Italy) are natural partners for mainstreaming NbS. Actors involved in these projects have identified CARDIMED as an opportunity to further advance discussions about the potential of using greening as a strategy to mitigate the effects of climate change in the region. Similarly, the monitoring of temperature and drought conditions in France and Cyprus (*case studies 5 and 9*) conducted within CARDIMED are seen as valuable to local actors, creating a direct link that can ensure the continuity of the NbS and the embedding of the monitoring activities beyond the individual projects.

Serving as an integrative typology, the four pathways for mainstreaming connect different mechanisms and advance our knowledge of how institutionalisation occurs beyond specific contexts. The findings reiterate lessons from other studies that show that mainstreaming innovations from niche experiments to systemic change should not be seen just as a simple process of linear 'trial and error' followed by the roll out of successful experiments¹³. Instead, we show that mainstreaming NbS at the local, regional and global levels requires an in-depth consideration of how diverse actors undertake the design, implementation and maintenance of NbS and how they relate to existing institutions in this process.

The experiences from the Mediterranean case studies show that mainstreaming of NbS requires not only the replication of projects as a viable strategy but also the embedding of new technologies and bottom-up initiatives in institutions (e.g. ensuring the implementation of NbS can inform and be informed by national policies or regional strategies, or programs). The lessons learnt from the case studies are aligned with the experiences from other studies^{40,83,84} and provide insights into both the synergies and misalignments between current institutions and the large-scale implementation of NbS. The projects offer opportunities to understand how NbS can be integrated into existing policies, and how these solutions could inform a transformative change of broader urban governance models²¹. The experiences indicate that small and medium-scale NbS projects should not be seen as ends in themselves, but as opportunities for creating new knowledge that is context-specific, building professional and social networks and testing new governance models that are in return, stepping stones for mainstreaming NbS and progressing urban climate resilience.

Data availability

The interview data that support the findings of this study is stored at Utrecht University, but restrictions apply to the availability of the data to protect the identity and privacy of the participants. A summary of the dataset is provided in the Supplementary Information. Additional anonymised data is available upon request.

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Author contributions

E.W. contributed to the conceptualization, methodology, formal analysis, data curation, writing of the original draft, review and editing, and visualization. K.H. and N.F. contributed to the conceptualization, methodology, formal analysis, data curation, review and editing.

Competing interests

The authors declare no competing interests.

Additional information

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Correspondence and requests for materials should be addressed to Erich Wolff.

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