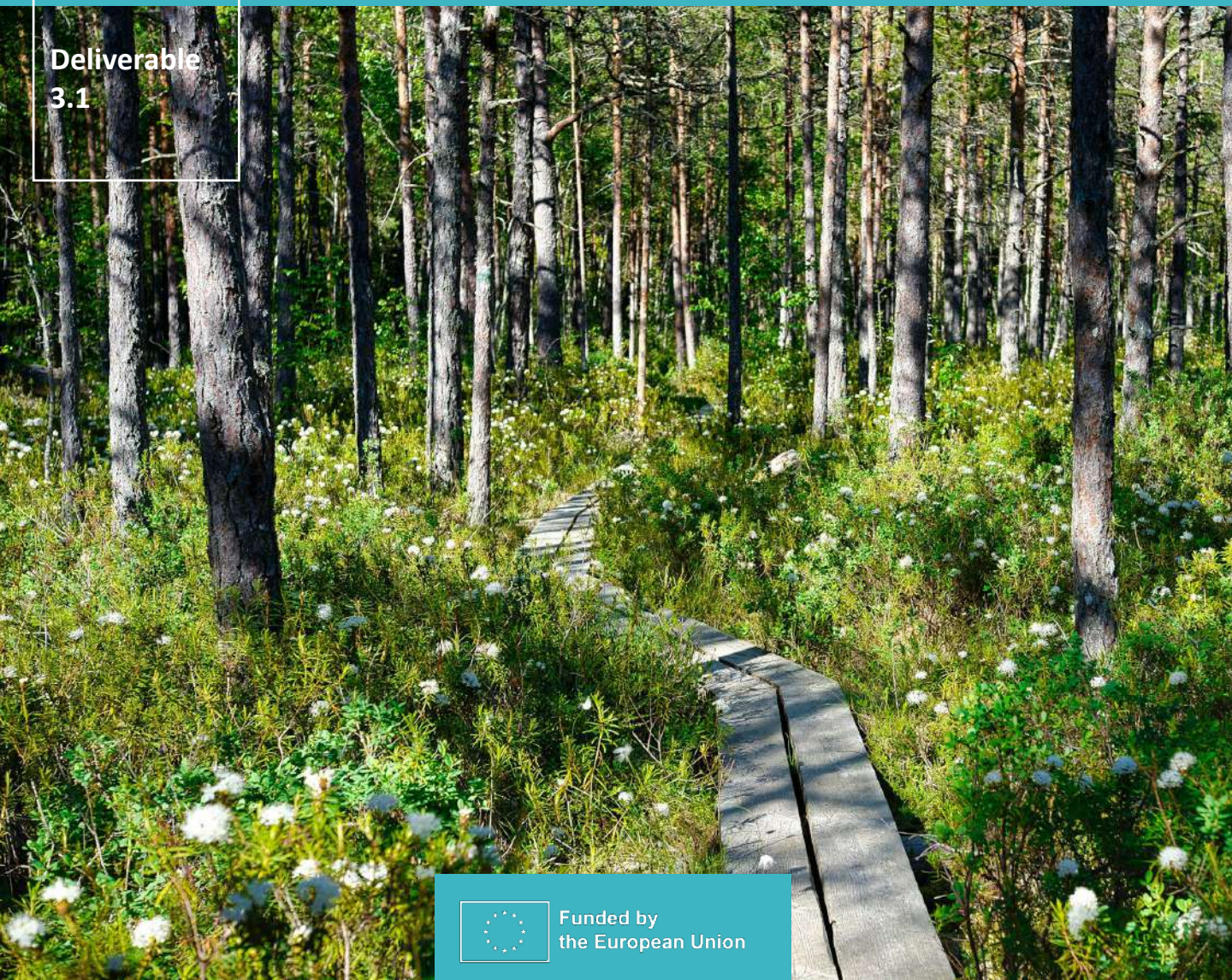




CLIMATE ADAPTATION AND RESILIENCE DEMONSTRATED IN THE MEDITERRANEAN REGION

A conceptual framework of knowledge pathways for mainstreaming Nature-based Solutions in cities and regions for fostering climate resilience in the Mediterranean

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Executive summary

This document outlines the conceptual and theoretical frameworks and principles that guide the exploration of knowledge pathways for the planning, implementation and governance of nature-based solutions (NbS) for climate resilience in the Mediterranean within CARDIMED. The approach recognises the transformative role of NbS in climate adaptation and highlights the importance of examining how knowledge is generated, shared and actioned upon across the different demo contexts. The theoretical framework builds upon the literature on dimensions of knowledge and knowledge pathways in the context of NbS to define the research scope and key questions. Using a transdisciplinary approach, it stresses the need for understanding NbS within local knowledge systems, in specific social and political contexts and through its connections with other governance mechanisms.

Knowledge dimensions

Understanding knowledge *in cities* emphasises how NbS relates to place-based knowledge within particular social, political and historic contexts. It focuses on co-creation and the role of communities influencing NbS to respond to local needs, priorities and cultural preferences. This dimension presents knowledge about NbS as a result of bottom-up, cross-sectoral place-making practices that make communities develop a sense of ownership towards NbS. Understanding knowledge *with cities* is premised upon the examination of collaboration between different actors and governance mechanisms that facilitate the uptake of urban NbS. This dimension acknowledges the various knowledge systems in cities that can inform changes and the production of NbS. Particularly in contexts shaped by different cultural, political and environmental forces, it explores co-production processes, and the actions of multiple stakeholders engaged in the conceptualisation, planning, design and implementation of NbS. Understanding knowledge *by cities* focuses on interrogating how knowledge is produced and disseminated in different realms (between cities, regions and institutions) including across scales and by both vertical and horizontal diffusion. It delves into the mechanisms that slow down knowledge sharing or that allow for policies, guidelines and success cases to be documented and shared among cities embarking on the implementation of NbS.

Principles

The research approach is guided by three principles to foster transformative climate resilience through NbS stewardship. These principles ensure that the research approach is:

Inclusive and empowering by recognising the importance of intersectional inclusivity and accounting for the diversity in the communities in its multiple forms and dimensions. The research empowers others through and with sharing knowledge and information, resources and decisions.

Connected to the context dynamics in and with place by recognising local specificities and being sensitive. The research is attuned to the character of the communities but is not necessarily constrained by current circumstances and limitations of each context.

Open to social innovations and future-oriented by recognising what exists to leverage its potential for the future. The research builds on existing relationships and their openness to fostering stewardship and transformative change in all scales.

Conclusion

The conceptual and theoretical background, as well as the principles adopted, are aligned with a research approach that champions context-based, inclusive and sensitive actions to inform the implementation of NbS. This approach stresses the need for integration between NbS and other policies while also accounting for different knowledge systems, narratives and values. By examining the different dimensions of knowledge, this research offers important insights into how NbS can be shaped by collaboration, diverse voices and empowered communities. The principles adopted in this research are key to informing a practice that reveals pathways to enable the adoption and mainstreaming of NbS for climate resilience in the Mediterranean region.

1 Introduction

Mainstreaming of nature-based solutions for climate resilience is hurdled by many barriers that have been documented over research on governance and planning (Castellar et al 2024; Sarabi et al 2022). An under investigated barrier relates to the unfit institutions to deal with the integrative nature of nature-based solutions that underlie the organisational silos and related complexity in identifying under which sectoral policy they will be implemented (Frantzeskaki et al 2020). Especially in governance contexts where policy implementation is plagued with delays and limited accountability due to institutional fragmentation, an institutional “surprise” of progressing nature-based solutions for climate resilience requires a closer look. From empirical observations and former conceptualisations (Adams, Tsatsou and Frantzeskaki 2025) we conceptualise (and argue) that in such contexts, knowledge can be instrumental in shifting systemic barriers to transformative action in cities, mainly how knowledge is mobilised and accessed about and for the implementation and management of urban NBS, the strategic or organisational ‘disorganisation/fragmentation’ that constructs silos rather than bridges for common knowledge and understanding across issues, sectors, and disciplines (Frantzeskaki et al 2019a, b; 2021; Nesshover et al 2017; Woroniecki et al 2020). For those knowledge-driven processes, a closer examination is needed to understand how they are organised, how they shape and are shaped by the institutional context (planning context) in which they are embedded and operate (van Cauwenbergh, 2022). It is thus essential to better understand how knowledge is used and has implications for the systems in which knowledge is produced, by whom, and for what or whose purpose.

Why to look at knowledge and knowledge pathways?

The governance of NBS requires the engagement of actors from multiple levels (micro, meso, macro, and transboundary - Sarabi et al., 2019), multiple disciplines (policy, planning, engineering, ecology – Frantzeskaki et al 2019), and knowledge from experts and locals for their design, planning, and management to be sustainable over time. All these interactions and collaborations between different actors, disciplines, and cities for the governance of NBS create complex settings of socio-political relations that require institutional readiness and institutional space to emerge and operate (Malekpour et al. 2021). Therefore, the wide variety of NBS characteristics and typologies call for different types of knowledges to be included in and weaved in their planning and governance (Collier et al 2023). As thus, considering that NBS are identified as strategic interventions that can achieve multiple urban resilience goals (Raymond et al 2017; Frantzeskaki et al 2019) like dealing with climate change impacts and social well-being, provides cities with an opportunity to mainstream nature-based innovation, enhancing healthy urban environments and building climate resilience.

The role of NbS in providing multiple benefits to people has led to a renewed interest in employing the knowledge generated from them to support climate adaptation, particularly in historically marginalized contexts (European Commission 2024; Greenwalt et al. 2023; UN-HABITAT 2023). Without knowledge of local implementation strategies and ways to overcome existing barriers, NbS are expected to be less effective at supporting biodiversity and improving access to ecosystem services to those who need them the most (Remme et al. 2024). Efforts to learn from previous experiences play a key role in a broader agenda that calls for research that is reflexive and that contributes to climate action through a critical approach (Preston et al. 2015; Ramirez-Lovering et al. 2020). Learning from how specific projects have expanded and built upon the knowledge that is grounded, in this sense, can be a unique opportunity to accelerate the uptake of NbS in less studied contexts such as those in urban peripheries or the Global South (Torres et al. 2023).

Experiences with NbS globally show that urban planning policies are gradually making space for new knowledge pathways in which climate adaptation, biodiversity protection and urban greening strategies can be integrated (Van Der Jagt et al. 2023). One of the ways in which this integration can be achieved is through the emergence of new forms of urban governance that build upon local knowledge and successful projects advancing the stewardship of nature in cities (Rauf et al. 2024; Toxopeus et al. 2020). Repositioning local knowledge pathways as a central element guiding the implementation of NbS is timely as it can reveal new opportunities for projects to grow and adapt to new environments. Building on this knowledge to inform context-specific governance models can help NbS solutions achieve their full potential (Castaldo et al. 2025; Frantzeskaki et al. 2019; King et al. 2023).

Analysing knowledge pathways can fill in gaps in our understanding of how this impact can be amplified. Examining the knowledge pathways that derive from implementing NbS in the demos (in the place-based NbS projects that will be realised within CARDIMED project) can provide insights into how similar projects can be embedded within more extensive climate adaptation strategies, scaled up, and maintained in the long-term future. Insights into these pathways can inform the practices used in other projects, ensuring that NbS are fair and produce equitable outcomes (Diep et al. 2022; Cousins 2021). With this, we openly conceptualise “who is the carrier” of the knowledge that is not limited to experts/scientists and “for whom” this knowledge is aimed at and will be used to not be limited to planners and policy makers.

2 Inclusive governance of nature-based solutions through knowledge pathways

In light of the above, conceptualising knowledge as a medium for institution building requires a conceptualisation and empirical investigation in terms of:

- **Mechanisms** - processes in which knowledge is produced, mobilised, assessed and used (Section 2.1);
- **Pathways** - pathways in which knowledge mechanisms are employed, through multi-actor relations across scales. To identify these pathways, the perspective of geographies of knowledge is brought up and constitutes the conceptual underpinning from a synthesis of current literature. The geographies of knowledge will be also employed as an analytical lens to guide empirical research for mapping and understanding who, by whom, and in which way knowledge mechanisms are employed (Section 2.2);
- **Settings** - science-community-policy/planning action situations organised through transdisciplinary research that ensure knowledge is actionable for climate- and ecologically resilient and sustainable cities. To design these settings, we first conceptualise and draw guiding principles to guide the transdisciplinary research designs that will underline and facilitate these settings (Section 2.3).

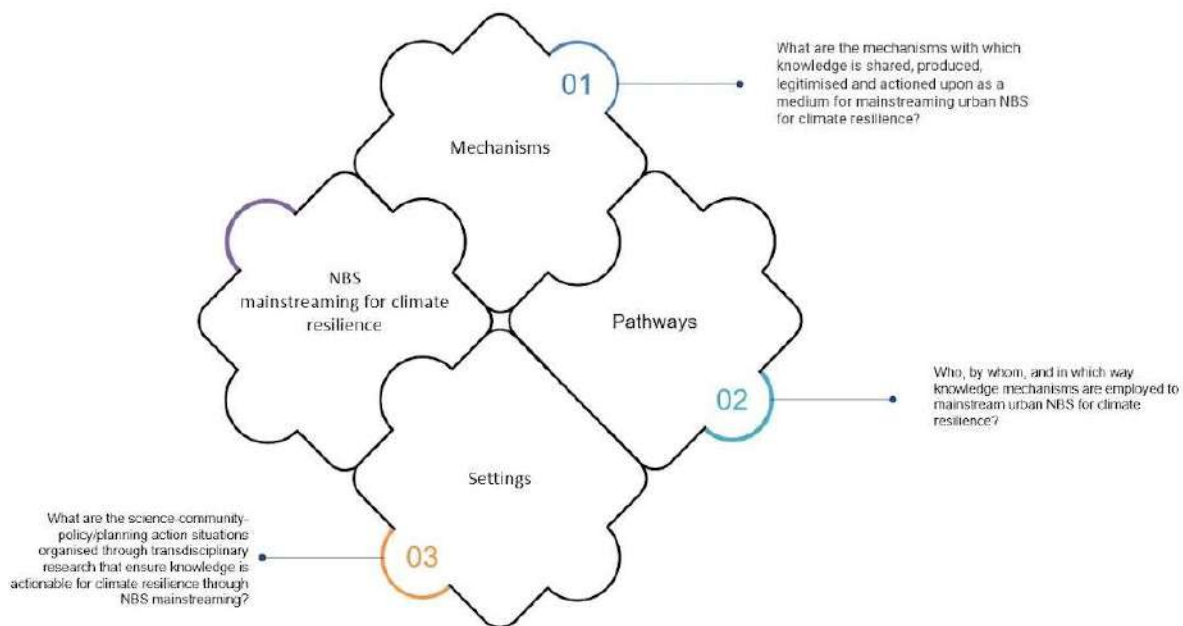


Figure 1. Proposed elements of the conceptual framework to guide the empirical work for identifying knowledge impact pathways for mainstreaming urban nature-based solutions for climate resilience.

2.1 Knowledge mechanisms: What are the knowledge mechanisms identified in the literature pivotal for NBS mainstreaming for climate resilience?

Our proposed conceptual framework aims to unpack the multiple and diverse settings of knowledge exchange that contribute to creating resilient cities through the adoption, implementation, and management/maintenance (use) of urban NBS and their governance (building from the work of Adams, Tsatsou and Frantzeskaki 2025). The overarching research question that guides the conceptualisation is: How does knowledge about urban NBS and their implementation in cities develops/grows through the interaction of multiple actors to cumulatively build (through learning from each other) the knowledges that drive best practices for NBS mainstreaming? We identify three knowledge mechanisms:

2.1.1 Knowledge sharing and transfer

We define knowledge sharing and transfer as a process of exchange, which is useful for understanding how best practice and practitioner knowledges are exchanged among different cities (Ilgen et al 2019). This is particularly important to understand how practice knowledges of urban NBS can (co)evolve and inform implementation. Therefore, knowledge sharing and transfer describes the processes by which knowledge becomes socialised or ‘commoned’ within or across a discipline, profession, or community of practice. For example, urban NBS knowledge and practices that are (co)produced can be diffused through knowledge networks that urban actors have access to without necessarily creating the knowledge (science-base, research, design, innovation) themselves. The knowledge sharing and transfer process focuses on who (co)produces or creates urban NBS knowledge that is actionable for enabling transformation in cities. This is important as

Negev and Teschner (2013) point at knowledge co-production filling the uncertainty gap of technical knowledge (cited in Grace et al., 2021). Knowledge sharing examines how knowledge systems (networks, national platforms etc) are configured to facilitate/trigger learning through accessing and participating in urban NBS knowledge networks. Therefore, this knowledge process seeks to capture and represent the ways urban NBS knowledge(s) are shared and reinforced in urban planning practices, design, and decision-making processes.

Knowledge sharing and transfer are important mechanisms to trace and as thus, understand how knowledge can become actionable. Firstly, it is helpful for understanding how knowledge systems are or can be mobilised, through multi-actor inclusivity and actions. Secondly, to appreciate diverse knowledges and how actors communicate across sectoral and disciplinary boundaries or silos. Thirdly, the impact of knowledge and innovation from one place to another can help to understand the impact of 'iconic' projects, such as the benefits of sharing knowledge and how this contributes cumulatively to the thinking and action in cities for climate resilience. Networks of knowledge(s) in cities are essential for a deeper understanding of reflexive urban governance (local, metropolitan, international).

2.1.2 Knowledge integration and weaving

We define knowledge integration and weaving, following from Tengö et al. (2017), as a process that brings together multi-actor and multi-knowledge traditions to enhance action towards more resilient cities. Therefore, knowledge integration and weaving describe the process in/with which knowledge that supports, underpins, or justifies decisions and actions and how this knowledge(s) are used in urban politics, policies, and practices. The knowledge integration and weaving process elevates diverse sources/(co)producers of knowledge and therefore attempts to transcend dominant knowledge claims and assumptions to allow the weaving of different, particularly non-western/science knowledges such as local and Indigenous knowledges (Tengö et al. 2017).

Knowledge weaving is also empirically investigated across a small number of case studies currently with the work of Woroniecki et al 2020 presenting Kenya case studies as a key area where Indigenous and Scientific knowledge shared, combined and brought together, but also where the separation around monopolies of knowledge are present: "These cases revealed that communities embraced both indigenous and scientific knowledge, and that this knowledge was shared and practiced through peer-to-peer learning" (p. 7).

The knowledge integration and weaving process conceptualizes knowledge as a boundary-spanning object (Opdam 2015, Willems 2022) and therefore focuses on what can connect or enable linking of knowledge systems. This knowledge process emphasizes the justice/equity aspect of multi-actor inclusivity to understand whose knowledges and practices are prioritized, elevated, incorporated, or ignored. It also has implications for how multi-disciplinarity is understood and operates/functions in terms of the knowledge and experts that are influential in decision-making processes (e.g. engineering solutions versus nature-based solutions). Further, this can help to understand the degree/level of plurality in the urban NBS knowledges and practices that is adopted by/in different cities.

The knowledge integration and weaving processes of urban NBS is important to unpack and understand the diversity of knowledge, such as from experts, policymakers, politicians, local, and Indigenous knowledge traditions, and their contributions to creating climate-resilient cities. Therefore, it can help to better understand how multiple knowledge systems can be bridged, i.e. how urban NBS knowledge integration and weaving happens. This is important for understanding the configuration of knowledge systems and therefore

which knowledges and practices create, design, plan, and manage/maintain urban NBS interventions, projects¹, and programs.

“There are hundreds of nature-based technologies that need to be considered as potential climate-resilient infrastructures. It is possible to weave ancient knowledge of how to live symbiotically with nature into how we shape the cities of the future before this wisdom is lost forever.” (Watson, 2020)

In this way, the knowledge integration and weaving process seeks to understand which knowledge is used and how it is used, i.e. who and whose values and interests are included in governance decisions/processes/actions. This can be seen in participatory planning processes, knowledge co-production, co-creation of plans, volunteers/citizen science. The integration and weaving of knowledge systems draws from multi-disciplinary knowledge perspectives and prioritises the inclusivity of diverse actors and knowledges. How different knowledge systems can interact, and be co-produced, is critical for understanding the knowledge, and values, that underpin the implementation of urban NBS, as well as who has a voice in these processes.

2.1.3 Knowledge translation

We define knowledge translation as the process of how knowledge can flow across multiple disciplines and ways of knowing (Caniglia et al 2019). Knowledge translation focuses on how urban NBS knowledge is communicated and re-purposed to contribute to or trigger reflexive governance processes beyond the originating city. The knowledge translation highlights that urban NBS knowledge translation is not ‘direct’. In other words, it emphasizes the agency of both the ‘creator’ and ‘receiver’ of knowledge, in that learning is not about replication of what has worked elsewhere, but rather about the adaptation of knowledge for a new city’s context. This is important given that connecting scientific knowledge to local context and becoming relevant for local dynamics and problems is a process of translation and co-creation. As such, setting up a knowledge co-production operating space for the cities aimed at creating capacity for sustainability and resilience learning in a dialectic way (Vilsmaier and Daniel, 2015). (As cited in: Grace et al., 2021).

The knowledge translation process focuses on generating understanding across knowledge systems for the purpose of learning and adapting urban NBS knowledges and practices for local, place-based contexts (i.e. environmental and ecological concerns and needs, socio-political structures and needs, etc). For example, to “adapt knowledge products or outcomes into forms appropriate to enable mutual comprehension in the face of differences between actors” (Tengö et al., 2016). For knowledge translation of urban NBS is important to

¹ Project or projects refer to any type of place-based nature-based solution consistently with how the word ‘project’ is used across the literature we have reviewed.

understand how urban NBS knowledge is used by multiple actors, whether they create ‘new’ knowledge and practices or adapt from the example of somewhere else. This flow of urban NBS knowledges and best practices can most clearly be seen in the learning that happens from exemplars or pioneers and the influence they have on the knowledges and practices of other cities (e.g. through metropolitan networks or international city-to-city learning networks). What is equally essential to the ‘original creators’ of these urban NBS knowledges and practices is the capacities and capabilities of actors in other cities to adapt and create their own transformative pathways through the methods/ideas they learn (i.e. not simple replication but complex processes of re-interpreting knowledge and practices to be relevant and effective in place).

To guide the empirical research on these mechanisms (who, how and what form they take), we propose the following formulated questions per mechanism and across all mechanisms (Table 1):

Table 1.- Questions to guide empirical research.

TABLE 1. QUESTIONS ON THE MECHANISMS AND HOW THEY CREATE INSTITUTIONS-IN-THE-MAKING FOR NATURE-BASED SOLUTIONS MAINSTREAMING FOR CLIMATE RESILIENCE
<i>Knowledge sharing and transfer</i> • How is knowledge about NBS operation and benefits shared across different stakeholders in the demo area? How is knowledge sharing initiated? • What types of knowledge are prioritized when planning and conceptualizing NbS projects? • Whose knowledge is shared and transferred prior to and during NBS implementation and post-implementation? • What alternate epistemologies/knowledge production processes can bring alternative perspectives to NbS? • What is the role of stakeholders/governance/planning structures to embed epistemological justice, and why is this important? • How are NbS, particularly those supporting greater epistemological justice and knowledge sharing, undermined by current power structures? <i>Knowledge integration and weaving</i> • How is knowledge of different stakeholders integrated in the planning (including maintenance and stewardship) of NBS in the demo cities/regions? • Whose knowledge is integrated and weaved? Whose knowledge is represented and recognised? • Whose knowledge frames debates/solutions/institutional processes? Are all stakeholders’ knowledge equitably represented? • What kinds of knowledge are lacking for the inclusive governance and planning of nature-based solutions in Mediterranean cities and regions? • How can diverse knowledge systems be valued and integrated? How can policy and practice be aligned to better support the recognition and integration of diverse knowledge systems in the mainstreaming of NBS? • What are the implications of privileging certain knowledge types or systems over others in the context of NBS mainstreaming? • What is blocking the integration and/or weaving different types of knowledge in NBS planning? What are the challenges and barriers to achieving epistemological justice and addressing power imbalances in NBS projects? <i>Knowledge translation</i>

- How is knowledge validated, used and translated within urban planning and governance to mainstream NbS for climate resilience?
- Which are the prevailing narrative frames for translating the impact/multiple benefits of NBS to, across, and with communities in the Mediterranean cities and regions?
- How do knowledge politics shape the discourse and practice of NBS?
- Why are different frames of nature crucial to understanding how different types of knowledge link to the planning processes around nature?

Reflection questions for identifying transformative research pathways for NBS mainstreaming:

- How does research itself favor specific epistemologies at the expense of others evinced in the research of nature-based solutions mainstreaming for climate resilience in the Mediterranean?
- What are the emerging trends and future research directions in knowledge integration, power dynamics, and epistemological justice for NBS?
- What alternate epistemologies/knowledge production processes can potentially bring alternative perspectives to NbS mainstreaming for climate resilience?
- How can knowledge production processes support or limit the mainstreaming of NbS?

2.2 Geographies of knowledge: What are the knowledge pathways pivotal for NBS mainstreaming for climate resilience?

In order to identify knowledge pathways, we use the theoretical lens of ‘geographies of knowledge’ to identify knowledge pathways in, with and by cities. Geographies of knowledge refer to the ways by which different spatial levels and contexts shape the knowledges produced within (Mahony & Hulme, 2016; Owens, 2024). This conceptual framing is used to explore how flows of knowledge occur at different spatial levels that surround, enable and impede the mainstreaming of NbS in cities. This multidimensionality is a response to the fragmentation and siloing identified in many urban contexts (Dickey et al., 2022), offering a route to encompass both the environmental and ecosystemic specificities in different contexts (i.e. cities, urban areas, bioregions), expanding strong need for epistemic justice and inclusive NbS identified prior (Woroniecki et al., 2020); where the diverse actors, knowledges and relationships must be situated with local needs, ideas and resources in order for them to have longevity (Mabon et al., 2022; Mahmoud & Morello, 2021; Mahony & Hulme, 2016; Pascual et al., 2023; Watson, 2020). This conceptualisation allows for examining the vertical and horizontal translation of knowledges by cities, within which the co-production of NbS, transformation visions and knowledge itself are all identified as ways to support inclusivity and longevity of NbS, and the stewardship of these NbS (Armitage et al., 2011; Basnou et al., 2020; Frantzeskaki & Kabisch, 2016; Hölscher et al., 2022; Mahmoud & Morello, 2021).

Within this conceptual framing, the dimensions of *in, with and by* aid in identifying what types of knowledges are present, and how the multidimensional flows of knowledge occur at different spatial levels. This is relevant to a broader framing of inclusive planning and governance of NbS in cities, centering the importance of situated knowledge (Heur, 2020; Wolff et al. 2022), and raising further questions around evolutions in changing climates, digital geographies, and the diffusion of knowledges contained in these spaces (Ash et al., 2018; Bulkeley & McFarlane, 2024), which this conceptualization seeks to respond to in order to support situated, inclusive transdisciplinary research within and beyond the CARDIMED project.

Despite these shared starting points and aims, we will build from and extend the conceptualisation by Holscher and Frantzeskaki 2019: the perspectives of in, with and by cities ask distinct questions about knowledge vis-a-

vis different spatial levels of planning and governing NBS. They look at place-based knowledge dynamics taking place in cities (“in”), the people-based dynamics to situate knowledge within urban systems (“with”), and knowledge dynamics on global and regional levels driven by cities (“by”). These entry points will elucidate differences of knowledge flows in mainstreaming NBS in cities. The differences are not contradictory: they generate complementary insights for understanding and supporting NBS mainstreaming given the different levels of aggregation, analysis and understanding of knowledge pathways.

These definitions build off (Hölscher & Frantzeskaki, 2021)’s conceptualisation of “In, By and For” cities, but given the focus on knowledge pathways in this conceptualisation we emphasize the place-based and people-based processes around/about knowledge as a means for institution-building to support urban NBS mainstreaming (i.e. “with” instead of “by”). The following table presents a set of analytical questions to unpack each of these dimensions: what type of knowledge? How are knowledge processes occur/work? Who and to what end the is part of the knowledge pathways.

Table 2. Analytical questions to guide a systematic literature review on geographies of knowledge for inclusive urban governance of nature-based solutions for climate resilience.

DIMENSIONS → ↓ KNOWLEDGE	IN	WITH	BY
WHAT KNOWLEDGE?	place based- knowledge embedded in place	people based	Spatial dynamics
HOW DO THESE KNOWLEDGE PROCESSES WORK?	How is knowledge generated, embedded, validated in relation to cities?		
WHO?	Who champions and drives NbS knowledge pathways?		
	Who maintains and sustains NbS knowledge pathways?		
	Who is Involved in the NbS knowledge pathways? (and at which stages?) Who gives legitimacy to knowledge?		

	Which are the local communities and civil society actors involved in the NbS knowledge pathways?	Who holds the knowledge about the bigger picture - e.g. city planners, issue-experts, scientists?	Who champions knowledge pathways for NBS mainstreaming?
TO WHAT END? (OUTCOMES)	Legitimation of local knowledge <i>for the design and implementation of NBS for climate resilience.</i>	Legitimation of knowledge pathways for NBS as a commons of multiple actors, contributing to <i>stewarding of NBS.</i>	Legitimation and <i>globalisation of knowledge pathways for NBS.</i>

Knowledge *IN* cities focuses on the **place-based knowledge**, including the local communities, entrepreneurs, etc. who are embedded in the specific place and site. Place-based knowledge is defined by the physical (i.e. urban form) and philosophical (i.e. imagination and representation) relationships between people and place. It is the result of the social construction by people responding to the opportunities and constraints of their locality. In this dimension, we align our framing with the elaboration presented by Hölscher & Frantzeskaki, 2021, where there is a need identified to “facilitate place-based innovation by going beyond sectoral infrastructuring and top-down master planning towards situated and cross-sectoral place-making”. This place-based knowledge focus is crucial to consider ensuring that local needs, ideas and desires are captured, that a continued sense of place and belonging is fostered in relation to the NbS, and that a legacy of co-stewardship is fostered through this knowledge being genuinely co-created, incorporated and situated in place.

This dimension raises questions about the range of different knowledge embedded in place, such as local knowledge, and the legitimisation of which can occur, but isn’t always done within NBS planning and governance. Thus, understanding the relationships and knowledge underpinning the material practices, which shape urban space (Tait and Jensen, 2007), and how to create spaces for place-making urban interventions, for instance by supporting and linking with bottom-up initiatives tied to their local contexts is crucial to understanding how planning and governance processes enable or impede the mainstreaming of NbS to take place in cities. Van Heur, 2020 argues that urban knowledge needs to be situated knowledge, a key part of the in dimension, going on to argue that urban knowledge must be “contributing to an understanding of research

as being situated and as part of substantive social relations.”, which is where the *with* dimension emerges. Co-creative place-making posits the co-creation process between people (e.g. citizens, innovators, policy officers, and scientists) and between people and place as a process that shapes and transforms their relations with place aiming at contributing to sustainability and resilience (Rauf, Wolff, and Hamel 2021). This results in new place-making narratives, understandings and meanings, and place-based interventions that care for both people and place. In this way, co-creation can leverage local ideas, needs and resources, and build and harness relationships and partnerships (Cousin 2021; Mahmoud and Morello 2021; Basnou et al. 2020).

Knowledge WITH cities sits adjacent to the “*of*” dimension elaborated by (Hölscher & Frantzeskaki, 2021), which covers outcomes of urban transformation dynamics in the urban (sub) systems, seeking to unpack the people, and their diverse knowledges, as key shapers of cities, for example within co-production processes, or the knowledge processes underpinning the development of transformative visions. This dimension thus looks to the way that knowledges emerging from “a place where multiple overlapping systems of different relationships are co-located: public and private, common and individual, formal and informal” (Sim & Gehl, 2019), impact the dynamism of urbanism itself as a process constantly in motion, rather than being static. Knowledge with cities further emerges as a critical dimension to consider in terms of geographies of knowledge due to its role in elaborating the knowledges which distinguish differences of “links between institutional geographies and the geographies which are the objects of institutional knowledge-making” (Mahony and Hulme, 2018) the former reflective of the *BY* dimension, the latter encompassing *IN*.

In furthering Sim’s explanation of how these relationships occur in cities where density of spaces creates density of ideas and people, knowledge *with cities* is where different knowledges that are not necessarily formalised in planning and governance structures are captured. In this regard, the dimension looks to historical shifts in the urban planning discipline, where Jane Jacobs has been a seminal figure arguing, as (Sim & Gehl, 2019) continue to do so, for the user, people and neighbourhood experiences to be centric in planning. Sassen, 2016 reflects upon Jacob’s influence, highlighting the impact of the erasure of this knowledge on place: “*She continuously returned to the issue of “place”, and its importance when considering the implementation of urban policies – notably the loss of neighbourhoods and erasure of local residents’ experiences*” Jacob’s work raises analytical questions around agency, exclusion, and the sharing of stories and knowledge- which may be temporal, historical or site specific. This dimension allows space for soft governance and power, intermediaries and less “formalised” or validated knowledges to emerge, ranging non-exhaustively from bottom-up experimentation, co-operative and community-based actions and initiatives (Hernberg & Hyysalo, 2024; Krogh & Roos, 1996).

Knowledge BY cities looks to the vertical and horizontal translation and diffusion of knowledge, and the ways that these fit together. These flows of knowledge shape NbS planning and governance in a city, and how others learn from it. In the vertical translation for example, regional level urban greening policies can result in programs (and funding) for NbS implementation, diffusing the projects *in* cities. Horizontal translation and diffusion capture knowledge flows across cities, which, using the previous example, could include city-level networks sharing knowledge, best practices, providing secondments etc. (mechanisms), to support the flows of knowledge about the NbS implementation, be it on site or into city/municipal planning mechanisms. Both vertical and horizontal translation and diffusion of knowledge move ideas across spatial scales, often in the form of more institutionalised plans and policies. A further example of the *by* dimension in action is “the “National Planning Policy Framework” in the UK that embraced sustainable urban drainage (SUD) legislation requiring municipalities to implement SUDs in residential developments with ten or more homes and in major commercial and mixed-use developments” (Sarabi et al., 2019).

Horizontal flows of knowledge are about the diffusion of urban NBS knowledge in other policy arenas, for example housing, transportation, infrastructure planning etc. The histories and practices of knowledge flows in institutional contexts greatly impact the ways by which “more flexible institutional mechanisms and bottom-up initiatives” (Bellinson & Chu, 2019) can be embedded or inhibited, where demonstratable experiences of collaborative learning proving effective build continued trust both in the process and the knowledge flows contained within. These layers need to be unpacked to understand how different networks operate to enable

or inhibit NbS, as well as addressing possible inequalities between cities, whose local contexts, climate risks, institutions and capacities can all differ greatly (Acuto & Leffel, 2021; Bathelt & Henn, 2014; Dickey et al., 2022; Sievers et al., 2024), supporting calls that NbS in planning move “away from neoliberal agendas and towards more emancipatory and just socio-ecological futures” (Kotsila et al., 2021). Vertical flows of knowledge are about diffusion, sharing and translation of knowledge with city-networks and transnational organisations. In the context of the Mediterranean bioregion within which the CARDIMED project sits, these geographies of knowledge are important to consider conceptually due to the “need to pay attention to epistemic and power dimensions that tend to be hidden in NbS” (Woroniecki et al., 2020), which are compounded by geographic factors that shape the institutional arrangements, soft-governance arrangements, research and project opportunities, implementation challenges, and relationships in place facilitating or inhibiting knowledge flows.

As we further consider the Geographies of Knowledge and dimensions within, conceptual questions emerge as follows within Table 3. These questions aid in supporting transdisciplinary empirical research, a process for activating knowledge/pathways and mechanisms for which is elaborated in 2.3. This will be embedded in the empirical research in CARDIMED:

Table 3. Questions to guide empirical research on knowledge pathways in, with and by cities.

TABLE 3. QUESTIONS TO GUIDE THE EMPIRICAL RESEARCH IN MEDITERRANEAN CITIES FOR IDENTIFYING KNOWLEDGE PATHWAYS FOR MAINSTREAMING NBS FOR CLIMATE RESILIENCE.	
In (cities)	• How are different forms of knowledge excluded or included from place-based NbS? • What historical and temporal place-based knowledge are present? How are these knowledge and stories shared, safeguarded and stored? • What agency over the implementation of NbS exists in local communities? • Are co-creation processes present, possible, genuine? • How are local communities' preferences for NbS reflected in place? Are sites cared for, respected?
With (cities)	• What networks exist to support NbS mainstreaming? Who is a part of them? Who decides on who is able to participate? • Who is championing NbS and what challenges are they facing in doing so? Who supports the addressing of challenges and barriers? • How are communities organised? What self-organisation, citizen collectives, communities of practice or otherwise exist? • What political voice, participation, or interfacing to planning and governance processes do actors and communities have? What barriers to participation and co-creation/co-development exist?
By (cities)	• What networks exist regionally to support NbS in the Mediterranean bioregion? • How is knowledge transfer and diffusion supported or inhibited institutionally? • What blocking/making embedding different types of knowledge in NbS mainstreaming at a planning/governance level • How is flexibility and collaboration at play in planning and governance arrangements? • How are existing planning & governance frameworks influencing and supporting (or limiting) NbS mainstreaming? • What types of knowledge are prioritised when planning and conceptualising NbS projects? • How are bottom-up approaches translated into policy? Are they? Can they subsequently be translated vertically and horizontally?

2.3 Approach and Principles: How to activate knowledge pathways for creating knowledge-in-action situations for co-stewardship of NBS?

This section outlines the principles that will inform our research process, which are informed by a co-creation approach. These principles, as well as their meaning, goals and implications were developed in a workshop held internally at Utrecht University in February 2025 with the participation of members of the CARDIMED team involved in the coordination, implementation and write-up of findings in work packages two, three and seven.

During this one-day workshop, the team reflected on the expectations and methods that would be more appropriate to investigate knowledge pathways underpinning NbS in the Mediterranean. We reviewed findings from previous work conducted within CARDIMED that focused on mapping the barriers currently slowing down the adoption of NbS in the Mediterranean and explored ways in which these challenges could be overcome. Exploring these ways as initial ideas on how to fulfill the potential for NbS in the context of the different demos, we outlined goals that were then used to inform the principles of this work. These principles and goals are aligned with previous research and findings from other projects such as the Connecting Nature Framework, which outlined knowledge pathways for the impactful implementation and stewardship of NbS (Collier et al 2023).

Building upon this workshop and references, we aim to generate knowledge that can unlock the potential of communities for transformative climate resilience and trigger transformative thinking, as illustrated in Figure 2. Situating our work in relation to the Connecting Nature Framework, we build upon their findings and advance knowledge on knowledge pathways particularly within the processes through which NbS stewardship is undertaken by the local communities (Collier et al 2023; Hölscher et al. 2024). In this context, communities are understood as a broader network of people and institutions that includes civil society, professionals, government officers and all other stakeholders engaged in the design, implementation and governance of NbS.

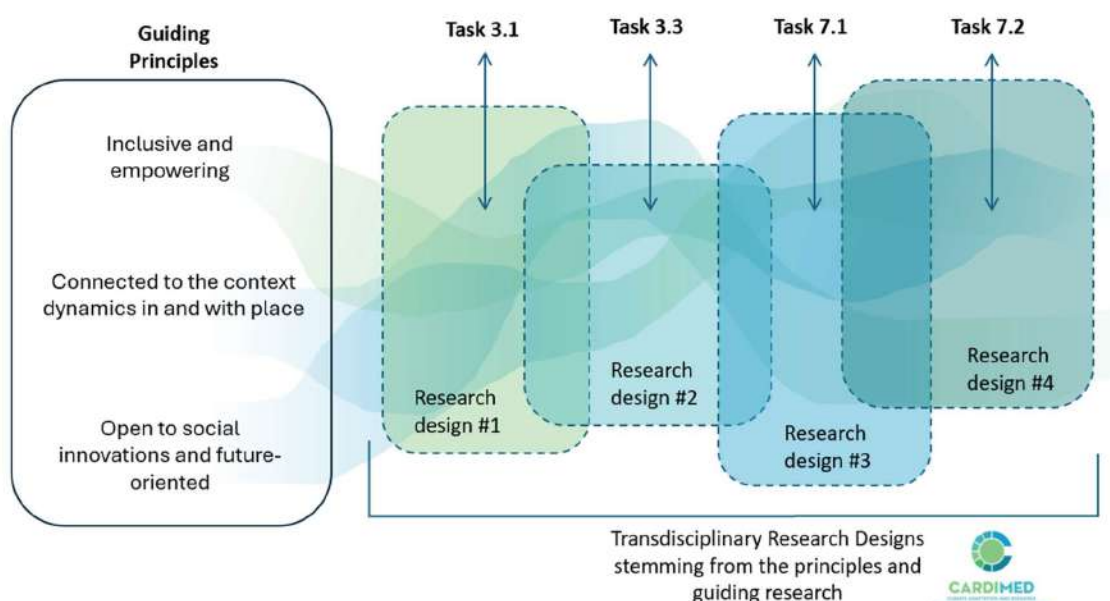


Figure 2: The principles inform the research designs and guide the development of transdisciplinary research within the work packages to unlock the potential of nature-based solutions in the Mediterranean.

Our transdisciplinary methodology to foster transformative climate resilience through NbS stewardship is guided by three key principles. Through them, we outline a commitment to using an approach that is:

- **Inclusive and empowering** by recognising the importance of intersectional inclusivity and accounting for the diversity in the communities in its multiple forms and dimensions. Our practices empower others through and with sharing knowledge and information, resources and decisions. We recognize the communities' capacities, inspiring through sharing and co-creating knowledge and mobilisation capacity. Design principles that will guide different process settings that aim to unlock the potential of communities for transformative climate resilience. We bring about the diversity of voices, the alternative knowledge and practices, and the power dynamics that exist and unpin these.
- **Connected to the context dynamics in and with place** by recognising local specificities and being sensitive. Our practices are attuned to the character of the communities but are not necessarily constrained by current circumstances and limitations of each context. We take into consideration the interaction with/ within and use of space as part of context dynamics and acknowledge that interactions with space are shaped by ownership, design and accessibility. Our practice recognises and brings to the surface the transformative potential of NbS in the ecology of place and in place meanings, relationships and place attachment. In doing so, we understand the processes and the ways of organising and mainstreaming climate resilience with and through NbS.
- **Open to social innovations and future-oriented** by recognising what exists to leverage its potential for the future. We build on existing relationships and their openness to fostering stewardship and transformative change in all scales. Our practices are open to innovations while also being transparent, surfacing the boundaries and limitations to allow for others to shape the process.

Adopting these principles, we advance a more inclusive practice of NbS that is open to plural narratives and meanings leveraging NbS and the power of nature to strengthen climate resilience in the Mediterranean region. These principles are set to build capacity with and for communities for climate resilience and support innovative and transformative climate governance processes to enable the mainstreaming of NbS. They also amplify community resilience through empowering, activating and connecting different communities of practice in the Mediterranean.

Understanding NbS and the knowledge around its implementation within a community is critical to situate it within a disciplinary, cultural, political and social background. In doing so, projects demonstrating the use of NbS offer opportunities for context-based transdisciplinary knowledge generation. This type of transdisciplinary practice can create a platform for interdisciplinary and multidisciplinary researchers, society and governments to co-define challenges, and subsequently co-create and co-manage solutions (Brandt et al. 2013; Nicolescu 2014). (As cited in Tzoulas et al., 2021).

While it is critical to adapt this approach to each context, a robust set of principles to guide NbS implementation and stewardship is a valuable resource to orient our work as we navigate the differences between the demos. Following principles that are committed to inclusion and empowerment and learning from other examples is critical because new projects are unlikely to be the ones first dealing with implementation barriers. Documenting the knowledge gained through these principles in different contexts and integrating it into institutional practices is an important step to ensure that the implementation of NbS is incremental and every new project draws on experiences from previous cases.

3. Conclusion

Mapping implementation pathways through the analysis of case studies where NbS are employed to support climate adaptation are a valuable response to growing concerns about the need for more research on the social and political dimensions of climate adaptation (Overland and Sovacool 2020). Case studies such as those of CARDIMED are critical to enable the emergence of new forms of governance of NbS, as they draw from the experiences of real projects and the relationships built between people and nature in them.

Documenting implementation knowledge in NbS must also be understood within the context of innovations and the diffusion of knowledge (Loorbach et al. 2020). Testing new ways of engaging society in the production, implementation and maintenance of NbS, should create platforms where the benefits and trade-offs of NbS can be articulated, negotiated and agreed upon with all stakeholders (Frantzeskaki and Kabisch 2016). This communication process, in turn, should overcome implementation models based on “consultations” and “informative sessions” by championing, instead, the co-production of transformative pathways (Wolff et al. 2022; Adams, Moglia, and Frantzeskaki 2024). This co-production process must advance the collaboration between civil society, NGOs and governments and bridge different value systems and ways of knowing (Pascual et al. 2023).

The analysis of the projects in CARDIMED can provide insights into how the co-creation and engagement processes can empower communities, amplify their resilience and enable embedding of NBS in urban planning, but this requires meaningful and collective knowledge production that is integrative (Hoffmann et al. 2022). The knowledge pathways observed in the projects indicate that practices that allow different stakeholders to collectively envision a future fulfill the role of fostering common goals facilitating the negotiation of trade-offs and distributing benefits (Pineda-Pinto et al. 2022). A common set of goals and a robust negotiation strategy also allows for communities to stand up for their rights while acknowledging differences in interests and values (Combrinck and Bennett 2016).

Recognising and building upon local practices that might derive from diverse ways of knowing is a promising way of situating knowledge about NbS and their impacts in different contexts (McEvoy et al. 2023). The diverse socio-technical governance mechanisms observed in CARDIMED indicate that the projects contribute to sustainability at the local level by engaging partners, translating knowledge to a particular context and creating momentum for longer and more ambitious transformations. These are all important pathways for expanding the benefits of NbS and ensuring their longevity (Köhler et al. 2019; Caniglia et al. 2020).

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