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CARMINE

co-create climate resilience

Climate-Resilient Development Pathways in Metropolitan Regions of Europe

Deliverable 1.4. - Geo-designed A&M pathways - Guidance document

January 2025

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Abbreviations

Abbreviations	Full Wording
A&M	Adaptation and mitigation
CCA	Climate change adaptation
CSA	Case study area
GIS	Geographical information system
LL	Living Lab
LULC	Land Use Land Cover
OSM	Opportunity space map(ping)
NbS	Nature-based solution(s)
SC-HUB	Stakeholder Community Hub
WP	Work package
WS	Workshop

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Key Terms

Adaptation: See 'climate change adaptation'.

Climate change adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects (taken from IPCC (2022) definition of 'adaptation').

Climate change mitigation: A human intervention to reduce emissions or enhance the sinks of greenhouse gases (taken from IPCC (2022) definition of 'mitigation (of climate change)').

Co-design, co-evaluate, co-implement, co-create: Terms that all emphasise the underlying essential need to use a multi-actor approach where these different aspects of working on enhancing climate adaptation and resilience functioning across metropolitan regions are implemented together with all relevant stakeholders.

Exposure: The presence of people; livelihoods; ecosystems; environmental functions, services, and species or resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected (taken from IPCC (2022) definition of 'exposure').

Geo-design: An analytical landscape design and planning method that combines the creation of design proposals through the consideration of key questions, geographic contexts, systems thinking, and digital technology (Flaxman 2010; Tran et al. 2020).

Hazard: The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources (taken from IPCC (2023) definition of 'hazard').

Mitigation: See 'climate change mitigation'.

Narrative: A description of a scenario (or family of scenarios), highlighting the main scenario characteristics, relationships between key driving forces and the dynamics of their evolution, including relationships among system characteristics such as social, economic, cultural, and political drivers (adapted from IPCC's (2022) definition of 'scenario storyline').

Nature-based solutions (NbS): Actions to protect, conserve, restore, sustainably use and manage natural or modified ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits (adapted from Cohen-Shacham et al. (2016) and UNEP.EA (2021) definition of 'nature-based solutions').

Pathways: The temporal evolution of natural and/or human systems towards a future state. Pathway concepts range from sets of quantitative and qualitative scenarios or narratives of potential futures to solution-oriented decision-making processes to achieve desirable societal goals. (taken from IPCC (2022) definition of 'pathways').

Risk: The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change impacts, risks result from dynamic interactions between climate-related hazards with

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the exposure and vulnerability of the affected human or ecological system to the hazards (adapted from IPCC (2023) definition of 'risk').

Road map: Incorporate pathways with spatial planning outputs to provide solution-oriented decision-making processes to achieve desirable societal goals.

Scenario: A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces and relationships. Note that scenarios are neither predictions nor forecasts but are used to provide a view of the implications of developments and actions (taken from IPCC (2022) definition of 'scenario').

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (taken from IPCC (2022) definition of 'vulnerability').

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Executive summary

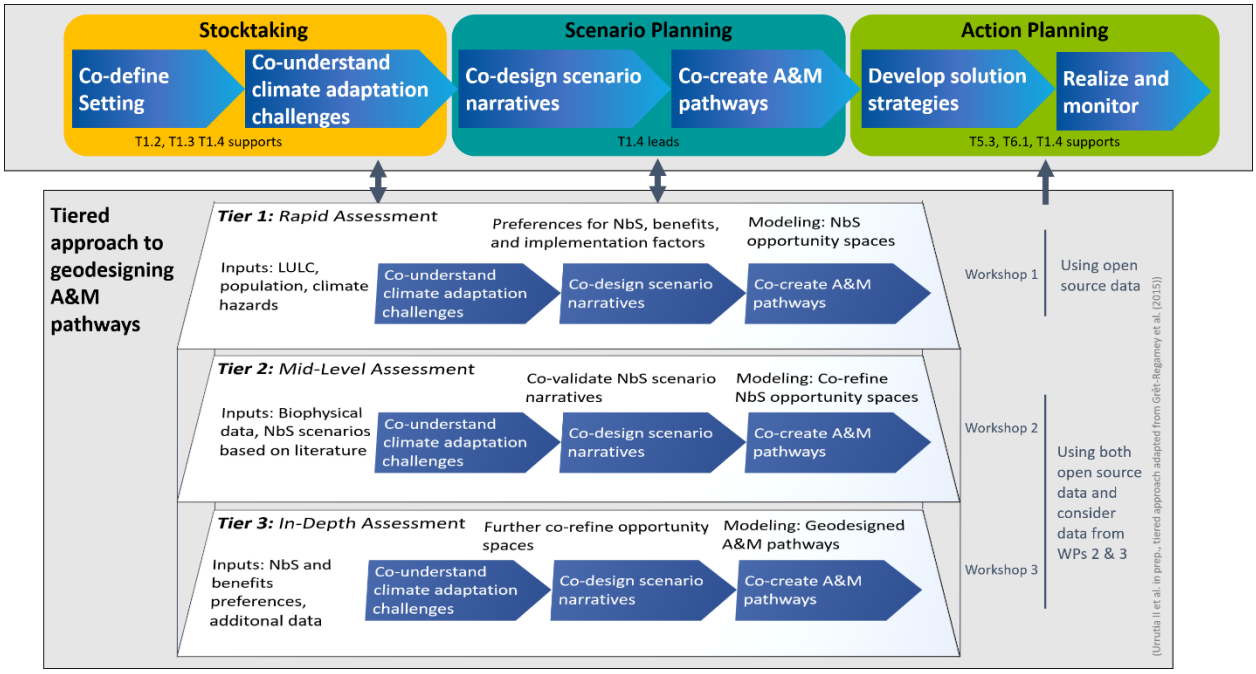

Figure 1: Deliverable 1.4 Graphical abstract

CARMINE will deliver a series of iterative geo-design workshops containing impactful outputs and interactive activities that foster climate adaptation and resilience within the Case Study Areas (CSA). Commencing with Workshop (WS) 1, the primary focus revolves around the introduction into the concept and prioritisation of Nature-based Solutions (NbS), their benefits, and implementation factors by stakeholders. This is followed by engaging stakeholders in dynamic mapping exercises and in-depth discussions to begin the NbS opportunity space mapping (OSM) process by identifying perceived well-functioning NbS and areas in need of NbS benefits. WS1 sets the groundwork for subsequent endeavours. Moving forward, WS2 begins the process of refining the OSM and co-developing NbS scenario narratives linking NbS planning to CSA climate adaptation and resilience goals. Here, collaborative efforts channel into envisioning exercises, fostering enriched narratives tailored to CSA-specific needs and aspirations. Building upon this momentum, WS3 delves deeper into the realm of adaptation & mitigation (A&M) by finishing the OSM refining process and linking the spatial possibilities for NbS with the scenario narratives to build A&M roadmaps.

The geo-design workshops build upon the specific challenges and transformative adaptation measures identified in CARMINE Task 1.2, harness the communication developed through the Stakeholder Community Hub (SC-HUB) in Task 1.3, and are opportunities to consider and inform the modelling and scenario-building efforts in WP2 and WP3 in an iterative process. Each workshop, structured with introductions and recapitulations of prior outputs, fosters an environment conducive to collaborative engagement, ensuring that everyone actively contributes to the development of A&M pathways to address pressing climate challenges and advancing sustainability within the CSA. D1.4 presents the CARMINE geo-design A&M pathways stepwise approach where stakeholders will be engaged through a series of workshops. It details the activities to be conducted within each workshop, designed to meet the project requirements.

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Each CSA follows the same geo-design strategy structure to ensure the outputs are comparable. Nevertheless, elements of the strategy remain flexible and will be adapted to the specific context of each CSA depending on the degree of advancement in terms of climate adaptation strategy, policy advancement, and data availability within the metropolitan area, as many CSAs have already started adapting to climate change. The geo-design approach described here is a general overview of the geo-design workshop structure. It is complemented by detailed guidelines for each workshop and dedicated facilitator training to ensure CSA leaders are well-equipped to implement the approach. As it is an iterative process, the activities proposed might be revised according to the needs of the project and the development of each CSA, taking into consideration stakeholder needs.

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1 Introduction

1.1 Geo-design

The geo-design approach (hereafter referred to as geo-design) at its core constitutes an analytical landscape design and planning method that combines the creation of design proposals through the consideration of key questions, geographic contexts, systems thinking, and digital technology (Flaxman 2010; Tran et al. 2020). Geo-design also involves the collaboration of relevant actor groups, including design experts, geographical information system (GIS) experts, and stakeholders in a participatory manner to co-design sustainable future landscape scenarios for their area of intervention (Steinitz 2012).

The geo-design approach focuses on changing the geography of landscapes through a participatory design process, which makes it ideal for the co-development of environmentally alternative scenarios for future landscapes. Indeed, a growing body of scientific evidence has shown how geo-design can be used to improve planning for climate change A&M through the integration of ecosystem services and NbS (Davis et al. 2023; Tran et al. 2023). The participatory nature of geo-design is well suited to complement CARMINE's CSA approach of engaging a diverse set of stakeholders to identify spatial challenges and solutions through collaborative discussion, design, and mapping. Applying the geo-design across urban and rural landscape planning contexts (Pettit et al. 2019; Davis et al. 2023; Li et al. 2022) makes it an ideal method for adapting to CARMINE's European metropolitan focus, where the diverse socio-economic and political contexts of the Living Labs (LLs) across the eight CSAs call for a spatially flexible approach that can be co-driven by the stakeholders according to their spatial needs. Therefore, geo-design is particularly well suited to link both narrative and spatial scenarios, as well as to help stakeholders co-develop and co-design A&M pathways towards resilient European metropolitan communities in each CSA considering both conventional and NbS approaches. While geo-design is inherently a GIS based approach requiring GIS resources to fully map out NbS approaches, its implementation within CARMINE will take a flexible approach wherein technological and resource barriers within CSAs will be considered so that the risk of implementation can be avoided.

1.2 Overview of tiered workshop approach

For the context of the CARMINE project, a tiered geo-design approach is utilised to ensure the completion of geo-designed A&M pathways per CSA (Figure 2). A focus on NbS is integrated throughout the geo-design process but other approaches will be considered within the scenario co-development phase. The general steps of stocktaking and action planning in the framework are adapted from overall climate adaptation planning steps found within various cities' climate adaptation and environmental planning documents (Schneider et al. 2016; Municipality of Athens 2017; Birmingham City Council 2022; Berlin 2023). These steps are in line with CARMINE Tasks 1.1, 1.2, and 6.2, where the necessary stocktaking of each CSA is completed to understand climate change adaptation (CCA) challenges to co-create CCA visions, co-create transformative CCA scenarios, and co-develop action plans to implement the visions and scenarios.

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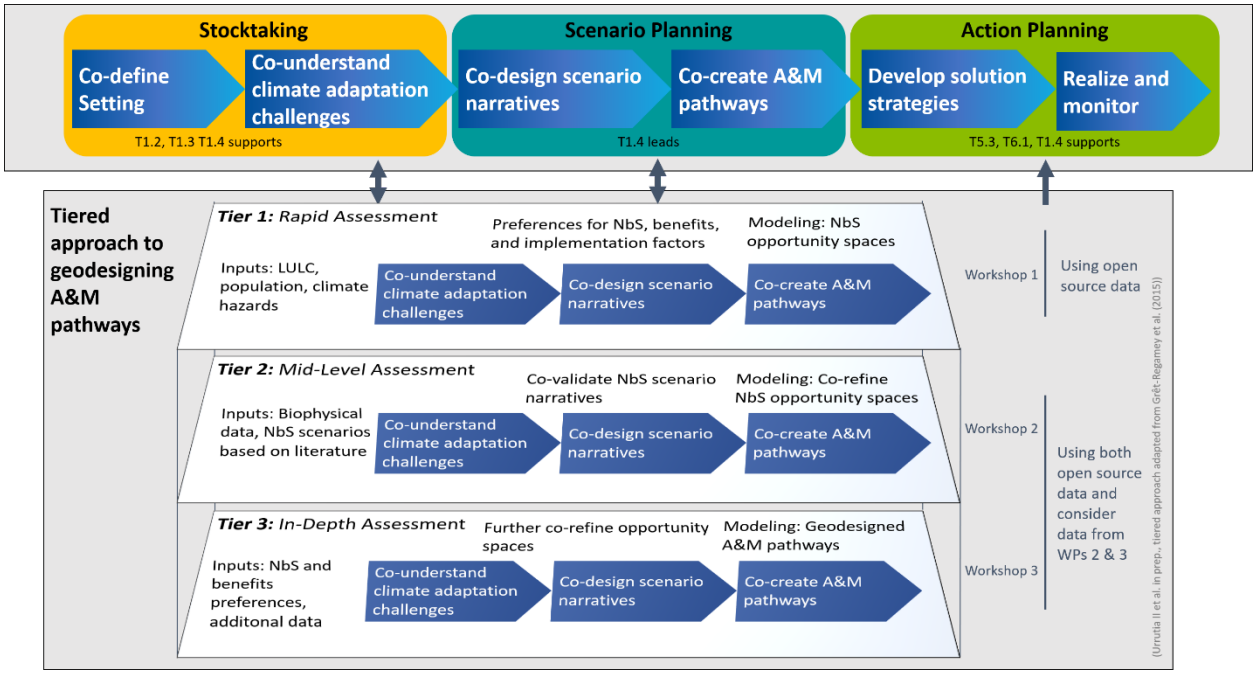

Figure 2: Tiered geo-design framework. The content of the blue arrows is not explicitly conducted in each of the corresponding Tiers, but instead shows a general flow of the geodesign process, that each workshop contributes to. Please see Figure 3 below for more detailed workshop descriptions (Urrutia II et al. in prep., adapted from Grêt-Regamey et al. (2015))

To guide the scenario planning process in Figure 2, a tiered assessment approach (adapted from Grêt-Regamey et al. (2015)) is used, that allows for flexibility in the level of depth and complexity of assessment within the CSAs. All tiers are spatially focused on the metropolitan level, but each successive tier has increasing complexity. Tier 1 is a rapid assessment that focuses on identifying and prioritising NbS and benefits preferences to address the CSA specific climate challenge(s). This begins the process of co-developing OSMs for specific NbS within each CSA. Furthermore, areas are identified within each CSA where current NbS are perceived to be successful at addressing the climate challenge(s) and areas that are perceived to need NbS benefits. Tier 2 focuses on co-refining NbS OSMs with the addition of NbS biophysical criteria, as well as co-validating NbS future scenarios to develop narratives. Tier 3 synthesises the previous tiers by integrating data, which could be socio-economic or environmental hazard impact data, to further co-refine NbS scenario narratives and OSMs to develop geo-designed A&M pathways.

Three WSs are conducted to implement the tiered geo-design approach, with each WS aligning with the three tiers (Figure 3). Materials will be made available to CSA leaders in local languages to ensure that stakeholders can fully engage in WS activities. CSAs are encouraged to conduct these WSs back-to-back with the CARMINE Living Lab (LL) WSs (see Deliverable 1.1 for more details), if possible. However, if considered inputs from WP2 & WP3 are not available in time for these LL WSs, the geo-design WSs, particularly WSs 2 & 3, should take this into consideration and are suggested to be completed sometime between project months M21-M23 (October-December 2025) for geo-design WS2 and M33-M35 (October-December 2026) for geo-design WS3 to ensure enough time for the reporting.

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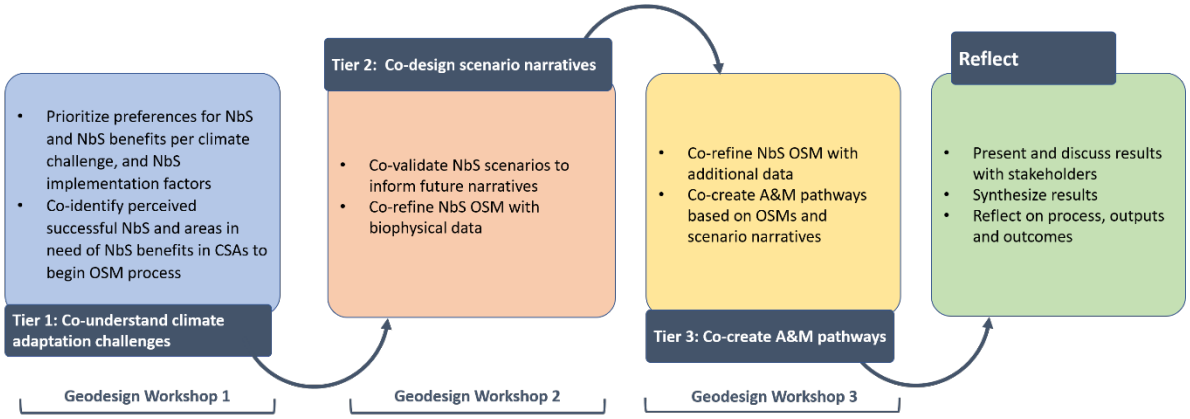

Figure 3: The objectives of CARMINE geo-design workshops

2 Methodology – Geo-designing A&M pathways

The groundwork for setting the context builds upon previous CARMINE work (see D1.1) wherein CSA leaders outlined the primary climate challenges they aim to address to achieve climate mitigation and adaptation goals. This information, in conjunction with meetings with CSA leaders, allowed for the integration of each CSA's specific climate A&M context, as well as their challenges, into the geo-design methodology.

2.1 Workshop 1 - Tier 1: Understanding preferences & perspectives to support NbS Opportunity Space Maps (OSM)

2.1.1 Overall objectives

WS1 aims to begin the process of producing NbS OSMs for the CSAs, a vital component of the geo-designed A&M pathways. The OSMs aim to highlight where NbS specific to a CSA's climate challenge context can best be planned within its metropolitan region. Throughout the OSM process, local contextual factors specific to each CSA will be considered. This WS will produce key outputs that will help to refine OSMs in future WS3.

WS1 starts this process by briefly introducing the concept of NbS, prioritising preferences for NbS, NbS benefits, and implementation factors that make NbS successful in order to address climate challenges within each CSA. Participants will identify which NbS they believe would be most suitable to implement within their metropolitan region to address their climate challenges, as well as which NbS benefits they would want to prioritise. This prioritisation is important to understand the local context of each CSA and to ensure that the final A&M pathways are aligned with local preferences and understandings of how to address climate change challenges in a bottom-up approach. Additionally, successful NbS implementation factors will also be prioritised in order to further support future NbS planning and implementation strategies.

Another objective of this WS is for participants, through two participatory mapping activities, to identify within their metropolitan region examples of existing NbS that they perceive to

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function well, as well as areas they believe need NbS benefits. For the first mapping exercise of identifying well-functioning NbS, the aim is to understand which and why the NbS is already working as a means to better understand the local context. The aim of the second mapping activity is to understand the socio-economic reasons why areas need benefits. The information generated from both of these mapping activities will improve the OSM process. These mapping activities, along with the prioritisation activity, will inform the development of geo-designed A&M pathways for each CSA, and will help to guide the strategic planning and implementation of effective, sustainable solutions that address both climate A&M needs within the CSA.

2.1.2 Workshop Description

The WS is to take place in conjunction with the first LL WS, to take advantage of the participants being together for the first time. The WS will commence with an introduction to the overarching project objectives and the geo-design process, providing participants with a contextual understanding of the WS's purpose and goals under the CARMINE project. A general timeline of WS sessions is outlined, offering a roadmap for the day's activities. Additionally, a brief introduction to NbS in metropolitan regions is given, ensuring that all participants have the same base level of understanding of the concept.

As the WS progresses, potential NbS are discussed. Participants have the opportunity to brainstorm various NbS options tailored to the specific challenges faced by each CSA, such as extreme heat, flooding, wildfires, etc., and explore the additional benefits of NbS, such as carbon sequestration, biodiversity conservation, reduction of discomfort due to heat and improved community well-being. Additionally, participants are able to identify and discuss perceived areas in their metropolitan region where NbS are already successfully providing benefits and why, as well as areas where they perceive these benefits are needed and why.

Expected outputs from WS1 include descriptive statistics from the individual survey and maps of successful NbS, NbS benefits, NbS implementation factors, and needs for each CSA. Outputs will be taken up later in geo-design WS2.

Part 1: Introduction to NbS

The first part of the WS involves a brief presentation to the WS participants with the objective of ensuring that all participants have the same base-level conceptual understanding of NbS in metropolitan regions. Slides are provided to CSA leaders translated into local languages that outline what NbS are, how NbS can address climate change A&M goals, and various examples of NbS that are commonly found in metropolitan regions.

Part 2: Individual survey of preferences for NbS, benefits, and implementation factors

In the second part of the WS, participants engage in an individual survey that aims to understand stakeholder preferences for NbS and their benefits for relevant challenges in their metropolitan region, as well as what they believe to be criteria and involved parameters for evaluating outcomes from NbS. The objective is to identify and prioritise NbS that geo-designed A&M pathways should emphasise to bolster climate resilience and sustainability within the CSAs, thereby aiding in strategic decision-making and planning for future CARMINE project phases.

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The NbS survey is an individual and anonymous activity that is to be completed on the online participatory GIS platform Maptionnaire© (Figure 4). Paper versions of surveys can be made available should there be a need. The survey is separated into four parts. The first part of the survey is a general introduction for the participants and provides information as to the nature and aim of the survey, as well as a consent statement. The survey was approved by the CARMINE Ethics Committee, which is included in the data privacy disclaimer to the participants, as well as contact information for the responsible individuals should the participants have any questions. This first part also asks participants background information questions that will provide important demographic data about the sample. Participants are not required to provide demographic data should they choose not to.

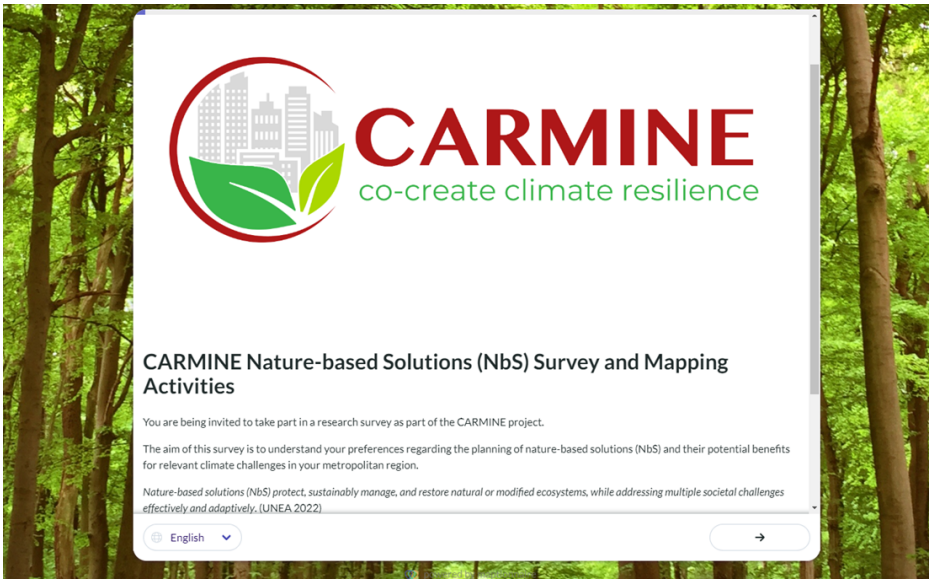

Figure 4: Maptionnaire© survey welcome page

The second part of the survey asks participants to prioritise which NbS they would prefer to implement in their metropolitan region to address the climate challenges specific to their CSA. This part is tailored to each CSA, so only NbS relevant in addressing their specific climate challenge(s) are presented to any given CSA. The third part of the survey asks participants which NbS benefits should prioritise for developing new NbS in their metropolitan region. The fourth part asks participants to consider NbS implementation factors that lead to the successful outcomes from NbS and indicate how much they agree with the given factors.

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Part 3: Participatory mapping of successful NbS and areas in need of benefits

The last part of the WS focuses on participatory mapping activities that aim at understanding the spatial distribution of well-functioning NbS and where NbS benefits are needed in the CSAs, and why. The objective is to better understand the spatial and social context of NbS and their benefits to begin the OSM process of identifying areas for greater climate resilience with the CSAs, thereby helping to improve future planning processes.

Using again the online tool Maptionnaire© (Figure 5) but with its participatory mapping capabilities, the first mapping activity aims to understand WS participants' perspectives of what makes NbS successful against the challenge(s) in their CSAs and where they may be located in their metropolitan region. The second mapping activity aims to understand where NbS benefits are needed the most in relation to the challenge(s) and why, in order to begin the OSM process.

Again, in this part of the WS, the mapping tool employed to carry out these activities is an online platform, but paper versions of the survey are available upon request to ensure full accessibility by all CSAs. Outputs from this WS include descriptive statistics of NbS, NbS benefits, and implementation criteria preferences, as well as maps detailing examples of successful NbS and areas in need of NbS benefits, and why these areas were selected.

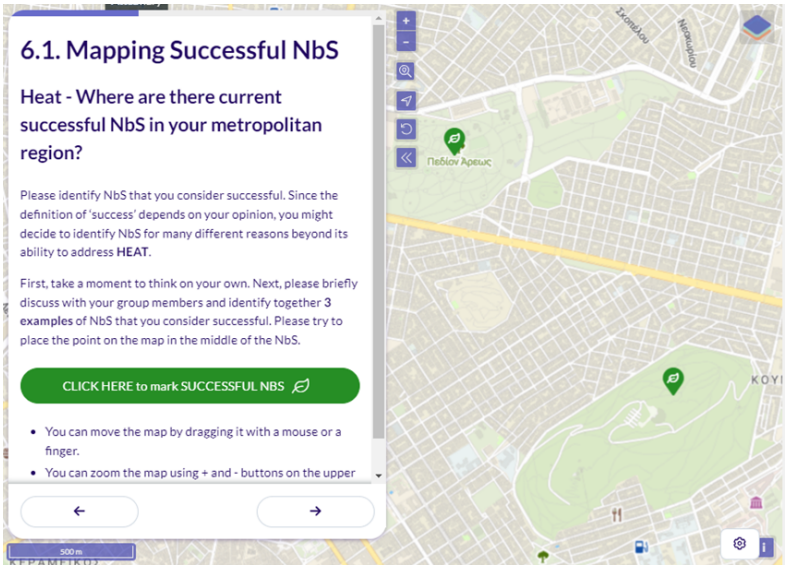

Figure 5: Screenshot of mapping activity 1, where participants are working in groups and they select areas of successful NbS in their CSA.

In-between workshops

Following geo-design WS1 and preceding geo-design WS2, an interim phase is dedicated to the analysis of WS1 outputs to delineate CSA preferences for NbS, their benefits, and implementation factors, as well spatial considerations for OSMs. The WS outputs will feed into WS2 & WS3, as well as Deliverable 1.5: Geo-designed A&M pathways – Synthesis, Report. Additionally, the results will be made available to the CSA leaders for dissemination to the participants of WS1 ahead of WS2. This will keep them engaged and will enable This stage also involves utilising the outputs to shape inputs for WS2 that will be shared with CSA leaders ahead of WS2, such as pre-identified NbS scenarios and NbS OSMs. Efforts are directed towards producing a detailed catalogue of relevant NbS, laying the groundwork for informed decision-making and strategic planning in subsequent WS, within the CARMINE project.

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2.2 Workshop 2 - Tier 2: Co-developing NbS OSM and future NbS narratives

2.2.1 Overall Objectives

WS2 aims to further the process of generating NbS OSMs for the CSAs as well as establishing NbS scenario narratives tailored to the specific NbS needs and priorities of the CSAs. These scenario narratives will outline ambitious yet attainable climate adaptation and resilience goals, serving as guiding principles for NbS planning across each CSA. Through collaborative exercises and group discussions, participants validate NbS OSMs and scenarios, which will be synthesised with the outputs of WS1 in the following WS3.

The co-refinement of an NbS OSM based on biophysical criteria by workshop participants can be considered a participatory validation process. Participants are engaged to identify technical criteria relevant to their metropolitan area that will help to refine areas within the OSM that should be prioritised for future NbS planning. This first stage NbS OSM refinement is important to further understand the NbS planning context of each CSA, which is necessary to ensure that the final A&M pathways are aligned with local climate adaptation and resilience goals.

An additional objective of this WS is for participants to validate NbS scenarios and develop narratives around these scenarios that are specific to their CSA in a participatory manner. For this part, it is not only the validated scenarios and created narratives that are important but also the discussions that are generated to ensure that different views and values from the participants are captured through a representative and participatory process.

2.2.2 Workshop Description

Part 1: Introduction and recap of WS1 outputs

WS2 commences with a recap presentation of the geo-design workshop flow (see Figure 3) in order to re-familiarise WS participants with the geo-design process. A brief presentation of the outputs from WS1 (the prioritised NbS, benefits, and implementation factors, as well as the examples of successful NbS and areas in need of benefits and the reasons why), providing participants with an opportunity to reflect on the results as they head into WS2, will be provided. An overview of WS2's objectives and activities are presented, setting the stage for the day's engagements.

Part 2: Co-creating future NbS narratives

The NbS narrative part, a key step within the CARMINE geo-design approach, is dedicated to validating NbS scenarios and forming narratives for addressing climate change adaptation and resilience within the designated CSAs in a participatory manner. The narratives are important steps towards envisioning and creating A&M pathways, which will be critical for helping to make decisions on climate adaptation and resilience strategy, direct actions, and enable policymakers to identify opportunities for facilitating change (Costanza 2000; Yusoff and Gabrys 2011).

The first phase of this part commences with a thorough validation process wherein WS participants engage in discussion to confirm and validate the relevance and significance of pre-identified future NbS scenarios. These pre-identified scenarios are provided by the Task 1.4 lead to CSA leaders ahead of the workshop and will be based on a number of contemporary and relevant scientific sources. These scenarios will be adapted to a European

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context and so are general in nature but will be shaped into CSA specific narratives by the stakeholders of each CSA, thus allowing for flexibility within this approach to fit the needs of each CSA's climate adaptation and resilience goals. These scenarios include the consideration of other conventional adaptation measures, in line with CARMINE project goals. Using a combination of workshop tools such as matrices, sticky notes, and potentially online tools (such as Mentimeter©, if necessary), participants engage in group discussions and through guiding questions, collaboratively inform the shape of the scenario based on specific CSA climate adaptation and resilience goals (see Figure 6 for an example process that will be adapted). This includes identifying what additional elements or modifications to the scenarios might be necessary to ensure a comprehensive and robust set of NbS scenarios for each CSA.

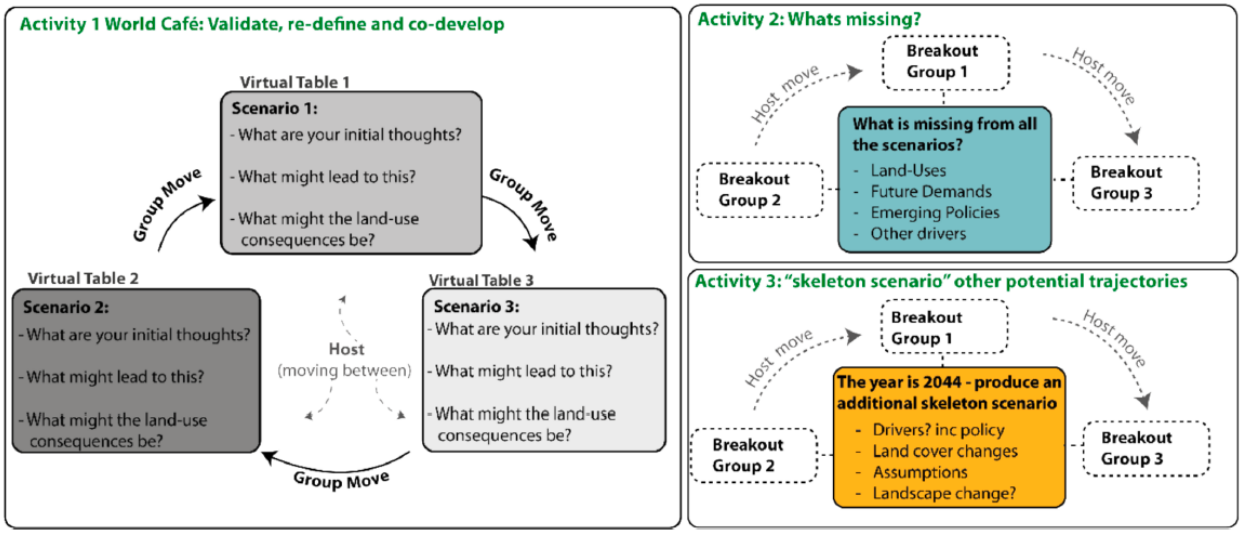

Figure 6: Example, to be adapted, of scenario validation with WS participants (taken from Kirby et al. (2025, p. 6))

In the second phase, workshop participants focus on building NbS scenario narratives by elaborating on, refining and envisioning their scenarios in more detail, building upon the sector-specific climate adaptation and resilience goals previously derived in the LL WS2 (see Deliverable 1.1 in CARMINE Teams repository). Through this process, participants synthesise their insights and strategies into cohesive and compelling narratives that address both local climate challenges and contribute to overarching sustainability targets. Various engagement tools are utilised that can be adapted for either in-person or online sessions, for example matrices, sticky notes, and potentially online tools (such as Mentimeter© or Miro©, if necessary). This participatory approach ensures that a diverse range of participants' inputs is captured, leading to a more comprehensive understanding of local NbS planning needs. These narratives will be taken up in WS3 by the participants and used to shape the NbS OSM within their CSAs.

The final phase of this part is the presentation in plenary. During this session, each group presents their NbS scenario narratives to the broader workshop participants, wherein participants also discuss how narratives fit their CSA climate adaptation and resilience goals. This presentation serves multiple purposes: it validates the developed narratives, gathers feedback from a diverse set of participants, and refines the narratives as necessary. The plenary session ensures that the collective narratives are aligned with CSA expectations and project objectives, fostering a shared understanding and commitment to the proposed climate adaptation and resilience strategies.

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By systematically validating NbS scenarios, constructing detailed NbS narratives, and reviewing these in a plenary session, part 2 ensures a well-rounded and participatory approach that contributes in part to the development of effective and sustainable climate adaptation NbS A&M pathways within the CSAs.

Part 3: Refining NbS OSMs

This part of the WS2 aims for participants to collaboratively conduct a first-stage refinement of the NbS OSM, a key step towards creating the geo-designed A&M pathways. The outputs from WS1 I are used to inform this OSM. Refining the OSM based on an understanding of local CSA contextual factors is important for ensuring that future NbS planning is aligned with climate adaptation and resilience goals.

The first phase of this part is a presentation of the pre-defined NbS OSM with the aim of familiarising WS participants as to where NbS could be implemented based on biophysical criteria derived from scientific literature. Participants have the opportunity to validate the OSM. Participants then provide technical criteria for refining the pre-defined NbS OSM for their CSA and then engage in discussion to identify spatial areas on the OSM where NbS would be most effective and easiest to implement based on the criteria. Additional criteria are also elicited from WS participants to further refine the OSM at a later stage. Using a combination of workshop tools such as matrices, sticky notes, and online mapping tools (such as Maptionnaire©), participants engage in group discussions. Paper versions of the OSM are made available if necessary. This participatory refinement of the OSM is important to ensure that future NbS planning aligns with local conditions, realities, and adaptation needs within the CSA.

The last phase of part 3 involves linking the refined OSM to the NbS scenario narratives through a process by which participants envision what their CSA would look like through the lens of the OSM at certain future time intervals for each of the scenario narratives. This part builds upon the vision activities that take place in the LL WS2 (see Deliverable 1.1), where in NbS scenario narratives are aligned with local sector-specific aspirations with broader global sustainability objectives. Various workshop tools such as matrices, sticky notes, and online tools (such as Maptionnaire© or Mentimeter©, if necessary) are used to engage participants in group discussions.

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In-between workshops

In the interim period between WS2 and WS3, several critical activities are undertaken to advance project objectives and refine strategic frameworks. For those activities that need to be undertaken by the CSA leaders, particularly those linked to other CARMINE WPs per the Grant Agreement, detailed guidance documents are shared in advance of the WS3 to ensure satisfactory completion of all Deliverable 1.4 goals. Foremost, concerted efforts are directed towards refining the OSMs, ensuring alignment with the NbS scenario narratives. WS2 outputs feed into WS3, as well as Deliverable 1.5: Geo-designed A&M pathways – Synthesis, Report, while results are summarised by the Task lead and provided to CSA leaders for presentation to WS participants CSA leaders have to consider the collection of additional inputs for further OSM refinement in WS3. These inputs should be in line with both the CSAs' climate adaptation and resilience goals and overall CARMINE project goals. Thematically, inputs could potentially consider climate risk and socio-economic vulnerability (see WP3), NbS environmental impacts (see WP2), and demographic characteristics specific to the CSA, for example. These concerted efforts during the interim phase serve to consolidate progress made in prior WSs and pave the way for informed decision-making and effective planning actions in WS3.

2.3 Workshop 3 - Tier 3: Geo-designing NbS A&M Pathways

2.3.1 Overall Objectives

WS3 results in the formulation of outlined geo-designed NbS A&M pathways by synthesising and building upon previous WS outputs, providing a strategic framework for advancing climate resilience and sustainability within the CSA. The pathways outline actionable steps and interventions aimed at both adapting to and mitigating the impacts of climate change. Through collaborative exercises and group discussions, participants further refine the NbS OSMs for the CSAs, design alternative NbS futures based on the scenario narratives from WS2, and identifying the intermediary steps needed to achieve NbS climate adaptation and resilience goals within the CSAs to outline geo-designed NbS A&M pathways.

2.3.2 Workshop Description

Part 1: Introduction and recap of previous WSs' outputs

The workshop begins with a recap presentation of the geo-design workshop flow (see Figure 3) in order to re-familiarise WS participants with the geo-design process. It is also an important step for new participants who did not attend the previous WSs. A brief presentation of the outputs from WS1 (the prioritised NbS, benefits, and implementation factors, as well as the examples of successful NbS and areas in need of benefits and the reasons why) and WS2 (first-staged refined NbS OSM and scenario narratives), providing participants with an opportunity to reflect on the results as they head into WS3. An overview of WS3's objectives and activities are presented, setting the stage for the day's engagements.

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Part 2: Co-creating spatial NbS scenarios

This part of the WS aims to finalise the refinement of the NbS OSMs with the consideration of additional data inputs. The first phase of this part is a presentation of the first-staged refined NbS OSM from WS2 with the aim of re-familiarising WS participants with this output. Participants then consider the additional inputs that are in line with both CSAs' climate adaptation and resilience goals and overall, CARMINE project goals in order to refine the NbS OSM. These inputs include consideration of CARMINE WP2 (climate physical risk assessment models and earth system processes) and WP3 (Community-Based Socioeconomic Vulnerability and Risk Assessment), as well as other inputs that the CSAs may want to consider based on their engagement with their LLs (more detail is be provided in subsequent WS specific guidance documents). Participants engage in collaborative discussions to identify new priority areas for NbS planning within the OSM through the consideration of the additional inputs. Using a combination of workshop tools such as matrices, sticky notes, and online mapping tools, participants engage in group discussions. Paper versions of the OSM and inputs are made available if necessary. This participatory second-stage refinement of the OSM is important to ensure that future NbS planning aligns with local conditions, realities, and adaptation needs within the CSA.

The second phase uses both the scenario narrative outputs from WS2 and the second-staged refined OSM to guide the identification of areas in OSM where NbS should be planned to achieve CSA climate adaptation and resilience goals. The scenario narratives from WS2 are be presented to the participants to re-familiarise them with their work. Using the scenario narratives as guidance, participants engage in collaborative discussions to identify on the second stage refined OSM where specific NbS should be planned within the context of each narrative. This part is crucial for the geo-designed A&M pathways as the outcome of this part is a set of NbS scenario maps that both improves planning decision-making processes and helps CSAs to achieve their climate adaptation and resilience goals.

Part 3: Co-generating roadmaps for NbS A&M pathways

This part focuses on identifying the intermediate steps to be achieved prior to implementing NbS according to the NbS scenario maps from the previous WS3 part. This activity aims to establish clear milestones and identify key actors, enablers, and barriers. Initially, participants engage in identifying critical milestones that mark significant steps towards achieving NbS implementation. These milestones serve as benchmarks to assess progress and ensure that the strategic objectives are met in a timely and effective manner. Using a variety of workshop tools, such as matrices, sticky notes, and digital mapping tools, this process enables participants to engage in collaborative discussions to pinpoint achievable targets and set realistic timelines.

The outcome of this part is an outline roadmap that includes strategic milestones and a thorough understanding of the key actors, enablers, and barriers. This roadmap guides CSA's future NbS implementation plans, ensuring that all actions are strategically aligned and supported by the necessary stakeholders, ultimately leading to the successful realisation of the climate adaptation and resilience vision for the CSAs. These road maps feed into Task 6.2.

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Next Steps

Following the culmination of WS3, the project enters a crucial phase dedicated to refining the established NbS A&M pathways. This entails a meticulous examination of the outputs produced during the workshop, with a focus on refining NbS OSMs and pathways for the CSAs. Results per CSA are be summarised by the Task lead and shared with the CSA leads for presentation with the WS participants. These outputs are also synthesised together for cross CSA analysis as Deliverable 1.5: Geo-designed A&M pathways – Synthesis, Report, and is be disseminated in alliance with Task 7.5.

Additionally, the outputs of the geo-design workshops contribute to the monitoring and evaluation of effectiveness of the adaptation measures and improvement of local authority's actions, decision-making and climate governance (jointly with Tasks 5.3 and 6.1). Through these concerted efforts, CARMINE aims to lay the foundation for tangible and sustainable climate action within the CSAs, driving transformative change and fostering resilience in the face of climate challenges.

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3 Conclusions

The geo-design WSs cover a multi-disciplined landscape, encompassing the strategic spatial identification of NbS as climate adaptation solutions, alongside the meticulous planning of workshop activities designed to operationalise the planning of these NbS, under the CARMINE project.

Through collaborative endeavours and methodical analyses, pivotal outputs, including NbS and benefits prioritisation, NbS OSMs, scenario narratives and NbS A&M pathways, have been delineated. These outputs act as indispensable guides that will improve the planning process of NbS across European metropolitan areas, contributing to a trajectory towards sustainable and resilient futures for the CSAs. Moreover, the structured agendas of the workshops, augmented by interactive engagements and participatory exercises, have fostered an environment conducive to knowledge dissemination and decision-making. By harnessing digital tools, such online mapping, in tandem with considered outputs from other WPs, stakeholders are empowered to make judicious decisions and effect transformative change within their respective communities.

As the project progresses, continuous refinement and rigorous analysis of these outputs, coupled with sustained CSA engagement and collaborative endeavours, will remain imperative in realising the overarching objectives of bolstering climate resilience and sustainability. Through these collective endeavours, we provide rigorous evidence-based knowledge to help communities plan sustainable and climate resilience futures.

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4 Publication bibliography

Berlin (2023): Stadtentwicklungsplan Klima 2.0. Senatsverwaltung für Stadtentwicklung, Bauen und Wohnen. Berlin. Available online at https://www.berlin.de/sen/stadtentwicklung/planung/stadtentwicklungsplaene/step-klima-2-0/, checked on 4/22/2024.

Birmingham City Council (2022): Our Future Nature City Plan Birmingham City of Nature Plan February 2022. Available online at https://www.birmingham.gov.uk/downloads/file/21805/city_of_nature_plan_-_february_2022, checked on 4/22/2024.

Cohen-Shacham, Emmanuelle; Walters, Gretchen; Janzen, Christine; Maginnis, Stewart (2016): Nature-based solutions to address global societal challenges. IUCN.

Costanza, Robert (2000): Visions of Alternative (Unpredictable) Futures and Their Use in Policy Analysis. In *CE* 4 (1). DOI: 10.5751/ES-00171-040105.

Davis, Jonathan; Albert, Joshua; Vavages, Alex; Pijawka, David; Wentz, Elizabeth; Hale, Michelle (2023): Resilience-Based Adaptation in Data Scarce Areas: Flood Risk Assessment Using Geodesign in the Tohono O'odham Nation. In *Journal of Planning Education and Research*, Article 0739456X231191543. DOI: 10.1177/0739456X231191543.

Flaxman, Michael (2010): Fundamentals of geodesign. In *Proceedings of Digital Landscape Architecture*, pp. 28–41. Available online at https://scholar.google.com/citations?user=q-bzfbkaaaaj&hl=en&oi=sra.

Grêt-Regamey, Adrienne; Weibel, Bettina; Kienast, Felix; Rabe, Sven-Erik; Zulian, Grazia (2015): A tiered approach for mapping ecosystem services. In *Ecosystem Services* 13, pp. 16–27. DOI: 10.1016/j.ecoser.2014.10.008.

IPCC (2022): Annex I: Glossary. With assistance of van Diemen, R., J.B.R. Matthews, V. Möller, J.S. Fuglestvedt, V. Masson-Delmotte. In P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera (Ed.): Climate Change 2022 - Mitigation of Climate Change: Working Group III Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Cambridge, UK and New York, pp. 1793–1820. Available online at https://www.cambridge.org/core/books/climate-change-2022-mitigation-of-climate-change/annex-i-glossary/72F1D61E1A4932842A259398934805D1.

IPCC (2023): Annex I: Glossary. With assistance of Reisinger, A., D. Cammarano, A. Fischlin, J.S. Fuglestvedt, G. In H. Lee and J. Romero (Ed.): Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. With assistance of Hoesung Lee (Chair), Katherine Calvin (USA), Dipak Dasgupta (India/USA), Gerhard Krinner (France/Germany), Aditi Mukherji. IPCC. Geneva, Switzerland.

Kirby, Matthew G.; Scott, Alister J.; Walsh, Claire L. (2025): A greener Green Belt? Co-developing exploratory scenarios for contentious peri-urban landscapes. In *Landscape and Urban Planning* 255, p. 105268. DOI: 10.1016/j.landurbplan.2024.105268.

Li, Tianjie; Huang, Yan; Gu, Chaoguang; Qiu, Fangbo (2022): Application of Geodesign Techniques for Ecological Engineered Landscaping of Urban River Wetlands: A Case Study of Yuhangtang River. In *Sustainability* 14 (23), p. 15612. DOI: 10.3390/su142315612.

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Pettit, Christopher; Hawken, Scott; Ticzon, Carmela; Nakanishi, Hitomi (2019): Geodesign—A Tale of Three Cities. In. International Conference on Computers in Urban Planning and Urban Management: Springer, Cham, pp. 139–161. Available online at https://link.springer.com/chapter/10.1007/978-3-030-19424-6_9.

Schneider, Michael; Rupp, Johannes; Wirth, Veronika; Teichmann, Ulrich; Bründl, Werner; Kossmann, Meinolf; Mühlbacher, Gudrun (2016): Konzept zur Anpassung an die Folgen des Klimawandels in der Landeshauptstadt München. Landeshauptstadt München Referat für Gesundheit und xUmwelt. Available online at https://stadt.muenchen.de/dam/jcr:8eb68d50-5c21-4948-92ae-62fa129ab566/bericht_klwa_10_2016.pdf, checked on 4/23/2024.

Steinitz, Carl (2012): A framework for geodesign. Changing geography by design. Redlands, Calif.: ESRI Press.

Tran, Duy; Pearson, Diane; Palmer, Alan; Gray, David (2020): Developing a Landscape Design Approach for the Sustainable Land Management of Hill Country Farms in New Zealand. In *Land* 9 (6), p. 185. DOI: 10.3390/land9060185.

Tran, Duy X.; Pearson, Diane; Palmer, Alan; Dominati, Estelle J.; Gray, David; Lowry, John (2023): Integrating ecosystem services with geodesign to create multifunctional agricultural landscapes: A case study of a New Zealand hill country farm. In *Ecological Indicators* 146, p. 109762. DOI: 10.1016/j.ecolind.2022.109762.

UNEP.EA (2021): 5/5. Nature-based solutions for supporting sustainable development : resolution / adopted by the United Nations Environment Assembly. UNEP/EA.5/RES.5. UNEP. Nairobi. Available online at https://www.unep.org/resources/resolutions-treaties-and-decisions/UN-Environment-Assembly-5-2.

Yusoff, Kathryn; Gabrys, Jennifer (2011): Climate change and the imagination. In *WIREs Climate Change* 2 (4), pp. 516–534. DOI: 10.1002/wcc.117.

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