NET ZERO CITIES
SGA-NZC

Deep Dive:
Integrating Mitigation and Adaptation

Pathways for urban climate resilience and justice

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Abbreviations and acronyms

Acronym	Description
WP	Work Package
EU	European Union
NbS	Nature-based Solutions
IPCC	Intergovernmental Panel on Climate Change
NZC	NetZeroCities
EEA	European Environment Agency
OECD	Organisation for Economic Co-operation and Development
R&I	Research and Innovation

Summary

This **deep dive** provides an exploration of the integration of climate change mitigation and adaptation strategies in urban contexts, with particular attention to pathways for resilience and justice in European cities. It is situated within the broader framework of the NetZeroCities (NZC) programme, which supports the transition towards climate-neutral, sustainable, and inclusive urban futures.

The study **considers** the historical predominance of mitigation over adaptation, the increasing recognition of the need to integrate the two approaches, and the shift in climate narratives that emphasise justice, equity, and human-centric perspectives alongside technical solutions. Key issues addressed include the lag in adaptation planning, challenges in financing holistic climate action, risks of maladaptation, and the importance of embedding justice frameworks and local self-determination. The role of nature-based solutions (NbS) as integrative tools is also **examined**.

Drawing on recent academic and grey literature, together with the expertise of the NZC consortium, the deep dive **highlights** both opportunities and risks associated with integration. Opportunities relate to governance improvements, funding alignment, the incorporation of local knowledge, and the multiple co-benefits of NbS. Risks include siloed approaches, insufficient financing, policy incoherence, and inequitable impacts.

The deep dive **points towards** key considerations for cities, including governance innovations, the definition of local adaptation objectives, the expansion of engaged sectors, the integration of funding mechanisms, and the enhancement of participation among vulnerable groups. By adopting integrated and justice-oriented approaches, cities can avoid unintended trade-offs, strengthen resilience, and design climate strategies that deliver co-benefits for people, ecosystems, and future generations.

Keywords

Climate adaptation; climate mitigation; climate resilience; just transition; urban governance; NetZeroCities; nature-based solutions; climate finance; maladaptation; multispecies justice.

Introduction

1 Introduction and Objectives

This horizon scanning deep dive is part of NetZeroCities' efforts to explore key concepts influencing the transition to a zero-emission future. This report is based on the analysis of findings from recent academic research, insights from grey literature, and the expertise within the NetZeroCities consortium. Its focus is on the integration of the two overarching strategies that cities can employ to address climate change: **mitigation** and **adaptation**.

As global temperatures continue to rise, evidence indicates that mitigation efforts alone are insufficient to prevent the negative impacts of climate change. Cities must not only persist in efforts to cut emissions but also work toward strengthening their adaptation strategies, building the necessary resilience to manage unavoidable consequences. Historically, mitigation and adaptation have been approached as separate endeavours. This report, however, examines the growing call for their integration and the challenges cities face in realising this shift. It also explores the factors that have led to the current landscape, where European cities must enhance their climate responses through more comprehensive and synergistic approaches. To support this transition, the report identifies the key risks and opportunities for integrating mitigation and adaptation while outlining potential pathways for European cities.

2 Context

2.1 Background

European cities are **increasingly experiencing the effects of climate change**, with climate extremes that will further increase in frequency and severity (EEA, 2024a). The record-breaking temperatures of summer 2023 illustrate this trend, with global temperatures in 2023 increasing by 1.35 °C compared to the pre-industrial average from 1850–1900 (Lindsey & Dahlman, 2024; Niranjan, 2024). Some risks have already reached critical levels, including risks to health due to heatwaves, to ecosystems and biodiversity, to inland flooding and to solidarity mechanisms (EEA, 2024a). Despite general advancements, efforts to reduce emissions have largely been unsuccessful (IPCC, 2022), leaving cities with the urgent need to enhance resilience to confront the unavoidable impacts. At the same time, cities must continue striving to cut emissions in order to prevent further damage.

Cities contribute over 70% of CO2 emissions and are particularly vulnerable to climate change, as they house the majority of the global human population (Sharifi, 2021). This significant role in both contributing to and suffering from climate change effects has made cities crucial agents of climate action (Kyprianou et al., 2023). In the face of climate change, cities can engage in actions that result in **mitigation**, **adaptation** or **maladaptation** to its effects (IPCC, 2022). Mitigation and adaptation are the primary strategies for responding to climate change and form the two key elements of preparedness for its negative impacts. The urgency of addressing both simultaneously while avoiding the risks of maladaptation has become increasingly evident (IPCC, 2022).

- **Mitigation** refers to strategies and actions aimed at **tackling the root direct cause** of climate change –the concentration of greenhouse gases in the atmosphere, either by reducing the amount of released **emissions** (e.g. by reducing energy consumption, switching to renewable energy sources or legal frameworks to limit emissions) or reducing the current concentration of CO2 by increasing carbon sinks (e.g. through increasing forested areas, or improving land use practices) (IPCC, 2022). Mitigation is in the core of actions for carbon neutrality targets e.g. Net Zero by 2050.
- **Adaptation** is defined, in human systems, as the process of **adjustment in response** to actual or expected climate change effects. Adaptation measures are designed to minimise harm and capitalise on potential opportunities (IPCC, 2022). Adaptation focuses on building **resilience** in both ecological and societal systems. Adaptation strategies are diverse in scope and outcomes. Examples include: altering agricultural practices to cope with changing precipitation, building coastal infrastructure to protect against sea level rise, re-design infrastructure to withstand extreme weather conditions, enhancing public health measures and emergency response to address climate risks, and planning relocation of vulnerable populations.
- In ecological systems, adaptation is the process of **autonomous adjustment** to the current climate and its effects through ecological and evolutionary processes. Ecological systems are capable of adapting and mitigating within limits. (IPCC, 2022).
- **Maladaptation** refers to **actions that inadvertently increase vulnerability** to climate change or exacerbate its impacts on people, biodiversity and ecosystems. These outcomes may include higher greenhouse gas emissions, increased vulnerability, reduced equity, or decreased welfare (IPCC, 2022). Often, maladaptation happens as an unintended consequence. Marginalised groups are particularly vulnerable to the adverse effects of maladaptation.

Measures to reduce greenhouse emissions and shield populations and ecosystems from the effects of climate change **differ substantially in nature and development.** However, mitigation and adaptation should be viewed as **interdependent strategies**—like two sides of the same coin (Howarth & Robinson, 2024). The urgency of climate change calls for cities to develop comprehensive climate action plans that not only implement these strategies simultaneously but also **interrelate** them effectively. A combined understanding of adaptation and mitigation is an opportunity to increase societal resilience. Mitigation and adaptation plans are being developed rapidly in many cities across the globe, driven by local initiatives and emerging alliances that support organisations across multiple jurisdictions (Kang et al., 2024). However, despite the progress and the imperative, recent evidence suggests a **persistent dichotomy**, indicating that this integrated approach is still far from being realised (Huang-Lachmann & Guenther, 2020).

2.2 The mitigation-adaptation dichotomy

2.2.1 Mitigation prevails over adaptation

International, national, and local climate efforts have historically **focused primarily on mitigation**, leading to a disparity in the development of adaptation plans (Cömert Baechler, 2023; Reckien et al.,

2018; Sharifi, 2021). This trend continues at the EU level. According to Grafakos et al. (2020), from a large sample of 885 European cities, 75% have adopted mitigation strategies alone, while 57% consider both mitigation and adaptation plans. No city had implemented adaptation plans alone. Similar conclusions have been reached by other studies (Heidrich et al., 2013; Melica et al., 2022; Pietrapertosa et al., 2019; Reckien et al., 2014; Reckien et al., 2018). The prevalence of mitigation is attributed to several interconnected factors, fundamentally arising from **cities' governance capacities** for implementing both policies, as well as **international networks and agreements** that inadvertently promote mitigation over adaptation.

- **Institutional context and governance capacity at the city level:** Cities generally possess governance and decision-making frameworks that enable them to implement and **manage mitigation strategies more effectively** than adaptation. Their typically robust regulatory and policy mechanisms provide greater control over urban technical systems through well-defined quantitative metrics and evaluation methods, such as those used for energy, transportation, and waste management (Cömert Baechler, 2023). Mitigation targets are clearly defined in quantitative metrics of CO2, which, when compared to adaptation targets, facilitates the integration of policies for decarbonisation (Howarth & Robinson, 2024). In contrast, social and ecological resilience lack universal evaluation metrics (see section 3.1). Consequently, **mitigation efforts are viewed as having more direct and measurable outcomes** and are more appealing to cities aiming to **demonstrate progress and secure ongoing public and international support** (Cömert Baechler, 2023). Moreover, the integration of adaptation and mitigation strategies is challenged by differences in spatial, temporal, jurisdictional, and institutional scales, leading to complexities that result in conflicting policies with contradictory objectives (Landauer et al., 2019).
- **Alignment with international and national climate objectives:** Cities often participate in international climate networks and benefit from global agreements primarily focused on mitigation (Cömert Baechler, 2023; Pietrapertosa et al., 2019). National climate priorities tend to align with international policy objectives, which are supported by strong regulatory frameworks and offer long-term global benefits. The external support from international networks, reinforced by national priorities, provides a framework for city action that often includes **technical and financial resources supporting the implementation of mitigation** strategies. Mitigation actions are perceived as **more cost-effective** in urban planning because they address evident existing sustainability goals, whereas adaptation strategies are typically more localised and lack equivalent legislative support. As a result, there is a **disparity in resource allocation,** with more efforts being directed toward reducing CO2 emissions than building resilience (IPCC, 2022).

The **EU Missions framework** has been implemented as an innovative and promising approach for funding, R&I and implementation of climate action (European Commission, 2023). In particular, the Mission for **Climate-Neutral and Smart Cities,** focused primarily on emissions mitigation to reach climate neutrality, and the **Mission for Adaptation to Climate Change,** focused on achieving climate resilience, are leading the implementation of climate pathways at the city and regional levels. The emphasis on multi-level governance and systemic approaches ensures that local actions align with national and EU-wide objectives. Recent discussions have sparked debates on how to **align synergistic efforts between the two missions** (EU Science & Innovation, 2022). This stems from the increased recognition of the need to address mitigation and adaptation together. For instance, a joint Horizon EU call between both Missions was launched in 2023 (European Commission, 2023). The potential areas of synergy between the missions within policies, strategies, capacity building, and joint programming are currently being discussed.

2.2.2 The urgent need for mitigation-adaptation integration

- **Identification of synergies and trade-offs:** Despite the advancements, **mitigation actions alone cannot resolve the current impacts of climate change.** For instance, even if the goals of Net Zero are met by 2050, weather extremes will still be on the rise (Howarth & Robinson, 2024). Given the urgency of climate impact, the need to implement holistic strategies combining mitigation and adaptation is broadly recognised. If well-implemented, integrated strategies can result in **synergies** of climate action that are able to build resilience while having positive effects on cutting and/or absorbing greenhouse emissions (Sharifi, 2021). However, they can also lead to **trade-offs** that exacerbate the negative effects of climate change and/or affect the capacity of communities to cope with its effects (Sharifi, 2020) (see **Table 1**).

  Mitigation measures can have trade-offs in adaptation if they increase climate vulnerability—for example, by exacerbating heat islands, flooding, eroding the livelihoods of marginalised communities, and/or broadening inequality gaps. Conversely, adaptation measures might inadvertently increase greenhouse gas emissions by reducing efficiency and raising energy demand (Sharifi, 2020). Understanding these synergies and trade-offs remains challenging due to the inherent **complexity and contextual nature of the interactions** between mitigation and adaptation, with outcomes depending on the interplay of multiple spatial and temporal dimensions (Boyd et al., 2022). There is broad recognition that these interactions have not been sufficiently studied, and that there is a **lack of literature, frameworks, and tools to facilitate the identification of synergies and trade-offs** (Pereira & Alho, 2019; Sharifi, 2020; 2021). At the local level, addressing this gap is resource-intensive and requires specific technical capacities (Grafakos et al., 2020), which, in turn, demands institutional coordination and prioritisation (Boyd et al., 2022). These complexities leave cities without adequate references or guidance for best practices, leading to stagnation (Sharifi, 2020; 2021). As a result, cities vary in their ability to identify co-benefits and trade-offs (Boyd et al., 2022)

- **Challenges for effective integration:** Real integration means that cities should be able to **increase synergies while avoiding trade-offs** in combined actions. There is consensus and substantial evidence supporting the **imperative for integrated approaches** (Grafakos et al., 2020; Howarth & Robinson, 2024; Huang-Lachmann & Guenther, 2020; Pasimeni et al., 2019; Pereira & Alho, 2019; Sharifi, 2021). However, examples of successful integration are still limited. Although research on integration is on the rise, particularly in Europe, it is still insufficient to provide actionable directions (Göpfert et al., 2019a; IPCC, 2023b; Sharifi, 2022).

Sector	Synergies	Trade-offs
Urban green infrastructure	Green infrastructure, such as parks, green roofs, and urban forests, naturally contribute to carbon sequestration while enhancing urban resilience by providing stormwater management and reducing heat islands, further reducing energy demands for cooling.	The implementation and management of green infrastructure may involve significant emissions of CO2 depending on the type of infrastructure and context. Emissions are reported mainly from transport and machinery during the construction, and from the use of fertilisers and irrigation during management.
Building design	Passive building design related to albedo, shading, orientation, and natural ventilation reduces need for air conditioning and helps in achieving thermal comfort during heatwaves.	Air conditioning of hospitals and elderly homes and vulnerable populations are effective adaptation measures. However, unless renewable energy sources are used, they considerably increase the energy demand and emissions.

Urban design and land use planning	Compact urban development emphasising density, land use mix, and improved connectivity promotes active and public transportation, reducing energy demands for travelling. As habitation space is smaller, it reduces energy for cooling and heating buildings and water consumption.	Highly dense urban areas with limited green and open spaces can intensify heat islands and intensify the energy for cooling. Increased density and rapid growth of high-rise buildings has resulted in intensive demand for steel with negative consequences for mitigation.
Energy	Decentralised and distributed energy systems based on renewable sources reduce emissions, improve efficiency, and are less reliant on water use. They enhance resilience by minimising the risk of component failures and reducing vulnerability during storms, floods, and extreme temperature events.	Redundant energy infrastructure based on renewable sources still demands substantial capital investment, which can undermine the distributional benefits of the energy transition. This may limit the availability of resources for other critical adaptation measures, such as poverty alleviation, particularly in vulnerable localities.
Water	Water efficiency measures are primarily linked to adaptation, but they also contribute indirectly to mitigation due to the close connection between water and energy. Stable water supplies often lead to increased demand, making efficient management critical. Rainwater harvesting can be used for non-potable purposes, easing water scarcity, while rainwater and greywater recycling can reduce the energy demand for freshwater treatment.	Adaptation measures to address water scarcity can be costly and may increase emissions due to the water-energy nexus. For example, desalination plants can enhance water supply resilience but are both expensive and energy-intensive. Similarly, rainwater harvesting systems, while beneficial, can lead to cost-related trade-offs.
Transport	Active and public transportation, combined with economic measures such (fuel and vehicle taxation, parking) are effective strategies for reducing emissions, offering multiple co-benefits, including increased physical activity and reduced air pollution. Enhanced adaptive capacities result from cost savings, improved public health, and lower congestion-related costs, such as productivity losses. Public transportation has proven more resilient in adverse events, facilitating emergency access and quicker evacuations.	Implementing efficient active and public transportation systems requires large-scale infrastructure modifications, resulting in direct emissions. Additionally, the management of such infrastructure may lead to gentrification and the displacement of vulnerable, low-income users. Vehicle and fuel taxes, along with public transport tariffs, can also disproportionately impact low-income households, exacerbating financial burdens and loss of jobs.

Table 1. Synergies & trade-offs examples in combined mitigation and adaptation actions at city level (Source: Sharifi 2020, 2021)

Typically, cities tend to implement mitigation and adaptation **strategies in silos,** with policies often focusing on one strategy at a time, within different institutional frameworks or across varying spatial and temporal scales (Howarth & Robinson, 2024; Huang-Lachmann & Guenther, 2020; Hurlimann et al., 2021; Landauer et al., 2019; Sharifi, 2020). **Systemic barriers**, such as the limited technical capacity of local governments to coordinate departments, establish shared goals and priorities, and integrate funding mechanisms, pose significant challenges to effective integration (Boyd et al., 2022). **Integration adds complexity** to planning processes and necessitates the efficient use of scarce human, technical and economic resources.

The complexities related to integration risks conceptualising climate action through the lens of a false dichotomy of having to choose between allocating resources to either adaptation or mitigation (see Shaw, 2023). However, isolated strategies are not only cost-ineffective but also fail to account for the complexity required to prevent maladaptation, often resulting in unintended trade-offs and missed opportunities for synergies. Furthermore, these fragmented approaches contribute to policy incoherence and resource inefficiencies (Howarth & Robinson, 2024).

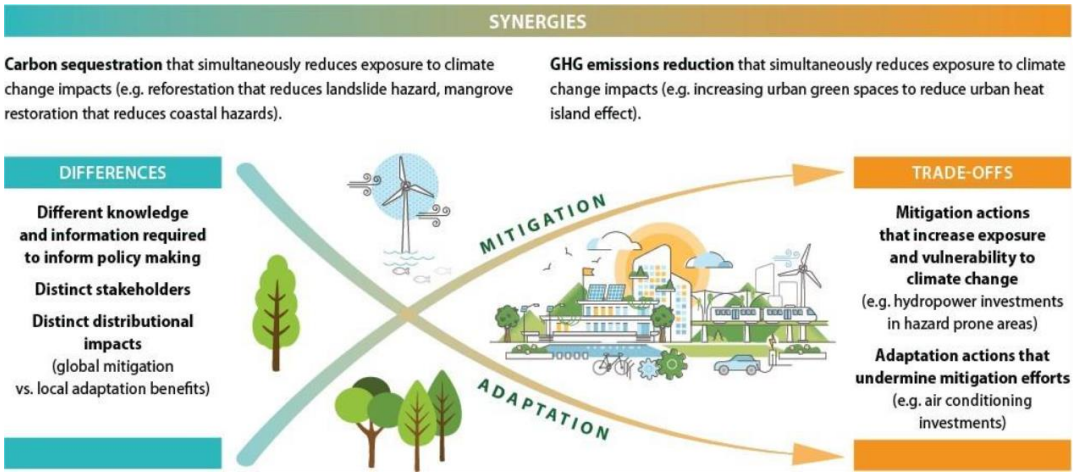

Figure 1. Aligning climate change mitigation and adaptation policies: differences, synergies and trade-offs (Source: OECD, 2021).

2.3 Evolution of climate narratives and research focus: from techno-scientific to holistic and human-centric perspectives

Over the past 40 years, there has been a **significant shift in climate change narratives**. In a nutshell, early research primarily focused on gathering and interpreting **quantitative environmental data**, such as emissions and temperature changes, in order to understand the causal effects of rising biophysical quantities. This quantitative analysis has served as the foundation for climate action based on technical and localised solutions (Baggio, 2021). Over time, as the real-world implications of climate predictions have become clearer, the techno-scientific focus has faced the need to expand its approach to better understand how these predictions and numbers impact societies. (Baggio, 2021).

The need for a mindset shift has become increasingly evident as more empirical research broadens our understanding of how various socio-technical systems contribute to environmental crises and how

human communities perceive and are disproportionately affected by them. This understanding highlights the imperative of addressing the **social, ecological, and technologica**l dimensions of the environmental crisis **as integrated systems.** Consequently, there is a growing focus on studying climate change through the lenses of **human vulnerabilities, community resilience, and political and institutional capabilities** (Baggio, 2021; Klein, 2017).

The focus of climate action is expanding towards a **more holistic and human-centred** conceptualisation of sustainability transformations, including the integration of topics of equity and justice, livelihood diversification, health services, migration and peace (IPCC, 2023a). It highlights the need for more collaborative efforts, transdisciplinary and political will. However, these narratives are still in the early stages of being translated into impactful actions. The early stages of empirical research often constrain practitioners seeking to integrate more socially oriented dimensions into projects of climate action (IPCC, 2023b; Castán Broto et al., 2023). Nonetheless, the ongoing momentum keeps pushing forward the exploration of actions that address climate issues while improving societal standards, the quality of livelihoods and socio-ecological wellbeing.

3 Key issues

This section highlights the most relevant topics from the horizon scanning, presented as seven key issues in narrative form. These issues are particularly significant from a city perspective, offering **insights into the emerging challenges and opportunities** cities should consider when designing climate strategies that enhance synergies between mitigation and adaptation measures while minimising trade-offs.

3.1 The shortfall of adaptation efforts

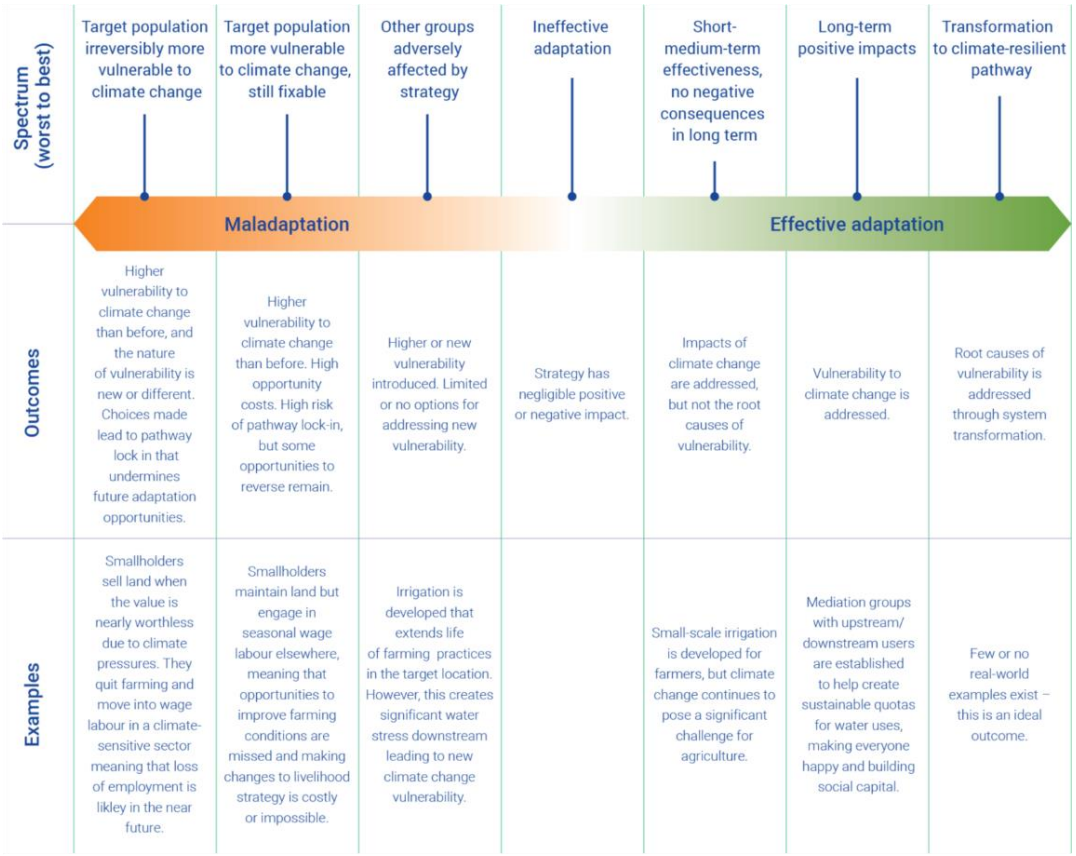

Figure 2: Simplified continuum of adaptation outcomes, from irreversible maladaptation to transformative adaptation (Source: UNEP 2021)

The current and future impact of climate change leaves little question that **adaptation measures need to be put in place and that adaptation will have an impact on people's livelihoods.** However, implementing adaptation in general has proven challenging in all contexts. The IPCC report (2022) highlights that even though adaptation efforts have increased, its **progress is insufficient and unevenly distributed**, leaving serious gaps between the goals that societies are setting for themselves and the implementation of these measures. Current approaches to adaptation tend to focus on the short-mid term, are sector-specific, and focus more on planning than on implementation (IPCC, 2022). This drastically reduces the transformational opportunities required by the urgency of the situation.

One key to understanding adaptation's challenging implementation is its **lack of evaluation methods** (Reckien et al., 2023). To date, there are no clearly transferable methods or universal metrics to monitor the effectiveness and progress of adaptation measures (Goonesekera & Olazabal, 2022; Howarth & Robinson, 2024; Loroño Leturiondo et al., 2023). The diverse nature of adaptation actions makes their implementation highly dependent on contextual factors such as the severity of climate change, data availability, and the degree of resilience and vulnerability of local communities and

ecosystems (Howarth & Robinson, 2024; IPCC, 2022). As such, understanding adaptation relies on **qualitative indicators that are not easily quantifiable** (Boyd et al., 2022) and this hinders its planning under traditional urban planning and decision-making frameworks. For example, not every adaptation action can be modelled into Earth scenarios (IPCC, 2023a). Also, financing adaptation tends to be challenging due to the need to **invest in highly speculative** and uncertain scenarios on long-term horizons. Although adaptation finance represents great opportunities, there is a critical gap between its conceptualisation and demonstrable impactful solutions (Fankhauser et al., 2023; Howarth & Robinson, 2024).

While recognised as context-specific, adaptation strategies are often transferred from one city's best practices—typically larger, more resource-rich—to others or applied uniformly, assuming the same conditions across different areas of the same city. This **one-size-fits-all approach neglects the unique conditions and diverse needs** of various local populations (Castán Broto et al., 2023). Furthermore, adaptation responses frequently **exclude the most vulnerable groups** from the planning process and provide unequal access to benefits (Prall et al., 2023; Reckien et al., 2023), exacerbating systemic vulnerabilities. Despite this, adaptation has traditionally been portrayed as a **neutral intervention, devoid of political or social implications** (Castán Broto et al., 2023).

Many actors are now strongly advocating for **new and more disruptive adaptation narratives** (Castán Broto et al., 2023). The core message is the imperative to employ adaptation actions for effective reduction of climate risk, while achieving multiple societal co-benefits at the same time, even beyond climate change. This includes the **benefits of decarbonisation (mitigation), the inclusion of marginalised voices, and improving livability, human health and environmental integrity.** Adaptation to novel climate scenarios needs to happen in fair and inclusive ways, respecting local culture (Gilmore et al., 2024). In this sense, it is imperative to redefine adaptation in terms of urgency, justice, social inclusion and mitigation synergies.

3.2 Integration of justice frameworks

Adaptation efforts will have a significant impact on people's livelihoods, underscoring crucial **equity issues in the distribution of burdens and benefits.** The IPCC emphasises the need for more thorough discussions on topics like healthcare, relocation, migration, security, and peace in direct relation to climate action (IPCC, 2023b). For example, relocation can effectively reduce risk but only when it is done in a safe, orderly, and voluntary way. There is growing awareness that climate strategies must be responsive to local realities, societal barriers, and access to support, with success defined by capturing more nuanced and personal expressions of vulnerability (Gilmore et al., 2024). Yet, in contrast, current imaginaries of climate-resilient futures tend to focus on problem-solving with **technological solutions, promote individual responsibility and safeguard the values, experiences and lifestyles of the more privileged groups** (Chu & Shi, 2022).

Cities must embrace the challenge of designing adaptation plans that recognize the diversity of experiences of vulnerabilities, especially of marginalised communities due to their intersecting identities (Gannon et al., 2022; Chu & Shi, 2022). But in doing so, it is essential not to homogenise societal groups within communities, which are often institutionally well represented. Scholars of **intersectionality** have examined **how various systems of oppression intersect, resulting in diverse experiences of discrimination and vulnerability** (Collins & Bilge, 2020). Their insights are increasingly being applied to the context of climate justice. Intersectionality emphasises understanding the range of potential responses to adaptation, the power structures shaping these responses, and their contributions to discrimination (Castán Broto et al., 2023; Chu & Shi, 2022; Ravera et al., 2016).

Including justice in climate responses involves ensuring that **benefits and burdens are fairly distributed** across all societal sectors and natural ecosystems. It also requires addressing existing and future disparities in adaptation and mitigation strategies and dealing with the **socio-political roots of vulnerability** (Chu & Shi, 2022). Key aspects to consider include participatory and inclusive decision-making, affordability and accessibility of resources and services, fostering community

resilience and sustainable livelihoods (including housing and jobs), addressing historical injustices, and respecting local and indigenous knowledge systems (Baggio, 2021).

However, while climate justice has been a significant topic in theoretical and academic discussions, the institutionalisation of justice frameworks into local climate action planning and related policies has largely been ineffective (Cannon et al., 2023; Prall et al., 2023). Implementing these frameworks requires reimagining climate resilience by incorporating elements beyond technical solutions to **redefine the success in relation to values and ethics of care.**

3.3 Financing holistic climate actions

The success of implementing and evaluating integrated mitigation and adaptation actions greatly depends on the availability of financial resources. The cost of climate change is no longer hypothetical. Hence public and private organisations need to better articulate their climate finance needs and map them against the available funding sources to detect financing gaps (Fankhauser et al., 2023). Between 2017 and 2022, funding for urban climate initiatives more than doubled, reaching a total of USD 831 billion (Press-Williams et al., 2024). However, there are substantial **gaps in understanding the distribution of climate costs and the effectiveness of funding schemes** (Grafakos et al., 2020).

Figure 3: Thematic split of climate finance provided and mobilised between 2016 and 2022 in USD (Source: OECD)

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Global and multinational networks and frameworks (e.g. EU Missions, Climate City Capital Hub, C40 Cities, etc.) play an important role in supporting cities with funds to promote and institutionalise climate actions. They also **affect the course and trajectory of those actions** as they support the development of integrated goals, visions and legislations (Göpfert et al., 2019a). An overwhelming **majority of funds are directed to mitigation** (IPCC, 2022; Shum et al., 2022). In fact, only 1.2% of total urban climate finance flows (USD 10 billion) are directed to adaptation (Press-Williams et al., 2024). Furthermore, only USD 7 billion are used for multiple objectives including both mitigation and adaptation (Press-Williams et al., 2024). As a consequence, even though climate finance has shown a positive trend in recent years, the current financial schemes are insufficient and limit the development of adaptation options (IPCC, 2023b). In other words, **siloed finance upholds siloed policies and easily leads to maladaptation** (Olazabal, M. personal communication, March 12, 2024).

In the context of adaptation, a critical gap exists between its conceptualization and proven solutions, creating considerable **uncertainty** around investment (Fankhauser et al., 2023). The 2024 State of Cities Climate Finance Report estimates that adaptation needs for cities in emerging markets and developing economies lie at USD 147 billion per year until 2030, and USD 165 billion per year from 2030 until 2050 (Press-Williams et al., 2024). Due to numerous uncertainties about climate impacts and risks, as well as shortcomings in the scenario-based models, data, and methodologies employed, these estimates are probably significantly lower than the true values (Press-Williams et al., 2024). It has been recognised that financial needs cannot be determined without a nuanced understanding of climate objectives and so it is essential to **define local goals of adaptation**, such as acceptable levels of risk, the desired outcomes, and regulatory expectations. But on the other hand, despite the uncertainties green finance investors are embracing the increased profitability of adaptation, projecting a market worth **$2 trillion by 2026** (Shum et al., 2022).

Still, current funding for adaptation is often seen as poorly structured. For instance, **financing mechanisms often fail to consider adequate time scales,** favouring short-term and specific problem-solving (Gilmore et al., 2024), overlooking the longer time scales required for adaptation efforts, whose benefits may not be evident for a decade or more (IPCC, 2022). Additionally, the sustained perception that climate impacts are distant in the future discourages organisations from making necessary financial commitments. At the same time, climate change impacts are not only physical and long-term; they are already affecting organisations in various ways across different time scales. For instance, mitigation efforts require substantial investment in clean and renewable energy, driving the transition toward low-carbon economies with significant financial risks and opportunities for different sectors and investors (TCFD, 2017). Moreover, adaptation is often overlooked in related investments such as **infrastructure development, capacity building** (Gilmore et al., 2024) and **security** (Lavandier, 2023). The IPCC (2022) also warns that the increasing costs of climate change will further strain financial resources for adaptation, as cities will need to allocate more funds to repair growing losses and damages.

Adaptation requires a significant upfront investment (IPCC, 2022); therefore, it is essential to **develop new finance streams** (Gilmore et al., 2024) and to mobilise current funding schemes to broaden their scope of climate actions into synergies with mitigation outcomes (beyond e.g. net-zero). It is especially important to increase climate finance flows to cities in emerging markets and developing economies, which currently receive only 11% of the total urban climate finance (Press-Williams et al., 2024). Innovation in finance structures should involve **partnerships between public, private and third sectors**, and for this, better and more accessible information has been recognised as a vital leverage. Better knowledge transference can be done through **financial disclosure** of climate-related data horizontally across sectors (Fankhauser et al., 2023; TCFD, 2017).

Funding directed to local governance can greatly benefit from transitioning from a fragmented and siloed **‘funding by project’ towards a ‘funding by programme’ logic.** This transition can enhance efficiency, reduce administrative burdens, and support the holistic design of climate action (Teubner, 2024). Funding programs should consider climate risk across the whole policy spectrum, directing funds not only to direct adaptation efforts but also to broader resilience initiatives (Fankhauser et al., 2023). In times of regional and national green policy pushback, cities need to build capacities to

access funds and remove barriers, and at the same time, ensure that funds are appropriately spent in ways that their impact reaches those who are in most need.

3.4 Support to local self-determination

Most severely affected localities by climate change are taking the initiative to decide how to adapt to current and future climate effects (Coger et al., 2022; GCA, 2023a; GCA, 2023b). **Locally led action** has the advantage of **addressing vulnerabilities, directing energy and resources toward the local known issues and enhancing engagement and participation of a diversity of communities**, who hold the deep knowledge about their territories (Gilmore et al., 2024; Morgado Simões, 2024). Examples of these actions of adaptation are seen globally in the most vulnerable regions to climate change (GCA, 2023b). In Europe, examples can be found particularly in regions prone to flooding, heatwaves and sea level rise (Morgado Simões, 2024).

Even though the local **self-determination to act needs to be recognised and supported** (Coger et al., 2022), its promotion should not be seen as an excuse for convenience. On the contrary, it should be critically discussed within foundations based on equity, justice and participation. Self-determination must be supported by regional and national governments and other international entities by **providing enough resources, sharing knowledge and helping localities build capacity.** Self-determination should ensure that local and indigenous people's experience and knowledge systems are taken into consideration in planifications, as well as addressing their needs and those of the local natural ecosystems (Gilmore et al., 2024; GCA, 2023b).

Self-determination becomes especially relevant in scenarios of severe weather events and adaptation choices that **disrupt livelihoods.** For instance, in the context of displacement of communities, there are risks that vulnerable populations would not be able to leave their homelands even in scenarios of significant impact (Coger et al., 2022). This highlights the importance of safeguarding the relocation of people while maintaining their cultural ties to place, environment and social networks. Climate measures, especially those that destabilise the everyday experience, should be carried out with **consent, transparency and accountability in order to promote equity and protect dignity** (Gilmore et al., 2024).

In this context, climate change is increasingly recognized as an **issue of conflict management and security**, underscoring the interconnections between **climate action and urban hazard mitigation plans**, which are often treated as separate planning strategies (Matos et al., 2023). The need for integration arises from the shared goal of hazard mitigation and adaptation plans: reducing vulnerability to future hazards, especially as the impacts of climate change become more apparent. For example, national security actors are advocating for collaboration between military institutions and public and private sectors in adaptation planning, foresight and implementation (Lavandier, 2023). Consequently, local climate strategies may need to **broaden their scope by collaborating with sectors traditionally not included in adaptation planning**, such as food production, public health, human welfare organisations, security sectors, and cultural institutions. The expertise within these sectors can provide valuable insights into safeguarding safety and dignity in the face of climate change.

3.5 Nature-based solutions for integrated adaptation and mitigation

Nature-based solutions definition:

"Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges (climate change, natural disasters, social and economic development, human health, food security, water security, ecosystem degradation and biodiversity loss) effectively and adaptively, simultaneously providing human well-being and biodiversity benefits." (IUCN, Nature-based solutions).

Examples:

- **Green infrastructure**: green roofs and green walls to reduce heat islands, manage stormwater and enhance habitat and food for pollinators.
- **Street trees and urban forests:** to reduce air pollution and promote wellbeing.
- **Permeable surfaces:** to absorb and filter rainwater and reduce flood risks.
- **Coastal buffer zones:** restore dunes, mangroves and marshes to protect against storms, higher sea levels while providing habitats for wildlife.

Better understanding human-environment relation has direct implications for urban policy and management practices. A growing body of research is backing up the notion that theoretical frameworks and methodologies should continue to develop to **better integrate people and their surrounding natural systems** in response to climate challenges (Baggio, 2021). **Climate change and biodiversity loss** are increasingly considered as interconnected pieces of the same environmental crisis, especially after the first collaborations between IPCC and IPBES (IPCC 2022; IPCC 2023b). It has become evident that climate issues and biodiversity loss need to be essentially tackled together to avoid trade-offs and maladaptation. This means that new topics need to be included in the adaptation and mitigation narratives to bring awareness that climate action should not be planned only in terms of human benefit and that natural species and ecosystems also adapt to and mitigate the effects of climate change (IPCC, 2023a).

	Associated ecosystem services							
Nature-based Solution	Coastal protection	Reduction in riverine flood impacts	Reduction in urban flood impacts	Filtering pollution	Carbon sequestration	Habitat creation	Heat mitigation	Recreational opportunities
Protecting/ restoring coastal habitats	●			●	●	●		●
Protecting/ restoring upland forests		●	●	●	●	●	●	●
Creating urban green spaces			●	●		●	●	●

Figure 4: Examples of the multiple co-benefits offered by NbS. Source OECD, 2021

In this context, **Nature-based solutions (NbS)** have been increasingly recognised as a valuable framework for integrating adaptation-mitigation actions while possibly improving biodiversity and the wellbeing of human and nonhuman urban residents (Maller, 2021). NbS are perceived as a great promise for climate action; for instance, 91% of European cities contemplate NbS in their mitigation and/or adaptation plans (EEA, 2024) and as a first step for integrating mitigation and adaptation measures (Pasimeni et al., 2019; Mazzeo & Polverino, 2023). This is due to the **great array of perceived co-benefits and synergies** for mitigation and adaptation when implementing solutions that include green infrastructure and their recognised effectiveness in providing risk reduction and enhancing environmental resilience while simultaneously absorbing and storing CO2. NbS are generally highlighted as effective in improving bio-retention to manage stormwaters and improving building insulation to manage heat islands, which reduces the energy demands, enhances biodiversity and improves human health and wellbeing (Senosiain, 2020). Green infrastructure such as green roofs and walls, green corridors and green spaces are the most common strategies where co-benefits were accounted for (Boyd et al., 2022).

However, the concept of **NbS is still the subject of debate,** with concerns for misunderstandings that NbS alone could provide all solutions to climate change (IPCC, 2022), and that they need to be applied at larger scales city-wide to be effective (Senosiain, 2020). Ecosystem-based mitigation and adaptation actions are context-specific and from a broad array of existing solutions not all are equally effective. If not well implemented, **they can lead to trade-offs and maladaptation.** For example, NbS initiatives are less likely to be implemented in lower-income neighbourhoods. At the same time, if social aspects are not integrated into their planning, NbS can lead to issues of green gentrification (Maller, 2021). Another concern is the oversimplification and romanticization of green spaces, leading to an implementation that does not recognise the **complexity of ecological dynamics,** even leading to unintended consequences like disrupting ecosystemic balance or aggravating human-nature conflicts (Luther, 2023; Parris et al., 2018). It is often assumed that green infrastructure can also create habitats for plants and insects, and provide benefits for pollinators. However, some researchers argue that these assumptions are rarely locally validated (Apfelbeck et al., 2020) and that the complexity of natural systems makes predicting all potential trade-offs an impossible task. These challenges make it difficult to decide **when to prioritise the integrity of ecosystems or the safety and concerns of human residents**.

New definitions of NbS (see IUCN definition) are shifting from a problem-solving approach that prioritises development needs to a broader recognition of societal needs and the interconnected needs of all species within urban areas (Maller, 2021). This shift embraces a more relational socio-ecological ontology, acknowledging the shared factors affecting both vulnerable human communities and ecosystems, and celebrates the entanglement of human and ecological well-being in city planning. These perspectives open up future scenarios where adaptation and mitigation actions are integrated into deeper transformations, promoting **imaginaries of mutual socio-ecological regeneration and flourishing** (Connolly, 2020). However, this evolution raises questions about how to effectively operationalize and institutionalise these ideas in urban planning while accounting for the complexity and unpredictability of nature and its metabolic processes and still addressing the effects of climate change.

Some directions point toward **expanding the scope of climate-biodiversity urban action** to include a broader range of concerns, such as **ethics, justice, and inclusion in decision-making** in a more direct relation to urban nature. For instance, the concept of **“multi-species justice”** has been increasingly proposed as a promising framework to address interrelated vulnerabilities (Maller, 2021). Within these ideas, key leverage points include ensuring **participatory planning** with all relevant stakeholders to represent the needs of all actors and adopting an **adaptive approach to NbS management** and governance that can react and adjust solutions as needed. However, these concepts are still in their early stages and require further experimentation.

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4 Risks and Opportunities

This section outlines the recognized risks and opportunities for cities to **better integrate and implement climate mitigation and adaptation actions** to enhance synergies and avoid trade-offs, ultimately addressing the causes and effects of climate change while advancing sustainability transformations, improving livelihoods, and fostering wellbeing and flourishing ecosystems. Ultimately, a sustainable vision of the future should always include an awareness of combined effects of both mitigation and adaptation.

4.1 Opportunities

Opportunity type	Impact
Strategic integration of adaptation and mitigation to foster governance synergies	• Optimised resource and skill allocation • Policy coherence • Integration of funding strategies • Foster innovation • Exploration of local novel governance models
Addressing the knowledge gap	• Increased context-specific knowledge on adaptation/mitigation synergies and trade-offs and technical capacities • Transdisciplinary and collaboration with new societal sectors: healthcare, welfare, security, food production, etc • New tools for sense-making and complexity
Integration of justice frameworks for more inclusive climate strategies	• Addressed equity and intersectional vulnerabilities • Equal access to benefits • Increased social resilience against climate uncertainty • Redefine success of climate outcomes based on ethics of care
Securing holistic financing of climate action	• Broaden scope of funding mechanisms to finance programmes with integrated approaches • Defined long and short term investment priorities • Partnerships with private and third sectors • Disclosure of financial climate-related data and learn from others
Local approach to climate response	• Local goals of adaptation, defined acceptable levels of risk and desired outcomes • Broad societal participation into climate decision-making • Integration of local and indigenous local knowledge systems • Consent, transparency and accountability when protecting dignity

	• Integrated urban hazard mitigation and climate change strategy
Leveraging Nature-based Solutions	• Benefits from urban ecosystems services while improving quality of biodiversity and societal well being • Introduction of ethics and justice frameworks (e.g. multispecies justice) to address ecological and societal integrated vulnerabilities • Participatory planning and adaptive management of NbS

Table 2. Opportunities relating to climate mitigation and adaptation strategies

4.2 Risks

Type of risk	Impact
Persistent mitigation-adaptation dichotomy	• International networks continue reinforcing dichotomy • Stagnation of adaptation strategies due to uncertainties and lack of evaluation methods • Siloed approach due to lack information on synergies and trade-offs • Unintended trade-offs and missed opportunities of synergies • Policy incoherences and resource inefficiencies
One-fits-all solution approach neglect contextual realities	• Overdependence on transferable best practices overlooks local needs • Over-reliance on international climate targets shifts focus from local adaptation needs • Over-reliance of techno-scientific narratives overlooks the need for societal change
Governance and structural challenges	• Complexity, systemic barriers, and limited resources reinforce the lack of integration • Depoliticisation of the climate debate results in a lack of commitment and prioritisation • Lack of participatory decision-making imposes misleading adaptation goals (e.g., acceptable levels of risk) and outcomes
Increase vulnerability to climate risk	• Persistent exclusion of vulnerable groups in planning exacerbates vulnerabilities • A shallow approach to inclusion homogenises vulnerable communities, neglecting intersectional identities

	• Adaptation measures become less effective, and risks increase as climate change effects become more severe
Financial risk	• Uncertainty in demonstrating impact reinforces low investment in adaptation • Insufficient investment in vulnerable regions leads to uneven adaptation efforts • Poor conceptualisations overlook adequate time scales for investment • Increased costs of climate change divert funds to repair losses and damages instead of building resilience. • Administrative burdens and lack of capacities result in missed opportunities to access adequate funding
Downplaying of local leadership	• Self-determination and need to timely reactions leads to uncoordinated and unsupported local action • Failure to include local knowledge misses opportunities to recognize synergies and trade-offs
Maladaptation when implementing NbS	• Failure to consider social aspects can exacerbate inequalities, e.g., green gentrification • Shallow implementation of ready-made solutions can lead to unintended ecological trade-offs • Lack of frameworks or tools to address ethical choices leads to stagnation or poor decisions • Linear management of NbS cannot react to the unpredictability of natural systems.

Table 3. Risks relating to climate mitigation and adaptation strategies

5 Key takeaways for cities

5.1 Governance innovations for integrating climate actions

To transcend the mitigation and adaptation dichotomy and align these strategies with broader societal and environmental goals, cities should move towards breaking down silos within governance structures and fostering integration across city departments. Adopting a multi-level governance approach ensures that climate actions are matched to the appropriate level of government and the specific needs of different communities, enabling more targeted and effective responses. Innovative governance models can enhance cities' capacity for anticipation, experimentation, and responsive action. Climate adaptation and mitigation must be treated as horizontal issues that permeate all areas of urban policy, while maintaining clear ownership and accountability to ensure these strategies are effectively implemented. Importantly, cities must continue further developing their adaptation strategies while continuing to advance their mitigation efforts. It is essential to communicate that adaptation and mitigation work hand in hand, with neither being sacrificed for the other, to ensure a balanced and just response to the climate crisis.

5.2 Knowledge and capacity supporting place-based approaches

To integrate climate strategies, cities should develop both technical and non-technical capacities, incorporating new knowledge and learning tailored to their unique contexts. This involves building a deep understanding of their specific adaptation needs, as well as recognizing the synergies and trade-offs that arise when combining these efforts with mitigation actions. By doing so, cities can enhance their self-determination, pursuing solutions that are best suited to their local realities. While established networks and programs can provide valuable support, it is crucial that the knowledge they offer is adapted to fit local circumstances. Cities should also leverage peer learning, especially with other cities facing similar challenges, and explore transformative capacities such as foresight, innovation, experimentation and embedding awareness.

5.3 Define local climate objectives

Cities must go beyond national and international targets to define their own climate objectives in collaboration with their communities. This involves determining how they want to adapt to climate change and setting clear parameters, such as acceptable levels of risk and what constitutes well-being and healthy lifestyles in their specific context. To achieve this, climate action should broaden its scope to incorporate often-overlooked dimensions like dignity, care, and well-being. It is essential to build on the evolving climate narratives that emphasise ethical and human-centred approaches, reimagining climate action in ways that connect these human dimensions to environmental integrity.

5.4 Expand engaged sectors

Cities must expand their collaborations beyond the traditional sectors involved in climate strategy — such as environmental departments, land management, infrastructure, transportation, energy, water management, business, finance, and academia—and actively engage with other sectors that play a crucial role in climate transitions. Since climate change adaptation will disproportionately impact livelihoods, sectors that ensure peace, safety, equity, and resource access are particularly important. These include food production, healthcare and public health, human welfare organisations, security sectors, and cultural institutions. Besides, integrating adaptation as a lens within these sectors is essential, requiring capacity building to equip them with the necessary tools and knowledge to effectively contribute to climate resilience.

5.5 Ensure funding integration

Cities must shift from a project-based to a program-based approach to funding to ensure a more comprehensive and sustained climate action. Building capacity for climate response includes equipping cities with the skills to navigate complex financing landscapes, secure available funds, and allocate them effectively, ensuring that both mitigation and adaptation actions are adequately supported. Integration between local governments and funding institutions is crucial, with an emphasis on aligning financing with long-term local adaptation objectives. This approach should consider both short- and long-term time scales, reinforcing the need for immediate investments to secure future resilience. Cities should also question frugal fiscal policies that restrict proactive and preventive actions, recognizing that such policies may hinder self-determination. Cities should partner with public, private and third sectors to leverage diverse resources to fund the initiatives that align with their specific needs.

5.6 Enhance local participation to address vulnerabilities

Local participation is essential to ensure that climate actions are inclusive and represent the diverse voices within a community, particularly those of vulnerable and marginalised groups. The recognition of local intersectional needs is crucial when defining adaptation objectives and preferred strategies. Cities should move beyond conventional "citizen engagement" models to embrace a deeper understanding of different perspectives, using concrete co-creation tools that foster genuine collaboration. This includes integrating traditional and Indigenous knowledge, which offers valuable insights into local landscapes and ecologies, and the participation of actors who are able to speak for the rights of nature and biodiversity. Exploring different emerging frameworks (e.g. intersectionality,

multispecies justice) can help cities to learn and internalise the broad diversity of perspectives and work toward ethics of care and inclusion.

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