



Intentionality and visibility in state- and society-led climate approaches: towards a more comprehensive understanding of local adaptation initiatives

Peter Eckersley^{1,2}, Wolfgang Haupt², Viviana Wiegleb³, Jens Niewind³, and Antje Otto⁴

¹Department for Accounting and Finance, Nottingham Trent University, Nottingham, UK

²Research Group on Urban Sustainability Transformations, Leibniz Institute for Research on Society and Space, Erkner, Germany

³Governance and Sustainability Lab, University of Trier, Trier, Germany

⁴Institute of Environmental Science and Geography, University of Potsdam, Potsdam, Germany

Correspondence: Peter Eckersley (peter.eckersley@leibniz-irs.de)

Received: 29 July 2022 – Revised: 22 February 2023 – Accepted: 4 July 2023 – Published: 3 August 2023

Abstract. Research into local climate adaptation has often focused on highly visible, intentional public policies that seek to improve resilience to climate threats or how societal actors have reacted to changing climatic conditions. We argue that these approaches neglect a range of unintentional and/or hidden initiatives, which deliver implicit and/or hitherto under-appreciated adaptation benefits. We present an analytical framework to organise studies of these under-explored initiatives, which advances social scientific conceptualisations of what local climate adaptation consists of and provides a heuristic for selecting appropriate methods of enquiry to examine it. Drawing on empirical research into the adaptation activities of municipalities and small businesses in Germany, we apply this framework to expand our knowledge of how communities are building climate resilience, gain a better understanding of the full range of adaptation activities within individual localities, and pose questions about the role of state and societal actors in addressing common problems.

1 Introduction

Studies into local climate adaptation often come from a public policy perspective in that they seek to examine how and why *state* organisations seek to reduce climate risks (van der Heijden, 2019; Wolf, 2011). In parallel, however, *societal* actors have developed their own approaches to addressing heatwaves, floods, storms and drought, operating outside the boundaries and oversight of the state (Hegger et al., 2022; Mauerhofer, 2013). Such initiatives increase societal resilience to climate change, but there is very limited overlap within the literature between these activities and the policies that governments seek to implement (Grüneis et al., 2016). As Teebken et al. (2023) recently argued, scholars need to consider both government policies and society-led initiatives in order to understand the full range of adaptation activities within any given territory. The findings from such studies can also reveal important insights into how societies operate.

Furthermore, governments and societal actors may have introduced adaptation initiatives without labelling them as such – indeed, they might even have been unaware that their actions were contributing towards climate resilience at the time they introduced them. Adaptation studies often limit themselves to *visible* and *intentional* activities – high-profile initiatives that seek explicitly to reduce the potential impact of climate threats. We recognise that labelling too many practices as adaptation initiatives could provide a false impression of the scale of activity, level of ambition and “substantiality” of climate policy (Dupuis and Biesbroek, 2013). Nonetheless, we suggest that existing approaches to conceptualising climate adaptation are likely to be insufficient, because they fail to take account of *hidden* and/or *unintentional* initiatives that contribute towards resilience – which may not be labelled as such – and/or may not be targeted specifically at reducing climate-related threats. Studies may have neglected these types of activity in the past, because they

were led by societal actors, were less visible than public policies and/or were not driven primarily by concerns about the impacts of climate change. However, any comprehensive assessment of where and how adaptation is taking place needs to highlight and account for such activities *before* considering the extent to which they may be “substantial” or ambitious.

For scholars, this poses a key methodological issue: how can we get a better understanding of the full range of climate adaptation in local communities? To that end, we present a new framework to help organise future adaptation studies, based on the *intentionality* and *visibility* of activities undertaken by both state and societal actors. We developed this framework based on both a literature review and our own experiences of two research projects into local adaptation, one of which focuses on municipal policies and the other on societal responses. We integrate the literature on state-led adaptation (most of which is located in public policy or human geography) with bottom-up perspectives on the responses of civil society, businesses or individual citizens (which often takes a sociological perspective). Rather than focusing on increasing the number of “known knowns” around climate adaptation, we therefore extend the scope of “known unknowns” related to adaptation initiatives as units of analysis. Although we recognise that this wider interpretation does not solve the long-standing “dependent variable problem” in adaptation research (Dupuis and Biesbroek, 2013), we suggest that our approach provides a useful heuristic for organising and undertaking future research by helping to identify and codify adaptation initiatives, which can then inform the comparison, measurement and evaluation of their impact. As such, we contribute to the social scientific conceptualisations of climate change adaptation by accounting for the diversity of actors and activities that shape adaptation in a particular locality and by posing questions about how responsibilities for improving resilience are shared amongst different actors. Such a comprehensive approach helps us to move beyond the technological framings of adaptation, which foster selective end-of-pipe solutions rather than a closer examination of societal responses.

In the next section we discuss the concept of adaptation and the types of intentional, unintentional, visible and hidden initiatives that contribute towards climate resilience. We then address state- and society-led adaptation approaches in turn, illustrating each one with empirical examples, before bringing them together into a discussion and presenting our framework. Finally, we summarise our findings in the conclusion.

2 Intentionality and visibility in local adaptation

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as “the process of adjustment to actual or expected climate and its effects” (IPCC, 2022). This encom-

passes a huge range of potential activities that are difficult to identify and isolate from other processes and initiatives. Dupuis and Biesbroek (2013) highlighted this “dependent variable problem” a decade ago, and it has contributed to difficulties in measuring and tracking progress over time and in comparing the progress of municipalities and countries (Ford and Berrang-Ford, 2011; Olazabal et al., 2018; Otto et al., 2021a, b). The contrast with climate mitigation, which is much easier to conceptualise and measure (because it focuses almost exclusively on reducing anthropogenic emissions of greenhouse gases), is stark.

One key element of the dependent variable problem relates to the intentionality of adaptation initiatives: in other words, the extent to which improving climate resilience was a deliberate objective rather than a “by-product” of any specific activity. Many public policies have contributed towards improved resilience but were not explicitly designed to achieve this objective. For example, governments in developed countries constructed public parks, flood barriers, firebreaks, and seawalls many decades before climate change became a widely accepted justification for such projects – instead, they were viewed purely as initiatives that would improve well-being and protect local communities. Such unintentional adaptation nonetheless contributes towards societal resilience, even if it occurred many years ago and remains largely hidden (Mercer, 2010). Reflecting this historical dimension, we suggest it is more prevalent in situations where actors are less aware of climate risks and how their activities could reduce these threats.

Another key issue is the visibility of adaptation initiatives to different audiences (Meerow and Neuner, 2021). Policymakers may expect different actors (e.g. politicians, citizens, researchers, municipal staff or higher tiers of government) to respond differently to the same initiative, and therefore they seek to tailor how proposed adaptation policies are framed or labelled in a way that maximises the chances that they will be met with approval (Kind et al., 2015). This is perhaps particularly the case in contexts in which the existence of climate change was (or still remains) politically contested (see Teebken, 2022, for some US examples). We can see how this type of adaptation may be intentional but nonetheless largely hidden. Even in situations where climate change might be mentioned explicitly, “harder” technical measures (e.g. the construction of new physical infrastructure) tend to be of a higher profile and therefore more visible than “softer” initiatives that aim to build capacity through information sharing, persuasion and improvement of relationships between those who might be affected.¹ As such, the type of initiative, cou-

¹Another key issue here relates to whether activities are more strategic and anticipatory (in that they seek to build community resilience over the longer term) or largely spontaneous and reactive (e.g. where actors respond quickly to extreme weather events). However, given that this temporal dimension could apply to initiatives undertaken by state or societal actors, might refer to hidden or

pled with the salience of climate issues within the locality, is likely to influence their degree of visibility.

3 State-led adaptation

To address the dependent variable problem, Dupuis and Biesbroek (2013) argued that studies of adaptation policy should concentrate exclusively on state-led activities and therefore narrow down their focus. Such *public policy* initiatives – adaptation-related activities that are funded, managed or led by government bodies or are planned and implemented with their comprehensive involvement (e.g. research projects) – focus on protecting both the public and private realms from climate risks. The main and leading actors are state institutions, although – especially at the local level – societal actors are often involved through public procurement (in the case of “hard” infrastructure projects) or various participation mechanisms (e.g. “softer” workshops or advisory committees). The dimension of (visible) state-led activities is normally quite easy to identify, conceptualise and examine, since most public bodies publicise these initiatives on a regular basis (e.g. by writing reports, passing laws, adopting strategies or implementing policy instruments).

State-led adaptation can take place on all administrative levels, but most studies have focused on municipalities. This may be partly because climate threats are very context-specific, and adaptation measures ultimately need to be implemented at the local level. However, previous studies were mostly restricted to (larger) cities: perhaps because city size is highly correlated with more active local climate policies (Kern, 2019; Otto et al., 2021a, b; Salvia et al., 2021), there has been much less research into smaller municipalities or counties (Häußler and Haupt, 2021). There is a growing literature on the contents of local plans, many of which provide details of climate vulnerabilities (e.g. projected changes in temperature and precipitation, urban heat islands, areas cut off from cold-air corridors or locations that are particularly vulnerable to heavy rainfall) and set out how municipalities aim to address these risks (Grafakos et al., 2020; Göpfert et al., 2020; Otto et al., 2021a, b; Reckien et al., 2023). These studies examine “state-led, visible, intentional adaptation” (see Table 1): they rely on easily accessible data related to activities that are clearly associated with the municipality, which seek to increase the locality’s resilience to climate threats. Amongst other things, they may focus on the implementation of specific adaptation measures (such as adding greenery to public buildings or developing heavy rain risk maps), the factors that facilitate or hinder progressive climate policy (Huber et al., 2022; Schmidt and Walz, 2021), or changes to administrative structures within the municipality (Wamsler, 2015; Kenkmann et al., 2021).

visible activities, and may be relevant for either intentional or unintentional approaches, we have not included it in our framework.

Alongside these examples of intentional, visible, state-led adaptation, the way in which certain public policies are marketed or portrayed means that some initiatives that are not officially labelled as adaptation could nonetheless improve resilience to climate threats. Indeed, this phenomenon pre-dates concerns about global weather systems: many urban parks and green spaces in large cities are a legacy of 19th-century public health policies or – going further back in history – aristocratic hunting grounds (Rosenzweig and Blackmar, 1992; Schmiedecke, 2011; Rabbitts, 2015). However, they now provide opportunities for shade and cooling during heatwaves, as well as permeable surfaces that reduce the risk of pluvial flooding. We can see how such historic examples could provide adaptation benefits that are not only largely hidden but also unintentional. More contemporary examples of unintentional adaptation include flood protection, drinking fountains and tree planting (Lewis, 1995; Millennium Ecosystem Assessment, 2005; Hale, 2019; Haris and Illingworth, 2021). Excluding such initiatives would limit the extent to which we can assess the vulnerability of any particular locality and therefore the extent to which a community is contributing towards its climate resilience. The visibility of such initiatives will probably depend on the local context, because municipal governments are likely to frame them to fit with dominant political narratives, and citizens (and scholars) in different places may well associate them with the climate crisis to varying extents. Nonetheless, they illustrate how more visible initiatives can also have unintentional adaptation benefits yet still fall outside the scope of traditional public policy analysis.

4 Society-led adaptation

Scientific debates have long recognised that non-state actors play an important role in climate governance by contributing to mitigation and sustainable development goals (e.g. Chan et al., 2019; Hale et al., 2021; Hsu et al., 2020; Kuyper et al., 2018; Okereke et al., 2009). While research on societal actors is well developed in the context of carbon reduction, these insights play a limited role in the debates about climate adaptation. Nonetheless, there is a growing literature on “autonomous”, “individual” or “private” adaptation (Bajec and Maruna, 2013; Ihemezie et al., 2018; IPCC, 2001; Malik et al., 2010), which covers those strategies and activities that are not directed or funded by the state. Since there is significant overlap between these different strands, and in order to contrast them more clearly with state-sponsored initiatives, we use the term “society-led” adaptation to refer to activities undertaken by non-governmental and private actors, such as businesses, voluntary groups, organisations and individuals.

Recent studies have argued that society-led adaptation is particularly important in smaller municipalities and places where governments have less capacity to improve local resilience through public policies, such as parts of the

Table 1. Intentionality and visibility in state- and society-led adaptation.

	Visible	Hidden
Intentional	High awareness within the municipality/household/organisation of climate risks and potential adaptation solutions High levels of public/customer support for adaptation initiatives	High awareness within the municipality/household/organisation of climate risks and potential adaptation solutions Low levels of public/customer support for adaptation initiatives
Unintentional	Low municipal/organisational/household awareness of climate risks and potential adaptation solutions Adaptation is a “by-product”; the level of public/customer support for action is irrelevant.	

Global South (Buschmann et al., 2022; Teebken et al., 2023; Bawakyillenuo et al., 2016; Fenton et al., 2017). Society-led adaptation often refers to reactive and small-scale measures that intend to reduce the impact of heatwaves, flooding or other severe climate change impacts on individual or household, community, and business/farm levels (Porter et al., 2014). For example, Bawakyillenuo et al. (2016) showed how the adaptation responses of Ghanaian village communities included changes in planting times for crops, intensifying irrigation and utilising non-traditional crop varieties. Studying household responses to riverine flooding in Bangladesh, Fenton et al. (2017) identified homestead alterations, domestic and international migration, and the conversion of agricultural land for aquaculture. In Tyrolean mountain agriculture, farmers have extended mountain grazing areas in response to changing vegetation periods (Grüneis et al., 2016). Such society-led activities are often informed by local knowledge and individuals’ understandings and perceptions of local climate patterns (cf. Khan et al., 2021) – in contrast to state-led adaptation, which is more likely to rely on scientific evaluations. Although society-led adaptation is practised by individuals at the local level, it can nonetheless contribute to larger-scale socio-ecological transformations.

As is the case with public policies, society-led adaptation initiatives are sometimes intentional and visible and often introduced in direct response to climate impacts. Private actors and individual households might need to adapt to climate change independently in locations where government support and institutional capacities for planned climate change adaptation are low (e.g. Khan et al., 2021). In such contexts, previous studies have suggested strengthening and aligning private adaptation efforts with state-led strategies to improve the overall adaptive capacity of certain communities (e.g. Rahman and Hickey, 2019).

However, society-led adaptation frequently remains hidden, particularly where activities are not directly motivated by climate threats (Grüneis et al., 2016) – in which case it is also often unintentional (see Tables 1 and 3). Typically, it occurs in response to interrelated factors that emerge in the context of “different drivers, needs and aspirations, operating over a range of time and spatial scales” (Stringer et al.,

2010) rather than climate change alone (Ford et al., 2011; Smit et al., 2000). Farmers, for example, respond to multiple socio-ecological stressors by implementing different initiatives that help maintain their livelihoods (Forsyth and Evans, 2013). Although these measures are typically not designed as a deliberate response to climate change, they emerge as hidden adaptations, unintentional “by-products” (Tompkins et al., 2010) or “unconscious co-benefits” (Meinel and Höferl, 2017) that can contribute to local climate resilience.

5 A new framework to examine different types of adaptation

Table 1 sets out how we can categorise any activity that reduces the potential impact of climate threats (such as heatwaves, droughts, flooding, storms, landslides, invasive species and threats to biodiversity) as a particular type of adaptation, according to which actor undertakes it and the extent to which it is intentional or visible. Not only does this broader interpretation ensure that we shine a spotlight on a more comprehensive range of initiatives, but we also suggest that it should reveal important gaps and differences in adaptation approaches, which themselves highlight structural differences and inequalities across jurisdictions (Buschmann et al., 2022). This is particularly the case in contexts where public bodies are unable or unwilling to lead adaptation efforts, and non-state actors have to take on additional responsibilities as a result (Mulwa et al., 2017).

In short, therefore, adaptation approaches may be state-led or society-led and intentional or unintentional. Regardless of their degree of intentionality, initiatives could also be highly visible or largely hidden. We use these dimensions to organise and categorise our empirical examples in Sects. 3 and 4 and incorporate them into a framework for organising future studies. In particular, we suggest that internal awareness of potential adaptation solutions within the municipality (in state-led adaptation) and organisation or household (in society-led adaptation) shapes the extent to which initiatives are intentional. For intentional activities, exogenous pressure from voters (in state-led adaptation) and customers or individuals (in society-led adaptation) influences their level of

visibility; where adaptation is unintentional and is delivered as a “by-product” or happens “by accident”, these exogenous drivers are less important (see Table 1). We recognise that the extent to which any policy is visible will depend on the audience, but for the purposes of simplicity we have not sought to break down this element any further. In addition, following Fankhauser et al.’s (1999) similar conceptualisation of the difference between *autonomous* and *planned* adaptation, we accept that these distinctions are often blurred. Nonetheless, we feel they help to highlight the fact that many initiatives might otherwise not appear on the radar of scholars and policymakers, and our table can serve as a framework to organise and direct future studies into different types of adaptation.

5.1 State-led adaptation in the ExTrass project

Three of the authors have been involved in the research project “Urban resilience against extreme weather events” (ExTrass; duration 2017–2023), which focuses on state-led climate adaptation initiatives at the city level and provides a useful illustration of how such activities may be more or less visible and more or less intentional. The project examines how medium-sized and big cities in Germany are adapting to heat and pluvial rain. The project partners include different academic institutions, a first-aid and care institution, and the responsible units for climate adaptation within three city administrations: Potsdam, Remscheid and Würzburg. All three cities have experienced heatwaves and pluvial rain in recent years and were already working on climate adaptation before the project began. The project’s transdisciplinary nature meant that we focused on initiatives that were largely intentional and led by officers in the climate mitigation and adaptation teams (Huber et al., 2022; Otto et al., 2022).

Table 2 sets out some of these initiatives, based on our collaboration with the partner cities through numerous interviews and workshops with climate managers, staff from other municipal departments, and external stakeholders (such as the users of buildings with greened façades). Apart from the development of action plans, we also carried out monitoring (e.g. through (micro-climatic) temperature measurements) and presented and discussed our findings with staff in the municipal administrations.

Reflecting the fact that we engaged directly with municipal managers in places that wanted to demonstrate that they were tackling climate change and responded to their understandings of what constituted adaptation initiatives, most of the initiatives in Table 2 are both intentional and highly visible. However, other parts of the city administrations have also undertaken adaptation-related activities that a narrow focus on the climate office might otherwise have missed. In many cases the adaptation benefits of such initiatives were less intentional in that they are not mentioned as explicit objectives. As an example, newly erected private buildings in Potsdam must now meet certain standards on rainwater seepage and retention, as well as on greening: although these reg-

ulations do not primarily aim to improve climate resilience, they could still contribute to it. In some cases, the way in which activities were framed depended on the funding programme, and the extent to which adaptation activities may be hidden or unintentional even extends to staff within municipal governments. For instance, Remscheid required all of its municipal departments to report about previous work related to urban sustainable development in order to develop a more comprehensive overarching strategy (Haupt and Kern, 2022).

5.2 Society-led adaptation in the Mosel-AdapTiV project

Two authors are involved in Mosel-AdapTiV, a transdisciplinary project led by Trier University and the small Moselle municipality of Traben-Trarbach (duration: 2020–2023). The project focuses on climate change adaptation in viticulture and tourism, two of the most important economic sectors in the Moselle Valley region. The project’s overall goal is to increase local adaptive capacities in these highly interlinked sectors through transdisciplinary work and knowledge co-production.

The results presented in this paper are based on insights derived from 16 qualitative interviews we conducted between May 2020 and August 2022 with municipal politicians and administrators ($n = 4$), winemakers ($n = 9$) and representatives of the tourism sector ($n = 3$). We conducted these interviews in person, with conversations lasting between 40 and 90 min and following a semi-structured format covering topics related to viticulture in Traben-Trarbach: (1) framework conditions, characteristics and work processes; (2) main challenges for winemakers and current development trends; (3) relevance of climate change; (4) perceived need for adaptation; and (5) specific adaptation measures already implemented. We also organised six workshops with local actors (including municipal politicians, winemakers and representatives of the tourist sector) between 2020 and 2022 to better understand local conditions, the effects of climate change and adaptation needs, and adaptation practices already apparent in viticulture.

Viticulture is a knowledge-intensive and highly climate-sensitive form of agriculture, and the Moselle Valley region is more vulnerable to climate threats than most other parts of Germany (Kahlenborn et al., 2021). Viticulture in the Moselle Valley is already experiencing climate change impacts such as rising temperatures, changes in precipitation patterns and more intense extreme weather events such as heatwaves, droughts and heavy rainfall events. In particular, heavy rainfall or hail events endanger the regionally prevalent steeply sloped vineyards through mechanical damage and soil erosion. Additionally, shifting climatic conditions cause changes in grapevine phenology, plant productivity and health.

As climate change progresses, the entire sector of viticulture along the Moselle will have to adjust to its effects. However, the typically small-scale and family-led businesses in

Table 2. Intentionality and visibility in state-led climate change adaptation: examples from the ExTrass project.

Activity	Degree of intentionality	Degree of visibility
Developing urban climate maps and heavy rain hazard maps with reports in one municipality (Dillenardt et al., 2022)	High: the maps inform the municipal administration about hot spots regarding heat and pluvial rain. As such, they help to support decisions on urban and land-use planning and increase public knowledge of urban climate risks.	High in the future: the municipality will publish these maps to allow residents and other stakeholders to assess their vulnerability to heat and pluvial flooding and use them to justify climate-sensitive urban development to the public (Potsdam, 2022).
Developing a map and report on potential soil cooling capacity based on public data (Dillenardt and Thieken, 2021a, b)	High: improving the knowledge base within the municipal administration for urban climate adaptation and incorporating this knowledge into statements on construction plans, e.g. in order to protect areas with a high cooling capacity.	Low–moderate: the report is published online via one of the scientific partners of the project but not shown prominently on the municipal website. The report and related publications explicitly refer to climate adaptation (Dillenardt and Thieken, 2021a, b; Dillenardt et al., 2022).
Developing action plans on heat prevention, shading and blue-green infrastructure	High: tailored adaptation measures aim to enhance heat prevention and reduce pluvial flooding in specific areas. Originally low in one case: climate adaptation was not an explicit objective in the action plan for blue-green infrastructure. Initially, this project aimed to increase greenery and biodiversity; adaptation was only added later as the key objective, due to the scope and funding of the research project.	Probably moderate–high in the future: these plans are still being established but they will probably refer explicitly to climate change and adaptation.
Greening of façades on public buildings (Schmidt and Miechielsen, 2022)	High: some of the key objectives related directly to adaptation, including micro-climatic cooling and raising awareness of climate adaptation. Other objectives related to enhancing green spaces, biodiversity and improving buildings aesthetically. The academic project partners sought to collect information on beneficial and obstructive factors in implementing green façades and data on the efficacy of greening.	High: the green façades are visible in the public space. Both of those established so far are explicitly linked to the needs of climate adaptation, alongside other topics such as biodiversity, although one case only refers to the greening in a limited way.

the Moselle Valley region do not necessarily attribute these current trends and developments to global climate change and do not perceive it as a pressing concern. Instead, impacts of climate change interact with and reinforce existing issues that they consider to be more important: (1) reduced economic viability of steep-slope viticulture; (2) demographic change resulting in uncertain business succession; (3) high administrative workload to comply with national and EU legislation; (4) difficult economic situation of many winegrowers, which prevents more long-term or risky investments and innovation; (5) many additional tasks beside core work in vineyards (e.g. tourism activities, online marketing); and (6) municipal debt and a lack of public investment (Niewind, 2021).

Confronted with these interacting challenges, winegrowers in Traben-Trarbach have been adjusting their practices and work processes. These responses, which are mainly of

technical, managerial and infrastructural nature, are usually motivated by shorter-term economic drivers (see Table 3 below) – crucially, winegrowers do not connect them directly to global climate change. Instead, they are mainly directed towards maintaining the winemakers' livelihood and family tradition, the existing agro-economic system, and economic viability of viticulture. Since these responses are generally implemented on the farm (or business) level, they reflect the individual winegrower's experiences and local knowledge of winegrowing. As such, we characterise them as largely unintentional adaptation, although their degree of visibility varies (see Table 3).

Although winegrowers' responses to socio-environmental changes are not intended as a direct response to climate change, we found that most, if not all, of these emerging practices create adaptation co-benefits or “by-products” for viticulture. As they are implemented by private actors with-

Table 3. Intentionality and visibility in society-led climate change adaptation: examples from the Mosel-AdapTiV project.

Activity	Degree of intentionality	Degree of visibility
Conversion to organic viticulture	Low: beyond personal environmental awareness, the key driver is to gain eco-certification that would enable winemakers to charge premium prices and meet changing consumer demands (i.e. the change is not driven by climate concerns). Nonetheless, adaptation by-products include strengthened ecosystems, reduced soil erosion and better drought protection and tolerance.	Medium–high: organic certification is high-profile and clearly associated with environmental sustainability; it is therefore relatively easy to make a connection to climate adaptation.
Diversifying wine varieties and products beyond traditional Riesling	Medium–low: key drivers are to improve economic viability, responding to consumer preferences and providing a broader range of products. Adaptation by-products include improved heat resistance and drought tolerance (e.g. by growing red instead of white varieties) and better resistance to fungal diseases (e.g. PiWi varieties).	Medium–low: diversification is not often associated with climate adaptation in the public consciousness, although some could make this connection.
Transforming steep slopes into transversal terraces	Low: key drivers are (a) to reduce operating costs through increased mechanisation and (b) the availability of subsidies. Adaptation by-products include reduced soil erosion, drought protection, a delayed ripening process and improved biodiversity, but these issues do not drive the change.	Medium–low: landscape transformations of this nature are very visible to local people. However, because most winemakers do not associate them explicitly with climate change, awareness of the link is likely to be low.
Transition to low input viticulture	Low: key drivers are lowering operating costs and workload. Adaptation by-products include reduced soil erosion, less water use, drought protection, and a delayed ripening process.	Low–medium: vineyards appear different through more foliage and vegetation, which is noticeable for the public. However, because most winemakers do not associate them explicitly with climate change, awareness of the link is likely to be low.
Winemaking techniques: managing acidity and alcohol levels	Very low: key drivers are maintaining wine quality and responding to customer preferences. Adaptation by-products include reduced dependence on yield quality and changes in climatic conditions during the ripening process.	Very low: for the public, there is no noticeable impact, and therefore these changes are likely to remain hidden unless they are researched intensively.

out state support and are often low in profile, we can see how they represent largely unintentional and hidden society-led adaptation. Nonetheless, we should take such activities into account when aiming to understand the full range of adaptation within a locality.

6 Discussion and conclusions

Existing approaches to studying climate adaptation are unlikely to be comprehensive. This may be understandable due to (a) the practicalities of examining such an amorphous concept and (b) the research questions that scholars seek to address within their individual disciplines. However, it means that many studies focus on a limited range of initiatives, particularly those that are state-led, intentional and visible. Since these activities can often be quite high in profile, practitioners

elsewhere sometimes become aware of them and they “diffuse” them to other localities (see, for example, Schoenefeld et al., 2022). However, discipline-specific norms mean that scholars might have neglected some of the *actors* who undertake these activities, and epistemological and methodological limitations often result in scholars and policymakers neglecting those activities that are unintentional and/or hidden. This means that scholars are probably developing incomplete analyses, and practitioners may also be unfamiliar with the full range of potential adaptation initiatives that might suit their particular contexts.

We therefore suggest that studies should adopt a range of different methods to gain a fuller understanding of local climate adaptation. Examining the contents of climate plans to identify what municipal governments are doing in this area (e.g. Grafakos et al., 2020; Otto et al., 2021a, b; Reckien

et al., 2023) can only capture information related to state-led initiatives that are both intentional and visible. Surveys of municipal practitioners that take the socio-economic and political context into account may be a more appropriate method to identify more hidden initiatives, whereas qualitative approaches, such as elite interviews with local government officials and politicians, should enable researchers to dig deeper and examine the intentionality of public policies and/or the role of different actors in shaping these initiatives. By involving a broader range of participants in these discussions (i.e. not just officials who work in the climate departments of municipal governments), scholars would be better placed to identify some of the unintentional and/or hidden policies that are not featured in official documents. The ExTrass project did uncover some such initiatives (see Table 2) and thereby helped to paint a more comprehensive picture of state-led adaptation in its case study cities. Given that all three municipalities involved in this project were keen to demonstrate to their residents that they were taking action on climate resilience, we suspect their activities were more intentional and more visible than in other places. Where awareness of climate risks is lower, however, state-led adaptation is perhaps more likely to emerge as an unintentional by-product of other initiatives. Where climate scepticism is more prevalent, but municipal actors are nonetheless keen to reduce the potential impact of climate threats, we might expect the adaptation elements of local policy initiatives to be relatively hidden.

Similarly, scholars can examine corporate strategies and survey non-state organisations to identify largely intentional and visible examples of society-led activity, whereas qualitative methods are probably better suited to digging deeper and identifying other initiatives. However, given that awareness of climate risks may be lower in smaller businesses, for example, we suggest that participant observation or ethnographic methods could be the most productive way of identifying and analysing society-led unintentional adaptation. Such approaches enable researchers to obtain a richer understanding of the processes, activities and actors involved in local placemaking and social spaces (Watson and Till, 2010) and, therefore, are more likely to identify possible adaptation by-products, of which the non-state actors involved may be unaware. For activities that are more hidden, focus groups might be the most appropriate method of teasing out responses from relevant organisations and individuals, because the combined knowledge of a group could well lead them towards discussing examples of adaptation, about which interviewers would not have otherwise asked (Short, 2006). In the Mosel-AdapTiV project we found that local winemakers undertook some initiatives primarily for reasons, which nonetheless resulted in unintentional and/or hidden adaptation benefits (see Table 3). As with the examples of state-led adaptation discussed earlier, we suggest that awareness of climate risks and potential adaptation approaches shapes the extent to which initiatives are intentional, whereas consumer

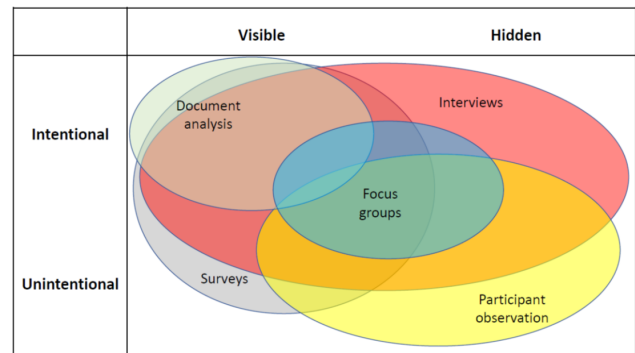


Figure 1. Intentionality and visibility in climate adaptation: methods for analysis.

(rather than voter) pressure for action influences their level of visibility. Figure 1 illustrates how scholars could apply these different methodological approaches to different types of adaptation in future studies.

In this paper, we sought neither to measure or assess the degree of “substantiality” or effectiveness of proposed initiatives nor to set standards for “what counts” as adaptation. Instead, we took a step back to point out that we are unlikely to have a full appreciation of how societies are adapting, because many activities that contribute towards climate resilience are often overlooked – because they are not led by public bodies, because they are hidden from view (either accidentally or deliberately) or because climate adaptation might not have been a major factor in the decision to undertake them. We suspect that governments may be more likely to undertake intentional, visible adaptation initiatives than societal actors, particularly where levels of internal awareness of climate risks and local public support for action are high. In contrast, however, societal actors may be involved in more unintentional and hidden activity, which is more difficult to identify and analyse. Nevertheless, we suggest that scholars need to broaden their focus to paint a more comprehensive picture of how communities are building resilience. Existing research tends to focus on intentional and more visible state-led activities (Walker et al., 2010), yet these occupy just one-quarter of our conceptual framework. Epistemological limitations mean that we are unlikely ever to get a full appreciation of those activities that deliver unintentional and hidden adaptation benefits, but we nonetheless suggest some methods that could help to provide a more rounded assessment and the conditions in which state- or society-led unintentional or hidden activities may be more common.

By extension, such understandings can feed into broader debates about how different actors are involved in climate adaptation and what this might reveal about the role of the state in addressing shared and/or wicked problems. This has particular implications for contexts in which the state is weak and/or underdeveloped, such as in those parts of the Global South where governmental capacity to step in and reduce cli-

mate impacts is limited. Most of the local climate adaptation literature focuses on cities in developed countries (Araos et al., 2016), and those studies of the Global South that do exist tend to examine state-led initiatives in urban areas (e.g. Le, 2020; Kareem et al., 2020; Singh et al., 2021). Building on Fünfgeld and Schmid (2020), we can see how our more comprehensive understanding of climate adaptation shines an even brighter spotlight on issues of climate justice and global inequality if governments are unwilling or unable to compensate for a lack of capacity amongst societal actors. Indeed, we can see how the division of responsibilities between state and non-state actors for local adaptation initiatives can reveal a lot about how different societies seek to tackle common problems more generally.

With this in mind, we caution that although unintentional and/or hidden adaptation may be occurring, it is nonetheless unlikely to be sufficient to build effective community resilience across a range of contexts around the globe. We would welcome further research into unintentional and hidden adaptation in communities worldwide, whether led by state or societal actors. We provide a structure to organise such studies, using a range of methodological techniques and approaches.

Data availability. The empirical vignettes that illustrate and support our conceptual argument were based on data we collected from practitioners on the condition of anonymity. As such, there are no publicly available datasets associated with this publication.

Author contributions. All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by all authors. All authors wrote different sections of the submitted manuscript. All authors commented on various versions of the manuscript and have read and agreed to the published version.

Competing interests. The contact author has declared that none of the authors has any competing interests.

Disclaimer. Publisher's note: Copernicus Publications remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Acknowledgements. This article draws on the findings from two projects funded by the German Federal Government. The project "Urban resilience against extreme weather events – typologies and transfer of adaptation strategies in small metropolises and medium-sized cities" (ExTrass) was funded by Germany's Federal Ministry of Education and Research (BMBF funding contract nos. 01LR1709A1 and 01LR2014A). The project Mosel-AdapTiV was funded by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV

funding contract nos. 67DAS197A and 67DAS197B) based on the decision of the German Bundestag.

Financial support. This research has been supported by the Bundesministerium für Bildung und Forschung (grant no. FKZ 01LR1709A1 and FKZ 01LR1709B1) and the Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz (grant nos. FKZ 67DAS197A and 67DAS197B).

Review statement. This paper was edited by Hartmut Fünfgeld and reviewed by two anonymous referees.

References

- Araos, M., Berrang-Ford, L., Ford, J. D., Austin, S. E., Biesbroek, R., and Lesnikowski, A.: Climate change adaptation planning in large cities: A systematic global assessment, *Environ. Sci. Policy*, 66, 375–382, <https://doi.org/10.1016/j.envsci.2016.06.009>, 2016.
- Bajec, N. L. and Maruna, M.: Planned and autonomous actions: Belgrade waterfront adaptation to climate change, *Environ. Eng. Manage. J.*, 14, 1–10, <https://doi.org/10.30638/eemj.2015.001>, 2013.
- Bawakyillenuo, S., Yaro, J. A., and Teye, J.: Exploring the autonomous adaptation strategies to climate change and climate variability in selected villages in the rural northern savannah zone of Ghana, *Local Environ.*, 21, 361–382, <https://doi.org/10.1080/13549839.2014.965671>, 2016.
- Buschmann, D., Koziol, K., Bausch, T., and Reinhard, S.: Adaptation to climate change in small German municipalities: Sparse knowledge and weak adaptive capacities, *Nat. Resour. Forum*, 46, 377–392, <https://doi.org/10.1111/1477-8947.12262>, 2022.
- Chan, S., Boran, I., van Asselt, H., Iacobuta, G., Niles, N., Rietig, K., Scobie, M., Bansard, J. S., Delgado Pugley, D., Delina, L. L., Eichhorn, F., Ellinger, P., Enechi, O., Hale, T., Hermwille, L., Hickmann, T., Honegger, M., Hurtado Epstein, A., La Hoz Theuer, S., Mizo, R., Sun, Y., Toussaint, P., and Wambugu, G.: Promises and risks of nonstate action in climate and sustainability governance, *WIREs Clim. Change*, 10, e572, <https://doi.org/10.1002/wcc.572>, 2019.
- Dillenardt, L. and Thieken, A.: Untersuchung der Kühlfunktion urbaner Böden auf Basis von frei zugänglichen Daten und einem GIS, *gis.Business*, 32–34, <https://gispoint.de/artikelarchiv/gis/2021/gisbusiness-ausgabe-52021/7186-im-spannungsfeld-von-hitze-duerre-und-starkregen> (last access: 31 July 2023), 2021a.
- Dillenardt, L. and Thieken, A.: Untersuchung der räumlichen Verteilung von Bodenkühlpotenzialen in Remscheid, Universitätsverlag Potsdam, Potsdam, <https://doi.org/10.25932/publishup-52667>, 2021b.
- Dillenardt, L., Rose, C., and Schmidt, K.: Verbesserungen der stadtklimatischen Planungs- und Entscheidungsgrundlagen, in: Urbane Resilienz gegenüber extremen Wetterereignissen, Universität Potsdam, Potsdam, 45–58, <https://doi.org/10.25932/publishup-55542>, 2022.

- Dupuis, J. and Biesbroek, R.: Comparing apples and oranges: The dependent variable problem in comparing and evaluating climate change adaptation policies, *Global Environ. Change*, 23, 1476–1487, <https://doi.org/10.1016/j.gloenvcha.2013.07.022>, 2013.
- Fankhauser, S., Smith, J. B., and Tol, R. S.: Weathering climate change: some simple rules to guide adaptation decisions, *Ecol. Econ.*, 30, 67–78, [https://doi.org/10.1016/S0921-8009\(98\)00117-7](https://doi.org/10.1016/S0921-8009(98)00117-7), 1999.
- Fenton, A., Paavola, J., and Tallontire, A.: Autonomous adaptation to riverine flooding in Satkhira District, Bangladesh: implications for adaptation planning, *Reg. Environ. Change*, 17, 2387–2396, <https://doi.org/10.1007/s10113-017-1159-8>, 2017.
- Ford, J. D. and Berrang-Ford, L.: Climate Change Adaptation in Developed Nations, in: *Advances in Global Change Research*, 42, Springer, Dordrecht, 487 pp., <https://doi.org/10.1007/978-94-007-0567-8>, 2011.
- Ford, J. D., Berrang-Ford, L., and Paterson, J.: A systematic review of observed climate change adaptation in developed nations, *Climatic Change*, 106, 327–336, <https://doi.org/10.1007/s10584-011-0045-5>, 2011.
- Forsyth, T. and Evans, N.: What is Autonomous Adaption? Resource Scarcity and Smallholder Agency in Thailand, *World Dev.*, 43, 56–66, <https://doi.org/10.1016/j.worlddev.2012.11.010>, 2013.
- Fünfgeld, H. and Schmid, B.: Justice in climate change adaptation planning: conceptual perspectives on emergency praxis, *Geogr. Helv.*, 75, 437–449, <https://doi.org/10.5194/gh-75-437-2020>, 2020.
- Göpfert, C., Wamsler, C., and Lang, W.: Enhancing structures for joint climate change mitigation and adaptation action in city administrations – Empirical insights and practical implications, *City Environ. Interact.*, 8, 100052, <https://doi.org/10.1016/j.cacint.2020.100052>, 2020.
- Grafakos, S., Viero, G., Reckien, D., Trigg, K., Viguie, V., Sudmant, A., Graves, C., Foley, A., Heidrich, O., Mirailles, J. M., Carter, J., Chang, L. H., Nador, C., Liseri, M., Chelleri, L., Orru, H., Orru, K., Aelenei, R., Bilska, A., Pfeiffer, B., Lepetit, Q., Church, J. M., Landauer, M., Gouldson, A., and Dawson, R.: Integration of mitigation and adaptation in urban climate change action plans in Europe: A systematic assessment, *Renew. Sustain. Energ. Rev.*, 121, 109623, <https://doi.org/10.1016/j.rser.2019.109623>, 2020.
- Grüneis, H., Penker, M., and Höferl, K.-M.: The full spectrum of climate change adaptation: testing an analytical framework in Tyrolean mountain agriculture (Austria), *SpringerPlus*, 5, 1848, <https://doi.org/10.1186/s40064-016-3542-1>, 2016.
- Hale, M. R.: Fountains for Environmental Justice: Public Water, Homelessness, and Migration in the Face of Global Environmental Change, *Environ. Just.*, 12, 33–40, <https://doi.org/10.1089/env.2018.0031>, 2019.
- Hale, T. N., Chan, S., Hsu, A., Clapper, A., Elliott, C., Faria, P., Kuramochi, T., McDaniel, S., Morgado, M., Roelfsema, M., Santaela, M., Singh, N., Tout, I., Weber, C., Weinfurter, A., and Widerberg, O.: Sub- and non-state climate action: a framework to assess progress, implementation and impact, *Climate Policy*, 21, 406–420, <https://doi.org/10.1080/14693062.2020.1828796>, 2021.
- Haris, P. I. and Illingworth, P.: Installing public handwashing facilities and integrating them with water fountains to reduce plastic pollution and prevent spread of infections, *Perspect. Publ. Health*, 141, 263–265, <https://doi.org/10.1177/17579139211002221>, 2021.
- Haupt, W. and Kern, K.: Explaining climate policy pathways of unlikely city pioneers: The case of the German city of Remscheid, *Urban Climate*, 45, 101220, <https://doi.org/10.1016/j.uclim.2022.101220>, 2022.
- Häußler, S. and Haupt, W.: Climate change adaptation networks for small and medium-sized cities, *SN Social Sci.*, 1, 262, <https://doi.org/10.1007/s43545-021-00267-7>, 2021.
- Hegger, D. L. T., Mees, H. L. P., and Wamsler, C.: The role of citizens in sustainability and climate change governance: Taking stock and looking ahead, *Environ. Policy Govern.*, 32, 161–166, <https://doi.org/10.1002/eet.1990>, 2022.
- Hsu, A., Brandt, J., Widerberg, O., Chan, S., and Weinfurter, A.: Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (NDCs), *Climate Policy*, 20, 443–457, <https://doi.org/10.1080/14693062.2019.1624252>, 2020.
- Huber, B., Miechielsen, M., Otto, A., Schmidt, K., Ullrich, S., Depermann, L., Eckersley, P., Haupt, W., Kern, K., Lipp, T., Neumann, N., Schneider, P., Sterzel, T., and Thieken, A.: *Instrumente und Maßnahmen der kommunalen Klimaanpassung: Empirische Befunde für einen erfolgreichen Transfer*, Universitätsverlag Potsdam, Potsdam, <https://doi.org/10.25932/publishup-56345>, 2022.
- Ihemezie, E. J., Onunka, C. N., and Nnaji, A. P.: Drivers and socioeconomic factors influencing individual and household adaptation to climate change: A case study of residents of Leeds, UK, *J. Dev. Agric. Econ.*, 10, 279–291, <https://doi.org/10.5897/JDAE2018.0956>, 2018.
- IPCC: *Climate Change: 2001: Impacts, Adaptation, and Vulnerability*, 1042 pp., <https://doi.org/10.1017/9781009325844>, 2001.
- IPCC: *Annex I: Glossary*, in: *Global Warming of 1.5 °C*, IPCC, Cambridge University Press, 541–562, <https://doi.org/10.1017/9781009157940.008>, 2022.
- Kahlenborn, W., Porst, L., Voß, M., Fritsch, U., Renner, K., Zebisch, M., Wolf, M., Schönthaler, K., and Schausser, I.: *Klimawirkungs- und Risikoanalyse für Deutschland 2021 (Kurzfassung)*, Dessau-Roßlau, 26 pp., https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/kwra2021_teilbericht_zusammenfassung_bf_211027_0.pdf (last access: 31 July 2023), 2021.
- Kareem, B., Lwasa, S., Tugume, D., Mukwaya, P., Walubwa, J., Owuor, S., Kasajja, P., Sseviiri, H., Nsangi, G., and Byarugaba, D.: Pathways for resilience to climate change in African cities, *Environ. Res. Lett.*, 15, 73002, <https://doi.org/10.1088/1748-9326/ab7951>, 2020.
- Kenkmann, T., Eisenmann, L., and Muckenfuß, L.: Municipal climate action managers: Evaluating the impact, <https://www.oeko.de/fileadmin/oeкодoc/Municipal-climate-action-managers.pdf> (last access: 31 July 2023), 2021.
- Kern, K.: Cities as leaders in EU multilevel climate governance: embedded upscaling of local experiments in Europe, *Environ. Politics*, 28, 125–145, <https://doi.org/10.1080/09644016.2019.1521979>, 2019.
- Khan, N. A., Gong, Z., Shah, A. A., Abid, M., and Khanal, U.: Farm-level autonomous adaptation to climate change and its impact on crop productivity: evidence from Pakistan, *Environ. Dev.*

- Sustain., <https://doi.org/10.1007/s10668-021-01978-w>, in press, 2021.
- Kind, C., Protze, N., Savelsberg, J., Lühr, O., Ley, S., and Lambert, J.: Entscheidungsprozesse zur Anpassung an den Klimawandel in Kommunen, Dessau-Roßlau, *Climate Change*, 101 pp., https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2017-07-18_climate-change_04-2015_klimalotse_inkl_zusamm.pdf (last access: 31 July 2023), 2015.
- Kuyper, J. W., Linnér, B.-O., and Schroeder, H.: Non-state actors in hybrid global climate governance: justice, legitimacy, and effectiveness in a post-Paris era, *WIREs Clim. Change*, 9, e497, <https://doi.org/10.1002/wcc.497>, 2018.
- Le, T. D. N.: Climate change adaptation in coastal cities of developing countries: characterizing types of vulnerability and adaptation options, *Mitig. Adapt. Strateg. Glob. Change*, 25, 739–761, <https://doi.org/10.1007/s11027-019-09888-z>, 2020.
- Lewis, C. A.: Human health and well-being: The psychological, physiological, and sociological effects of plants on people, *Acta Hort.*, 31–40, <https://doi.org/10.17660/ActaHortic.1995.391.2>, 1995.
- Malik, A., Qin, X., and Smith, S. C.: Autonomous Adaptation to Climate Change: A Literature Review, The George Washington University Medical Center, USA, <http://www.eldis.org/document/A59539> (last access: 31 July 2023), 2010.
- Mauerhofer, V.: Social capital, social capacity and social carrying capacity: Perspectives for the social basics within environmental sustainability, *Futures*, 53, 63–73, <https://doi.org/10.1016/j.futures.2013.08.006>, 2013.
- Meerow, S. and Neuner, F. G.: Positively Resilient? How Framing Local Action Affects Public Opinion, *Urban Affairs Rev.*, 57, 70–103, <https://doi.org/10.1177/1078087420905655>, 2021.
- Meinel, U. and Höferl, K.-M.: Non-Adaptive Behavior in the Face of Climate Change: First Insights from a Behavioral Perspective Based on a Case Study among Firm Managers in Alpine Austria, *Sustainability*, 9, 1132, <https://doi.org/10.3390/su9071132>, 2017.
- Mercer, J.: Disaster risk reduction or climate change adaptation: Are we reinventing the wheel?, *J. Int. Dev.*, 22, 247–264, <https://doi.org/10.1002/jid.1677>, 2010.
- Millennium Ecosystem Assessment (Ed.): *Ecosystems and Human Well-Being: Wetlands and Water: Synthesis*, Washington, DC, 80 pp., <https://www.millenniumassessment.org/documents/document.358.aspx.pdf> (last access: 31 July 2023), 2005.
- Mulwa, C., Marenja, P., Rahut, D. B., and Kassie, M.: Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics, *Clim. Risk Manage.*, 16, 208–221, <https://doi.org/10.1016/j.crm.2017.01.002>, 2017.
- Niewind, J.: *Vulnerabilitätsstudie: Klimawandel und Weinbau an der Mittelmosel*, Geographie und Geowissenschaften, Mosel-AdapTiV Ergebnisberichte 2, Universität Trier, Trier, 37 pp., <https://doi.org/10.25353/ubtr-xxxx-5e14-6f3d> (last access: 31 July 2023), 2021.
- Okereke, C., Bulkeley, H., and Schroeder, H.: Conceptualizing Climate Governance Beyond the International Regime, *Global Environ. Polit.*, 9, 58–78, <https://doi.org/10.1162/glep.2009.9.1.58>, 2009.
- Olazabal, M., Chiabai, A., Foudi, S., and Neumann, M. B.: Emergence of new knowledge for climate change adaptation, *Environ. Sci. Policy*, 83, 46–53, <https://doi.org/10.1016/j.envsci.2018.01.017>, 2018.
- Otto, A., Göpfert, C., and Thieken, A. H.: Are cities prepared for climate change? An analysis of adaptation readiness in 104 German cities, *Mitig. Adapt. Strateg. Glob. Change*, 26, 35, <https://doi.org/10.1007/s11027-021-09971-4>, 2021a.
- Otto, A., Kern, K., Haupt, W., Eckersley, P., and Thieken, A. H.: Ranking local climate policy: assessing the mitigation and adaptation activities of 104 German cities, *Climatic Change*, 167, 5, <https://doi.org/10.1007/s10584-021-03142-9>, 2021b.
- Otto, A., Thieken, A., Haupt, W., Eckersley, P., Kern, K., Ullrich, S., Hautz, T., Rocker, P., Schulz, R., Sausen, H., Dillenardt, L., Rose, C., Schmidt, K., Huber, B., Sterzel, T., Marken, M., and Miechielsen, M.: *Urbane Resilienz gegenüber extremen Wetterereignissen*, 112 pp., <https://doi.org/10.25932/publishup-55542>, 2022.
- Porter, J. J., Dessai, S., and Tompkins, E. L.: What do we know about UK household adaptation to climate change? A systematic review, *Climatic Change*, 127, 371–379, <https://doi.org/10.1007/s10584-014-1252-7>, 2014.
- Potsdam: *Stadtklimakarte für die Landeshauptstadt Potsdam*, <https://www.potsdam.de/de/stadtklimakarte-fuer-die-landeshauptstadt-potsdam> (last access: 31 July 2023), 2022.
- Rabbitts, P. A.: *Hyde Park: The people's park*, Amberley Publishing, Stroud, 128 pp., ISBN 9781445642888, 2015.
- Rahman, H. M. T. and Hickey, G. M.: What Does Autonomous Adaptation to Climate Change Have to Teach Public Policy and Planning About Avoiding the Risks of Maladaptation in Bangladesh?, *Front. Environ. Sci.*, 7, 2, <https://doi.org/10.3389/fenvs.2019.00002>, 2019.
- Reckien, D., Buzasi, A., Olazabal, M., Spyridaki, N. A., Eckersley, P., Simoes, S. G., Salvia, M., Pietrapertosa, F., Fokaides, P., Goonesekera, S. M., Tardieu, L., Balzan, M. V., De Boer, C. L., De Gregorio Hurtado, S., Feliu, E., Flamos, A., Foley, A., Geneletti, D., Grafakos, S., Heidrich, O., Ioannou, B., Krook-Riekkola, A., Matosovic, M., Orru, H., Orru, K., Paspaldzhiev, I., Rižnar, K., Smigaj, M., Szalmáné Csete, M., Viguié, V., and Wejs, A.: Quality of adaptation plans over time, *npj Nat. Urban Sustain.*, 3, 13, <https://doi.org/10.1038/s42949-023-00085-1>, 2023.
- Rosenzweig, R. and Blackmar, E.: *The park and the people: A history of Central Park*, Cornell University Press, Ithaca, NY, London, 623 pp., ISBN 9780801425165, 1992.
- Salvia, M., Reckien, D., Pietrapertosa, F., Eckersley, P., Spyridaki, N.-A., Krook-Riekkola, A., Olazabal, M., Gregorio Hurtado, S. de, Simoes, S. G., Geneletti, D., Viguié, V., Fokaides, P. A., Ioannou, B. I., Flamos, A., Csete, M. S., Buzasi, A., Orru, H., Boer, C. de, Foley, A., Rižnar, K., Matosović, M., Balzan, M. V., Smigaj, M., Baštáková, V., Streberova, E., Šel, N. B., Coste, L., Tardieu, L., Altenburg, C., Lofrencová, E. K., Orru, K., Wejs, A., Feliu, E., Church, J. M., Grafakos, S., Vasilie, S., Paspaldzhiev, I., and Heidrich, O.: Will climate mitigation ambitions lead to carbon neutrality? An analysis of the local-level plans of 327 cities in the EU, *Renew. Sustain. Energ. Rev.*, 135, 110253, <https://doi.org/10.1016/j.rser.2020.110253>, 2021.
- Schmidt, K. and Miechielsen, M.: *Begrünungsmaßnahmen in den Fallstudienstädten*, in: *Urbane Resilienz gegenüber extremen Wetterereignissen*, Universität Potsdam, Potsdam, 66–81, <https://doi.org/10.25932/publishup-55542>, 2022.

- [/doi.org/10.25932/publishup-55542](https://doi.org/10.25932/publishup-55542) (last access: 31 July 2023), 2022.
- Schmidt, K. and Walz, A.: Ecosystem-based adaptation to climate change through residential urban green structures: co-benefits to thermal comfort, biodiversity, carbon storage and social interaction, *One Ecosyst.*, 6, e65706, <https://doi.org/10.3897/oneeco.6.e65706>, 2021.
- Schmiedecke, R.: Berlin-Tiergarten, Die Reihe Archivbilder, Sutton, Erfurt, 125 pp., ISBN 9783866808386, 2011.
- Schoenefeld, J. J., Schulze, K., and Bruch, N.: The diffusion of climate change adaptation policy, *Wiley interdisciplinary reviews, Climate Change*, 13, e775, <https://doi.org/10.1002/wcc.775>, 2022.
- Short, S. E.: Focus Groups, in *A Handbook for Social Science Field Research: Essays and Bibliographic Sources on Research Design and Methods*, edited by: Perelman, E. and Curran, S. R., Sage, 103–115, <https://doi.org/10.4135/9781412983211.n5>, 2006.
- Singh, C., Iyer, S., New, M. G., Few, R., Kuchimanchi, B., Segnon, A. C., and Morchain, D.: Interrogating ‘effectiveness’ in climate change adaptation: 11 guiding principles for adaptation research and practice, *Clim. Dev.*, 14, 650–664, <https://doi.org/10.1080/17565529.2021.1964937>, 2021.
- Smit, B., Burton, I., Klein, R. J. T., and Wandel, J.: An Anatomy of Adaptation to Climate Change and Variability, in: *Societal Adaptation to Climate Variability and Change*, edited by: Kane, S. M. and Yohe, G. W., Springer Netherlands, Dordrecht, 223–251, https://doi.org/10.1007/978-94-017-3010-5_12, 2000.
- Stringer, L. C., Mkwambisi, D. D., Dougill, A. J., and Dyer, J. C.: Adaptation to climate change and desertification: Perspectives from national policy and autonomous practice in Malawi, *Clim. Dev.*, 2, 145–160, <https://doi.org/10.3763/cdev.2010.0042>, 2010.
- Teebken, J.: *The Politics of Human Vulnerability to Climate Change*, Routledge, London, <https://doi.org/10.4324/9781003183259>, 2022.
- Teebken, J., Mitchell, N., Jacob, K., and Heimann, T.: Classifying Social Adaptation Practices to Heat Stress – Learning from Autonomous Adaptations in Two Small Towns in Germany, *Weather Clim. Soc.*, 15, 95–108, <https://doi.org/10.1175/WCAS-D-22-0003.1>, 2023.
- Tompkins, E. L., Adger, W. N., Boyd, E., Nicholson-Cole, S., Weatherhead, K., and Arnell, N.: Observed adaptation to climate change: UK evidence of transition to a well-adapting society, *Global Environ. Change*, 20, 627–635, <https://doi.org/10.1016/j.gloenvcha.2010.05.001>, 2010.
- van der Heijden, J.: Studying urban climate governance: Where to begin, what to look for, and how to make a meaningful contribution to scholarship and practice, *Earth Syst. Govern.*, 1, 100005, <https://doi.org/10.1016/j.esg.2019.100005>, 2019.
- Walker, W. D., Liebl, D. S., Gilbert, L., LaGro, J., Nowak, P., and Sullivan, J.: Adapting to Climate Change: Why Adaptation Policy is More Difficult than We Think (and what to do about it), https://www7.nau.edu/itep/main/iteps/ORCA/2985_ORCA.pdf (last access: 31 July 2023), 2010.
- Wamsler, C.: Mainstreaming ecosystem-based adaptation: transformation toward sustainability in urban governance and planning, *Ecol. Soc.*, 20, 30, <https://doi.org/10.5751/ES-07489-200230>, 2015.
- Watson, A. and Till, K. E.: Ethnography and Participant Observation, in: *The SAGE handbook of qualitative geography*, edited by: DeLyser, D., SAGE, Los Angeles, California, 121–137, <https://doi.org/10.4135/9780857021090.n9>, 2010.
- Wolf, J.: Climate Change Adaptation as a Social Process, in: *Climate change adaptation in developed nations: from theory to practice*, edited by: Ford, J. D. and Berrang-Ford, L., Springer, London, https://doi.org/10.1007/978-94-007-0567-8_2, 2011.