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## Exploring the affective dimension in citizen science to support urban climate adaptation: a conceptual framework

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Despite the urgent need to take action on climate adaptation, public engagement remains relatively low. This low engagement poses significant challenges to the effective adaptation process, highlighting the need for innovative approaches in governance. In this paper, we explore the importance of the affective dimension in enhancing citizen engagement in climate adaptation. Drawing from a review of recent literature, we identify the primary challenges of fostering citizen engagement by integrating research on climate adaptation with the exploration of the affective dimension and the conceptualization of affective practices. We aim to identify specific “affective facilitators” that have the potential to enhance citizen engagement and drive actionable outcomes. We advocate for the use of Citizen Science as a means to support citizen engagement, due to its potential to harness the identified facilitators. We illustrate the practical application of our conceptual framework with the Citizen Sensing Project.

**Keywords:** urban climate adaptation; citizen engagement; affective dimension; citizen science

### 1. Introduction

As an increasing body of evidence substantiates the irreversible shifts in global climate, cities are confronted with the adverse consequences of climate change and extreme weather events, which pose significant risks to the health and well-being of their inhabitants (IPCC 2022; Romanello *et al.* 2022; Wanyama *et al.* 2023). This pressing situation necessitates ongoing adaptation efforts. At the community level, the impacts of climate change are particularly keenly experienced, including the effects of extreme weather events such as local flooding and heatwaves (Granderson 2014). Consequently, the implementation of most adaptation strategies needs to occur within these communities (Duerden 2004; Moser and Pike 2015). Previous studies have indicated that addressing the impacts of climate change successfully requires not only the

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establishment of new governance structures and institutions but also the active involvement of affected communities through citizen participation (Hügel and Davies 2020; Moser and Pike 2015; Wamsler and Riggers 2018). Moving beyond governmental actions entails citizens becoming integral to the complex process of societal transformation, including participating collectively in decision-making and engaging in co-production (Galego *et al.* 2022; O'Brien and Sygna 2013; Ponthieu 2020). Transformational adaptation, which goes beyond incremental changes, has been extensively discussed (Lonsdale, Pringle, and Turner 2015; Mustelin and Handmer 2013; Nelson, Adger, and Brown 2007; Pelling, O'Brien, and Matyas 2015), and involves a more substantial scale or intensity of actions, constituting genuinely new approaches and engendering profound shifts in regions or resource systems (Kates, Travis, and Wilbanks 2012). It emphasises long-term perspectives and acknowledges the incorporation of future uncertainties in decision-making (Lonsdale, Pringle, and Turner 2015). Both personal and collective levels of change are required, encompassing changes in perceptions, individual practices, behaviours, and beliefs. Therefore, social change has been identified as a fundamental element of transformational adaptation (Lonsdale, Pringle, and Turner 2015; Wilbanks *et al.* 2014).

Climate adaptation can occur through various processes, including top-down institutional decision-making, such as assessing climate impacts and urban climate adaptation governance based on scientific knowledge, and bottom-up approaches that rely on local knowledge of vulnerabilities, adaptation measures, and personal experiences. The relationship between these processes is considered complex and problematic, both in theoretical and practical terms. In this context, the importance of integration (Butler *et al.* 2015) and bottom-linked forms of governance (Castro-Arce and Vanclay 2020) is emphasised. Governing climate change adaptation should increasingly incorporate a collective effort from multiple societal actors - individuals, organisations, and institutions connected in social networks, with key actors providing leadership and trust (Huitema *et al.* 2016). Several authors (e.g. Archer *et al.* 2014; Ziervogel *et al.* 2022) have advocated for community-based adaptation as an opportunity to better align planning activities with local dynamics.

Climate adaptation relies on the interconnectedness of public institutions, diverse private organisations, and individuals (Agrawala 2011; Bremer *et al.* 2019; Wamsler *et al.* 2020). However, further research is needed to understand the most effective forms of cooperation that lead to impactful climate adaptation outcomes (Bisaro and Hinkel 2016; Hinkel and Bisaro 2016; Malik, Qin, and Smith 2010). Some studies have demonstrated the influence of participatory approaches in adaptation planning in general (Hügel and Davies 2020). However, citizens' responses to climate-related challenges affecting their communities can vary significantly (Wolf and Moser 2011), as their understandings of climate change are shaped by various factors, such as their residential location, cultural contexts, or daily life experiences (Phadke, Manning, and Burlager 2015; Thaker *et al.* 2016). Consequently, these responses are context-dependent and often challenging to quantify (Dang *et al.* 2019).

Wamsler and Riggers (2018) conducted an examination of research on cooperative relationships between city administrations and citizens spanning over two decades. Their findings revealed that apathetic citizen behaviour may be attributed to a lack of institutional support for individual adaptation. Citizens may unintentionally rely on such assistance, mistakenly assuming that institutions will support their individual actions. Furthermore, non-material aspects, including emotional qualities, affective attachments, and 'non-rational' behaviours, are frequently overlooked (Wamsler and Riggers 2018).

Therefore, there is a need for alternative approaches that encompass both cognitive and affective processes capable of enhancing motivation and citizen engagement in climate adaptation (Brink and Wamsler 2019).

Much of the existing literature on climate change adaptation has predominantly focused on structural or tangible factors (Chipfupa, Tagwi, and Wale 2021; Shi and Moser 2021; Vulturius *et al.* 2018) that influence the capacity of communities and institutions to adapt. These factors suggest that adaptation capacity stems from favourable socio-economic conditions and the ability to access resources that enable the prediction and response to climate-related risks. However, several studies have highlighted the relevance of non-tangible or subjective factors (Adger, Lorenzoni, and O'Brien 2009; Chipfupa, Tagwi, and Wale 2021; Dang *et al.* 2019; Grothmann and Patt 2005; Iniguez-Gallardo, Bride, and Tzanopoulos 2020; Kuruppu and Liverman 2011; Lorenzoni, Nicholson-Cole, and Whitmarsh 2007; Thaker *et al.* 2016). These factors include psychological influences on decision-making, personality attributes, attitudes, and motivation.

Despite the growing recognition of these subjective factors in scientific and policy contexts, authorities often overlook the inherent subjectivities involved in understanding citizens' perspectives and risk perceptions (Dang *et al.* 2019), as well as their local realities based on everyday experiences (Iniguez-Gallardo, Bride, and Tzanopoulos 2020). However, people primarily act and make decisions based on subjective factors rather than relying solely on rationality. Alternative rationalities or the 'non-rational' components play a crucial role in driving individual motivation and action (Nightingale 2015).

There has been a particular emphasis on the study of affect and emotions in the fields of social sciences and humanities to better understand spheres of experience. The *Affect Theory* explores how lived experiences can significantly enhance our understanding of events and even knowledge, thereby becoming ways of knowing and relating (Nightingale, Gonda, and Eriksen 2022). and ultimately enabling change and action. Consequently, transformational adaptation involves a more profound change in the socio-political and economic spheres, with a focus on processes rather than solely on outcomes (Shi and Moser 2021). Given the need to reconcile multiple stakeholders and perspectives (Fedele *et al.* 2019; Owen 2020), citizen engagement plays a crucial role, although it is still acknowledged as being insufficient. To underscore the importance of affects and emotions in climate adaptation, Nightingale, Gonda, and Eriksen (2022) have recently introduced the concept of 'affective adaptation', which emphasises a process of change rather than merely the end results. It evokes a form of transformation that is relational, uncertain, and performative. Building upon this research direction, we will specifically focus on citizen engagement and further explore its connection with citizen science.

In this paper, we explore how the affective dimension can foster citizen engagement in urban climate adaptation through the employment of Citizen Science (CS). CS is broadly defined as the involvement of citizens in scientific research (Bonney and Janis 2012; Bonney *et al.* 2014; Societize 2013) and has experienced significant growth in recent decades. It seeks to engage citizens in the scientific process, benefiting both scientists and communities by supporting research development and scientific literacy (Bremer *et al.* 2019; Brossard, Lewenstein, and Bonney 2005; Conrad and Hilchey 2011; van Brussel and Huyse 2019; von Gönner *et al.* 2023).

By involving citizens in everyday practices and fostering emotional and affective behaviours, CS aims to support citizen action (Baptista, Reis, and Andrade 2018; Gray and Colucci-Gray 2019; Sharma *et al.* 2019). In their analysis of the transformative impact of CS in the Central European context, von Gönner *et al.* (2023) highlighted its

significance in community building, individual empowerment, and collective action. Thus, CS has the potential to play a meaningful role in climate adaptation by enhancing citizens' perceptual abilities (Sharma *et al.* 2019) and stimulating their engagement in addressing climate challenges.

In Section 2, we delve into the topic of citizen engagement in climate adaptation and identify the primary challenges that impede such engagement. We argue for the significance of the affective dimension in increasing citizen engagement and propose four main aspects, referred to as 'affective facilitators', which play a crucial role in promoting engagement.

Section 3 is dedicated to exploring how Citizen Science (CS) can enhance citizen engagement. We put forth a conceptual framework that examines how the 'affective facilitators' can be nurtured through CS to support climate adaptation. To illustrate the potential consideration of these facilitators within citizen science, we turn to the Citizen Sensing project. Our intention is to provide an example of how these key aspects can be integrated into the design of a citizen science project.

## **2. Enhancing citizen engagement in climate adaptation through affective facilitators**

### ***2.1. Citizen engagement in governing urban climate adaptation***

According to scientific reviews (Chaffin *et al.* 2016; Karpouzoglou, Dewulf, and Clark 2016; Munaretto, Siciliano, and Turvani 2014), contemporary social-ecological systems highlight the limitations of traditional governance approaches, necessitating adaptive forms of steering collective action. In the context of urban climate adaptation, there is a need for changes in the public engagement process, fostering more collaborative and democratic systems that address citizens' and stakeholders' concerns and transform power structures in deliberative processes (Chaffin *et al.* 2016; Huitema *et al.* 2016; Karpouzoglou, Dewulf, and Clark 2016; Munaretto, Siciliano, and Turvani 2014).

Building adaptive capacities becomes a collective and interactive process that relies on public support and the involvement of various stakeholders (Moser and Pike 2015). Many authors emphasise the importance of considering the type, diversity, and representativeness of actors involved and mobilised at different scales (J. Clark and R. Clark 2011; Munaretto, Siciliano, and Turvani 2014) and advocate for decentralised and power-sharing deliberative processes (Ansell and Gash 2008; Chaffin *et al.* 2016). Collaborative networking and trust-building relationships offer more flexible and resilient arrangements compared to traditional forms of governance (Huitema *et al.* 2016) and integrate multiple governance scales and institutions (Vandergert *et al.* 2016).

Transformational adaptation entails processes of experimentation and learning by doing (Chaffin *et al.* 2016; Folke *et al.* 2005). The governance of climate adaptation highlights the significance of the relationship between science and governance, the integration of diverse knowledge bases, and the need for action (Wyborn 2015). This also encompasses the role of social memory and its narratives (Mistry *et al.* 2014), as well as the selection of steering and evaluation mechanisms. Therefore, engaged citizens are essential to the urban climate adaptation process.

However, there is increasing evidence indicating that citizen engagement in urban climate adaptation initiatives has been quite limited in cities worldwide (Klein *et al.* 2018). The involvement of citizens, though scarce, often relies on the provision of information promoting adaptation. Several studies have questioned the notion that there is a direct progression from information and awareness to action in the context of

climate adaptation (Collins and Ison 2009; Domingues *et al.* 2018; Hügel and Davies 2020). Hügel and Davies (2020) also highlight that while much of the literature emphasises the positive effects of higher levels of engagement and participation for successful climate adaptation, there is little explicit consideration of what constitutes appropriate participation, why it is important, and how it should be framed and assessed in relation to achieving predefined goals. Similarly, Sprain (2016) discusses the paradoxes of public participation in climate change governance. To generate the transformative knowledge necessary for effective engagement in urban climate adaptation, public participation needs to go beyond the traditional unidirectional flow of information from urban planners to policy-makers to citizens (Klein *et al.* 2018).

## **2.2. Challenges to increasing public engagement in urban climate adaptation**

Several aspects emerge as hindrances or limitations to the two-way interaction between citizens and institutions in governing climate adaptation. In this section, we discuss these aspects, highlighting how responses could benefit from considering the emotional or affective dimension. We categorise these issues into four types of challenges: communication, legitimacy, empowerment, and ownership.

### *2.2.1. Communication*

Climate adaptation is influenced by interconnected biophysical and political processes (Nightingale 2017), which have implications for the effectiveness of communication. However, communication in climate change matters has predominantly relied on technical and scientific discourse, failing to resonate with the values, attitudes, and perceptions of citizens (Hendersson and Wamsler 2020; Morris *et al.* 2019; Nisbet 2009). The manner in which communication is conducted reflects how climate change risks are framed within top-down science-policy processes, which in turn impacts public engagement. Technocratic narratives suggest that valid knowledge is solely produced by specific actors, such as scientists, relegating citizens to passive roles in participatory processes that often become mere symbolic gestures (Carvalho, Van Wessel, and Maesele 2017).

Moreover, reducing climate change to a purely physical and rational problem fails to address the cultural, socioeconomic, and psychological factors that shape individuals' behaviours within their specific contexts. Consequently, it fosters a disconnection towards climate adaptation, as citizens may neither recognize global or local climate change risks, nor perceive their own agency in adapting to them (Domingues *et al.* 2018; Hendersson and Wamsler 2020). Gustafson *et al.* (2020) demonstrate that sharing personal stories about how climate change impacts communities or individuals, rather than relying solely on information, has a greater impact in mobilising and engaging diverse audiences. Personal stories evoke emotions of concern or compassion, thereby increasing risk perception and belief in climate-related impacts. Communication on climate change should adopt an evidence-based understanding of the intricate ways in which emotions, communication, and public engagement are interconnected.

### *2.2.2. Legitimacy*

*Legitimacy* refers to the proper representation of the governed individuals, ensuring inclusive participation and the ability of governing bodies to deliver public benefits. It

encompasses both input legitimacy, which involves the involvement of citizens in decision-making processes, and output legitimacy, which entails the capacity of governing bodies to produce favourable outcomes for the public (Scharpf 1999). However, citizens may feel excluded or inadequately represented in decision-making processes, leading to a rejection of the resulting outcomes (Nightingale 2017; Sprain 2016). This is particularly true when citizens are involved in processes with predefined goals aimed at legitimising solutions predetermined by institutional stakeholders, or when the issues addressed do not align with the concerns of the community (Sprain 2016). Conversely, practitioners and institutional decision-makers may perceive public participation as being driven solely by citizen self-interest and conflicts, which can often lead to undesirable outcomes (Wamsler *et al.* 2020). This perception can potentially breed scepticism regarding new collaborations and hinder the establishment of effective partnerships between institutions and citizens.

Furthermore, legitimacy also pertains to the inclusion of diverse expertise in decision-making processes (Arnesen and Peters 2018). The local knowledge, needs, and values held by communities and citizens are crucial for developing effective climate adaptation strategies. For this knowledge to have an impact, it is important to adopt a co-production approach that involves all stakeholders from the beginning. Citizens should be recognized as experts in their own right, drawing on their lived experiences and contributing to the resolution of conflicts and decision-making processes, including the reconciliation of opposing views (Hügel and Davies 2020).

### 2.2.3. *Empowerment*

Power dynamics are inherently intertwined in the governance of resources and communities within climate adaptation initiatives. Consequently, empowering citizens through participatory approaches necessitates a reconfiguration of power and knowledge, redefining the roles of each participant in the process (Nightingale 2017). This shift relies on trust-building through collaboration and networking. One significant power dynamic prevalent in top-down climate adaptation projects is rooted in the underlying assumption that climate change vulnerability stems from biophysical changes combined with socioeconomic risks. Consequently, these projects often prioritise institutional design and technical actions, disregarding the intricate social and political contexts that can significantly influence the adaptation process (Bremer *et al.* 2019; Nightingale 2017). Such assumptions reinforce exclusive patterns within participatory environmental governance, manifested through the creation of bureaucratic and highly technical procedures by governmental institutions. These procedures can restrict the involvement of lay citizens and potentially favour the engagement of local elite stakeholders who have specific interests in decision-making processes that may not align with the broader public interest (Parkins and Sinclair 2014). Therefore, power dynamics shape not only the outcomes of adaptation but also determine who participates in the process, whether leading or supported, and how (Nightingale 2017).

### 2.2.4. *Ownership*

*Ownership* pertains to the notion that transformative climate adaptation is more focused on pathways rather than predefined solutions. It involves individual and collective adaptive learning cycles that unfold over time within contexts characterised by



uncertainty and complexity (Tschakert *et al.* 2016; Wise *et al.* 2014). Adaptation, in this sense, arises from a process of learning-by-doing, where individuals and communities take ownership of their experiences and engage in a reflective and iterative learning process. This process is deeply connected to their values, concerns, and worldviews. Transformational change is inseparable from personal experiences and the meanings attributed to them, fostering a sense of ownership, empathy, and self-identification.

In line with this argument, recent research has examined the effectiveness of climate change communication by comparing emotionally evocative stories with informational narratives. These studies have shown that stories that elicit emotional arousal, as opposed to purely informational content, are more successful in engaging participants, fostering empathy, and promoting pro-environmental behaviour (Morris *et al.* 2019). However, the dominant narrative surrounding climate change often lacks personal authorship, resulting in a sense of distance, disconnection, and individual helplessness, thus, undermining the adaptive capacities of citizens and communities (Hendersson and Wamsler 2020; Pidgeon and Fischhoff 2011).

### **2.3. 'Affective facilitators' in climate change adaptation**

In this section, we explore the role of the affective dimension in enhancing citizen engagement in climate adaptation. We propose four key aspects, referred to as 'affective facilitators': subjective and emotional narratives, local knowledge, social identities, and personal experiences.

Although terms like 'affect,' 'feeling,' and 'emotion' are often used interchangeably, they have distinct meanings. 'Feelings' are sensations resulting from past memories and experiences, while 'emotions' are projections of those feelings (Shouse 2005). It has been found that inducing hope can be more effective in promoting action and engagement compared to instilling fear or concern (Chapman, Lickel, and Markowitz 2017). However, the relationship between emotions and action is complex, and emotions should not be seen as simple triggers in communication. Nevertheless, emotions play a significant role in decision-making processes, as they can drive actions or inaction (Davidson and Kecinski 2022; Lerner *et al.* 2015).

Identity and social capital have been identified as influential factors in shaping emotions in collective contexts. However, emotions do not always lead to positive behaviours, as maladaptive reactions can occur (Davidson and Kecinski 2021). On the other hand, 'affect' refers to experiences that are usually unconscious and involve a quantitative dimension of intensity in addition to the quality of the experience (Massumi 2015), playing a crucial role in shaping the relationship between ourselves, the others, and the environment (Shouse 2005). Some scholars (Ahmed 2014; Fortier 2016) prefer to see affect and emotions as intertwined, as "emotions involve bodily processes of affecting and being affected" (Ahmed 2014, 208). Thus, 'affect' can be understood as categories of emotions and feelings, shaping individuals' perceptions and experiences of the world. The concept of 'affective practice' captures the ongoing and dynamic nature of affect as it is embodied, situated, and operates psychologically, through which individuals construct and navigate their world (Wetherell 2015). Affective practices mobilise individuals and shape their actions, and studying these practices allows social researchers to understand and analyse events within the broader context of social action.



Transformational climate adaptation is closely tied to experiential and embodied forms of knowledge, where affects and emotions play a significant role in the adaptation process. A shift is occurring in climate change knowledge politics, which integrates scientific knowledge with “affective knowing” that emerges from everyday affective practices and experiences (Nightingale, Gonda, and Eriksen 2022). Understanding the emotional dimension in climate change responses is becoming increasingly important, particularly in recognizing the influence of emotions on decision-making and behavioural attitudes. Davidson and Kecinski (2022) highlight various threats to behavioural responses associated with climate change, including apathy (not paying sufficient emotional attention), denial (rejecting to avoid unpleasant emotions), and withdrawal (overwhelmed by fear and despair). These responses arise from complex and sometimes contradictory emotions. However, the authors also emphasise that certain emotional pathways can promote pro-climate action, such as engaging in personal and collective deliberation communications, direct experience, and actions driven by empathy.

Numerous studies have explored the significance of *personal experiences* with climate events in inducing behavioural and attitudinal change, as they reduce the psychological distance, meaning that individuals perceive events as closer, thereby influencing their decision-making (Kates and Wilbanks, 2003; Leiserowitz, 2007; Niles, Lubell, and Brown, 2015; Scannell and Gifford, 2013). Psychological distance is a concept described by Trope and Liberman (2010) that refers to the perceived temporal, geographic, social or hypothetical proximity of events, with closer events exerting a greater influence on individual decision-making (Niles, Lubell, and Brown 2015), as they rely more on direct experiences rather than on mental construal or abstract reasoning (Niles, Lubell, and Brown, 2015). The decision to take action in climate adaptation is similarly influenced by individuals’ own experiences of climate events. Gustafson *et al.* (2020) conducted a study on the effects of using personal stories or subjective narratives and found them to be a persuasive communication strategy for engaging diverse audiences. Paschen and Ison (2014) suggest that the way people tell ‘stories’ of their past experiences play a crucial role in shaping understandings and practices of future adaptation within a community. Narratives are seen as “structures of knowledge and storied ways of knowing” (Cortazzi 2001, as cited in Paschen and Ison 2014), capable of building rationales and creating opportunities where differences emerge as the ground for new insights and practices.

Past climatic experiences and their influence on adaptation are highlighted by authors including Adger, Lorenzoni, and O’Brien (2009), who emphasise the role of values and perception in shaping the limits to adaptation within society. In addition to considering different forms of climate communication, the characteristics of the receivers are also crucial in determining their responsiveness to climate narratives. It is worth noting that individuals can respond differently to the same stimulus, and even the same person may exhibit inconsistent responses on different occasions due to their emotional state (Davidson and Kecinski 2022). This variability in responses could explain certain discrepancies observed in empirical research findings. Nevertheless, adopting approaches that incorporate affective and emotional factors in climate adaptation implies a paradigm shift towards transdisciplinary research (Vanderlinden *et al.* 2020), where the emphasis is placed on the procedural benefits of collaboration (Krauß 2020) rather than on factual knowledge and where ambiguity or inaccuracies may occur (Vanderlinden *et al.* 2020).

Personal experiences, perspectives, and expertise play a crucial role in building knowledge. The significance of knowledge co-production for climate adaptation, achieved through collaborative deliberation and social learning, has been widely acknowledged in the literature (Lemos and Morehouse 2005; Ziervogel, van Garderena, and Price 2016). *Local* and indigenous *knowledge* and practices have been documented to enhance preparedness in climate adaptation and risk reduction (Audefroy and Sánchez 2017; Hiwasaki *et al.* 2014; Kettle *et al.* 2014). In this process, all actors involved contribute their unique viewpoints, wisdom, and expertise, collectively building knowledge from diverse sources (often referred to as dispersed knowledge), highlighting the importance of sharing information and practices. Moreover, knowledge that emerges within a specific community or context is intrinsically linked to the specific circumstances and situations in which it was acquired (situation-specific knowledge) (Ashwood *et al.* 2014). These components come together as traditional or *local knowledge*.

Various types of self-identity associated with personal climate action have been the focus of recent research, including place identity, connectedness to nature, environmental self-identity, and social identity (Wilcox *et al.* 2012; Fresque-Baxter and Armitage 2012; Fritsche *et al.* 2018; Vesely *et al.* 2021; Whitmarsh and O'Neill 2010). Social identity, in particular, plays a significant role in climate adaptation, as aspects of identity related to belonging and confidence in the local community can facilitate adaptive behaviours (Barnett *et al.* 2021). Promoting self-efficacy and self-esteem within communities and reinforcing feelings of place attachment can support the engagement of citizens in climate adaptation efforts (Wilcox *et al.* 2012).

In this section, several aspects are identified as potential drivers of climate adaptation, referred to as key 'affective facilitators'. These factors contribute to and enable citizens to embrace adaptation measures, moving beyond passive attitudes and motivating action. The identified affective facilitators include:

***Subjective/Emotional narratives*** – This pertains to the way citizens are engaged in climate adaptation, particularly through the use of narratives that evoke emotions. These narratives focus on subjective factors such as values, meanings, and attitudes, aiming to explore risk perception and encourage the adoption of new behaviours.

***Local Knowledge*** – This refers to the incorporation of specific types of knowledge from local (and indigenous) communities, in addition to the knowledge provided by scientists or experts. It emphasises the convergence of both types of knowledge.

***Social identities*** – This refers to how citizens identify with groups within their community are more inclined to engage in collective action for climate adaptation. Fostering empathy and strengthening psychological bonds among community members, therefore consolidating social identity, nurtures the feelings of civic belonging that enable adaptive behaviours.

***Personal experiences*** – This refers to how past lived experiences with climatic events condition individuals' future actions and their predisposition towards climate adaptation initiatives. These affective practices and personal encounters lead to individuals developing new modes of knowing.

In [Figure 1](#), the main challenges of citizen engagement are systematised and connected with the identified affective facilitators essential for enabling transformative climate adaptation.

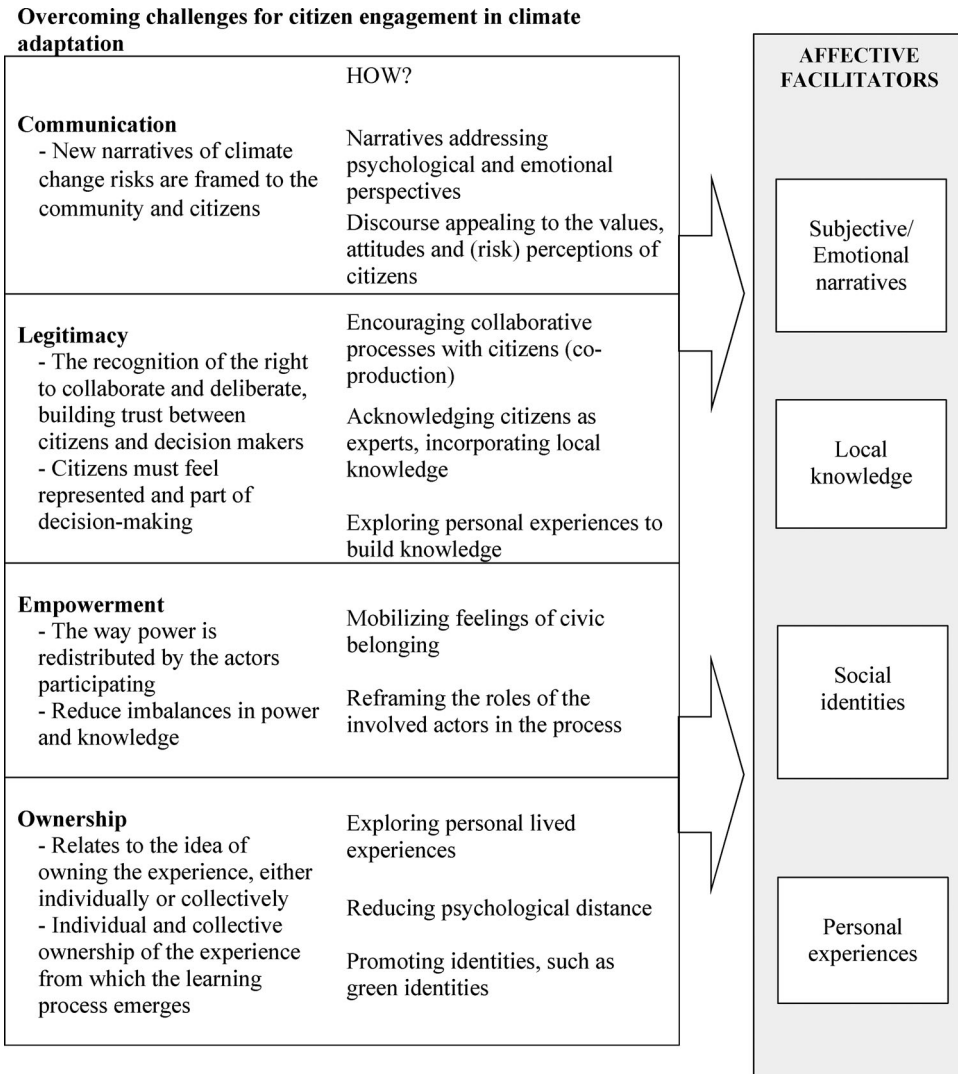


Figure 1. Affective facilitators to enable citizen engagement in climate adaptation.

### 3. The potential of citizen science in supporting climate adaptation

#### 3.1. Citizen science to enhance citizen engagement in climate adaptation

CS facilitates various levels of citizen participation and engagement, ranging from crowdsourcing, where citizens serve as sensors and contribute data, to more participatory forms such as extreme citizen science or citizen social science, where citizens play crucial roles in research, action, and policy change. The integration of CS has been seen as a means to democratise knowledge production and disrupt traditional top-down science-policy models, which prioritise scientific expertise and power in determining the “truth” that shapes political decisions (Kythreotis *et al.* 2019).

CS has been recognized as a valuable approach for enhancing adaptive governance capacity, particularly in the context of climate adaptation (Bremer *et al.* 2019;

Spellman 2015; Wildschut 2017). By involving citizens directly in the research process, CS enables the generation of information and insights that are specific to local climate impacts and unforeseen outcomes, thereby enhancing understanding of these processes (Azzurro *et al.* 2013; Fulton *et al.* 2019). Such knowledge can inform urban planners in effectively allocating resources and devising appropriate planning strategies. Moreover, CS plays a crucial role in enabling citizens to develop a deeper understanding of the natural processes and risks associated with climate change in their local urban environments. This firsthand experience and tangible connection to climate issues have been shown to foster civic agency, empowering individuals and communities to respond to societal challenges (Ballard, Dixon, and Harris 2017; Bremer *et al.* 2019). Therefore, CS has the potential to raise awareness about increasing local-scale risks while simultaneously facilitating the development and implementation of adaptive measures by individuals and communities.

Thus, while recognizing the advantages of CS in the research process, such as enabling the collection and analysis of large datasets by citizens (Bonney *et al.* 2014), our focus in this paper is on the less explored role of CS in promoting adaptive behaviour and citizen agency specifically in urban climate adaptation. We argue that CS approaches have the potential to address some of the key challenges that hinder citizen engagement, as identified in Section 2.2. By establishing a direct communication channel with citizens, CS can incorporate the affective dimension and integrate the identified facilitators. The overall conceptual framework supporting our argument is presented in Figure 2, and the rationale for our approach is further elaborated in the subsequent section.

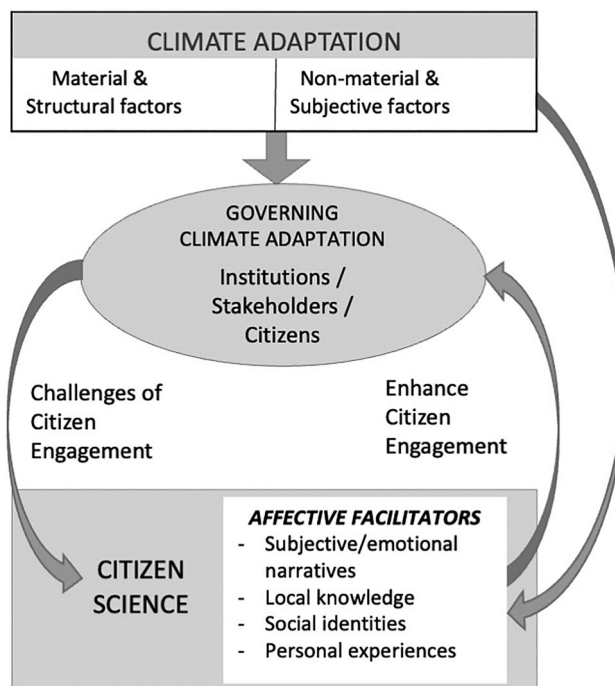


Figure 2. General conceptual framework.

### **3.2. Exploring the affective facilitators in citizen science to support climate adaptation**

CS has the potential to facilitate the reframing of climate adaptation communication in a way that aligns with the values and experiences of communities, incorporating **subjective narratives**. Additionally, CS can foster the co-production of knowledge between citizens and scientists when there is genuine collaboration in identifying the relevant issues and determining effective strategies for positive change (Bremer *et al.* 2019). Communication practices play a significant role in shaping the emotional and cognitive processes associated with climate adaptation, and therefore require addressing explicitly in participatory processes and CS initiatives (Wolf and Moser 2011).

CS can serve as a mediator for the redistribution of expertise between citizens and scientists, providing a platform for public engagement and the co-production of knowledge necessary to address environmental challenges. This process challenges established forms of knowledge and underlying beliefs (Bonney *et al.* 2014; Bremer *et al.* 2019; Landström *et al.* 2011). Through CS projects, citizens can gain a deeper understanding of scientific practices and contribute to the legitimacy of adaptation research (Bäckstrand 2003; Bremer *et al.* 2019; Shirk *et al.* 2012). By harnessing the collective knowledge of individuals, CS can effectively utilise dispersed and localised information to build a robust foundation of **local knowledge**.

Initiatives that incorporate CS have the potential to promote a more inclusive and diverse representation of the community, empowering citizens and facilitating the integration of different forms of expertise in climate adaptation efforts. By providing structured and accessible opportunities for the participation of lay citizens, CS initiatives can help balance the governance of collective resources and climate adaptation. In doing so, CS can contribute to revitalising a culture of active citizenship and genuine community membership, which may have been overshadowed by professionalised governance of public affairs (Bäckstrand 2003). Additionally, CS can foster the development of individual and collective political capabilities, enhancing climate adaptation agency. Sharing experiences and finding common ground with others can foster a sense of belonging (**social identity**) and facilitate collective action. The reinforcement of social bonds through empathy and compassion has proven to be relevant in addressing group or community challenges and threats (Davidson and Kecinski 2022).

Furthermore, CS holds the potential to facilitate climate adaptation as a transformative learning-by-doing process, especially when the focus is on recognizing the value of experience and meaning as sources and mediators of knowledge, as well as the value of CS for local climate governance (Bonney *et al.* 2014; Bremer *et al.* 2019). Traditionally, CS initiatives have served as platforms for scientific learning through **personal experiences**, involving individuals from diverse backgrounds and cultures. These initiatives establish a connection between science and education, supporting innovation and the co-production of knowledge, while advancing societal objectives, policy development, and opportunities for citizen engagement with environmental challenges (Bäckstrand 2003; Bonney *et al.* 2014). Consequently, CS climate adaptation projects have the potential to serve as effective pathways for public engagement and widespread climate adaptation if they actively foster an inclusive social learn-by-doing process. This process should address the significance of meanings, experiences, and ownership of the issues at hand, while ensuring appropriate framing of scientific information and outputs (Collins and Ison 2009).

Climate adaptation necessitates consideration of both material and structural factors, as well as non-material and subjective factors. However, the exploration of this has been limited within top-down climate adaptation governance. The existing literature offers insights into addressing the challenges that impede citizen engagement, such as the incorporation of everyday practices that involve affects and emotions. These practices have the potential to facilitate individuals' responses to climate adaptation, as illustrated in Figure 2. The suggested affective facilitators aim to influence citizens' behaviours, encouraging the adoption of more adaptive practices.

### 3.3. *An illustrative case as basis for discussion*

The Citizen Sensing project<sup>1</sup> is utilised in this section as an illustrative example to demonstrate how Citizen Science (CS) can be designed to incorporate the "affective facilitators" and further support citizen engagement in urban climate adaptation. The project, that is the basis for the discussion, aimed at developing a participatory system to engage citizens in collecting and sharing information on urban climate impacts and adaptation measures, establishing a means of communication to enable interaction between citizens, communities, and authorities. The project built on a co-design approach, involving primarily municipal stakeholders and citizens (Neset *et al.* 2021), to identify local weather events and climate impacts of concern. Citizens were then invited to report on these events and impacts through a web application,<sup>2</sup> accessible *via* smartphones or portable devices, where they could submit site-specific information, including data, images, and text (Navarra *et al.* 2021; Opach *et al.* 2023). The participatory system aimed to establish a two-way communication channel between citizens and authorities, recognizing citizens as both providers and receivers of information. The system consisted of three main components: (i) the CitizenSensing web application, which facilitated the reporting of observed impacts and allowed users to add text or photographs to their reports. The application interface also enabled users to explore reports submitted by other citizens. (ii) a web portal that provided visual exploration of the reported data, and (iii) a network of sensors accessible through the web application (Navarra *et al.* 2021; Opach *et al.* 2023). In addition to reporting impacts, citizens received information through the web application, including weather data from the sensor network and adaptation recommendations related to different climate impacts. It is important to note that the observed impacts reported through the web application cannot be directly attributed to climatic changes. However, the application included impacts that the involved municipalities deemed important to address, as they are expected to increase in the future due to climate change (Neset *et al.* 2021).

*Subjective/Emotional Narratives* were utilised to enable each participating citizen to contribute their lived experience, providing valuable insights from their subjective perspective. The app allowed citizens to share information on the weather event and climate impact, accompanied by images and text, thus creating a subjective narrative of the observed climate impact. Besides, recommendations on adaptive measures were also available for consultation. This approach facilitated a more personal and engaging form of communication between public organisations and citizens, making information more accessible. Citizens could access the information at any time and place, in a comprehensive language and suitable format that was easily understandable. The narratives encompassed a combination of scientific and non-scientific information, tailored

to the specificities of each location and community, thereby reaching a broader audience.

*Local Knowledge* is collected as site-specific information, submitted by citizens from diverse locations. This dispersed knowledge contributes to the development of consistent local knowledge, which is crucial for institutions and stakeholders involved in effective climate adaptation governance. The observations submitted by citizens serve as the foundation for providing site-specific information to authorities and planners. This information can be accessed, selected and analysed through the web portal, facilitating informed decision-making regarding local adaptation strategies. By actively collaborating with local knowledge, citizens are not merely participating in the process but also recognized as experts with valuable insights, thereby enhancing their legitimacy in contributing to the search for solutions.

*Social Identities* are fostered through the establishment of networks that promote collaboration and trust among various stakeholders, ultimately empowering citizens. The system ensures that citizens' perspectives are not only heard but also recognized and acknowledged. Through their engagement with the system, citizens have the opportunity to gain deeper insights into scientific practices related to climate adaptation and develop a better understanding of local climate impacts and risks. Additionally, by accessing and reviewing reports submitted by other users in the app, citizens can find commonalities and identify with others who share similar experiences, perceptions, concerns, or feelings. This sense of belonging to a shared community or group, along with the activation of citizenship, has the potential to inspire action and foster a collective response to climate challenges.

*Personal Experiences*, such as citizens' observations of weather events and climate impacts, as well as their personal comfort levels, are narrated and shared. This allows for a diverse range of perspectives on risk perception and adaptation measures to be captured and shared. Each contribution reflects an individual's introspection and can include personal perceptions of comfort, such as how they individually experience and perceive heat based on their own thermal comfort level. By incorporating personal lived experiences and stories from others, the system fosters a sense of ownership and provides new ways of knowing. These personal narratives have the potential to evoke

Table 1. The use of affective facilitators in the Citizen Sensing Project.

Affective facilitators	Citizen Sensing Project
Subjective/Emotional narratives	<ul style="list-style-type: none"> <li>• Citizens communicate experiences and observations in an accessible format and language</li> <li>• Enables citizens to provide their individual climate adaptation narratives by sharing observations in the form of text and images</li> </ul>
Local knowledge	<ul style="list-style-type: none"> <li>• A collaborative process gathering local information on climate impacts</li> <li>• Builds knowledge from the submitted observations, providing site-specific information for authorities and planners</li> </ul>
Social identities	<ul style="list-style-type: none"> <li>• Facilitates the communication and sharing of knowledge among communities with similar concerns</li> <li>• Sharing of experiences and adaptation recommendations</li> </ul>
Personal experiences	<ul style="list-style-type: none"> <li>• Citizens report on their personal experiences and adaptation measures</li> <li>• Sharing and learning from each other's stories, perceptions, and recommendations</li> </ul>



emotional reactions such as worry or compassion and can ultimately contribute to the enablement of adaptation initiatives.

In [Table 1](#), we provide a systematic overview of how the four affective facilitators identified in [Section 2.3](#) are addressed in the Citizen Sensing Project.

#### **4. Conclusion**

Recent research on climate adaptation has indeed emphasised the importance of citizen engagement and addressing the gap between intention and action. We concur that affects and emotions play a significant role in mobilising individuals and enabling them to construct or reconstruct their understanding of the world, particularly in relation to new routines and experiences that shape their actions. In the context of urban climate adaptation, exploring the affective dimension can empower citizens and increase their motivation to adopt adaptation strategies in collaboration with institutions, organisations, and other stakeholders. We identify four key affective facilitators – subjective/emotional narratives, local knowledge, social identities, and personal experiences – as essential elements to be considered in climate adaptation.

In our framework, we demonstrate how citizen science approaches can effectively incorporate and leverage these affective facilitators to enhance citizen engagement in urban climate adaptation. Citizen science provides a platform for interactive engagement with citizens, enabling diverse modes of communication through informal and alternative channels. By actively involving citizens in data collection, citizen science promotes the generation of site-specific data, utilising localised and situated knowledge. This process enhances the understanding of local climate impacts and risks, allowing individuals to develop a stronger connection with their environment and facilitating a sense of belonging to their communities or groups.

Further empirical research is still needed to better understand the relationship between emotional approaches and climate change concern and action, specifically in the context of climate adaptation. The complexities (and occasional inconsistencies) inherent in the emotional dimension, though they may deviate from purely science-based approaches, ultimately, appear to have a more beneficial social impact.

#### **Notes**

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2. <https://citizensensing.eu>

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