Understanding collective adaptation to climate change in socio-culturally diverse contexts – General conceptual models and empirical insights from Jakarta

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Summary

The intensifying and more frequent impacts of climate change, coupled with unequal urban development, require more dedicated and integrated approaches to adaptation. Recognizing climate change as a collective action problem necessitates a shift for researchers and policymakers, moving from focusing solely on individual needs and capacities to a more social perspective. This shift is most urgently needed in highly exposed and vulnerable coastal cities, where climate change already has severe impacts. To effectively address future adaptation needs, understanding local visions, needs, and capacities related to climate change adaptation is imperative. This entails considering another characteristic of these particular high-risk locations that has been rather neglected in the research on climate change adaptation so far. Socio-cultural diversity significantly influences risk perceptions, vulnerabilities, and behaviors, thereby shaping the formation of social groups and their behaviors in response to climate change. Despite some academic attention to the psychological influences on (collective) climate change adaptation, empirical evidence as well as theoretical and conceptual debates are lacking – especially for socio-culturally diverse contexts like cities.

With this study, I aim to address these gaps by conceptually and empirically examining the phenomenon of collective adaptation in socio-culturally diverse, high-risk contexts. Therefore, this study will answer several pertinent research questions: Is there evidence for collective adaptation? Which groups form to adapt collectively? What motivates them to become and stay actively engaged in collective adaptation? And if and how do differently adapting groups interact?

I apply a mixed-method approach combining deductive and inductive methods to develop a comprehensive framework that conceptualizes the emergence of collective adaptation in socio-culturally diverse contexts from a social psychology perspective. The framework covers the entire collective adaptation process encompassing the development of risk-based social identities, their materialization into groups, their activation, and potential types of adaptation in socio-culturally diverse settings.

I empirically tested and validated the framework through data from Jakarta, the highly exposed, urbanized, and socio-culturally diverse capital city of Indonesia. Through semi-structured interviews, expert elicitations, and a representative survey of kampung cooperatives – a collective phenomenon in high-risk neighborhoods in Jakarta – I examine the validity of the three sequences of the developed conceptual framework. The results provide evidence for the socio-cultural diversity among *the* most vulnerable. Furthermore, I am able to demonstrate that in the face of climate risk, only three out of many social identities become salient in highly exposed and diverse neighborhoods in Jakarta. Materialized into groups and networks, they largely differ in their collective adaptation capacities. The results also indicate that the materialization of identities into groups is insufficient for explaining their collective actions, given a high share of inactive group members. Against this background, the study identifies a set of temporally differentiated motivating factors. Initial triggers motivate group members to start becoming active; long-term motivators keep them engaged over time. A few identified general facilitators contribute to both, the initial activation as well as long-term engagement. Lastly, the developed conceptual framework illustrates that the interaction of differently adapting groups is mediated by multiple influencing factors which ultimately affect urban adaptation patterns.

While the empirical findings and their implications are mostly relevant for Jakarta or very similar cultural contexts in which social trust, reciprocity, and mutual support are strong societal values, the more abstract conceptual framework for collective adaptation is applicable more broadly. It is based on underlining socio-psychological factors that influence engagement in collective adaptation and is hence independent of varying context conditions.

Overall, this study expands the current knowledge on collective adaptation in multiple ways. The conceptual framework and its sequences address the lacking theoretical and conceptual discussions around the topic. It also represents a valuable analytical lens and can guide future scientific work on collective adaptation as its sequences can be well operationalized, informing data collection and analysis. At the same time, the empirical findings resulting from the application of the conceptual framework differentiate the current understanding of urban adaptation to climate change in Southeast Asian coastal cities, particularly in terms of soft adaptation options, heterogeneous collective capacities to adapt, and collective adaptation actions. It emphasizes the importance of considering socio-cultural differences and diversity in shaping adaptation behaviors and interactions. Both, the conceptual and the empirical insights are also valuable for policy development and the practical facilitation of socially just urban adaptation strategies.

Zusammenfassung

Die zunehmenden und häufigeren Auswirkungen des Klimawandels in Verbindung mit ungleicher städtischer Entwicklung erfordern integrierte Ansätze zur Anpassung. Die Anerkennung des Klimawandels als ein kollektives Handlungsproblem verlangt einen Wandel von ForscherInnen und PolitikerInnen, weg von der alleinigen Fokussierung auf individuelle Bedürfnisse und Fähigkeiten hin zu einer sozialeren Perspektive. Dieser Wandel ist besonders dringend in stark gefährdeten und verwundbaren Küstenstädten, wo der Klimawandel bereits schwerwiegende Auswirkungen hat. Um zukünftige Anpassungsbedürfnisse effektiv anzugehen, ist es entscheidend, die lokalen Visionen, Bedarfe und Fähigkeiten in Bezug auf die Anpassung an den Klimawandel zu verstehen. Dies beinhaltet auch ein erweitertes Verständnis bezüglich einer weiteren Besonderheit von stark Klimawandel-gefährdeten Orten, die bisher überraschend wenig Beachtung in der Anpassungsforschung gefunden hat – Soziokulturelle Vielfalt hat einen signifikanten Einfluss auf die Wahrnehmung von Risiken, Verwundbarkeiten und das Risikoverhalten und prägt somit die Bildung von sozialen Gruppen und deren Verhalten im Kontext von Klimawandelrisiken. Obwohl die wissenschaftliche Aufmerksamkeit auf die psychologischen Grundlagen (kollektiver) Anpassung an den Klimawandel im Verlauf der letzten zehn Jahren gewachsen ist, fehlen noch immer fundierte empirische Beweise sowie tiefere theoretische und konzeptionelle Debatten zum Thema kollektive Anpassung - insbesondere in soziokulturell vielfältigen Kontexten wie Städten.

Mit dieser Studie möchte ich diese Lücke adressieren, indem ich das Phänomen der kollektiven Anpassung in soziokulturell vielfältigen Hochrisiko-Kontexten konzeptionell und empirisch untersuche. Zu diesem Zweck behandelt diese Studie mehrere relevante Forschungsfragen: Gibt es empirische Belege für kollektive Anpassung? Welche Gruppen bilden sich, um sich kollektiv anzupassen? Was motiviert sie dazu, aktiv an kollektiver Anpassung teilzunehmen und dabei zu bleiben? Und wie interagieren Gruppen, die sich unterschiedlich anpassen?

Ich nutze einen Mixed-Method-Ansatz, der deduktive und induktive Methoden kombiniert, um ein umfassendes konzeptionelles Framework zu entwickeln, dass das Entstehen kollektiver Anpassung in soziokulturell vielfältigen Kontexten aus einer sozialpsychologischen Perspektive konzeptualisiert. Das Framework umfasst den gesamten Prozess der kollektiven Anpassung, angefangen bei der Entwicklung von risikobasierten sozialen Identitäten über die Gruppenentwicklung, ihre Mobilisierung und schließlich die potenziellen Arten von kollektiver Anpassungen in soziokulturell vielfältigen Umgebungen.

Ich teste und validiere das konzeptionelle Framework anhand von empirischen Daten aus Jakarta - der stark exponierten, urbanisierten und soziokulturell vielfältigen Hauptstadt Indonesiens. Durch semi-strukturierte Interviews, Expertenbefragungen und eine repräsentative Umfrage von Kampung-Kooperativen - einem kollektiven Phänomen in exponierten Vierteln in Jakarta – untersuche ich empirisch die Validität der drei entwickelten Sequenzen des konzeptionellen Frameworks. Die Ergebnisse weisen auf eine hohe soziokulturelle Vielfalt unter *den* Verwundbarsten hin. Darüber hinaus zeigen die Analysen, dass in stark exponierten und vielfältigen Vierteln in Jakarta im Kontext von Klimawandelanpassung nur drei von vielen koexistierenden sozialen Identitäten salient werden. Die so entstehenden Gruppen und Netzwerke unterscheiden sich stark in ihren kollektiven Anpassungskapazitäten. Die Studie zeigt auch, dass die reine Mitgliedschaft in Gruppen nicht ausreicht, um kollektives Handeln zu erklären, da ein hoher Anteil der Gruppenmitglieder inaktiv ist. Vor diesem Hintergrund identifiziert die Studie eine Reihe von zeitlich differenzierten Motivationsfaktoren. Erste Auslöser motivieren Gruppenmitglieder dazu, aktiv zu werden,

während langfristige Motivationsfaktoren sie über längere Zeiträume motivieren. Einige allgemeine Faktoren erleichtern sowohl die anfängliche Aktivierung als auch das langfristige Engagement. Des Weiteren verdeutlicht die Studie, dass die Interaktionen zwischen sich unterschiedlich anpassender Gruppen durch bestimmte Faktoren beeinflusst werden, die sich schlussendlich auf städtische Anpassungsmuster auswirken.

Während die empirischen Erkenntnisse und ihre Implikationen hauptsächlich für Jakarta oder sehr ähnliche kulturelle Kontexte relevant sind, in denen soziales Vertrauen, Reziprozität und gegenseitige Unterstützung starke gesellschaftliche Werte sind, ist das abstraktere konzeptionelle Framework für kollektive Anpassungen in einem breiteren Maße anwendbar. Es basiert auf grundlegenden sozio-psychologischen Faktoren, die das Engagement in kollektiver Anpassung beeinflussen und ist daher unabhängig von anderen variablen Kontextbedingungen.

Insgesamt erweitert diese Studie den aktuellen Wissensstand über kollektive Anpassung auf unterschiedlichen Ebenen. Das konzeptionelle Framework und seine Sequenzen adressieren die bisher weitgehend vernachlässigte theoretische und konzeptionelle Auseinandersetzung mit dem Thema. Es stellt außerdem eine wertvolle analytische Perspektive dar und kann zukünftige wissenschaftliche Arbeit informieren, da die Sequenzen gut operationalisierbar sind und somit das Sammeln von Daten und deren Analyse anleiten können. Gleichzeitig differenzieren die empirischen Ergebnisse, die aus der Anwendung des konzeptionellen Frameworks resultieren, das derzeitige Verständnis von Anpassung an den Klimawandel in südostasiatischen Städten, insbesondere im Hinblick auf weiche Anpassungsmaßnahmen, heterogene kollektive Anpassungsfähigkeiten und –maßnahmen. Sie betonen die Bedeutung der Berücksichtigung soziokultureller Unterschiede und Vielfalt bei der Gestaltung von Anpassungsverhalten. Sowohl die konzeptionellen als auch die empirischen Erkenntnisse sind weiterhin wertvoll für die Entwicklung von Politik und die praktische Unterstützung von Städten in der Entwicklung von sozial gerechten, urbanen Anpassungsstrategien.

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1. Introduction

1.1. Background of the thesis

Despite significant progress in research and knowledge generation, societies worldwide continue to struggle with responding to the complex interplay between climate change and human development. This challenge is particularly pronounced in low-lying coastal cities and urban areas in the Global South, where high exposure to climate change-induced coastal hazards converges with challenges of rapid urbanization such as socio-economic inequalities, inadequate basic infrastructure, pollution, urban sprawl, and environmental degradation (IPCC, 2022b). Over the past decade, scholars and policymakers have increasingly focused on understanding this interplay (Aerts et al., 2013; Hallegatte et al., 2013; IPCC, 2022b; Pelling & Blackburn, 2013). Research on urban adaptation to climate change has identified a range of potential options for cities to prepare for and adapt to climate change impacts such as increased urban heat, coastal flooding, and sea-level rise under consideration of other challenges arising from human development and urbanization (Adelekan et al., 2022; IPCC, 2022b). However, while adaptation strategies and plans, such as urban development or urban adaptation plans have been developed, there is still little scientific evidence for the implementation of such adaptation measures. This indicates a deficit in urban adaptation. However, meaningful advances in adaptation are required to address current and future needs in the face of climate change (Dodman et al., 2022).

Coastal urban areas in Southeast Asia are prime examples of the aforementioned trends. Cities like Jakarta, Hanoi, and Manila face significant risks regarding climate change impacts on their people, land, and infrastructure (Adelekan et al., 2022). At the same time, these cities have undergone rapid urbanization over the past decades (United Nations, 2018). Given the long history of exposure and vulnerability in many coastal cities in this region, they have accumulated rich experience in risk management. Furthermore, the high scientific attention on high-risk coastal cities has created a solid foundation for understanding climate change-induced hazards, related vulnerabilities, and shortcomings in current response and adaptation strategies. A common feature and longstanding tradition among Southeast Asian coastal cities in addressing coastal hazards such as coastal flooding, sea level rise, and storm surges is their reliance on reactive infrastructural and/or technological management approaches (Cao et al., 2021; Hornidge et al., 2020). Such hard adaptation measures are very useful and necessary to address current as well as future climate change impacts. However, studies have shown that they are most effective in combination with soft adaptation measures (Du et al., 2020). The latter encompass for instance ecosystem-based measures such as environmental conservation and/or restoration (e.g. of wetlands, coral reefs, mangroves) and reforestation (Adelekan et al., 2022), as well as institutional and social measures, including building codes, regional urban planning, community participation, empowerment, and capacity building (ibid.; (Sovacool, 2011)). Despite their effectiveness in complementing hard adaptation measures, soft adaptation measures have received less attention so far. They require careful and integrated planning, however, their outcomes are often not immediately visible (Adelekan et al., 2022).

Zooming to the sub-urban scale in Southeast Asian coastal cities, a considerable share of the urban population faces high levels of disaster risk because they are living in highly exposed urban areas while having limited capacities to cope with and adapt to recurrent hazards and daily livelihood struggles. Their vulnerabilities are driven by various aspects, including poverty, inadequate access to basic infrastructure,

informality, and low levels of education. The interplay of these vulnerabilities with their high levels of exposure results in disproportionate impacts on their livelihoods, well-being, and ability to cope with and adapt to climate-related hazards (Hallegatte et al., 2017). State-led adaptation and hazard mitigation measures primarily prioritize the protection of valuable urban assets and higher-income groups, often neglecting these disproportionately affected urban communities and failing to provide equal access to adaptive solutions (Swanson, 2021). Such distributive injustices also include cases in which implemented measures reinforce existing vulnerabilities and exposure (ibid.). In the absence of adequate state-led adaptation, these residents often rely on soft coping and adaptation measures to accommodate climate change impacts to sustain their urban livelihoods. Considering their limited assets and capacities to adapt, their coping and adaptation potentials predominately draw upon local knowledge and hazard experience (Dodman et al., 2022), as well as their ability to act collectively (Adger, 2003). Overall, these autonomously coping and adapting residents share many socio-demographic characteristics such as living in poverty, being employed in the informal sector, residing in informal and exposed housing, lacking access to state services and limited access to basic infrastructure, as well as having lower levels of education (IPCC, 2022b). Due to these broadly shared similarities, they are sometimes still referred to as *the* urban poor or *the* most vulnerable in policy-making and development work (e.g.(United Nations, 2015)).

However, this framing glosses over their diverging characteristics. Beyond the surface of similarities, those residing in highly exposed areas exhibit socio-cultural differences in terms of for instance ethnicity, religion, migration status, beliefs, norms, aspirations, and worldviews. Such cultural aspects have been demonstrated to influence risk perception, vulnerability, and behavior (Adger et al., 2013; Bankoff, 2017; International Federation of Red Cross and Red Crescent Societies, 2014; Mercer et al., 2012). Therefore, adopting a more differentiated view on *the* community(Titz et al., 2018) beyond social categories like gender, age, class, and income status enables a more nuanced understanding of local vulnerability patterns, capacities, and risk behaviors. Moreover, culture and by extension cultural differences can impact how individuals interact and collaborate (e.g. (Larson & Lewis, 2017; Meer & Tolsma, 2014; Thomalla et al., 2015)), potentially influencing collective capacities to adapt. Considering the significant number of residents living in the described conditions in Southeast Asian coastal cities like Jakarta, they present an urban adaptation potential for which we currently only have limited knowledge. However, to harness and integrate local capacities within broader urban adaptation pathways, many questions need to be addressed: Who works together to adapt to climate change in the long-term? What are their collective capacities to adapt? Which adaptation actions do they concretely implement, and how do these collectively adapting groups interact?

Against this background, this study is dedicated to coming to terms with the phenomenon of collective adaptation in high-risk neighborhoods taking into account if and how socio-cultural differences among *the* most vulnerable create different vulnerabilities, risk perceptions, collective capacities, and risk behaviors to adapt to climate change.

1.2. Research gaps

This section dives deeper into the concrete study context by describing identified research gaps that limit our current understanding of collective adaptation in socio-culturally heterogeneous cities and its potential contributions to and impacts on urban adaptation. These gaps represent the motivations and entry points for developing this study.

First, two global literature reviews assessing empirical evidence for adaptation in general (Berrang-Ford et al., 2021) and specifically in coastal cities ((5.1; Wannewitz et al., forthcoming); (Adelekan et al., 2022)) reveal limited evidence for adaptation to climate change, that is, implemented or concretely planned adaptation action on the ground. While these reviews reflect the state of research rather than real-world adaptation practices, they provide valuable insights into general adaptation trends. In combination with findings from a review of flood risk management research in Jakarta (5.2; (Wannewitz & Garschagen, 2020)), these results hint towards an important research gap. The reviews suggest that behavioral and cultural adaptation strategies are highly relevant and widely employed. In coastal cities in lower-middle-income countries, they are mostly implemented by individuals and households (5.1; Wannewitz et al., forthcoming). However, the scientific research on adaptation to flooding in Jakarta primarily focuses on understanding the hazard, including the modeling of exposure and infrastructure-based approaches. Fewer studies are dedicated to examining integrated and soft adaptation strategies (Sovacool, 2011), including behavioral and cultural adaptations (5.2; (Wannewitz & Garschagen, 2020)). In other words, while in coastal cities in middle-lower income countries, much of the adaptation is currently implemented by individuals and households through behavioral and cultural changes, scientific research on Jakarta still concentrates more strongly on modeling and assessing technocratic approaches and solutions. This indicates a lack of research on assessing and evaluating urban soft adaptation options such as behavioral change, collective initiatives towards adaptation, and institutional adaptation in Jakarta. This aligns with the global finding that recent literature reviews on local/indigenous knowledge – which is closely tied to soft adaptation - do not explicitly mention publications that deal with this specific type of knowledge in cities (Petzold et al., 2020; Schlingmann et al., 2021), despite the recognition that it plays a crucial role in urban coping and adaptation plans and strategies ((Dodman et al., 2022): 919).

Second, and closely linked to the first identified gap, there is a lack of theoretical and conceptual debates around the concept of collective adaptation. While current and future climate change in coastal cities is acknowledged as a large and cross-scale collective action problem requiring the cooperation of various actors across scales (IPCC, 2022b), there is neither a concrete definition for collective adaptation, nor conceptualizations that explain its process. Also, research has yet insufficiently addressed questions around the actual potentials, benefits, limits, and risks of collective adaptation. Debates around such topics exist for much broader theories of collective action ((Duncan, 2012; Olson, 1965; van Zomeren et al., 2008)) as well as related concepts in the climate change adaptation realm such as community-based adaptation (Forsyth, 2013; Kirkby et al., 2018; Reid & Huq, 2014), and social capital (Lin, 2001; Putnam, 1995; Woolcock & Narayan, 2000). However, these approaches do not adequately cover the initiation and process of collective adaptation implemented by residents in high-risk neighborhoods (for details see 3.3.2). In addition, the key theories to explain collective adaptation, namely, social identity and collective action theories are based on and developed for “Western cultures” and they are not explicitly tailored to long-term engagement, which is a pre-requisite for adaptation. That said, the transferability of existing collective

action models to collective adaptation can be called into question and requires a new perspective on conceptualizing collective action for adaptation and its empirical validation for non-Western cultural contexts such as high-risk coastal cities like Jakarta.

Third, this study argues that cities are unique in their particularly high levels of socio-cultural, demographic, and economic diversity; they are centers of encounters and (re-)production of various cultural elements and practices (Reckien et al., 2016; Warf, 2015). While such heterogeneities are likely to create uneven patterns of exposure and vulnerability, they are currently often overlooked because many studies on collective action to cope with or adapt to hazards focus on rural and/or culturally rather homogeneous groups and not on urban diversity contexts (e.g. (Dove, 2008; McNeeley & Lazrus, 2014; Tozier de la Poterie et al., 2018)). The few studies on urban contexts limit their assessments on the immediate disaster response in which those who are impacted often work together without reservations to cooperate across socio-cultural boundaries (e.g. (Surtiari et al., 2017)), or they do not explicitly consider internal heterogeneities among those who engage in it by using terms such as "community", e.g. in community-based adaptation (Kirkby et al., 2018; McNamara & Buggy, 2017), community engagement (Baybay & Hindmarsh, 2018; Geekiyanage et al., 2020) or community autonomy (Pisor et al., 2022). When diversity within *the* community regarding for example vulnerability is acknowledged (e.g. (Archer et al., 2020; Hossain & Rahman, 2018; Samaddar et al., 2021), implications for the formation of groups and collective action for adaptation are not sufficiently considered. In many cases, differences in vulnerability are taken into account by considering socio-economic and/or demographic groups like the elderly, children, or disabled people that are generally known to be more vulnerable to climate change (e.g. (Kuran et al., 2020)). However, this perspective neglects their social embeddedness, which influences (collective) capacities. Hence, it represents a rather superficial differentiation that cannot realistically depict local vulnerability and capacity patterns.

Lastly, urban diversity research around concepts such as multiculturalism, and cosmopolitanism originates from an Anglo-Saxon perspective and it can hence be questioned if findings and insights are transferable to Southeast Asian cities like Jakarta which may be influenced by very different variables such as post-colonial structures, diversity in local cultures, climatic factors or rapid changes in the course of accelerating urbanization that are not comparable to "Western" cities (Thynell 2018).

Together, the comparably small share of research on soft adaptation measures and their evaluation in Jakarta, the lack of theoretical and conceptual debates around collective adaptation in general and in cities in particular, and the neglect of socio-cultural heterogeneities in urban adaptation research represent the starting points for this study.

This study concretely concentrates on these gaps by mainstreaming the phenomenon of socio-cultural diversity throughout the conceptualization of collective adaptation as well as its empirical validation. It does so by investigating how different socio-cultural groups emerge in the face of disaster risk, how they mobilize to adapt collectively, and which actions they take together to adapt to recurrent climate change impacts and other livelihood struggles. Jakarta, the capital city of Indonesia is taken as a case study; it can be considered as an archetype of Southeast Asian cities at risk (for more see 4).

1.3. Research questions and objective of the study

In due consideration of the presented research gaps, this study has the overarching goal to assess, understand and conceptualize collective adaptation to flooding in contexts of high socio-cultural diversity in Jakarta and beyond. I operationalized the overarching aim through the following research questions (RQs):

RQ 1: Is there evidence for collective adaptation in highly exposed and vulnerable neighborhoods in Jakarta?

RQ 2: Who works with whom to collectively adapt to climate change impacts? Or in other words: Which groups form to collectively adapt?

RQ 3: What triggers individuals to change from individual to collective behavior? And what keeps them engaged in collective adaptation over time?

RQ 4: What are the groups' capacities to adapt?

RQ 5: How do different collectively adapting groups interact?

By answering these questions, I aim to contribute to existing knowledge on two fronts. First, in terms of conceptual innovation and theorizing, I will propose a conceptual framework that explains the emergence of collective adaptation in socio-culturally diverse contexts including potential adaptation outcomes. The framework is meant to encourage and guide future research in this particular field. It is also envisioned to guide practice and policy-making regarding advocacy and support for fostering collective adaptation. Second, in terms of empirical knowledge, I will provide a new perspective on collectively adapting groups in Jakarta, which will deepen our understanding of the differentiated vulnerability and adaptive capacity patterns in the city. Furthermore, the empirical findings together with the conceptualization of collective adaptation may represent potential entry points for better recognizing, and integrating collective adaptation capacities in Jakarta.

These contributions can be considered relevant and timely because they provide a novel and unique perspective on a social phenomenon that has so far received considerably little attention in urban disaster and climate risk research despite its societal relevance and potential to contribute to or undermine adaptation efforts. Current and particularly future urban adaptation requires the combination of hard and soft adaptation measures (Du et al., 2020) for which the horizontal and vertical cooperation and coordination of various actors is a central prerequisite. This study addresses a component that may facilitate such cooperation by raising awareness for and extending current knowledge about collective adaptation from a conceptual perspective. It is unique in the way it considers socio-cultural heterogeneities in the formation of social identities, their materialization, and mobilization, as well as their respective risk perceptions and adaptation behaviors, which might be particularly relevant for cities. With this holistic perspective on collective adaptation, the study aims to add to the current understanding of urban vulnerability patterns, acceptance of implemented adaptation measures, and local collective adaptation behaviors. Such research is timely given the need for more sustainable and transformative pathways to

ensure urban adaptation and development, which require deep societal changes (Pelling et al., 2015; Romero-Lankao et al., 2018; Rosenzweig & Solecki, 2018).

Furthermore, by applying the conceptual framework to assess collective adaptation in high-risk urban neighborhoods in Jakarta, I aim to deepen the state of knowledge on vulnerability patterns and adaptive capacities among residents at risk in Jakarta. The study grapples with the homogenization of at-risk residents by taking a more nuanced perspective on their differences. Thereby, this approach shifts the focus from individual capacity and needs assessments to a collective perspective on local climate change adaptation. Empirical insights from Jakarta provide entry points for acknowledging, assessing, and advancing collective adaptation in high-risk neighborhoods in the city.

2. Research design and methods

2.1. Ontological and epistemological approach

Reflections on ontologies and epistemologies are an important pillar in every research endeavor as they define what the researcher can acquire knowledge about and how this knowledge can be created (Porta & Keating, 2008). Such reflections are closely linked to the research interest and represent the foundation for the choice of methods for data collection and analysis as well as interpretation (Moon & Blackman, 2014).

This research roots in several social science research disciplines, namely cultural anthropology, social psychology, human geography, and disaster risk and vulnerability research. Against this background and my research interest, I followed the ontological position of constructivism which is linked to the line of thought that "social phenomena and categories are not only produced through social interaction but that they are in a constant state of revision." ((Bryman, 2012):33). It allows me to approach key concepts of this research such as vulnerability, risk perception, and intangible cultural aspects as social constructions that are constantly redefined. At the same time, I adopt a postmodernist perspective, which has a relativist understanding of reality. It builds on the idea that there is not one definite version of any reality (ibid., 382f.) but that there are multiple co-existing, constructed intangible realities (Moon & Blackman, 2014). While I believe that material context conditions including hazard exposure are real - rather following a critical realist perspective (ibid.) - this study focuses predominately on the assessment of individual perceptions and subjective constructions of reality and knowledge. Together, these ontologies allow me to understand social relations, vulnerability, culture, disaster risk, and perceptions as intangible, subjective, constructed, co-existing realities, which I can never fully and objectively grasp through scientific inquiries – not least due to my subjectivity.

Epistemologically, I found it particularly useful to follow the lines of interpretivism, constructionism, and humanism which guided my choice of methods, data analysis, and interpretation of results (Bernard, 2012). Constructionism and interpretivism allowed me to understand the objective (context conditions, hazard exposure) as real and inherently linked to subjective perceptions and meaning-making. Following these lines of thought means that realities and knowledge are constructed through the interplay between subjects and objects; that is between humans and their surroundings. Accordingly, this study comprehends exposure to hazards as well as material and structural context conditions as inherently intertwined with individual

perceptions and meaning-making, influenced by social interactions and practices as well as historical, political, and economic aspects. Therefore, knowledge and reality have to be approached as contextual and multifaceted, depending on the perspective. This includes the idea of co-existing realities and knowledge. Humanism goes further by stating that there is no objective knowledge. Considering the particular research interest of this study – the influence of socio-cultural differences on vulnerability and (collective) risk behavior – this epistemology is useful to focus on human subjectivity and to understand how individual constructions of reality result in material and social living conditions including vulnerabilities and risk behaviors.

Taken together, these epistemologies helped me to comprehend culture and its elements, risk perception, and adaptation knowledge as multi-faceted, changing constructs that can be perceived differently depending on the individual and/or social context and perspective. In that sense, I see culture as well as risk perception as latent objects that can never be objectively and comprehensively assessed and penetrated with scientific research methods. I follow the line of thought that in the particular context of culture in disaster risk, multiple perspectives and interpretations of culture and its elements co-exist, requiring a relative and interpretative understanding of the phenomenon and its influence on human social risk behavior as well as the reverse; the influence of human social behavior in a disaster risk context on culture. Both have also implications for physical, tangible vulnerabilities and exposure to risk, which may however be perceived differently. My ontological and epistemological position led to the choice of predominately qualitative research methods, including hermeneutic and interpretative data analysis and interpretation (described in Section 2.3.).

Given the study's interest in latent and intangible concepts related to culture and their influence on collective adaptation in Jakarta, it was particularly important to take into account my own culture and positionality in my research. Self-reflection and awareness of being a German, white, privileged, non-religious, female researcher in a Muslim-dominated, low-income, high-vulnerability context were important throughout the data collection and interpretation. Biases in data collection as well as analysis and interpretation arising from my positionality cannot be fully avoided, however, I tried to minimize them to the extent possible in multiple ways. First, I used a mix of inductive and deductive research elements which linked empirical data collection, analysis, and interpretation with established social science theories and vice versa (more details in 2.3.) to validate the conceptualization of observed phenomena. Second, I worked in hermeneutic cycles, a typical method of anthropological research (Bernard & Gravlee, 2014), to assess various perspectives on local beliefs, values, worldviews, and practices through locally-grounded inquiries and observations as well as literature-based external perspectives on the context. Lastly, close interaction and discussion of my impressions and findings with Indonesian colleagues and translators accompanying the research grounded the research in the local context.

2.2. Research ethics

Ethical considerations were an integral part of the design and implementation of this study. I adopted the key principles of the American Anthropological Association (AAA) code of ethics (American Anthropological Association, 2012) to ensure my research meets established ethical standards. This meant considering the following tenets: 1. Do no harm; 2. Be open and honest regarding your work; 3. Obtain informed consent

and necessary permissions; 4. Balance ethical obligations to collaborators and affected parties; 5. Make your results accessible; 6. Protect and preserve your record; and 7. Maintain respectful and ethical professional relationships. All of these are in line with and further detailed in (Fluehr-Lobban, 2014), which also informed my ethical considerations.

I used the following measures to meet these principles in designing and implementing my research: First, I obtained ethical clearance for my research proposal from the Indonesian research partner, the National Research and Innovation Agency (BRIN), to ensure meeting national research ethics and requirements. The research topic and design detailed in the proposal were of low risk for humans involved, however, it entailed the collection and analysis of socio-culturally sensitive information, which I treated with sensitivity, engagement of local support, and confidentiality. Second, I developed my research design in close collaboration with Indonesian research partners from (BRIN), who were very experienced in the field of empirical data collection in high-risk neighborhoods in Jakarta. An Indonesian social science researcher reviewed my questionnaire for the semi-structured online interviews, was present for support in interviews with insecure respondents, proposed suitable fieldwork sites where respondents could be approached without disturbing local routines or violating social and/or cultural norms, as well as briefing me for cultural differences and their implications for my fieldwork. Third, I hired, trained, and worked closely together with Indonesian translators, who translated all questionnaires and the consent forms into Indonesian language. In that way, the interview respondents could always choose which language they prefer during the interview, to make them more comfortable and confident in answering the questions. Third, before each interview the respondents received a written consent form, in which I summarized the purpose and aims of my research, the role of the respondents, data use and handling in terms of anonymization, storage, and accessibility, as well as information about the interview procedure, and their right to stop the interview at any time. I repeated the information at the beginning of each interview; informed consent could be provided verbally or by signing the form digitally or in person. I saved interview records and transcripts on the university server to ensure their security.

Given that I interacted with many civil society actors and exposed households, the question of how my research would benefit them or what they may receive in return for spending their time to answer my question was a recurrent issue. Besides small souvenirs, I could not provide other material or financial incentives. In terms of immaterial benefits which could be achieved through the influence of my research on policy-making, I answered honestly, keeping expectations low. To ensure that those who are interested in this research may access the results, revisit their interview records, and/or ask questions, I provided all respondents with my contact details.

The translators, who were key for this study during data collection and my fieldwork, received adequate salaries upon delivering their work. Moreover, they were provided with reference letters, recommending them for future employment.

2.3. Research design and methods

In accordance with the epistemological approach taken in this study, the research design comprises a mix of different social science research methods generating both quantitative and qualitative data.

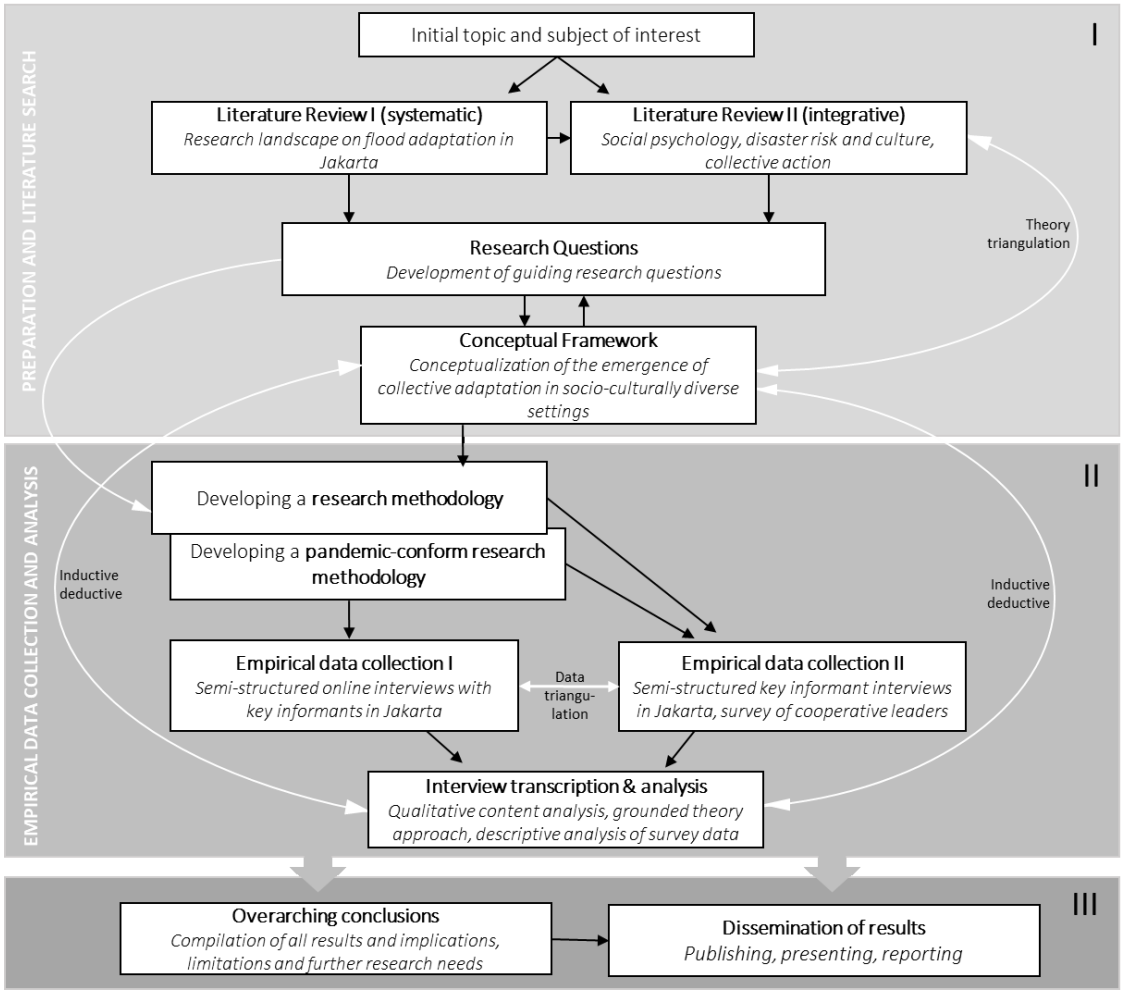


Figure 1: Research design, black arrows signify the workflow, white arrows represent non-chronological loops and integration

Figure 1 illustrates the research flow, including used methods, data, and analysis approaches. The research design includes both, theoretically-based deductive elements as well as empirical, inductive elements, which I used in a complementary way. Different types of triangulation ensure the validity and robustness of the results. Table 1 provides details on the employed methods.

As depicted in part I of Figure 1, this research roots in a systematic as well as an integrative literature review to define and narrow down the research topic and questions.

> Systematic literature review: Given that systematic literature reviews are useful for synthesizing and comparing evidence on a specific topic (Snyder, 2019), I employed this method for assessing two different topics: First, the current state of scientific literature presenting empirical evidence for urban adaptation in coastal cities (2013-2020, in Scopus and Web of Science). Second, I assessed the research landscape of flood risk management in Jakarta (2000–2019, in Scopus). For both reviews, I implemented search terms linked through boolean operators to systematically search reference databases (details on the search strings can be found in 5.1 and 5.2). The first review followed a strict coding protocol (for details see 5.1); resulting codes were analyzed quantitatively with standard statistical tests.

For the second review, I scoped the resulting literature for relevance and inductively categorized them according to their main research focus (see 5.2). While this resulted in an overview of the current landscape of flood risk research in Jakarta, I qualitatively analyzed the literature of selected categories with the aim to understand which soft and integrated adaptation measures are studied in Jakarta. Altogether, the results and their implications were published in a review paper (see Section 5.2).

Integrative literature review: Integrative reviews are instrumental for critically reviewing existing theories and concepts to develop new theoretical perspectives and frameworks (Snyder, 2019). Hence, I used this type of review to identify theories and concepts which might be useful to explain collective adaptation to climate change in socio-culturally diverse contexts. I applied a continuous search process of varying search term combinations, as well as alerts in the reference databases Web of Science and Scopus to scope different bodies of literature more broadly and subjectively, identifying relevant theories for application in my research context. A mix of deductive and inductive qualitative coding of the various theories and concepts (see Appendix A.3), and their transfer to the climate change adaptation field informed the deductively developed conceptual framework. Short descriptions of the most relevant theories and concepts and their potential implications for collective adaptation can be found in Section 3. The insights from this review, including the resulting coding scheme furthermore represents the basis for the interview analysis.

Research that assesses contextual knowledge and constructed realities is often linked to fieldwork applying methods from critical ethnography. These include among others long-term field stays with holistic participation in the new environment, and in-depth interviews that dive deep into the research context and phenomena of interest (Stahlke Wall, 2015). While my initial research design contained various of these elements, the global COVID-19 pandemic forced me to change the envisioned research design (Figure 1, part II). Due to travel restrictions, I used two online-based methods, namely semi-structured interviews (Bernard, 2012) with Indonesian key informants and expert elicitations with scientific experts from different countries as the main methods for the first round of data collection (see Table 1).

Semi-structured key informant interviews (online): Semi-structured interviewing is a suitable method for inquiring knowledge from selected informants in a limited amount of time by following an interview guide but leaving room for freewheeling (Bernard, 2012). Selected key informants came from different backgrounds such as civil society, non-governmental organizations, public authorities, religious institutions, and academia, and had considerable knowledge about or own experience with social dynamics in vulnerable and flood-exposed neighborhoods in Jakarta. The project partner in Jakarta facilitated the contact and interview scheduling with some of the interviewees, given personal contacts and knowledge about their expertise as well as being able to approach them in Indonesian. These informants then helped to identify further relevant interviewees, following the snowball sampling method to the point of saturation, meaning that no new key informants were mentioned and no new content emerged. The online interviews took place via Zoom in English or Indonesian language, depending on the preference of the interviewee. It consisted of seven questions, covering topics such as vulnerability patterns, collective adaptation activities, and their effectiveness, as well as changes in social cohesion at the neighborhood scale

(English version of the questionnaire in Appendix A.1). Due to this online-based approach's high flexibility, interviews were re-scheduled frequently, considerably prolonging the data collection process.

Translators transcribed and – in cases in which the interviews were conducted in Indonesian language - translated the recorded interview material, which I subsequently analyzed by applying a mix of deductive and inductive analysis frames in MAXQDA software. Following the general principles of qualitative content analysis (Mayring & Brunner, 2009), I developed a coding scheme before the text analysis, containing codes linked to my conceptual framework and hence the theories and concepts the research builds upon. However, I used the coding scheme as a flexible set of codes, which I extended in the process of coding whenever I discovered new aspects not covered in my initial coding scheme. With this, I followed a grounded theory approach (Bernard, 2012) through which I inductively enriched the coding structure through new codes and/or refined existing codes by creating sub-codes (Appendix A.2). Repetitive coding of the interview material, or in other words, working in hermeneutic circles (Bernard & Gravlee, 2014; Grondin, 2015), helped me to penetrate direct and indirect meanings of the transcribed material through an increasingly dense structure of codes and sub-codes. In the last step, I abstracted, clustered, and summarized similar codes and used them in a qualitative manner to answer the research questions.

Expert elicitations (online): Based on the literature assessed during the systematic review process, I selectively approached scholars who had conducted research and published on flood management in Jakarta and related topics in the past. It is important to mention that the elicitation process did not follow the same process as structured elicitations which are for instance aimed at reducing uncertainties in climate modeling (Hemming et al., 2018). Instead, I adopted a semi-structured, narrative approach that allowed for discussing and verifying hypotheses developed from the key informant interviews while at the same time leaving room for additional comments, aspects, and details that I might have missed or that did not come up during the interviews. The procedure was similar in all elicitations: after an introduction to the research topic and information about the key informant interviews, I presented five distinct hypotheses (see Appendix A.4) to each scientific expert, asking him/her for an evaluation and discussion of it. Follow-up questions facilitated the discussion. After transcribing the recorded elicitation material, I analyzed it in two ways: first, I coded the material with the same coding scheme as the semi-structured interviews to add all mentioned aspects to the pool of codes. Second, I assessed the material qualitatively, identifying important emphases, contextual knowledge, as well as potential contradictions.

In 2022, the second round of data collection took place in different locations in Jakarta in person. Besides participant observations, I mainly used interviews and a survey for data collection.

Semi-structured interviews in different neighborhoods in Jakarta: Informed by the results from the first empirical data collection and analysis, the second round of data collection took place in person in Jakarta and had two main objectives. First, validating the derived findings, which I pursued through follow-up interviews with informants from my first round of data collection using the same questionnaire but emphasizing questions around differentiated vulnerabilities, collective adaptation actions, and social cohesion. And second, reacting to a collective phenomenon

mentioned during these interviews, I decided to assess the emergence of kampung cooperatives. For this, I conducted additional interviews with members of different kampung cooperatives following a new semi-structured questionnaire that concentrated explicitly on the collective phenomenon of kampung cooperatives (see Appendix A.5). A majority of interviews were conducted in Indonesian language so that a translator accompanied me to every interview. All interviews took place in the interviewee's home, which allowed me to better understand their respective living situations and it gave them a secure feeling. After my field stay, translators transcribed all interviews and I coded the material using the same coding scheme as for the first round of interviews. However, as mentioned before, the flexible set allowed for adding new codes, which in this case focused on the topic of activation/motivation as well as collective activities and social cohesion within neighborhoods.

(Participant) observation: Together with a translator, I joined the annual two-day meeting of representatives from all 26 kampung cooperatives from across Jakarta in Kampung Kunir, North Jakarta. Field notes of the presentations of the cooperative representatives as well as notes on observations of interpersonal and group behavior complemented the interview and survey data. Furthermore, I took part in a public discussion on kampungs and historical urban landscape, where discussants presented on kampung culture and design from an urban development perspective. On both occasions, I participated rather passively but I had to introduce myself and interacted with other participants informally.

Semi-structured survey: To be able to refine and triangulate information collected through the interviews, I implemented a semi-structured survey (Indonesian language) of cooperative representatives (see Appendix A.6) of the 26 cooperatives present in the annual two-day meeting in Kampung Kunir. The survey was composed of a mix of open and closed questions and was very short to ensure high rates of participation. The paper-based version of the survey was distributed to the kampung cooperative representatives at the end of the first day of the annual meeting; the leader of the workshop introduced the purpose and aim to all participants and encouraged them to answer the questions. A translator translated the answers into English. I clustered similar answers to the open-ended questions and quantitatively assessed the closed questions by assessing counts.

Table 1 summarizes the research methods and provides detailed information about the implementation as well as to which research questions and publications they are linked.

Table 1: Details on employed methods

Data collection methods	Sampling and sample size	Time of data collection	Data analysis	Linked to RQ	Contributed to
Systematic literature reviews	Review 1 · Search string with boolean operators in Scopus and Web of Science + GAMI database · 683 peer-reviewed publications, thereof 185 completely coded Review 2 · Search string with boolean operators in Scopus · 339 peer-reviewed publications, thereof 93 considered in depth in the analysis	January 2020	· Inclusion, and exclusion criteria · Quantitative statistical analyses · Qualitative content analysis · For the key interest of analysis: grounded theory approach, deductive coding	RQ 1	Publication 2
Integrative literature review	· Repetitive searches with search term variations in Scopus, Web of Science, and Google · 390 publications skimmed, thereof more than 220 completely coded	continuous	· Qualitative content analysis	RQ 1-5	Publication 5
Semi-structured key informant interviews (online)	· Sampling: through local project partner and snowball sampling · N= 23	July 2021 – January 2022	· Qualitative content analysis · Grounded theory (hermeneutic circles)	RQ 1, 2, 4	Publications 3 & 4
Expert elicitations (online)	· Sampling: literature-based · N= 6	December 2021 - January 2022	· Qualitative content analysis · Grounded theory (hermeneutic circles)	RQ 1, 2, 4	Publications 3 & 4
Semi-structured interviews (in person)	· Sampling: snow-ball sampling · N = 8	November – December 2022	· Qualitative content analysis · Grounded theory (hermeneutic circles)	RQ 2-5	Publications 3 & 4
Semi-structured survey	· Sampling: all representatives present at the annual meeting of kampung cooperatives · N = 41	November – December 2022	· Qualitative analysis, clustering of similar answers, basic descriptives	RQ 3, 4	Publication 4
Participant observation	· Annual, two-day meeting of kampung cooperatives Public discussion on kampung and historical urban landscape	November 2022	· Field notes	RQ 1, 2, 4	Publications 3 & 4

The results of the different data analyses were published in peer-reviewed scientific journals, which are listed in Table 2.

Table 2: Peer-reviewed publications

	Title	Authorship	Status	Journal	IF (2023)	Addressed RQs	Section
1	Coastal urban adaptation patterns	Wannewitz, M.; et al.	Under preparation	n.a.	n.a.		
2	Mapping the adaptation solution space – lessons from Jakarta for other coastal cities	Wannewitz, M.; Garschagen, M.	Published (04.11.2021)	Natural Hazards and Earth System Sciences (NHESS)	4.580	1	5.2
3	The role of social identities for collective adaptation capacities– General considerations and lessons from Jakarta, Indonesia	Wannewitz, M.; Garschagen, M.	Accepted with major revisions, re-submitted (21.06.2023)	International Journal for Disaster Risk Reduction (IJDRR)	4,841	2, 4	5.3.1
4	What makes people adapt together? An empirically grounded conceptual model on the enablers and barriers of collective climate change adaptation	Wannewitz, M.; Petzold, J.; Garschagen, M.	Accepted for publication (12.06.2023)	Frontiers in Climate	n.a.	3	5.3.2
5	Collective adaptation to climate change	Wannewitz, M.; Garschagen, M.	Published (30.11.2022)	Current Opinion in Environmental Sustainability (COSUST)	7.964	5	5.3.3

2.4. Selection criteria for the case study site Jakarta

Jakarta, the capital city of Indonesia, was selected as a case study for several reasons, which I will explain in the following.

First, Jakarta continues to face severe consequences of recurrent flood events, despite being a very experienced and well-researched city in terms of flood risk. While flood risk and impacts have been reduced over the past decades, both, annually recurring floods and infrequent large-scale flood events still have adverse effects on Jakarta's inhabitants and its economy, as evidenced by recent flooding in 2020 (Suhartono & Goldman, 2020). Despite the wealth of experience and research, it seems that important gaps remain, some of which this study identifies and tries to address.

Second, Jakarta is a socio-culturally diverse city due to its many migrants from Indonesia (Martinez & Masron, 2020). Despite increasing trans-local identification (ibid., (Simone, 2020)), many neighborhoods and kampungs in Jakarta a still characterized by strong social norms for reciprocity, mutual support, and collective engagement. This has for instance been shown by studies examining the collaboration among citizens in the direct aftermath of a disaster (Surtiari et al., 2017). It hence represents a perfect test bed for examining group formation processes in the face of risk in highly socio-culturally diverse settings and identifying collective adaptation measures. As of now, collective long-term adaptation initiatives – as opposed to reactive collaboration after disasters - have not been systematically assessed in Jakarta yet.

Third, Jakarta and its metropolitan region serve as a stereotypical example of a Southeast Asian coastal mega city in terms of its exposure to natural hazards and its urban development. The city's exposure is driven by hydro-meteorological hazards like storms, cyclones, heavy precipitation events, and sea-level rise as well as by human-driven processes such as land subsidence, and settling in floodplains in the course of unplanned urban expansion (Shaw et al., 2022) p. 1497). Vulnerability roots in various interlinked processes including socio-economic inequalities, inadequate and inequitable infrastructure and services, limited adaptive capacities, and informality (ibid.). These patterns of exposure and vulnerability are not unique to Jakarta but are also observed in other Southeast Asian coastal cities (ibid.). This resemblance also applies to the relocation of highly vulnerable and exposed neighborhoods in the name of flood protection (ibid., p. 1505), the emergence of social movements advocating for social justice (Padawangi, 2022), the significant role played by neighborhood groups and civil society organizations (ibid.), the prevalence of social norms and beliefs regarding reciprocity, solidarity, and mutual support (Bertelsmann Stiftung, 2018) - especially during times of disasters- and a high diversity of languages, religions, and ethnicities, which weaken in the course of globalization (Ullah & Ming Yit Ho, 2021). Given these similarities in vulnerabilities, exposure, and socio-cultural context conditions, some of the key findings of this research are likely to be transferable to socio-culturally similar cities in the region.

Altogether, the continuously high impacts caused by a mix of human and environmental risk drivers, the city's socio-cultural diversity, and its stereotypical characteristics make Jakarta a perfect testbed for examining how socio-cultural diversity influences vulnerability and collective adaptation to climate change.

2.5. Limitations

This study is limited in several ways, due to challenging research conditions as well as methodological constraints. To be transparent about the value and robustness of this research, I will briefly discuss the challenges linked to my research and how I tried to address and limit them. I will also propose ideas on how future research could address these limitations to increase the validity and robustness of my findings.

First, both, systematic and integrative reviews have limitations that should be considered. Systematic reviews focus on scientific literature using specific search terms, potentially excluding relevant studies in different languages or with alternative terminology. Similarly, integrative reviews carry the risk of selectivity. Both types of reviews offer an incomplete representation of reality; they can only approximate the state of research on a selected topic. To address these limitations, I conducted tests with various search strings for the systematic review to identify the most inclusive approach. For the integrative review, I took a continuous approach, combining manual searches with alerts from reputable reference databases like Scopus and Web of Science to stay updated on new research in the field of collective adaptation and related areas of investigation.

Second, the research faced limitations due to contextual factors at the time. As the COVID-19 pandemic started in the second year of this research, I had to swiftly adjust the planned in-person fieldwork for data collection. I replaced in-person activities with online interviews, with the hope of conducting on-site research later. However, online interviews are not ideal for assessing latent concepts such as social identities, cultural constructs, as well as differences in vulnerability, risk perception, and behavior as they

lack personal contact and visual understanding of the local living conditions of the informants. To mitigate these limitations of online interviews, I adjusted my initial methodological approach in two ways. First, I changed the target group from residents to key informants from various backgrounds offering meta-information on neighborhood groups and networks, social dynamics, and collective activities related to disaster risk. They were better accessible and could provide valuable insights into my key research interests and local context conditions (for more details see 2.3). Second, I conducted additional expert elicitations to verify and contextualize information collected through the key informant interviews (for details see 2.3).

Third, assessing latent and subjective concepts such as risk perceptions, social relations, and cultural factors like worldviews, social values, and beliefs are subject to methodological limitations. These concepts, which cannot be directly measured, present challenges regarding their assessment – especially during a pandemic when access and interactive research are limited. To address these constraints and potential biases arising from my methodology and the limited sample sizes, I employed data triangulation. Furthermore, I engaged extensively with interview partners, translators, and Indonesian colleagues, immersing myself in the cultural research context to increase my understanding of the local conditions.

Fourth, the sampling process for online interviews, expert elicitations, and in-person interviews was influenced by multiple aspects which may have created biases and/or gaps. While an Indonesian, well-experienced research partner initially selected and approached informants for the online interviews, the selection was random and mostly based on the expertise of one person. However, subsequent snowball sampling reduced the risk of biases by continuing until no new informants were mentioned and data saturation was reached. The availability of informants also affected the selection, as some key individuals could not be interviewed due to time constraints or non-responsiveness. I addressed this constraint by interviewing alternative informants with similar expertise to ensure their perspectives were considered. Finally, the random and pragmatic sampling of kampung cooperative representatives for the interviews may limit the representative of the findings. However, triangulation with field notes from the participant observation and with data from the survey addresses this problem.

Lastly, as mentioned in Section 2.1, my positionality, subjectivity, and distinct research interest partly pre-defined by the research project may have led to biases in this research. Awareness and reflection on these aspects helped to counter the potential effects of these biases to a certain extent – however, an influence cannot be excluded.

Future research could address the limitations of this study to further improve and validate the findings. By and large, the data collection and analyses of this study concentrated on qualitative methods and data because I deemed them as better suited for assessing and understanding latent, intangible constructs, which are at the core of this research. However, quantitative data from a household survey on vulnerabilities and collective activities could complement my qualitative data, as to increase the robustness of the identified social identities, their respective collective adaptation capacities, and their link to implemented collective activities through data triangulation. This research could furthermore benefit from additional and repetitive in-depth interviews. A long-term approach would allow for capturing potential dynamics and changes in risk perceptions, vulnerabilities, group formations, and collective adaptation. In times of dynamically changing hazard patterns and urban development, I deem such longitudinal assessments as particularly useful to provide more solid explanatory models for collective adaptation.

Finally, future research needs to assess other types of collective adaptation initiatives such as non-institutionalized, small-scale collective engagement to adapt to climate change impacts.

3. Theoretical background and conceptual considerations

This study builds on various theoretical and conceptual considerations from different research realms. I selected them based on their usefulness in explaining the phenomenon and process of collective adaptation to climate change. As illustrated in Figure 2, four key bodies of literature played a central role; however, particularly the publications featuring concepts, theories, and frameworks in the overlapping areas of these four research realms represent the foundation for this study.

Figure 2: Assessed bodies of literature

The following sections will give brief insights into the most central theories and conceptual considerations which I used as foundations for my research. However, it has to be noted that the overview is neither holistic nor exhaustive given the complexity and breadth of each of the used theories. Instead, I will briefly describe the key principles of the most relevant theories with a particular focus on those that come from different disciplines and are not common to be applied in the climate change adaptation context. I will also outline why they were useful for this study and detail which assumptions I derived from their transfer to the climate change adaptation context.

3.1. Conceptualizing disaster risk and urban climate change adaptation

Working on flood risk and its management requires elaborating on how disaster risk and adaptation to climate change are conceptualized in this study with a particular focus on cities. Together, they build the foundation for understanding urban vulnerabilities, risk perceptions, and risk behaviors in the face of climate change.

This study adopts the IPCC's definition of climate change risk, understanding it as "dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards." (IPCC, 2022a):822). In that sense, cities are hotspots of disaster and risk (Pelling, 2003). Especially coastal cities such as Jakarta are highly exposed to climate change-induced natural hazards such as coastal flooding, and storm surges, exposing a myriad of urban central functions, assets, and human life. At the same time, urban disaster risk is driven by human factors which lead to increasing vulnerabilities in the course of urban development. Examples are socio-economic inequalities, informality, unplanned urban growth, segregation, and unequal access to infrastructure and basic services. Those who are at the highest risk are residents who live in highly exposed areas and who have the least capacities to cope with and adapt to the vulnerabilities and exposure they face. This can be referred to as double exposure (O'Brien & Leichenko, 2000), that is, facing negative consequences of urbanization and climate change.

Overall, this interplay between climate change impacts and urbanization puts cities under high pressure to adapt. At the same time, adaptation strategies should not jeopardize urban development. Therefore, adaptation, here defined as "the process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities." (IPCC, 2022a), poses considerable challenges to urban administrations, institutions, and populations (Birkmann et al., 2010; Glavovic et al., 2022; Wamsler et al., 2013). While there are growing efforts toward urban climate change adaptation at various scales, the potential of urban areas to advance and sustainably anchor adaptation has not yet been used sufficiently (Romero-Lankao et al., 2018). Urban adaptation pathways may compose of different combinations and sequences of adaptation options (Adelekan et al., 2022). Currently, different archetypes of coastal cities exhibit different levels of adaptation (Magnan et al., 2022). Following a long-lasting paradigm of protection against hazards, hard, technological, and infrastructural adaptation approaches remain important in coastal cities. While they are central for mitigating current hazard impacts, many of the measures will lose effectiveness under increasing hazard intensities in the future (ibid.). Moreover, they mostly protect high-value urban assets and not necessarily the most vulnerable neighborhoods, leaving those with deficits in protective and basic infrastructure at the highest risk (Adelekan et al., 2022). Given their disadvantages and limitations, hard adaption measures are most effective when combined with soft adaptation options which include, among others, capacity building at individual and institutional levels, local empowerment, ecosystem-based approaches, and collective approaches to mitigate disaster impacts (Sovacool, 2011).

In terms of the implementation of such measures, cities can be considered centers of opportunity or "agents of change" ((Romero-Lankao et al., 2018):754) that play a significant role in adapting to climate change across scales (ibid.;(Birkmann et al., 2013; Carter et al., 2015)). Urban adaptation actors are highly diverse and the urgency to adapt may be perceived differently, depending on the respective actor and its social and institutional context (Adger et al., 2013; Dietz & Shwom, 2017). Given that this study is particularly interested in strongly exposed and vulnerable urban residents, I find it worthwhile highlighting their

particular adaptation situation. As mentioned earlier, their high-risk neighborhoods often receive less infrastructural protection due to low-value housing or informal status; in some cases, they even suffer from infrastructural adaptation elsewhere (Dodman et al., 2022). At the same time, they have limited capacities to adapt (ibid.). Nonetheless, they do not remain passive but use various adaptation measures to accommodate hazards in order to maintain their livelihoods. This has been assessed by a wealth of scientific studies on individual and/or household adaptation action on the one hand and collective initiatives on the other hand. The latter is of more interest to this study and includes among others assessments of community-based adaptation (CBA) ((Forsyth, 2013; Kirkby et al., 2018; McNamara & Buggy, 2017; Reid & Huq, 2014), and social capital (Adger, 2003; Lin, 2001; Ling & Dale, 2014). Such studies shed light on local collective capacities and significantly enhanced our understanding of collective approaches to managing climate risks. In the following, I will briefly introduce these two prominent concepts before detailing why I found them useful but not sufficient to explain collective adaptation to climate change.

Community-based adaptation (CBA) is "a community-led process, based on communities' priorities, needs, knowledge, and capacities, which should empower people to plan for and cope with the impacts of climate change' (Reid, Cannon, Berger, Alam, & Milligan, 2009)." (cited in Reid, Huq 2014:291). CBA is mostly initiated and funded by international or national NGOs (McNamara, Buggy 2016; Reid, Huq 2014) who aim at implementing tailored participatory approaches to adaptation at the community level (McNamara, Buggy 2016) taking into account social capital, community cohesion, social networks, and collective action. As expressed by Kirkby et al. (2017: 7) "[…] CBA attempts to integrate local and 'western scientific' knowledge systems." In that sense, I consider CBA to be helpful in successfully implementing participatory adaptation strategies at the local level under the guidance of/in cooperation with external implementers. However, it exhibits little explanatory power and conceptualization of the phenomenon of collective adaptation. In addition, CBA approaches mostly portray "community" as a homogeneous group that shows high levels of social cohesion and a shared will of the community members to work together towards common goals. However, "such a romantic notion of 'community' does not often reflect reality" ((Kirkby et al., 2018):7), which is very much in line with the argumentation in this study. I particularly focus on heterogeneities with "*the* community", which I found to be mostly neglected in CBA.

Social capital is a much-applied concept in the climate change adaptation realm. While there are many definitions, social capital can be broadly described as one besides many other types of capitals (e.g. cultural, human, physical capital) that "stands for the ability of actors to secure benefits by virtue of membership in social networks or other social structures" ((Portes, 1998):6). In very simple words the concept of social capital translates to "It's not what you know, it's *who* you know." ((Woolcock & Narayan, 2000):225). By and large, the literature on social capital in disaster risk research exhibits two perspectives on social capital (Meyer, 2018). While some researchers adopt an individual take on social capital by focusing on network resources that can be accessed by their individual members (e.g.(Coleman, 1988)), others take a more collectivist perspective. They see social capital as trust, norms, and networks that facilitate coordinated action (e.g.(Putnam, 2000)). In the climate change adaptation context, social capital is described to be important resources and assets that are bound in social ties to friends, neighbors, and associates. The type of social ties, as well as the number of memberships in different social networks influence potential individual capacities (Woolcock & Narayan, 2000). Overall, the concept of social capital is very valuable for the climate change adaptation context as it allows to understand, conceptualize, and assess collective

adaptation capacities bound in social networks. It offers a more differentiated view on persisting vulnerabilities by looking at both, material as well as latent social capacities considering differences in socio-cultural and institutional context conditions. However, for conceptualizing and assessing collective adaptation, I found it to be of limited explanatory power in two particular regards: first, while focusing on networks and mentioning the importance of trust, reciprocity, and social norms (Cook, 2005), it does not explain how these networks and ties come about or how they may change depending on the context settings. Second, most scholars use the concept of social capital to assess potentials but not explicitly the mobilization and realization of these potentials (Ishihara & Pascual, 2009); the few exceptions show how relevant this perspective is (e.g. (Petzold, 2016)).

3.2. Culture and disaster risk – risk perceptions, vulnerability, and behavior

3.2.1. Definition of culture in this study

Culture has been defined and used in a myriad of different research disciplines so that a comprehensive review and discussion would go beyond this study. In the following, I will shortly highlight several selected definitions that build the foundation for the understanding of culture in this study.

First, I found it useful to adopt one of the earliest and most prominent definitions of culture by E.B. Tylor, who broadly defines culture as “that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by a man as a member of society” ((Tylor, 1871):1). Second, given that this study focuses on dynamics and interactions between different humans, I align my understanding of culture with Geertz by seeing it as “a historically transmitted pattern of meanings embodied in symbols, a system of inherited conceptions expressed in symbolic forms by means of which men communicate, perpetuate, and develop their knowledge about and attitudes toward life.” ((Geertz, 1973):89). Third, adopting a more action-oriented approach, I understand culture as “a "tool kit" of symbols, stories, rituals, and world-views, which people may use in varying configurations to solve different kinds of problem” ((Swidler, 1986):273).

Accordingly, this study defines culture as composed of shared tangible and intangible components (the latter including social representations and categories, mental models, shared beliefs, values, norms, and attitudes); culture dynamically evolves and changes in a shared process of meaning-making. It can be learned and passed on and rather than a static system it represents a dynamic process in which its forms and symbols serve people to make experiences, express meaning and develop shared modes of behavior and vision. It is something “we actively (re)produce rather than something external to us” (Duncan 1999:54 cited in (Hall & Barrett, 2018):159)).

Given that this study aims at better understanding collective adaptation behavior, it is important to mention that culture also influences social identification and hence the formation of groups, an important prerequisite for collective action. Beliefs, norms, attitudes, and worldviews shape social comparison and hence who we identify and ultimately engage with. In turn, the groups we identify with influence our beliefs, norms, attitudes, and worldviews. Culture and social psychology are thus mutually constitutive (Fiske et al., 1998).

3.2.2. Culture and disaster risk

In 2014, the International Federation of the Red Cross (IFRC) picked up on the topic of culture by dedicating its World Risk Report 2014 on "Culture and Risk", highlighting the twofold character of culture as both, a potential enabler and barrier for the success of disaster risk reduction (DRR) and adaptation strategies. Culture can hence be a driver of resilience as well as vulnerability (International Federation of Red Cross and Red Crescent Societies, 2014). The report calls for a stronger consideration of cultural aspects in vulnerability reduction and DRR. Empirical research confirms the importance of cultural factors like social norms, traditions, beliefs, and emotions for understanding vulnerability to climate change, risk perception, and behavior (see e.g. (Ford & Norgaard, 2020; Hoff & Stiglitz, 2016; Norgaard, 2011; van Valkengoed & Steg, 2019).

Reversing the context, there is solid evidence for the influence of disasters on culture. The terms disaster culture (Moor, 1964) and subculture (e.g., (Wenger & Weller, 1973)) emerged in the 20th century but are used until today (e.g. (Bankoff, 2017). A disaster subculture develops based on learning from disaster experiences and the preservation of gained knowledge by passing it on to new members of the community. A disaster subculture hence materializes in "the perpetuation of successful patterns of adaptation to the disaster context through socialization." ((Wenger & Weller, 1973):1).

Figure 3: Schematic relationship between culture and disaster risk

Against this background, I understand the mutual relationship between culture and disaster risk as depicted in Figure 3. Cultural characteristics such as ethnicity, religion, belief, social norms within networks, and language influence vulnerabilities, exposure, the perception of hazard risk, and the behavior towards it. While this creates differentiated patterns of risk perception and behavior at the global scale (Lee et al., 2015), the same is likely to be true for the urban scale due to the cultural heterogeneity of cities' populations. At the same time, disasters influence urban cultures due to the lessons learned from disaster experiences which are integrated into socialization processes, culminating in the emergence of disaster subcultures (Wenger & Weller, 1973). For the particular context of this study, this means that in a socio-culturally diverse urban context, multiple potentially different risk perceptions, vulnerabilities, and behaviors co-exist and evolve in the form of subcultures.

3.3. Social identities and collective action

3.3.1. Social identity theories

Understanding why, and under which conditions individuals work together lies at the center of this study because it explains the "collective" in collective adaptation. It represents the prerequisite for understanding group behavior and hence collective action (Hornsey, 2008). Such group formation processes are duly studied and conceptualized in the field of Social Psychology. I found it useful to turn to the early and foundational theories of this field, namely, Social Identity Theory (SIT) (Tajfel, 1981) and closely related Self-Categorization Theory (SCT) (Turner 1985). Both are also used to explain collective action in various other research disciplines and I found them instrumental to examine and conceptualize the formation of groups in the face of flood risk in exposed neighborhoods in Jakarta.

Social Identity Theory (SIT)

SIT explains inter-group behavior, particularly inter-group conflict, and discrimination in the absence of competition over resources. It draws on minimal-group experiments and consists of three key principles.

First, SIT assumes that societies compose of social categories with varying status and power, influenced by economic and historic factors (Abrams & Hogg, 1990). All individuals categorize themselves based on perceived similarities and differences of the self to stereotypic group characteristics such as attitudes, beliefs, values, behavioral norms, affective reactions, and language. Examples of such categories include gender, nationality, religious confession, and profession. Social categories help individuals understand their environment through stereotyping and the cognitive distinction between "us" and "them" (Hornsey, 2008; Kawakami & Dion, 1995; Tajfel, 1981). The values attached to these categories affect individuals' self-concept and self-esteem ((Chryssochoou, 2004): 132f.).

Second, SIT states that an individual's self-concept consists of an identity, which can be understood as a continuum with two poles; the personal and the social identity. Personal identity emphasizes one's unique characteristics and values, as well as one's independence from other individuals and social categories (Oxford Reference, 2023). Social identity connects individuals to a specific group. When salient, individuals think and behave as members of a distinct social group[1] (Tajfel 1981: 255). Depending on the situation, individuals can identify with different social groups simultaneously, with varying salience.

Third, SIT explains that individuals engage in social comparison to enhance their self-esteem. They positively evaluate their in-group through positive prejudices and stereotypes (in-group favoritism), while discriminating against out-groups. The choice of reference frames such as different in-group or out-group

[1] "a social group is 'two or more individuals who share a common social identification of themselves or, which is nearly the same thing, perceive themselves to be members of the same social category' (Turner 1982:15)" cited in (Abrams & Hogg, 1990): 7)

members, different scales, or points in time, mediates the process. This process of social comparison aims to achieve positive distinctiveness to boost self-esteem (Abrams & Hogg, 1990).

Self-Categorization Theory (SCT)

While SIT mostly focuses on explaining intergroup behavior, SCT (Turner et al., 1987) offers an intragroup perspective. It refines SIT by diving deeper into the psychology behind the processes of social categorization and comparison (Hogg & Grieve, 1999), aiming to understand the functioning of the mind and behavior (Turner & Reynolds, 2012). SCT identifies three levels of identities: superordinate (human vs. other forms of life), individual interpersonal (unique individual), and social intergroup (representing a group). These levels differ in inclusiveness (Hornsey, 2008) and their salience is determined by three key aspects. First, the degree of accessibility of the group. Second, if the individual feels s/he fits into the group based on in-group similarities and out-group differences (comparative fit). And third, if the social behavior of the group meets stereotypical expectations (normative fit) (Hornsey, 2008). Individuals who identify with a group internalize its stereotypes, attitudes, norms, and behaviors, leading to depersonalization and self-categorization. Group members become trusted sources of information, affecting self-categorization and comparison. Hence, social identity also reflects back on the individuals (Turner & Reynolds, 2012). In addition, these intragroup processes, including categorization, comparison, and normative fit are dynamic and influence power constellations within the group. Members, who best embody the group's stereotypes may have a stronger influence and become leaders.

Social identity approaches have faced criticism for neglecting personal identity and its relationship to social identity (Carr, 2021). Scholars have also emphasized the need to understand the conditions under which individuals identify with a group and which identity becomes salient (Davis, 2007; Hogg & Grieve, 1999). Nonetheless, I consider them useful for explaining group formation processes and their contextual salience.

Social identities have also proven to play an important role in climate change adaptation (Barnett et al., 2021). In this context, exposure and vulnerability can serve as social categories that individuals identify with, leading to the formation of what I will call risk-based social identities. Shared vulnerability and exposure facilitate identification among individuals and shape their risk perception and behavior (Pearson & Schuldt, 2018). Such risk-based social identities can enable or inhibit adaptation action (Barnett et al., 2021). However, the impact of conflicting identities (e.g., personal vs. social, or different social identities) on perceptions, beliefs, and social norms within a society remains unclear. In addition, social identity theories led me to assume that considering intra-group processes is central to the implementation of external adaptation interventions. The theories demonstrate that values, norms, behaviors, and interventions are more likely to be accepted and adopted within the in-group, while externally introduced ideas often face resistance. Local leaders play a crucial role in introducing new ideas and mobilizing groups, which may be transferable to the introduction of adaptation initiatives at the neighborhood level.

3.3.2. Collective action theories

Collective action research investigates why people work in groups, overlapping with research on social identities, group dynamics, economics, and social capital. A few concepts from this field are instrumental for this study because they help to understand and conceptualize the "action" part of collective action.

Drawing on this body of literature, I consider an action to be collective, when a member of a group acts as a representative of his/her group, aiming at improving the group's position (drawing on (Tilly, 2008; Wright et al., 1990) cited in (Bamberg et al., 2015)).

This study builds upon prominent theories such as Mancur Olson's Collective Action Theory (Olson, 1965), Relative Deprivation Theory (RDT) (Crosby, 1976; Walker & Smith, 2002), and Resource Mobilization Theory (RMT) (McCarthy & Zald, 1977), as well as Klandermans' and Oegema's model of social movement participation (Klandermans & Oegema, 1987). To understand and conceptualize collective adaptation in socio-cultural diverse settings, I decided to focus on more recent collective action theories, which build on these earlier theories but which duly consider the role of social identities for collective action, allowing for taking into account diversity.

The Social Identity Model for Collective Action (SIMCA) (van Zomeren et al., 2008) (see Figure 4) is one of the first theoretical frameworks that brings together SIT and Collective Action Theory to explain collective action in the form of social protest against socio-structural injustices. From a social psychology perspective, it singles out three of the many factors influencing the occurrence of collective action in a fundamental and generally applicable way. Namely, perception of injustice, social identification, and belief in group efficacy are most predictive for collective action to occur. They emphasize the central role of social identity not only as an important predictor of collective action but also as a bridging concept between perceived group-level injustice and belief in group efficacy (van Zomeren et al., 2008).

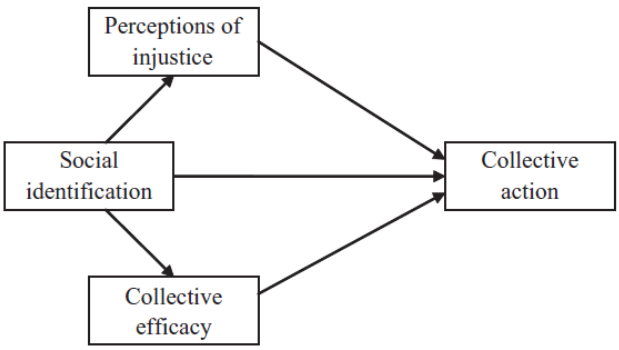


Figure 4: Social identity model of collective action (van Zomeren et al., 2008)

The SIMCA model does however not allow for inferring causality: while social identity is argued to link feelings of injustice and group efficacy, it may also be possible that the latter two lead to the emergence of social groups that take action. Later studies found a relationship between perceptions of injustice and belief in group efficacy (Thomas et al., 2012), where outrage and the feeling of agency facilitate collective action, shaping social identities. These reverse influences of collective action on shared beliefs and social identities (Thomas et al., 2012; Wlodarczyk et al., 2017) are not considered in the SIMCA model but they are crucial for this dynamic process. Duncan (2012) cautions that conscious group membership and politicized group identification are necessary for collective action (Duncan, 2012). Other important factors not addressed in SIMCA include life experiences (family background, discrimination experiences, resources, education, material resources, etc.) and personality traits (political orientation, self-efficacy, generativity, optimism, etc.), which influence engagement in collective action, group consciousness, and reciprocal effects (ibid.).

While SIMCA's popularity partly stems from its general applicability, there are also models in the climate change sciences that aim at explaining climate-related actions, such as pro-environmental behavior, protest movements for climate protection, or social change towards climate-friendly and sustainable ways of living (e.g. (Bamberg et al., 2015; Carmona-Moya et al., 2021; Fritsche et al., 2018). These models are valuable for my research for two reasons. First, they consider the influence of climate change impacts on social identity formation, moral convictions, and beliefs in group efficacy. Second, they allow for examining more long-term collective actions, which are not explicitly addressed in collective action theories.

In particular, I found the Environmental Identity Model of Environmental Collective Action (EIMECA) (Carmona-Moya et al., 2021) worth considering as it directly builds on the SIMCA but complements it from a climate change perspective by examining the effect of a particular social identity (environmental identity) on a particular type of action (pro-environmental behavior) (see Figure 5). The latter can be conducive to adaptation so that the model comes relatively close to the focus of this study.

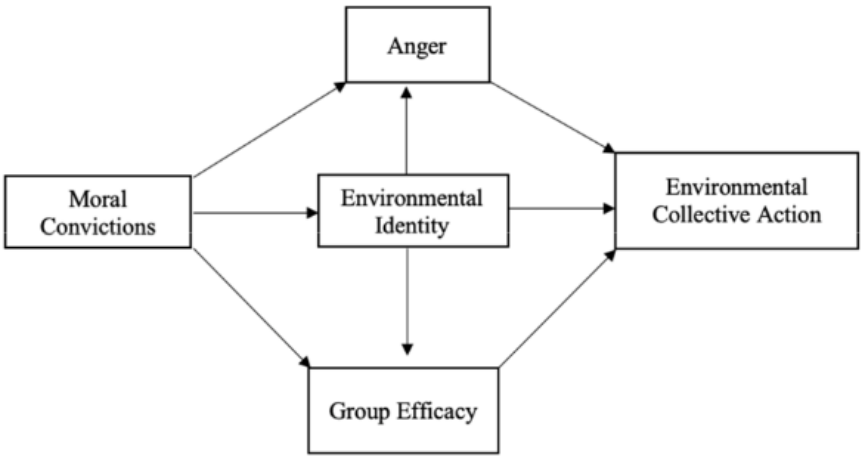


Figure 5: Environmental Identity Model of Environmental Collective Action (EIMECA) (Carmona-Moya et al., 2021)

The authors highlight the central role of environmental identities in predicting environmental collective action. At the same time, they find that emotional effects, and in particular hope, play a key role in the emergence of environmental collective action. Lastly, the study adopts an interesting take on politicized groups in the context of climate change. While many studies argue that social identities are not sufficient to trigger collective climate change action but that politicized group identities are a prerequisite, this study argues that environmental identities entail moral convictions and normative considerations that may predict collective environmental action without politicization.

While the EIMECA includes elements that could be relevant for understanding collective adaptation in highly exposed neighborhoods in Jakarta, its explanatory power for that particular context might be limited due to several reasons. First, the EIMECA was developed and validated for Western socio-cultural contexts, which very much differ from Southeast Asian contexts in terms of culture. Second, if politicization does not play a role in collective adaptation in Jakarta remains to be seen. In the city, flood risk management is a highly politicized topic and at the same time, strong normative considerations rooted in social norms influence household-scale flood adaptation. Further testing is needed to evaluate the role of politicization

in this particular context. Finally, I consider moral convictions regarding environmental protection to be different from the need to adapt arising from climate change threats. Hence, moralization might not play a relevant role in the case of collective adaptation in Jakarta.

Overall, it shall be noted that a majority of the considered conceptual and empirical studies explaining and assessing collective action – including SIMCA and EIMECA - examine the intention or willingness to participate in collective action, not actual active engagement. Furthermore, none of them focuses explicitly on long-term collective engagement, which is needed for collective adaptation to climate change. Nonetheless, together they represent a solid foundation of knowledge for examining the emergence of collective adaptation. They allowed me to understand and considered the influence of psychological factors on group formation processes and collective action in the development of my conceptual framework as well as in the design of my empirical data collection approach.

3.4. Socio-cultural diversity in cities

Assessing collective adaptation in Jakarta, a socio-culturally diverse city requires considering the impact of different ethnicities, religions, worldviews, values, norms, and traditions on vulnerability and risk behaviors. Various concepts from different disciplines may help to understand the implications of urban diversity for urban social life. Multiculturalism, cosmopolitanism, pluralism, conviviality, and diversity all pertain to the increasingly complex and dense population of diverse socio-cultural groups inhabiting the urban space (e.g. ethnic, artistic, professional, national, international). These concepts have different definitions and connotations and until today there is not one commonly agreed scientific perspective on the effects of urban diversity on human (collective) behavior in the city.

Empirical evidence on the effects of cultural diversity on social cohesion, conflict, and urban development is mixed (International Organization for Migration, 2019; Nowicka & Vertovec, 2014). While some studies (e.g.(Putnam, 1995, 2007)) indicate increased conflict risk and decreased social capital in socio-culturally diverse neighborhoods, others find no significant impact of diversity on social capital (Silver & Messeri, 2014). In this study, I draw upon some of these concepts to explore how socio-cultural diversity might influence collective adaptation to climate change in Jakarta. The concepts explained hereafter represent the foundation for the conceptual framework developed in the course of this study (see Section 5.3Fehler! Verweisquelle konnte nicht gefunden werden.).

Multiculturalism refers to the conservation of an individual's own culture in a different cultural setting (Vertovec, 2010), highlighting multiple belongings and identities citizens may have (Rossio & Vanolo, 2012; Vertovec, 2010). This can be looked at from two perspectives. On one hand, urban multiculturalism fosters co-presence and dialogue, promoting socio-cultural resources, intercultural skills, and acceptance of differences (Rossio & Vanolo, 2012; van Leeuwen, 2010). In its ideal form, this is referred to as cosmopolitanism (van Leeuwen, 2010). Thinking of this as a process and not so much as an ideal, the concept of conviviality describes a social pattern where diverse groups coexist peacefully without problems arising from racial, linguistic, and religious particularities (Gilroy, 2004). This process turns socio-cultural differences into ordinary day-to-day urban life through social norms such as tolerance, recognition, and respect towards each other independent of difference, allowing for peace and satisfaction (Nowicka &

Vertovec, 2014). Polyculturalism goes one step further by suggesting that exposure to and exchange between different cultures promotes tolerance and the formation of new shared social identities (Bernardo et al., 2019; Morris et al., 2015). This may also include a weakening of for instance ethnic attachment so that new forms of shared social identity culminate in the homogenization of culture in a certain location (Bazzi et al., 2017; Bott et al., 2019). On the other hand, the presence of many co-existing minorities strains cities (Hall & Barrett, 2018; Vertovec, 2010). The differentiated embeddedness of various cultural groups in the material landscapes of cities may lead to their invisibility, power inequalities, and in consequence discrimination, isolation, alienation, and neglect based on ethno-cultural origin (Putnam, 2000; Rossio & Vanolo, 2012; van Leeuwen, 2010). Tension and conflicts can for instance arise when urban minorities struggle for recognition, demanding rights to the city (Rossio & Vanolo, 2012).

Besides such black and white perspectives on diversity, two more granular concepts have informed my work. Acculturation (Berry, 1997) refers to cultural and psychological changes emerging through the interaction and exchange between different cultural groups. While individuals may pursue different strategies within this process, I focused on assimilation, as the others, integration, separation, and marginalization, are indirectly covered in the concepts mentioned earlier. Assimilation describes a process in which individuals or groups adopt the culture of another group and abandon their own (Berry, 2005). The other perspective describes urban society as composed of isolated, co-existing but mutually tolerant social groups, which lack meaningful exchange and shared cultural ground. Terms like “indifferent tolerance” (Hall & Barrett, 2018) and “mutually tolerant side-by-side citizenship” (van Leeuwen, 2010) represent this perspective, emphasizing the absence of intercultural dialogue while maintaining tolerance among diverse groups.

The existing literature on multiculturalism and urban diversity mainly reflects an Anglo-Saxon perspective, which may not fully capture the unique variables influencing Southeast Asian cities like Jakarta, such as post-colonial structures, local cultures, societal values, climate, and rapid urbanization (Thynell 2018). In fact, Nagy 2014 (quoted in Hoon 2017:478) states that multiculturalism is rarely mentioned in East Asian countries; instead, concepts like diversity and pluralism dominate the discourse (Hoon, 2017).

Due to a lack of English literature on urban diversity concepts suitable for the Southeast-Asian context, I transferred the described concepts to the context of collective adaptation in socio-culturally diverse neighborhoods in Jakarta. That said, I derived the following hypotheses for this particular study. First, socio-cultural diversity would lead to a multicultural neighborhood in terms of risk perceptions and behaviors. Assimilation would result in a mutual adjustment in risk perception and behavior, hence reducing these differences up to the point where they fade to exist. Conviviality would facilitate mutual learning between different social groups, resulting in innovative, new, and widely accepted adaptation strategies. If the different socio-cultural groups would co-exist without meaningful exchange, isolated adaptation approaches may lead to redundancies and conflicts.

4. Case study site Jakarta

This section will detail relevant background information about the case study site Jakarta. It includes general information about its location and administrative division, selected socio-cultural aspects, as well as the city's disaster risk profile and management approaches.

Jakarta, officially called the Special Capital Region of Jakarta (DKI Jakarta) is the capital city of Indonesia[2]. It is located on the low-lying North coast of Java, the most populated island of Indonesia. As illustrated in Figure 6, DKI Jakarta is situated in the center of the metropolitan region called JABODETABEK (short for Jakarta, Bogor, Depok, Tangerang, Bekasi), one of the biggest urban agglomerations globally (Rustiadi et al., 2021).

Figure 6: Geographic location and administrative structure of Jakarta and its metropolitan area (map of JABODETABEK taken from (Rukmana & Ramadhani, 2021))

DKI Jakarta has experienced considerable growth in recent decades, accompanied by high growth rates in the surrounding metropolitan area given the urban sprawl into JABODETABEK (Rustiadi et al., 2021). In 2022, DKI Jakarta had a population of 10,679,951 (BPS, 2022b), while JABODETABEK is home to more than 30,000,000 residents (Setiadi et al., 2020). Both numbers do not yet consider informal settlers. As the economic and political hub of Indonesia, Jakarta has attracted substantial national investments and planning efforts, leading to the concentration of urban functions and reinforcing the city region's primacy (Indraprahasta & Derudder, 2019). While urban development has led to positive developments such as

[2] In January 2022, Indonesia's government approved a bill to relocate the nation's capital to East Kalimantan, located on Borneo island with the objective to reduce the strain on Jakarta. According to the plan laid out in the law, government agencies, foreign embassies, and international organizations are the first to move to the new capital called Nusantara. The initial phase of relocation is scheduled for 2022 – 2024 (Westfall, 2022).

decreasing poverty rates, it also came with considerable challenges such as social inequalities, segregation, pollution, informality, and lacking basic infrastructure (Martinez & Masron, 2020).

Jakarta is also subject to various environmental impacts, which are increasing in frequency and intensity in the course of climate change and urban development. Being situated on the low-lying coast of Java, the city is highly susceptible to coastal hydrological hazards such as storm surges, coastal flooding, and rising sea levels. Additionally, the presence of 13 rivers makes Jakarta prone to severe flooding when heavy rainfall coincides with storm surges and high tides (Garschagen et al., 2018). While these natural drivers of flooding are expected to be reinforced through climate change (IPCC, 2022a), human drivers also considerably contribute to increasing levels of exposure and vulnerability. Rapid urban population growth and associated land-use changes reduced the urban drainage capacities and narrowed rivers and waterways (Salim et al., 2019). Furthermore, land subsidence plays a crucial role in human-induced flood risk in Jakarta, resulting from excessive groundwater extraction, soil consolidation, infrastructure load, and tectonic activities (Abidin et al., 2015).

For this particular study, two characteristics of Jakarta require further elaboration. First, the administrative organization of the city to understand local neighborhood structures and living conditions. And second, Jakarta's flood risk management.

4.1. Administrative organization and kampung life in Jakarta

DKI Jakarta is a province, which is administratively divided into three official levels of organization (Figure 7). It comprises five cities (*Kota*), which are further divided into districts (*Kecamatan*). The lowest level of the official administrative organization is the sub-district (*Kelurahan*) (BPS, 2022a). Following an unofficial administrative structure, sub-districts are again divided into communities or neighborhood associations (*Rukun Warang*) hereafter referred to as RW, and the smallest administrative units which are neighborhoods (*Rukun Tetangga*), called RT (Obermayr, 2017). This study focuses primarily on social dynamics and collective adaptation activities at the RT scale and/or *kampung kota*, which are another important structural element in the administrative fabric of Jakarta.

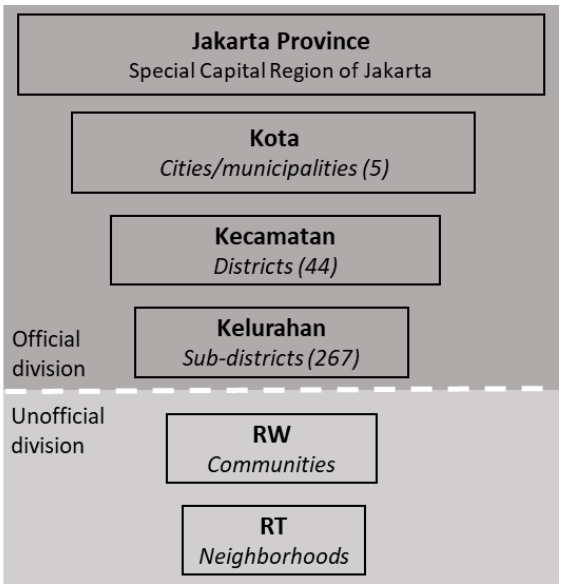


Figure 7: Official and unofficial administrative division of Jakarta Province ((Source: BPS, 2022a, Obermayr, 2017))

Kampung kota, or short kampungs, are urban villages or settlements that persist within the urban structure growing around them (Suhartini & Jones, 2023). They emerged predominately during the time of Dutch Colonialization in the twentieth century and were racially and ethnically homogeneous settlements, clearly separated from European settlements (Tilley et al., 2019). Given their ethnic homogeneity back in time, they were often named after the ethnicity or place of origin of their residents. Such ethnic enclaves remain

visible until today (Kehoe, 2015). Examples in Jakarta are Kampung Bali, Kampung Bugis or Kampung Arab (Suhartini & Jones, 2023). However, urban development, in-migration, and the diversification of beliefs and worldviews have introduced greater socio-cultural diversity within kampungs as well (see 5.3.1.).

Figure 8 maps the urban villages against RWs that are officially considered slums based on Governor Regulation 90/2018. The mapping was conducted manually by the RUJAK Center for Urban Studies in 2019 (RCUS) (Sutanudjaja, 2022); it is – to my knowledge – the only map showing the locations and extent of kampungs in Jakarta.

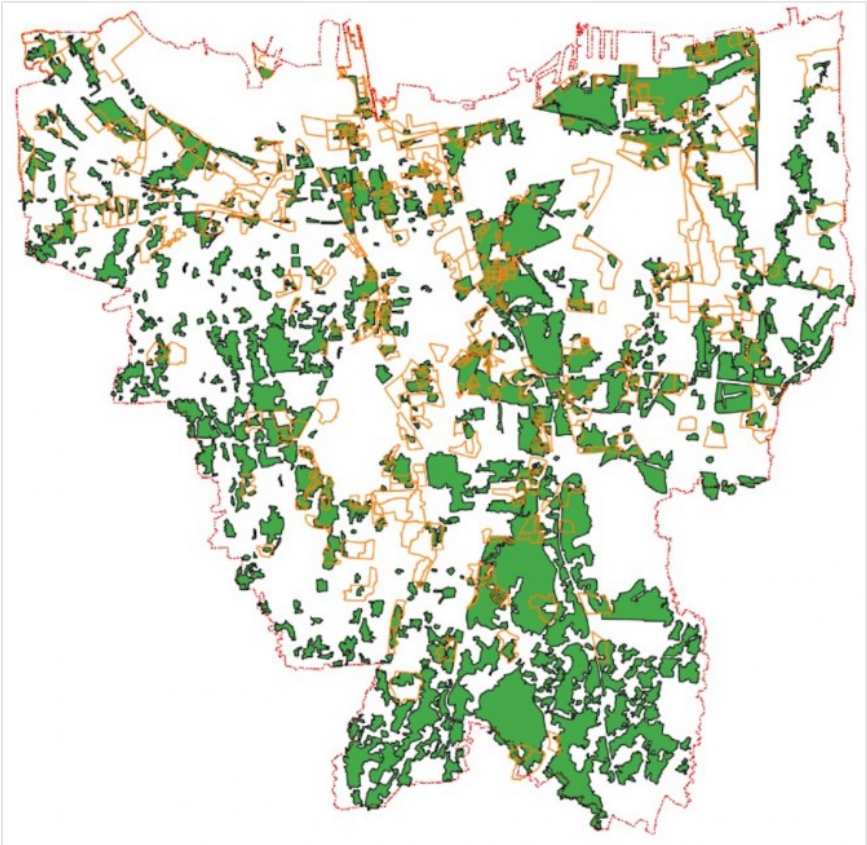


Figure 8: Map of kampungs (green areas) and slums (orange lines) in Jakarta in 2019 (Source: RUJAK Center for Urban Studies, (Sutanudjaja, 2022)

Until today, kampungs are mostly dominated by one ethnicity, however, migration has led to socio-cultural diversification (Kusumaningrum et al., 2019). While there is no universal definition of kampung, they share many physical and socio-economic characteristics. Kampungs are often located in environmentally hazardous or exposed places and are inhabited by lower-middle and low-income residents working predominately as low-wage laborers in the informal economy. Kampungs exhibit a high share of self-built one to two-story houses of poor quality (see Figure 9). The high population and building density, lack of basic infrastructures, and unresolved and/or non-formalized land tenure status lead to overall poor living conditions. Nonetheless, as the map shows, a majority of kampungs are not considered slums.

Figure 9: A street in Kampung Marlina (North Jakarta), faces were blurred for privacy reasons

Despite the implementation of various kampung improvement programs, the challenges mentioned earlier persist. These programs were initiated during Dutch Colonialism and later revitalized by the Jakarta city government after Indonesian Independence. The Kampung Improvement Program (KIP) aimed to protect kampungs, access vacant land, and upgrade existing infrastructure such as housing, roads, water, and waste management depending on in-situ conditions. It also contributed to the construction of schools and health facilities (Suhartini & Jones, 2023). Recent reforms of the program focus on encouraging the private sector to provide low-cost housing and promoting self-housing concepts through financial assistance and partnerships (ibid.). While there have been improvements in kampung infrastructures overall, settlements in flood-exposed areas continue to face infrastructural and socio-economic disadvantages with adverse impacts on their vulnerabilities as well as coping and adaptive capacities.

Another important aspect of kampungs for this particular study is their residents' high degree of self-organization, which roots in historical, social, and cultural norms (Suhartini & Jones, 2023). Kampungs exhibit complex and intertwined social networks that arise from diverse social relations, daily interactions in the narrow alleys, and interdependencies in economic and housing matters. Such a construct fosters continuous cooperation among kampung residents, including kin, and neighbors, to sustain and organize their livelihoods (Simone, 2014). Shared social norms and values such as reciprocity, mutual support, and trust underpin this cooperative dynamic, shaping kampung life and its informal economy (ibid.). As mentioned earlier kampungs are rather homogeneous in terms of ethnicities, religions, beliefs, and

traditions – contrary to DKI Jakarta as a whole, which is highly diverse in this respect (Hadi & Tirtosudarmo, 2016). Kampungs' socio-cultural homogeneity tends to reinforce established social norms and traditions.

Today's kampung governance emerges through an interplay between the formal administrative structures at the kelurahan level and the informal, locally elected community and neighborhood representatives, RW and RT respectively (ibid). The intermeshing of top-down state responsibilities with locally elected representatives and local leaders spans a complex network of formal and informal rules and responsibilities that have organically developed in each kampung over many years. Such local self-organization often takes messy and unpredictable forms (Suhartini & Jones, 2023). Residents engage in these networks to varying degrees, however, social norms and rules are often strictly applied so that kampungs are places of commoning and social support (Leitner & Sheppard, 2017). One notable example observed not only in kampungs but also at the RW and RT levels across Jakarta, is the practice of collective neighborhood work known as *gotong royong*, in which each household is expected to participate regularly (Surtiari et al., 2017). A rather recent phenomenon examined in this study is the emergence of kampung cooperatives supported by the Jaringan Rakyat Miskin Kota (JRMK) Network[3]. Kampung cooperatives are groups of neighborhood residents with clear membership criteria who engage in kampung self-governance to showcase the self-sufficiency and sustainability of their respective kampung, improving living conditions and protecting it from external threats. Residents who meet the inclusion criteria - that is being able to pay membership fees, having time to attend cooperative meetings, and being house owners (not renters) - are free to decide whether or not to join the kampung cooperative. Hence, the share of neighborhood residents in kampung cooperatives depends on local context conditions and the success of the kampung cooperatives' advocacy work. Examples of collective activities undertaken by kampung cooperatives in Jakarta include opposing relocations in the name of flood protection and initiatives to secure affordable rice during the COVID-19 pandemic (Muhammad & Irawaty, 2022). Their activities also involve resource pooling, collective businesses, neighborhood improvement initiatives, and capacity building supported by JRMK (ibid.).

4.2. Overview of Jakarta's flood risk management

Given its natural exposure to hydro-climatological hazards, Jakarta has rich experience in managing flood risk. In colonial times, Dutch expertise in engineering, and infrastructural water management paved the way for Jakarta's predominately infrastructure-driven flood risk response following the paradigm of control and protect (Garschagen et al., 2018; Octavianti & Charles, 2019). Throughout history, most of Jakarta's flood risk measures concentrated on infrastructural protection of the city from inland flooding (Garschagen et al., 2018), that is floods emerging from heavy precipitation and high-runoff that cause the urban rivers and drainage channels to overflow. Examples are river diversions, widening and dredging, canalization, retention ponds, and river embankments (see Figure 10) – all of which are still pursued today and fall into the category of hard adaptation to climate change (Sovacool, 2011). They aim at mitigating flooding with quick results, however, they do not comprehensively address the drivers of flooding (Octavianti & Charles, 2019).

[3] Jaringan Rakyat Miskin Kota (JRMK) Jakarta translates to Jakarta Poor People Network in English. It is a civil society organization that fights for the rights of the urban poor such as pedicap drivers, street vendors, and kampung residents, to create a city for all. In close collabortation with kampung residents, they are for instance working towards the improvement of kampung living and housing conditions. Their support builds on three strategies: organizing, advocating, and networking. Organizing in among kampung residents who are members of JRMK is realized through the formation of kampung cooperatives (Nur Indah Sari, 2020).

Figure 10: Flood protection measures in Jakarta, A-River dredging at the Ciliwung, B-River canalization of the Ciliwung, C-Rebuilding embankments at the Kali Krukut River, D-Pluit Reservoir

While the Indian Ocean Tsunami in 2004 substantially increased Indonesian attention to disaster risk management at the national scale (Djalante & Garschagen, 2017), a severe flood event hitting Jakarta in February 2007 represents a demarcation point in the capital city's flood risk management. The confluence of heavy precipitation in the city area, high-run-off rates from the adjacent regions, and a spring tide from the seaside inundated almost 60% of Jakarta, causing unprecedented damages and fatalities (Garschagen et al., 2018; Octavianti & Charles, 2018). In response to this event and another severe flooding in 2013, the city government adopted the so-called Jakarta Coastal Defense Strategy (JCDS), which is known as the National Capital Integrated Coastal Development (NCICD) Plan at the national level. Developed by a Dutch planning consultancy in collaboration with the Indonesian National Government and Jakarta Provincial Government (Colven, 2020), it represents a paradigm shift in flood risk management in that it considers sea level rise and land subsidence to be crucial drivers of flood risk in Jakarta (Garschagen et al., 2018; Octavianti & Charles, 2019). While the new flood risk management plans also included non-infrastructural elements such as urban as well as regional planning to mitigate flooding, the dominance of the infrastructural approach continued, building on four key measures: the regulation of rivers and waterways, including dredging and clearance of river banks, canalization, expansion of retention ponds and reservoirs, and the development of a large-scale sea wall including land reclamation (ibids.). The latter represents the central building block of the NCICD, as it envisions marrying coastal protection with urban development while also addressing land subsidence. Known as the Great Garuda (illustration on p. 68) - the giant off-shore sea wall

is designed to resemble Indonesia's national emblem, the Garuda bird – it will compose of a new central business district, residential and commercial spaces as well as flood protection elements.

All measures, and in particular river widening and dredging, have been accompanied by forceful evictions of mostly informal and highly vulnerable settlers living on or along Jakarta's rivers (Colven, 2017). The magnitude of these evictions and the subsequent destruction of kampung economies for flood protection purposes reached an unprecedented scale between 2015 and 2016, displacing approximately 14,000 families and 11,600 businesses from their kampungs (Tilley et al., 2019). With Anies Baswedan becoming governor of Jakarta in 2017, evictions receded because the new governor entered into negotiations with representatives of the urban poor, forging a new instrument called Community Action Plans (CAP) to improve kampung living conditions in a more participatory way (Colven & Irawaty, 2019). Despite these efforts, criticism and contentious debates surrounding flood risk management, particularly the construction of the giant sea wall, persist. Scientists, civil society activists, and even some Indonesian politicians voice concern about the potential negative impacts resettlements may have on urban social vulnerabilities and caution about potential environmental impacts. Furthermore, they question the effectiveness and sustainability of the sea wall as it does not address the root cause of flooding - land subsidence (Colven, 2020; Garschagen et al., 2018; Minkman et al., 2021).

In the past and today, Jakarta's city government follows a flood risk management approach that is dominated by infrastructural and engineered solutions which try to protect the city from flooding and mitigate the impacts. This lock-in on infrastructural solutions since colonial times can be considered a path dependency (Octavianti & Charles, 2019)– understanding why such solutions are still pursued even though recent flood events have shown that they are not sufficient to adapt the city to future flooding was one of the key motivations of the first papers of this study, described in the following section.

5. Research results and publications

In the following, I will detail the key findings of my research published in the form of scientific papers as listed in Table 2. I will briefly introduce each publication and provide a crisp summary of their respective main findings. The results cover an assessment of adaptation in coastal cities globally, a review of the state of research on flood management in Jakarta, conceptual findings on the process of collective adaptation to climate change, and empirical insights into collective adaptation and its emergence in high-risk neighborhoods in Jakarta.

5.1. A global assessment of coastal urban adaptation

Globally, coastal cities are hot spots of risk where the exposure to hazards such as storm surges and sea level rise converge with urban vulnerabilities such as inequality, poverty, and inadequate infrastructure. At the same time, cities are engines of development, possessing considerable capacities and options to adapt. Scientific research has identified four general adaptation strategies for coastal cities: protect, accommodate, advance (with ground elevation), and retreat; with combinations of different adaptation measures to be most effective in terms of adaptation to climate change. While this knowledge is widely

acknowledged, the latest IPCC report shows that cities predominately adapt responsively, however, a systematic overview of coastal urban adaptation is still lacking.

Inspired and guided by the Global Adaptation Mapping Initiative (Berrang-Ford et al., 2021), I addressed this gap by conducting a systematic review of empirical evidence for coastal urban adaptation presented in the scientific literature. Together with a team of international scientific researchers, we systematically identified 683 publications, of which we coded a total of 185 publications following a strict coding protocol. Subsequent statistical analyses reveal five key findings. First, the review identifies a geographical bias in terms of coverage of empirical evidence for adaptation from coastal cities. Coastal cities in high-income countries in North America and Asia are comparably better covered than coastal cities in upper- and lower-income countries. Particularly small and mid-sized cities in Africa and Asia as well as Central and South America are underrepresented. Second, coastal cities' responses to hazards are mostly based on the consideration of past and current hazards and do seldom take into account future exposure and vulnerability trends. Third, research mostly assessed technocratic adaptation approaches in coastal cities in high-income countries, while behavioral/cultural responses were predominately examined in lower-middle-income countries. Fourth, assessments on which actors implement responses vary in dependence on income levels and city size. In coastal cities in lower-middle-income countries, individuals/households are most covered by research; they predominately use behavioral and cultural responses to accommodate hazards. However, the bigger a city, the less likely that individuals/households are assessed as adaptation actors. Lastly, across country regions, income groups, and city sizes, the assessed evidence for coastal urban adaptation remains at low depth, speed, and scope. These findings represent a valuable first overview of scientifically covered adaptation evidence in coastal cities and allow for identifying research gaps. While reviews can only approximate real trends due to their methodological limitations, they may give insightful indications – in this case about the state of coastal urban adaptation.

The annex of the publication can be found in Appendix B.6

A global assessment of coastal urban adaptation

Wannewitz, M.; Garschagen, M.; Ajibade, Ulibarri, N.; J., Nielsen, M.; Nagle Alverio, G.; Villaverde, I., Reimuth, A.; Chalastani, V.; Ti Mai Huyunh, L.; Nunbogu, A.; Hawxwell, T.; Mach, K.; Kirchhoff, C.; Scarpa, Pentz, B.; Petzold, J.; Seeteram, N.; Agopian, A.; Jingyao, Zhou; Reckien, D.; Magnan, A.

Introduction

Coastal urban areas are engines of development and hotspots for climate change impacts (Hallegatte et al., 2013; Kuhl et al., 2021). Given their specific locations, coastal cities are at the forefront of climate risk, where high exposure to hazards such as sea level rise and storm surges dynamically interacts with urban vulnerabilities such as inequality, poverty, and inadequate infrastructure. The impacts and risks of climate change vary across coastal cities depending on factors such as local geomorphological conditions, climatic and human drivers of coastal change, and urban contexts ((Glavovic et al., 2022):2169)). These cities face significant pressure to address urbanization challenges and simultaneously mitigate and adapt to climate change, as the combinations of both factors compound and put them under extreme strain (Rosenzweig et al., 2018; Wolff et al., 2020). Given their centrality and functions in the global political economy, coastal cities have enormous capacity to shape the future of climate adaptation and mitigation in meaningful and innovative ways.

To adapt to coastal threats, researchers have identified four potential adaptation strategies for coastal cities: protect, accommodate, advance (with ground elevation) and retreat (Ajibade, 2019; Beatley, 2009; IPCC, 2022; Mach & Siders, 2021). Protection can be achieved through hard urban engineering measures such as seawalls and dikes, as well as soft measures like beach nourishment and coastal ecosystem restoration. Accommodation involves elevating or flood proofing buildings and infrastructure, creating early warning systems, and adjusting urban planning. Advancement through land reclamation is popular in densely populated coastal cities with limited space. However, negative impacts on ecosystems and high costs of implementation and future impacts must be considered (Ajibade, 2017). Retreat, including through voluntary or involuntary movement of people and assets aware from risk zones, is already occurring in highly exposed areas facing severe climate change impacts. The latest IPCC report summarizes these adaptation options and emphasizes the need for coastal cities to implement them to reduce the risks associated with climate change.

The implementation of adaptation options in coastal cities depends on various factors including feasibility, effectiveness, social and cultural acceptability, as well as economic, political and institutional preferences (IPCC, 2022). To address future risk and uncertainties, it is important to combine different adaptation measures and pathways. Additionally, integrating urban planning with disaster risk reduction and policy incentives in other sectors such as land use planning and development, insurance, housing, transportation and community development will be crucial for meaningful progress in climate adaptation (Broto et al., 2015; Patterson, 2021; Rosenzweig et al., 2018; Solecki et al., 2011).

Given the unique challenges and opportunities in coastal cities as hotspots of risks and centers of development and innovation, we argue that assessing their current state of adaptation is as important as tracking countries progress under the Paris Agreement (Paris Agreement, 2015). Understanding how

coastal cities are responding to climate impacts is crucial for identifying successes and gaps and advancing global adaptation efforts. The latest IPCC report shows that coastal cities tend to implement adaptation interventions reactively in response to high-impact events such as floods and storms. However, a systematic global assessment of the literature on coastal urban adaptation is yet to be conducted, which makes it possible to answer important questions such as which coastal cities are adapting to coastal hazards? What strategies do they use? Who is implementing them? Do coastal cities engage in transformative adaptation? What are predictors or evidence? Addressing this gap, this study is partly based on and complements the Global Adaptation Mapping Initiative (GAMI) (Berrang-Ford, Siders, et al., 2021) by assessing and analyzing empirical evidence of coastal urban responses to climate change in a systematic way.

The added value of this study is threefold. First, this first global stocktake of empirical evidence of adaptation in coastal cities provides a valuable and unique overview of where cities stand in terms of adaptation, including gaps and shortcomings which need to be addressed. Second, it may guide future research through its identified gaps, e.g., in coverage. And lastly, it raises awareness for the yet untapped adaptation potentials in coastal cities, which could be used as entry points to develop effective, equitable, and socially-relevant adaptation strategies in response to current and projected climate impacts.

Methods

The findings of this paper were derived through the combination of a structured literature review that identified scientific literature on coastal urban adaptation to climate change impacts across three reference databases (see figure X) with a systematic content analysis based on a coding protocol, following the GAMI process.

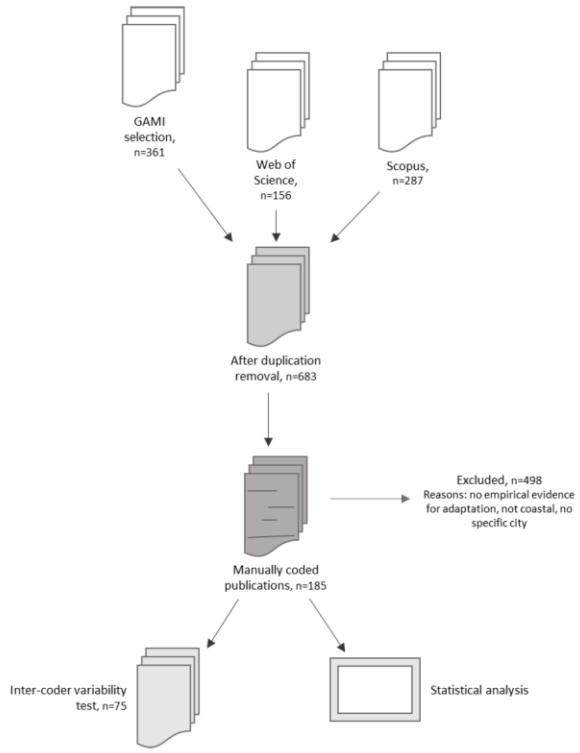


Figure X: Workflow

Relevant peer-reviewed, scientific, English-language literature on the topic of coastal urban adaptation was identified in a three-tiered search process. First, publications of the category "cities and settlements by the sea" were extracted from the GAMI database, a systematic dataset of over 1600 articles on climate adaptation. After a preliminary overview of the 361 resulting publications, quick additional searches in Web of Science and Scopus, and lively discussions among the co-authors–most of whom are well-acquainted with the literature in this particular field–it was decided that the GAMI selection did not adequately represent the large pool of existing literature on coastal urban adaptation. Hence, in a second step, a search string based on boolean search terms was used to systematically search the reference databases Web of Science and Scopus for relevant literature for the years 2013 to 2020. With this we extended the original GAMI search (Berrang-Ford, Lesnikowski, et al., 2021) by one year; we did not include 2021 and 2022 based on the coding time-frame. While the basis of the search string was adopted from the GAMI process (Lesnikowski et al., 2021), it was extended by tailored search terms to yield more topic-relevant publications. The search strings and respective hits can be found in the Annex (Table 1). In a final step, the results of all three searches were combined and duplications were removed.

A total of 683 scientific publications entered the next part of the analysis, which consists of several steps. First, coders assessed whether a publication presented empirical evidence for adaptation and excluded it if such evidence was absent following strict inclusion/exclusion criteria (see Annex, table 2). Second, included publications were analyzed via a systematic content analysis. Using the online survey platform SoSci Survey, coders completed one coding-questionnaire per city covered in the manuscript.

This means that for one publication, several questionnaires could have been completed in the case that it dealt with two or more cities. In total, 186 publications covering 208 cities and/or settlements with central functions such as schools, supermarkets and doctors were included in the coding and statistical analysis, as well as four unspecified urban areas. Coder consistency and reliability was ensured by an introduction to the commonly developed questionnaire, a code book/protocol with detailed definitions of all codes, a pre-coding period with interim meetings to discuss issues and confusions as well as multiple other meetings with all involved coders. Third, about 10 percent of the entire dataset, i.e. 72 publications, was double coded to check inter-coder reliability. For 12.8%, conflicts regarding inclusion/exclusion arose. Of the 16 fully double-coded publications, inter-coder variability rose to a maximum of 22.2%, meaning a convergence in roughly 80% of provided answers, which was accepted as sufficient to consider the dataset as robust. Fourth, the data in the form of codes were extracted from the platform, cleaned and statistically analyzed in IBM SPSS Statistics 23, following the original GAMI approach (Berrang-Ford et al. 2021, Ulibarri et al. 2022, Thomas et al. 2021).

To get an overview of the dataset, descriptive statistical analyses were performed assessing the frequency and proportion of all variables, namely, hazard type, exposure and vulnerability, actor type, adaptation type according to GAMI and IPCC adaptation categories, and the depth, speed and scope of adaptation. To identify potential patterns, frequencies were assessed across the World Bank income economies categories (hereafter income groups) as well as across country regions following the GAMI classification.

To explain identified patterns, we used different correlation tests to explore potential relationships between Gross National Income (GNI) per capita as well as city size (in terms of population) and patterns of actor involvement, adaptation type and depth, and speed and scope of adaptation. The objective was to evaluate the existence of any relationship between these two variables (GNI per capita and city size) and in particular to determine their potential impact on our assessed variables. The chi-square test, applied to test the relationship between GNI per capita as well as city size with actor involvement was based on Pearson's chi-square (p) values, where a p value greater than 0.05 signified a statistically significant correlation, while a p value less than 0.05 indicated a lack of statistical significance. The same analysis was performed to evaluate the relationship between adaptation actors and income groups, and geographic regions, as well as the relationship between the IPCC response type and GNI per capita.

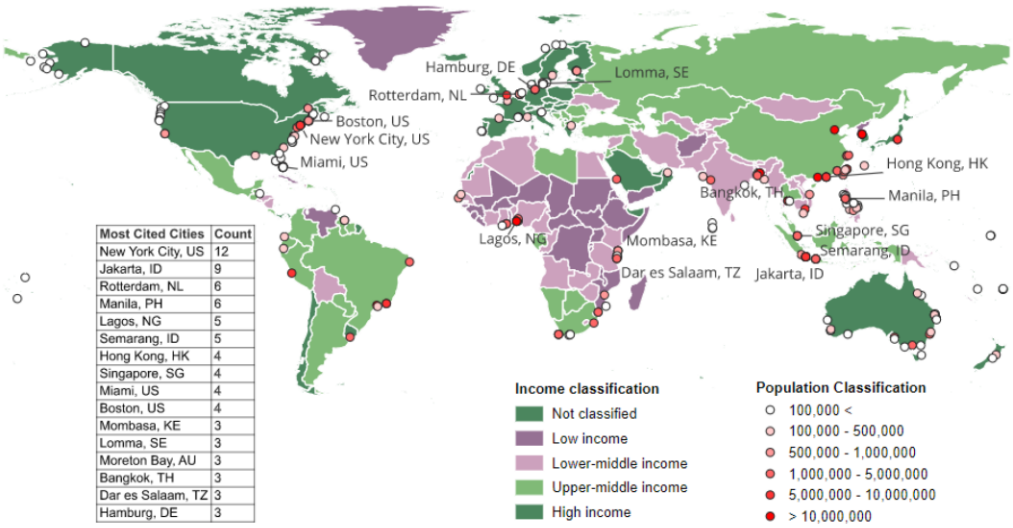
Finally, the Spearman rank correlation test was utilized to determine the statistical significance of differences between the rankings of sub-samples and the total sample, as well as differences between sub-samples themselves.

Results

Coverage of coastal urban areas

While there is a considerably-sized body of literature and case studies for adaptation in coastal cities, our sample shows that cities in certain regions and income groups are less well researched than others.

The considered literature covers adaptation evidence from all country regions and income groups, though there are considerable differences in the number of studies. Most publications (31%) present coastal-city adaptation evidence in Asia, 23% in North America, 15% in Europe, 13% in Africa, and 11% in Australasia. Coastal cities in Central and South America as well as Small Island States are less well covered, representing only 4% and 3% respectively of all considered publications.



Most Cited Cities	Count
New York City, US	12
Jakarta, ID	9
Rotterdam, NL	6
Manila, PH	6
Lagos, NG	5
Semarang, ID	5
Hong Kong, HK	4
Singapore, SG	4
Miami, US	4
Boston, US	4
Mombasa, KE	3
Lomma, SE	3
Moreton Bay, AU	3
Bangkok, TH	3
Dar es Salaam, TZ	3
Hamburg, DE	3

Figure 1: Geographical and economic distribution of considered cities

Looking at the coverage of publications according to the World Bank's income categorization, a majority (56%) focuses on coastal cities in high income economies, 19% cover coastal cities in upper-middle income economies, and 23% present findings from lower-middle income economies. Only 2% showcase empirical evidence for adaptation from coastal cities in low-income economies (see Annex, Table 3).

Literature identified through our systematic search mostly covers evidence for adaptation in coastal cities with more than one million inhabitants. Some cases portray evidence for adaptation in megacities such as New York, Jakarta, Manila and Lagos; some of which are covered by multiple studies (see figure 1) and can hence be considered as well researched. The sample showcases little evidence for adaptation for mid-sized coastal cities in Africa and Central and South America, while mid-sized cities are better assessed in Asia, Australasia and Europe. In North America, a majority of cases are dedicated to mid-sized cities.

Hazards and trends of exposure and vulnerability

Coastal cities by and large face similar natural hazards, which are mostly considered either as past or current events or without specification of time scales of occurrence.

Overall, most of the considered studies focus on coastal, hydro-meteorological events, especially sea level rise as well as coastal and pluvial flooding (see figure 2). Similarly, storm surges, coastal erosion

and tropical cyclones represent important topics in coastal urban climate adaptation research. In contrast to this, tornadoes, flash and sewer floods as well as saltwater intrusion are less researched hazard types in the context of coastal urban adaptation. The correlation analysis found that coastal flooding, and saltwater intrusion are more likely to be assessed in cities with bigger population sizes, while flash floods and unspecified flooding are less likely to be studied the higher the GNI per capita (Annex, Table 4). Apart from these, no significant differences in hazard patterns addressed by urban adaptation can be reported.

Many studies in our sample consider more than only one hazard. Such consideration of multiple hazards is most evident for the combination of sea level rise with coastal flooding, storm surges and coastal erosion as well as pluvial flood events.

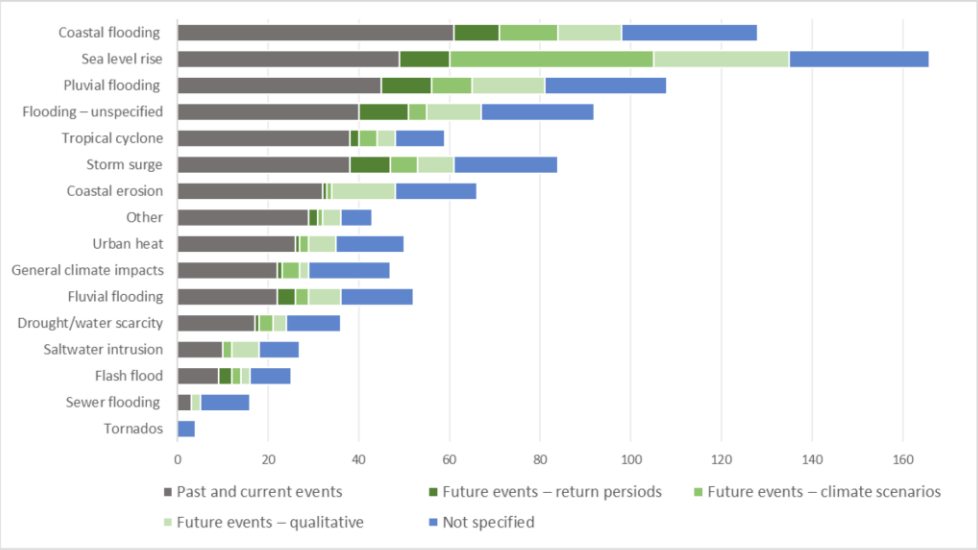


Figure 2: Hazard types and temporal dimensions considered across cities

Across hazards, past and current patterns most frequently shape adaptation actions; in many cases the point in time that the considered hazards occur remains undefined (see figure 2). However, there are also examples where adaptations take into account future hazards, especially among the most dominant hazard types. For instance, half of the publications providing evidence of adaptation to sea level rise in coastal cities consider future patterns; one third of them on the basis of either scenarios or return periods and roughly 20% by mentioning qualitative future occurrences. Almost one third of papers considers adaptation to storm surges, pluvial flooding, coastal and unspecified flooding in the future.

Coastal adaptation research varies in its focus on exposure and vulnerability of buildings, infrastructure, people, and environmental assets (Figure 3). Most cities considered vulnerability of the human population in general, but less frequently discussed particular groups or businesses. Residential buildings receive the most attention of buildings and infrastructure. For both buildings and environmental assets, most papers only consider risks in a general sense.

Figure 3: Number of cities that mention the exposure and vulnerability of 1. buildings and infrastructure, 2. people and businesses and 3. environmental assets

Across our sample, the consideration of exposure and vulnerability of buildings and infrastructure, people and businesses as well as environmental assets and services correlates weakly with the income level of a country (Annex table 5). The higher the income group, the more likely that exposure and vulnerability aspects are considered. Overall, they are predominately mentioned in an unspecified way (see figure 3). In particular, our study identifies a lack of exposure and vulnerability assessments of different business sizes. In cases where vulnerable or exposed elements are considered in more detail, the assessments are mostly limited to past or current exposure and vulnerability and rarely extend to future patterns.

Actors

Actors involved in the implementation of coastal urban adaptation action are correlated with income levels as well as city size and differ significantly across country regions.

Overall, we find that individuals/households are by far the most mentioned actors implementing adaptation action in our sample, followed by the assessment of city governments. While there are many examples of studies looking at several actors involved in urban adaptation, the combinations vary (see figure 4). In many cases, individuals/households and city governments are mentioned together. Additionally, city government and national government, or a combination of the two with sub-city local government are assessed together more frequently than other combinations.

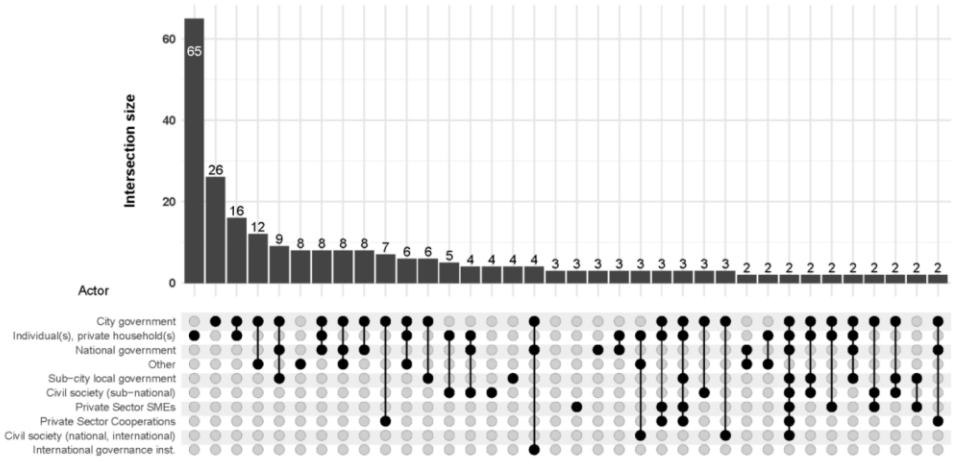


Figure 4: Actor combinations involved in adaptation in coastal cities

Our findings indicate that the higher the GNI per capita and the higher the income group, the more likely that the city government is assessed as an actor in adaptation and the less likely that individuals/households are mentioned (p=0.01, 2-tailed) (Annex table 6). As depicted in figure 5, adaptation assessments in cities in high-income countries focus predominantly on city governments as adaptation actors, most likely for implementing protection measures and advances (with ground elevation) (see Annex table 7). Besides this, individuals and households of cities in high income countries are also often assessed as implementing actors; probably for accommodation action. At the same time our analysis shows that the higher the income group, the less likely behavioral/cultural responses (GAMI response type) is assessed (see Annex table 6 and 7), suggesting that accommodation is not likely to be achieved through behavioral or cultural responses in coastal cities in high income countries. In coastal cities in lower-middle income countries, the focus is more on assessing individuals and households as adaptation actors; they seem to be more heavily involved in implementing both protective and accommodating adaptation strategies. In comparison to cities in high income countries, retreat is considerably more often used to adapt. City government action is less well assessed in coastal cities in lower-middle income countries. Given the low involvement of individuals in low income economies, this pattern could be questioned; however, the very small number of cases in the low income category may bias the data.

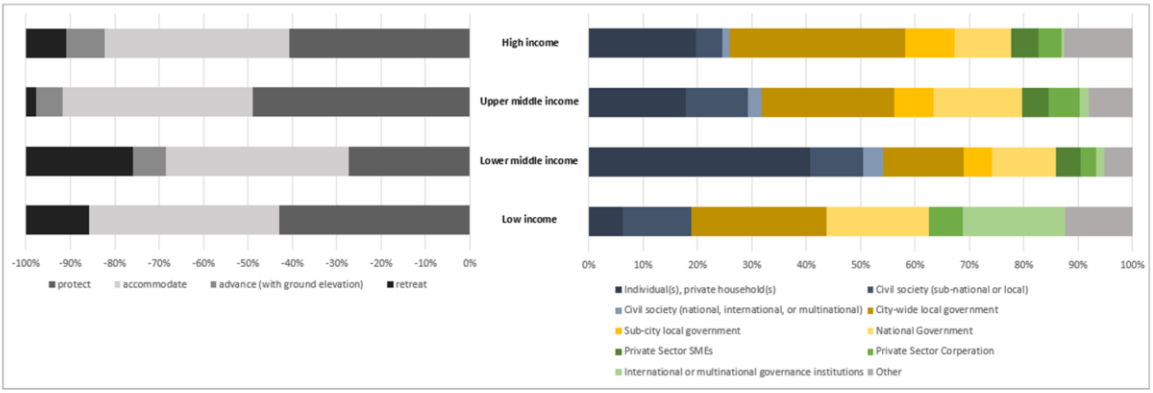


Figure 7: IPCC response type and actor involvement across income groups

Finally, the bigger a city in terms of population size, the less likely that individual/household adaptation action is mentioned and the more likely that city government is assessed as actor involved in adaptation (p=0.01, 2-tailed) (see Annex, table 6).

Responses

Which adaptation types are most dominantly assessed varies and can partly be explained by income levels as well as city size.

Overall, for the GAMI response categories, behavioral/cultural and technological/infrastructural adaptation were the most dominant in our sample. But also combinations of these two, as well as technological and institutional responses were frequently assessed.

Considering IPCC categories, accommodation alone and the combination of protection and accommodation were assessed most frequently in our literature sample. Also, protection was often assessed in isolation from other response categories. Retreat was most often assessed in combination with accommodation, while advance with ground elevation was often mentioned together with protection.

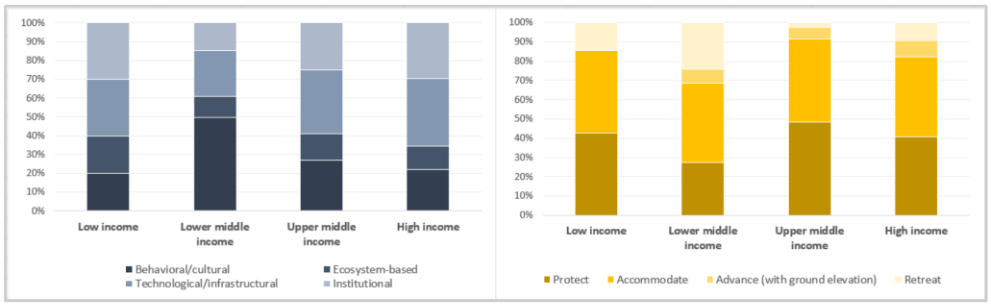


Figure 5: GAMI response types (left) and IPCC response types (right) across income groups

As figure 5 illustrates, the share of the different response types varies across country income groups. Behavioral/cultural adaptation plays the biggest role in lower-middle income economies and is less important in high income economies compared to the other response types. Technological/infrastructure adaptation is important across all income groups, while ecosystem-based measures seem to be much less applied across groups. Institutional adaptation appears to be well assessed in low income economies, however, this might be due to the low number of cases in this category. The pattern that institutional adaptation is of higher importance in high income and upper-middle income economies is confirmed by the correlation analysis (Annex table 8). It finds that the higher the GNI per capita, the more likely that institutional adaptation (GAMI classification; p=0.01; 2-tailed) and the less likely that behavioral adaptation (GAMI classification; p=0.01; 2-tailed) are mentioned.

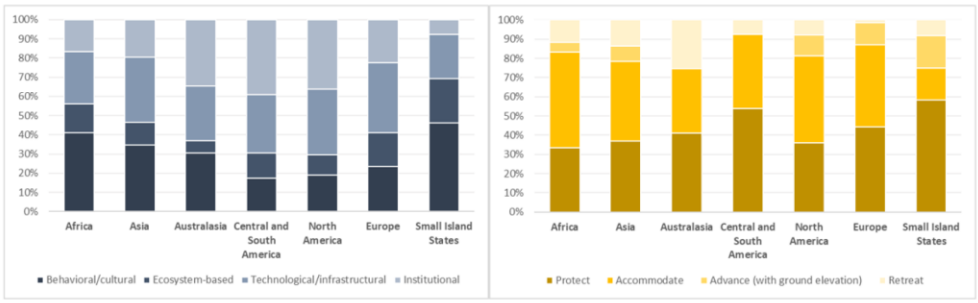


Figure 6: GAMI response types (left) and IPCC response types (right) across country regions

Looking at adaptation types across country regions (Figure 6 and Annex table 9), urban behavioral adaptation is significantly less likely to be assessed in North American coastal cities (p=0.001) and coastal cities in Central and South America but more likely to be assessed in coastal cities in Africa and Asia. For the latter two, we find less evidence for institutional and ecosystem-based adaptation in our literature sample; these adaptation categories are more likely to be assessed in Europe and North American coastal cities. Evidence for technological adaptation measures is most likely to be assessed in European coastal cities; research on institutional adaptation evidence features highest in North and South America. The IPCC response categories showcase subtler patterns with protection and accommodation to be the predominantly assessed adaptation types across coastal cities in all country regions. There is very little evidence for advance with ground elevation in our sample with the exception of Small Island States, where it features comparably high. However, the low number of city case studies from Small Island States in our sample represents a high risk of a skewed picture. Retreat is more likely to be examined in coastal cities in Australasia (p=0.001, 2-tailed), otherwise it is rarely mentioned.

Additional correlation analyses show a significant (p=0.01, 2-tailed) relationship between GNI per capita and adaptation type (Annex table 8). We find that the higher the GNI per capita, the more likely that institutional adaptation (GAMI classification) is mentioned; the less likely that behavioral adaptation is assessed.

Speed, scope, depth and evidence of risk reduction due to adaptation

Assessed adaptation remains at low depth, scope and speed in coastal cities across income groups and country regions. Neither income level, vulnerability score nor population size predicted more or less progressive adaptation behavior.

Overall, the sample showcases little evidence of deep coastal urban adaptation across income groups (see figure 8). Few examples of more transformative urban adaptation, meaning entirely new practices involving deep structural reform, a fundamental change in mindset, major shifts in perceptions or values, and/or changing institutional or behavioral norms, stem from cities in high income economies or from cities on small islands. Given the small number of cases which feature more fundamental forms of adaptation, we will provide an aggregated overview in the following.

Some cases reported self- or state-led resettlement (Albert et al., 2018; Islam et al., 2014) to adapt to climate change impacts in coastal cities. In cities such as Singapore and Hong Kong (Chan et al., 2013) and several Swedish cities (Wamsler et al., 2016) existing infrastructural measures are now complemented by preparedness and recovery measures as well as ecosystem-based approaches. Progress in the institutionalization and mainstreaming of basin-wide planning, the integration of adaptation into mitigation and development planning, as well as the establishment of legislation to reinforce adaptation in sectors like construction, for instance, are considered as evidence of more transformative adaptation in coastal cities. We also identified evidence for medium adaptation depth across income groups, where the assessed responses reflect a shift away from existing practices, norms, or structures to some extent. A considerable number of studies on adaptation in coastal cities also identified medium depth adaptation. In cities located in high income countries in Europe such as Rottterdam, Dodrecht and Helsinki, medium depth adaptation is linked to testing of innovative, design-oriented adaptation approaches, the development of networks and collaborative governance approaches as well as public-private partnerships for improving funding and innovation (Blok, 2020; Dircke & Molenaar, 2015; Francesch-Huidobro, 2015; Gersonius et al., 2016; Mees et al., 2014). In smaller U.S. cities such as Dunedin and Fernandina Beach, changes towards cross-sectoral, comprehensive and more integrative risk management plan structures (Butler et al., 2016; Díaz et al., 2017) were described. Bigger U.S. cities such as New York and Miami Beach are implementing both large scale infrastructure investments for flood protection (Jeuken et al., 2015; Molinaroli et al., 2019; Wakefield, 2019) and planning and/or implementing complementary adaptation measures such as ecosystem-based and soft adaptation approaches (Jeuken et al., 2015; Pinto et al., 2018). In Asian cities in lower-middle and upper-middle income countries, medium depth adaptation include changes in adaptive behaviour of both individuals and households, e.g. though changes in livelihoods or migration (Alam & Miller, 2019; Buchori et al., 2018; Khan et al., 2018; Rahman et al., 2015; See & Wilmsen, 2020) as well as at institutional scale adaptations, e.g. through the establishment of new institutions responsible for adaptive planning, disaster risk reduction planning across scales or mainstreaming climate change policies in other sectors (Porio, 2014; Walch, 2019; Wong et al., 2013). The only city in a low income country with evidence of medium depth adaptation is Maputo, which has mainstreamed climate change adaptation in its development plans, attributed clear responsibilities for addressing climate change impacts and started participatory urban planning processes.

However, for the majority of cities covered in our sample, adaptation remains at low depth across income groups and country regions meaning that evidence for adaptation represents largely expansions of existing practices, with minimal change in underlying values, assumptions, or norms.

The scope of responses in our sample is mostly narrow, both across income groups as well as country regions, which means that evidence for coastal urban adaptation measures is largely localized and fragmented, with limited evidence of coordination or mainstreaming across sectors, jurisdictions, or levels of governance.

Figure 8: Depth, speed and scope of adaptation across income groups

The speed of coastal urban adaptation is mostly considered low, especially in high, upper-middle and lower-middle income countries and a majority of country regions. This means that adaptations are incremental, consisting of small steps and slow implementation.

Given that depth, scope, and speed of adaptation were evaluated as rather low across our sample, it is not surprising that there is little evidence for risk being reduced through these measures. There is however one example that contrasts this picture: In Asia, there is considerably more evidence for risk overcome as compared to the other country regions.

Discussion and conclusion

Based on the analysis of our sample of literature there are five key messages with significant implications for research and policy-making in the field of coastal urban adaptation to climate change.

First, our results align with the results of the national GAMI assessment, as the analysis of our coastal urban literature sample hints towards a lack of – urgently needed -- transformative adaptation in coastal cities. Assessed adaptation remains at low depth, scope and speed in coastal cities across regions. Neither income level, vulnerability score nor population size can predict more or less progressive adaptation behavior. Given the high exposure and vulnerability of many coastal cities already today, this finding is rather alarming as climate change will significantly increase existing risks. While this is in line with other assessments of urban adaptation ((IPCC, 2022):942f.)), it has to be considered that urban scale transformation processes are very complex when considered as a whole system approach (Kuhl et al., 2021). However, cumulative effects of incremental responses could potentially still lead to meaningful and even transformational adaptation eventually. Yet given that most of the assessed

evidence was in the early stages of implementation, results may not yet be visible and hence not reported. In addition, more transformative adaptation approaches are often developed at the national, not at the local level (Filho et al., 2019), which may be another explanation for the predominantly low depth of adaptation at city scale.

Second, we find significantly more assessments of individuals/households as adaptation actors the lower the income group of the coastal cities. This indicates a significant relationship between income level and actor types involved in adaptation. The poorer a city is on average, the more likely it is that adaptation takes place at the household level, while government responses are more likely in richer coastal cities. Accordingly, in poorer coastal cities, residents who can be expected to have limited adaptive capacities, are burdened with adaptation responsibilities which they mostly meet through behavioral changes given their lack of other means. This is in line with findings on the inequality of the urban adaptation gap ((IPCC, 2022):942)), which is most pronounced among the poor. In comparison to the national GAMI assessment (Berrang-Ford, Siders, et al., 2021), our sample showcased adaptation implemented by many different actors, with most studies focusing on city government and individuals/households as implementing actors.

Third, the bigger a city, the more likely there is technological response and protection. This relationship was also found in other studies (Filho et al., 2019). At the same time, there is a lack of reported empirical evidence on ecosystem-based adaptation as well as retreat and advance. Technology-based measures such as flood-barriers or pumping installations are an essential part to protect existing cities in the short- and mid-term. However, they can lead to a lock-in and maladaptive path dependency in the long-term if coastal hazards continue to rise and hard protection fails or reaches limits of financial and technical feasibility as well as cultural acceptance (Haasnoot et al., 2020).

Fourth, we found evidence for the consideration of not only past and current hazard patterns but also of future trends of coastal hazards. This holds true in particular for coastal flooding, storm surges and sea level rise. Taking into account not only current but also future trends in coastal hazards is a key prerequisite for successful adaptation planning.

Fifth, the knowledge about and coverage of adaptation in coastal cities is highly uneven with some cities receiving a lot of scientific attention and large gaps remaining (e.g. small and mid-sized cities in Africa or Asia as well as Central and South America not being part of the global scientific debate). This corresponds by and large with findings regarding the reporting of empirical evidence for adaptation at the national scale, where a similar pattern was identified in the original GAMI assessment (Berrang-Ford, Siders, et al., 2021). In our assessment, cities in low-income and lower-income countries are starkly underrepresented in the literature. As mentioned earlier, our search criteria may have influenced this result; however, the general pattern is drastic and noteworthy. Against the background that cities in Africa, Asia and Central and South America are expected to experience a highly dynamic interplay of urbanization, highly vulnerable informal settlements and future climate change impacts (Adelekan et al., 2022) this is a significant gap in research that needs to be addressed urgently.

While the findings are insightful and valuable for better understanding the current state of knowledge on urban adaptation, this review is limited in several ways. It is based on peer-reviewed, mostly English literature; evidence for adaptation reported in grey literature or other languages is not considered. Also reported empirical evidence for adaptation that does not mention our selected search terms is missing

in this analysis. Examples are studies presenting evidence for adaptation that do not explicitly mention terms such as “urban”, or “coastal”, e.g. in Small Island States. Accordingly, the patterns and trends identified though our analysis mirror the current scientific research landscape on coastal urban adaptation rather than actual adaptation especially because non-reported adaptation evidence is obviously not covered. However

Despite these limitations, this review identified general trends in real adaptation based on the assessed cases. Furthermore, our findings are valuable in that they help to identify gaps in empirical research on adaptation which need to be addressed in future research.

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5.2. Mapping the adaptation solution space - lessons from Jakarta for other coastal cities

Building on the key findings of the global review of coastal urban adaptation evidence, the review of research on flood risk management in Jakarta dives deeper into my specific case study. Despite being extensively studied and having many years of experience in flood management, Jakarta is still severely impacted by flooding every year. A disruptive flood event at the beginning of 2020 exemplified this right at the beginning of the development of the manuscript. The paper aimed to systematically assess the research landscape on flood risk management in Jakarta composing of scientific studies on the effectiveness, sustainability, feasibility, and acceptance of various flood adaptation measures. Together, these studies contribute to the solution space for adaptation, which may inform political decision-making in the realm of adaptation to climate change (Haasnoot et al., 2020).

The systematic review provides an overview of the research landscape on flood risk management in Jakarta. It demonstrates that the current scientific debate fails to adequately consider all dimensions of risk because scientific inquiry in Jakarta is skewed towards understanding the hazard and examining hard, infrastructural protection measures. This is in line with findings from the global review of urban adaptation evidence, which found that the bigger a city, the more likely that technocratic adaptation approaches are assessed (see 5.1). In this review, a comparatively smaller share of the identified literature criticizes this technocratic approach, presenting empirical evidence for persisting vulnerabilities. However, I identified a lack of research on soft adaptation options such as social insurance schemes, empowerment, and capacity building and more importantly a gap in comparative analyses of different adaptation options. This imbalance in research on flood management in Jakarta leads to a bias in the adaptation solution space. In the bigger picture, the findings of this review may represent one piece of the puzzle to explain the path dependency of Jakarta's flood risk management approach. Beyond the case of Jakarta, the review confirms findings about the lack of adaptation and mitigation action despite high levels of climate knowledge (Knutti, 2019). In connection to the global review of coastal urban adaptation evidence, this systematic review confirms some of the identified trends, when assuming that research coverage approximates real-world adaptation trends. In that case, the review confirms the strong focus on technocratic responses in coastal megacities and the finding that behavioral/cultural responses to accommodate climate change impacts are mostly borne by individuals and households.

The annex of the publication can be found in Appendix B.7.

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Review article: Mapping the adaptation solution space – lessons from Jakarta

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Abstract. Coastal cities are under rising pressure to adapt to climate change. They suffer from the severe effects of increased frequencies and intensities of coastal hazards, particularly flooding, while oftentimes continuing to sprawl into hazard-exposed areas and grow beyond the pace of sufficient infrastructure development. Even though these problems have been quite well understood for a while, there is still comparatively little knowledge and scientific assessment of the solution space, i.e., on the options available for adaptation and the ways in which they are being perceived, framed and evaluated in the scientific literature. Focusing on Jakarta, this study presents findings from a systematic assessment of peer-reviewed scientific literature on the adaptation solution space with regard to current and future flooding. Jakarta is chosen as a case study since it is among the cities with the highest flood risk and adaptation pressure globally while also being one of the most heavily researched coastal cities in this regard, certainly in the Global South. Based on a structured keyword search, we assess 339 articles. Results indicate that the perceived solution space is skewed towards hard protection against flooding, while measures to accommodate flooding or retreat from exposed areas are less widely considered in the scientific debate. Soft adaptation measures for the reduction of social vulnerability receive less attention in the literature than those measures targeting the taming of flood hazards, often through engineering solutions. Likewise, hybrid adaptation approaches, which combine soft and hard measures in a complementary way, are only rarely considered. Looking into the future, the findings suggest that despite the importance of hard flood protection as a main adaptation solution in Jakarta, other fields of the solution space deserve increased scientific attention. This relates in particular to urgently needed feasibility and effectiveness assessments of ecosystems-based solutions for flood mitigation and adaptation options targeting social vulnerability. While the empirical results are specific to Jakarta, heuristic observations from research on other coastal cities suggest that similar scoping exercises of the predominantly perceived solution space might be of relevance in many cities beyond Jakarta.

1 Introduction

Many coastal cities around the world suffer from chronic flooding, straining their development (Hallegatte et al., 2013). Looking into the future, risks related to flooding in these cities are set to rise sharply (IPCC, 2019a). This rise in risk is driven by climate change effects (e.g., sea level rise and the increasing intensity of heavy precipitation, river flooding and storm surges) but also the effects of urbanization itself (e.g., land subsidence, urban sprawl into flood-prone areas, or the accumulation of people and infrastructure) (Tellman et al., 2020; Wolff et al., 2020). As a result, coastal cities are under increasing pressure to adapt over time and in some instances transform fundamentally (IPCC, 2019a; Revi et al., 2020). While this is not a new phenomenon, even well-researched cities like Jakarta, Indonesia, with sound scientific knowledge of their flooding problems and considerable efforts to improve flood risk management and climate change adaptation, keep suffering from flooding year after year.

Persistent flooding hints towards the existence of "adaptation gaps" (UNEP, 2018). In order to better understand and address such gaps, this study looks at scientific research not

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only on past, current and future trends in flood risk but particularly on adaptation for the case of Jakarta. Research on this city shows a pattern which appears to be typical of coastal cities: while the problem of flooding and its drivers has been quite well researched for Jakarta (e.g., Abidin et al., 2015; Asdak et al., 2018; Budiyono et al., 2016; Garschagen et al., 2018; Latief et al., 2018; Mishra et al., 2018; Moe et al., 2017; Ward et al., 2011a), much less attention has been given to analyzing different potential adaptation options. The main focus of this paper is therefore on examining how the so-called "adaptation solution space" for Jakarta is being covered and framed in the literature. The concept of "solution space" for adaptation to climate change has been receiving increasing attention since the IPCC's Fifth Assessment Report (WGII AR5) (IPCC, 2014). The adaptation solution space can broadly be understood as being made up of potential adaptation options including their synergies and trade-offs as well as barriers and enablers. Assessing the adaptation solution space, including the feasibility, effectiveness and adequacy of different adaptation options – and their combinations over time – is essential for informing the composition of adaptation pathways. The solution space for climate change adaptation therefore represents a socially constructed, multi-dimensional space of opportunities for adaptation that determines "why, how, when and who adapts to climate change" (Haasnoot et al., 2020, p. 1), restricted by hard and soft limits to adaptation (Dow et al., 2013). This study assumes that the scientific discourse is one important arena in which the solution space is formed and shaped. The questions of which adaptation solutions are being conceived in science and how they are being scientifically evaluated have great influence on the practical and political debate shaping actual solution decisions (Haasnoot et al., 2020). This paper therefore focuses on the assessment of scientific literature and how adaptation solutions are being perceived and treated in them. Further research might complement this analysis with empirical work on adaptation perceptions among, for example, practitioners, policy-makers and affected actors.

Jakarta represents an example worth analyzing. The city's flood problems are so pressing that it can serve as an early laboratory for current and future adaptation challenges that many other major coastal cities, which are also located in low-elevation coastal zones, e.g., Mumbai, Dhaka, Ho Chi Minh City or Lagos, will also have to deal with (IPCC, 2019a). The combination of continuing urbanization and environmental changes results in increasing risks for the urban population today and in the future, turning Jakarta into one of the most at risk coastal cities globally (Hallegatte et al., 2013; Hanson et al., 2011).

To examine which adaptation options are being considered in the scientific literature and how, the study uses a structured literature review to address the following research questions:

- Which flood risk drivers are considered in research on Jakarta?
- To what extent does scientific research consider different hard, soft and hybrid measures for risk management and adaptation, and how are these measures being evaluated?

While the paper is focused on Jakarta, it aims at providing lessons for the assessment and understanding of adaptation solution spaces in other coastal cities facing similar risk and adaptation pressure. The paper is structured into seven parts. Section 2 lays out conceptual considerations around flood risk and adaptation adopted in this study before Sect. 3 briefly introduces the flood context of Jakarta. Subsequently, Sect. 4 describes the methods and data of our analysis. Section 5 presents the results starting with general publication patterns and author affiliations. Subsequently, the results chapter describes drivers of flooding mentioned in the literature before it summarizes the hard adaptation measures discussed. Then, soft and hybrid adaptation measures mentioned in the literature are presented. Section 6 summarizes and discusses the results, relating them to the solution space for flood adaptation for Jakarta. It also presents identified gaps. Section 7 offers key conclusions and an outlook.

2 Conceptual considerations – flood risk and adaptation options

Climate change adaptation first and foremost means action to limit and reduce climate risks (Garschagen et al., 2019). In order to understand whether and how adaptation is being framed and perceived, it is therefore, we argue, necessary to concentrate on the links between adaptation and risk. In other words, to unpack the adaptation solution space – or rather how it has been discussed in the scientific literature in this case – one therefore has to ask whether and how different adaptation options are considered to have an effect on the different components and drivers of risk (Garschagen et al., 2019). In addition, a key question is which factors of risk might be underrepresented in the current adaptation literature. For these reasons, understanding how risk is being produced and composed is essential.

In this study, we draw on a few decades of risk research and understand risk in line with current concepts used in the IPCC to be a function of hazard, exposure and vulnerability (Wisner et al., 2004; IPCC, 2012). According to this, hazards can be defined as (environmental or climate-related) events or processes with the potential to cause damage and harm (IPCC, 2019b). In the case of Jakarta this predominantly means floods. Exposure is understood as the presence of assets or activities (social or environmental) in the spatial, temporal and/or functional reach of hazards. Exposure therefore has a hybrid character as it can be altered by environmental changes (e.g., sea level rise) as well as socio-economic change (e.g., urban sprawl). Vulnerability refers to the propensity or predisposition to be adversely affected if exposed to a hazard (IPCC, 2019b). For example, the de-

gree of susceptibility of livelihoods or infrastructure to suffer harm from floods contributes to vulnerability.

Adaptation links into the causal fabric of risk by aiming to reduce existing as well as future vulnerability (e.g., through health care or other social security programs); exposure (e.g., through planned retreat from hazard-exposed areas); and/or, where possible, hazards (e.g., by limiting flood intensity through retention areas) (Garschagen et al., 2019). Overall, adaptation can hence be defined as the process of adjustment to actual or expected climate change and its impacts in order to moderate harm or, where possible, even exploit beneficial opportunities (IPCC, 2019b). Addressing the different risk components (hazards, exposure and vulnerability) involves assessing and selecting options for policy and action (Garschagen et al., 2019). Such decision-making entails evaluation of the effectiveness, efficiency, efficacy and acceptance of actions (Garschagen et al., 2019). Limits to adaptation apply where available options no longer allow actors to secure valued objectives, functions or assets from intolerable risk (Dow et al., 2013). While coastal cities might reach technical limits of adaptation only rather late (e.g., in terms of the engineering limits theoretically applying to coastal protection), financial, social and institutional barriers and limits are expected to be reached much earlier (Oppenheimer et al., 2019).

Risk analysis is often split into understanding the hazard and understanding other driving forces – including physical and/or social exposure as well as vulnerability. For a long time, scientific research has focused primarily on understanding the hazard with the objective to control nature and protect people from it (Hewitt, 1983; Wisner et al., 2004; IPCC, 2012). In the same vein, the role of "hard" adaptation solutions, which aim at controlling hazards and protecting exposed elements, have grown in importance, becoming a centerpiece of the predominant paradigm for risk reduction in the second half of the 20th century (Hewitt, 1983; Wisner et al., 2004). Hard adaptation measures in the context of flood risk reduction are mostly large-scale engineered human-built structures, e.g., floodwalls or storm barriers (Sovacool, 2011; Oppenheimer et al., 2019; Du et al., 2020). While they often meet their objective to protect people and systems from harmful events and are widely considered an important element within portfolios of risk reduction measures especially in coastal cities (Oppenheimer et al., 2019), they rarely work towards reducing underlying hazard drivers or social vulnerability and they often entail significant downsides. First, they tend to be technologically complex – often prone to failure – and very cost-intensive (Sovacool, 2011). Second, they are comparably inflexible as concrete structures remain for a long time. This can be challenging in the face of high levels of uncertainty regarding climate change and dynamic trends in its impacts, which mean that such structures need constant assessment and sometimes costly updates (David et al., 2016). Third, hard measures in the aggregate generate comparatively few co-benefits and, depending on the planning and implementation process, have even been harmful to local communities and ecosystems (David et al., 2016; Sovacool, 2011). And lastly, infrastructural measures might give people a false sense of security, increasing the overall damage potential in the case of failure (IPCC, 2012). Risk reduction and adaptation regimes centered around hard protection predominantly or exclusively have therefore been problematized for their emphasis on technocratic fixes for solving symptoms rather than causes of risk (Ribot, 2011; Garschagen, 2015; Solecki et al., 2017), paving the way towards addressing the need for changing the protection paradigm towards more holistic risk management approaches (e.g., Viero et al., 2019).

Next to hard adaptation, the importance of soft adaptation measures has therefore also been emphasized for a while, especially for reducing socio-economic vulnerability (Wisner et al., 2004; Ribot, 2011; Solecki et al., 2017) or for absorbing residual risk remaining beyond hard measures (Du et al., 2020). In contrast to hard adaptation, soft adaptation includes an emphasis on ecological and institutional responses, notably ecosystems-based approaches and institutional adjustments, e.g., in terms of land-use planning, building codes, social protection or awareness raising. Soft adaptation is less clearly defined than hard protection, meaning also that the consideration of properties, advantages and disadvantages of measures belonging to soft protection is multifaceted. Yet, a number of overall observations have been suggested in the literature, notably that soft protection is focused on empowering and capacitating local communities to respond to changing hazards and is often based on modular technologies which do not require large outlays of capital or human resources (Sovacool, 2011). However, this is not to argue that certain soft measures also require a large amount of central planning, investment and steering, e.g., in the case of large-scale wetland or mangrove restoration.

Hard and soft adaptation measures are often combined and can both be mapped onto the main response types against sea level rise and coastal flooding as used by the IPCC, i.e., protection, accommodation, advance and retreat (Oppenheimer et al., 2019). However, certain clusters can be observed, e.g., in that protection typically relies on hard measures, whereas accommodation typically also requires a stronger integration of soft measures. Assessing coastal adaptation approaches and potential across the globe, the IPCC stresses that hard adaptation is technologically feasible and economically efficient for coastal cities and therefore will continue to play a central role in adapting such cities further (Oppenheimer et al., 2019). However, the IPCC also stresses that hard protection does not come without disadvantages and raises questions of affordability, particularly in poorer regions of the world (Oppenheimer et al., 2019). There is therefore high agreement that hybrid approaches, combining different hard and soft approaches, is a promising way forward in many coastal settings (Oppenheimer et al., 2019). For Shanghai, for instance, hybrid approaches of combin-

ing hard storm-surge barriers with wetland development and wet-proofing of infrastructure have been assessed to bring about the highest potential for overall risk reduction (Du et al., 2020). An example from Padua (Italy) shows how proper floodgate operations are ensured by including the end user in designing and implementing control structures and protocols (Mel et al., 2020).

The above considerations mean that measures of both types jointly make up the so-called solution space for climate change adaptation which can be understood as a flexible space spanning multiple dimensions (biological, political, institutional, socio-economic, cultural), scales and actors, containing all potential solutions for climatic risks (Haasnoot et al., 2020). The solution space is confined by soft and hard limits (Dow et al., 2013) and can hence change in form depending on internal and external influencing factors (Haasnoot et al., 2020). This study assumes that scientific research in the field of flood risk management and adaptation represents one of these influencing factors. Through scientific inquiry, scholars assess and evaluate potential flood adaptation options from many different perspectives, creating a diverse and constantly widening landscape of adaptation options, which are readily available for the consideration of decision-makers. Accordingly, scientific perspectives play a vital role in shaping the actual solution space.

3 Brief overview of Jakarta's flood risk and its root causes, impacts and recent management

Urban flooding has a long history in Jakarta. The city is naturally prone to coastal hydrological hazards due to its geographical location in a low-lying coastal area facing the Java Sea, and it having more than 13 rivers, including the Ciliwung, flowing through it (Marfai, 2015). Urban flooding in Jakarta is most severe when heavy precipitation, high runoff rates, and storm and/or high tide levels coincide (Garschagen and Surtiari, 2018). In the future, climate change is expected to increase Jakarta's "natural" drivers of flood risk, mostly through sea level rise and the increasing potential for heavy precipitation in the entire Ciliwung catchment area (Mishra et al., 2018; Januriyadi et al., 2018).

However, besides natural drivers of flooding, there are also multiple human-made causes which significantly contribute to the city's flood problem. First, continuous population growth, urbanization and land-use changes in Jakarta as well as in its surrounding areas, including the upstream area of the Ciliwung, have significantly altered the hydrological system and runoff patterns (Garschagen et al., 2018). Urban densification processes have led to a degradation of the urban drainage system as rivers and canals have been filled and floodplains paved over, reducing the retention and discharge potential (Garschagen et al., 2018). Second, the narrowing of urban waterways due to informal settlements along the banks of the rivers, sedimentation and pollution with waste have further reduced water flow capacities and urban drainage (e.g., Mathewson, 2018). Third, land subsidence is a key driver of the city's flood problem because it exacerbates the impacts of precipitation and sea level rise (Salim et al., 2019). Today, 40 % of Jakarta's urban area lies below sea level (Marfai, 2015; Salim et al., 2019). Subsidence has four major drivers: excessive groundwater extraction, natural consolidation of soil, increasing infrastructure and building load, and tectonic activities (Abidin et al., 2015). The impacts of floods, resulting from the interplay of both natural and human-made drivers as described above, have represented a strain on the city's development until today. Major flood events hit the city in the 21st century, i.e., in 2002, 2007, 2013, 2014 and 2020. They resulted in several deaths, up to 500 000 evacuees, and massive direct and indirect economic losses related to infrastructure damage and reduction in productivity as well as business value losses (e.g., Budiyono et al., 2015; Djalante et al., 2017; Octavianti and Charles, 2019). The 2007 floods stand out in their extent and severity. The floods submerged more than 60 % of the city, causing an unprecedented flood extent and unprecedented fatalities, damage and losses (Texier, 2008). They resulted from the confluence of high precipitation in the city, water runoff from upland areas and a strong spring tide pushing water into the city from the sea (Octavianti and Charles, 2019; Garschagen et al., 2018). This extreme event, driven by compound flood drivers including the seaward intrusion of water, can be described as a demarcation point, triggering a paradigm shift in flood risk management in so far that sea level rise was from then on portrayed to be one of the risk drivers (Garschagen et al., 2018; Octavianti and Charles, 2019). While prior to the 2007 event the city government had mostly focused on protecting the city from inland flooding, it then developed the so-called Jakarta Coastal Defence Strategy (JCDS) to also protect the city from coastal hazards (Garschagen et al., 2018). Since then, the city government has concentrated its flood risk management on four key infrastructural measures: namely river and waterway regulation, including dredging and clearance of river banks; canalization; expansion of water reservoirs; and the development of a massive sea wall including land reclamation (Garschagen et al., 2018; Octavianti and Charles, 2019). The so-called Great Garuda is one of multiple flood protection measures of the National Capital Integrated Coastal Development (NCICD) plan adopted in 2014. Its shape resembles a Garuda, the Indonesian national bird (see Fig. 1). Developed by a consortium of Dutch and Indonesian planning consultancies, the "giant sea wall" is supposed to protect Jakarta's bay area from the sea. In combination with other infrastructural measures of the NCICD master plan, the bay area will be completely re-invented and developed as a new residential and business district (Garschagen and Surtiari, 2018), aiming at marrying coastal protection with urban development while at the same time addressing land subsidence – a problem that started receiving increased attention particularly after major floods in 2013 and 2014.

The question of to which extent the entire project with all its elements will be implemented is the subject of continued debate (cf. Garschagen et al., 2018; Minkman et al., 2021).

4 Methods and data

This study builds on a two-tier analysis scheme. First, a systematic search for English scientific literature in the citation database Scopus was conducted, aiming at obtaining an overview of the state of research on adaptation and flood risk reduction in Jakarta. While capturing the majority of the international scientific literature, this selection does not capture studies published in other languages such as Indonesian. Nonetheless, the scoping of articles as well as the discussion of our approach and preliminary findings with Indonesian colleagues suggests that our approach is able to capture the ongoing scientific debate quite comprehensively. This is in large part due to the fact that Indonesian scholars today quite actively contribute to the English-language peer-reviewed scientific literature, thereby transporting research results of many local to regional studies into that body of knowledge (Djalante, 2018; see also Sect. 5).

As shown in Fig. 2, the Scopus literature database was searched with a deliberately broad combination of the search terms Jakarta AND ("flood*" OR "coastal hazard*" OR adaptation), limited to roughly the past 20 years (2000–2019). In total, 339 publications in English (see Appendix A) resulted from the structural searches after excluding non-relevant research fields (medicine, mathematics, chemistry, biochemistry, nursing, chemical engineering, dentistry, immunology, veterinary medicine), building the basis for the following filtering and analyses. For seven papers, either they could not be accessed or no full-text versions could be found (Appendix B). In a first step, all abstracts of resulting publications were skimmed and topical categories were developed, resulting in an inductively derived thematic scheme (see Table 1 and Appendix C). Based on the number of papers per category as well as their content, we obtained an overview of Jakarta's flood risk and adaptation research landscape and its centers of gravity. This is taken as an indication of whether and how different fields of scientific inquiry contribute to the assessment of flood risk and adaptation solutions. Of course, the number of papers alone does not sufficiently evaluate the importance of a study field for framing the solution space and shaping political decision-making. Nonetheless, we argue that the number of publications can be one proxy – among others – for evaluating the intensity of a certain debate, in this case the engagement with particular flood drivers and adaptation solutions.

What is more, our analysis draws not only on a bibliometric assessment but also on the content analysis of a subset of papers. In line with the research interest of our paper, we selected 93 publications for a detailed content analysis, which deal with otherwise underrepresented segments of the adaptation solution space, i.e., those focusing on soft and mixed adaptation options and a focus on social vulnerability, policy analysis and integrated management (categories 1, 2, 7 and 8 of Table 1). The analysis was guided by the research questions (Sect. 1). It follows the principles of a qualitative content analysis (Mayring and Früh, 2002) and draws on a combination of deductive and inductive codes (see Appendix C and D).

5 Results

As depicted in Fig. 3, scientific research on flooding in Jakarta has been rapidly rising since the year 2015. Between the beginning of 2015 and today, almost 3 times as many documents were published compared to the period of 2000 to 2014. In comparison to global flood risk research, which has increased steadily over the years, this represents a remarkable surge, hinting towards the relevance of the topic of flooding in Jakarta as well as an increasing scientific interest.

Research attention was especially high among Indonesian scholars. As visualized in Table 2, almost 50 % of first authors are affiliated with Indonesian institutions. With regard to international attention to Jakarta's flooding issue, most first authors are affiliated with Japanese and Dutch institutions, each making up roughly 11 % of the resulting publications, followed by researchers from Germany, the USA, Australia and Singapore.

According to the subject fields provided by the Scopus citation databank (multiple fields are possible per paper), more than three-quarters of all publications include a natural science or engineering perspective (environmental science, Earth and planetary sciences, engineering, computer science, energy, physics and astronomy, agricultural and biological sciences, materials science, mathematics, psychology, decision sciences) (see Fig. 4). Only 15 % can be attributed fully or partially to social sciences, and very few include an economics perspective (business, management and accounting, economics, econometrics and finance). Only 2 % are labeled to include an arts and humanities angle.

To obtain a clearer and more detailed overview, Fig. 5 shows a classification of the resulting publications in terms of the studies' content and focus, building on an inductively developed categorization scheme (Table 1). Some clear clusters and patterns emerge: first, studies on quantitative flood modeling, land-use (change) impacts on flooding and hard adaptation options together dominate the research field, representing almost 50 % of all publications (grey fields). This corresponds with the high number of papers in subject fields from the natural sciences (see Fig. 4). Second, with around one-third of all publications, studies in the areas of soft and hybrid adaptation analyses, soft factors of adaptation, policy and legal analyses, and watershed management (green fields) together represent another stream of scientific research. The rest of the studies of this analysis are very diverse, spanning

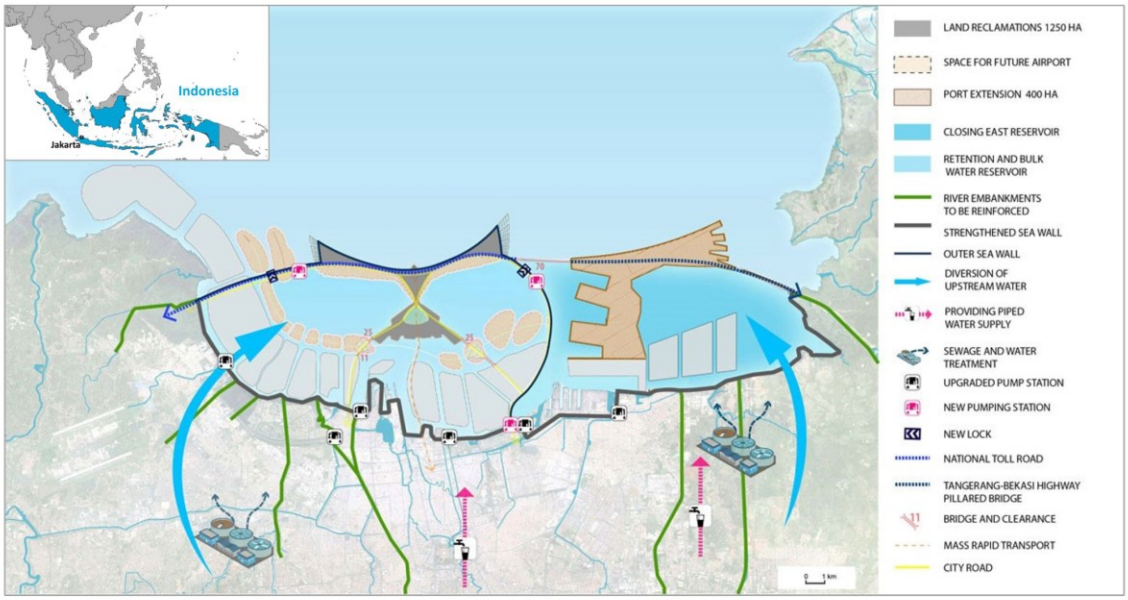

Figure 1. The Great Garuda project in its originally planned version (taken from Mezzi, 2016, based on the NCICD Master Plan 2014, Coordinating Ministry for Economic Affairs of the Republic of Indonesia, 2014).

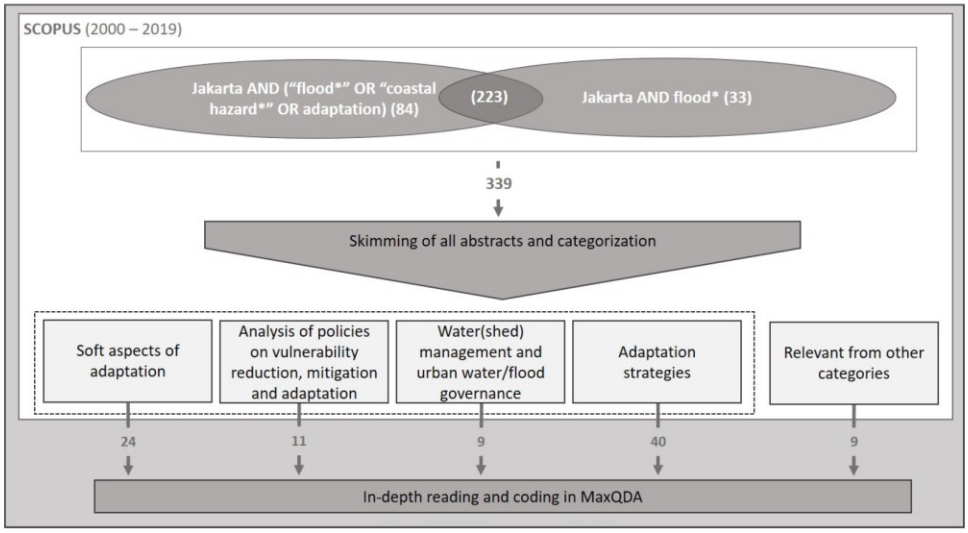

Figure 2. Literature search, extracted categories and numbers of resulting publications.

qualitative risk descriptions, the employment of new data types for risk analysis, responses to early warning systems and other decision support systems, and land-use change analysis in the context of flooding. Together, they represent roughly one-quarter of all analyzed publications.

5.1 Understanding the drivers of the flood hazard

As shown in Fig. 5, there is a strong focus on flood modeling and mapping, representing almost one-third of all papers published since the year 2000. Flood models (Bahtiar et al., 2018; Farid et al., 2012; Formánek et al., 2013; Jati

Table 1. Categories of publications.

Code	Topic	Description
1	Soft factors of adaptation	Papers on soft factors that influence adaptation such as psychology, behavior, culture, understanding of risk, how risk is framed, willingness to pay for ecosystem services, participation in planning.
2	Policy and legal analysis	Papers focusing on, e.g., institutional analysis, national policy, legal frameworks of risk management, vulnerability reduction and adaptation.
3	Hard adaptation	Papers that exclusively look at hard physical adaptation measures such as the Great Garuda project, infrastructure for rainwater harvesting, polders, dikes and flood barriers, embankments and river diversions.
4	Flood models & flood mapping	Papers that present quantitative precipitation models, subsidence models, flood loss estimation models, urban drainage models, sea level rise models, community-based flood risk mapping, shoreline retreat models.
5	Land-use (change) impact on flooding	Papers that examine the criticality of watersheds or land-use change and its impacts on flooding with the help of quantitative models or qualitative case studies.
6	New data types	Papers that investigate the potential of using new data sources like social media, big data or high-resolution data or new data-generating formats such as crowdsourcing or e-participation for flood risk mapping and analysis.
7	Watershed management and water governance	Qualitative analyses of reasons for flooding and water pollution, including drinking water source analysis and/or models.
8	Soft and hybrid adaptation	Papers that focus on soft and hybrid adaptation strategies including soft measures, local/community-led adaptation, firms and adaptation, resettlement/relocation, alternative energy sources, disaster management, urban adaptation planning.
9	Early warning	Papers that present GIS-based early warning systems, risk communication and information needs during disasters.
10	Decision support systems	Decision support systems for locations of warehouses, disaster information management systems, socio-economic vulnerability indices, hydrological infrastructure flood vulnerability indices, integrated assessment framework for subsidence.
11	Qualitative risk descriptions	Papers presenting information on flood events and impacts or evolution and impacts of land subsidence. In contrast to category 4, no quantitative hazard or risk models are employed.

and Santoso, 2019.; Hurford et al., 2010; Kadri, 2008; Lin et al., 2016; Mishra et al., 2018; Ogie et al., 2016a; Remondi et al., 2016; Rojali et al., 2017; Takagi et al., 2016b; Tambunan, 2018) and non-model-based flood analyses (Asmadin et al., 2018; Priambodo et al., 2018; Syafalni et al., 2015; Supomo et al., 2017), rainfall and/or runoff (Aditya et al., 2017; Anggraheni et al., 2018; Anindita et al., 2016; Farid et al., 2011; Hermawan et al., 2017; Kurniawan, 2019; Moe et al., 2017; Otsuka et al., 2017; Rafiei Emam et al., 2016; Riyando Moe et al., 2017) and non-modeled rainfall/runoff analyses (Liu et al., 2015; Nuryanto et al., 2017; Wu et al., 2013), and models and analyses of land subsidence (Agustan et al., 2013; Andreas et al., 2019, 2018; Chaussard et al., 2013; Koudogbo et al., 2012; Park et al., 2016) all aim to better understand and simulate the physical factors that cause or influence flooding issues and measuring its impacts in Jakarta. The same holds true for flood damage or estimated loss models (Budiyono et al., 2015, 2016; Fajar Januriyadi et al., 2018; Kurniyaningrum et al., 2019; Marko et al., 2019; Wahab and Tiong, 2017; Ward et al., 2011b; Wijayanti et al., 2017).

With the objective to identify spatial patterns of rainfall (Latifah and Setiawan, 2014), subsidence (Abidin, 2005; Abidin et al., 2015; Prasetyo et al., 2018) and flooding/inundation (Andreas et al., 2017; Latief et al., 2018; Margatama et al., 2018; Nuswantoro et al., 2016; Tambunan,

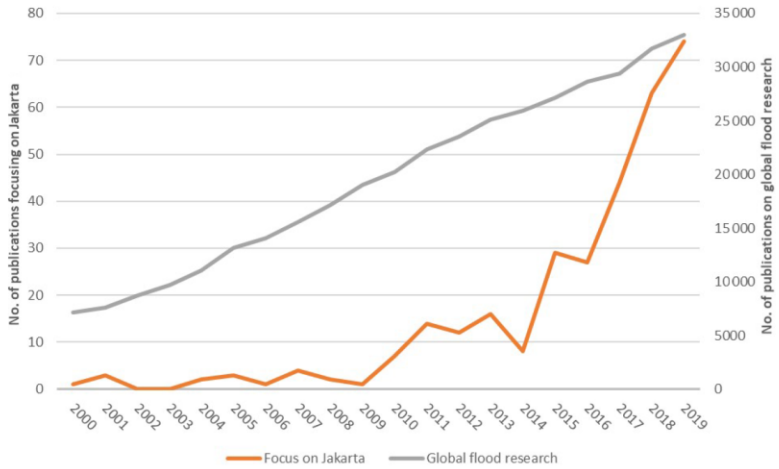

Figure 3. Number of scientific publications in flood and adaptation research in Jakarta and globally (searches in Scopus were (1) Jakarta AND ("flood*" OR "coastal hazard*" OR adaptation) and (2) "flood*" OR "coastal hazard*" OR adaptation, both for the years 2000–2019 and excluding the following subject areas: medicine, mathematics, chemistry, biochemistry, nursing, chemical engineering, dentistry, immunology and veterinary medicine).

Table 2. Number of publications sorted by the location of affiliation of the first author.

Country (or region) of affiliation	No. of publications	%
Indonesia	218	48.6
Japan	48	10.7
The Netherlands	47	10.5
Unknown	26	5.8
Germany	20	4.5
USA	18	4.0
Australia	17	3.8
Singapore	15	3.3
Switzerland	14	3.1
UK	9	2.0
China	3	0.7
South Korea	2	0.4
Thailand	2	0.4
Austria	1	0.2
Brazil	1	0.2
Canada	1	0.2
Denmark	1	0.2
EU	1	0.2
France	1	0.2
Greece	1	0.2
Italy	1	0.2
Philippines	1	0.2
Spain	1	0.2

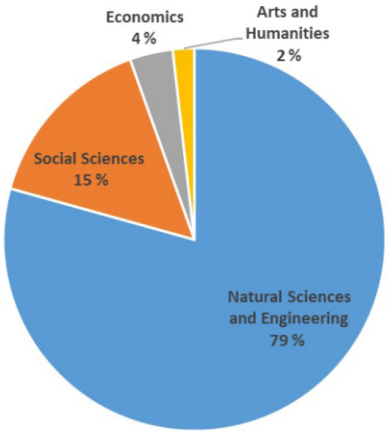

Figure 4. Subject fields of analyzed publications according to Scopus classification.

2017; Ward et al., 2013c), the phenomena were mapped for specific rainfall and/or flood events. Soemabrata (2018) adopts a more comprehensive perspective, developing a flood risk map that also considers vulnerability and urban growth, and Padawangi et al. (2016) highlight the role of community risk perception and local knowledge by referring to the use of community-based and participatory flood mapping.

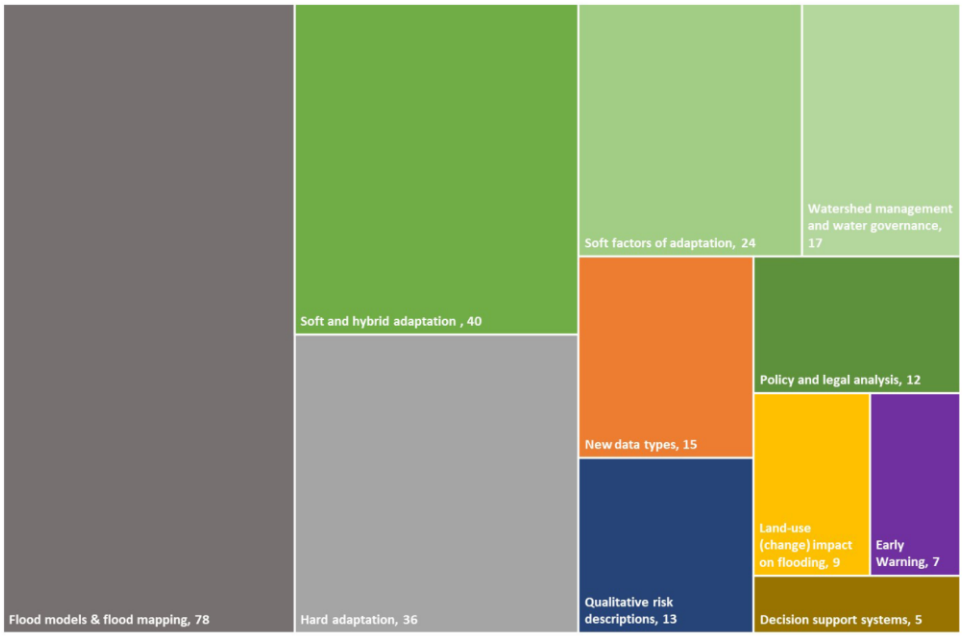

Figure 5. Thematic clusters of publications resulting from the structured literature search.

Apart from the latter two exceptions, studies from the categories flood models & flood mapping and hard and physical adaptation tend to focus on climatic, hydrological and physical factors contributing to flooding, thereby providing key information on flood drivers and patterns. Such studies are much higher in number than risk assessments that also include non-hydrological risk drivers (see below).

Publications which focus more on soft and hybrid adaptation as well as on social vulnerability issues (i.e., the green categories in Fig. 5) predominantly argue that the flooding problem is caused not only by the local topography, geology, tidal influence and regional climatic patterns that successively change in the course of climate change but also – potentially even more so – by anthropogenic factors (Aerts et al., 2013; Akmalah and Grigg, 2011; Asdak et al., 2018; Batubara et al., 2018; Costa et al., 2016; Esteban et al., 2017; Firman et al., 2011; Garschagen et al., 2018; Garschagen and Surtiari, 2018; Hellman, 2015; Ichwatus Sholihah and Shaojun, 2018; Kadri, 2008; Leitner and Sheppard, 2017; Marfai et al., 2015; Mathewson, 2018; Neise and Revilla Diez, 2018, 2019; Neolaka, 2012; Noviandi et al., 2017; Nurhidayah and McIlgorm, 2019; Octavianti and Charles, 2018, 2019; Padawangi and Douglass, 2015; Rahayu et al., 2020; Salim et al., 2019; Shatkin, 2019; Sheppard, 2019; Simanjuntak et al., 2012; Simarmata, 2018; Texier, 2008; Varrani and Nones, 2018; van Voorst, 2014, 2016; van Voorst and Hellman, 2015; Ward et al., 2011a, 2013a; Wicaksono and Herdiansyah, 2019; Yoga Putra et al., 2019a; Yuliadi et al., 2016). Three of the most important and frequently mentioned anthropogenic factors are accelerating land subsidence (e.g., Andreas et al., 2019; Colven, 2017; Costa et al., 2016; Fitrinitia et al., 2018; Garschagen et al., 2018; Goh, 2019; Padawangi and Douglass, 2015; Salim et al., 2019; Sari et al., 2018; Shatkin, 2019; Ward et al., 2011b), river clogging due to waste disposal (e.g., Akmalah and Grigg, 2011; Garschagen et al., 2018; Garschagen and Surtiari, 2018; Kadri, 2008; Marfai et al., 2015; Mathewson, 2018; Padawangi and Douglass, 2015; Shatkin, 2019; Simarmata, 2018; Texier, 2008; Varrani and Nones, 2018; van Voorst and Hellman, 2015; Ward et al., 2011b) and land conversions (e.g., Asdak et al., 2018; Batubara et al., 2018; Garschagen et al., 2018; Garschagen and Surtiari, 2018; Kadri, 2011; Marfai et al., 2015; Padawangi and Douglass, 2015; Shatkin, 2019; Varrani and Nones, 2018; Ward et al., 2011b, 2013a).

5.2 Hard flood protection measures and their evaluation

Considering the focus on natural or geo-physical drivers of flooding (see Sect. 5.1), it is not surprising that there are many publications that concentrate exclusively on so-called structural, engineered or hard flood protection measures. Such measures had already begun to be implemented during colonial times and remain, until today, a main pillar of Jakarta's approach to mitigate flooding (Colven, 2017;

Garschagen et al., 2018; Goh, 2019; Mathewson, 2018; Octavianti and Charles, 2018; Owrangi et al., 2015; Padawangi and Douglass, 2015; Simanjuntak et al., 2012; Ward et al., 2013a). Publications from the category of hard adaptation form a major part of flood risk management research in Jakarta overall (Fig. 5). They focus on specific solutions such as levees, dams, dikes and embankments and analyze or model their protective capacity or suitability for flood protection as well as their vulnerability (Mardjono et al., 2018; Mardjono and Setiawan, 2018; Ogie et al., 2016b; Su et al., 2018; Sujono, 2012; Susilo et al., 2019; Suprayogi et al., 2018; Takagi et al., 2016a, 2017; Wurjanto, 2018). Others are concerned with water channeling, retention ponds and drainage systems as a means to mitigate flooding (Indrawati et al., 2018; Kadri, 2011; Kartolo and Kusumawati, 2017; Mahanani and Chotib, 2018; Mohajit, 2015; Nugroho et al., 2018; Sholichin et al., 2019; Wihaji et al., 2018).

Some authors focus exclusively on the Great Garuda project, the central element of the NCICD master plan. Besides outlining the plan and its objectives, a number of studies question its effectiveness regarding flood protection (e.g., Badriana et al., 2017) and its potential impacts on the local environment (Rusdiansyah et al., 2018; van der Wulp et al., 2016). Modeled scenarios of flooding with and without the Great Garuda by Yahya Surya et al. (2019) show that the protection wall would slightly increase wave amplitudes, so the authors conclude that the project requires improvements to meet its aim of flood protection. David et al. (2016) point towards the option to complement the sea wall project with ecosystems-based adaptation measures.

Studies outside the category of hard adaptation (Fig. 5) mostly adopt a rather critical perspective on infrastructural solutions in general and on the Great Garuda project in particular. The latter is criticized to be a politically and economically driven, technocratic mega-project that fails to comprehensively address the flood problem (e.g., Colven, 2017; Octavianti and Charles, 2018; Salim et al., 2019). The respective studies do not argue that the project cannot provide any protection from flooding, but they are concerned that it addresses neither land subsidence nor other socio-economic factors contributing to flooding; it therefore does not present a comprehensive and sustainable solution to the flooding problem (e.g., Colven, 2017; Garschagen et al., 2018; Garschagen and Surtiari, 2018; Octavianti and Charles, 2019; Salim et al., 2019; Shatkin, 2019; Wade, 2019). Infrastructural solutions in general are often portrayed as "technocratic fixes", which do not sufficiently address the hazard's root causes, which are argued to stem from socio-economic and structural-context conditions and vulnerabilities, so the problem persists (Colven, 2017; Padawangi and Douglass, 2015; Wade, 2019).

5.3 Soft and hybrid approaches to flood risk management and their evaluation

With a less model-driven and engineering-based perspective, another stream of literature is dedicated to describing, analyzing and/or proposing adaptation strategies and flood governance approaches from a more integrated perspective, i.e., also considering soft measures or hybrid approaches combining soft and hard measures, which, according to the literature, are implemented through both state-led and community-driven initiatives. The analyzed publications provide multiple examples of state-led soft measures. Amri et al. (2017), Dwirahmadi et al. (2013), Faedlulloh et al (2019), Hellman (2015), Sugar et al. (2013) and Yoga Putra et al. (2019a, b) for instance mention the government's involvement in community empowerment and capacity building to facilitate and improve climate change adaptation. Other studies point to the involvement of government at different levels in the dissemination of information about flood risk and adaptation options, which help to raise awareness as well as prepare for and mitigate flooding (Dwirahmadi et al., 2013; Guinness, 2019; Texier, 2008; Ward et al., 2013a). Furthermore, the government's approach of combining hard flood protection infrastructure with the relocation of exposed populations as in the case of, e.g., the Great Garuda could be described as a hybrid approach, which is the subject of discussion in many publications of this stream of literature (e.g., Colven, 2017; Rusdiansyah et al., 2018; Salim et al., 2019; Wade, 2019).

Local and community- or NGO-led adaptation initiatives are argued to build on a wealth of context-specific knowledge about and experience with flooding and are often composed of soft as well as hard measures (e.g., Bott et al., 2019; Fitrinitia et al., 2018; Marfai et al., 2015; Padawangi and Douglass, 2015; Purba et al., 2018; Simarmata, 2018; Sugar et al., 2013; van Voorst and Hellman, 2015; Yoga Putra et al., 2019b). The review of community-led adaptation efforts revealed a strong focus on the importance of what can be summarized as social capital for adaptation. A number of studies describe the key role of social networks, which allow for sharing knowledge, experience and best practices (Sugar et al., 2013; Yoga Putra et al., 2019a), which facilitate cooperation and coordination within and among communities, with NGOs, and with universities (Fitrinitia et al., 2018; Goh, 2019; Hellman, 2015; Mathewson, 2018; Padawangi and Douglass, 2015; van Voorst, 2014; Yoga Putra et al., 2019a) and which foster mutual support as well as "practices of communing" (Leitner and Sheppard, 2017) such as the pooling of resources (Guinness, 2019; Leitner and Sheppard, 2017; Padawangi and Douglass, 2015; van Voorst and Hellman, 2015). Social cohesion within networks has also been directly linked to collective action for adaptation (Rahmayati et al., 2017). Empirical examples put forward are for instance collective community works – in Indonesia known as *gotong royong* – for example collective action in river monitoring

and the issuance of flood warnings (Bahri and Purwantiasning, 2019; Dwirahmadi et al., 2013; Fitrinitia et al., 2018; Hellman, 2015; Padawangi and Douglass, 2015; van Voorst, 2014, 2016); flood risk mapping (Dwirahmadi et al., 2013); and the establishment of local, community-based institutions to collectively develop and administer saving schemes and funds used for flood response and recovery (Dwirahmadi et al., 2013; Marfai et al., 2015; van Voorst, 2014).

Looking at how soft and hybrid measures are being evaluated in the literature, this review finds that many studies exhibit a rather critical perspective on state-led soft adaptation measures. Fitrinitia et al. (2018), Mathewson (2018) and Ward et al. (2011a) elaborate that increased state investments into non-structural soft measures, as described above, are not materializing on the ground. Hellman et al. (2018) refer to this as an "implementation deficit", which they find is facilitated by a lack of reinforcement of laws and regulations. The state's hybrid approach, i.e., the combination of protective infrastructure and relocation of exposed populations, is criticized for not only incomprehensively addressing flood risk (e.g., Colven, 2017; Garschagen et al., 2018; Garschagen and Surtiari, 2018; Octavianti and Charles, 2019; Salim et al., 2019; Shatkin, 2019; Wade, 2019) but also causing serious negative effects on the environment and local communities (e.g., Dovey et al., 2019; Garschagen et al., 2018; Garschagen and Surtiari, 2018; Leitner and Sheppard, 2017; Neolaka, 2012; Rahmayati et al., 2017; Surtiari et al., 2017; Texier, 2008; van Voorst, 2016; van Voorst and Hellman, 2015; Ward et al., 2013a) due to the major relocations of informal settlers and the urban poor living in highly exposed areas at banks of the river and coastal areas in the name of flood mitigation (e.g., Goh, 2019; van Voorst and Hellman, 2015). This state-led approach is described as having accelerated since 2009 (Dovey et al., 2019; Ichwatus Sholihah and Shaojun, 2018), and some authors even claim the evictions to be a bigger threat to those evicted than flooding itself (Dovey et al., 2019; Hellman, 2015; Saridewi and Fauzi, 2019).

At the same time, studies highlight the potential of soft adaption measures to create co-benefits with other development objectives. Many studies analyze how the adaptation measures' impacts go far beyond mitigating flood vulnerability as they function as social and financial security, addressing a wide range of vulnerabilities (Hellman et al., 2018; Padawangi and Douglass, 2015; van Voorst, 2015). However, social networks and community cohesion are also described as leading to problematic adaptation effects in some instances. An example is the preservation of exposure to flooding because individuals refuse to leave at-risk areas as they want to stay in the network that gives them a strong sense of belonging and livelihood security (Hellman, 2015; Neolaka, 2012; Rahmayati et al., 2017). Besides this, there are authors who criticize that the often positively portrayed community-led adaptation approaches do not lead to optimal and sustainable adaptation, as actions are often implemented in a reactive, ad hoc and rather uncoordinated manner without sufficient financial means (Marfai et al., 2015; Ward et al., 2013b).

6 Discussion

Our review shows that there is a rich, diverse and rapidly growing body of literature analyzing Jakarta's flood problem and identifying as well as evaluating adaptation options. Looking at the discussed drivers of flooding to answer our first research question, we find that one stream of literature, i.e., publications from the fields flood models & flood mapping as well as hard adaptation, predominantly frames flooding as being caused by environmental physical factors and hence as a hazard that can be controlled through engineering solutions and environmental management. Looking at the size of this body of literature measured by the numbers of publications, this can be considered the main stream of flood risk research in Jakarta. A significantly smaller body of literature composed of studies on soft and hybrid adaptation measures, including a focus on social vulnerability reduction and integrated water management, acknowledges the natural and environmental drivers of flooding but also highlights the importance of socio-economic flood drivers, arguing that these drivers have to be considered equally in the consideration and design of adaptation solutions.

Research question two of this study asks which measures for risk management and adaptation are considered in the literature. Our analysis shows that there are largely two separate perspectives on suitable measures for adapting to flooding in Jakarta. One follows a protection approach, identifying predominantly infrastructural measures such as dams, sea walls, water canalization or reservoir constructions as solutions to protect the city from flooding. The second one is not opposed to infrastructural measures but criticizes how they are implemented and demands among other things the inclusion of soft adaptation options to achieve comprehensive flood risk management and hybrid adaptation approaches. This literature argues that without consideration of the root causes of social vulnerability and flood risk, hard infrastructure solutions are bound to be insufficient or even ineffective in the long-run. Likewise, these studies argue that social and environmental effects of hard protection measures need to be considered more stringently and that soft or hybrid approaches are oftentimes better placed to create synergies with other development objectives.

Evaluating these findings from our own perspective we identify the following five points, which we argue might be helpful for advancing the debate and complementing the current perception on the adaptation solution space in Jakarta.

First, the focus on natural drivers of flooding reinforces the perception of flooding being a hazard that can be controlled by technical measures, skewing the perceived solution space towards hard adaptation measures. While it is, of course, very important to assess and understand natural drivers of flooding

in Jakarta, other drivers of flood risk need to be considered with the same rigor in order to design effective adaptation options. Hard measures are – and will be – undoubtedly an important part of Jakarta's solution space. Yet, a shortfall in the consideration of the anthropogenic flood drivers yields the risk of designing infrastructural solutions that only address parts of the flood problem, hence risking being less effective.

Second, we find an overall lack of considering future developments in terms of both environmental as well as socio-economic changes. Surprisingly, the majority of studies that focus on flood modeling does not yet consider future changes in environmental conditions due to climate change. Some studies look at different flood event return periods as a proxy for changing environmental conditions, although with considerable uncertainties remaining (Budiyono et al., 2015; Juliastuti et al., 2018; Kurniyaningrum et al., 2019; Liu et al., 2015; Syafalni et al., 2015; Supomo et al., 2017). Only a few of the publications focusing on flood modeling and hard adaptation measures consider future urbanization or socio-demographic changes and their impacts as drivers of flood risk. While some incorporate future changes in land use (Budiyono et al., 2016; Fajar Januriyadi et al., 2018; Latief et al., 2018; Mishra et al., 2018; Rafiei Emam et al., 2016; Riyando Moe et al., 2017; Jalilov et al., 2018; Sutrisno, 2011; Takagi et al., 2016b; Vollmer et al., 2015, 2016; Ward et al., 2011b, 2013c), no study in the sample considers future changes in exposure due to, e.g., population growth or urban development. Similarly, the publications on hard flood protection measures mostly neglect future climatic, demographic, socio-economic and land-use changes when assessing the effectiveness of existing or suggested infrastructural measures for flood protection. Some authors use return periods of rainfall events (Mantasa Salve Prastica, 2018) or floods (Ajiwibowo, 2018; Indrawati et al., 2018; Nugroho et al., 2018; Wurjanto, 2018), although without referring to potential future changes. An exception (Takagi et al., 2017) evaluates the effectiveness of planned coastal dikes using flood and subsidence projections until the year 2050. The implications of this shortcoming for the solution space are rather weighty: developed solutions – hard, soft and hybrid – that are lacking the consideration of future developments have an inherent risk of not being sustainable and effective in the long run. While they might address current challenges very well, there is a risk that dynamic changes in environmental and/or socio-economic aspects will impact their effectiveness in the future.

Third, most publications that assess and evaluate the effectiveness of hard measures for flood management in Jakarta do not consider social aspects such as the measures' impacts on social vulnerability or the acceptance of the analyzed measures. This can be an important shortcoming when evaluating the overall adequacy and success of a hard adaptation measure. For instance, resettlements, which are often a precondition for the implementation of hard adaptation measures, significantly influence communities' livelihood opportunities and social structures (Garschagen et al., 2018; Garschagen and Surtiari, 2018; Ichwatus Sholihah and Shaojun, 2018; Surtiari et al., 2017). Furthermore, authors claim that soft aspects such as risk perception and awareness, risk communication (e.g., van Voorst, 2016), behavioral and cultural factors (e.g., Bott et al., 2019; Yoga Putra et al., 2019b), collective action as well as participatory planning (e.g., Sugar et al., 2013), coordination capacities (e.g., Marfai et al., 2015; Padawangi and Douglass, 2015), and law enforcement (e.g., Akmalah and Grigg, 2011) are inherently intertwined with the success of mitigation and adaptation efforts in the long run, hence calling for rigorous consideration. The neglect of aspects such as social acceptance as well as impacts of infrastructural flood protection on local communities influences the solution space in that hard adaptation measures will be considered for flood risk management despite their potential negative impacts on social vulnerabilities. Accordingly, the solution space contains measures that are beneficial for some groups of people while representing a threat to other groups. While this is already alluded to in the assessed literature (e.g., Van Voorst and Hellman, 2015), this seems to have had only marginal influence on flood risk research in Jakarta until today.

Fourth, studies focusing on soft and hybrid adaptation measures converge in their critique of technocratic approaches and provide a broad variety of needs with respect to improving flood risk management, although without providing concrete recommendations for how to achieve them. Depending on the perspective of the author(s), different approaches are advocated for, for instance more integrated and hybrid adaptation approaches (e.g., Akmalah and Grigg, 2011; David et al., 2016; Jalilov et al., 2018) and awareness raising and dissemination of risk and response information to foster behavioral change within the public and authorities and among urban planners (e.g., Akmalah and Grigg, 2011; Amri et al., 2017; Esteban et al., 2017; Goh, 2019; Marfai et al., 2015; Neolaka, 2012, 2013; Nurhidayah and McIlgorm, 2019; van Voorst and Hellman, 2015; Ward et al., 2013b). Others call for regional approaches to land use and urban planning (e.g., integration of upstream and downstream, Jakarta and Jabodetabek[1]; Asdak et al., 2018; Firman et al., 2011; Goh, 2019; Mathewson, 2018; Noviandi et al., 2017) and more integrated legal and institutional frameworks as well as strong institutional bodies for disaster risk reduction and climate change adaptation (Akmalah and Grigg, 2011; Asdak et al., 2018; Firman et al., 2011; Garschagen et al., 2018; Garschagen and Surtiari, 2018; Nurhidayah and McIlgorm, 2019; Octavianti and Charles, 2018; Ward et al., 2013b). Moreover, studies highlight a need for stronger law enforcement (e.g., Akmalah and Grigg, 2011) and increased community-participation in risk management planning and

[1] Jabodetabek is an acronym for the metropolitan area of Jakarta. Besides the city of Jakarta, it includes Bogor, Depok, Tangerang and Bekasi.

decision-making (Goh, 2019) as well as in resettlements (Ichwatus Sholihah and Shaojun, 2018; Texier, 2008). However, the publications provide few concrete recommendations on how to achieve these goals: how can different adaptation measures be adopted for a balanced hybrid adaptation approach? How can the legal and institutional setup be improved, which would most likely include altering current political structures and decision-making processes? How can flood risk policies be integrated with the wider development agenda? How can participatory flood risk management be facilitated? There are only very few publications (e.g., Amri et al., 2017; Asdak et al., 2018; Firman et al., 2011; Nurhidayah and McIlgorm, 2019) providing slightly more detailed information on the implementation and feasibility of suggested measures. Hence, while studies on soft and hybrid measures add valuable knowledge and potential options to the solution space, their lack of actionable recommendations limits their utility. They are more difficult to consider in actual adaptation planning – especially in comparison to hard adaptation measures which often have clear requirements and quantitative assessments of their use.

Fifth, there is a lack of studies that compare multiple adaptation solutions. Apart from a few exceptions (e.g., Lin et al., 2016; Fitrinitia et al., 2018) this lack applies to comparisons between different infrastructural measures as well as between hard and soft measures. This is surprising against the background of the rich diversity of assessments of single measures – be it hard adaptation options such as levees, dams, dikes and embankments (Mardjono et al., 2018; Mardjono and Setiawan, 2018; Ogie et al., 2016b; Su et al., 2018; Sujono, 2012; Susilo et al., 2019; Suprayogi et al., 2018; Takagi et al., 2016a, 2017; Wurjanto, 2018) and water channeling, retention ponds and drainage systems (Indrawati et al., 2018; Kadri, 2011; Kartolo and Kusumawati, 2017; Mahanani and Chotib, 2018; Mohajit, 2015; Nugroho et al., 2018; Sholichin et al., 2019; Wihaji et al., 2018) or soft adaptation measures like mutual support through social networks (Guinness, 2019; Leitner and Sheppard, 2017; Padawangi and Douglass, 2015; van Voorst and Hellman, 2015), collective action in, e.g., river monitoring and early warning (Bahri and Purwantiasning, 2019; Dwirahmadi et al., 2013; Fitrinitia et al., 2018; Hellman, 2015; Padawangi and Douglass, 2015; van Voorst, 2014, 2016), or self-organization of rescue groups for flood response and recovery (Dwirahmadi et al., 2013; Marfai et al., 2015; van Voorst, 2014). For the solution space, this aspect can be considered the most important gap. The absence of comparisons of different measures leaves decision-makers without scientific guidance in understanding the advantages and disadvantages of one adaptation solution over the another. Without comparatively considering the effectiveness, social and environmental impacts, and feasibility of different measures, it is very difficult to identify the "best" adaption options and combine them into sustainable adaptation pathways.

7 Conclusions and outlook

This study aimed at assessing how the solution space for flood risk reduction and climate change adaptation in Jakarta is currently being perceived, framed and evaluated in the academic literature. Learning from Jakarta, one of the cities with the highest flood risk globally, is relevant since many other cities around the globe will be faced with similar challenges over the course of the next decades. The findings show that a focus on environmental flood drivers, numeric flood modeling and hard flood protection solutions constitutes the main center of gravity within the current epistemic landscape of the flood risk and adaptation science on Jakarta. Soft and hybrid adaptation measures as well as potential shortcomings in hard protection approaches are receiving increasing, yet overall considerably less, scientific attention. While hard adaptation measures are – and will remain to be – of key importance for Jakarta to address current and future flood risk in an effective manner, the results nevertheless suggest that the identified imbalance in the current focus is problematic. If not complemented by other perspectives, the focus on hard protection bears the risk that measures which address flood symptoms are prioritized over those addressing the root causes of flood risk and the sources of social vulnerability. In addition, there is the risk that the potential of additional or complementary soft adaptation measures at different scales and implemented by different actors (state, civil society, private sector) is not being given adequate attention in adaptation discourses at the science–policy interface and eventually will not be used and fostered for crafting actual adaptation pathways. Hence, the findings suggest that a considerable part of the potential solution space remains underrepresented in the debate and not advanced with full proficiency.

Relating these findings to global research frontiers, it is striking that the above gaps in the state of science on Jakarta's flood risk and its reduction are so persistent. The literature on Jakarta has been rising sharply, and Jakarta certainly belongs to the most-researched high-risk coastal cities in the world. Yet, our analysis suggests that this high potential has so far not been sufficiently used to inform and advance some of the most pressing frontiers in coastal urban risk and adaptation research: how to develop and test better approaches to model and assess future trends in socio-economic vulnerability within cities, how to evaluate different competing adaptation options in an integrative way while also including aspects of social acceptance and equity, how to design adaptation pathways with a mixture of hard and soft adaptation options so as to seek synergies while overcoming the shortcomings any isolated approach would have, and how to chart and navigate transformational adaptation that shifts the political economy of risk production and the existing paradigms of adaptation away from technocratic fixes and towards the root causes of flood risk and social vulnerability.

While our findings and lessons from Jakarta cannot easily be transferred one-to-one to other risk contexts, recent global assessments (Oppenheimer et al., 2019) suggest that many cities might be facing similar patterns to the ones identified for Jakarta, calling for follow-up research. We therefore hope that the perspectives and questions raised in this paper are useful to inspiring studies on the solution spaces in other high-risk settings.

Code availability. No code was used in this research. The search strings for the literature research are provided in the methods section.

Data availability. The papers used in the review can be accessed through the respective journals. The data underlying the statistical analysis can be shared upon request to the authors.

Author contributions. MG and MW designed the study. MW performed the literature analysis. MW and MG drafted the manuscript.

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5.3. Conceptualizing collective adaptation to climate change

The centerpiece of this thesis is a deductively developed conceptual framework (Figure 11) that I inductively tested through empirical data for the example of collective adaptation implemented by highly vulnerable and exposed residents in Jakarta. It addresses the gaps identified in the systematic reviews by focusing on enhancing our knowledge on soft and integrated, collective adaptation implemented by residents of cities to adapt to recurrent climate change impacts.

For the particular context of high disaster risk in a socio-culturally diverse setting, the framework illustrates and explains under which conditions individuals start identifying with others and how they form social groups that collectively adapt to disaster risk and livelihood challenges. Furthermore, the framework takes into account how socio-cultural diversity may lead to the emergence of multiple collectively acting groups and demonstrates how their interaction may influence adaptation efforts at larger scales.

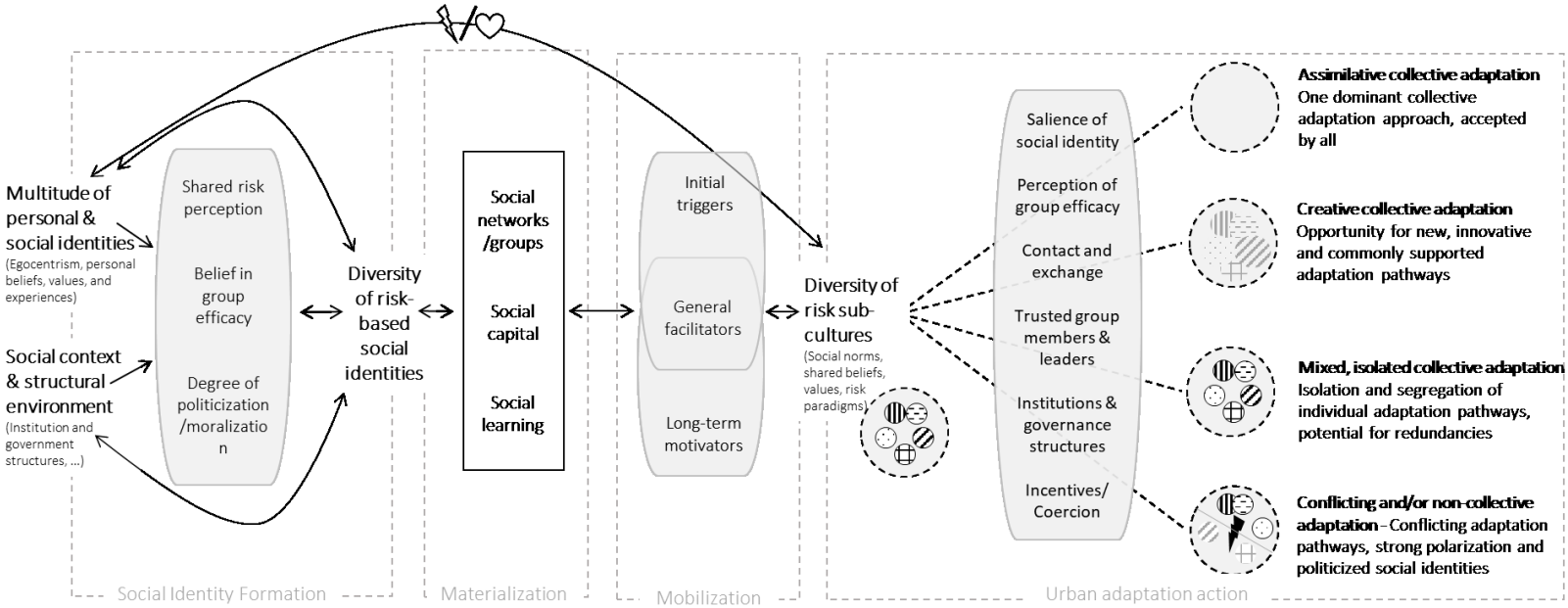


Figure 11: Conceptual framework explaining the formation and mobilization of risk-based social identities in socio-culturally diverse settings

In the following, I will explain the key principles of the conceptual framework by drawing on three scientific publications that validate the framework through empirical application in Jakarta.

5.3.1. The role of social identities for collective adaptation capacities– General considerations and lessons from Jakarta, Indonesia

Social identity theories indicate that social identities form through the interplay of personal identities with social as well as structural and environmental context conditions as illustrated in the first part of the conceptual framework (Figure 11). According to many collective action theories (see Section 3.3), their formation represents the foundation for the materialization of collectively acting groups. It is therefore crucial to consider the psychological underpinnings of group formation for examining and understanding

collective adaption to climate change and its development under changing social and environmental future conditions.

The first scientific publication linked to my conceptual framework examines the formation of groups in the context of climate change adaptation, using the example of vulnerable, flood-exposed neighborhoods in Jakarta. Based on data from semi-structured online interviews with key informants from Jakarta, and expert elicitations with international researchers, I assessed the diversity among *the* most vulnerable in highly exposed neighborhoods in Jakarta. The social identity analysis revealed that out of a plethora of co-existing social identities, only three are salient in the context of adaptation. Informants mentioned family and kin networks, traditional local neighborhood groups, and CSO-supported, cross-neighborhood groups as acting collectively to adapt to climate change. Accordingly, these social identities materialize into groups in the context of climate change adaptation and play a vital role in local adaptation efforts. To better understand the adaptive capacities of these groups, I used a social capital perspective. Analyzing their organizational structures, including their network ties revealed differences in their adaptive capacities, predominately determined by the type of ties they develop. While family networks have the least collective capacities, they can still successfully accommodate recurrent hazards. CSO-supported, cross-neighborhood groups have significantly larger capacities to adapt as they are able to access external resources and knowledge. In brief, the results confirm the socio-cultural diversity at the neighborhood scale and provide evidence for differentiated collective adaptation capacity patterns determined by the types of ties they possess.

The following publication was accepted with major revisions. The version below is the revised and re-submitted manuscript that currently awaits peer-review. The annex of the publication can be found in Appendix B.8.

The role of social identities for collective adaptation capacities– General considerations and lessons from Jakarta, Indonesia

Highlights

- Social identification is the basis for the development of social capital, which partly determines collective adaptation capacities.
- In cities, socio-cultural diversity leads to the co-existence of many different social identities, influencing the collective adaptation capacities of highly exposed and vulnerable inhabitants.
- For Jakarta, Indonesia, we found that three social identities are most important in the context of long-term adaptation to flooding, which significantly differ in their social capital, and hence adaptive capacities.

Abstract

Cities worldwide increasingly host populations which are highly exposed and vulnerable to the effects of climate change and hence need to adapt collectively, whilst featuring high degrees of socio-cultural diversity. While differences in local vulnerabilities and adaptive capacities are increasingly acknowledged, they are mostly explained by drawing on individual social categories such as age, gender, or health status. However, given that residents' capacities to adapt are largely bound in their ability to work together, a stronger focus on social interaction and collaboration is needed. This study presents an analytical approach to analyze the diversity of collective adaptation capacities among sub-groups within allegedly homogenous groups. It does so by examining which social (sub-) groups are salient in adaptation and assessing their respective collective adaptation capacities. We apply this approach in the city of Jakarta, based on empirical data from semi-structured interviews with key informants. The results reveal that in the case of Jakarta, three social identities with differing adaptive capacities are active in the context of flood adaptation. First, kinship and close neighborhood are characterized by very tight networks with limited capacities. Second, institutionalized local neighborhood groups with strict social norms and traditions. Third, cross-neighborhood, civil society supported groups have far-reaching capacities thanks to bridging and linking ties. The findings extend current knowledge on collective adaptation capacities among hitherto ill-perceived and supposedly homogenous groups of *the* most vulnerable. Findings therefore can be valuable for improving adaptation policies and programs, particularly in the field of supported adaptation.

Keywords: urban diversity, social identity, social capital, collective adaptation capacities, Jakarta

1. Introduction

Globally, coastal cities face increasing challenges due to the interplay of environmental change and urbanization (IPCC, 2022b). This is particularly evident in highly exposed Southeast Asian coastal cities, where increasingly intense impacts from natural hazards such as flooding and storm surges interact with dynamic socio-cultural and economic changes (Januriyadi et al., 2018). Such high-risk areas are often home to urban residents with limited capacities to deal with high exposure, making them highly vulnerable (IPCC, 2022b). They share many characteristics such as being poor, being employed in the informal sector, living in informal and exposed housing, having no access to state services and limited access to basic services, and

being less educated (IPCC, 2022b). As a result of these widespread similarities, they are sometimes still referred to as "the urban poor" or "the most vulnerable" in programs of civil society and non-governmental organizations, as well as in policy-making. For instance, the 2030 Agenda for Sustainable Development frequently refers to "the poorest and most vulnerable" (United Nations, 2015). While the scientific community has increasingly recognized and considered a more nuanced understanding of vulnerability and adaptive capacity patterns, these differentiations primarily focused on explaining individual-level differences using social categories such as gender, age, health status, and class (Otto et al., 2017). Although these categories uncover differences in individual vulnerabilities, this study argues that it is worthwhile to consider the social embeddedness of individuals. Being member of a network or group can provide access to collective capacities and resources, buffering individual vulnerabilities.

Given that groups and networks develop on the basis of shared socio-cultural aspects (Brewer & Yuki, 2007), the latter are important to consider when assessing local vulnerabilities and capacities to adapt. Residents living in highly exposed areas often exhibit socio-cultural differences in ethnicity, religion, migration status, beliefs, norms, aspirations, and worldviews. Besides being the basis for group formation, such cultural aspects are also important to consider because they can significantly influence risk perception, vulnerability, and behavior (Adger et al., 2013; Bankoff, 2017; International Federation of Red Cross and Red Crescent Societies, 2014; Mercer et al., 2012). To gain a more nuanced understanding of "the community"(Titz et al., 2018), we must acknowledge and better consider the influence of culture on social collaboration, including collective adaptation (Larson & Lewis, 2017; Meer & Tolsma, 2014; Thomalla et al., 2015). The relevance of local collective efforts and the role of communities in urban adaptation has already been flagged by Adger in the early 2000s (Adger, 2003). The latest IPCC report (Ara Begum et al., 2022) describes transformation in the context of climate change as a collective action problem and calls for stronger emphasis on adaptation governance, which is strongly linked to collective adaptation. Effective adaptation governance, according to the AR6, requires strong, multi-level systems of governance, spanning global, regional, national, local, trans-regional, and trans-national levels (ibid.). Furthermore, the AR6 emphasizes the importance of understanding and considering "behavioral factors (incl. cultural and psychological factors) in adaptation behavior." (Chapter 10.5.3), which are closely linked to collective adaptation, as we will show later.

However, our understanding of collective adaptation is still limited, particularly in relation to two key gaps we identified. First, many studies on collective coping and adaptation focus on rural and/or culturally more homogeneous groups (e.g. (Dove, 2008; McNeeley & Lazrus, 2014; Tozier de la Poterie et al., 2018)). We lack a comprehensive understanding of which groups actively engage in long-term adaptation to climatic changes and how they form in socio-culturally diverse contexts. This is crucial because socio-culturally different groups likely vary in adaptive capacities and hence vulnerabilities, acceptance of state-led adaptation initiatives, as well as collective behaviors, including engagement in coping with and adapting to flooding. Second, those studies that assess collective action in urban contexts showcase several gaps. Some studies concentrate on the immediate disaster response, where impacted individuals often collaborate across socio-cultural boundaries without reservations (e.g. (Surtiari et al., 2015)). However, this differs greatly from long-term engagement in adaptation. Studies that in fact focus on urban long-term collective action for adaptation often fail to consider internal heterogeneities among participants. By using terms such as "community" in concepts like community-based adaptation (Kirkby et al., 2018; McNamara & Buggy, 2017), community engagement (Baybay & Hindmarsh, 2018; Geekiyanage et al., 2020) or community autonomy (Pisor et al., 2022) they overlook the existence of heterogeneities and non-participation within "communities". In other words, the co-existence of various social identities and hence groups in close proximity in hazard-prone areas and their interactions, including dynamic changes due to politicization and stigmatization remain poorly studied. Lastly, even when acknowledging diversity within communities in terms of vulnerability (e.g. (Archer et al., 2020; Hossain & Rahman, 2018), the implications for group formation and collective action for adaptation are not considered.

2

In-depth knowledge about the formation of collectives in socio-culturally diverse settings, including their respective adaptive capacities, vulnerabilities, and mutual influences is key for improving and scaling up urban adaptation action. Our study addresses two concrete questions to advance current knowledge in this particular field: 1. Which social identities co-exist among "the most vulnerable"? The number of identified social identities serves as an approximation of socio-cultural heterogeneity among the most vulnerable. 2. Which social identities are salient and active in the context of adaptation to flooding and what are their respective adaptive capacities?

This study showcases that the combination of social identity theory with the social capital approach can deepen our understanding of the dynamics of social identity salience and related capacities to adapt to flooding in two particular ways: First, it allows us to analyze how diverse *the* most vulnerable are, assessing diversity based on co-existing social identities. And second, by examining the adaptive capacities of those social identities that become salient and active in the context of flood adaptation, we get a better understanding of their adaptation potentials. By combining this deductive, theory-driven research approach with inductive elements rooted in grounded theory principles, we generate valuable insights into our case study's social fabric, the emergence of groups in flood adaptation, and their respective used and unused capacities. Such insights add to the current knowledge on collective adaptation to climate change, while offering a new, more social perspective to urban policy makers to better understand and consider adaptation capacities bound in local groups.

2. Understanding social identities among *the* most vulnerable and exposed and their respective capacities– conceptual considerations

Considering the broader context of the study which focuses on flood risk, vulnerability, and adaptive capacities in socio-culturally diverse contexts, we follow the IPCC's definitions of risk and vulnerability. Accordingly, we see risk as a result of the interaction between exposure to a hazard, its likelihood, and vulnerability. The latter is defined as "the propensity or predisposition to be adversely affected." (IPCC, 2022a) and emerges through an interplay of sensitivity, susceptibility, and a lack of coping and adaptive capacity (IPCC, 2022a). In line with this definition, this study uses collective adaptation capacities as a proxy for the vulnerability of a group. The higher the collective adaptation capacities, the lower the vulnerability of the group to suffer in the face of hazard exposure. Adaptive capacities among highly vulnerable individuals are largely bound in social capital (Adger, 2003), so that the vulnerability varies depending on the type of social capital (Fraser & Naquin, 2022). Taken together, we assume that social identities represent the precondition for the development of social capital, which is an important source of adaptive capacity among highly vulnerable and exposed individuals. The higher their adaptive capacities, the lower their vulnerability in the face of climate change risks.

To unpack presumed homogeneities among *the* most vulnerable, we make use of Social Identity Theory (SIT) (Tajfel, 1974, 1981) and Self-Categorization Theory (SCT) (Turner & Reynolds, 2012) because they are instrumental in assessing group formation processes from a psychological perspective. According to SIT, human identity can be understood as a spectrum from identifying as an individual (personal identity) to being group-oriented (social identity). When personal identity becomes active and dominant, or salient as it is called in psychology, individuals primarily focus on their own attitudes, memories, and emotions, emphasizing their uniqueness and independence from social groups (Hornsey, 2008). However, individuals mostly evaluate, understand, and judge themselves in comparison to others, that is in social comparisons, so identities are always social to a certain extent (Carr, 2021). Social identity salience is triggered through specific context conditions and leads individuals to think and behave as group members, with shared beliefs and values shaping their self-understanding (Hornsey, 2008; Kawakami & Dion, 1995; Tajfel, 1981). The

determination of ones in-group depends on perceived similarities with the group as well as differences to at least one out-group and hence depends on social comparison and categorization. In our study, aspects that may trigger feelings of similarity are called identification factors. Examples are ethnicity, religion, profession, age, place attachment, worldviews, and particular experiences. Hence, social identities are often closely interlinked with cultural orientation and social norms which largely shape human evaluation of who belongs to "us" and who to "them".

Recent literature has demonstrated that social identities and (collective) adaptation to climate change are linked through a mutually influential relationship. On the one hand, climate risks and threats shape cultural values, individual and collective identities as well as risk perceptions and behavior of both, individuals and groups (Adger et al., 2013; Barnett et al., 2021). On the other hand, a reverse influence from identities on climate risk perceptions, beliefs, and group interactions exists (Bliuc et al., 2015; Pearson & Schuldt, 2018; Postmes, 2015; van der Linden, 2015). Self-categorization and group identification in the face of climate risks lead to the adoption of crucial in-group norms, the feeling of group efficacy, and collective emotions, which together influence collective action in the face of climate change (Masson & Fritsche, 2021). Hence, it is crucial to identify which social identities are salient in the face of climate risks to better understand varying risk perceptions and behaviors.

Given that the identified groups' adaptive capacities are partly bound in their social capital (Adger, 2003), this study uses the social capital approach to assess the groups' adaptive capacities. We adopt Woolcock's encompassing definition of social capital, describing it as "the norms and networks that facilitate collective action" ((Woolcock, 2001):9). Potential adaptive capacities are those that are theoretically available but not yet utilized. Collective action outcomes can benefit both, the collective and the individual; combining perspectives of earlier (e.g.(Coleman, 1988) and later (e.g. (Putnam, 2000)) understandings of social capital as described by (Portes, 2000). Similar to established social capital scholars, we differentiate between binding, bonding, linking, and bridging ties that result in potential social capital (Adger, 2001; Lin, 2008; Woolcock, 2001). *Binding ties* are tight-kid, intimate social relations between for instance close family members, characterized by strong mutual trust, support, and intense interaction (Lin, 2008). *Bonding ties* exist among a majority of members in a closed group, with slightly looser but still reciprocal social connections manifested through frequent interaction, knowledge sharing, and mutual support in times of crisis (Adger, 2001; Lin, 2008). Such networks are characterized by a strong presence of social norms. Both, binding and bonding ties are exclusive, extending horizontally based on family, kinship, and/or close friendships. Due to their closed nature, resources, and information within these networks are limited and homogeneous (Lin, 2008). *Bridging social capital* is formed through less strong connections between individuals and represents the capital emerging from horizontal as well as vertical connections between different social groups. Such networks are less dense, and individuals interact in less trust-based relationships. However, such networks are often more resource-diverse (Lin, 2008). *Linking social capital* can be considered a refinement of bridging social capital. It differs from the latter in that it emerges from linkages between individuals and institutions (Woolcock, 2001) and/or across social classes (Bott & Braun, 2019). In that sense, it functions mostly vertically and facilitates access to higher levels of governance.

3. Jakarta

Jakarta – a multicultural city

With more than 1000 ethnic and sub-ethnic groups, the archipelago nation Indonesia is shaped by a remarkable level of plurality regarding ethnicities, religions, beliefs, and traditions due to the development and preservation of different cultures on its many islands (Hoon, 2006). In national politics, this diversity has always played a pivotal role, and political leaders have employed varying approaches to manage it since

independence. The country's capital Jakarta is a representation of the nation's cultural diversity. Located on the island of Java, which is home to over 58% of the country's population (Randolph & Naik, 2017), Jakarta's social and built structure is influenced by its colonial past. During the era of Dutch colonialism, Jakarta experienced strict ethnic segregation enforced by the colonialists to secure their dominance over urban ethnic groups (Kehoe 2015). To this day, remnants of these ethnic enclaves remain visible in many parts of the city. In-migration in the course of Jakarta's rapid growth mostly happened along family ties, keeping ethnic compositions in their former boundaries rather homogeneous, while ethnic heterogeneity at the city scale is high (Hadi & Tirtosudarmo, 2016).

Table 1 visualizes the ethnic composition of the city. The capital's diversity is commonly known and was already highlighted by Castles in 1967 (pp.153) who describes Jakarta as a "melting pot" as it composes of a large variety of migrants from all over Indonesia (Bernado et al., 2019; Hoon, 2017).

Table 1: Ethnic groups in Jakarta in 2010 (based on Hadi, Tirtosudarmo 2016)

Ethnic Groups in Jakarta in 2010	%
Javanese	36.16
Betawi	28.29
Sundanese	14.61
Chinese	6.62
Others	4.67
Batak	3.42
Minangkabau	2.85
Malay and from other islands	1.16
Madurese	0.84
Bugis	0.72
Palembangnese	0.66

The diversity is spread across the entire metropolitan region which is named Jabodetabek, an acronym for Jakarta, Bogor, Depok, Tangerang, Bekasi, Puncak, and Cianjur. According to (Padawangi & Douglass, 2015), this metropolitan region grows by 250.000 migrants every year (p.522), leading to a rapid expansion of the urban space as well as to an overall transition of its socio-demographic patterns (Jones et al., 2016).

Administratively, the province of Jakarta is divided into five municipalities (*kota*), i.e. North, West, South, East, and Central Jakarta. These municipalities are again divided into sub-districts which are called *kecamatan*. The latter compose of villages (*kelurahan/desa)* with leaders who are appointed and paid by the central government (Nasution, 2016). The lowest level of administrative units in Jakarta are neighborhood associations (*Rukun Warga (RW)*) and neighborhoods (*Rukun Tetangga (RT)*). While being the smallest units, the number of households with RWs and RTs varies considerably depending on the size and density of the neighborhood. RW and RT leaders are elected by the residents and play an important role in all local administrative processes. This study focuses predominately on assessing diversity at the RT level.

Flood risk and management in Jakarta

As a low-lying coastal city with many rivers running through it, Jakarta has a very long history of flooding (Marfai et al., 2015). It is highly prone to pluvial, fluvial, and coastal flooding as well as to other coastal hydrological impacts such as storm surges and sea level rise (Garschagen et al., 2018; Januriyadi et al., 2018; Mishra et al., 2018). In the recent past, very severe flood events occurred when heavy precipitation coincided with high run-off rates and high tide levels (Garschagen & Surtiari, 2018). Especially low-lying

coastal areas in North Jakarta and the banks of Jakarta's various rivers including the Ciliwung are highly exposed (Tambunan, 2017). In the future, the city is likely to experience even higher levels of exposure and risk due to climate change impacts and urban development (Moe et al., 2017). The combination of sea level rise and more intense precipitation events in the Ciliwung river catchment is expected to lead to more frequent and intense flood events (Januriyadi et al., 2018; Mishra et al., 2018), while urban development is likely to reinforce land subsidence, which is a key driver of flooding in Jakarta already today (Garschagen et al., 2018).

Due to the city's long experience with flooding, knowledge about and management of Jakarta's flood risk management builds on rich scientific research as well as hazard experience. For a comprehensive overview of the research landscape around flood risk research as well as responses and flood risk reduction measures, the reader is directed to (Wannewitz & Garschagen, 2020). Despite efforts to protect the city from flooding, increasing hazard frequencies and intensities as well as continuous land subsidence lead to recurrent flooding in Jakarta year after year. In particular, highly exposed areas, which are mostly inhabited by the urban poor are at high risk – not the least due to their high vulnerability. In the absence of effective flood protection from the state, they have developed their own, small-scale coping and adaptation mechanisms, which help them to accommodate flooding (Bott & Braun, 2019).

4. Methodology

Given that this study aims at identifying and assessing social constructs that are salient under distinct environmental and social context conditions, we adopt a social constructivist perspective (Chipangura et al., 2016; Quarantelli, 1998). It allows us to take a differentiated perspective on the influence of socio-cultural underpinnings on social identity formation and its implications for social vulnerabilities, risk perceptions as well as behaviors.

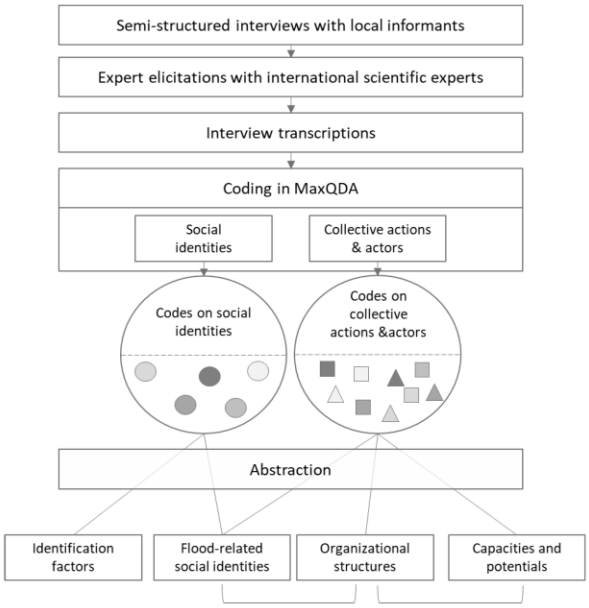


Figure 1: Overview of the methodological approach

To address the two questions outlined in the introduction, we applied a mix of inductive and deductive research methods. Following the illustrated research flow (see Figure 1), we used semi-structured key informant interviews (see Appendix for questionnaire) to collect data on social groups, and networks as well as their collective activities related to climate change adaptation. We identified key informants through two processes. First, our Indonesian project partner – a Jakarta-based researcher with in-depth knowledge about flood-vulnerable groups in Jakarta – recommended and put us in contact with a few knowledgeable informants. Second, the interviews with these purposefully selected informants were used for snowball-sampling further key informants, who met the following criteria.

- Local embeddedness (e.g. living in flood prone areas together with highly vulnerable residents, working in high-risk contexts with vulnerable residents for several decades, strong personal relationships with residents living in high-risk neighborhoods)
- In-depth knowledge (e.g. acquired through personal experiences in the high-risk context, through close interaction with residents, through previous research conducted in the high-risk context)
- Context-awareness (not only focused on local context conditions but their embeddedness in the larger Jakarta context because of links to higher levels of governance, political advocacy work for the needs of the most vulnerable, or research)
- Different professional backgrounds (social, academic, religious, or international interaction with highly vulnerable residents in high-risk neighborhoods)

We consider key informant interviews suitable for this study for several reasons. First, the inclusion criteria (see above) ensured that key informants could provide representative information about local living conditions, social processes, and collective actions. Second, even if we would have conducted interviews with a large number of local, highly vulnerable residents, we would not have been able to obtain a finite overview of all existing social identities. Given that the aim of this study was to approximate co-existing social identities in high-risk neighborhoods but focus explicitly on those salient in the context of adaptation to flood risk, contextual knowledge by key informants was more valuable than a large number of highly localized insights. Third, in contrast to for instance a large-scale household survey, key informant interviews about those who are at risk allowed us to circumvent difficult and controversially discussed priming for contexts of collective adaptation action which would otherwise have been necessary to trigger related social identities (Molden, 2014; van Hoorn, 2018). Finally, interviewing local residents would have posed considerable challenges for avoiding response biases, given the exploration of latent concepts and local social relations.

The interviews were conducted online via Zoom with 23 local informants from four different stakeholder categories (see table 2) between July 2021 and January 2022. Once no new information came about and the interviewees did not mention new informants, we stopped the process assuming that we reached saturation. However, given that some of the identified and invited informants never replied, our findings might suffer from a slight bias. Furthermore, nine interviews were conducted in Indonesian language with a translator which is a source for misunderstandings and misinterpretation of the transcribed translations.

Table 2: Interview partners

Stakeholder type	Number	Description
International Organizations	5	Multiple UN organizations as well as international development organizations
Indonesian Civil Society Organizations	11	Jakarta-based, international aid organizations, local faith-based organizations, and Jakarta-specific civil society organizations as well as community-based activist groups
Indonesian Research Institutes	4	Indonesian, Jakarta-based think tanks, research institutes, and research centers
Governmental Actors	3	National and provincial disaster management agencies as well as Jakarta provincial government
Scientific experts	6	Researchers from renowned universities as well as research institutes in Australia, the US, Singapore, and Germany

In addition to the semi-structured interviews, we used expert elicitations to put the acquired insights into context. Between December 2021 and January 2022, we interviewed six international scientists, who we purposefully selected based on their scientific research experience in Jakarta. All of them have conducted empirical work in the city and published on the topic of flooding and/or related topics including evictions, social vulnerabilities, and risk management in Jakarta. During the interviews, the selected scientific experts were presented the central hypotheses resulting from the interviews with local informants, which they were asked to reflect upon to validate the preliminary findings (see Appendix B for questionnaire). The scientific experts provided additional knowledge, which complemented the findings and set them into context.

The transcriptions and analyses of all interviews were implemented with MaxQDA software. The qualitative content analysis (Mayring & Brunner, 2009) was guided by pre-defined research questions and implemented in four analysis steps as visualized in figure 1. First, we broadly coded for themes of interests, that is "social identities" and "collective actions and actors". These initial codes are based on literature and were hence derived deductively. In the second step, we re-assessed these codes by inductively and iteratively developing sub-codes (see Appendix C for coding scheme). For example, we refined the broad codes on social identities into sub-codes representing the different social identities mentioned by the informants (e.g. family, fishermen, Muslim, Sundanese, etc.). In the same step, we also assessed which of them were mentioned in relation to climate risks. Similarly, we reassessed the codes on collective actions and actors by refining them into codes reflecting on their adaptive capacities and their respective internal structures. In the third step, we categorized the refined codes. Social identities were assessed for their respective identification factors, that is, the overarching factors individuals identify with. For the social identities *newcomers*, *international migrants*, and *long-term residents* the identification factor is for example the *time of residence*. The identification factors help to create inductively derived clusters within the high diversity of identified social identities. In the last step and guided by our second research question, we assessed overlaps and connections between the categories, particularly between social identities and collective actors to assess which social identities are salient and active in adaptation to flooding. Furthermore, we examined the connections between flood-related social identities and mentioned structures, giving implications on their social capital and adaptation capacity. Assessing the connections between these aspects allowed us to identify social identities salient in adaptation and how they are structured, evidencing their social capital, which includes parts of their collective capacities to adapt.

5. Results

The study resulted in two key findings. First, there is a rich variety of social identities in Jakarta's most flood-prone areas out of which only three become salient and active in collective adaptation. Second, these three social identities, once materialized into groups and networks, significantly differ in their capacities to cope with and adapt to flooding. In the following, the key findings will be detailed.

Informants highlighted unanimously that the entire city of Jakarta is highly diverse with respect to the socio-cultural characteristics of its inhabitants. Similarly, those who are most exposed and vulnerable to flooding are very heterogeneous in this respect. The qualitative content analysis of the key informant interviews yielded many identification factors, based on which individuals can identify and form different social identities as detailed in Table 3. More detailed information including supporting quotes on all identified social identities can be found in Appendix D.

Table 3: Identification factors and related social identities

Identification factor	Social identity
Kinship and emotional relations	Family
	Relatives
	Close friends
	Close neighbors
Time of residence	Newcomers
	International migrants
	2nd-3rd generation residents
	Long-term resident
	Native residents
Threat/risk	River flooding
	Coastal flooding
	Evictions/resettlement
Occupation	Fishermen
	Seasonal workers
	Daily wage laborers
Religion	Ahmadiyya
	Shia
	Christian
	Muslim
Ethnicity	Betawi
	Padang
	Javanese
	Sundanese
	Bugis
	Minangese
	Batak
	Bima
Administrative entity	RT
	RW
	Kampung
Traditional, institutionalized local groups	Gotong royong
	RT/RW
	PKK
	Arisan
	Youth group

	Women group
	prayer groups
Cross-neighborhood CSO-supported groups and their related sub-groups	Jaringan Rakyat Miskin Kota (JRMK)
	Jakarta Legal Institute (LBH)
	Urban Poor Consortium (UPC)
	Ciliwung Merdeka
	Ciliwung Institute
	ArKom,
	Cooporatives Komunitas Ciliwung
	River Schools
	Kampung cooperatives
Flood location	Riverbanks
	North Coast

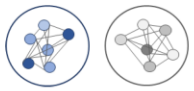
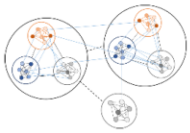
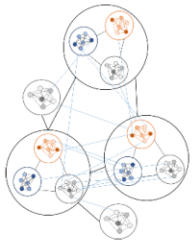
It can be assumed that these are only the most dominant social identities. Key informants mentioned them when asked for collective activities carried out in highly exposed neighborhoods in Jakarta. Many of them are closely interlinked and may overlap, depending on the context conditions. For instance, religious social identities are often strongly correlating with ethnicity, kinship, administrative entities, and traditional local groups in Jakarta. Practically, this means that those identifying with for instance the Muslim community might also be close friends or family, live in the same RT or kampung, and be member of the same neighborhood groups. Although these social identities exist independently and become salient through particular context conditions or social settings, the overlaps can be significant which is why it is difficult to separate them clearly. Therefore, we can only approximate the dominance of salient social identities by observing the materialization of groups in certain context conditions.

Throughout the interviews it became clear that not all social identities that exist in exposed areas are relevant in the context of collective adaptation to flooding[1]; at least not when it comes to actual adaptation efforts. Three social groups stand out in terms of salience in collective adaptation action. 1. Families and close neighborhood, 2. Traditional, institutionalized local groups, 3. Cross-neighborhood, CSO-supported networks. While other social identities may be salient too, these three were mentioned most often and in direct connection to active engagement in collective activities related to long-term adaptation to flooding. While we do not directly assess their adaptation-related activities but deliberately focus on examining their capacities to adapt, we use their activities as an indication for their salience and importance in collective adaptation.

We assessed the adaptive capacities of these three most relevant salient social identities by examining their social capital. Due to differences in their internal organization and the type of ties they possess, they have a differentiated access to resources and knowledge to adapt to climate risks in the long-term. This includes resources and knowledge obtained through their group that may help them as individuals as well as the entire group to adapt to climate change impacts. Accordingly, the capacities are not exclusively collective but obtained through the collective for individual as well as collective benefit. Table 4 provides an overview of the structures, members, and capacities of the three most relevant salient social identities in adaptation to flooding in exposed neighborhoods in Jakarta.

[1] This does not include the immediate response to flooding, as this triggers other combinations of social identities, which have been researched in other studies already (e.g. (Surtiari et al., 2015)). Instead, it was decided to map out all identities actively involved in any type of long-term adaptation action.

Table 4: Social identities linked to flood adaptation and their respective capacities

	Kinship and close friends/neighborhood	Traditional, institutionalized local groups	Cross-neighborhood, CSO-supported networks
Structure			
Who forms the group and how is it organized?	- Entire family, close neighborhood, and close friends - Very local - Natural/organically grown groups	- At least one household member in one neighborhood group - Neighborhood - Traditional, administered local groups with clear leadership	- Different in every context, seldom the entire neighborhood - Cross-neighborhoods - Emerging, externally supported groups with shared leadership
Reasons for salience in the context of adaptation	Tradition, social norms and pressure, trust, emotional ties, dependence, shared threat	Social norms/pressure, dependence on network structures, leadership, collective culture	Belief in group efficacy, good practice/success examples, shared visions, popularity
Capacities	Binding ties lead to social capital in the form of mutual support in the form of food, assets, shelter, workforce, emotional support, information (exclusive, no common goods)	Bonding and bridging ties lead to social capital in the form of informal early warning, evacuation plans, distribution and coordination of assets and help, provision, and distribution of community food and health items, cleaning Linking ties leading to social capital in the form of emergency services, disaster funds, capacity building, asset donations, infrastructure investments	Bonding ties at the neighborhood level enable social learning, mutual support, self-organization, collective business-development, and empowerment. Linking ties lead to social capital in the form of advocacy of local needs, community development (structuring and organizing), capacity building, education, social justice

Families and close neighborhood (smaller and closer than RT)

Family, close friends, and neighborhood become a salient social identity and active groups in the context of adapting to recurrent flooding with capacities released through binding ties resulting in social capital. In Indonesian culture, kinship networks are omnipresent and very important. The close-knit family relations are characterized by strong social norms of mutual support and trust. Shared ethnicity, religion, worldviews as well as threats further reinforce these ties. However, it is exclusively accessible for members of this particular social network, that is family and in the context of exposed and vulnerable neighborhoods in Jakarta also very close friends and neighbors. With respect to their adaptation capacities, limited adaptation

knowledge, assets, and long-term vision lead to rather small-scale, short-term efforts to deal with flooding. Examples mentioned by the informants were for instance small infrastructural adjustments implemented with the help of family members, trust in mutual support in and after the immediate flood situation as well as access to workforce and small family loans used to accommodate flooding. Given the exclusivity of family networks, and lacking bridging and bonding ties, external knowledge, and capacities that could potentially increase their adaptive capacities rarely enter such networks.

Traditional, institutionalized local groups

The second social identity salient and collectively active in the context of adaptation to flooding is linked to traditional neighborhood-scale institutions such as RT and closely related groups like gotong royong, arisan, youth, and women groups. Traditionally, these rings of coordination with clear leadership are very important for each and every household of any RT in everyday life conditions and there is a strong tradition and high social pressure to engage in them. Within these rings of coordination, bonding ties free social capital in the form of for instance information exchange, asset sharing, mutual support, informal loans, and informal preparedness measures like collective river cleaning to mitigate flooding. These collective capacities help group members to prepare for and accommodate flooding. Engaged and knowledgeable local leaders may develop bridging ties by linking up and coordinating the different RT groups, which can considerably increase collective potentials, knowledge exchange, and coordinated mutual support at the RT level. Lastly, local leaders may also establish linking ties to higher levels of administration opening up opportunities to access support structures and knowledge. *"So it's really the case that the RT leaders and the RW leaders function very strongly as gatekeepers. That is, they are the mouthpiece to the outside world and they are the ones who provide the social networks and contacts to the outside world. This means that if you have someone who is very committed, a lot works, and if you have someone who is not, very little works." (SE-1, own translation).*

While this potential exists, informants stressed that in many cases RT leaders as well as their respective traditional sub-groups are highly localized, self-centered, and act in isolation rather than joining forces. This is not the least due to the practical aspect that the life of the most exposed and vulnerable predominantly takes place within their RT boundaries (SE-3). In some cases, conflicts between local leaders within one RT hinder cooperation.

Cross-neighborhood, CSO-supported networks

Cross-neighborhood, CSO-supported networks have become important social identities with significant capacities in the context of adaptation to flooding. Key initiators are for instance Ciliwung Merdeka, Ciliwung Institute, the Urban Poor Consortium, and JRMK with their respective charismatic leaders who work in close collaboration with the neighborhood associations (RT) or with individuals in exposed areas. While creating strong bonding ties at the local level through among others shared visions, these social identities are not only local but span across neighborhoods in areas with similar exposure profiles. With their clear mandate to support residents in meeting their basic needs and right to the city, they have over the last years significantly supported RTs to organize and empower themselves. Beyond this, these identities are the only ones that exhibit strong linking social capital. The latter enables them to access adaptation knowledge, international expertise, and legal support. Furthermore, their linking ties allow connections to higher administrative levels, and political decision-makers, making them instrumental in advocating for local needs and making otherwise overlooked parts of the population visible in urban planning initiatives. In the case of Jakarta, these organizations did not shy away from suing their government to fight for their members' needs and visions.

Upon analyzing the location and geographic coverage of the most dominant CSOs' engagement, it appears that they focus on communities within a particular flood context. For instance, Ciliwung Merdeka and Ciliwung Institute mostly support selected communities along the Ciliwung River. In recent years, their

efforts in flood adaptation have primarily revolved around awareness raising, capacity building and local empowerment by fighting against evictions of riverbank settlers. "*[…] what we are doing is not fighting against the government, but we are defending the rights of citizens based on the law. We won in the court, up to Level 2 court we still won in court.*" (CSI-7). Ultimately, the evictions could not be avoided, however, the court cases significantly increased these organizations' popularity. Social identification, belief in group efficacy, and the moral conviction to have the right to stay strengthened the movement and hence their role in flood management in Jakarta. Ciliwung Merdeka successfully gave voice to the most exposed in higher levels of decision-making for the first time. Recently, proposals developed by community architects in a participatory way were at least considered in local development planning initiatives by the local government, showcasing their degree of influence and hence capacities in urban planning.

Along the North Coast, as well as in East and West Jakarta, two CSOs are key in terms of social capital for adaptation. The Urban Poor Consortium (UPC) together with JRMK, a civil society organization that historically roots in UPC but now works independently, focus on community organization and empowerment for self-organization and decision-making. *"So RUJAK [is] assisting about the technical things and UPC […], the member of UPC is assisting more about the social, social strategies or social movement and the JRMK itself is the community organizations. So, […] there are a lot of kampungs [which] become […] member of JRMK and then they build a network to do many things like advocate their issues to the government or to build their capacities."* (CSI-10). Similar to the Ciliwung area, avoiding evictions and division of local neighborhoods through urban development projects, is a key objective at the North Coast. Besides court cases against evictions supported by the Jakarta Legal Institute, JRMK started to support interested residents to establish kampung cooperatives to obtain collective land ownership. *"[…] many of these kampungs now create cooperatives in the kampungs as part of the one who will take care of these buildings so what we propose is collective ownership through cooperatives […] to still secure the land, secure the buildings in the long future but also to prevent transfer of ownership [which] happens in many slums, right. […] the poverty begins when the poor don't have title to their property so they cannot somehow use it or capitalize it as their income for example like put it on the bank, getting the loan, starting their own business […]." (SE-5).*

All in all, CSO-supported networks are instrumental in the development of social capital that significantly extends the adaptive capacities of the network members. While these CSOs create strong bonding ties within neighborhoods though shared visions, belief in group efficacy, and shared moral convictions, they also facilitate links across neighborhoods, and to external actors. Linkages to international experts, and higher levels of governance are crucial to go beyond accommodating flooding, but to potentially address some of the key drivers of their flood vulnerability. While the CSOs are hence instrumental in increasing their members' adaptive capacities, cooperation between them does not take place in an institutionalized form yet.

6. Discussion

This study addresses two important research questions to advance our understanding of collective adaptation capacities using the case of Jakarta, a highly at-risk coastal megacity.

In response to our first research question, that is, which social identities co-exist among *the* most vulnerable, our results provide empirical evidence for the high diversity of socio-cultural characteristics and consequently social identities among the city's most flood-exposed and vulnerable residents. This is in line with calls for a more nuanced perspective on "*the* community" (e.g. (Titz et al., 2018)) or *the* most exposed or vulnerable. Our approach demonstrates diversity beyond conventionally assessed social categories such

as gender, age, health status, or class. This is relevant for two particular reasons. First, identifying diversity beyond established social categories helps to understand the social embeddedness of individuals, which changes depending on social and environmental context conditions. It demonstrates how individuals can identify with others based on various identification factors, allowing them to tap network or group resources in situations when the particular identity is salient. This offers a dynamic and social perspective on diversity within *the* community. Second, socio-psychological and cultural influences on life are co-constitutive (Fiske et al., 1998); social identification emerges on the basis of shared socio-cultural factors. Hence, assessing social identification allows us to consider socio-cultural characteristics of groups, which can influence risk perception and behaviors of both individuals and groups (Adger et al., 2013; Bankoff, 2017; International Federation of Red Cross and Red Crescent Societies, 2014).

In response to our second research question, i.e. which of the social identities are salient and active in adaptation to flooding, this study finds that only three of the various social identities, namely, family and kin, traditional neighborhood groups, and CSO-supported groups, are relevant and active in this particular context. While more research is needed to analyze why exactly these three social identities are activated in the context of collective adaptation, our empirical data provides first insights. For the first two social identities, family and close neighborhood/friends as well as RT-related social identities, we posit that they become salient and active in long-term adaptation because of their high salience and relevance in individuals' daily lives. These social identities facilitate the access to capacities that those living in exposed areas need frequently - even during normal circumstances. Essentially, these social identities can be considered commonplace collective structures in such areas which are governed by strict social norms. The third social identity, CSO-supported groups, have gained importance only in recent years, particularly during the fight against evictions in the name of flood protection in 2015 and 2016. We hence assume that they become salient in the context of long-term adaptation because of a strong shared vision and hope for the future regarding flood adaptation. At the same time, a strong belief in group efficacy seems to be present within this social identity, with members perceiving that their (adaptation) goals are better achieved through collective rather than individual efforts. Hope, moral convictions and belief in group efficacy are strong predictors of social identification and are known to facilitate collective action (van Zomeren, 2019; van Zomeren et al., 2019). It is important to note that further empirical research is required to validate these assumptions.

Finally, this study showcases how assessing the social capital of salient social identities can help to examine differences in adaptive capacities. These differences are reflected in their organizational structure and adaptive capacities with the latter mostly being determined by the extent to which networks can access external knowledge, assets, and capacities. Small, exclusive groups like families, relying solely on binding and bonding social capital, are unlikely to escape local vulnerability pockets because they are limited in their capacities and resources. However, in Jakarta they are very successful in accommodating flooding and at least among those living in highly exposed areas this type of adaptation is crucial for local livelihoods not the least due to the lack of access to state support. Given Indonesia's strong collective culture and social norm for family life, social capital bound in these groups will remain even if urban context conditions will change. Institutionalized self-organization at RT scale, including associated sub-groups can access social capital through bonding and bridging ties. Such institutions can be considered key for flood adaptation in highly exposed areas because they are both, entry points for external support as well as sources of local collective capacity thanks to their coordinative and bridging functions within their RT. Their success and effectiveness largely depend on local leadership. Strong local leaders, well-connected horizontally, creating a strong neighborhood social identity as well as vertically to higher levels of governance, are key to successful adaptation at the RT scale. Finally, membership in Indonesian CSOs and activists' networks significantly enhances local capacities by improving self-organization, adaptation knowledge and empowerment. These networks also facilitate connections between different geographical locations and

integrate external experts as well as higher governance levels. Such linking social capital is crucial for local vulnerable groups as it provides access to financial capital and advocacy for their needs and demands in urban planning and risk management process, knowledge transfer, and legal support. Good practice examples (e.g. avoided eviction thanks to self-organization at the community level supported by JRMK and UPC) play a vital role in motivating the local population to join such trans-local initiatives. As these initiatives gain more members and successfully implement ideas such as collective land ownership and participatory urban design processes, they exert greater pressure on the local government and higher governance levels.

All identified social identities salient in long-term adaptation are exclusive to varying degrees, meaning that not all residents may access their respective capacities. Close-knit family networks are limited to kin relationships. Neighborhood groups often exclude short-term renters, and CSO-supported groups such as cooperatives have membership criteria. Accordingly, despite strong pro-social norms in Indonesia, not all neighborhood residents can automatically be assumed to be able to access social capital, increasing their adaptive capacities. At the same time, being a member of one or several of these networks does not automatically translate into active engagement that is sustained over time. Particular facilitating and motivating factors play an important role in mobilizing individuals to use their collective capacities to adapt together ((Wannewitz et al., 2023), forthcoming.).

Overall, this study shows how the combination of a social identity assessment with a social capital analysis allows us to gain a more differentiated understanding of local collective adaptation capacities at sub-city scale. While the study presents findings for the particular case of Jakarta, the perspective and analytical approach can be transferred to other socio-culturally diverse settings globally. The analytical approach uses a qualitative content analysis of identification factors and related social identities in combination with a qualitative assessment of the social ties and adaptive capacities of salient identities in a particular situation and environmental context. While the identification factors, related social identities, their salience, and their capacities are likely to be considerably different in socio-culturally different contexts, the approach itself is widely applicable and can provide valuable insights into various adaptation contexts.

The concrete findings regarding the salient social identities in long-term adaptation in Jakarta and their respective capacities are not broadly transferable because social identification is driven by highly context-specific socio-cultural and environmental conditions which differ between regions, and countries. For example, in countries or regions in which reciprocity within the neighborhood is less highly valued, it is unlikely that neighborhood groups will emerge as an important social identity in the context of climate change adaptation. However, the findings may be transferable to other big cities in Indonesia, given the similarities in the cultural setting, including traditions, social norms, and social institutions.

While this study presents valuable contributions to current knowledge on collective adaptation capacities, it exhibits limitations that need to be addressed by future research. First, we base our analysis and findings on the assessment of meta-knowledge and not insights from local residents directly, which entails the risk of biases and missing local perspectives. However, building on purposefully selected informants from fields such as civil-society and non-governmental organizations, academia, and public officials with sound and in-depth, situational knowledge due to long-time involvement on the ground allowed us to obtain grounded data. In addition, their valuable evaluation of social groups and collective activities in the context of adaptation was helpful to get a more holistic picture of local adaptation settings. Furthermore, we tested and triangulated their insights through additional interviews with scientific experts who have worked in and on Jakarta, validating our findings from the key informant interviews. Nonetheless, more data from the individuals involved in collective actions themselves could further solidify the findings. Secondly, social identities are latent and highly context-specific constructs that are difficult to grasp from external and structured analyses. Nonetheless, we still believe that even if the picture of social identities existing within the most flood-prone areas is likely to be incomplete, we are able to showcase how diverse *the* most

exposed are in terms of their vulnerability to flooding. More importantly, we are confident in having identified those social identities which represent crucial sources of collective adaptation capacities in highly exposed and vulnerable neighborhoods in Jakarta. To identify and assess potential smaller neighborhood initiatives or networks, additional, on the ground ethnographic data collection could validate and extend our findings. Thirdly, this study focused on assessing the adaptive capacities of salient social identities but not the direct adaption actions. Having a capacity does not equal using it. We have addressed the activation and mobilization in another study, which identifies three different types of facilitating factors for collective adaptation ((Wannewitz et al., 2023), forthcoming).

7. Conclusion

The need for collective adaptation to complement state-led adaptation measures is widely acknowledged and can be expected to increase in the future with unfolding climate change impacts. Against this background it is surprising how little we still know about collective adaptation; especially in most at-risk areas, which are often characterized by high levels of socio-cultural diversity. Addressing this weighty gap, this study presents an analytical approach that is suitable to identify and assess differentiated patterns of local collective capacities to adapt. Combining a social identity assessment with a social capital analysis yields new insights into heterogeneous collective capacities to adapt to climate change at the neighborhood scale. Against this background, our findings have larger implications for research and policy.

First, our findings call for adopting a more social perspective in adaptive capacities research. Identifying and considering salient social identities within the context of adaptation allows for approximating the social embeddedness of individuals in groups and thereby their access to collective capacities under specific conditions. Combining this assessment with a social capital analysis diversifies our knowledge on local patterns of adaptive capacity going beyond conventional social categories like age, gender, or health status. Individual-level vulnerabilities linked to these categories could be reduced through social embeddedness. This holds particularly true for cases in which adaptive capacities are bound in the individuals' ability to work together. Given that the presented analytical approach can be used to analyze co-existing social identities that change in salience depending on the context, it also allows for considering dynamics in social embeddedness. By applying this analytical approach, future research can provide deeper and more nuanced insights into at-risk societies and especially their collective capacities to adapt to climate change. Furthermore, the analytical approach may guide future in-depth investigations on who falls through the cracks of social networks in collective adaptation.

Second, given the transferability of the presented analytical approach, it can be instrumental to raise awareness among policy-makers and practitioners for the effects of social embeddedness on collective capacities to adapt. Applying the presented approach can help policy-makers and practitioners to uncover diverse patterns of collective adaptation capacities among the homogenous groups of *the* most vulnerable. It can also reveal redundancies and conflicts between different, co-existing groups and networks adapting to climate change. Ultimately, such nuanced knowledge can help them to tailor adequate adaptation support strategies; it helps to identify collective capacities that may be integrated in urban adaptation planning, complementing other adaptation measure; and it is instrumental for exploring yet untapped collective capacities to adapt which could be mobilized through targeted support approaches. Testing and validating the approach in other cultural settings can significantly contribute to our understanding of collective adaptation capacities and improve the robustness of this analysis approach.

Third, for the specific case of highly exposed areas in Jakarta, this study identifies three salient local social identities with different collective adaptation capacities assessed based on their different types of social

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5.3.2. What makes people adapt together? An empirically grounded conceptual model on the enablers and barriers of collective climate change adaptation

While the previous section showcases how social identities and ultimately group membership in the context of climate change adaptation influences collective capacities to adapt, research tells us that identifying with and being a member of a group does not necessarily equal becoming active with this group (Agostini & van Zomeren, 2021; Jost et al., 2017; Klandermans, 1984). In other words, even if I identify with others based on shared climate risk perceptions, if I believe in group efficacy, and if I am politicalized through for instance a civil society group, this does not mean that I will automatically become an engaged group member, using the embedded social capital for climate protection, adaptation, or alike. Inaction can be caused by various reasons which are well-researched for highly developed countries (see for example (Norgaard, 2009)) but gaps remain in understanding the mobilization of groups from other geographical and cultural contexts. This gap is particularly weighty for contexts in which the capacities of individuals are mostly bound in their ability to work together and in which reciprocity and mutual support are strong societal values and social norms. With Jakarta representing a vivid example of these differences from the Western context, the second paper linked to the conceptual framework empirically assesses what activates and mobilizes members of groups to use their capacities to adapt collectively.

The results provide a novel and more nuanced perspective on enablers of collective action. Based on semi-structured interviews and a representative survey among kampung cooperative representatives, I identified three different types of motivating factors. Individuals start to actively engage in their in-group through initial triggers, however, these triggers alone cannot sustain engagement over time. Long-term motivators facilitate collective activities over longer periods of time, which is needed for adaptation action. Besides these two types of motivating factors, general facilitating factors can contribute to both, the initial engagement and its maintenance over time. Furthermore, the study presents barriers, which hinder individuals to engage. While some of them are well-known and researched, some are new and complement existing knowledge. All in all, the temporal differentiation of motivating factors enhances our conceptual understanding of the mobilization of collective action, while at the same time providing entry points for policy and practice to activate existing groups to actively engage in collective adaptation over time.

The supplement material for the publication can be found in Appendix B.9. The version below is the galley proof, which is why the author names are highlighted.

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What makes people adapt together? An empirically grounded conceptual model on the enablers and barriers of collective climate change adaptation

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Coping with and adapting to climate change impacts are collective action problems that require broad joint efforts to reduce current and future risks. This is most obvious for highly vulnerable and exposed individuals, whose capacities to adapt to recurrent environmental threats are mostly bound in their ability to work together—not only in the immediate disaster situation but also in the long-term to secure their livelihoods. While there are explanatory models for collective action in the context of climate change, there is still a need to validate them further for vulnerable residents in high-risk contexts that prioritize cultural values of collective self-understanding, mutual support, and reciprocity. Additionally, the identified factors that facilitate collective climate action are currently quite abstract and may not be very useful for practical application and policy development. Addressing these gaps, we build on existing collective action models and empirical data from kampung cooperatives in Jakarta to develop a conceptual framework explaining what triggers individuals to start acting collectively and which factors motivate them to keep being engaged in long-term collective adaptation action. It highlights the need to differentiate between what we will call initial triggers and long-term motivators to better understand and advance collective adaptation efforts in high-risk contexts.

KEYWORDS

activation of collective action, long-term collective engagement, collective adaptation to climate change, cooperatives, Jakarta

Introduction

Climate change is a collective action problem; accordingly, the Intergovernmental Panel on Climate Change (Pörtner et al., 2022) highlights in its most recent report that addressing climate change requires actions across scales and collective efforts of various actors to face increasingly frequent and intense climate change impacts. This holds particularly true for populations at the frontline of climate change, such as highly vulnerable residents of exposed coastal cities in the Global South.

Collective action is a popular research field that originates from the assessment of protest movements. It is by now widely applied across disciplines such as psychology (e.g., van Zomeren et al., 2008; Jost et al., 2017; Badaan et al., 2022; Galesic et al., 2022), political sciences (e.g., Ostrom, 1990, 2009; Jagers et al., 2020), sociology (e.g.,

Oberschall, 2004), and more recently also climate change research. For the latter, collective action and social identity theories are used to explain, among others, protests for climate protection (e.g., Schmitt et al., 2019; Fernandes-Jesus et al., 2020), pro-environmental behavior and activism (e.g., Masson and Fritsche, 2014; Carmona-Moya et al., 2021; Castiglione et al., 2022), disaster preparedness (Paton, 2019), collective adaptation (Adger, 2003; Ireland and Thomalla, 2011; Petzold and Ratter, 2015; Wannewitz and Garschagen, 2023) and disaster resilience more broadly (Aldrich and Meyer, 2015; Babcicky and Seebauer, 2020). While these studies showcase the utility of collective action and social identity theories for analyzing the role of collective action in the context of climate change, there is little deeper conceptual engagement with the mechanisms behind the actual mobilization of individuals for collective adaptation.

As of today, a few explanatory models and perspectives have been used within climate change research to assess collective climate action. Most prominently, social capital theory (e.g., Adger, 2003; Ling and Dale, 2014) and the concept of community-based adaptation (e.g., Forsyth, 2013; Ensor et al., 2018) have identified various factors influencing group dynamics and capacities in the climate change adaptation context. While they explain structural and social factors influencing collective climate action, they do not yet sufficiently consider the underlying psychological aspects that motivate or hinder individuals from engaging in collective climate action—and in particular long-term and sustained collective climate action. Recent approaches to integrate socio-psychological considerations are the Social-Identity Model of Pro-Environmental Action (SIMPEA) (Fritsche et al., 2018; Masson and Fritsche, 2021) and the Environmental Identity Model of Environmental Collective Action (EIMECA) (Carmona-Moya et al., 2021) which both tailor the Social Identity Model of Collective Action (SIMCA) to the climate context. Moreover, Wannewitz and Garschagen (2023) provide a conceptual model for the interaction of collectively adapting groups in socio-culturally heterogeneous settings. These examples illustrate how the transfer and abstraction of social identity and collective action theories to the climate change context can help to explain broader social behavioral changes toward collective climate actions. We aim at complementing Wannewitz and Garschagen (2023). While that paper focuses on the formation of and identification with collectives and their potential interactions, this study here empirically analyzes and conceptualizes whether and how individuals identifying with a group decide to actually engage in collective adaptation. With this, we address four specific gaps in research around collective action in the context of climate change adaptation.

First, there is little empirical validation of the above-mentioned models in places considered to be climate change hot spots; that is, locations with high exposure to hazards and environmental threats which are inhabited by vulnerable residents with limited coping and adaptive capacities (IPCC, 2014). Many examples can be found in the Global South, where levels of exposure and vulnerability are comparably high. In such locations, the capacities of the vulnerable inhabitants are mostly bound in their ability and motivation to work together toward risk reduction (Adger, 2003). While there is empirical evidence of collective activities of highly vulnerable groups in high-risk contexts (e.g., Surtiari et al., 2017; Hagedoorn et al., 2019), explanatory frameworks or specific conceptualizations of collective behavior to reduce or adapt to abstract future risks strategically are largely missing. Taking the example of Southeast Asia, we would moreover argue that it is essential to take into account cultural differences such as a more dominant collective self-understanding and reciprocity, proverbially known as collectivist cultural traits[1], which may require adjustments of existing conceptual frameworks explaining collective climate actions.

Second, current applications of social identity and collective action theories in climate change research predominately focus on climate activism, such as protests or pro-environmental behavior/mitigation, while climate change adaptation has been less considered. However, significant differences between short-term actions (protest movements) and more long-term climate change adaptation and mitigation movements (Castiglione et al., 2022; Wannewitz and Garschagen, 2023) require a close assessment of the transferability of existing knowledge.

Third, the majority of studies transferring social identity and collective action theories to the climate change context assess and explain the capacity and intent to engage in climate action, not the actual engagement. Considering the intention-behavior gap (Sheeran and Webb, 2016), they may predict intention and potential to act collectively but not necessarily actual collective engagement. In addition, assessing the willingness to engage can be influenced by response effects such as social desirability (Bogner and Landrock, 2016).

Finally, neither SIMCA nor SIMPEA clearly differentiates between initiating and moderating factors of collective climate action. This is problematic regarding the practical usability of the conceptual frameworks, for example, for policy design targeting long-term collective action. We argue that it is worthwhile to differentiate between triggers that initiate the first decision to change from individual to collective engagement and long-term motivators that keep individuals willing to engage in collective actions over time. Distinguishing these two factors is particularly important for the context of collective adaptation to climate change, as it requires a long-term perspective and planning; and for more transformative approaches also deeper structural, institutional, and behavioral changes to be implemented over a long period of time with results not being visible immediately (Wannewitz and Garschagen, 2023). Furthermore, there is a lack of understanding of how collective action is purposefully mobilized for climate change adaptation, as opposed to incidentally contributing to community resilience (Pelling and High, 2005). Along the same lines, we need to understand which exact factors hinder individuals to start acting collectively, and which ones lead to them becoming passive members of a movement after initial activation.

Against this background, this study addresses the following research questions:

RQ 1: Which factors trigger individuals to start acting collectively?

1 Overall, we refrain from distinguishing *per se* between individualist and collectivist countries, considering sub-national and small-scale differences in self-representations, beliefs and values (Brewer and Chen, 2007) which make it difficult to generally classify a country as a whole as individualist or collectivist.

RQ 2: What are the barriers for individuals to engage in collective action?

RQ 3: What long-term motivators keep individuals engaged in collective action over time?

Based on an empirical example, this study develops a conceptual model addressing the three research questions, which we suggest to be applicable to other societies and/or groups in which collective self-understanding, reciprocity, and mutual support are strong social norms and part of their respective culture. We use the example of kampung cooperatives in Jakarta because they can be considered institutionalized forms of collective action in the city's low-income neighborhoods, which are often exposed to multiple hazards, including flooding. The cooperatives act collectively to reduce their livelihood risks and advocate for their members' interests in urban development processes with the aim of reducing background stressors, such as evictions. Also other, more informal, and small-scale, collective activities among vulnerable residents in Jakarta exist that contribute to adaptation. However, we deliberately focus exclusively on kampung cooperatives to be able to identify distinct triggers and motivators for engagement. The study used triangulated data from semi-structured interviews and a representative survey of cooperative members to assess which factors triggered kampung residents to become active members of the cooperatives and which factors hindered them from either becoming members or making them turn passive over time.

Before describing the methods, we will introduce the conceptual considerations underlying this study by bringing together insights into collective action enablers and barriers from different research fields. Subsequently, we provide a brief introduction to the study site and why examining and differentiating different types of enablers of collective adaptation is relevant before coming to the methods used in this research. Afterwards, we present our results. The discussion summarizes the findings and discusses them against the background of the limitations of this study.

Conceptual considerations about the motivators for collective adaptation

Motivators for collective action

The literature on collective action across various fields suggests a wide range of factors that facilitate or inhibit collective action, which can be broadly understood as a "number of people working together voluntarily to achieve some common objective" (IPCC, 2022b; p. 809).

Two of the most popular models, the dual pathway model (Stürmer et al., 2003), and SIMCA (van Zomeren et al., 2008) provide the fundamentals for collective actions by drawing on social identity theories. Building on in-depth studies and earlier models (van Zomeren et al., 2008, 2011, 2018), van Zomeren (2013, 2019) identifies four "core social-psychological motivations" that make individuals act collectively; namely, social identification, perceived group efficacy, group-based anger due to violated moral convictions and/or feelings of being treated unjustly as well as politicized identities.

TABLE 1 Core motivators and influencing factors for collective action (for references see Supplementary material 1).

Core motivators	Indirect motivation factors	Enabling conditions
Perceived injustice	Group-based deprivation	Quality of formal local institutions and governance Physical community layout/built structure Targeted mobilization Hazard experience Freedom to enter or exit group
Violation of moral convictions	(Protection of) norms and moral convictions	
Social identification	Shared emotions like anger and/or (social) hope	
	Existing networks and flows of information between individuals/meaningful exchange (social capital)	
	Engagement of government and/or NGO and/or religious actors to inspire and support collective action	
	Shared social beliefs	
Belief in group efficacy	(trusted) group leaders	
	Trust in group members	
	Engagement of government and/or NGO and/or religious actors to inspire and support collective action	
	Prior experience in (successful) collective action	

Adopting SIMCA, many studies from various research fields have identified factors that influence individual motivation to act collectively; however, most of them can be seen as indirect motivation factors as they influence the core motivators identified by van Zomeren (2013). Such indirect motivation factors are important to consider because they are highly context-specific and their interactions may change over the course of collective engagement (Hartwich et al., 2022). Accordingly, the indirect motivation factors have a meaningful and dynamically changing influence on the emergence of collective action. Enabling conditions are context settings that influence both, indirect motivation factors as well as core motivators. Table 1 provides a synthesized overview of factors identified in social psychology research as well as in collective action and climate change research that influence the four core motivators.

While the presented factors show which aspects need to be taken into account for understanding the emergence of collective action, it remains unclear which of them initially motivate individuals to engage in collective action in the first place and which factors keep them engaged over time. Only a few conceptual frameworks dedicate more attention to the initiation phase, for instance, by including two distinct appraisal processes in an individual's decision to engage in a collective coping

exercise. The assessment of feedback loops between the appraisals indicate that positive feelings and collective successes can influence aspects such as trust in other group members, belief in group efficacy, social identification, and meaningful exchange. Negative experiences may lead to the opposite. This in turn, influences the willingness to engage in collective action (Becker and Tausch, 2015; Bou Zeineddine and Leach, 2021). This example showcases a multi-layered decision-making process, which is in line with the argumentation of this paper.

Conceptualizing collective adaptation

In the climate change adaptation context, collective adaptation has often been called for but it has rarely been defined and assessed in detail as of today. Who exactly is supposed to adapt collectively? The most vulnerable themselves in the form of autonomous collective initiatives? Actors across scales, requiring widespread collaboration? Political actors so far acting in silos? How should such actions be initiated and maintained?

We follow the IPCC's definition of adaptation describing it as a "process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities" (IPCC, 2022a; p. 2898), and adopt a working definition of collective adaptation to climate change, understanding it as "actions of a group of individuals or subcultures collaborating according to shared rules to reduce their climate risk, exploit climate change opportunities and/or achieve additional common development objectives adopting a long-term perspective. The adaptation outcome they achieve collectively represents a common good that can be either exclusively for the group's benefit or for the wider public. Collective adaptation can refer to joint efforts within as well as across social groups or subcultures" (Wannewitz and Garschagen, 2023; p. 2).

The review of empirical climate change research suggests that the general set of core motivators for collective action (see Table 1) is broadly transferable to the context of collective climate actions for mitigation and adaptation. Regarding the violation of moral convictions, studies showcase how climate change is an increasingly political issue, opening up the possibility to use it for politicization, that is, the polarization of individuals through local or political leaders or the alignment of political positions with climate change beliefs (Bliuc et al., 2015; Fielding and Hornsey, 2016). Vestergren et al. (2022) demonstrate that more frequent and intense disasters can increase feelings of injustice, mobilizing people through shared fate. Other studies confirm that the identification with other people at risk in one particularly exposed area creates strong, risk-based social identities and social memories (Ratter, 2013) that solidify with increasing frequency and intensity of hazards (Barnett et al., 2021), facilitating collective responses. Jugert et al. (2016) show that increasing individuals' belief in group efficacy can amplify their intentions to engage in pro-environmental behavior. Furthermore, research on the mobilization of social capital for adaptation addresses the indirect motivation factors for collective adaptation, such as social identification in the form of communities of place and communities of practice (Pelling and High, 2005) or directly mentions aspects like the feeling of injustice and belief in group efficacy as motivators to act collectively (Petzold, 2017). In contrast to the core motivators, indirect motivation factors may vary depending on the context, which is what we assess through empirical data from our case study site Jakarta.

Various factors can also hinder collective action. One of the most often discussed problems is free-riding, meaning that a group member receives individual and/or collective benefits without engaging in collective action. This is particularly likely in bigger groups with higher anonymity among group members. Free-riding, or the conjecture that group members may free-ride, reduces the willingness to engage in collective action actively (Mancur, 1971; Jagers et al., 2020). Similarly, various forms of heterogeneity, for instance, in terms of types and levels of knowledge, perspectives, and social behaviors (Patterson, 2017; Tajima et al., 2018) but also regarding the socio-economic status, power asymmetries, traditions, and beliefs (Pearson et al., 2016; Jagers et al., 2020) within the group are described to potentially inhibit collective action. Besides this, the absence or weak social norms for cooperation (Boon-Falleur et al., 2022) and system justification (Jost et al., 2017; van Zomeren and Louis, 2017) decrease individuals' motivation to engage in collective action.

In the context of climate change, additional barriers have been identified, such as the feeling of powerlessness in the face of the large-scale problem of climate change (Thaker et al., 2015; Pearson and Schuldt, 2018), uncertainty about the long-term effects of climate change (Pearson and Schuldt, 2018), hopelessness (Badaan et al., 2022) and also the fading out of shared social identity after disasters (Drury et al., 2019). In particular cases, some motivators may also turn into barriers. For instance, when external support structures suppress local collective action capacities (Meyer, 2018) or individuals think that engagement in collective action is not needed anymore due to external support (Petzold, 2017).

This overview of core motivators, indirect motivating factors, enabling conditions, and barriers of collective action and their link to the climate change contexts showcases their utility for explaining collective climate action. While the rather abstract core motivators are directly transferable to the climate change context, we assume that the indirect motivation factors and their interplay as well as the barriers differ depending on the particular context of collective adaptation to climate change. They are subject to socio-culturally as well as geographically specific settings, especially when it comes to climate-related hazard risks. Therefore, a context-sensitive assessment is needed that considers cultural aspects such as collective self-understanding and reciprocity, since such social norms, values and beliefs may fundamentally influence individual motivators to engage in collective activities. This study uses an inductive approach to identify indirect motivation factors for the case of flood-exposed residents in Jakarta.

Study site and relevance

Our case study city is Jakarta, a highly exposed and vulnerable city in Southeast Asia. It presents a valuable example given its high risk and long history in dealing with natural hazards such as flooding. The city's at-risk population, that is, residents who live in highly exposed areas and who are at the same time very vulnerable to flood impacts given their high sensitivity and limited

adaptive capacities, have rich experience in coping with flooding and other livelihood struggles. Hence, assessing their collective adaptation action to understand triggers that initiate the change from individual to collective behavior, motivating factors that keep them engaged in collective activities over a longer time, and inhibiting factors can provide valuable insights which can potentially be transferred to other contexts.

Jakarta is a low-lying city located on the north coast of the island of Java. Beyond other natural hazards, Jakarta faces frequent flooding due to four interacting natural and human processes which are expected to intensify due to climate change: First, increasing sea levels and more intense and frequent storm surges lead to coastal flooding (Budiyono et al., 2016; Januriyadi et al., 2018). Second, high-intensity rainfall events in the catchment area of the city's rivers cause massive pluvial flooding (Budiyono et al., 2016; Januriyadi et al., 2018). Third, groundwater extraction, soil compaction, tectonic activities, and the high weight of the dense city contribute to increasing land subsidence (Abidin et al., 2015), with varying sinking rates across the city, so that the anyhow low-lying urban area becomes even more prone to inundations (Salim et al., 2019; Bott et al., 2021). And lastly, river clogging and a general lack of drainage due to the narrowing of waterways reinforce and prolong urban flooding (Mathewson, 2018). In situations where multiple flood drivers interact, severe flood events occur, impacting up to 60% of the city like the flood in 2013 showcased (Garschagen et al., 2018).

Accordingly, the residents as well as the city administration have long experience in protecting against and dealing with flooding. Flood management approaches and policies were and remain infrastructural for the most part (Colven, 2017; Octavianti and Charles, 2019), with a focus on three key strategies. First, the widening of rivers and clearance of riverbanks. Second, the expansion of water reservoirs. Both measures aim at increasing the city's drainage capacities. Lastly, a coastal flood protection plan [the latest version is called National Capital Integrated Coastal Development (NCICD)] tries to marry coastal protection with urban development. One major element of the plan is a giant flood wall, the so-called Great Garuda—A much-contested flood protection measure to be implemented within the next years (Colven, 2017; Garschagen et al., 2018; Salim et al., 2019). All of these strategies are linked to the resettlement and partly forceful eviction of poor urban residents along the rivers, the reservoirs, and the coast, with severe consequences for their livelihoods and social networks (Padawangi and Douglass, 2015; Hellman et al., 2018; Ichwatus Sholihah and Shaojun, 2018).

Against this background, the most exposed and vulnerable populations in Jakarta face at least two daunting threats at the same time: the risk of being frequently flooded and the risk of being forcefully evicted from their exposed neighborhoods in the name of flood protection. For many, the latter represents a more severe threat to their livelihood and security than flooding (van Voorst and Hellman, 2015). To organize resistance against evictions and increase attention to unjust treatment, affected neighborhoods started to organize themselves with the help of powerful local civil society organizations such as the Urban Poor Network, JRMK, and Ciliwung Merdeka. Their leadership, network, and facilitation of bottom-up initiatives increased local capacities to voice their needs and get heard by local politicians. Nonetheless, threats continued emerging in the course of urban development processes (especially after changes in government which set established links to local, city, and national government representatives back to zero), so the locally rooted civil society organizations pushed the idea to form neighborhood-based cooperatives.

Today, there are 26 kampung cooperatives in the North, East, and West of Jakarta; one of the first ones along the Ciliwung River ceased after the forceful eviction of Kampung Pulo. According to Indonesian Law, cooperatives are suitable local representations of the residents and hence officially recognized, legal entities that can act on their members' behalf (The President of the Republic of Indonesia, 1992). The cooperatives are led by dual leadership; members have to pay membership fees, possess a Jakarta ID card, and have assets at their disposal. Accordingly, they are not the poorest of the poor but low-income residents that considerably contribute to the urban economy while at the same time being very prone to fall into poverty. Renters and non-permanent residents are only able to join under an extraordinary membership regulation in some of the cooperatives. Guided by JRMK and UPC, each cooperative develops a vision and a plan for how to achieve it based on its members' needs and desires. Depending on the required support, technical or social assistance can be obtained through UPC's network of external partners; however, the cooperative remains in the driving seat. In Jakarta, cooperatives are an example of how collectives enable otherwise excluded members of the society to voice and claim their position and needs in urban development processes (e.g., change land zoning, land consolidation).

Building on Pelling and High (2005), we understand cooperatives to be purposefully developed, institutionalized forms of collective action aiming at implementing both material as well as structural and/or institutional changes to reduce stressors. In the case of kampung cooperatives, this does not necessarily mean that they directly pursue collective adaptation to climate change and its impacts. Rather, they take a broader collective approach to improving local livelihoods which in turn increases their members' coping and adaptive capacities.

Data and methods

This study builds on a non-structured literature review and empirical data collection and analysis. We implemented predominantly qualitative methods for both data collection and analysis to fully penetrate the engagement process leading to collective adaptation among vulnerable individuals in high-risk, "collectivist" contexts.

We reviewed the literature on social identity and collective action theories and their applications in various fields in a deductive manner to understand and collect potential factors that may influence engagement in collective adaptation. The empirical data was used to inductively identify those influencing factors that were of importance for the specific case study context and differentiate them by considering their influence along the temporal progression of collective action. For this purpose, we focus on a selected number

of interviews with highly knowledgeable and representative key informants rather than applying a large-N quantitative empirical studies approach.

Empirical data was collected during a 1-month field visit in Jakarta in November 2022. During the stay, multiple methods were used during various trips to different locations in the city to collect impressions and data that allowed for getting a comprehensive picture of kampung life and engagement in collective adaptation in Jakarta. Frequently flooded areas on the North coast (e.g., Waduk Pluit and Muara Angke) as well as along the Ciliwung River (e.g., Kampung Pulo, Bukit Duri) were visited to observe physical flood mitigation and adaptation measures, housing structures, and socio-demographic characteristics of the residents. Overall, five different kampungs were visited; field notes were used to document impressions and observations.

Participant observation was used during the 2-day annual meeting of JRMK cooperative heads convened by UPC in Kampung Kunir. Informal and unstructured note taking as well as short discussions with meeting participants in breaks allowed for obtaining insights into cooperative achievements as well as future plans. A representative survey (see Supplementary material 2 for questionnaire) among all cooperative heads ($n = 41$) assessing their reasons for joining, engagement, achieved benefits and future goals represents the third data source used for this study. Three out of four questions required open-ended answers. In the analysis, similar answers were clustered and aggregated to get an overview of triggers, motivators, and barriers for engaging n kampung coopertives' collective action.

Finally, eight semi-structured interviews (see Supplementary material 2 for questionnaires) were conducted with four network leaders and four cooperative members. Network leaders were selected based on previous online interviews; cooperative members were approached through snowball sampling, starting with recommendations by one of the network leaders. Four of them were conducted with the support of a translator. All interviews were transcribed and subsequently coded in MAXQDA following qualitative content analysis (Mayring and Brunner, 2009). The set codes used in this particular analysis is exclusively focusing on collective action and include the following: "activator/trigger," "motivating factor to stay active," "barrier." Handwritten field notes were coded with the same codes as the interviews and considered in the analysis as well.

Results

The analysis and triangulation of data resulted in three types of motivators for collective action, and a set of barriers (Figure 1). We identified distinct triggers that make individuals start to engage in collective activities for the first time (left-hand side of the figure). They differ from a set of factors that motivate them to stay active over a longer course of time (right-hand side of the figure). In addition, multiple aspects contribute to both, the activation as well as the long-term motivation to act collectively, which are depicted in the center of the figure. Finally, particular barriers can hinder individuals from joining collective activities and/or staying active members over time (bottom element of the figure).

The following sections illustrate and explain the different types of motivators and the factors they contain with practical examples and quotes from the field. A more comprehensive description can be found in the annex (Supplementary material 3).

Initial triggers

Whether individuals decide to engage in collective adaptation in the first place largely depends on the threat context. In contexts where a threat—be it directly from climate change impacts or indirectly from climate change threatening livelihood stability—is perceived to be beyond individual capacities, collective engagement is more likely. Sharing goals and a vision of how to overcome a threat with people in the same situation and being actively targeted by local leaders who advocate for facing the challenge through collective activities are two key aspects triggering behavioral change toward collective action. Both aspects create a social identity that becomes salient in the face of the threat. Advocacy also helps initiation by making people aware of the potential common and individual benefits of collective action. However, joining a group also depends on the individuals' beliefs that the group will be capable of successfully achieving the collective goal. Finally, initial active engagement—as opposed to passive membership—is influenced by the type of collective activities the group decides to implement. Activities that are accessible for all with low individual investments, low time commitment, and low individual risk are likely to attract attention and engagement easily.

To illustrate how initial triggers function in practice, we take the example of flood-exposed, poor neighborhoods in Jakarta, where residents are often threatened by evictions in the name of flood protection. "Of course, the initiative comes from the people themselves because the goal is very simple, that is to avoid eviction and to avoid being displaced from their kampung" (CSI-6). In the words of a local resident who is member of a cooperative: "This cooperative is not like cooperatives in general. Other cooperatives may have a vision in economic matters, but we are different. Our cooperative has an important vision, which is to protect and defend the village" (NJ-LR-2). The constant fear of losing their assets and livelihood is perceived to be beyond the individual's capacity, increasing the wish to join forces to counter potential evictions. Or in the words of one survey respondent "Together we sure can do it" (R12) when asked for her/his motivation to join the cooperative. The shared goal to stay in the area and collectively improve the living conditions as well as livelihoods was frequently mentioned as shared vision in response to why the respondent joined the cooperative. "The same goals for land legality" (R40) and "To achieve collective prosperity" (R38). It is often encouraged either through local leaders or supporting civil society organizations that are deeply rooted in the neighborhoods. "The key is for the community themselves to have the will to fight and the presence of a key figure who can lead the organization" (CSI-6). This creates a strong social identity among many of the residents and they believe that only together they stand a chance to avert potential evictions. Activities such as frequent meetings for strategizing are easy to join and increase the feeling of belonging to the group and having decision-making power.

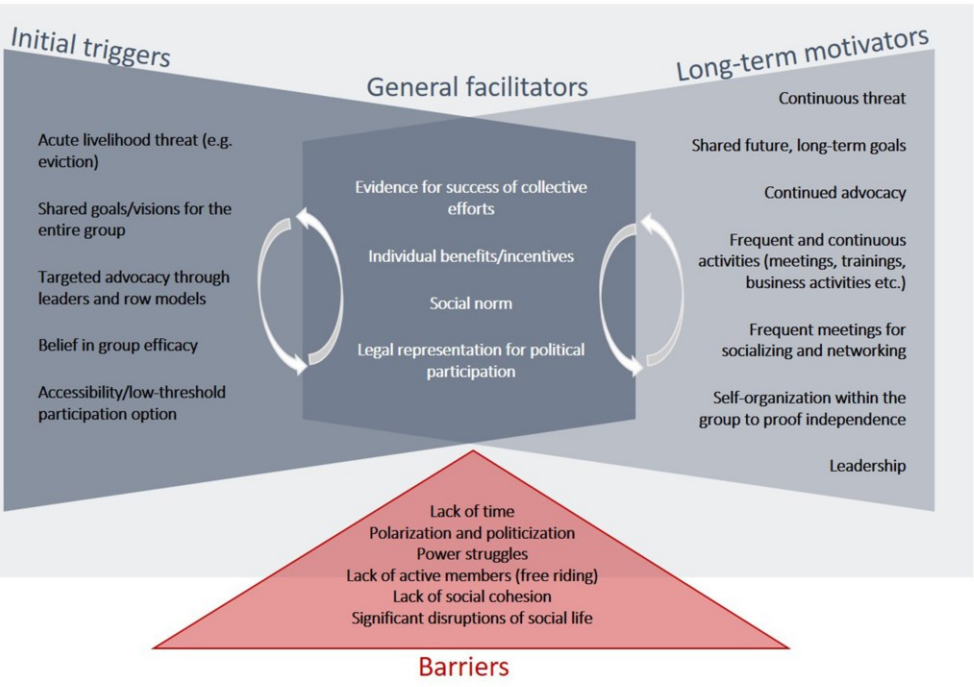

FIGURE 1
Conceptual framework for triggers, motivators, and barriers of long-term collective action.

Long-term motivators

Keeping individuals engaged in collective adaptation over time requires first and foremost the continuation of the threat itself. When threats continue, shared long-term goals ensure social identification. However, long-term visions are often less effective identification factors as compared to short-term visions which are linked to more tangible and immediate benefits. Nonetheless, long-term goals are key for continuous collective adaptation; the definition of interim goals may help to keep up the motivation to engage. Social identification through shared visions can be maintained and reinforced by continuous advocacy, which can also help to mobilize new members. To keep the social identity salient, frequent collective activities as well as meetings of group members are essential. Working together and exchanging with each other solidifies identification with the group and the trust in group members. Finally, and in particular for disadvantaged groups who are excluded from (political) decision-making processes, self-organization within the group is key for being able to, on the one hand, showcase independence and group efficacy and, on the other hand, put forward shared needs and visions at higher levels of decision-making through their respective representatives. All of the mentioned points can be strengthened by the active engagement of group leaders.

Looking at kampung cooperatives in Jakarta, collective actions have shown to be difficult to be maintained over time. Only when the threat of eviction or very frequent flood occurrences are constantly present in the members' lives, engagement remains at a high level. In the case of kampungs, such threats are omnipresent as a resident explains "This kampung is vulnerable to government threat such as evictions. If information about eviction spreads, the residents will panic. The first threat is from JSS IPAL zone 2 in 2019 for wastewater management which is planned to be built in two places. Then, the NCICD Project for embankment along Muara Angke. Actually this project is against the floods however the impact has not been considered. There is also a threat of eviction from the widening project for a transmission tower (sutet) that always haunts everyone" (NJ-LR-2). Long-term engagement can be supported by continuous advocacy of the cooperative leaders and supporting civil society organizations (CSOs) as being expressed by a cooperative leader. "I think if we can explain it as clearly as possible, they will definitely want to join the Cooperative. Moreover, being a member of a cooperative has many benefits. For example, our cooperative sells groceries (sembako). The price is quite competitive with other stalls. Then we will share the SHU that we get" (NJ-LR-1). On the one hand, these key figures help to strengthen the social identity by emphasizing shared goals and visions and increase social pressure by alluding to the social norm

of collectivity. On the other hand, they mobilize new members keeping the cooperatives vivid. Cooperative members highlight how they enjoy frequent exchanges and learn from each other during activities in various regards; two key motivation factors over time. "Before the pandemic, we had every meeting in a different house so that each member would know each other. After we reciting Qur'an, we discussed about the cooperative" (NJ-LR-4). In the survey, respondents mentioned "got lots of friends" (R13, R15), "could exchange ideas" (R14), "develop own knowledge in cooperatives" (R1, R5, R14, R31) as achievements realized through their cooperative membership. At the same time, the internal structure of kampung cooperatives helps to organize day-to-day life and achieve shared goals such as collective kampung upgrading in a more coherent and independent way, showing local authorities their autonomy and strength in self-organization as well as capability to accommodate flooding. "Back then, this area was called "slums." So we, the cooperative, tried to make a program. If the government thinks that dense settlements cannot be managed, the solution must be relocation. Then we tried to come up with other solutions, to show the government that we can manage the land use, that's it (NJ-LR-1)." This capacity is an important aspect for averting evictions and obtaining collective settlement rights in their places of residence.

General facilitators

A few of the factors identified can be considered relevant for both dimensions—the initial engagement in collective adaptation and keeping engaged over time. The most important factor is evidence of success of collective engagement. Only if individuals see that shared visions and goals are reached, they consider engaging. Ideally, the successful implementation of collective adaptation is also linked to benefits not only for the group but also for the participating individuals. Besides this, incentives for group members help facilitate engagement. In contexts in which collective self-understanding and reciprocity are highly valued, initial as well as long-term engagement in collective activities is supported through strong social norms. Individualism as well as passivity is frowned upon and in some cases even results in social sanctions and/or exclusion, which is why the motivation to participate is rather high. Finally, group leaders can act as (legal) representatives to advocate for the shared visions and needs at higher levels of decision-making.

In practical terms, general facilitators among kampung cooperative members in Jakarta can be considered essential for initiating and maintaining their collective activities as well as the collective construct. Members highlighted, for instance, that success stories of how kampung cooperatives successfully obtained building permits and urban zoning changes for their members encouraged individuals to join. "Of course, with the success that we have in making the residents get compensation of housing, it will make them believe more and many are now believing, especially because we started all this with a community cooperative, so every community that grows is using this basis" (CSI-7). Benefit at the neighborhood scale as well as individually Are essential motivators, too. "The member, he can borrow the money from the cooperative to repair his house. […] So this house and that house from the next community also repaired by the cooperative fund but it's very long time to pay it back" (NJ-CSI-1). At the same time, the social norm of collective engagement and reciprocity is traditionally very strong in urban poor communities in Jakarta. "[…] citizens in urban cities have the norm to help each other" (RII-1a). This lowers the initial barrier to behavioral change toward collective engagement and keeps them active, given the social pressure to adhere to cultural values and norms. Finally, kampung cooperatives are legal, officially recognized entities in Indonesia, which gives them the right to be official representatives of their members in political decision-making processes. "So their cooperative also registered to the government so now the cooperative is a legal entity. Before, this community was not […] recognized by the government because the land is […] not really recognized by the government. But now, when they became a cooperative and a legal entity, they are recognized by the government" (NJ-CSI-1). Accordingly, kampung cooperatives empower their members and provide the opportunity to fight for shared visions and goals, for example, by participating in urban development processes. This allows them to effectively fight for maintaining their livelihoods which reduces their vulnerability to threats such as flooding or forced evictions.

Barriers

A plethora of factors can hinder individuals from starting to act collectively and staying engaged over time. In general, the absence or inverse of initial triggers and long-term motivators as well as general facilitators represent major hindrances to collective action. Besides this, other factors were mentioned as barriers. A lack of time due to other duties is a very obvious but important barrier. Polarization and potential politicization, along with different visions, beliefs, and convictions may inhibit collective activities or at least lower collective power when they separate a neighborhood into various sub-groups. Similarly, power struggles between different local leaders may hinder larger-scale collective action due to the separation of groups as well as redundant or conflicting collective action. Apart from this, the lack of active members can also function as a barrier because passive members are perceived as free riders, meaning members who benefit from collective achievements without engaging in collective activities themselves. This reduces trust and the willingness to engage among the group members, which consequently reduces group benefits, thus risking a downward spiral of engagement until the collapse of the collective structure. Another reason for not engaging is lacking social cohesion, given that low levels of mutual trust and reciprocity hinder social identification and limit belief in group efficacy. Finally, severe disruptions in social life can inhibit the emergence of collective action or stop existing initiatives.

In flood-prone, poor neighborhoods in Jakarta, one of the most important barriers for residents to join kampung cooperatives is a lack of time due to work or family duties as well as other social obligations. "[…] they still have difficulties to find members who really want to provide time for meetings etc. because in order to get organized you still have to do lots of things such as training meetings […]" (NJ-RII-2). When the cooperatives do not have

enough members or constantly lose members, decreasing power to achieve common visions, fewer activities and lower belief in group efficacy threaten the existence of kampung cooperatives. In cases where local leaders fear losing power with the emergence of kampung cooperatives, they may fight against their development, polarizing the residents between different movements. "There are 8 RTs; not all of them are members of the cooperative. It seems like the presence of this cooperative is considered as a competitor [...] for RT or RW. Because the program from the government will not go through the RT or RW, but through to cooperatives" (NJ-LR-1). This also lowers levels of social cohesion in the neighborhood, which represents an important precondition for collective engagement. Disruptions of mundane kampung live may also hinder collective action. Examples are the recent COVID pandemic, which limited social contacts to a minimum or forcefully implemented evictions due to which former neighbors were geographically separated and traumatized, unable to continue collective efforts. As a CSO worker describes based on his work "For kampungs which have not been evicted by the government, their social cohesion is really good. They are working closely with each other but forced evictions in certain areas is making them, there are no social cohesions anymore" (CSI-9).

Discussion and conclusions

Our study aimed at advancing the current knowledge on collective action in the context of climate change by assessing what triggers vulnerable individuals in high-risk contexts and with strong collective self-understanding to start adapting collectively, which factors keep them engaged over time, and what hinders them to act collectively. Based on one of the first English-speaking assessments of kampung cooperatives in Jakarta, we developed a conceptual framework that refines existing conceptualizations of collective climate action motivators. We put forward the following three key findings.

First, while the core motivating factors identified in other studies (van Zomeren, 2013; Fritsche et al., 2018; Agostini and van Zomeren, 2021; Carmona-Moya et al., 2021)—which mostly build on the assessment of protest movements in lower-risk contexts—also play an important role for why and to what extent individuals engage in collective adaptation in high-risk contexts, their high level of abstraction makes it difficult to use them for understanding our research context. The core motivators alone are too broad to understand and explain collective adaptation. Some of the listed influencing factors from Table 1 (e.g., "prior experience in collective action" or "physical community layout") do not apply to the context we assessed and we identified additional ones such as "legal representation for political participation," "self-organization within the group to proof independence" and the importance of social desires such as exchanging with neighbors and friends and building a network, which are rarely discussed in the literature on collective action in the context of climate change. Also, the feeling of being threatened by a major force (livelihood threat) played an important role in initiating as well as keeping up collective adaptation over time. This finding is confirmed by other studies on Jakarta (Bott et al., 2019) and in different risk contexts (Vestergren et al., 2022). Hence, while many of the established influencing factors apply to the collective adaptation context, some additional ones should be considered which are important to explain why individuals engage in collective adaptation.

Second, the results show that facilitating factors for collective adaptation differ temporally, that is between initial triggers, long-term facilitators, and those contributing to both types. Such temporal differentiation is a first attempt to understand and capture dynamics during the process of collective action; a need voiced by other scholars as well (Boda and Jerneck, 2019; Hartwich et al., 2022). While many of the listed triggers and motivators we identified through the literature review as well as the empirical data influence one or several of the core motivation factors identified by van Zomeren (2013), our findings demonstrate how to temporally separate them.

Third, the barriers we identified partly diverge from other studies. For example, a lack of time due to daily work obligations, which was one of the most important barriers in our case study, is less prominently discussed in other studies. This might be linked to the fact that most studies assess the willingness to engage in collective action and not their actual engagement with related practical issues such as lacking time. Compared to the literature on barriers that was considered in this research, in our study, hindering factors such as uncertainty about the long-term effects of climate change (Pearson and Schuldt, 2018), hopelessness (Badaan et al., 2022), weak social norms for cooperation (Boon-Falleur et al., 2022), system justification (Jost et al., 2017; van Zomeren and Louis, 2017), or heterogeneity issues did not surface. An explanation could be the small sample size and the socio-cultural context of the study site. Instead, aspects of polarization and politicization of neighborhood groups due to local power struggles were more prominent. Also, we found that too few or passive members hamper collective activities and may even start a downward spiral: The fewer (active) members, the less visible success, the fewer benefits for members, the lower the belief in group efficacy, the lower social identification, and the lower the incentive to actively engage. Such downward spirals of collective engagement may be difficult to stop and are a risk for any collective action process that is meant to exist long-term. Similar observations have been made in small island communities, where changing demographic compositions result in a decreasing potential for the mobilization of social capital for collective adaptation (Petzold, 2017). However, also very big groups may hamper collective action due to free-riding, finding consensus over shared goals and problems of coordination and cooperation (Marshall, 2013; Jagers et al., 2020).

While our three key findings extend the current state of knowledge on collective adaptation, we want to highlight some of the study-specific limitations, which are mostly related to the transferability of our findings to other cultural contexts. First, the identified triggers, long-term motivators, general facilitators, and barriers base on the analysis of collective adaptation in the context of institutionalized cooperatives in a cultural context where collective self-understanding and reciprocity are high cultural values. We did not consider other informal, non-institutionalized groups, which may be similarly important to consider in research

on collective adaptation to climate change. Second, we did not extend our assessments to cultural contexts in which the collective is less valued. Against this background, our findings may not be generally applicable to any form of collective action and not to very different cultural contexts. However, we consider it to be transferable to other high-risk contexts where collective self-understanding and reciprocity are strong social norms and values. Third, the collective activities implemented by kampung cooperatives in Jakarta are not exclusively contributing to adaptation; rather, they have a multi-purpose character and increase coping and adaptive capacities through ensuring livelihood stability and hence reducing vulnerability, through empowerment and political participation as well as through access to resources and knowledge. In that sense, the identified initial triggers, long-term motivators, and general facilitators explain collective actions that contribute to individual as well as collective adaptation in an indirect manner.

For the case of Jakarta, institutionalized collective adaptation in the form of cooperatives is an example of how collectives enable otherwise excluded members of the society to voice and claim their position and needs in urban development processes (e.g., change land zoning, land consolidation). However, cooperatives can only thrive through active membership; that is, a sufficiently large number of active members who dedicate time and passion to the collective pursuit of their shared visions. Challenges regarding mobilization and self-organization may soon end their growth and relevance. At the same time, their visions may not necessarily contribute to risk reduction in the future, a caveat that limits their benefits.

Overall, our findings have implications for the conceptual understanding of collective adaptation. The novel differentiation between initial triggers, long-term motivators, and general facilitators can help understand collective action that goes beyond one-off engagements. Long-term and sustained engagement of local residents to shoulder adaptation to climate change and other livelihood threats is key for facing future threats that cannot be exclusively handled by state actors and institutions. This is not to say that collective adaptation can or should replace state-led adaptation. However, it might complement current strategies and enhance the benefits.

For practice and policy design in cultural contexts similar to our study site, the identified triggers and long-term motivators can be used to design targeted mobilization policies and activities to advance bottom-up collective adaptation. Especially the general facilitators may be of interest to advance collective adaptation because they represent low-regret entry points for triggering and maintaining long-term collective adaptation. Long-term motivators could be used to develop strategies managing fatigue to engage, a particular challenge for long-term collective action. For practitioners and policy-makers who wish to enable collective action it is important to consider that outcomes of collective adaptation may be maladaptive or non-sustainable, given that decisions are taken democratically based on the visions and ideas of the collective's members, which are not necessarily aligned with political goals. Also, the exclusion of individuals who do not meet the inclusion criteria of social groups or collectives or who do not share their respective visions and goals may limit the equitable spread of potential benefits.

Our study should encourage future research that tests the validity and transferability of the identified triggers and long-term motivators to informal, small-scale collective adaptation actions in different socio-cultural contexts. Furthermore, a detailed examination of the interplay of identified motivators would help to further unpack the emergence of collective adaptation. While it can be assumed that not all factors need to be present to trigger and maintain collective efforts to adapt, our results do not allow for evaluating the different levels of importance and interconnections between the factors over time of collective adaptation. Given that the interplay is likely to be dynamic (Hartwich et al., 2022), especially long-term motivating factors must be assessed more closely as they are likely to change over time. More in-depth knowledge about the individual motivation to engage in collective action that contributes to climate change adaptation is important to meaningfully advance adaptation not only at the local level but across scales.

Data availability statement

The datasets presented in this article are not readily available because interview partners provided their consent to use the data for the research but not for making it publicly available. Requests to access the datasets should be directed to mia.wannewitz@lmu.de.

Ethics statement

The studies involving human participants were reviewed and approved by BRIN (National Research and Innovation Agency, Indonesia). The patients/participants provided their written informed consent to participate in this study.

Author contributions

MW: data collection, data analysis, and writing (original draft preparation). JP: writing (reviewing and editing). MG: supervision (reviewing and editing). All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fclim.2023.1213852/full#supplementary-material

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5.3.3. Collective Adaptation to Climate Change

In the previous two sections I explored the coexistence of social identities with varying collective adaptation capacities and how they can be mobilized to actively use their collective capacities to adapt. The last part of the proposed conceptual framework assumes that the first two sequences have materialized to the point at which various coexisting groups adapt differently to climate change impacts in a geographic location. Cities like Jakarta exemplify such circumstances, as they are not only climate risk hot spots but also very diverse in terms of the socio-cultural composition of their inhabitants. International and internal migrants as well as generational and cultural changes create a highly dynamic socio-cultural interplay across urban scales, from the local neighborhood to the larger metropolitan area. Taking the local neighborhood as the most approachable level of examination, the third scientific publication related to the conceptual framework is dedicated to the question, of what types of collective adaptation may evolve under conditions of socio-cultural heterogeneity. It assumes that climate risks lead to the emergence of different risk-based social identities within neighborhoods. Presuming that these groups act collectively to adapt to climate risks, this paper conceptually explores potential types of interaction between these co-existing collectively acting groups and how these types may influence adaptation at the urban scale.

Based on findings from the integrative literature review, the paper presents a conceptual framework for the development of and potential interactions between different co-existing risk-based social identities in socio-culturally diverse neighborhoods. It illustrates how social identification based on shared risk perceptions may over time lead to the emergence of different local risk-sub-cultures with varying systems of social norms, values, and risk behavior including adaptation. The paper identifies and exemplifies four ways different collectively adapting groups might interact with different implications for urban-scale adaptation. While the framework does not represent a theory or predictive model, it addresses the lack of conceptual and theoretical debate around collective adaptation by proposing a new analytical perspective that can guide urgently needed research on collective adaptation behaviors in socio-culturally diverse settings. It also raises awareness of the need to consider diversity in urban adaptation planning and offers potential entry points for policymakers and practitioners in this respect.

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Current Opinion in Environmental Sustainability

Collective adaptation to climate change

Mia Wannewitz and Matthias Garschagen

'Collective adaptation' has recently become a widely used concept in climate change science and advocacy work. Yet, the current engagement with collective adaptation suffers from a few shortcomings: While the debate has been normative for the largest part, a coherent conceptual framing and theoretical engagement have been underdeveloped, hampering the empirical assessment of the extent and patterns of collective adaptation as well as the factors that foster or hinder it. In addition, the majority of emerging empirical assessments are concerned with rather homogenous sociocultural communities, while collective adaptation in heterogeneous settings such as urban melting pots has been far less in the focus — even though the most heterogeneous neighborhoods are often those with the highest vulnerability, least resources and gravest lack of formal adaptation. Sociocultural diversity has the potential to foster resilience through integrating a multitude of perspectives but, at the same time, presents a challenge for trust-building and collaboration. The paper develops and illustrates a heuristic conceptual framework on different types of collective adaptation and their formation as well as mobilization in socioculturally diverse settings. It is meant to help guide future research and inform policy debates in what is a critical decade for climate change adaptation, particularly in an increasingly diverse world.

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Introduction

It is increasingly clear that adapting to current and expected impacts of climate change is a growing — oftentimes dominant — challenge for communities across the globe [1]. What is far less clear is how communities collectively deal with that challenge and which role the sociocultural composition plays in doing so. Ample research has shown that communities are often characterized by a high degree of internal diversity and steep gradients of vulnerability and adaptive capacity (e.g. [2,3••]). At the same time, adaptation is at least partly a communal task given that communities are in many ways bound together through infrastructure, geography, or resource management [4]. There has therefore been an increasing realization that successful adaptation requires collaborative efforts on the ground, particularly in settings with a lack of formal or other external adaptation such as in many marginalized community contexts [4–6]. However, apart from the normative claims for collective adaptation, the concept remains surprisingly poorly defined and conceptualized in the literature. While there are many definitions of related concepts such as communal adaptation [7], collective climate action [8••], and alike, they are not directly transferable to collective adaptation because they only cover fractions of it. A Scopus search for 'collective adaptation' AND 'climate change' OR 'disaster' OR 'hazard' resulted in only 24 publications for the years 2010–2022, with no significant increase in recent years. The IPCC's Sixth Assessment Report [1] describes transformation as a collective action challenge (Chapter 1, p. 6), mentions collective adaptation (e.g. Chapter 1, p. 56), and stresses the promising potentials that collective action provides, however without mentioning a detailed definition of these terms. Instead, examples of success are brought forward (e.g. Chapter 4, p. 111). The glossary of the Special Report on Climate Change and Land only defines collective action in general. A deeper conceptual engagement with collective adaptation is therefore needed.

Cities illustrate that need in a particularly drastic manner. Many urban and urbanizing areas combine a high exposure to climate hazards, for example, on coasts, with high vulnerability, a lack of formal adaptation, and a high degree of sociocultural diversity [9–11]. In theory, this diversity can yield opportunities for adaptation and resilience-building. Bringing together a multitude of perspectives and actors can facilitate effective and widely accepted solutions, foster innovation and reduce inequities [12,13]. At the same time, however, the high sociocultural diversity in cities can be argued to generate a multiplicity of views on and behaviors towards risk reduction (e.g. [14–16•]). Considering that individuals identify with each other based on perceived similarities

such as shared perceptions of hazard risk, a high diversity of such perceptions in close proximity can lead to the emergence and coexistence of different risk-based social identities. Individuals who adopt one of these social identities define themselves partly by delineating their in-group from other out-groups — which in the case of environmental risk are other risk-based social identities. Such differences might hinder cooperation in adaptation between different risk-based social identities, for example, when within a neighborhood or city, climate change deniers ought to interact with climate change believers. Both social identities are described to root in different world views and political orientations [17,18•], and hinder collective adaptation efforts at a larger scale.

The importance of acting collectively towards adaptation has been acknowledged, as mentioned earlier, and it is known that the identification with others in the face of climate change gives individuals a sense of control over climate change impacts which they are lacking when they think of themselves purely as individuals (i.e. in terms of their personal identity) [19]. Moreover, there is ample research that cultural differences lead to different risk perceptions and behaviors even when facing similar environmental threats [20–23•]. But the impacts of the latter have not yet been soundly examined in the context of collective long-term adaptation in socioculturally diverse settings such as cities. Currently, '*the* vulnerable', '*the* urban poor' or '*the* informal settlers' are commonly described as homogeneous groups, thereby brushing aside the internal sociocultural heterogeneity within these alleged groups including diverse perspetives on the potential benefits and downsides of cross-group interaction and the respective implications for long-term urban adaptation.

To address these gaps, this study has two key objectives. First, it suggests a working definition for collective adaptation to facilitate its identification and assessment. Second, the study uses social identity and collective action theory to conceptualize collective urban adaptation in contexts where different risk-based social identities coexist in close proximity. The framework shows which factors affect group interaction and engagement in collective adaption and how they lead to different degrees and types of urban collective adaptation. We illustrate the four identified types of collective adaptation with examples from the climate change adaptation literature. Altogether, we aim at providing a guide for empirical investigations in this particular field and hope to advance the scientific debate on this important topic.

Towards a working definition for collective adaptation to climate change

While collective adaptation as a concept and phenomenon has been addressed in recent climate change adaptation literature, it has not always been explicitly called 'collective adaptation'. Other terms have been used as well to refer to collective action in the field of climate risk or resource management more broadly. While most of the contributions do not explicitly define the respective term they used, they put forward certain characteristics and enabling factors for collective action which we briefly summarized in Table 1.

These characteristics of selected terms related to collective adaptation provide valuable insights and are helpful for the respective contexts they were applied in. However, we would like to bring forward three reasons why we would hesitate to use one of them as universal definition for collective adaptation in the context of climate change. First and foremost, from our perspective, the current terms individually only cover part of the picture; that is they do not capture the full complexity of collective adaptation as a comprehensive concept of multilevel interindividual and group interaction, mobilization as well as degrees and types of adaptation with differentiated benefits. Second, definitions of collective action from social psychology mostly refer to engagement in protest movements, which we assume to be very different from long-term climate change adaptation engagement. Aims of protest tend to be ad-hoc action aimed at immediate gains, while achieving common adaptation goals calls for high levels of risk awareness, adaptation knowledge, and capacities — all of which are difficult to mobilize quickly and on an ad-hoc basis. Third, none of the definitions adequately covers the multiscale character of collective action, that is between individuals within a group and between different groups.

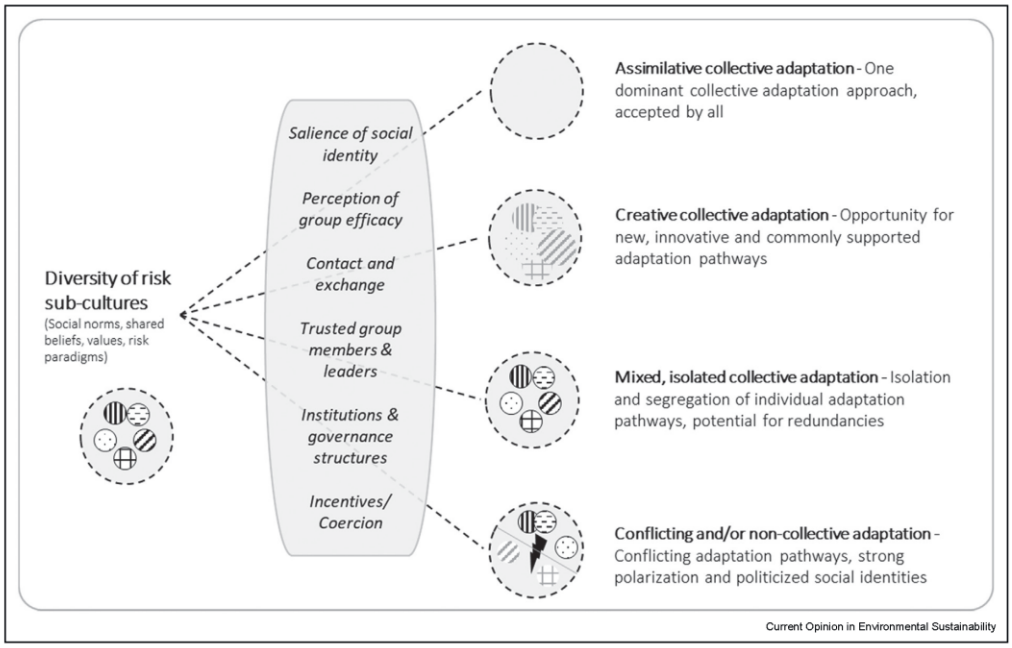
In an attempt to merge and tailor existing definitions around collective action to the climate change adaptation context, we adopt the IPCC's definition of adaptation as a "process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities" [33]. Against this background, we propose to define collective adaptation as actions of a group of individuals or subcultures collaborating according to shared rules to reduce their climate risk, exploit climate change opportunities and/or achieve additional common development objectives adopting a long-term perspective. The adaptation outcome they achieve collectively represents a common good that can be either exclusively for the group's benefit or for the wider public. Collective adaptation can refer to joint efforts within as well as across social groups or subcultures and hence builds on three key processes: First, the formation of collectives, second the process of their mobilization towards action and third, the actual joint adaptation action of those collectives, which may differ in degree and type.

Table 1

Selected terms related to collective adaptation from different contexts, their characteristics/core elements, and enabling factors.

Term	Context	Characteristics/ core elements	Enabling factors	Reference
Collective action for environmental management	Natural resource management	Collective action is described as an instrument to solve common resource issues	Social capital, networks and flows of information between individuals and groups in order to be able to make decisions	[5]
Communal adaptation	Flood risk adaptation	Adaptation on the basis of shared risk practices that are used by community members to protect against hazards	Coping practices, homogeneity in risk-handling behavior, sharing a sense of humor	[7]
Joint adaptation	Effectiveness of private and joint adaptation	Responses to climate impacts benefit many individuals at the same time; it is a public good and more than just the sum of individual adaptation actions	Government action	[24]
Adaptive neighborhoods	Flood risk adaptation	Spatial entities that facilitate exchange between individuals and groups, creating social capital for long-term adaptation	Suitably built environment, bonding, bridging, linking ties	[25]
Collective climate action	Social psychology of climate change action	Differentiation between actions taken based on personal and social identity; actions being taken from a social identity perspective are considered collective	Collective emotions and motivations, in-group identification, perceived group efficacy, in-group norms and goals	[8••]
Community's adaptive capacity	Individual and collective adaptation to urban heat and flooding	A community's adaptive capacity composes of the group's coping capacities and actions and collectively organized direct actions which reduce their level of impact directly and on the long-term	Politicization of climate-driven threats and related vulnerabilities, belief in effect of direct social actions	[26]
Collective adaptation goods	Social dilemma in climate change adaptation	Adaptation achieved through group action providing a collective adaptation good for their own or the collective's benefits	Adaptation dilemma arising through different interdependencies between providers and beneficiaries needs to be addressed	[27]
Collective action	Protest movements	Participation in social movement to obtain a collective good which is of use for the individual	Persuasive mobilization campaigns, selective incentives for individuals to engage	[28]
Collective action	Protest movements	Engagement of individuals in social protest and support of such groups by external groups	Social identification, group-based anger, group efficacy beliefs, politicization	[29,30••]
Collective action	Collective action problems (social dilemma)	Collective action as a means to overcome social dilemma (deciding for individual short-term benefits on the cost of joint benefits for the collective)	Social norms, trust, small, homogeneous groups interacting face to face, punishment of free-riders	[31]
Swarm intelligence	Cognitive sciences, organizational sciences, computational modeling	Ability of groups to act in an intelligent way to solve different types of problems collectively	Social integration strategies, social networks	[32]

Figure 1



Conceptual framework depicting the formation of risk subcultures, factors influencing their mobilization and potential types of collective adaptation.

Conceptualizing the formation of collective adaptation in heterogeneous settings

To advance adaptation, we argue that we need to better understand which degrees and types of collective adaptation might exist, how they emerge, particularly in socio-culturally heterogeneous settings, and how they might be fostered more widely across risk subcultures in one location. We hence propose a heuristic conceptual framework (Figure 1), which addresses the following key questions, drawing on a diverse range of literatures: First, how do risk subcultures form? Second, which factors influence the interaction between and mobilization of different risk subcultures? Third, what are different potential types of collective adaptation?

The framework is not meant as a universal theory or predictive model but as a heuristic analytical tool for guiding further theoretical and empirical research as well as, eventually, fostering collective adaptation in practice. It uses knowledge from social psychology (e.g. [34–36]) to conceptualize the formation of risk subcultures (left-hand side in Figure 1). Theoretical insights from collective action research (e.g. [28–30••,37•–40]) and disaster risk management research (e.g. [5,20,22•,23•,41–43]) were combined with literature on urban diversity [44–53] to identify the factors that shape the formation of collective approaches across different risk subcultures and their mobilization to evoke collective adaptation. The framework is considered particularly relevant for contexts in which the sociocultural heterogeneity is particularly high due to high degrees of human mobility, for example, in terms of language, race, ethnicity, origin or profession but also world views, values, beliefs, traditions, and generally ways of living, and where diverse subcultures with respect to the treatment of risk have formed while the pressure to adapt to increasing climatic and other hazards is high.

Key principles of the framework

The framework postulates three interacting key elements: The formation of risk subcultures in a given geographical unit, for example, a city district (Figure 1, left-hand side), the formation of different degrees and types of collective adaptation across risk subcultures (Figure 1, right-hand side), and the factors which shape the formation of collectives and their mobilization to evoke adaptation action (middle-segment).

Formation of risk subcultures

Building on social identity and self-categorization theory [34], [35], the framework assumes that individuals identify with other individuals or groups based on perceived similarities (e.g. job, beliefs, social situation) and

shared systems of meaning, that is common sense-making and shared cultural worldviews (Figure 1, left-hand side). Shared so-called social identities are different from an individual's personal identity, delineating a person's perceived in-group from one or multiple out-groups [34,35,54,55]. Social identification represents an important determinant for cooperation within the in-group [40]. Each individual has multiple social identities, which change according to context (e.g. [56]). To exemplify, a person can identify for instance as member of a certain type of social class, job, religious affiliation or as a parent — depending on the context. To a certain degree, differences can be overcome by social integration [32•]. Social identities can be place-specific, as well as independent from location thanks to worldwide communication and globalization [55].

In locations where people with different sociocultural backgrounds (e.g. ethnicities, religions, languages, world views, traditions) live in close proximity in at-risk locations, like in many cities, the social identity approach lets us assume that individuals with similar perceptions of risk and similar approaches to its reduction identify with each other when the risk adaptation context is salient. We call these identities risk-based social identities. Such identities may exist besides multiple other identities based on the situational context. Risk perception and risk behavior tend to differ among socioculturally heterogeneous citizens given that they come with different preconceptions, ways of sense-making and attitudes toward risk [16•,20,22•,41,43,57•–59]. Therefore, a multitude of risk-based social identities and risk-reduction behaviors can exist in parallel in any social system. Over the course of time, risk-based social identities develop their own social norms, values and traditions, meaning that they turn into risk subcultures (in line with [60••–62]).

Factors shaping the formation and activation of collective adaptation

According to the collective action literature, there are a plethora of different factors that facilitate or hinder the formation of collective action across different subcultures. The framework highlights the most frequently mentioned factors (Figure 1, middle segment): First, the risk-based social identity needs to be salient [12,29,30••,63–68]. This includes that the group members share emotions like fear, anger and/or hope [29,38,64,66,69] as well as moral convictions [70,71]. While the latter is often mentioned as a separate factor influencing collective action, we follow Vertovec [52••], arguing that it is deeply intertwined with social classification and identification. Secondly, group members need to strongly believe in their group's efficacy [28–30••,64–66,69,72,73]; that is that they as a group can successfully address the challenges of adaptation. Third, for groups to become active, contact and meaningful exchange between group members are essential [25,52••,74,75]. Fourth, trust in group members as well as guidance and mobilization through trusted and authentic leaders, who are often seen as the personified ideal and charismatic -archetype of a social identity play a critical role in initiating members of a group to take action [63,74–79]. Finally, the level and quality of governance arrangements to facilitate group formation and action are essential, which can comprise governmental structures but also other institutional arrangements in contexts of high informality [5,25,74,80,81]. This includes the use of instruments such as coercion or incentives to motivate group members to actively engage in collective adaptation [75,82]. The set of factors suggested here might still be incomplete as additional factors might emerge in future research. Also, there are controversial findings on some influencing factors such as hope [37•,83,84]. Lastly, the degree of influence of the single factors depends on context, and the assessed literature so far remains unclear regarding which combinations of factors in detail facilitate or hinder which of the identified collective adaptation types.

However, it would for instance be intuitive to assume that a combination of one common and salient risk-based social identity in a neighborhood with cross-cultural exchange governed by established institutions of social integration, reduction of prejudices and social injustices as well as an authentic and charismatic leader would facilitate the emergence of creative collective adaptation (see below). In contrast to this, a diversity context in which, for example, different ethnic groups dominate social identity salience even in the face of climatic risks and where cross-ethnic communication is limited due to lacking incentives to collaborate, either isolated or even conflicting collective adaptation seem more likely to appear. The interplay of factors presumably is dynamic and is influenced by among others the media and social power structures [52••]. More research on the combination of influencing factors as well as their respective effects in socioculturally diverse contexts is needed.

Degrees and types of collective adaptation

Building on urban diversity literature (e.g. [45–48,51•]), we argue that four basic types of interaction of risk subcultures can evolve, representing four possible degrees and forms of collective adaptation. Given that social relations never remain fixed [52••], we do not assume to find the adaptation types as clear-cut as presented here but rather in potential coexistence, depending on the context and scale of observation. Short examples from a variety of contexts will illustrate the different options.

Assimilative collective adaptation describes a case in which minority or subordinate risk subcultures adopt the risk subculture of the dominant or majority risk culture in a

given context. This might for instance include the weakening of individual subcultures so that the new forms of shared social identity may lead to a homogenization of culture in a certain location [25,47,85]. Depending on how assimilation is achieved — for example, by highlighting a superordinate social identity that all can relate to, through coercion or incentives, or through codification — the level of motivation to support and advance the majority's adaptation strategy may significantly differ [47].

An example of assimilative collective adaptation can be found in Jakarta, where local residents tend to show strong social cohesion, information exchange and mutual support across economic, ethnic, and other sociocultural boundaries in the context of disaster risk thanks to their strong Indonesian social identity [58]. Decades back, the national government developed the concept of Unity in Diversity to provide a superordinate social identity, which can be shared by all Indonesians. Until today, it appears to eclipse many perceived differences between different ethnicities, religions, and other sociocultural characteristics so as to conceve and enact a joint Indonesian and superordinate way of disaster risk management [85], [86].

Creative collective adaptation can occur when sociocultural differences become ordinary and accepted in day-to-day life [44], similar to an ideal form of multiculturalism [53]. This comes with normative claims regarding the rules and values of mundane togetherness, such as mutual respect, tolerance, meaningful exchange, and interaction independent of difference that allow for peace and satisfaction [48]. It is linked to the assumption that the exposure to and exchange between different risk subcultures facilitates mutual tolerance and even the formation of new shared social identities [87], for example, urban citizenship faced with climate change challenges [88] as well as innovative, emerging ways of collective adaptation which draw on and utilize the strengths of the respective individual risk subcultures.

The citizen initiatives launched by Verdir et divertir and Bien vivre à Saint-Roch for Urban Greening in Quebec [89] illustrate this type of collective adaptation. The initiatives brought together people who shared the aim to substantially improve the area's living quality and counter urban heat through urban greening. However, the participants strongly differed regarding their function in the neighborhood. The collaboration of local shop owners, entrepreneurs, and residents allowed the initiatives to swiftly find new spaces for their greening measures such as vacant parking lots. Businesses' support secured sponsorship and advocacy in the members' networks facilitated general acceptance and support. Hence, meaningful exchange and collaboration of these very different actors and their subcultures accelerated the process of change toward a green neighborhood in Quebec.

Isolated collective adaptation of different risk subcultures describes a situation in which multicultural risk subcultures coexist in respectful indifference (in line with [45]). The lack of productive intercultural exchange and preservation of the subcultures' original risk paradigms hinder the development of a commonly shared adaptation approach but daily contact leads to a tolerant side-by-side existence [50] of risk subcultures, which follow their respective adaptation pathways without interference [85].

An illustrative example of isolated collective adaptation can be found in Bangalore, India, [90] a city that is subject to increasing climate change impacts such as recurrent flooding due to extreme precipitation events and urban heat waves, especially during the summer. In many slums in Bangalore, local residents are members of self-help groups, which offer valuable capacities to cope with and accommodate everyday challenges, including climate change impacts [91]. The groups differ in terms of their members' sociocultural backgrounds and hence potentially their risk perceptions. Some self-help groups have members from a specific segment of the informal sector only, for example, cab drivers, domestic or construction workers mostly fearing job loss. Other self-help groups or citizen associations are based on caste and linguistic identities and may rather see flooding extremes as a direct threat. The self-help groups hence differ in their respective values, traditions, structures, and risk perceptions, however, they exist side-by-side and pursue similar goals such as improved access to basic services and livelihood security.

Conflicting adaptation is a situation in which tensions between different risk subcultures arise and reinforce the accentuation and preservation of cultural differences [51•] and inequalities [88], potentially up to the point of extremism and social breakdown.[1] This can result in conflicts between different risk subcultures; including the formation of coalitions between some risk subcultures against others. Not only does this setting hinder collective adaptation but it also carries the risk of undermining the effectiveness of adaptation within different subcultures, for example, in downstream vs. upstream conflicts.

[1] Empirically, there is mixed evidence on the effects of cultural diversity on social cohesion and conflict. While some studies (e.g. [49,92]) found evidence for an increasing risk of conflict and decrease of social capital in socioculturally diverse neighborhoods, other studies could not support these findings. In fact, Silver and Messeri (2014) for instance found that diversity has no significant impact on social capital in neighborhoods in New York City [93].

Conflicting water management approaches in Oklahoma [14] illustrate this context. The Arbuckle–Simpson aquifer in the US is an important water source for many surrounding municipalities. Because of increased drought risk, water conservation plays a central role in the area, however, different world views on nature have shaped conflicting risk subcultures with contradicting risk management approaches. While a public interest group advocates for more restrictive water management regulations to protect the aquifer's capacities, a group of private landowners rejects such regulations as infringements of their rights, arguing the aquifer has always provided water to the region and will continue to do so [14]. The conflicting world views hinder the identification of a shared management strategy to adapt to the risk of water scarcity.

Conclusions: added value, limitations, and outlook

In light of the increasing need for climate change adaptation at the community, neighborhood, or city level, we here aimed at reviewing the current state of scholarship on collective adaptation with a specific focus on socioculturally diverse settings. We found that current definitions and conceptual engagements from different academic disciplines do not yet adequately capture the multilevel interactions between individuals and groups and the respective consequences for adaptation. Therefore, we suggest a new working definition for the concept of collective adaptation to be applicable more broadly and to generate scientific debate around it.

Furthermore, we found a lack of conceptual and theoretical engagement with collective adaptation and its formation as well as activation, particularly in socioculturally diverse settings. While there are frameworks and theoretical models for collective action in general and also, for example, environmental behavior (e.g. [37•]), a more dedicated engagement has been missing with contexts in which different risk perceptions and behaviors at individual as well as at group level coexist in close proximity.

The presented framework addresses this gap by using the social identity approach to explain the formation of risk-based social identities in socioculturally diverse contexts. It further draws on theoretical considerations from collective action and urban diversity research to show how interactions between these identities may affect the activation of shared risk identities and how different types of collective adaptation can emerge. In this respect, the framework identifies four different types of collective adaptation, which differ in their degree of cooperation and collaboration between the interacting risk-based social identities. The proposed framework hence goes beyond existing studies by refining the currently predominant view on collective action enacted by 'the community'. It also disentangles -group formation as well as inter-group relationships in the context of climate change adaptation at subcity scale. We argue that the framework can be helpful in three ways. First, it helps to raise awareness that the current debate on collective adaptation lacks a critical view — or even romanticizes — group formation and action in 'communities', neglecting that sociocultural diversity within them generates different, sometimes conflicting, risk subcultures against the backdrop of which collective adaptation efforts need to be sought. Second, the framework can guide urgently needed empirical research: it suggests collecting empirical data on the mentioned facilitating factors and using it as an analytical tool to identify different risk-based social identities within '*a* community'. The different potential types of collective adaptation can serve as analytical lenses when assessing the collected data to better understand the degrees and forms of collective adaptation in a certain area as well as the factors that can shape, foster or hinder their emergence at a selected scale. Third, the framework can help to guide practice and policy towards fostering collective adaptation through an advanced understanding of group constellations and leverage points for incentivizing collective adaptation.

Yet, the framework is limited in several regards, calling for further research and advancement: First, a lot of the underlying theoretical work on urban diversity originates from a Global North perspective, calling for further investigation on the cross-cultural transferability of core assumptions and principles [38,94]. Second, the framework is not yet empirically applied, calling for more research to validate its core postulations and identify as well as test indicators to operationalize the assessment of the degree, type and factors of collective adaptation. This also includes a need for assessing the degree of influence of the listed factors (Figure 1, middle-segment) as well as the potential impacts of their combinations on the different types of collective adaptation. Third, the framework currently sheds little light on how to change from one type of collective adaptation to another, for example, from those with limited collective adaptation progress to those that advance adaptation more effectively. We argue that attention to all these fronts is needed within the adaptation research community.

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Data Availability

No data additional to the sources cited were used for the research described in the article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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The authors provide a crisp overview of The Social Identity Model of Pro-Environmental Action developed by one of the authors. In a review style, they unpack the various interlinkages between social identification, collective efficacy beliefs, in-group norms, and collective emotions as well as motivational states influencing proenvironmental collective action. They go beyond other climate action models by considering the shared perception of environmental change as an enabler of collective action.

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6. Discussion

6.1. Key findings, innovations and implications for urban adaptation research

In this study, I addressed and examined five research questions around the emergence and types of collective adaptation in socio-culturally diverse high-risk neighborhoods. Through a mix of inductive and deductive methods, I collected theoretical and empirical data to develop a conceptual framework for collective adaptation and validated its applicability and explanatory power for the case of high-risk neighborhoods in Jakarta. Through this approach, I connected different research disciplines and fields of inquiry to shed light on the connections between culture, group formation, their activation, as well as their collective behavior toward climate change risks (see Figure 12).

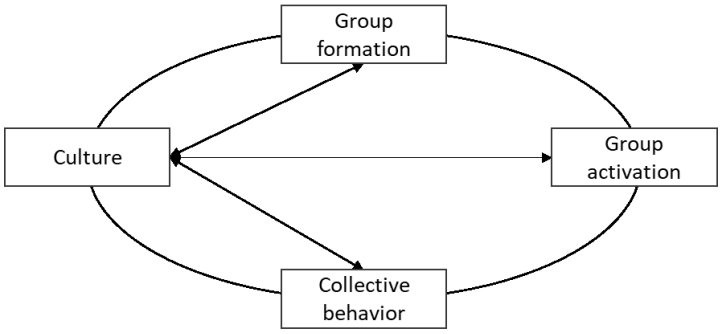

Figure 12: Fields of inquiry connected to collective adaptation to climate change

The results add to and extend the existing body of literature on collective adaptation to climate change in multiple ways. In the following, I will discuss the value of the conceptual framework as a whole, and of its sequences. Furthermore, I will highlight the new insights this study provides for vulnerabilities and adaptation capacities and actions at the neighborhood scale in Jakarta.

6.1.1. Conceptual innovations

In this study, I put forward the first working definition of collective adaptation (see Section 5.3.3). Previous research has highlighted how inconsistencies, contradictions, and inadequacies in definitions related to climate change concepts such as urban resilience, urban sustainability, or transformation hinder their practical use and policy development (Elmqvist et al., 2019). In contrast to existing definitions of collective action in the context of climate change (e.g. in (Becker & Tausch, 2015; IPCC, 2019; McNeeley & Lazrus, 2014)), the proposed definition clarifies the meaning of "collective" by describing who benefits from collective adaptation outcomes and detailing the collective adaptation process. It is instrumental for sharpening research, as it establishes a concrete basis for identifying and assessing collective adaptation actions and processes. In addition, it may contribute to larger scientific debates around adaptation to climate change, including normative debates about the winners and losers of adaptation (Kuhl et al., 2021). The proposed definition also holds significant value for policymakers, as it can inform political discussions

and aims regarding the visions and implementation of different types of adaptation to climate change – particularly in socio-culturally diverse cities.

Furthermore, I developed a conceptual framework (Figure 11) for long-term collective adaptation to climate change in socio-culturally diverse settings. It is unique and innovative in comprehensively covering the entire process of interlocked sequences starting from the formation of social identities in the face of climate risks, to the materialization of groups, their mobilization, and ultimately their potential interactions including implications for adaptation types at the urban scale. While the framework is not meant to represent a theory or a predictive model for collective adaptation, it holds significant explanatory power with respect to collective adaptation at the neighborhood scale. The presented findings of its application demonstrates how important it is to understand the embeddedness of its sequences to fully grasp the process of collective adaptation. By drawing upon long-established and valuable research from social psychology and other fields (detailed in Section 3), I showcase how their transfer and application to the climate change adaptation context can significantly enrich our understanding of collective risk behaviors. In particular, the conceptual framework re-emphasizes and addresses the need to better consider socio-psychological factors for enhancing the current knowledge on adaptation behavior (Barnett et al., 2021). Acknowledging the co-constitutive relationship between psychology and culture (Fiske et al., 1998), mainstreaming psychological considerations in the conceptualization of the collective adaptation process also addresses calls for better consider cultural aspects in adaptation research (Adger et al., 2013; Bankoff, 2017; International Federation of Red Cross and Red Crescent Societies, 2014). As the framework shows, they are deeply intertwined – for instance, cultural values are an important basis for social identification - and play a central role in understanding group formations in the face of risk, their mobilization to act collectively as well as their intra- and inter-group interactions. All of these processes have implications for adaptation processes across urban scales, which the conceptual framework tries to disentangle. With this, it offers a sound foundation for operationalization so that the topic becomes more approachable. Further empirical testing and validation can increase the robustness of the framework as a whole and improve its explanatory power.

While the holistic framework helps to obtain a comprehensive understanding of the process of collective adaptation as a whole, it simultaneously offers options to break down the process into sequences, thereby reducing its complexity and enabling the operationalization of key working principles for data collection and analysis while maintaining awareness of their interconnected nature. To be more precise, the conceptual framework's sequences represent an added value to our understanding and conceptualization of collective adaptation in four distinct ways.

First, it confirms the rarely examined link between social identities and climate change adaptation (Barnett et al., 2021). This study conceptualizes and empirically demonstrates how social identities materialize into collectively acting groups at the neighborhood level, each possessing varying collective capacities to adapt. The findings, detailed in Section 5.3.1, directly address the second research question of this study: Which groups form to collectively adapt? With this, this study responds to calls for a deeper understanding and closer examination of the role social identities play in climate change adaptation (Barnett et al., 2021; Barth et al., 2018; Masson & Fritsche, 2021). Aligning with (Titz et al., 2018), the study conceptualizes and empirically validates the salience of social identities in the face of climate-induced risk, thereby offering a more nuanced perspective on *the* community, *the* most vulnerable, or *the* urban poor. This study goes one

step further by shedding light on the dynamics of group formation processes driven largely by socio-psychological factors and context conditions. I built upon established theoretical models and theories from social psychology (see 3.3) and integrated them into climate change adaptation research (see 3.1), to effectively conceptualize and examine the formation of social identities in high-risk contexts. Acknowledging the co-constitutive nature of psychology and culture (Fiske et al., 1998), the framework addressed the need to better consider the role of culture in climate change adaptation (International Federation of Red Cross and Red Crescent Societies, 2014) in an indirect way. Culture emerges and is constantly re-configured through social interactions and shared processes of meaning-making. I employed social psychology approaches to assess and conceptualize the psychological foundations of socio-cultural factors that influence the formation of groups in the face of climate risks. By decomposing the term culture (as described in 3.2.1) into some of its principles such as social norms, societal values like reciprocity, social identities, common perceptions, as well as shared visions and convictions, the framework provides a first attempt to more concretely consider culture in assessing vulnerabilities and adaptive capacities. While these principles do not comprehensively capture culture, they surpass current debates (e.g. (Webb, 2018)) by offering a more tangible approach to consider different, subjective, and dynamically changing facets of culture in assessing climate change adaptation.

Second, the conceptual framework uses the well-established social capital approach to examine the collective adaptation capacities of social identities that materialize in the face of flood risk. The findings (5.3.1) speak to research questions one and four of this study: Is there evidence for collective adaptation in highly exposed and vulnerable neighborhoods in Jakarta? And what are collective capacities to adapt? I combined social identity analysis with a social capital assessment to identify the heterogeneous group capacities at the local scale and their dependence on social identity salience. Given that the latter dynamically changes with varying context conditions, I argue that it is not enough to measure social capital solely through network membership. Instead, it is crucial to consider the salience of social identities within a specific context and time. The results show that social identities are important to consider because they represent the precondition for accessing social capital (Bamberg et al., 2018). By combining social capital assessments with the analysis of social identity salience, including dynamics in group membership, social interactions, and social network access, I address (Engbers et al., 2017) call to better operationalize social capital for being able to assess it. This novel combination of analytical approaches is helpful in this regard and extends the explanatory power of the social capital approach, which is often criticized to be limited (Haynes, 2009). The identified differences in social capital for adaptation among different groups salient in high-risk neighborhoods in Jakarta re-emphasize the importance to take a differentiated perspective on *the* most vulnerable. Not only do they differ in terms of collective adaptation capacities; such capacities may even change dynamically depending on the context conditions. Given that adaptive capacity or a lack thereof partly makes up vulnerability to disaster risk, assessing collective adaptation capacities and their dependence on social identity salience allow inferring vulnerabilities of group members in a more dynamic and socio-culturally nuanced way.

Third, the framework offers empirical evidence and engages conceptually with the crucial finding that mere social identification and group membership alone are insufficient to sustain long-term engagement in collective adaptation. The answers to research question three - What triggers individuals to change from individual to collective behavior? And what keeps them engaged in collective adaptation over time? – are outlined in 5.3.2. This novel and empirically grounded perspective on the mobilization of collective

capacities suggests a more nuanced perspective on the mobilization of groups for the context of collective adaptation and therewith speaks to debates about the mobilization of social capital (Schobert et al., 2023). By proposing a temporal differentiation of motivation factors into initial triggers, long-term motivators, general facilitators, and barriers, this study expands current knowledge on the mobilization of collective action (see 3.3.2). The temporal differentiation of motivation factors adds value to our understanding of what is often generically called "enablers" or "enabling conditions" (IPCC, 2022a). While some general facilitators exist, this study proposes that depending on where individuals that identify with a group stand in their decision-making process, different types of motivation factors need to be considered to understand the final decision to engage in collective adaptation. Besides deepening current conceptual knowledge on the mobilization of collective capacities, the temporal differentiation of motivation factors holds practical value, particularly in policy-making. The motivation factors can serve as entry points for designing more targeted mobilization campaigns for collective adaptation. It is important to note that further testing and empirical validation in similar as well as different cultural contexts can enhance their robustness.

Fourth, the framework introduces a new and unique conceptualization of the potential interactions between different collectively adapting groups in a limited space, including implications for larger-scale adaptation. The results, detailed in 5.3.3, speak to research question five - How do different collectively acting groups interact? By drawing on urban diversity literature (Section 3.4), the framework distinguishes four potential types of collective adaptation, which emerge in dependence on different influencing factors. In reality, these types are more likely to coexist and manifest with varying strengths, making it challenging to assign a single collective adaptation type to a city or even a neighborhood. Nonetheless, this separation enhances our conceptual understanding of the potential types of collective adaptation by providing clarity amidst the complex landscape of coexisting and potentially interacting adaptation strategies within cities. It also serves as a valuable analytical lens to assess the adaptation behaviors of different urban groups. In that sense, the framework represents an initial effort to conceptually grasp the potential collective adaptation types and their influence on urban-scale adaptation. It has to be considered that this approach largely builds on the transfer of urban diversity concepts developed for and in "Western" countries to cities in Southeast Asia and the particular context of adaptation. In the face of controversies around transferability (Thynell, 2018), this part of the conceptual framework has to be considered with caution. In its current version, its primary purpose is to enhance our awareness and conceptual understanding of the heterogeneity present in collective adaptation within cities. At the same time, this part of the framework is envisioned to stimulate scientific debates and encourage interdisciplinary research on this particular aspect for which the framework can serve as a valuable analytical tool. Currently, the impact of diversity in adaptation strategies at the urban scale remains under-researched – this study is a first attempt to grapple with this diversity and presents an analytical tool that may guide future research in this field.

6.1.2. Novel empirical insights into collective adaptation to flooding in Jakarta

On an empirical level, I provide two novel insights into the well-researched vulnerability context of Jakarta.

First, it is to my knowledge the first study that uses a social identity perspective to analyze socio-cultural diversity at the neighborhood scale beyond conventional social categories such as age, gender, ethnicity, and income class in Jakarta. Contrary to initial assumptions, the empirical evidence reveals that diversity in

terms of religion, ethnicity, beliefs, worldviews, and alike can predominantly be observed between neighborhoods rather than within the smallest administrative units of RTs or kampungs. Nonetheless, even the smallest administrative unit is highly diverse, for instance in terms of professions, social network memberships, moral convictions, and visions. The findings, presented in Section 5.3.1., demonstrate that at this particular scale, out of a plethora of different social identities only three distinct social identities emerge as salient in the context of adaptation: families and close friends, traditional neighborhood groups, and CSO-supported, cross-neighborhood groups. These groups/networks exhibit varying collective capacities to cope with, adapt to, and recover from flood impacts. This perspective shifts the focus from social categories that are conventionally assumed to be most vulnerable, such as the elderly, children, or disabled (Lwasa et al., 2022), to a capacity-oriented perspective that considers social embeddedness. While being older generally increases vulnerability in the face of hazards, some elderly may identify with and be part of social groups with capacities buffering their inherent vulnerabilities to climate change impacts. This is not to call into question the potential vulnerability of the elderly, children, and other groups that valuable research has demonstrated to be vulnerable in the face of climate change impacts. Instead, it is an offer to consider their social embeddedness to obtain a more nuanced perspective on their vulnerability context. The empirical results for Jakarta go beyond conventional social capital and vulnerability assessments because they carefully consider the formation and salience of social identities, a prerequisite for the materialization of collectively acting groups/networks. Confirming the explanatory power of this approach, I identified a high socio-cultural diversity at the neighborhood scale - however not in conventionally considered social categories like ethnicity or religion but in group/network membership. By assessing the social capital of the three salient social identities, namely families and close friends, traditional neighborhood groups, and CSO-supported, cross-neighborhood groups, I am able to provide evidence for their differentiated collective capacity patterns. Moreover, the findings illustrate that despite strong social norms, mere group membership does not guarantee engagement in collective adaptation. Residents of high-risk neighborhoods in Jakarta are mobilized through different motivation factors, depending on their stage in the decision-making process to engage. In the case of kampung cooperatives, passive membership represents an existential threat because cooperatives strive through the active engagement of their members. The identified motivation factors can serve as entry points to mobilize their members. This may advance local adaptation capacities because – as the study demonstrates - those residents of high-risk neighborhoods who identify with kampung cooperatives have more capacities to adapt than those who rely on direct neighbors and friends or traditional neighborhood groups.

Second, this study is the first to explicitly examine the emerging phenomenon of kampung cooperatives. They represent an important local social identity in most kampungs which overshadows other identities in contexts linked to self-organization and livelihood protection, including protection against hazards and other threats. They foster a shared risk perception and behavior through their common vision and institutionalized structures, thereby enhancing the perception of group efficacy and identification. Consequently, in kampungs where cooperatives have substantial membership, collective adaptation is not hindered by divergent risk perceptions stemming from differences in ethnicity, religion, beliefs, values, and alike. This can be attributed to the strength of the salience of the kampung cooperative identity which unifies individuals across socio-cultural differences. Accordingly, they represent a significant adaptation potential. Especially because kampungs are not inhabited by “the poorest of the poor”; they are home to the lower-middle classes in Jakarta and hence a significant share of the urban population. Informality and

recurrent flood impacts keep kampung residents around the poverty line with the risk to fall into severe poverty with every heavy flood event. While being highly at risk, kampung residents also represent an important driver of the urban economy, possessing unneglectable adaptation capacities which have been insufficiently considered in research as well as adaptation policies as of now.

However, the study also found that at the neighborhood level in at-risk areas, climate change adaptation does not represent a major concern; at least not when compared to the fear of being evicted and losing local context conditions due to relocation which aligns with other studies (van Voorst & Hellman, 2015). Collective activities primarily revolve around the right to stay and secure local neighborhood and livelihood structures. Given their size, unity, and access to external knowledge, kampung cooperatives can exert pressure on local governments to consider their needs and visions in urban development processes. Notable outcomes include the prevention of forced resettlements and modifications in the urban land use plan, with implications for urban flood risk management. Many kampungs are located on land that was previously not designated for residential use. Through formal processes and, in some cases, lawsuits they successfully altered the land use class, obtaining a temporal right to stay. These changes in classification and the provision of temporary residency enable kampung residents to stay in their current locations, even if they will be severely flood-exposed in the future. Accordingly, the consideration of the needs and visions of residents is not always contributing to adaptation. Short-term perspectives focused on preserving present livelihood conditions overshadow more long-term considerations of future flood risk in their particular area. The finding that kampung cooperatives predominately aim at preserving their current social and livelihood context, aligns with findings from other cultural contexts as well. Barnett's study on social identities in adaptation in the UK for instance finds that the "desire to maintain in-group continuity […] appears to be key to understanding community responses to adaptation imperatives," (Barnett et al., 2021).

Besides the emergent collective phenomenon of kampung cooperatives, it is important to acknowledge various other autonomously implemented collective initiatives contributing to adaptation at the neighborhood scale, which I have not assessed in detail in the course of this study. They are smaller in scale and primarily adhere to strong social norms. A notable example is the practice of collective neighborhood work, known as *gotong-royong*, which is a prevalent social institution in almost every neighborhood in Jakarta. Through monthly participation, where each household sends one resident, neighborhoods engage in collective activities such as regular neighborhood cleaning, including the maintenance of drainage systems to mitigate flood risks (Marfai et al., 2015). While this type of collective action contributes to adaptation, it does not directly address the drivers of flood vulnerability and structural disadvantages due to limited capacities as elaborated in Section 5.3.1. Another prominent collective phenomenon prevalent among residents of high-risk neighborhoods are informal early warning structures, which have been comprehensively researched (van Voorst, 2015, 2016). However, these systems are limited to providing flood warnings within at-risk neighborhoods and do not encompass other adaptation measures that require consolidated group action beyond information dissemination. It would be interesting to explore the spread of flood warnings from one local group to another in high-risk, socio-culturally diverse neighborhoods, hence combining this study's approach with the assessment of warning chains. There are also some collective initiatives undertaken by micro-, small-, and medium-sized enterprises that contribute to urban adaptation (Neise et al., 2019). Given the business context, the findings are not directly applicable to at-risk residents.

7. Conclusion and future research needs

In the preceding sections, I extensively discussed the framework's overall innovations and the added scientific value and empirical insights derived from its different sequences and their empirical application in Jakarta. To conclude, I will now delve into the broader implications of my findings for research and policy-making, including an outlook on potential future research directions.

To evaluate the implications of this research and its value beyond the case of Jakarta, requires addressing questions on the transferability of the conceptual framework and the findings of its application. While the transferability has been discussed for each of the sequences of the conceptual framework in the respective publications, I will briefly elaborate on it again as it largely determines the value of the study beyond Jakarta.

I developed the presented conceptual framework by deductively drawing on various relevant and established theories and concepts from different research disciplines (see Section 3) to conceptualize the process of collective adaptation. I inductively tested and validated the applicability of the framework through empirical data from Jakarta. Given the abstract nature of the overall conceptual framework (Figure 11), I suggest it to be transferable to other cultural contexts beyond the scope of the case study. The processes conceptualized in the framework can capture collective adaptation in various settings because it exclusively builds on the underlying socio-psychological principles that influence collective adaptation without incorporating socio-culturally specific elements. Nevertheless, further research is necessary to validate the transferability by applying the conceptual framework to similar as well as different socio-cultural contexts. In contrast, the transferability of the results of the framework's sub-processes is limited to some extent. The identified motivation factors as detailed in Section 5.3.2., are suggested to be transferable to contexts that exhibit similarities in societal values, norms, and beliefs. However, the importance of the identified motivation factors may vary depending on the social and environmental context. In socio-culturally very different settings, a similar assessment may derive similar general facilitators, however, the initial triggers as well as the long-term motivators are likely to vary. Therefore, empirical testing of the temporally differentiated motivation factors and barriers in other socio-cultural contexts is required to ascertain the robustness of the identified factors and to obtain a more universally applicable list of temporally differentiated motivation factors. Regarding the identified social identities and their respective adaptive capacities in high-risk neighborhoods in Jakarta (5.3.1), it is important to note that they are not transferable, due to the highly context-specific nature of social identities. I have detailed the limitations as well as the added value of these components of the conceptual framework in 5.3.2, and 5.3.1 respectively.

In summary, I suggest the working definition for collective adaptation as well as the conceptual framework - covering the entire process of collective adaptation - to be applicable beyond the presented case study. Future validation can increase their robustness. The other findings are partly context-specific, requiring further testing in similar and different socio-cultural settings to evaluate their applicability beyond Jakarta. That said, one could ask: So what? How can this transferable conceptual framework enhance existing knowledge about collective adaptation and the role of social identities in climate change adaptation? How can it help to improve adaptation to climate change?

I will answer these questions around the added value and relevance of this study by highlighting six contributions resulting from this study that can meaningfully advance current adaptation knowledge and be applied in practically useful ways in science and policy-making.

First, the definition and the conceptual framework break disciplinary barriers by connecting the different processes leading to collective adaptation. A concise definition and comprehensive process understanding can not only facilitate the development of holistic approaches for further scientific examinations of collective adaptation but also enable the development of tailored approaches to advance collective adaptation through political support. Considering the cross-disciplinary character of the presented conceptualization of collective adaptation, I emphasize the value of more interdisciplinary collaboration among different research fields such as human geography, social psychology, cultural anthropology, and sociology. Increasing such collaboration can advance adaptation knowledge and action, as well as mainstream the topic across disciplines.

Second, this study offers a novel perspective on adaptation processes at the urban scale, thereby generating new insights that are urgently needed considering the scarcity of empirical evidence for coastal urban adaptation globally (see 5.1). Coastal cities will be at the forefront of climate change but they also possess considerable capacities to adapt and thus play a pivotal role in adaptation and resilient development more broadly (Adelekan et al., 2022). It is crucial to acquire detailed knowledge about how residents adapt, particularly those who are at the highest risk and often lack state support. In many coastal cities in Southeast Asia, these vulnerable residents represent a significant share of the urban population. As this study demonstrates, they possess adaptive capacities that are bound in their ability to work collectively. Therefore, when adequately considered and supported, they can play a vital role in advancing urban adaptation. However, the global review of urban adaptation evidence indicates that individuals/households in coastal cities in lower-middle-income countries like Indonesia are often lacking state-led support in adaptation (see 5.1). This study uncovers this mismatch and provides entry points for understanding and mobilizing neighborhood-scale sources of adaptive capacity. Gaining deeper and more nuanced insights into local patterns of capacities and visions can facilitate their integration into state-led adaptation initiatives. Such integration is urgently needed to be able to face, mitigate, and adapt to future urban risks in times of climate change.

Linked to this, the framework's third contribution to improving urban adaptation lies in acknowledging and incorporating diversity. Despite the recognition that culture influences risk perceptions and behaviors (Bankoff, 2017; Dietz & Shwom, 2017; International Federation of Red Cross and Red Crescent Societies, 2014) and the longstanding awareness of increasing social, cultural, economic, and demographic diversity in urban areas, the influence of socio-cultural diversity on urban adaptation remains a blind spot in adaptation research. Addressing this critical gap, the conceptual framework is the first to offer an explicit consideration of socio-cultural diversity in urban adaptation research. Concretely, it proposes an analytical frame for assessing social identities, their materialization into different groups, their mobilization, and potential interactions at the neighborhood scale. While the findings from its application only provide first insights into the implications of diversity for urban adaptation, they demonstrate how such considerations can deepen our understanding of local vulnerability and capacity patterns, thereby showcasing the explanatory power of the conceptual framework.

Fourth, in terms of scientific applicability and utility, the framework encourages and facilitated future research in urban adaptation to climate change because it conceptualizes the process of collective adaptation and its sequences in a way that allows for operationalization. This may guide future empirical investigations of collective adaptation, which is urgently needed to complement other adaptation measures and strategies. In addition, the conceptual framework and findings of its application may inform other contemporary scientific conceptual debates around related and currently much-discussed concepts such as social contracts, social adaptation, distributive justice, and participatory urban planning.

Fifth, for policy-making the framework offers a valuable analytical perspective on current urban adaptation processes and raises awareness for the diversity of local collective capacities to adapt to climate change. Using this framework to analyze collective adaptation at the neighborhood level can provide urban policymakers with crucial insights to understand, support, guide, and integrate local collective adaptation initiatives into state-led adaptation strategies. Concrete entry points are for instance the identified influencing factors that shape the adaptation types in socio-culturally diverse contexts.

Lastly, for the case of Jakarta, the study's results underscore the significance of considering the collective adaptation capacities and actions of at-risk kampung residents in the city. I present empirical evidence for the collective capacities and adaptation actions of residents living in high-risk neighborhoods, showcasing that they are not merely waiting passively for government support. Instead, they possess capacities to adapt which are bound in their ability to work collectively. Given Jakarta's stereotypical characteristics for Southeast Asian megacities, I assume that this holds for other Southeast Asian coastal cities as well. However, the results also reveal that the success of collective adaptation efforts hinges on the knowledge and long-term visions of cooperative members. In cases where climate change is not highly prioritized and short-term visions prevail, neglecting future climate change threats, collective adaptation efforts may prove maladaptive in the long run. In other words, collective movements like kampung cooperatives can be a double-edged sword: While they improve the livelihood conditions of their members and with this their adaptive capacities; they may inadvertently increase long-term exposure by aligning with members' short-term visions. This is likely to be valid beyond the case study of Jakarta.

Altogether, the aforementioned points demonstrate the relevance and timeliness of this study and how the findings meaningfully contribute to and advance the current state of urban adaptation knowledge. At the same time, the research process has also given rise to several new questions. In the following, I will provide concise insights into the ones that particularly captured my interest:

First, in this study, I predominately focused on examining the collective adaptation of one institutionalized collective, namely kampung cooperatives, without assessing its interplay with other institutionalized or non-institutionalized collectively adapting groups. Applying the framework in a context where multiple, equally strong collectively adapting groups co-exist, would enable testing and validating the adaptation types presented in 5.3.3. Additionally, it would be interesting to explore variations in the overall cultural context, meaning a change from a rather collectivist context to cultural settings where reciprocity and mutual support are less strongly valued.

Second, and linked to the previous point, it would be worthwhile to explore the interplay of the examined local collective adaptation strategies with top-down state-led adaptation approaches. As the empirical results show, collective adaptation at the neighborhood scale in Jakarta partially emerges as a response to

state-led adaptation (see 5.3.2). Kampung cooperatives for instance fight against resettlements in the name of urban flood protection. It would be interesting to adopt a more positive perspective on this interplay by investigating how local collective adaptation initiatives could complement state-led adaptation strategies and vice versa. The conceptual framework could help identify co-existing adaptation visions and capacities at the local scale, which is essential for making them visible to policymakers. This visibility can enable the consideration and integration of local capacities and visions in urban development processes. At the same time, such a solutions-oriented approach could also investigate the conditions under which beneficial adaptation types such as assimilative or creative adaptation could be achieved. This would include assessing the relevance of the identified influencing factors and which of them can be instrumentalized to change from isolated and potentially redundant collective adaptation types to co-creative, mutually supportive adaptation in neighborhoods and at the urban scale.

Third, future research should examine feedback loops between the different sequences of the conceptual framework. How do the different adaptation types affect individual and collective risk perceptions? To what extent do risk sub-cultures influence personal identities? Such questions are worthwhile considering to enhance the explanatory power of the framework, diving deeper into the underlying drivers of collective adaptation.

Fourth, as the global stocktake of adaptation progress approaches, it is crucial to address persistent gaps in identifying and assessing adaptation. The insights of recent reviews ((Berrang-Ford et al., 2021); 5.1) showcase how little empirical evidence is available for implemented adaptation, not to speak of its success to reduce risk. However, as this study demonstrates, adaptation can be contributed to through measures that are not conventionally labeled as adaptation. In Jakarta, where exposure is the daily normal, adaptation is not prioritized but anyhow contributed to through collective activities that enhance individual as well as collective coping and adaptive capacities. In other words, many activities such as education, livelihood security, or better access to basic services contribute to adaptation in indirect ways; they are currently not sufficiently covered in adaptation research. Potentially, adopting a resilience lens could offer a broader perspective and incorporate such efforts. Resilience is defined as the “capacity of social, economic, and ecological systems to cope with a hazardous event, trend, or disturbance, responding or reorganising in ways that maintain their essential function, identity, structure, and capacity for adaptation, learning, and transformation.“ (Adelekan et al., 2022). Nonetheless, challenges in operationalizing and practically assessing resilience necessitate clearer conceptualization and improved methods to identify and assess factors that contribute to adaptive capacities and adaptation to climate change.

In conclusion, this study both addresses and raises important questions related to collective adaptation to climate change. With this study, I aimed to bring clarity into the concept of collective adaptation and provide a comprehensive perspective on, and analytical frame for its entangled processes to encourage and guide future conceptual as well as empirical research. Addressing the identified lack of empirical evidence for urban adaptation (5.1), I present insightful empirical evidence for the heterogeneous collective adaptation capacities and strategies at the neighborhood scale to raise awareness for existing, yet often overlooked sources of adaptation and their heterogeneous patterns. For the particular case of Jakarta, I demonstrate the emergent and crucial role of kampung cooperatives in local climate change adaptation and livelihood struggles, while also acknowledging the potential risks arising from their growing influence.

In light of my findings, I advocate for more interdisciplinary and co-designed research on collective adaptation processes, that is collaborative research between geographers, sociologists, cultural anthropologists, and social psychologists. More empirical insights as well as wider theoretical and conceptual debates around the role of diverse risk subcultures in urban adaptation are urgently needed in the face of increasing climate change impacts and the necessity to address climate change as a collective action problem. Collective adaptation holds significant untapped potential for advancing current adaptation efforts, and it is my hope that this study, including the conceptual framework and the empirical insights from Jakarta, catalyzes further exploration of this alternative pathway of adaptation.

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Appendix A

A.1 Questionnaire: semi-structured key informant interviews (online)

What do I want to find out?	Question	Follow-up questions
Impression of flood vulnerability	1. **According to the literature, the urban poor, marginalized groups, and minorities are most vulnerable to flooding. Would you agree with this statement?**	
Are there differences in flood vulnerability between the groups? (RQ 1) What are the drivers of vulnerability? (RQ 2)	2. **Are there differences among these groups regarding their vulnerability to flooding?**	If yes: What are the differences? Can you give examples? Different perception of flooding? Are there spatial patterns in the city (segregation or mixed up) If no: What about minorities such as migrants from other Indonesian Islands or from abroad (e.g. Chinese)? If no: What unites people of different backgrounds, worldviews, ages, etc.?
Evidence for collective adaptation (RQ 3c., 4)	3. **Do you know of any examples where people on the ground work together to adapt to flooding? Can you describe them?**	Not just in response to floods but more for long-term adaptation. Who supports whom? Are there individuals who cannot receive such support/who are excluded?
Effectiveness of collective adaptation	4. **Would you evaluate such measures and collective adaptation strategies as effective? Do they reduce flood risk for the participants?**	Are local initiatives effective in risk reduction compared to state-led measures? What are the limits of local collective adaptation strategies? Would you consider them as long-term solutions or rather short-term coping mechanisms?
Changes in social cohesion and mutual support linked to collective action and adaptation	5. **From your perspective, have there been any changes in mutual support among citizens or in the groups you just described? How do you think will it develop in the future here in Jakarta?**	What are and will be the consequences be for the groups you mentioned?

Complementing or conflicting with state-led adaptation	6. How do you think these described measures and collective initiatives go together with state-led adaptation strategies, for example, local or city government adaptation measures?	Are there any conflicts? Examples?
Vision	7. From your perspective, what would be needed to really use and integrate the local level's potential in flood risk adaptation?	

A.2 Coding scheme for interview material

First round of coding	Second round of coding
Achievement of collective action	Group(s) - in-group, out-group
Problem/gap	Place attachment

- Urban diversity
- **Group(s) - in-group, out-group**
- **Identification factor**
  - Identification scale
- Bonding social capital
- Bridging & linking social capital
  - Excluded individuals/groups
- Social cohesion (changes)
- Collective action/adaptation
  - Achievement of collective action
- Collective actor
- Individual adaptation
- **Factors facilitating collective action**
- **Factors hindering collective action**
- Leaders of collective action
- Effectiveness of collective action
  - Religion
  - Time of residence/migration
  - Family, kin, neighbors
  - Social, political orientation
  - Shared place of origin/ethnicity
  - Common threat
  - Organized groups
- **Identification factor**
  - Religion
  - Shared threat, risk, concern
  - Place of origin/ethnicity
  - Migrant status
  - Close neighbors
  - Organized group
  - NGO, CSO, faith-based organization
- **Factors facilitating collective action**
  - Trigger/activator
  - Motivating factor to stay active
- **Factors hindering collective action**
  - Barriers

A.3 Coding scheme for integrative literature review

- Code System
  - Adaptation definition
  - Influencing factors adaptive capactiy
  - Questionnaire construction
  - Location of empirical study

(statisitcal) method
Diversity in Indonesia/India
(Urban) diversity
Multiculturality, cosmopolitalism definition, examples
Diversity benefits
Diversity problems
Personal identity
Social identity
Collective action definition and examples
Activator/trigger
Urban collective action
Inhibiting collective action
Facilitating collective action
Heterogeneous group collective action
Social capital (in disasters)
Effects (Benefits etc.)
Definition - social capital
Factors influencing risk PERCEPTION
Factors influencing risk BEHAVIOR
Factors influencing VULNERABILITY
Delineation of groups
Culture definition/ Aspects of culture
Research gaps/problems

A.4 Questionnaire: expert elicitation

#1: Most vulnerable groups and intra-group differences

Hypothesis: *The most vulnerable are not one homogenous group; they differ internally. From the interviews, I can assume that they differ with respect to the type of exposure (river or coastal flooding), experience in flood response, the strength of RT risk management, and individual capacities through networks.*

1. What is your perspective on differences within the group of “the most vulnerable”; different sub-groups? What determines/delineates them?
2. Who exactly is excluded in poor, highly exposed communities? (It was mentioned that coverage in autonomous coping and adaptation is somewhat selective/not comprehensive)
3. Flood risk for migrants? Are there migrant communities that are isolated? (e.g. Batak?)
4. What is the most important criterion for social identity formation? (from interviews it seems to be proximity/RT, neighbors, and relatives)

#2: Active groups & collective adaptation strategies

2.1 H adjusted: *At the very local/household scale, cultural or ethnic differences do not play a role in the formation of social groups; either because the communities (RT) are internally culturally homogeneous or identification with the RT is more dominant than with own cultural background. At the RT scale, cultural differences (religion, ethnicity, migration status) shape delineation and degree of interaction.*

5. It was described that community organization for how to cope with flooding and information distribution also takes place in Mosques, Churches, or more generally religious places (besides RT meetings). From your experience: do religious groups go about flooding differently?
6. Do isolated migrant communities adapt/accommodate flooding the same way as Javanese communities?

2.2 H adjusted: *Evidence for collective adaptation to flooding can be found in poor, frequently exposed areas in Jakarta, where inhabitants have a lot of experience with flooding and where community coordination is working well. However, current adaptation actions only facilitate the accommodation of flooding.*

7. Most of the mentioned measures, when I asked for collective adaptation, are actually reactive, short-term coping measures (flood warning distribution, neighborhood support in crisis situations). Only a few collective adaptation measures were mentioned (e.g. collective cleaning of river banks, pooling of resources/saving groups, informal early warning structures, RT evacuation plans (all depending on local leaders). Is my impression right or could you observe/identify any other long-term collective adaptation strategies?
8. What or who mobilizes action?
9. Do you think flooding is perceived and dealt with differently along the coast as compared to along the rivers?
10. Interference of state-led adaptation measures with local strategies (besides relocation)?

#3 Social cohesion

H: *Due to the collective culture of Indonesia social cohesion has a high value and is generally high. However, living conditions and electronic connectedness have the potential to lower the strength of place-*

based social cohesion – especially in middle- and upper-income classes which are at risk to be flooded more frequently in the future.

11. From your perspective, what is the **role of social cohesion in adaptation** to flooding?
12. Did/does increasing access to and **use of social media** change the social fabric of communities and if yes how?
13. Social cohesion was described as being very high – especially among the poorest. In **middle and higher income groups it was described to slowly erode**. Would you agree? Would you say that could become a problem seeing that by now also middle and high-income areas are hit by flooding?

A.5 Questionnaire: kampung cooperative members

What do I want to find out?	Question	Follow-up questions
Motivation to join	**A.6 Why did you join the cooperative?**	How did you get to know about it? What do you like about their approach?

		Are there also other networks/groups with similar visions and if yes, why did you join the one you chose?
Network and group membership	B.6 Are you a member/supporter of any other networks or groups?	If yes: Which ones and why?
Expectations and benefits	C.6 What did you expect when joining the cooperative?	Were your expectations met? Was there anything that surprised you (positive or negative)?
Social cohesion	D.6 How close are you with the other cooperative members?	Do you know all members? Do you trust them? How often do you see each other? How often do you meet and what do you do during these meetings?
Benefits for flood adaptation	E.6 Which benefits do you have as a member in case of flooding?	Which actions do you take as a group? How does that help you to better deal with recurrent flooding?
	F.6 Did you try to convince others to join?	If yes: Why?

A.6 Survey questionnaire

Name of location:

1. Why did you join the koperasi?

2. What are you doing as a member?
   - o I pay the membership fee.
   - o I participate in koperasi meetings.
   - o I frequently exchange with other members of the koperasi.
   - o I participate in koperasi business activities.
   - o Other (please explain):

3. What did you achieve with the help of the koperasi until today?

4. What do you want to achieve with the koperasi in the future?

Appendix B

B.6 Annex of the publication "A global assessment of coastal urban adaptation"

DRAFT

Annex

Table 1: Search strings, combinations and resulting numbers of publications (the original GAMI-search was complemented by terms tailored to the specific research interest (added terms in italics)

	Reference data bank	Search terms	Limitations	Hits	Combined*	Combined with GAMI**
GAMI #1	GAMI	Cities and settlements by the sea		361	-	-
Reference databases	Web of Science	TS= (climat* or "global warming") AND TS= (adapt* or resilien* or "risk management" or "risk reduction") *AND TS= ("coast* city" OR "ocean cit*" OR "port cit*" OR "harbor* cit*" OR "coast* urban" OR "urban coast*" OR waterfront)*	Refined by: DOCUMENT TYPES: (Art Data Paper OR Database Review OR Review) Timespan: 2013-2020. Index EXPANDED, SSCI, A&HCI, CPCI-S, C ESCI.	156	337	GAMI #1: 683
	Scopus	TITLE-ABS-KEY (climat* or "global warming") AND TITLE-ABS-KEY (adapt* OR resilien* OR "risk management" OR "risk reduction") *AND TITLE-ABS-KEY ("coast* city" OR "ocean cit*" OR "port cit*" OR "harbor* cit*" OR "coast* urban" OR "urban coast*" OR waterfront)*	AND (LIMIT-TO (PUBYEAR , 2020) OR (LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "le"))	287		

* titles that appeared in both searches were deleted; ** Combination from WoS and Scopus combined with GAMI #1; publications appearing in both searches were only counted once

Table 2: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria	Examples for inclusion/exclusion
Population/ Problem (P)		
Focused on adaptation to actual, projected, or perceived impacts of *climate change*.	Focused on responses to environmental variability that are not conceptually linked to climate change.	*Example of document that would be excluded*: Responses to flooding or heat waves with no justification or mention in full text that variability may be affected by climate change. *Note*: evidence of detection and attribution is not required, but there must be some justification for how climate can, or may in the future, be an important driver of impacts.
Interest (I) and Context (Co)		
Substantive focus on *adaptation* to climate change	Primary focus on *mitigation* to climate change or on *impacts* of climate change that are not framed as potentially adaptive	*Examples of documents that would be excluded*: Energy efficiency programs; planting trees to absorb CO ; energy conservation; solar power; carbon taxation; agricultural shifts to increase soil carbon storage. *Examples of documents that would be included*: climate legislation or policy to reduce or minimize the impacts of climate change; changing crop types to move to a more climate-resilient crop; changing livelihood strategies to avoid climate risks; migration out of flood-prone areas; improving health systems or surveillance systems to prepare for changing disease incidence

Presents *empirical* data on on observed/documented adaptation responses	Primary contributions are conceptual or theoretical; or presents potential adaptations, adaptation constraints, or adaptation opportunities	*Examples of documents that would be excluded*: Papers theorizing adaptation opportunities, but results are not based on empirical data collection. *Examples of documents that would be included*: Assessing or proposing potential benefits of adaptation options, adaptation planning, or assessment of constraints to, or opportunities for, adaptation. Must be based on qualitative or quantitative data collection (e.g. interviews, focus groups, policy analysis, field work). Can be secondary analysis, combining multiple empirical studies. Must be evidence in the title or abstract that there is substantial empirical data presented.
Presents empirical data on adaptation responses from *coastal cities*	Primary focus on empirical response data from non-coastal cities	*Examples of documents that would be excluded*: Empirical response data stems from a non-coastal city and is only partly compared with coastal cities. In the coding questionnaire, the document must be ticked as "non-coastal city example" to reconsider it at a later stage. *Examples of documents that would be included*: Case studies or comparative studies providing empirical response data from coastal cities.
Adaptation responses must be *initiated by humans*	Autonomous or evolutionary adaptations in natural systems that are not human-assisted	*Examples of documents that would be excluded*: Changing range of a species with no involvement of humans; evolutionary responses by animals or plants that are not initiated or assisted by humans. *Examples of documents that would be included*: restoration or conservation measures to protect sensitive ecosystems; fishing or hunting policies; changes to coastal management policy.
Focuses on actions that are directly aimed at *risk/vulnerability reduction*	Focuses on actions that are aimed at assessing vulnerability or proposing potential actions, with no clear evidence of activity that directly reduces risk	*Examples of documents that would be excluded*: Vulnerability assessments (including consideration of adaptive capacity); adaptation planning that does not involve actions to directly reduce risk/vulnerability; adaptation financing alone (unless funded risk reduction actions are documented). *Examples of documents that would be included:* Advocacy activities to help citizens reduce their risk; provision of climate services to aid decision-making in risk reduction; climate legislation or policy designed to minimize risk; adaptation finance that supports actions that are directly aimed at reducing risk/vulnerability.

Table 3: Considered countries according to World Bank income categorization

Country Name	Count	Mean Vul. score	GNI	Income-Group	Count

Mozambique	4	0.864814	490	Low	5
Niger	1	0.848233	590		
Tanzania	10	0.669106	1100	Lower Middle	67
Senegal	2	0.606838	1430		
Kenya	3	0.820342	1830		
Trinidad and Tobago	1	0.916884	1930		
Bangladesh	9	0.916884	1930		
Nigeria	6	0.747458	2030		
India	3	0.732066	2120		
Ghana	4	0.550608	2230		
Solomon Islands	1	0.779711	2370		
Vietnam	4	0.699562	2570		
Kiribati	3	0.545723	3430		
Vanuatu	1	0.778882	3450		
Philippines	19	0.8415	3850		
Micronesia	1	0.681746	3930		
Indonesia	15	0.659823	4050	Upper Middle	57
Samoa	2	0.496155	4230		
Belize	1	0.658927	4690		
Tonga	1	0.697107	5150		
Fiji	3	0.675474	5800		

Ecuador	2	0.570909	6090		
Guyana	2	0.601652	6630		
South Africa	8	0.556295	6670		
Peru	1	0.583937	6790		
Thailand	4	0.595334	7260		
Brazil	5	0.48088	9270		
Maldives	3	0.261786	9640		
China	7	0.540071	10310		
Oman	1	0.394588	16430	High	225
Uruguay	1	0.43964	17760		
Greece	1	0.416398	19670		
Saudi Arabia	1	0.248622	22840		
Portugal	3	0.343181	23200		
Taiwan	5	#N/A	26561		
Spain	1	0.357945	30380		
South Korea	4	0.251577	33830		
Italy	2	0.41675	34910		
Japan	4	0.428623	42330		
France	4	0.336836	42550		
New Zealand	2	0.236681	42870		
United Kingdom	3	0.269889	43460		

Canada	6	0.246531	46540
Denmark	3	0.31114	49190
Germany	4	0.31114	49190
Finland	3	0.036334	49990
Hong Kong	3	0.540071	50480
Netherlands	8	0.341963	53230
Australia	25	0.349358	54910
Sweden	8	0.09535	56410
United States	58	0.04183	58390
Singapore	4	0.04183	58390
Ireland	1	0.182188	63300
Denmark	3	0.122805	63460
Norway	3	0.068533	81640

Table 4: Correlations between hazard type and GNI per capita, urban population size, and country vulnerability index

	Spearman's rho	Urban heat	Drought/ water scarcity	Fluvial flooding	Pluvial flooding	Sewer flooding	Coastal flooding	Flash flood	Un-specified flooding	Storm surge	Tropical cyclone	Tornados	Sea level rise	Coastal erosion	Saltwater intrusion	General climate impacts	Other
GNI per capita (Atlas method (current US$)	*Correlation Coefficient*	-0.063	-0.064	0.022	-0.102	-0.017	-0.007	-.230**	-.224**	-.146*	0.080	-0.068	0.028	-.154*	-0.075	-.197**	-.199**
	Sig. (2-tailed)	0.292	0.284	0.709	0.086	0.772	0.905	0.000	0.000	0.014	0.178	0.251	0.640	0.009	0.208	0.001	0.001
City Population	*Correlation Coefficient*	.153*	.152*	0.072	0.034	0.019	.229**	-0.011	-0.011	-0.039	-0.041	-0.016	0.041	-0.005	.265**	.208**	.211**
	Sig. (2-tailed)	0.011	0.011	0.232	0.576	0.752	0.000	0.857	0.852	0.521	0.494	0.784	0.498	0.940	0.000	0.000	0.000
Vulnerability score	*Correlation Coefficient*	-0.087	-0.087	0.019	0.095	-0.087	-0.113	.148*	.144*	.121*	-0.018	0.079	-0.073	0.048	-0.007	.125*	.129*
	Sig. (2-tailed)	0.148	0.150	0.751	0.112	0.148	0.060	0.014	0.016	0.044	0.770	0.190	0.226	0.421	0.905	0.037	0.031

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5: Correlations between exposure assessment and GNI per capita, urban population size, and country vulnerability index

	Spearman's rho	Buildings/ infrastructure	Businesses	Environmental assets
GNI per capita (Atlas method (current US$)	*Correlation Coefficient*	.145*	0.014	-0.051
	Sig. (2-tailed)	0.015	0.811	0.388
City Population	*Correlation Coefficient*	-0.079	0.087	-0.020
	Sig. (2-tailed)	0.191	0.148	0.744
Vulnerability score	*Correlation Coefficient*	-.136*	-0.042	0.013
	Sig. (2-tailed)	0.023	0.481	0.825

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6: Correlations between actor type and GNI per capita, urban population size, and country vulnerability index

	Spearman's rho	Individual(s), private household(s)	Civil society (sub-national)	Civil society (national, international)	City government	Sub-city local government	National government	Private Sector SMEs	Private Sector Cooperations	International governance inst.	Other
GNI per capita (Atlas method (current US$)	*Correlation Coefficient*	-.232**	-.142*	-0.010	.299**	.125*	-0.111	0.002	0.008	-.155**	0.115
	Sig. (2-tailed)	0.000	0.017	0.864	0.000	0.036	0.062	0.977	0.887	0.009	0.053
City Population	*Correlation Coefficient*	-.295**	0.085	-0.022	.199**	0.032	.155**	0.094	.174**	0.006	0.074
	Sig. (2-tailed)	0.000	0.159	0.721	0.001	0.597	0.010	0.116	0.004	0.925	0.218
Vulnerability score	*Correlation Coefficient*	.216**	0.095	0.101	-.253**	-.177**	-0.009	-0.081	-0.032	0.103	-.133*
	Sig. (2-tailed)	0.000	0.114	0.091	0.000	0.003	0.878	0.175	0.596	0.085	0.026

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 7: Correlations between actor types and response categories according to GAMI and IPCC

			Individual(s), private household(s)	Civil society (sub-national)	Civil society (national, international)	City government	Sub-city local government	National government	Private Sector SMEs	Private Sector Cooperations	International governance inst.	Other
GAMI response types	**Behavioral/cultural**	*Correlation Coefficient*	.683**	0.000	0.012	-.380**	-.181**	-.141*	-0.042	-.129*	-0.104	-.225**
		Sig. (2-tailed)	0.000	0.994	0.838	0.000	0.002	0.017	0.481	0.030	0.079	0.000
	Ecosystem-based	*Correlation Coefficient*	-.202**	.163**	0.086	.207**	.248**	.166**	-0.012	0.066	0.000	-0.052
		Sig. (2-tailed)	0.001	0.006	0.149	0.000	0.000	0.005	0.839	0.271	0.998	0.380
	Technological/infrastructural	*Correlation Coefficient*	-.222**	-0.049	0.021	.289**	0.018	.147*	0.107	.154**	-0.004	.128*
		Sig. (2-tailed)	0.000	0.412	0.719	0.000	0.765	0.013	0.072	0.009	0.945	0.031
	Institutional	*Correlation Coefficient*	-.218**	.140*	0.077	.426**	.188**	.185**	.146*	.161**	.164**	0.020
		Sig. (2-tailed)	0.000	0.018	0.194	0.000	0.001	0.002	0.014	0.006	0.006	0.739
IPCC response types	**Protect**	*Correlation Coefficient*	-.193**	-0.023	-0.043	.219**	0.101	.122*	.135*	.208**	-0.002	0.015
		Sig. (2-tailed)	0.001	0.697	0.467	0.000	0.089	0.039	0.023	0.000	0.979	0.806
	Accommodate	*Correlation Coefficient*	0.055	0.001	0.008	-0.043	0.107	0.093	0.063	-0.064	0.025	-.184**
		Sig. (2-tailed)	0.359	0.983	0.900	0.469	0.073	0.116	0.293	0.284	0.673	0.002
	Advance (with ground elevation)	*Correlation Coefficient*	-0.107	0.065	0.085	.213**	.214**	.152*	0.106	.124*	-0.063	-0.073
		Sig. (2-tailed)	0.073	0.278	0.151	0.000	0.000	0.010	0.075	0.037	0.288	0.219
	Retreat	*Correlation Coefficient*	.166**	-0.086	-0.005	-.198**	0.014	-0.043	-0.054	-0.073	0.084	-0.020
		Sig. (2-tailed)	0.005	0.148	0.935	0.001	0.811	0.468	0.368	0.218	0.157	0.731

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 8: Correlations between response type according to GAMI and IPCC and GNI per capita, urban population size, and country vulnerability index

	Spearman's rho	Response type GAMI: Behavioral/cultural	Response type GAMI: Ecosystem-based	Response type GAMI: Technological/infrastructural	Response type GAMI: Institutional	Response type IPCC: Protect	Response type IPCC: Accommodate	Response type IPCC: Advance (with ground elevation)	Response type IPCC: Retreat
GNI per capita (Atlas method (current US$)	*Correlation Coefficient*	-.347**	-0.001	0.095	.236**	0.018	-0.070	0.062	-.154**
	Sig. (2-tailed)	0.000	0.991	0.109	0.000	0.759	0.241	0.298	0.009
City Population	*Correlation Coefficient*	-.171**	0.098	.183**	0.099	.127*	0.047	.138*	-.118*
	Sig. (2-tailed)	0.004	0.104	0.002	0.099	0.034	0.439	0.022	0.050
Vulnerability score	*Correlation Coefficient*	.285**	-0.038	-.156**	-.141*	-0.113	-0.066	-0.066	.186**
	Sig. (2-tailed)	0.000	0.523	0.009	0.019	0.060	0.271	0.272	0.002

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 9: Correlations between country region or income group and response type according to GAMI and IPCC

			Africa	Asia	Australasia	Central and South America	North America	Europe	Small Island States	Income_Group (1-4,low-high)
GAMI response types	**Behavioral/cultural**	*Correlation Coefficient*	.157**	.131*	-0.019	-0.074	-.214**	-0.048	0.082	-.346**
		Sig. (2-tailed)	0.008	0.027	0.754	0.211	0.000	0.421	0.171	0.000
	Ecosystem-based	*Correlation Coefficient*	0.039	-0.024	-0.105	0.014	-0.065	.123*	0.063	-0.010
		Sig. (2-tailed)	0.512	0.689	0.076	0.811	0.276	0.039	0.292	0.870
	Technological/ infrastructural	*Correlation Coefficient*	-0.074	0.041	-0.081	0.007	-0.005	.119*	-0.066	.122*
		Sig. (2-tailed)	0.214	0.488	0.171	0.907	0.936	0.045	0.268	0.039
	Institutional	*Correlation Coefficient*	-.119*	-.128*	0.076	.131*	.167**	-0.007	-0.108	.172**
		Sig. (2-tailed)	0.045	0.032	0.200	0.027	0.005	0.904	0.069	0.004
IPCC response types	**Protect**	*Correlation Coefficient*	-0.027	-0.042	0.083	0.010	-.150*	.125*	0.108	0.081
		Sig. (2-tailed)	0.656	0.484	0.164	0.868	0.011	0.036	0.069	0.174
	Accommodate	*Correlation Coefficient*	.153**	-0.001	-0.036	-0.078	-0.074	0.073	-.121*	-0.020
		Sig. (2-tailed)	0.010	0.984	0.547	0.190	0.213	0.222	0.041	0.735
	Advance (with ground elevation)	*Correlation Coefficient*	-0.038	0.012	-.123*	-0.074	0.027	0.100	0.077	0.039
		Sig. (2-tailed)	0.523	0.836	0.039	0.217	0.646	0.093	0.196	0.508
	Retreat	*Correlation Coefficient*	0.024	0.060	.245**	-0.045	-0.100	-.162**	-0.017	-.175**
		Sig. (2-tailed)	0.691	0.311	0.000	0.452	0.093	0.006	0.774	0.003

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 10: Correlations between depth, scope and speed of adaptation and GNI per capita, urban population size, and country vulnerability index

		Depth	Scope	Speed
GNI per capita (Atlas method (current US$) 2019)	*Pearson Correlation*	0.102	0.047	0.058
	Sig. (2-tailed)	0.087	0.426	0.331
City Population	*Pearson Correlation*	-0.036	0.064	-0.058
	Sig. (2-tailed)	0.546	0.289	0.337
Vulnerability score	*Pearson Correlation*	-0.082	-0.062	-.124*
	Sig. (2-tailed)	0.174	0.302	0.039

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

B.7 Annex of the publication “Mapping the adaptation solution space – lessons from Jakarta”

Appendix A: Results from the structured literature search

In total, 339 publications were identified by the keyword search. A total of 14 proceedings and 2 publications for which no full-text versions were available have been excluded. The below list shows the remaining 323 publications. All references that are marked with an asterisk were included in the detailed content analysis and are cited in the paper.

*Abidin, H. Z.: Land Subsidence in Urban Areas of Indonesia: Suitability of levelling, GPS and INSAR for monitoring, GIM Int., 19, 12–15, 2005.

Abidin, H. Z., Andreas, H., Gamal, M., Gumilar, I., Napitupulu, M., Fukuda, Y., Deguchi, T., and Riawan, Y. M., and Riawan, E.: Land subsidence characteristics of the Jakarta basin (Indonesia) and its relation with groundwater extraction and sea level rise, in: Groundwater Response to Changing Climate, CRC Press, 2010.

Abidin, H. Z., Andreas, H., Gumilar, I., Sidiq, T. P., and Fukuda, Y.: On the Roles of Geospatial Information for Risk Assessment of Land Subsidence in Urban Areas of Indonesia, in: Intelligent Systems for Crisis Management: Geo-information for Disaster Management (Gi4DM) 2012, edited by: Zlatanova, S., Peters, R., Dilo, A., and Scholten, H., Springer, Berlin, Heidelberg, 277–288, https://doi.org/10.1007/978-3-642-33218-0_19, 2013.

*Abidin, H. Z., Andreas, H., Gumilar, I., Yuwono, B. D., Murdohardono, D., and Supriyadi, S.: On Integration of Geodetic Observation Results for Assessment of Land Subsidence Hazard Risk in Urban Areas of Indonesia, in: IAG 150 Years, vol. 143, edited by: Rizos, C. and Willis, P., Springer International Publishing, Cham, 435–442, https://doi.org/10.1007/1345_2015_82, 2015a.

Abidin, H. Z., Andreas, H., Gumilar, I., Yuwono, B. D., Murdohardono, D., and Supriyadi, S.: On Integration of Geodetic Observation Results for Assessment of Land Subsidence Hazard Risk in Urban Areas of Indonesia, in: IAG 150 Years – Proceedings of the 2013 IAG Scientific Assembly, Postdam,Germany, 1–6 September, 2013, edited by: Rizos, C. and Willis, P., Springer International Publishing, 143, 435–442, https://doi.org/10.1007/1345_2015_82, 2015b.

Abidin, H. Z., Andreas, H., Gumilar, I., and Brinkman, J. J.: Study on the risk and impacts of land subsidence in Jakarta, Proc. Int. Assoc. Hydrol. Sci., 372, 115–120, https://doi.org/10.5194/piahs-372-115-2015, 2015c.

Achmad Santosa, M., Khatarina, J., and Assegaf, R. sjarief: Indonesia, in: Climate Change Liability: Transnational Law and Practice, edited by: Brunnée, J., Rajamani, L., Lord, R., and Goldberg, S., Cambridge University Press, Cambridge, 178–205, https://doi.org/10.1017/CBO9781139084383.011, 2011.

*Aditya, M. R., Hernina, R., and Rokhmatuloh: Geographic Information System and Remote Sensing Approach with Hydrologic Rational Model for Flood Event Analysis in Jakarta, IOP Conf. Ser. Earth Env., 98, 012008, https://doi.org/10.1088/1755-1315/98/1/012008, 2017.

*Aerts, J., Botzen, W., Bowman, M., Dircke, P., and Ward, P.: Climate Adaptation and Flood Risk in Coastal Cities, Routledge, https://doi.org/10.4324/9781849776899, 2013.

*Agustan, A., Sanjaya, H., and Ito, T.: Jakarta Land Subsidence and Inundation Vulnerability Based on SAR Data, 34th Asian Conference on Remote Sensing (ACRS) 2013, Bali, Indonesia, 2013.

*Ajiwibowo, H.: The Influence Of The Jakarta Bay Reclamation On The Surrounding Tidal Elevation And Tidal Current, Int. J. Geomate, 15, 55–65, https://doi.org/10.21660/2018.48.22773, 2018.

*Akmalah, E. and Grigg, N. S.: Jakarta flooding: systems study of socio-technical forces, Water Int., 36, 733–747, https://doi.org/10.1080/02508060.2011.610729, 2011.

Alatas, I. F.: Becoming Indonesians: The Bā ’Alawī in the Interstices of the Nation, Welt Islams, 51, 45–108, https://doi.org/10.1163/157006011X556120, 2011.

Alfida, A., Maryam, S., and Rianti, F.: Information in the Age of Misinformation: Counteracting the Problems of Online Radicalization with Digital Literacy, Libr. Philos. Pract. E-J., 2019.

Álvarez, J. C. and Resosudarmo, B. P.: The cost of floods in developing countries’ megacities: A hedonic price analysis of the Jakarta housing market, Indonesia, Departmental Working Papers, The Australian National University, Arndt-Corden Department of Economics, 2018.

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Appendix C: Literature categories

Table C1. Literature categories and counts (Scopus 2000–2019).

Code	Topic	Sub-topics	Resulting publications (2000–2019)
1	Soft factors of adaptation	psychology behavior culture understanding of risk vulnerability analysis framing of flood and subsidence willingness to pay for ecosystem services of river communities participation in flood control strategy planning	24
2	Policy and legal analysis	institutional analysis national policy analysis legal framework political economy of flood protection	12
3	Hard adaptation	Great Garuda project lakes and rainwater harvesting polders dikes and flood barriers embankments river diversions	36
4	Flood models & flood mapping	precipitation models subsidence models flood loss estimation models urban drainage model sea level rise models community-based flood risk mapping shoreline retreat model	78
5	Land-use (change) impact on flooding	criticality of watershed land-use change assessment and impacts	9
6	New data types	social media big data crowdsourcing e-participation high-resolution data PetaJakarta project	15
7	Watershed management and water governance	qualitative analysis of reasons for flooding water pollution drinking water source analysis/models	17
8	Soft and hybrid adaptation	local/community-based adaptation firms and adaptation resettlement/relocation alternative energy sources disaster management urban adaptation planning	40
9	Early warning	GIS-based early warning systems risk communication information needs during disasters	7

Table C1. Continued.

Code	Topic	Sub-topics	Resulting publications (2000–2019)
10	Decision support systems	Decision support tool (DST) for location of warehouses disaster information management systems socio-economic vulnerability index (SEVI) + multi-criteria analysis (MCA) hydrological infrastructure flood vulnerability index (HIFVI) integrated assessment framework (IAF) for subsidence	5
11	Qualitative risk descriptions	subsidence types flood impact	13
x	No link to flooding or Jakarta		70
	Conference proceedings		14

Appendix D: Coding scheme in MAXQDA

- Methodology/research design
- Location of flooding
- Root causes of flood risk
  - Socio-economic causes
  - Political/structural causes
  - Environmental/physical causes
- Coping or adaptation strategy/measure
  - Hybrid approach
  - Non-structural/soft measures
  - Structural/hard/physical measures
- Flood governance system
- Needs and/or suggestions
- Gaps and/or persistent problems

B.8 Annex to the publication "The role of social identities for collective adaptation"

Appendix A
Questionnaire: semi-structured key informant interviews (online)

What do I want to find out?	Question	Follow-up questions
Impression of flood vulnerability	1. According to the literature, the urban poor, marginalized groups, and minorities are most vulnerable to flooding. Would you agree with this statement?	
Are there differences in flood vulnerability between the groups? (RQ 1) What are the drivers of vulnerability? (RQ 2)	2. Are there differences among these groups regarding their vulnerability to flooding?	If yes: What are the differences? Can you give examples? Different perception of flooding? Are there spatial patterns in the city (segregation or mixed up) If no: What about minorities such as migrants from other Indonesian Islands or from abroad (e.g. Chinese)? If no: What unites people of different backgrounds, worldviews, ages, etc.?
Evidence for collective adaptation (RQ 3c., 4)	3. Do you know of any examples where people on the ground work together to adapt to flooding? Can you describe them?	Not just in response to floods but more for long-term adaptation. Who supports whom? Are there individuals who cannot receive such support/who are excluded?
Effectiveness of collective adaptation	4. Would you evaluate such measures and collective adaptation strategies as effective? Do they reduce flood risk for the participants?	Are local initiatives effective in risk reduction compared to state-led measures? What are the limits of local collective adaptation strategies? Would you consider them as long-term solutions or rather short-term coping mechanisms?

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Changes in social cohesion and mutual support linked to collective action and adaptation	5. **From your perspective, have there been any changes in mutual support among citizens or in the groups you just described? How do you think will it develop in the future here in Jakarta?**	What are and will be the consequences be for the groups you mentioned?
Complementing or conflicting with state-led adaptation	6. **How do you think these described measures and collective initiatives go together with state-led adaptation strategies, for example, local or city government adaptation measures?**	Are there any conflicts? Examples?
Vision	7. **From your perspective, what would be needed to really use and integrate the local level's potential in flood risk adaptation?**	

Appendix B

Questionnaire for expert elicitation

#1: Most vulnerable groups and intra-group differences

Hypothesis: *The most vulnerable are not one homogenous group; they differ internally. From the interviews, I can assume that they differ with respect to the type of exposure (river or coastal flooding), experience in flood response, the strength of RT risk management, and individual capacities through networks.*

1. What is your perspective on differences within the group of "the most vulnerable"; different sub-groups? What determines/delineates them?
2. Who exactly is excluded in poor, highly exposed communities? (It was mentioned that coverage in autonomous coping and adaptation is somewhat selective/not comprehensive)
3. Flood risk for migrants? Are there migrant communities that are isolated? (e.g. Batak?)
4. What is the most important criterion for social identity formation? (from interviews it seems to be proximity/RT, neighbors, and relatives)

#2: Active groups & collective adaptation strategies

2.1 H adjusted: *At the very local/household scale, cultural or ethnic differences do not play a role in the formation of social groups; either because the communities (RT) are internally culturally homogeneous or identification with the RT is more dominant than with own cultural background. At the RT scale, cultural differences (religion, ethnicity, migration status) shape delineation and degree of interaction.*

5. It was described that community organization for how to cope with flooding and information distribution also takes place in Mosques, Churches, or more generally religious places (besides RT meetings). From your experience: do religious groups go about flooding differently?
6. Do isolated migrant communities adapt/accommodate flooding the same way as Javanese communities?

2.2 H adjusted: *Evidence for collective adaptation to flooding can be found in poor, frequently exposed areas in Jakarta, where inhabitants have a lot of experience with flooding and where community coordination is working well. However, current adaptation actions only facilitate the accommodation of flooding.*

7. Most of the mentioned measures, when I asked for collective adaptation, are actually reactive, short-term coping measures (flood warning distribution, neighborhood support in crisis situations). Only a few collective adaptation measures were mentioned (e.g. collective cleaning of river banks, pooling of resources/saving groups, informal early warning structures, RT evacuation plans (all depending on local leaders). Is my impression right or could you observe/identify any other long-term collective adaptation strategies?
8. What or who mobilizes action?
9. Do you think flooding is perceived and dealt with differently along the coast as compared to along the rivers?
10. Interference of state-led adaptation measures with local strategies (besides relocation)?

#3 Social cohesion

H: *Due to the collective culture of Indonesia social cohesion has a high value and is generally high. However, living conditions and electronic connectedness have the potential to lower the strength of place-based social cohesion – especially in middle- and upper-income classes which are at risk to be flooded more frequently in the future.*

11. From your perspective, what is the role of social cohesion in adaptation to flooding?
12. Did/does increasing access to and use of social media change the social fabric of communities and if yes how?
13. Social cohesion was described as being very high – especially among the poorest. In middle and higher income groups it was described to slowly erode. Would you agree? Would you say that could become a problem seeing that by now also middle and high-income areas are hit by flooding?

Appendix C
Coding scheme

First round of coding
Social identity / Group
Collective action/adaptation
Collective actor(s)
Individual adaptation
Leaders of collective action

Second round of coding
Social identification factors (already clustered)
Family, close friends/neighbors
Time of residence
Administrative entity
Shared threat/concern
Occupation
Religion
Ethnicity
Locally organized groups
NGOs, CSOs, and related groups
Certain location
Collective action/adaptation
Adaptive capacity
Collective actor
Bonding social capital
Bridging & linking social capital

Appendix D

Detailed information about social identities present in highly flood-exposed areas in Jakarta

Identification factor	Social identity	Description	Supportive quotes
Kinship and emotional relations	Family, relatives, close neighbors, close friends	Family and the close local neighborhood and friends are a very strong social identity in Jakarta. In-group relations are very tight, members trust and support each other so that this identity represents a source of support, e.g. in the form of job opportunities, mutual support, disaster assistance, financial and emotional support. However, it is limited in extent and depth.	*"The first community of them is their family."* (CSI-5) *"[…] cooperation is based on very strong kinship ties. Thus, it does not go very far to other places."* (RII-2) *"[…] people were very attached to place, very embedded in their community and their neighbors. And that was really important for them."* (SE-4)
Time of residence	New-comers, international migrants, 2nd-3rd generation residents, long-term resident, native residents	Attracted by the city's labor market, business opportunities, and other urban promises, migrants usually try to settle in the footsteps of relatives. This is how kinship and migration status overlap regarding identity development. Short-term migrants such as seasonal workers are highly vulnerable because they don't know the local risk context, are not well socially integrated and often live and work under informal conditions.	*"Jakarta has a complex population composition because Jakarta is the main destination for citizens from all over Indonesia."* (CSI-4) *"In Jakarta, there are migrants who only come to the city for a short term and then when they face difficulty in the city, they will go back to their hometown […]. However, there are also migrants who live long-term in Jakarta or basically settle in the city. So it's important to differentiate the types of migrants […]."* (RII-1a).
Threat/risk	River flooding, eviction, resettlement, coastal flooding	In the immediate risk situation (e.g. a flood), the threat identity is at the fore and bridges all other socio-cultural differences. Risk-based social identities differ depending on the type of risk; i.e. their structures and behaviors are	*"What's interesting is that when a flood occurs people no longer differentiate between each other."* (RII-1a). *"[…] it's kind of apples and oranges because you have the risk from tidal flooding which is a very different process entirely really from the risk of monsoon rain*

		different in coastal flood contexts as compared to river flood locations.	*flooding and then the rivers although it's also connected."* (SE-4).
Occupation	Fishermen, seasonal workers, daily wage laborers	Occupation represents an important social identity because of its frequent salience due to the high dependence on daily income. Occupations largely differ among the exposed and vulnerable but overall daily income dependency hinders participation in CSO-initiatives and capacity building, which generally increases flood vulnerability. Fishermen are distinct in the context of flood risk because this social identity has a lower risk perception regarding flooding.	*"There are those who participate with the local residents and there are some who do not participate because they need to work for a living in that day. For instance, they can be online transportation drivers whose income depends on daily wages. As far as their assets and family are safe, they no longer participate there."* (CSI-1).
Religion	Ahmadiyya, Shia, Christian, Muslim	Religious identification is important in Jakarta and represents a rich source of social cohesion and collective action. At the neighborhood scale, religious affiliation is rather homogeneous due to the continued existence of ethnic enclaves. If differences exist, good leadership can bridge differences. At the city scale, social identities based on religion are diverse.	*"That means, if we observe it on the RT or RW level [...], ethnic differences would not cause such vulnerability because the same ethnicity, religion, and others."* *"In my experience, if [...] the village leader[s] [...] are good in basically organizing this community, usually there will be no difference when it comes to let's say backgrounds or even religion. So they are just an organic group when this leader is actually a very good leader."* (CSI-5).
Ethnicity	Betawi, Padang, Javanese, Sundanese, Bugis, Minangese, Batak, Bima	Ethnicity is still an important identification factor as citizens first and foremost identify with his or her place of origin. Segregation persists across Jakarta as families stay together and incoming migrants try to settle along kinship lines; however, it is less clear-cut than in the past. Given the high number of ethnicities in Jakarta, it is difficult to assess differences in their vulnerabilities to flooding.	*"Jakarta was boxed based on ethnicity by the Dutch."* (CSI-1) *"There are enclaves such as Jlayeravanese enclave, Sundanese enclave, there is also the Bima enclave in Manggarai. In Kampung Makassar there is the Bugis ethnicity, and the Madura ethnic in Muara. Ethnicities are almost divided into these enclaves."* (RII-2).

Administrative entity	RT, RW, Kampung	Due to dependence on the administrative body RT as well as its elected leader (RT), every local resident identifies with this entity to a certain extent. The strength and salience of identification with the RT strongly depend on the leadership qualities of the local leader. Similarly, informal settlements, so-called kampungs, represent an important identification factor for local residents. As kampung residents share many characteristics such as informality, poverty, and exposure, which strongly influence their daily life, identification among kampong residents is considerably high.	*"[…] geographically they [RTs] do say something […] if there is any subsidies or any official help […] from the city government, from the provincial government,* *the RT will be the point person […] for the distribution of these and for the coordination that needs to be done with the government. And in that case, probably that does play a role in terms of dampening issues about religious or ethnic boundaries because the RT leader is responsible for everyone within just one geographical unit, regardless of your ethnicity or your background."* (SE-2). *"I actually think the social relations within the kampung is extremely tight. They are inside a kampung ecosystem, within which exists social and economic modalities, including their livelihoods. This means that as an individual, their dependence on the large group of the kampung is strong."* (CSI-6).
Traditional, institutionalized local groups	Gotong royong, RT/RW, PKK, arisan, youth group, women group, prayer groups	At the RT scale, there is a long tradition and strong social norm for self-organization in the form of smaller working groups, which are often headed by local leaders that exist next to the RT. Such locally-administered groups exist for various purposes (e.g. neighborhood works, saving groups) and represent important social identities that can even bridge other cultural differences such as beliefs or ethnicity.	*"The system itself includes a number of layers. So you have RT, RW, the smallest hamlet, then you have also groups of mothers who are usually getting together under the name of PKK, the family welfare center, then you have Puskesmas, the health center. I think in our community there are a number of small rings of coordination, whether it is formal or informal, […] people are becoming members of that networks […] and use that mechanism to have support."* (IO-4) *"They were also doing things like collectively financing sort of community infrastructures like public spaces and different things […]. You know at the RT level so […] together to be able to achieve a particular goal." (SE-6).*

Cross-neighborhood CSO-supported groups and their related sub-groups	JRMK, LBH, UPC, Ciliwung Merdeka, Ciliwung Institute, ArKom, Corporatives Komunitas Ciliwung, River Schools	Indonesian NGOs, CSOs, faith-based organizations, and social movements work directly at the local level to help communities organize themselves for whatever they define as their threats and risks as well as their needs and visions. Also, they advocate for the identified needs and demands at local government or higher levels. Their success in local support and defending their members' interests against government initiatives led to rising interest from highly exposed and vulnerable individuals in linking up with them to improve their situation. However, who identifies with such organizations varies.	*"The one that […] unites them as a network is their visions. […] in Muara Angke, if they want to realize their visions about secure land tenure or like legalize their land, they will become more active […]."* (CSI-10). *"[…] even inside the one kampung you cannot really have one unified idea about who's UPC or who's Pak Sandyawan even within their own kampung. So I guess they could be like a main actor to drive for the transitional change within the, transformational change within the community but again sometime they are quite local as well, they are very local in terms of they only willing to help as long as you join the cause. So they're not really as a city-wide […]."* (RII-4)
Flood location	Riverbanks, North Coast	Identification with the place of residence is important for Jakarta's residents. E.g. riverbank settlers strongly identify with living at the river; the identification is reinforced by sharing similar threats, prejudices as well as knowledge about the local type of flooding.	*"Along the river they are more established […]. In the coastal [areas], they are harder because they are fishers and […] the coast gives them a different characteristic."* (RII-2)

B.9 Supplement material of the publication "What makes people adapt together"

SUPPLEMENT MATERIAL 1

1. Table: Core motivators and influencing factors for collective action with references

Core motivators	Indirect motivation factors	Enabling conditions
Perceived injustice (Gulevich et al., 2017; Ling & Dale, 2014; Thomas et al., 2012; van Zomeren et al., 2008, 2018; Vestergren et al., 2022; Wlodarczyk et al., 2017)	Group-based deprivation (Kawakami & Dion, 1995; Osborne et al., 2017; van Zomeren et al., 2008)	Quality of formal local institutions and governance (Adger, 2003; Bott et al., 2019; Ireland & Thomalla, 2009; Miciukiewicz et al., 2012) Physical community layout/built structure (Bott et al., 2019; de Jong & da Silva, 2015) Targeted mobilization (Klandermans, 1984) Hazard experience (Bott et al., 2019; Vestergren et al., 2022) Freedom to enter or exit group (Ostrom, 2009)
Violation of moral convictions (Agostini & van Zomeren, 2021; Pauls et al., 2022; van Zomeren et al., 2011)	(Protection of) norms and moral convictions (Carmona-Moya et al., 2021; Masson & Fritsche, 2014; Thomas et al., 2012; van Zomeren et al., 2011, 2012, 2018)	
Social identification (Agostini & van Zomeren, 2021; Bamberg et al., 2018; Benford & Snow, 2000; Carmona-Moya et al., 2021; Fritsche et al., 2018; Kawakami & Dion, 1995; Leap & Thompson, 2018; Osborne et al., 2017; Pearson & Schuldt, 2018; Thomas et al., 2012; van Zomeren et al., 2008; Wlodarczyk et al., 2017)	Shared emotions like anger and/or (social) hope (Badaan et al., 2022; Bamberg et al., 2018; Carmona-Moya et al., 2021; Fritsche et al., 2018; Gulevich et al., 2017; Thomas et al., 2012; Wlodarczyk et al., 2017)	
	Existing networks and flows of information between individuals/ meaningful exchange (social capital) (Adger, 2003; Bott et al., 2019; Ireland & Thomalla, 2009; Ostrom, 2009; Petzold, 2016)	
	Engagement of government and/or NGO and/or religious actors to inspire and support collective action (de Jong & da Silva, 2017; Ireland & Thomalla, 2009; Marshall, 2013; Mendelsohn, 2000)	
	Shared social beliefs (Gulevich et al., 2017)	
Belief in group efficacy (Agostini & van Zomeren, 2021; Bamberg et al., 2018; Carmona-Moya et al., 2021; Fritsche et al., 2018; Gulevich et al., 2017; Hornsey, 2008; Kawakami & Dion, 1995; Klandermans, 1984; Ling & Dale, 2014; Osborne et al., 2017; Thaker et al., 2015; Thomas et al., 2012; van Zomeren et al., 2008; Wlodarczyk et al., 2017)	(trusted) group leaders (Hornung et al., 2019; Ireland & Thomalla, 2009; Marshall, 2013)	
	Trust in group members (Ireland & Thomalla, 2009; Leap & Thompson, 2018; Marshall, 2013; Smith & Mayer, 2018; van Zomeren et al., 2018)	
	Engagement of government and/or NGO and/or religious actors to inspire and support collective action (de Jong & da Silva, 2017; Ireland & Thomalla, 2009; Marshall, 2013; Mendelsohn, 2000; Petzold, 2017)	
	Prior experience in (successful) collective action (Begeny et al., 2022; Lizzio-Wilson et al., 2021; Patterson, 2021)	

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SUPPLEMENT MATERIAL 2

1. **Questionnaire: Survey of cooperative representatives**
   Questions were translated to Bahasa Indonesia and distributed in written format among all participants of the annual meeting of cooperatives in Kampung Kunir, November 2023.

   Name of location:

   1. Why did you join the koperasi?

   2. What are you doing as a member?
      - I pay the membership fee.
      - I participate in koperasi meetings.
      - I frequently exchange with other members of the koperasi.
      - I participate in koperasi business activities.
      - Other (please explain):

   3. What did you achieve with the help of the koperasi until today?

   4. What do you want to achieve with the koperasi in the future?

2. **Questionnaire: Semi-structured interviews with cooperative members**
   The questionnaire was translated into Bahasa Indonesia; interviews were conducted with the help of a translator.

Question	Follow-up questions
1. Why did you join UPC/JRMK/the cooperative/Ciliwung Merdeka?	a) How did you get to know about them? Did someone invite or recommend you to join? b) What do you like about their approach? c) Were there also other groups or networks with similar aims and if yes, why did you decide for the one you chose?
2. Are you a member of any other groups in your neighborhood?	d) If yes, which ones?

3. What did you expect when joining the group?	e) Were your expectations met? f) Was there anything that surprised you (positively or negatively)?
4. How close are you with the other members of the group?	g) Do you know all group members? Do you trust group members? h) How often do you see each other? What do you do when you meet?
5. Which advantages do you have from being a member of the group when it comes to flooding?	i) Which actions do you take as a group? How does that help you to deal with flooding in the long-term?
6. Did you try to convince others to join?	j) If yes, why and how?

3. Questionnaire: Semi-structured interviews with civil society leaders and experts

Question	Follow-up questions
1. Why and how did your network/organization/movement come into being?	
2. Would you describe your network/organization/movement as diverse with respect to the culture of its members (e.g. different ethnicities, religions)?	a) What are the different members' reasons for joining? b) Does diversity have an impact on their interactions and/or engagement, e.g. on finding a shared vision or how to pursue shared goals?
3. What are difficulties within your network/organization/movement when it comes to collective actions?	c) What are reasons for the problems? d) What are strategies to overcome them?
4. Do you interact with other networks/organizations?	e) If yes, which ones and why? f) Do members of the respective networks then also interact with each other? g) What are benefits?
5. Where do you see your network's/organization'/movement's role in a. flood risk management and b. urban development?	h) Will that role change in the future?

SUPPLEMENT MATERIAL 3

1. Table: Descriptions of initial triggers, long-term motivators, and inhibiting factors of collective action in the context of climate change adaptation

Type of factor	Factor	Description	Example from the study site	Supporting quote
Initial triggers	Acute livelihood threat	Individuals need to feel threatened directly by a hazard or indirectly by the consequences of or responses to hazards; both function as a wake-up call and make individuals aware that the threat needs to be overcome but is beyond individual capacities.	In Jakarta, recurrent flooding and more frequent big flood events represent major threats especially to highly exposed and vulnerable residents. However, evictions in the name of flood protection are considered even more dangerous for losing livelihood and social networks. Such threats are considered beyond individual capacities and trigger them to join forces.	*Usually the kampung that wants to join JRMK have a case first. When they got evicted, when they don't want to be evicted. So, when a kampung think that they still save, they usually being resistant with this kind of advocacy but some kampungs also which they already realized that they will get the threat, they start to join JRMK eventhough the threat has not come yet. (NJ-RII-1)* *After a lot of threats from the government, we got together to form a cooperative. We start with 20 members, even though there were only 20 members, we were able postponed the JSS IPAL Project in 2019. After that, the residents saw that the cooperative could be used to negotiate with the government. (NJ-LR-2)*
	Shared goals and visions	Shared visions are the seed of identification and mobilization; they can be illustrated during e.g. advocacy work to make people identify with the movement, willing to act as a group to achieve them.	The shared vision of avoiding eviction by achieving land legality and improving local living conditions was a key trigger for individuals in Jakarta to join cooperatives. This motivation especially surfaces in situations of acute threat, e.g. eviction; successfully obtained building permits and legalization of buildings in some kampungs increased membership.	*Of course, the initiative comes from the people themselves because the goal is very simple, that is to avoid eviction and to avoid being displaced from their kampung. (CSI-6)* *Our cooperative has an important vision, which is to protect and defend the village. (NJ-LR-2).*

		Such success then also motivated others to join.	
Targeted advocacy through leaders	Advocacy can make individuals aware of benefits for both, individual members and the entire collective through joint action. Local leaders, locally rooted civil society members, row models, or alike can create a strong collective feeling and vision; in other words a group identification that encourages individuals to engage.	The creation of cooperatives in highly vulnerable kampungs in Jakarta to face environmental, structural, and political threats was initiated by locally rooted CSOs; leaders actively advocated for joining among residents, highlighting benefits and creating a vision of what could be achieved collectively.	*For the Muara Angke we used the land status as the issues, as the bigger issue, as the biggest issue to gather more people. (CSI-10)*
Belief in group efficacy	It needs to be believed that the shared visions can be achieved better through collective actions than individually; perception of and trust in group cohesion and strength is key for activation. Evidence for the success of collectives increases belief in group efficacy	Cooperatives present themselves as a legal, powerful representation of their members; local residents belief that this officially acknowledged and culturally rooted form of representation is the best possible way to fight for their shared vision; past examples of successful negotiations with the government or partially successful lawsuits against evictions strengthened the perception of group efficacy among members.	*Because together we sure can do it. (R12)* *For advocacy, we try to gather all of the member as many as possible. Our principle is to build up the strength. Because we (the poor) do not have a capital financial power, but we have capital in the form of numbers. So the bigger the number of people, the more we can change the policy. That is our principle. (NJ-LR-1)*
Accessibility/low-threshold participation	First actions should be easy to engage in so that crossing the initial inhibitory threshold happens quickly and without much effort. Joining a first collective action increases the feeling of belonging to the group (i.e. social identification).	Participating in meetings, paying the very low membership fee, and collectively deciding about future goals by participating in discussions are examples of how first low-threshold participation options activated individuals to join cooperatives without much effort.	*The activities in PKK, for example, we have routine meetings every month in the village (Kelurahan). There is also a regular meeting in RW every week. (NJ-LR-1)* *The organization is usually also very unique because they need to find common free time. For example, during evening time because it is when all of them have finished working. Then, they would create small discussion groups to discuss how they can collectively propose*

				offers and contending solutions to reject evictions. (CSI-6) *So if they want to become a member of this cooperative, there are 2 conditions. First is the ID card (KT) and second is that they have assests here. (NJ-LR-2)*
Long-term motivators	Continuous threat	Short-term threats are quickly forgotten; engagement decreases. A constant threat scenario keeps the need to overcome it alive.	After flooding hits a kampung, neighbors and family members help each other to cope with the impacts; however, no long-term achievements or adaptation emerge as the immediate problem is quickly solved. The constant threat of eviction is daunting in many kampungs and a constant threat that residents feel they need to overcome to survive. As they are unlikely to achieve land security quickly, the threat is likely to remain and keep them united.	*This kampung is vulnerable to government threat such as evictions. If the eviction issues have been socialized, the residents will be panic. The first threat is from JSS IPAL zone 2 in 2019 for wastewater management which is planned to be built in two places. Then, the NCICD Project for embankment along Muara Angke. Actually this project is against the floods however the impact has not been considered. There is also a threat of eviction from the widening project for a transmission tower (sutet) that always haunts everyone. (NJ-LR-2).*
	Continued advocacy	One-time activation without further advocacy, guidance, and input is unlikely to spur long-term lively collective activities; new members need to be activated to keep participation constant and divers	Urban Poor Consortium and its sister CSO JRMK maintain a strong presence in the cooperatives and frequently organize meetings to recruit new members or found new cooperatives in other kampongs to strengthen the movement.	*I think if we can explain it as clearly as possible, they will definitely want to join the Cooperative. Moreover, being a member of a cooperative has many benefits. For example, our cooperative sells groceries (sembako). The price is quite competitive with other stalls. Then we will share the SHU that we get. (NJ-LR-1).* *We want this place to be more developed, better, and prosperous. As such, we created the cooperatives so that we can provide space for the people's wants and make sure what the government is working on aligns with*

			what the people themselves actually want. (CSI-11)
Shared, future long-term goals	While short-term goals are often more beneficial in terms of success and perception of group efficacy, engagement after their achievement often weakens; hence long-term goals are needed to keep individuals engaged and also to avoid maladaptive tendencies.	Long-term goals such as official land tenure rights and adequate housing are used as strong visions local residents are eager to fight for. Besides these long-term goals, smaller, interim-aims are used to keep up the momentum of collective engagement. Examples are building rights and the change of urban land use plans to get a legal residence status.	*We want to get a decent place to live like flats, managed by the cooperative. (R41)* *Cooperatives as an organization of power for economics and politics. (R38)* *Have a joint venture with the community so as to make their standard of living better. (R3)*
Self-organization within the group	Given that capacities among the most vulnerable are mostly bound in their ability to work together, strong self-organization is required to untap their potential. The wish for self-organization is linked to a stronger belief in group efficacy and the wish to gain political negotiation power.	The wish for better social organization in kampung cooperatives is mainly driven by the wish to show self-sufficiency and independence. Also, well-organized cooperatives can bridge socio-ethnical differences so that they can make use of the full potential of collective efficacy.	*In the past, I mean people before the eviction they don't really have gotong royong or arisan […] but after they finished the social housing, they were already quite organized because they really wanted to manage the kampung by themselves. (RII-4)* *Looking at the current activities in the society, it is much more organized, which means the people have begun to understand this organization. This helps connect us to the government which so far we have never realluy known of, but now we can discuss with the government and create several proposals although not all of our proposals are fulfilled yet. (CSI-11)*
Frequent and continuous activities	Organizing frequent activities keeps the social identity of collectively acting groups alive. They are important for members to feel the collective and how efforts can lead to (the feeling of) success.	The organization of frequent activities such as planning processes, development, and maintenance of a collective business and alike facilitated exchange among cooperative members and increased their willingness to engage; especially when activities	*The cooperative have many activities such as UMKM, clean water service, postponed threat eviction from JSS IPAL Project, and also threat eviction from widening project transmission tower. We have done many activities, so the residents have asked for help from the*

			resulted in success with benefits for all members.	*cooperative. So the number of members of the cooperative has increased. Because what we do is successful. (NJ-LR-2)*
	Frequent meetings	Meeting with other members of the group to exchange strengthens the network, and trust in others and facilitates social learning and the wish to engage. It keeps the social identity salient and vivid.	Many cooperative members use the recurrent meeting to uphold and widen their network and friendships. Depending on the congruence of the kampung residents and cooperative members, frequent exchanges increased social cohesion and overall social interaction in the area.	*Before the pandemic, we had every meeting in a different house so that each member would know each other. After we reciting Qur'an, we discussed about the cooperative. (NJ-LR-4)*
	Leadership	Trusted, engaged, and knowledgeable leaders or representatives of a movement embody the principles of the movement and can provide valuable inputs, guidance, and directions of the collective. They have the power to increase social identification and create social norms of reciprocity and collective commitment.	Locally rooted CSOs such as UPC and JRMK provide guidance and support to cooperatives e.g. in the form of long-term planning of activities, participative creation of common vision, and capacity building of cooperative heads. In addition, their continuous support and advocacy ensure stability, identification, motivation, and self-organization of the cooperatives.	*The key is for the community themselves to have the will to fight and the presence of a key figure who can lead the organisation. (CSI-6)*
General facilitators (functioning as triggers and motivators)	Evidence for the success of collective efforts	When participation in collective activities means sacrificing time and potentially income, the benefits of the investment need to be obvious. Past successes and resulting benefits for the collective need to be evident to motivate new individuals to join but also to keep members active over time.	Once the cooperatives succeeded in increasing their participation in urban planning processes, attention grew. First results such as the change of land zoning and the obtaining of building permissions were perceived as steps towards official recognition of kampung settlers; this success increased the efforts of cooperative members while at the same time, new members joined.	*"Of course, with the success that we have in making the residents get compensation of housing, it will make them believe more and many are now believing, especially because we started all this with a community cooperative, so every community that grows is using this basis. (CSI-7)* *We joined at the time when our neighbouring kampung already joined JRMK. We saw how JRMK's assistance was successful in establishing RT and RW, so we thought we should also go there to*

			study what the others have fought for and succeeded in. (CSI-11)
Individual benefits	Besides benefits for the entire collective, individual benefits and privileges are important to convince individuals to engage in collective activities and to maintain their active participation – otherwise invested time and money would be perceived as lost. Such benefits can be financial as well as capacity building, social learning, and personal empowerment.	Committing time and financial assets to collective activities is a high risk for vulnerable residents; it could for instance mean changing from an individual business to a collective one. Individual benefits are key to triggering behavioral change and keeping members motivated. This could be in the form of discounts for collectively produced goods and cheap loans but also capacity building, new social relationships, and empowerment.	*The member, he can borrow the money from the cooperative to repair his house. So, in this community they have experience about that. So this house and that house from the next community also repaired by the cooperative fund but it's very long time to pay it back. (NJ-CSI-1)*
Social norm	In cultures with a predominant collective self-understanding and reciprocity, the norm to support each other and join forces to achieve a collective good is a longstanding tradition and hence a strong predictor for individuals to engage in collective activities. Not participating in collective activities is frowned upon; social pressure leads to both, starting to engage and continue being active.	Social life in kampungs is mostly structured by social norms. Liabilities such as participation in neighborhood meetings, collective community works, and alike are very traditional and represent important pillars of social life, especially in urban poor kampungs. In other words, social norms force residents to engage in collective actions, as remaining passive and not contributing to collective goods is frowned upon and would inhibit access to important informal social security structures within the neighborhood.	*Citizens in urban cities have the norm to help each other. (RII-1a)*
Legal representation for political participation	Highly vulnerable residents are often neglected and don't have access to decision-making processes; collectives can increase their negotiation power through representation. The wish to achieve this participation can trigger individuals to join; those who are already members are encouraged by being able	In Jakarta, kampung residents are often neglected in urban decision-making processes. Cooperatives are legal entities and officially recognized by the Indonesian constitution. Through democratic processes, cooperatives allow local residents to voice their needs and visions regarding urban development processes that often threaten their	*So their cooperative also registered to the government so now the cooperative is a legal entity. Before, this community was not […] recognized by the government because the land is […] not really recognized by the government. But now, when they became a cooperative and a legal entity, they are recognized by the government. (NJ-CSI-1).*

		to voice their needs and being considered in decision-making processes.	livelihoods. The wish for political participation can trigger them to join and keep them engaged over time as they would otherwise lose this opportunity.	*If previously the flats were managed by the government and individuals, now the flats are managed by cooperatives, like in Kampung Akuarium, the flats are managed by cooperatives, not the government and not individuals anymore, the cooperatives are legal entities to the government. (CSI-8)*
Barriers	Lack of time	Collective engagement requires time besides daily duties and habits; especially individuals depending on daily incomes may have difficulties being flexible for collective activities.	Making time for collective activities is particularly difficult for individuals with lower incomes as they often depend on daily wages and multiple jobs. In addition, many other obligations such as gotong royong fill the schedule of kampung residents.	*They still have difficulties to find members who really want to provide time for meetings etc. because in order to get organized you still have to do lots of things such as training meetings. (NJ-RII-2).* *There are those who participate with the local residents and there are some who do not participate because they need to work for a living in that day. For instance, they can be online transportation drivers whose income depends on daily wages. (CSI-1)*
	Polarization	Polarization due to differing (social) beliefs, risk perceptions, world views, visions, political affiliations, and alike can hinder social identification with collective adaptation movements; polarized divergences split potential collaborators along cultural, political, or social divides inhibiting collective activities across such boundaries.	In Jakarta, political fights at the national level can reach the local level and polarize residents along political convictions and/or support of different political figures. Religion is sometimes used as a tool to polarize individuals as well; both inhibit local residents to join forces across such boundaries due to heated debates and polarization.	*So, it's kind of like you have several community leaders in one place and then you're following this leader and you following Ibu Y. or you're following others; so I think it's a typical in any community. (NJ-RII-2)*
	Power struggles	Vulnerable residents joining forces in democratic movements to fight for their shared visions often entails the loss of power of local leaders; when the latter are afraid to lose their influence and are highly regarded by the residents, they	Kampungs compose of multiple groups of local residents which are led by different local leaders. Examples are the RT, leader of women's groups and alike. Cooperatives united members across these groups, decreasing local leaders'	*There are 8 RTs; not all of them are members of the cooperative. It seems like the presence of this cooperative is considered as a competitor […] for RT or RW. Because the program from the government will not go through the RT or*

	may oppose collective efforts to maintain their power with residents potentially following their lead.	power and influence. When these leaders do not support cooperative activities, neighborhood residents are often torn between following their long-established and high-regarded leaders or joining a promising movement with individual benefits and legal representation.	*RW, but through to cooperatives. (NJ-LR-1.)* *The RTs feel the cooperative is a threat. At first I was opposed by RT. When this village wanted to be legal, the RT made it difficult because they can't cooperate with cooperative. (NJ-LR-3)*
Lack of active members	Collective adaptation is based on joint efforts of all members; i.e. all are responsible for activities to happen. Being a passive member of collective adaptation (free riding) can lead to the inability to realize sufficient successes and benefits and even the collapse of the collective construct. Diverging perceptions of responsibility can be one reason for being passive; if members hold leaders of collective efforts responsible for realizing activities and successes, the movement is likely to fail due to their unwillingness to actively engage.	Free riding is popular among cooperative members. Many do not pay the required fee and come to meetings infrequently. Nonetheless, they benefit from some achievements such as regional building permissions. However, without their active participation, many benefits cannot be realized, e.g. the option to obtain cheap loans, or develop a collective business. Lack of active members hence reduces shared and individual benefits which in turn lowers the perception of group efficacy, leaving cooperative leaders with disproportionately high amounts of work, which they often cannot meet. This downward spiral can finally lead to the ceasing of collective activities and hence the cooperative.	*I mean but if you become a member of a cooperative doesn't necessarily mean that you have to be very active all the time. (NJ-RII-2)* *As for plans to make them more active, I also don't know. That's exactly what we're trying to solve now.* *Sometimes I get mad, because they always rely everything on me [cooperative leader]. They always think that the leader has to do everything. (NJ-LR-3)*
Lack of social cohesion	Social cohesion is the kit between residents of one area including trust, and reciprocity. Without social cohesion, collective activities are unlikely due to a lack of group efficiency beliefs and social identification.	Mutual trust, reciprocity, and support are often very high in urban poor kampungs due to the closeness of the residents who often live there for a long time and their strong dependence on each other. However, if such social cohesion is absent, e.g. in areas inhabited by many seasonal workers or newcomers, collective engagement of any kind is	*In the context of Jakarta, individualism is the main problem. So we are coming to back to what I have previously said. Social cohesion needs to become the main point to be established in Jakarta, in that each individual in a region should know each other, and then mutually understand each other so that they can collectively build an environment that can support them to solve their problems together. Typically, in big cities, the*

		unlikely due to lacking social identification and shared visions.	*people are individualistic. It is a challenge for Jakarta and other big cities. (CSI-4)* *Here, even though we are in the city, we still have sense of unity (rasa kekeluargaan). If there is an events here, like weddings, or anything, we will help them to prepare food and drinks. And also if someone dies, we will help the family. (NJ-LR-3)*
Significant disruptions of social life (pandemic, eviction)	In cases in which social interactions are completely down and almost no exchange and activities are possible for a long time, collective adaptation is almost impossible to realize.	*In the past, the eviction of kampung Pulo led to the geographic separation of kampung residents, leading to the end of their cooperative. Similarly, the pandemic led to a long-lasting disruption of social interaction, turning down all cooperative activities which made it difficult to keep individuals active.*	*From the beginning, we had a meeting once a month. But because of pandemic we are not active again. (NJ-LR-4)* *For kampungs which have not been evicted by the government, their social cohesion is really good. They are working closely with each other but forced evictions in certain areas is making them, there are no social cohesions anymore. (CSI-9)*