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RESEARCH ARTICLE



# Linking climate change adaptation and disaster risk reduction: reconceptualizing flood risk governance in Mumbai

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## ABSTRACT

Climate-related hazards, urban development and changing vulnerability patterns compel cities across the world to deal with new and emerging forms of risk. Academic literature and recent international policy documents suggest potentials of conceptually and practically linking the fields of climate change adaptation (CCA) and disaster risk reduction (DRR) and emphasize the need to mitigate climate-related risks at local level. However, there is limited knowledge on how this link is established at local levels and the role of ground-level actors and practices therein. Using the case of recurrent and disastrous floods, this paper discusses the significance of linking DRR and CCA in Mumbai. It analyses policies, plans, institutions and interventions related to DRR and CCA and uses interviews and a field study to assess flood risk governance at the level of municipal wards and neighbourhoods. The findings suggest that although flood risk governance has been significantly strengthened, three gaps exist: First, a lack of a comprehensive plan for Mumbai that anticipates future risks and vulnerabilities and integrates CCA and DRR down to local level. Second, a lack of an overarching and decentralized institutional framework across sectors and scales that recognizes the multiplicity of formal and informal actors. Third, the potential of civil society and informal actors for disaster risk management and adaptation planning has not been tapped into sufficiently. The paper argues that potential exists to reconceptualize flood risk governance in Mumbai by focusing on future risks and vulnerabilities and by recognizing the work of informal actors like emergent groups at local level.

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## 1. Introduction

Several floods in recent years (e.g. Mumbai 2005, Chennai 2015) have highlighted the vulnerability of Indian cities as well as the uneven distribution of vulnerabilities and affectedness in these cities. Similar to other cities around the globe, Indian cities are constantly

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transforming due to climate change induced changing frequencies, intensities, spatial extents and durations of extreme climatic events as well as rapid urbanization, growing socio-economic disparities and respective changes in vulnerability patterns (Sherly et al. 2015; Blok 2016; Yenneti et al. 2016). The constantly altering risk profiles of cities urge the need to better connect disaster governance with climate change-related risks.

The potentials of conceptually and practically linking the fields of climate change adaptation (CCA) and disaster risk reduction (DRR) down to local level have been highlighted both by academic literature (e.g. Birkmann and Teichman 2010; Kelman 2015; Mitchell et al. 2009; Schipper et al. 2016; Thomalla et al. 2006; Venton and La Trobe 2008) and international policy frameworks such as the Sendai Framework for Disaster Risk Reduction 2015–2030 (SFDRR) and the Sustainable Development Goals 2030 (SDGs). Also the Pathways to Transformation mentioned in IPCC AR 5 cannot be envisioned without engaging with this linkage (IPCC 2014). Progress in both fields has enabled conceptual and methodological convergence and increased the potential for cross-cutting expertise and strategies: climate change governance increasingly considers the integration of adaptation and mitigation needs and disaster governance, which traditionally focused on post-event response, shifts towards risk reduction (United Nations 2015; UNISDR 2015). Commonalities of CCA and DRR are the focus on society-risk dynamics and the aim of reducing vulnerability, strengthening adaptive capacity and enhancing resilience (Schipper 2009).

In India, the fields of climate change and disaster governance have historically developed separately and overlaps, synergies and concrete steps for convergence between policy and planning frameworks have only been identified and taken up in recent years (GoI 2008; NDMA 2019). It will take time until intentions formulated in more recent national and state-level documents become implemented at ground level, and as of now, limited knowledge exists on how this linkage can be established, implemented and unfolded in the different levels of governance for anticipating and reducing emerging risks in cities. Although disaster risk governance, climate change adaptation and resilience have been studied in an urban context in India and elsewhere (e.g. Prabhakar et al. 2009; Hughes 2013; Anguelovski et al. 2014; Bahadur and Tanner 2014; Blok 2016; Chu et al. 2016; Rumbach 2016; Allen et al. 2017; Garschagen and Marks 2019; Joshi 2021), research that targets the linkage of DRR and CCA explicitly at local levels and the role of ground-level actors and practices is scarce.

Against this background, this paper studies whether and how DRR and CCA are linked in Mumbai and, more specifically, in the city's northwestern suburb of Dahisar. As climate change, urbanization and changing vulnerability patterns will make flooding in Mumbai more frequent, intense and localized, the study focuses on current approaches in urban flood risk governance. In the next section, conceptual notes on linking DRR and CCA at local level and research gaps with regard to Mumbai are introduced. Section three delineates the objectives, the selection of the field study area and the methodology. Section four then introduces how flood risks in Mumbai and Dahisar are approached through policies and plans, institutions, and governmental interventions and discusses contributions by groups formed spontaneously and voluntarily in disasters. The last section argues that potential exists to reconceptualize flood risk governance in Mumbai by focusing on future risks and vulnerabilities and by recognizing the work of civil society and voluntary collectives at the local level.

## 2. Linking climate change adaptation and disaster risk reduction in urban flood risk governance

### 2.1 *Responding to emerging risks at local level*

As risks have become a persistent characteristic of cities around the world, urban actors are in need to constantly negotiate various forms of risks in their current and future practices, activities and processes (Parthasarathy 2021). Studies suggest that fostering linkages between DRR and CCA at local levels can be an important means to unfold synergies in tackling climate-related risks and related uncertainties. For example, resources can be used more efficiently when overlaps between projects and programmes are considered and their duplications avoided (Schipper 2009; Begum et al. 2014). The risk of maladaptation (Noble et al. 2014) can be reduced when disaster-related risks are considered in climate change adaptation projects and climate change projections are integrated in disaster risk reduction efforts. Conceptual approaches like adaptive governance (Folke et al. 2005; Chaffin et al. 2014; Varma et al. 2014; Boyd and Juhola 2015; Yasmin et al. 2020) or transformative governance (Aylett 2011; Garschagen 2015; Garschagen et al. 2018; Romero-Lankao et al. 2018; Hölscher 2019) have emerged to describe, initiate or foster governance approaches that aim at enabling cities to cope with climate-related risks and uncertainties. In reality, however, practices and policies for DRR and CCA at different levels are often disconnected, which can result in policy inconsistency, redundant investment and competing approaches to addressing the same problems while inhibiting cross-disciplinary and holistic collaboration (Schipper 2009; Gero et al. 2011; Forino et al. 2015; Schipper et al. 2016). Barriers for effective integration of climate risk and disaster management planning at the local level include the lack of suitable institutional governance frameworks including cross-scale and cross-institutional linkages (Parthasarathy 2016; Parthasarathy et al. 2019), but also knowledge gaps in identifying climate hazards and risks at the local level and understanding impacts of socio-economic processes on urban vulnerabilities (Birkmann and Teichman 2010; Fünfgeld 2010) as well as lacks of bringing together climate-related knowledges from “above” and “below” (Movik et al. 2022).

Furthermore, studies on the adaptation to current and future climatic risks in cities – drawing on concepts like urban resilience (e.g. Bahadur and Tanner 2014; Meerow and Newell 2016; Allen et al. 2017; Daniere and Garschagen 2019), urban risk management regimes (e.g. Solecki et al. 2017; Garschagen et al. 2018), urban risk governance (e.g. Murray 2017; Joshi 2021), multi-level climate and risk governance (Beermann et al. 2016; Ishtiaque 2021) or political ecologies of urban risks (e.g. Ranganathan 2015; Goh 2019; Shatkin 2019) – suggest that risk governance in cities in the Global South is complex, multilayered, contentious, concerns multiple risks and involves actors at all levels. As the planning and implementation mechanisms of local governments themselves often remain impeded due to inadequate decentralization and devolution, lack of resources and capacities, as well as fragmentation of institutional structures (e.g. Brown 2011; Garschagen 2016; Marks and Lebel 2016; Parthasarathy 2016; Rumbach 2016), a growing number of international and national networks, private businesses and civil society groups have emerged to share expertise and facilitate their interests in the processes.

It is in this context that in recent years, the involvement of communities, civil society groups, and NGOs has been studied in the context of urban risk governance (Sarzynski 2015; Butsch et al. 2016; Challies et al. 2016; Shaw 2016; Kita 2017; Wolff 2021). Besides more institutionalized citizen–government partnerships, it has been found that informal actors and spontaneously emerging groups at local levels take over important roles in emergency management and cater to the needs of people in times and places where the normal government machinery is unable to facilitate support (Stallings and Quarantelli 1985; Twigg and Mosel 2017; Strandh and Eklund 2018; Duda et al. 2020). In some cases, people who had never previously met form networks online or offline to spontaneously and collectively channelize rescue and relief efforts, provide knowledge or gather information, as it was the case during and after the severe floods in Chennai in December 2015 (Ashok 2015; Subramanian 2015; BBC; News 2016; Guaita 2020). In other cases, existing initiatives or organizations show quasi-emergent character by taking on new roles and responsibilities during disasters (Stallings and Quarantelli 1985; Scanlon 1999). Emergent groups have been found to be valuable in terms of proximity, speed and efficiency in responding to disasters (Stallings and Quarantelli 1985; Twigg and Mosel 2017), but as they are self-organizing and may lack formalization (Kapucu 2012; Strandh and Eklund 2018), their efforts are often not integrated with official responses and their potentials for flood risk governance and adaptation to emerging risks beyond emergency management remain underexplored.

## **2.2 Knowledge gaps for linking DRR and CCA in the Indian context**

In India, recent national-level policy and planning documents are creating a scope for linking DRR and CCA. The Disaster Management Act (DMA) 2005 (GoI 2005) focuses largely on the institutional and legal structures for disaster management, but also enables risk reduction through the inclusion of vulnerability analysis and prevention and mitigation measures into disaster management plans, through the establishment of disaster mitigation funds and by equipping the state and district disaster management authorities with more powers in the mainstreaming of prevention and mitigation measures. The National Disaster Management Plan (NDMP) 2019 clearly outlines climate change as a risk driver and introduces the concept of “futuristic DRR and CCA planning” that includes reliable projections on disaster risks considering climate change impacts (NDMA 2019, p. 50). Thus, the widely advocated paradigm shift from acute emergency management and relief and rehabilitation activities towards the prevention and mitigation of disasters (Gupta 2018) has become manifested in disaster policies and plans of recent years, thereby opening bridges to climate change adaptation. Although the National Action Plan on Climate Change (NAPCC) 2008 mainly focuses on climate change mitigation, it also provides scope for adaptation to climate change and dedicates attention to disaster management by suggesting to mainstream risk reduction into the design of infrastructure projects, to develop regional hazard scenarios, to upgrade forecasting and early warning systems, to conduct disaster response trainings at community level and to establish disaster management facilities across various levels (GoI 2008). As in India’s federal system the states and districts are eventually responsible for the implementation of disaster risk management and climate change adaptation, several policy recommendation and guidance documents for integrating DRR and CCA at the different levels have been

developed (Gupta et al. 2014; AIDMI et al. 2016; Government of India and UNDP 2017). These, however, mainly focus on macro-level perspectives and institutionalized actors and do not consider stakeholders at the local and community levels extensively.

In Mumbai – although both disaster risks and climate change have been addressed in recent studies, for example, in the context of climate change impacts (Ranger et al. 2011; Murali et al. 2020), uncertainty (Mehta et al. 2019a, 2019b; Adam et al. 2022b), of urban development (Zope et al. 2015, 2016, 2017; Chouhan et al. 2017; Khosla and Bhardwaj 2019; Weinstein et al. 2019), of river restoration and infrastructural ecologies (Chitra 2021), of health (Dholakia et al. 2020), of risk assessments and vulnerability patterns (Parthasarathy 2009; Tatano and Samaddar 2010; Samaddar et al. 2011; Peters et al. 2015; Sherly et al. 2015; Sherbin and Bardy 2016; Dhiman et al. 2019) or of household responses to flooding (Chatterjee 2010a, 2010b; Samaddar and Tatano 2012) – a knowledge gap exists on how DRR and CCA are integrated down to the local level. Only a few publications have studied policy and planning responses (Whitehead 2007; Chatterjee and Mitchell 2013; Butsch et al. 2016; Parthasarathy 2016; Texier-Teixeira and Edelblutte 2017), and the role of communities and private sector in this process (Surjan and Shaw 2009; Samaddar and Tatano 2012; Samaddar et al. 2012a, 2012b, 2014; Schaer and Patankar 2018). The role of volunteers, spontaneously emerging groups and informal actors has been highlighted for disaster response and recovery (Anjaria 2006; McFarlane 2012; Parthasarathy 2015), but has not been further conceptualized in the context of risk reduction and adaptation to emerging climate-related risks.

### **3. Research objectives, study area and methodology**

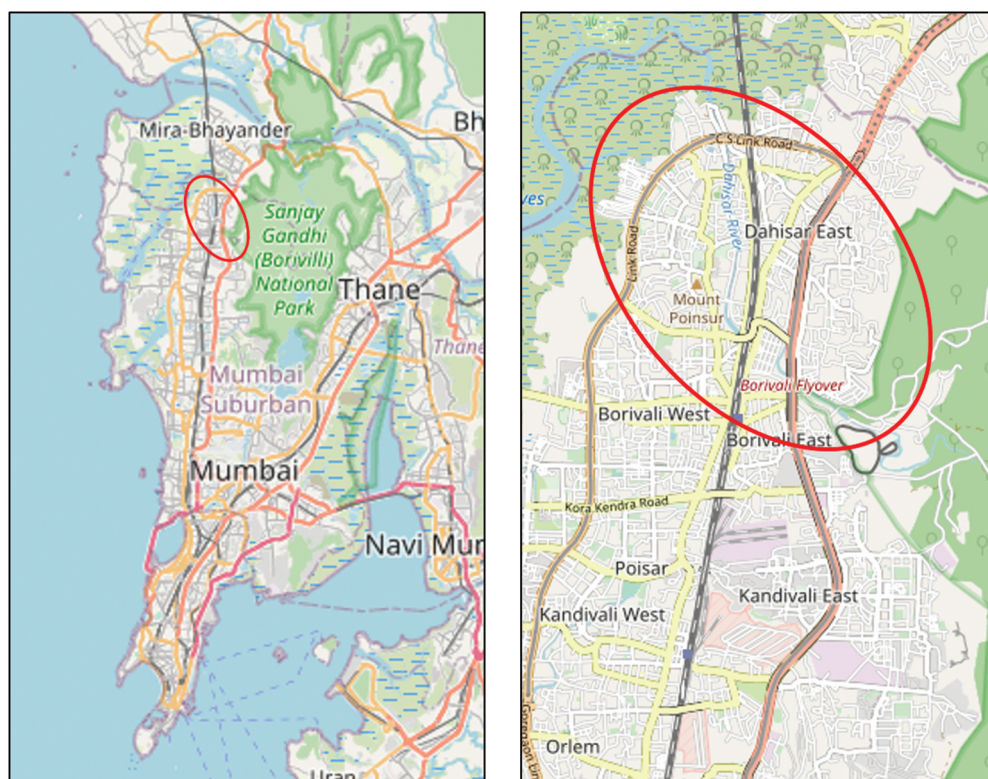
#### **3.1 Objectives**

This research paper addresses the knowledge gap by investigating flood risk governance in Mumbai at the intersection of DRR and CCA through (1) reviewing how policy and planning frameworks for DRR and CCA are integrated and encourage to consider climate-related risks in local-level flood risk governance, (2) studying how flood risks are approached through institutions and interventions at municipal and local levels, and (3) assessing how non-state actors like voluntary and spontaneously emerging groups contribute to flood risk governance in emergency assistance as well as long-term risk reduction and adaptation planning.

#### **3.2 Study area**

Mumbai, the capital of Maharashtra state, builds a good case for the investigation as the city has been repeatedly classified as highly vulnerable due to its coastal, low-lying location and its high population density with overburdened infrastructure (Patankar et al. 2010; UN-HABITAT 2010; Sherly et al. 2015). While many cities face similar problems and constraints, Mumbai is one of the few cities that has taken the initiative to develop a climate action plan and also civil society organizations as well as local-level initiatives advocate for responding to current and future flood risks. It can be assumed that an analysis of local-level initiatives in Mumbai offers lessons for scaling up and out DRR and CCA linkages in Mumbai and beyond. In recent years, the city has experienced regular





**Figure 1.** Map of Mumbai (left) and location of Mumbai's northwestern suburb Dahisar, the field study area (right). Source: OpenStreetMap; [openstreetmap.org/copyright](https://openstreetmap.org/copyright).

flooding and waterlogging as well as severe flood disasters triggered by excessive rainfall such as in 2005, 2017, and 2021. In many parts of the city, localized flooding is an annual occurrence, especially in areas located on the banks of rivers and creeks. The suburb Dahisar (see Figure 1), comprising of R/north and R/central administrative wards, was chosen as a field study site for three reasons. First, the neighbourhoods along the floodplains of Dahisar River are prone to regular flooding and were largely submerged during the 2005<sup>1</sup> and partly in the 2017 floods, when the newly built flood retention wall along the Dahisar river broke<sup>2</sup>. Second, the average peak rainfall in Dahisar was high.<sup>3</sup> Third, the suburban area has been undergoing constant development and infrastructure activities, altering the localities' topographies, the floodplains and local flooding patterns (CCC 2006; FFC 2006; Gaikwad 2016; Shinde et al. 2021).

### 3.3 Methodology

The analysis draws on research conducted in 2015–2016 by the first author, research conducted in 2019 by the first and second authors and two interviews conducted in 2022 in Dahisar by the second author.<sup>4</sup> Research projects of both authors concern flood risk governance in Mumbai and the data collection described below stems from the methodologies used in the respective research projects. While some of the data was

gathered individually, several interviews and field visits were conducted jointly. Data and insights which are relevant for DRR-CCA integration have been evaluated for the purpose of this paper.<sup>5</sup>

Joint field visits in Dahisar Gaothan, Daulat Nagar and Sanjay Nagar were conducted in 2019 by the first and second author<sup>6</sup> and comprised of transect walks along the Dahisar river, photographic documentation, as well as interviews and ad-hoc group discussions with residents and were used to assess flood risk governance at community level and linkages to institutionalized approaches. Fourteen interviews with residents and three interviews with ward-level officials were conducted. As the interviews aimed at gathering perceptions, experiences and measures taken by people living and working in the three locations, they were problem-centred and a purposive sampling method was used for selection of the interview partners. Interviewees included residents of different settlement types, shop owners, members of an industrial complex and a doctor active in the area. As some interviews were joined by other residents spontaneously, they developed into ad-hoc group discussions. Interviews at ward level were semi-structured.

Additionally, seven semi-structured interviews of 2019 and six semi-structured interviews of 2015–2016 with government officials at state, city and local level, policy advisors, residents and members of civil society groups including emergent groups conducted by the first author and two semi-structured interviews with government officials by the second author in 2022 were used for the preparation of this paper.<sup>7</sup> The interviews were used to identify policy and planning documents, to evaluate their relevance for current and future flood risk governance in Mumbai and to assess collaboration between state and non-state actors.

While some interviews were recorded and later transcribed, notes were taken during those interviews where recording was not possible or not permitted. The written text was not fully coded, but analysed for topics and content relevant to this paper.

For the purpose of policy analysis, 11 DRR and CCA policy and planning documents and further guidelines with relation to urban flood risk governance in Mumbai (see [Figure 2](#)) were analysed by the authors using a document analysis which combines elements of content analysis and thematic analysis as explained by Mayring (2010), Bowen (2009) and Braun et al. (2019). A table with the categories functionality & horizontal linkage, temporality & vulnerability reduction, scale & vertical linkage<sup>8</sup> and relevance for urban flood governance was filled for each document. The results from the table were later condensed, analysed and the findings conflated and summarized in written text. As the Mumbai Climate Action Plan (MCAP) was released after the first submission of this paper, it was not part of the primary document analysis, but later broadly assessed for relevant points.

#### 4. Flood risk governance in Mumbai

Flood loss and damage assessments point to the tremendous impacts which flooding has on Mumbai's citizens and the economy (Hallegatte et al. 2010; Tatano and Samaddar 2010; Chatterjee 2010a; Patankar and Patwardhan 2016; Ganapatye 2019). While such assessments have been done selectively for major flood events, tracing impacts of smaller or localized floods is not done on a regular basis. Especially marginalized groups of society are affected more than usual in annual water-logging and major floods due to high



exposure, pre-existing vulnerabilities and limited possibilities to take up preventive measures (Parthasarathy 2009; Hallegatte et al. 2010; Chatterjee 2010b; Samaddar et al. 2011; Samaddar and Tatano 2012; Patankar 2015; Sherly et al. 2015). It is suggested that economic and social costs of flooding could rise tremendously if climate-related risks, urbanization and changing vulnerability patterns are neglected (Abadie et al. 2020; Picciariello et al. 2021).

In the following sections, the paper briefly outlines how flood risks in Mumbai alter due to climate hazards and urbanization and traces flood risk governance in Mumbai with a focus on municipal wards and neighbourhoods by assessing how climate change and disaster governance are linked in local-level plans, by studying the institutional framework and actors involved, by introducing flood risk interventions and by assessing contributions of non-state actors like emergent groups.

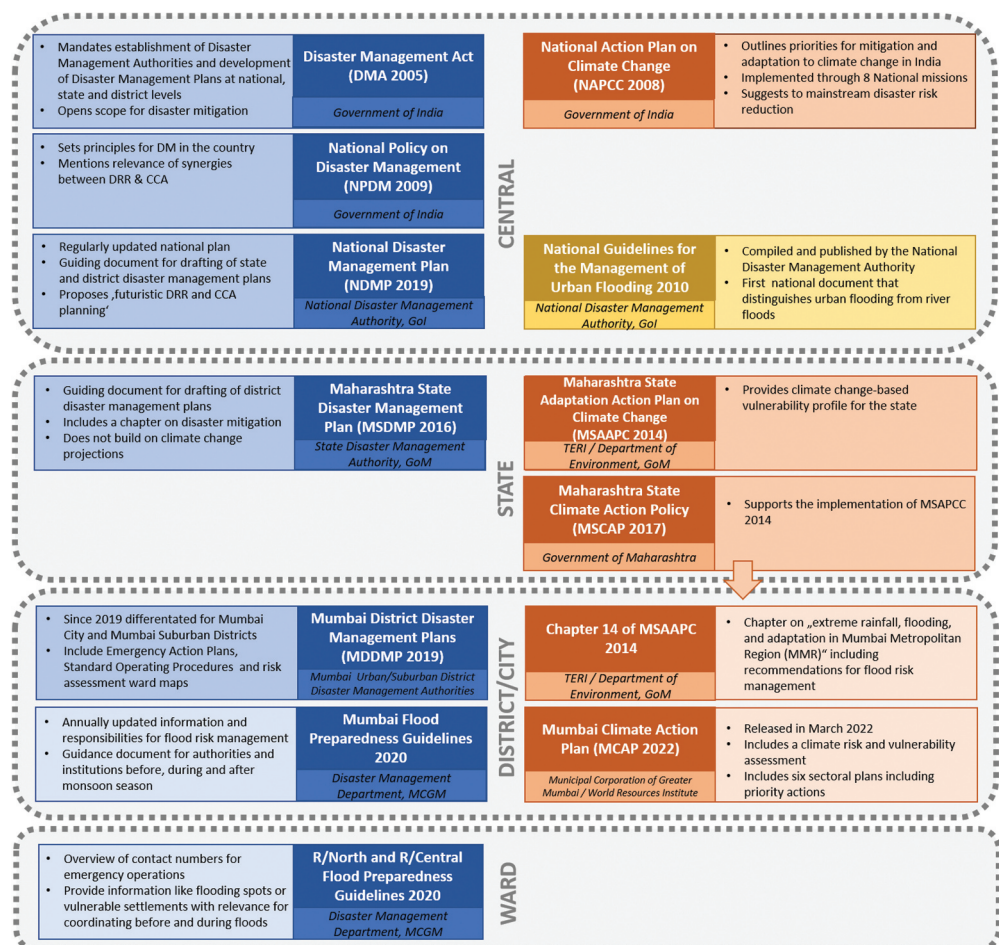
#### **4.1 Flood risks in Mumbai**

Currently, the average annual rainfall for Mumbai is about 2000 mm (MCGM 2022b) with the monsoon season accounting for 96% (Rana et al. 2012). About 50% of this rainfall is received in 2–3 spells (FFC 2006). In recent years, both the total rainfall per season and the annual number of extremely heavy and very heavy rainfall events have been increasing (MCGM 2022a, 2022b). The intensity and frequency of extreme precipitation events is likely to increase further and could result in more frequent and more severe urban flooding (Ranger et al. 2011; IPCC 2021; MCGM 2022b). There is also a wide variation in the rainfall across the island and suburban parts of Mumbai and most extreme rainfall events tend to fall in localized clusters (MCGM 2022a). During the devastating floods of 26<sup>th</sup> and 27 July 2005, the observatory in Santacruz suburb of Mumbai recorded 944 mm rainfall within 24 hours, while the observatory at the island city in Colaba recorded only 74 mm for the same duration of time (Rafiq et al. 2016). The differential distribution of rainfall suggests a need to investigate causes and variation of impacts at local level. Further, other climate-change induced conditions such as sea-level rise, heat waves, tropical cyclones and storm surges could possibly lead to new vulnerabilities and impacts in Mumbai (Ranger et al. 2011; TERI 2014; Kumar et al. 2020; MCGM 2022b).

In the Mumbai Metropolitan Region (MMR), urbanization has acted as a driver for accelerated flood risks with rising population, large reclamations from the sea, and increased surface runoff due to concretization and changes in social vulnerability (Ranger et al. 2011). In recent years, the phenomenon of flooding has become more localized due to land use changes, local topography, infrastructure developments, pollution of rivers and creeks, and defective storm water drainage. Flooding is now observed in isolated pockets and in areas where no flooding happened earlier (Shinde et al. 2021). About one-third of Mumbai's population lives within the influence zone of flooding hotspots reported by the municipal corporation<sup>9</sup> (MCGM 2022b). In Dahisar it was observed that local conditions such as building structures and infrastructures, along with social fabric and socioeconomic conditions influenced the severity of flood impacts, coping mechanisms and flood experiences in the 2005 floods (Zimmermann 2016). Therefore, there is a need to make Mumbai's flood risk governance strategy more robust and attuned to localized flooding.

## 4.2 Policy and planning approaches to flood risk governance in Mumbai at local level

Several policy and planning documents exist for both climate change and disaster (risk) management at central, state, district/city and ward levels (see Figure 2). The Maharashtra State Adaptation Action Plan on Climate Change<sup>10</sup> (MSAAPC) (TERI 2014) suggests the integration of future climate change projections and uncertainties into state disaster management plans. It furthermore comprises a chapter on flooding in the MMR, including modelling assessments for the areas likely to be flooded during extreme rainfall events, which could be used for disaster management (TERI 2014). In recent years, the state government has further taken steps for integrating CCA and DRR, which could also contribute to enhancing flood risk governance across the state and in Mumbai. Amongst these are the release of the Climate Change Policy of Government of Maharashtra (GoM 2017) in support for the implementation of the MSAAPC 2014, the publication of the Handbook on Maharashtra Action Plan on Climate Change in 2018



**Figure 2.** DRR and CCA policies and plans with relevance for flood risk governance in Mumbai. Source: Compiled by T. Zimmermann.

and the development of sectoral climate action plans. In March 2022, Mumbai's first Climate Action Plan (MCAP) and the accompanying Climate and Air Pollution Risks and Vulnerability Assessment for Mumbai were released<sup>11</sup> (MCGM 2022b). As part of sectoral actions regarding urban flooding and water resource management, the MCAP lists disaster risk-related actions such as improved and integrated early warning systems or an integration of community-based approaches in the city's disaster risk management, for which the city's Disaster Management Department would be a key stakeholder (MCGM 2022b).

Although the Maharashtra State Disaster Management Plan (MSDMP) (GoM 2016) has included climate-related risks, Mumbai's current District Disaster Management Plans<sup>12</sup> (MDDMPs) do not yet reflect the shift towards disaster mitigation and adapting to climate-related risks to the same extent (DDMA 2019a, 2019b). They outline the institutional structures for emergency management, standard operating procedures and emergency support functions as well as disaster mitigation measures for various hazard types. Yet, with the exception of including climate change in the course content of capacity-building trainings, these plans do not give an indication on how climate change projections and climate-related and emerging risks are or could be reflected in disaster management structures and flood mitigation. Therefore, further scope exists for making the linkages between climate change and disaster risk explicit, which are crucial for understanding and addressing the specificities of future flooding in different localities of the city. R North and R Central Ward-level disaster management plans map flooding spots, but otherwise focus on emergency management and are not oriented towards emerging risks. Epistemological challenges here are that climate hazards and related risks are rarely identified at local levels, resulting in a lack of knowledge and data for local level, and that flood-related problems are understood, perceived and conceptualized differently by actors depending on their role, level of action, and ways of knowing (Giddens 2011; Parthasarathy 2016; Mehta et al. 2022; MCGM 2022b).

Mumbai's DDMPs 2019 have formulated the aim to reduce the vulnerability of communities and enhance their resilience in the context of future risk scenarios, but portray vulnerability in a relatively static manner and do not discuss potential changes in vulnerability patterns and emergent risks. Enhancing this perspective by including social vulnerabilities, outlining Mumbai-specific measures to reduce risks for vulnerable sections of society and acknowledging the dynamic character of such vulnerabilities in the light of climate change, urban development, and socioeconomic transformations could be a means to integrate DRR and CCA strategies and enhance risk reduction efforts at the city level and below. The MCAP 2022 lists improving early warning systems for the empowerment of vulnerable communities and an integration of community-based approaches in the overall disaster risk management of the city as priority actions. It is yet to be seen whether the plan's implementation lays ground for a comprehensive governance framework that integrates DRR and CCA specifically in the context of future climate change risks, urbanization and vulnerabilities down to local levels.

### **4.3 Institutional framework, governmental interventions and multitude of actors**

While flooding in Mumbai has long been perceived as an issue of inadequate and ill-functioning stormwater drainage systems and disaster management (CCC 2006; FFC 2006), in recent years it has been increasingly problematized in the context of urban development and climate change induced changing rainfall patterns (Revi 2005; Gupta 2007; Chatterjee and Mitchell 2013; Weinstein et al. 2019; Murali et al. 2020). Yet, despite continuous enhancements in the institutional structures and coordination mechanisms and despite a push towards carrying out various prevention and mitigation measures stimulated by the 2005 floods (Zimmermann 2019), Mumbai still lacks an overarching and decentralized institutional framework which enables and encourages linkages between DRR and CCA across scales and agencies – from the national level that provides guidelines and regulatory frameworks down to the community level where many flood-related measures are actually implemented and experienced. As will be outlined in the following, flood risks in Mumbai are largely approached from a disaster governance perspective and flood-related interventions by the government are mainly hazard-based and less focusing on vulnerability reduction and adaptation to climate-related risks.

The DMA 2005 provides the legal foundation for decentralizing disaster risk reduction to the district level, the NDMP 2019 proposes an institutional responsibility framework for urban flood risk governance in which it considers the state and district disaster management authorities as responsible for developing local climate change adaptation strategies (Gol 2005; NDMA 2019, 129ff), and the NAPCC 2008 and the MSAAPC 2014 suggest the inclusion of civil society and local institutions in climate change adaptation (Gol 2008; TERI 2014). Yet, the role of local-level authorities and Urban Local Bodies is not sufficiently outlined in the policies and plans. In Mumbai, the Disaster Management Department (DMD) of Mumbai's Municipal Corporation MCGM directs the activities related to the mitigation, prevention and preparedness as well as the acute management of (flood) disasters jointly for Mumbai Suburban and Mumbai City District Disaster Management Authorities.<sup>13</sup> It publishes the District Disaster Management Plans, releases the annual Flood Preparedness Guidelines, hosts the city's Emergency Operation Centre (EOC) and coordinates between various involved stakeholders and institutions such as the Fire Brigades, Police, medical facilities, research institutions and industry, but also the ward offices that host ward-level EOCs. The Maharashtra State Disaster Management Unit, located within the Department of Revenue and Forests, provides guidance for risk mitigation and preparedness and facilitates emergency support in case of severe disasters that go beyond the capacity of the districts.

In addition, a variety of city and state-level authorities and planning bodies are directly or indirectly involved in flood risk governance, for example, with regard to stormwater drainage, rainwater harvesting, solid waste management, public works, the management of green spaces like mangrove lands and waterbodies. Yet, the absence of integrated plans and the corresponding sectoral and institutional "balkanization"<sup>14</sup> can create difficulties in coordination and hinders holistic and forward-looking flood risk governance approaches (Parthasarathy 2016).

At local level, the 24 administrative wards of Mumbai are responsible for disaster preparedness and emergency relief, unless the scale of flooding exceeds their resources. R North and R Central ward offices are thus regularly updating their flood preparedness

guidelines and have set up disaster control rooms that work 24 hours during monsoon season to coordinate between residents in need, supporting institutions like the fire brigades or police and the central MCGM EOC. The ward offices further oversee the desilting of the Dahisar river and stormwater canals in the pre-monsoon season, are involved in resettlement processes and the mapping of flooding spots. Although they have good knowledge of the localities and have access to the observations, perceptions and needs of the local residents, facilitating longer-term processes towards climate change adaptation is not a focus of their work.<sup>15</sup> It is yet to be seen whether the MCAP implementation including the proposed ward-level climate officers will initiate climate change-related activities at ward level.

As the MDDMPs 2019 consider flooding as a seasonal challenge between June to August, current flood-related efforts are largely directed towards monsoonal rainfall (see Table 1 for a list of key governmental interventions in Dahisar). Although some recent studies suggest that large parts of Mumbai face inundation due to rising sea level and cyclones over Mumbai's coastline will become more likely both before and after monsoon season (Evan et al. 2011; Murakami et al. 2017; Sobel et al. 2019; Murali et al. 2020; Climate Central 2021), knowledge about climate hazards and risks at local level remain limited. Thus, there exists a need to strengthen the recent efforts of weather forecasting and rainfall predictions (e.g. through the Integrated Flood Warning system IFloWS which aims at sending alerts between 6 to 72 hours in advance<sup>16</sup>) and localize predictions and warnings, for example through now-casting using radars. While some of the flood-related interventions are carried out specifically at ward level, others are coordinated and overseen by a variety of city and state-level authorities. Their usefulness for reducing and mitigating flood risks at the local level needs further assessment.

Works are in progress to enhance the knowledge basis and enhance capacities regarding climate-related risks, for example by preparing departmental disaster management

**Table 1.** Key flood-related interventions in Dahisar undertaken by the government authorities.

Interventions	Responsible authority	Mitigation	Preparedness	Emergency management
Extension of storm water drainage networks through the BRIMSTOWAD project	MCGM Storm Water Drains Department	√		
Widening of Dahisar river and construction of flood retention walls	MCGM Storm Water Drains Department	√		
Resettlement of people affected by the widening of rivers	MCGM ward offices and others	√		
Dredging of rivers and nallas before monsoon season	MCGM ward offices		√	
Development and updating of ward level disaster management plan and flood preparedness guidelines	MCGM ward offices, MCGM Disaster Management Department		√	√
Establishment of ward level control room	MCGM ward offices		√	√
Further Mumbai-wide measures (selection):				
<ul style="list-style-type: none"> <li>• Weather forecasting and warning: installation of automatic weather stations, Doppler radars and IFloWS-System</li> <li>• Establishment of State and District Disaster Mitigation and Relief Funds</li> <li>• Mangrove protection as natural flood barriers</li> <li>• Publication of annual Flood Preparedness Guidelines and Emergency Action Plan</li> <li>• Capacity development through training of administrative staff, first responders, volunteers and communities</li> <li>• Installation of CCTV cameras</li> <li>• Coordination through MCGM and Maharashtra State Emergency operations Centre</li> </ul>				

Source: compilation by authors



plans and by training administrative staff, volunteers and communities through the State's YASHADA training institute for government officials.<sup>17</sup> Besides the formal institutions, a diverse set of actors and organizations are contributing to the extension of climate change risk-related knowledge as well as the development of appropriate responses and strategies. Some of them directly collaborate with formal institutions, others see their role in challenging them (Boyd and Ghosh 2013). In recent years, local, national and international academic institutions, governmental and nongovernmental organizations, multi-lateral agencies and private consultancies have been assisting state and city-level institutions in developing strategies and plans for integrating CCA and DRR.<sup>18</sup>

Mumbai has a long history of civil society groups and NGOs advocating for recognizing risks in land-use planning, urban development and infrastructure projects, thereby building pressure on institutions and policymakers (Thomas 2018; Dixit 2019; Singh et al. 2021). While some groups and organizations have been working on city level, others focus their work on specific localities. For example, the River March Group has been advocating for the rejuvenation of the Dahisar River and has gradually extended their scope on issues of forest and mangrove protection, beach clean-up drives and flood prevention (Mumbai March 2021b). At local level, visits to the neighbourhood by local corporators and politicians remain an important means of staying connected to residents and taking care of flood-related grievances. In Dahisar, cases were reported in which local corporators assisted in reducing current and future flood risks, for example, by financing the heightening of roads to prevent water influx into residential areas.<sup>19</sup>

Although it can be noticed that most civil society groups engaged in flood risks do not yet centre their campaigns and contributions on climate-change related emerging risks, the variety of actors including their resources, knowledge and expertise can be crucial for enhancing linkages between DRR and CCA at various levels of governance, in pointing out controversies and in directly assisting flood-affected residents. As the given policies and plans focus on techno-managerial and state-centric approaches (Samaddar et al. 2012a; Texier-Teixeira and Edelblutte 2017), they do not reflect this multitude of actors involved in flood risk governance, thereby leaving the potential of local groups underexplored.

#### ***4.4 Local level flood risk governance in Dahisar and the role of emergent groups***

Previous research pointed out that apart from the state, various non-state actors like individuals, communities, civil society groups and the private sector have been essential in coping with annual flooding and major flood events at local level in Mumbai (Anjaria 2006; Chatterjee 2010b; Samaddar and Tatano 2012; Parthasarathy 2015). Also in Dahisar, in addition to government authorities and formal non-state actors like NGOs or schools, a variety of informal non-state actors spontaneously emerged to help the local communities voluntarily during and after the 2005 floods. Although they had not been entrusted any responsibility from the government, civil society groups or private sector engaged in the rescue and relief operations at local level. These groups are not registered, usually have no formal relations to the state apparatus and are not recognized in the current governance frameworks. However, due to their proximity to flood locations and affected communities, their understanding of the on-field flooding situation, and their readiness to jump in to provide support, they contributed significantly in emergency situations where undertaking relief and rescue measures through formal channels via government was difficult. In Dahisar,



these groups engaged significantly in rescue and relief operations and as will be demonstrated in the following section, they also show potential to contribute strategic knowledge and resources for understanding differentiated vulnerability patterns and local needs in the context of changing local riskscape. However, more studies and further research will be required to understand these aspects and unpack their full potential.

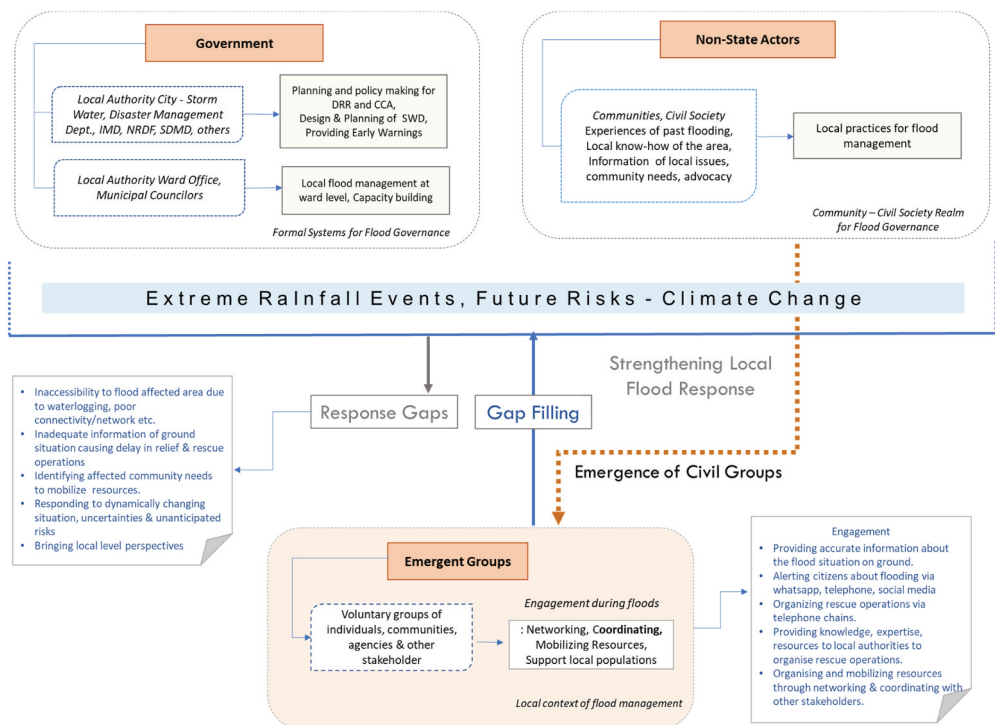
In response to recent heavy rainfall events in 2017, many people in Dahisar have spontaneously formed networks on common platforms of social media and messengers like Whatsapp to exchange flood warnings and provide information about flood affected areas. Thereby, knowledge of local flooding patterns and related risks was gathered and shared to an extent, accuracy and speed which authorities could not provide. Examples from neighbourhoods in the flood plains of the Dahisar river demonstrate that existing groups of temple trusts and NGOs in the area also spontaneously and voluntarily provided help to affected communities beyond their routine roles and functions, thereby showing quasi-emergent behaviour (Stallings and Quarantelli 1985). In 2005, members of Daulat Nagar's Jain temple trust spontaneously formed a network to assist residents of the highly affected adjacent Sanjay Nagar. Due to the proximity of the two neighbourhoods, they acted as first responders and played a crucial role in rescue efforts, but also in providing shelter and food and in assisting with clean-up work in the weeks after the floods. As some houses in Sanjay Nagar got completely submerged and many residents lost all their belongings, they depended on help from outside the community. Although the neighbourhoods barely interacted before, the members of the temple trust felt a need to facilitate support, especially as governmental help was not immediately available.<sup>20</sup> Further downstream along the Dahisar river, members of AGNI, an NGO advocating for improving services to citizens, and other CBOs and NGOs in the area used their networks and connections to organize rescue activities via telephone chains in order to assist people in need and provided rescue equipment and trucks to evacuate flood victims.<sup>21</sup>

Being located in the same area, these groups could organize resources and cater to the needs of the flood-affected communities much faster than others and could fill gaps where the formal mechanisms were unable to anticipate or channelize support because of various reasons such as inaccessibility of the location due to waterlogging, low network and telephone connectivity, or lack of resources. As members of these groups come from various backgrounds, they can help in networking with other citizens' groups, associations, stakeholders and organizations to communicate warnings, raise awareness, identify needs in and across localities, and organize support to the affected communities. Due to the dynamic nature of emergent groups, various other individuals like media reporters, technical subject experts, street-level bureaucrats or scientists also feed into them by sharing their knowledge, technical expertise and information.

Insights from Dahisar and other parts of the world (Stallings and Quarantelli 1985; Green et al. 1989; Drabek and McEntire 2003; Guldåker et al. 2015) suggest that non-state actors including emergent groups also engage in flood risk governance beyond emergency management and acquire roles as knowledge providers, facilitators and advocacy catalysts for flood prevention and risk reduction. After experiencing flooding in 2017, members of a housing society in Daulat Nagar collectively approached the government regarding flood zoning and development control in the area.<sup>22</sup> The previously mentioned River March group that originally focused on rejuvenating the Dahisar River has started engaging in the construction of check dams on the Dahisar River, a flood prevention

measure suggested by the Fact Finding Committee Report after the devastating 2005 floods (FFC 2006, p. 167). The group petitioned the state and city-level officials for receiving the construction permissions and the first check dam has been completed in collaboration with the Art of Living Foundation (Singh 2019; Telang 2019; Mumbai March 2021a). In another part of Dahisar, members of a resident forum started a blog as an information and networking tool for citizens who engage in the protection of mangroves (Boyd and Ghosh 2013), as the destruction of mangroves has been considered a major cause of flooding in the western suburbs (Parthasarathy 2011). As knowledge of local climate risks in Dahisar is limited, a group of senior students at the School of Environment and Architecture started overlaying rainfall data, tidal conditions and settlement patterns at ward level to create flood risk maps (Varshney 2020).

Building on literature (Stallings and Quarantelli 1985; Guldåker et al. 2015) and insights from Dahisar, we posit that emergent groups can help in bridging the gaps between the formal and informal systems of flood risk management adopted by the government and citizens respectively (see Figure 3). They could act as transmitters of local knowledge into policy and planning strategies and facilitate and engage in participatory processes of community-based risk reduction planning (Samaddar et al. 2015). Mehta et al. (2021) furthermore argue that hybrid and co-produced initiatives create emergent spaces for new practices and may reconfigure power and knowledge relations. They challenge dominant development trajectories and can enable transformative societal changes. Yet, such collaborations between emergent groups, local residents, community-based organizations, academia and other stakeholders usually form at local scale (see also



**Figure 3.** Emergent Groups in Urban flood risk governance. Source: Figure by S. Shinde

Bhadgaonkar and Bhadgaonkar 2019; Oxley 2020), but less at city scale and respective knowledge and voices are seldomly translated into policy (Adam et al. 2018).

As of now, the variety of groups engaged in flood-related actions in Dahisar and beyond is not recognized in policy or planning documents and their potential for flood risk governance at local level remains underexplored. Some collaborations between ward officials and members of civil society groups and groups operating in emerging spaces were observed, but these relations are usually informal and contacts as well as shared experiences can be lost, for example, if ward officers are transferred.<sup>23</sup> Current governance frameworks do not provide for including insights and expertise from emergent groups, which act voluntarily and spontaneously, and often do not have organizational structures or a spokesperson (Stallings and Quarantelli 1985; Twigg and Mosel 2017; Strandh and Eklund 2018). NDMA (2010, p. 72) signifies the relevance of establishing participatory planning processes as a basic principle in urban flood risk management and the MSAAPC 2014, MSDMP 2016 and Mumbai's DDMPs 2019 propose community participation in flood mitigation and preparedness measures. However, concrete suggestions on how this can be done are rare and the existing frameworks consider communities mainly as recipients of information, warnings and training for their role as first responders (e.g. DDMA 2019a, 2019b). What is missing in most policy and planning documents is the understanding of non-state actors including spontaneously emerging groups also as providers of knowledge and experience regarding localized flooding patterns, new and emergent forms of risks and the variations of vulnerabilities and needs in different communities, places and times. The newly launched MCAP 2022 might initiate some change here, as it proposes to conduct community resilience assessments, to establish climate action officers in all 24 wards, and to develop community resilience action plans at local area level (MCGM 2022b). Research is needed to shed more light on the functioning of existing alliances and reasons for the lack of transformational collaborations at different scales.

## 5. Potential for reconceptualizing Mumbai's flood risk governance

In Mumbai, the increase in extreme rainfall events combined with high levels of urbanization not only surges the likelihood and intensity of flooding, but also makes the phenomenon of flooding more localized. The changing local risk and vulnerability patterns and the resulting uncertainty urge the need to develop plans, strategies, collaborations, and mechanisms that enable to anticipate and respond to new and emerging risks dynamically.

Our findings suggest that recent policy and planning frameworks have progressed in strengthening linkages between DRR and CCA efforts and flood risk governance in Mumbai has seen considerable enhancements both in terms of development of an institutional framework as well as the implementation of interventions related to flood mitigation, preparedness and response. Yet, climatic hazards and dynamic and future vulnerabilities due to climate change, urbanization and socio-economic developments have not been sufficiently addressed and flood risk governance in Mumbai largely builds around understanding flooding as a seasonal hazard that should and could be managed by enhancing formal institutions, upgrading infrastructure, improving forecasting and warning systems and making emergency operations more efficient, rather than through a long-term strategy which acknowledges the multitude of actors involved, builds on

experiences, needs and capacities of flood affected citizens and manages to dynamically respond to new and emerging forms of risks.

The preceding analysis has pointed towards three significant gaps in Mumbai's current flood risk governance framework. First, a lack of a comprehensive plan that anticipates future risks and vulnerabilities and bridges CCA and DRR down to local level. Current climate change-related plans consider disaster risks and the newly published MCAP builds bridges to disaster management, but the existing disaster management plans do not adequately identify climate hazards, exposure and emerging risks. Second, an absence of an overarching institutional framework across sectors and scales which recognizes the multiplicity of formal and informal actors engaged in actual flood risk governance and enables to develop and implement strategies targeting current and future risks and vulnerabilities. Third, the full potential of informal non-state actors like emergent groups for both acute disaster management and longer-term risk reduction and adaptation planning has not been tapped into sufficiently. The reasons for these gaps are multifold. Amongst them are a strong top-down and technocratic orientation of current approaches (Texier-Teixeira and Edelblutte 2017; Zimmermann 2019; Adam et al. 2022b) and lacking integration of strategies from different stakeholders into policy approaches (Chatterjee and Mitchell 2013; Parthasarathy 2015), a pluralization and balkanization of institutions and responsibilities (Parthasarathy 2016), limited knowledge on vulnerability patterns at community level and climatic hazards and risks at local level (Samaddar et al. 2011; Sherly et al. 2015; MCGM 2022a), different perceptions of uncertainties by the multiplicity of actors involved (Adam et al. 2022b), and a negligence of climate change and lack of a city climate action plan until recently.

In order to diminish these gaps, the paper argues that potential exists to reconceptualize flood risk governance in Mumbai by focusing on future risks and vulnerabilities at local level and by establishing decentralized approaches with hybrid alliances. As future risks are not only a matter of climate change, but also of urbanization and socio-political and socio-economic dynamics, more work is required to understand current and future vulnerability patterns at different spatial and temporal scales. Important components could be to establish alternative visions in terms of transformation, to mainstream climate change across departments and sectors dealing with flood risk mitigation and to develop a joint and decentralized strategy (Parthasarathy 2016). We suggest that local non-state actors including emergent groups not only act as an important resource during disasters, but also have a potential to bring in strategic knowledge for understanding such differentiated vulnerability patterns and local needs. Based on their experiences they can comment on, challenge and point out unintended impacts of interventions to the local government agencies, thereby helping to avoid the possibilities of maladaptation. A first step towards unpacking the potential of emergent groups for coping with current and future risks could be to acknowledge their existence in policy and planning documents and to document their contributions. More research is needed on the constitutions, structures, scopes, interests and endurances of different types of emergent groups and hybrid alliances in all phases of flood risk governance in Mumbai and their collaboration with authorities at different administrative, spatial and temporal scales in order to further explore their potentials and limitations as well as pathways to strengthen and widen their scope.

The recently published MCAP creates new possibilities for flood risk governance by placing it in the context of climate change. The implementation process will initiate more

discussions and actions to reduce existing gaps and barriers and has potential towards the reconceptualization of governance, including steps towards unifying the governance structure for addressing development, climate and environmental concerns jointly. Yet, the implementation process at ground is expected to take some time and it is to be seen whether the proposed ward-level climate action officers take over the role to integrate potentials and knowledge of communities and emergent groups and moderate between their needs and interests.

The paper contributes to literature that discusses linkages between disaster risk reduction and climate change adaptation (e.g. Birkmann and Teichman 2010; Schipper et al. 2016) and highlights the need to assess how such linkages are established in policy and planning documents, and the gaps that remain in practice at the local level. We suggest that insights from Mumbai can offer lessons for scaling up and out efforts for linking DRR and CCA through formal and informal processes and networks. Thus, the findings also contribute to the growing body of research that acknowledges the need to critically discuss governance arrangements and the role of informal actors and hybrid alliances in urban responses to climate-related risks (e.g. Blok 2014; Chu 2018; Titz et al. 2018; Seebauer et al. 2019; Weinstein et al. 2019; Clark-Ginsberg et al. 2020; Adam et al. 2022a).

## Notes

1. In the 2005 floods, about 100 people lost their lives along Dahisar river (Business Line 2005), and 10,000 houses and shops got severely damaged (FFC 2006, p. 143).
2. Field work conducted by T. Zimmermann and S. Shinde, March–May 2019, Dahisar.
3. Based on the data analysis of peak rainfall events in Mumbai carried out by the second author. The rainfall data of 5 years i.e. 2012–13 and 2015–18 for 24 hours in mm, provided by MCGM, was used for the analysis. The results showed high rainfall in Hindmata-Byculla and Dahisar areas.
4. Research in 2015–2016 was conducted as part of the first author's Master's thesis which focused on the 2005 floods and the way perceptions on flood risks, institutional structures and interventions taken altered in the ten years after. Data comprised thirty-six semi-structured interviews and sixteen informal conversations with government officials, researchers, journalists, representatives of non-governmental organizations (NGO), community-based organizations (CBOs) and residents of Sanjay Nagar and Daulat Nagar neighborhoods in Dahisar. Research in 2019 and 2022 was conducted as part of the first and second authors' ongoing PhD projects on flooding in Dahisar.
5. While parts of the previous research have been published selectively or presented at conferences (Zimmermann 2019, 2021; Shinde et al. 2021; Zimmermann et al. 2021), the major results have not been published yet. Therefore, respective content is treated as primary data in this paper.
6. Joint field visits and interviews in Dahisar conducted between 28/03/19 to 08/05/19 by T. Zimmermann and S. Shinde as part of their respective ongoing PhD research projects have been used for the preparation of this paper. Interviews outside Dahisar were conducted separately.
7. While the interviews conducted in 2015–2016 had a focus on the 2005 floods, the interviews conducted in 2019 concerned the evolution and advancements of (decentralized) flood risk governance more broadly. Interviews which concerned current and future risks as well as climate change governance were integrated and re-analyzed for the preparation of this paper. The interviews conducted in 2022 were to assess the implementation of MCAP. As the plan's implementation process has only started, its full implications cannot be represented in this paper.

8. Functionality & horizontal linkage included the document's perspective on urban flooding as well as linkages between CCA and DRR; temporality & vulnerability reduction included whether the documents focused on shorter- or longer-term measures, whether and how vulnerability reduction is addressed and whether also future risks are assessed or mentioned; scale & vertical linkage included cross-scale linkages as well as whether and how the role of communities and emergent groups is addressed by the documents.
9. Influence zone as described in MCAP 2022 comprise of 250 meters radius buffer around the flood hot spot.
10. The MSAAPC draws from the outputs of the study "Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra" which was commissioned by Government of Maharashtra to The Energy and Resources Institute (TERI) and includes model-based climate projections for Maharashtra's geography (TERI 2014).
11. The MCAP has been developed by the Municipal Corporation of Greater Mumbai (MCGM) with technical support by the World Resources Institute (WRI) India.
12. Mumbai's first Disaster Management Plan was released in 1999 and two further plans followed in 2007 and 2011. In May 2016, the Greater Mumbai Disaster Management Authority published the Mumbai District Disaster Management Plan 2016 and updated it in 2018. In 2019, MCGM released two separate but almost identical District Disaster Management Plans (MDDMPs 2019) for Mumbai City District and Mumbai Suburban District.
13. The Greater Mumbai Disaster Management Authority was split up in two after a court ordered in 2018 that each district needs to have a separate Authority (PTI 2018a, PTI 2018b, Chaudhari 2018).
14. For example, the Mithi River, which regularly overflows, is governed by the Mithi River Protection and Development Authority (MRPDA), although flood-related activities are split in two segments between MMRDA (downstream) and MCGM (upstream) (Parthasarathy 2016).
15. Field work conducted by T. Zimmermann and S. Shinde, March–May 2019 and interviews by S. Shinde in May 2022, Dahisar.
16. IFlows was developed for Mumbai by the Ministry of Earth Sciences in collaboration with the Disaster Management Department of MCGM and was launched in 2020 (Gol, Ministry of Earth Sciences no year, n.d.). In 2021, the system was not fully functional yet and failed to provide warnings during some of the heavy rainfall days (Mumbai Live Team 2021).
17. Interview with government officer conducted by first author on April 4, 2019
18. E.g. The UK-based initiative Action on Climate Today (ACT) has assisted in developing sectoral strategies for climate change adaptation. YASHADA, the state's administrative training institute, has developed climate change modules for decision-makers and nodal agencies for disaster management at state, district and ULB (Interviews conducted by T. Zimmermann in March and April 2019). The MCGM has been collaborating with the World Resources Institute (WRI) and the C40 Climate Leadership Group to develop Mumbai's first Climate Action Plan (MCGM 2022b).
19. Field work conducted by T. Zimmermann and S. Shinde, March–May 2019, Dahisar.
20. Fieldwork conducted by T. Zimmermann, November 2015 – January 2016, Dahisar.
21. Interview with NGO representatives conducted by T. Zimmermann, March 2019, Dahisar.
22. Field work conducted by T. Zimmermann and S. Shinde, March–May 2019, Dahisar.
23. Field work conducted by T. Zimmermann and S. Shinde, March–May 2019, Dahisar.

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## Ethical statement

We hereby declare that ethical standards were followed during the study and all interviewees gave their informed consent (oral or written). Please see the respective self-attestation for further information.

## Data availability statement

The data are not publicly available due to their containing information that could compromise the privacy of research participants. Certain data pertaining to the findings of this study are available on reasonable request from the corresponding author, TZ.

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