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Climate adaptation to Multi-Hazard climate related risks in ten Indonesian Cities: Ambitions and challenges

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ABSTRACT

Indonesian coastal cities are faced with a double imperative to urbanize quickly and to adapt to climate-related disasters. These disasters include droughts, storms, regular floods, tidal waves, and water pollution. This article investigates how ten small- and medium-sized coastal cities in Indonesia are developing resilience strategies to cope with disaster risks. It approaches their level of exposure, the current impacts of climate change, and the existing, local resilience strategies or response. It identifies key discussion points related to the implementation and the feasibility of these strategies. We argue in this article that the priorities are severalfold, and that local governments are increasingly faced with trade-offs when selecting specific interventions and neighborhoods or districts to prioritize to the detriment of others. The current coping strategies seem insufficient to reduce, respond to, and recover from climate-related impacts as well as address the question of vulnerabilities. The population in the coastal areas and in informal settlements, mainly the poor population, is more directly exposed to these climate-related hazards. The local research highlights the difficulties of multi-stakeholder cooperation, the inevitable trade-offs or difficult choices, and the lack of adequate instruments in climate adaptation. Finally, this article calls for more specific timely research on climate adaptation in cities.

1. Introduction

"The alarming projections of global warming consequences stand in stark incommensurability with the available proposed solutions" (Russill 2008: 147) (See Map 1.).

There is a consensus that climate change is one of the major threats of our time. It is expected that in the next decades, climate disasters such as typhoons, floods, sea level rises, and dry spells will be more frequent, while the disruptions in the ecosystems and water resources will jeopardize the wellbeing of local populations and lead to displacements and unrest (Nicholls et al., 2007; Glasser, 2020; IPCC, 2021).

Due to its geographical condition and archipelagic nature, Indonesia is highly vulnerable to climate impacts. Sea level rise is a direct hazard to Indonesia, which is the 14th largest country in the world but has the 3rd longest coastline. Indonesia has 17,504 officially listed islands. This geographical situation increases its exposure to floods and storms. It is expected that climate change will amplify the intensity of rainfall which, in turn, will give rise to more floods (Vij et al., 2017). Soil subsidence, saline infiltration, and water scarcity contribute to the country's vulnerability, which is further compounded by its rapid population growth and

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Map 1. Location of the Pilot Cities in Indonesia.

Table 1
cities' main data.

City	Population 20,21[1]	Area km^2	Density /km^2	Urban Growth *in 2019*
Pekanbaru	1, 227, 299	632	1,941	1.9%
Pangkal Pinang	212,727 *(2019)*[2]	118	1,802	2.21[3]%
Bandar Lampung	1,107,542	169	6,553	1.79%
Cirebon	322,027	37	8,703	0.9%
Banjarmasin	740,109	98	7,552	–
Samarinda	1,030,947	718	1,435	(-)[4]
Mataram	512,433	61	8,400	–
Kupang	463, 360 *(2019)*[5]	180	2,570	2.58%
Gorontalo	219,399[6]	60.07	3,656	([7])

urbanization[1]. This situation is likely to fuel conflicts between the authorities in charge and segments of the population, especially while the poorer population and minorities are more exposed and less likely to be informed about climate disasters.

Climate adaptation refers to any adjustment, whether passive, reactive, or anticipatory, that can respond to anticipated or actual consequences associated with climate change (IPCC, 1995; IPCC, 2022). The necessity of climate adaptation has been increasingly recognized both by international organizations and by research. Islands and coastal areas draw particular attention as they are becoming especially vulnerable (Nicholls et al., 2007; IPCC, 2014). It has been implicitly acknowledged that future climate-related changes had to be accommodated in policy (IPCC, 2021). In this framework, the role of local governments and cities in climate mitigation and adaptation has been progressively recognized as important (Grimmond, 2007; Oleson et al., 2015; Raven, 2011; Rosenzweig et al., 2018). Cities are considered a relevant level tier to understand the socioeconomic dynamics of the territories, to take appropriate decisions, and to protect the populations and the local ecosystems (Gaborit 2015; Wijaya et al., 2020).

In this study, we approach the case of ten medium-sized cities spread across Indonesia to study their climate adaptation strategies and proposed solutions as response, and also the remaining challenges and discussion points in each of these areas. We argue that despite the high level of knowledge and the existing cooperation among the national and local stakeholders, the lack of available funding, adequate land use mechanisms, and the insufficient international commitments are currently hampering medium-sized cities in developing enough resilient adaptive mechanisms.

2. Background and context: Urbanization, climate Change, and disaster risks

The Indonesian context is characterized by both a growing urbanization and an increased focus on climate adaptation by the

[1] Climate Resilient and Inclusive Cities - Policy Briefs for Pilot Cities (resilient-cities.com).

different government tiers. Since 2012, Indonesia's urban population has grown by more than half (Salim and Hudalah, 2020; Dwitama, 2021). Over half of the population now lives in urban areas, and the urbanization rate is expected to keep rising. Indeed, projections show that cities in Indonesia will be accommodating at least 72.9% of the total population by 2045[2]. Urban migrants move to the existing cities, adding more pressure to current housing needs. The cities' growth and the increasing housing demands are therefore creating challenges, not only in terms of accommodation and housing, but also in terms of access to basic services and the enactment of inclusive policies (e.g. through the "cities without slums program"). A city like Samarinda in East Kalimantan for instance grew 78% between 1990 and 2000 (Amri et al., CRIC, Urban Analysis Report 2020). The provision of basic services and construction needs are equally increasing simultaneously amid a period of climate-related challenges.

The country has been at the forefront of climate change issues with the National Action Plan to Reduce GHG (RAN GRK) and the Rencana Aksi National – Perubahan Iklim (RAN-API) which is Indonesia's national action plan on climate change adaptation. The latter identifies two key areas of climate change and their impacts on livelihoods. These two areas are: 1) increases in sea levels and 2) changes in weather, climate, and rainfall. BAPPENAS – the Ministry of National Development Planning – has drafted the RAN-API. Climate change is also integrated into the Strategy called RPJMN (*Rencana Pembangunan Jangka Menengah National/Medium-Term Development Strategy)*, the national strategic development plan.

Each city is required to include and execute a detailed implementation plan integrating both climate mitigation and climate adaptation into their local policies and spatial development plans. A national platform for reporting data (SignSmart)[3] has also been set up together with reporting tools on the vulnerability such as SIDIK[4]. Most of the city governments and other relevant stakeholders have initiated the implementation of adaptation activities, with the support of international development agencies and NGOs. The developed programs assume that the cities (including the local governments, national agencies, planning boards, and the different stakeholders) have the capacity to develop the required mechanisms for stronger resilience to climate-related disasters (See Fig. 3). They are expected to develop adaptive capacity to increasing rainfall and sea level rise and to successfully implement the principles of the Disaster Management Cycle (UNDRR, UNISDR, 2004; Glasser, 2020), namely disaster prevention, preparedness, response, and recovery (in cooperation with the local disasters agencies *BPBD*). Moreover 160 million US dollars were allocated to the Indonesia Disaster Resilience Initiatives Project (IDRIP).[5] The funding will be used for priority investments to increase the preparedness of selected local governments to manage natural hazards and to strengthen Early Warning Systems (EWS), although it remains a very limited amount (lower than the green funds' budgets of cities like Paris), it adds up to the national funding schemes such as the climate budget tagging per ministry, the Indonesia Impact Fund (supported by the UNDP) and the 2018 Green Bonds green Sukuk initiative. These mechanisms aim, among others, to enhance and strengthen the urban resilience of cities which can be defined by their capacity to respond and adapt to and recover from the pressures and crises related to climate change and other changes: subsidence, demographic growth, poor land management, insecurity or attacks, economic downturns, social unrest, unsustainable use of resources, and declining ecosystems (Ziervogel, 2017; Diab, 2020; Gaborit, 2021).

Several research studies have shown that, in Indonesian cities, the level of awareness and knowledge of the different stakeholders involved in the adaptation of climate change was very high (Wijaya et al., 2020). Discussions between focus groups and the ten pilot cities in March 2020 and throughout 2021 showed the same trend.

In this article, we will use as a theoretical framework 4 bladed framework (Fig. 1), adapted from Simpson et al., 2021). The theory is reflected in the diagram below. In addition to this, Fig. 2 focuses on the response part of climate adaptation. This theory (Fig. 1 and Fig. 2) will structure the discussion points in part III, especially for the interrelation of risks and the impacts on the socioeconomic processes (governance, adaptation and resilience, socioeconomic pathways, funding, and infrastructure).

The main local research focuses on the local response (policies, local coping adaptation strategies). It considers the theory of interrelated risks (Simpson et al., 2021) according to which the impacts of climate change are equally cross-sectoral as they embed questions of droughts or access to water (See Fig. 4). As an example, in several cities, such as Ternate, sea level rises in coastal areas are leading to sea salt intrusion in groundwater reservoirs and decreasing the availability of clean water (Nagu et al., 2016, CRIC Urban Analysis report 2021). Research on the policies related to climate adaptation shows that there are two categories of analysis or policies: 1) the concept of adaptation as an "adjustment" to climate change where the physical infrastructure and the communities adapt to the change in climate patterns and develop solutions (e.g. toward a more adaptive capacity of urban development), and 2) climate adaptation as a "transformational" concept in which the cities and policies transform to become more resilient (Basset and Fogelman, 2013). The reality is much more complex, as climate-related disasters transcend geographical territories, communities, and tier-level government legal jurisdictions. Part II will present the project's methodology, the ten cities' exposure to the main climate risks, and their policies and coping mechanisms as response, before the main discussion points are addressed in part III.

[2] Indonesia Ministry of National Development Planning BAPPENAS 2018 The annual increase in the urban population is about 3 million people. Every year, the country needs to build a city the size of Surabaya, to accommodate the annual increase in the number of urban dwellers (Salim and Hudalah, 2020: 176).

[3] https://signsmart.menlhk.go.id/v2.1/app/

[4] SIDIK (Vulnerability Index Data Information System/*Sistem Informasi Data Indeks Kerentanan*).

[5] World Bank Project: Indonesia Disaster Resilience Initiatives Project (IDRIP) - P170874.

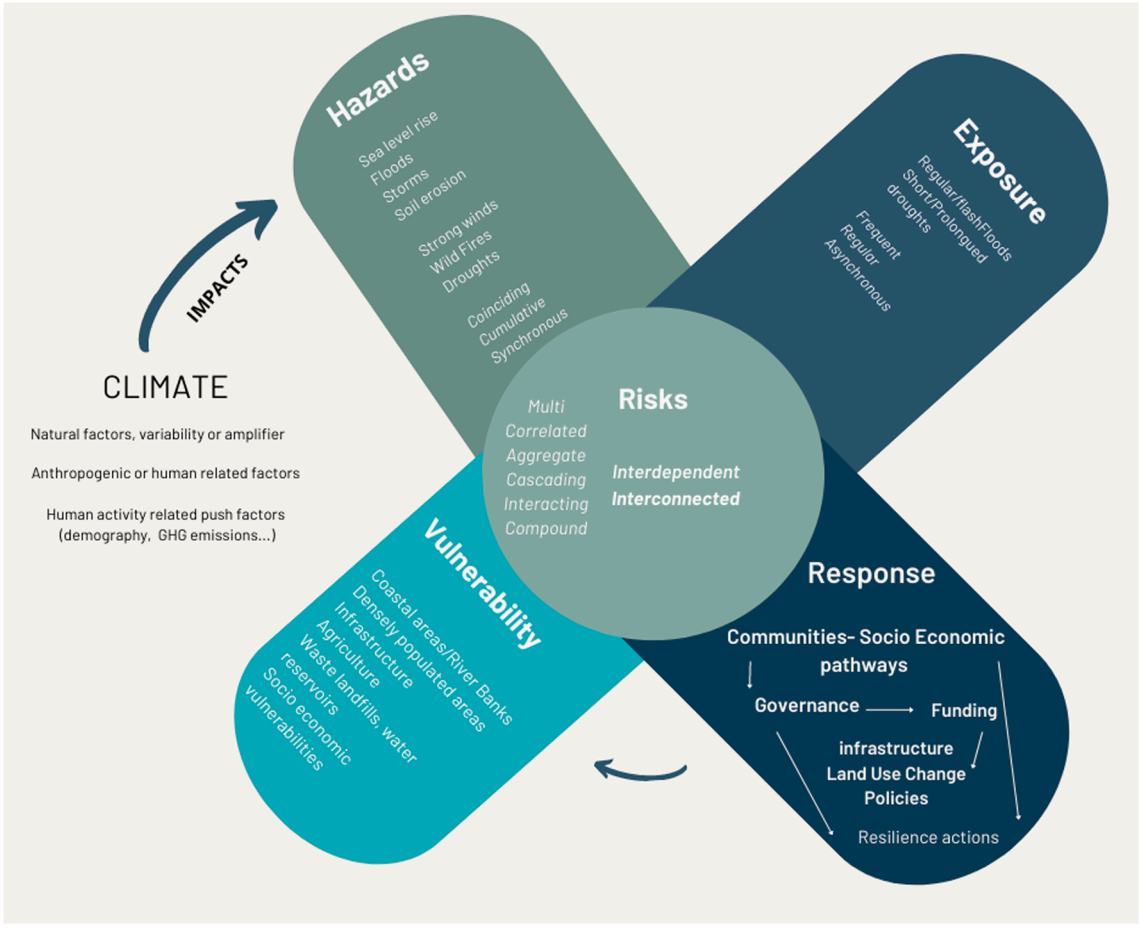

Fig. 1. Theory Framework. Adapted from Simpson et al. 'A framework for complex climate change risk assessment' 2021.

3. Exposure and adaptation of ten pilot cities to disaster risks

3.1. Research and methodology

The proposed article 'Climate Adaptation to Multi-Hazard Climate-Related Risks in ten Indonesian Cities: Ambitions and Challenges' is based on the collective research-action project Climate Resilient and Inclusive Cities (CRIC)[6] spanning over 5 years and involving 13 multi-level researchers from 12 organizations and more than twenty people working on the coordination teams. It also crosses the analysis with identified literature and with the author's and teams' current research on urban resilience, disaster risk reduction, and climate adaptation. The CRIC project has selected ten pilot cities for further research on planning, climate adaptation, and preparedness for climate disasters. This project is funded by the European Union in cooperation with the Indonesia Ministry of the Environment and Forests and is implemented by cities' networks[7], think tanks, grassroots organizations, universities, and research centers.

The selection of case cities: The project has decided not to include the largest cities but to address the question of climate adaptation in small and medium-sized coastal cities which are also exposed to multi-climate related hazards. The findings are based on desk literature search, ten urban analysis reports, and ten policy briefs drafted by the project's experts, local experts, and five field officers and researchers. The ten studied pilot cities are spread over the country and most of them are coastal cities, meaning that they are exposed to climate change such as sea level rises, strong winds, and storms. They are medium-sized cities (entailing that their total population is below 2 million inhabitants). They represent *Kota,* which is the second level administrative subdivision in Indonesia below the province and above the district (*kecamatan*) and administrative village (*Kelurahan*). Each city is headed by an elected payor

[6] https://www.resilient-cities.com.
[7] UCLG-ASPAC, ACR+, ECOLISE.

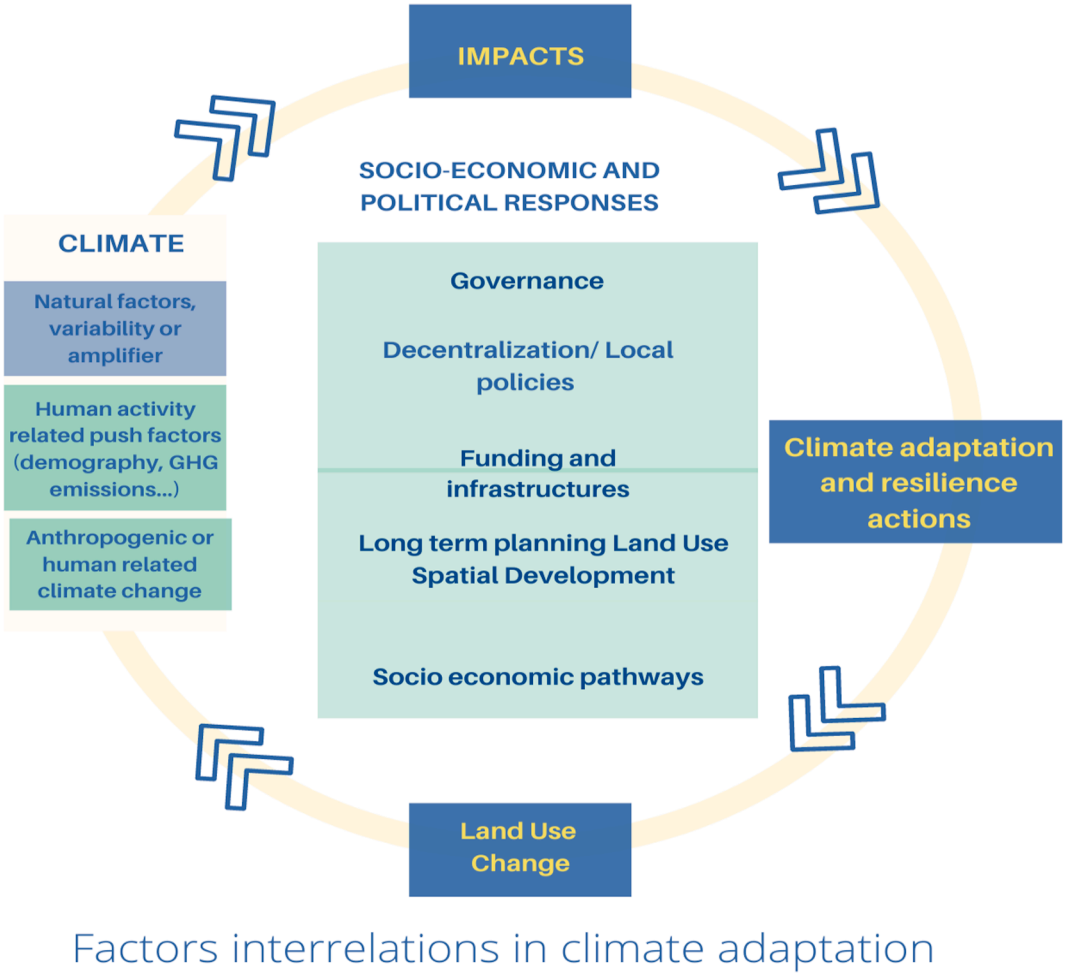

Fig. 2. The factors' interrelation in climate adaptation and resilience.

(Walikota). The selection of small- and medium-sized cities means that they are of secondary concern for national policies in terms of funding for climate adaptation, response building, and local investments. The selected cities benefit less from international development aid cooperation than large cities, although some of them have benefited from international aid cooperation to an extent (Kupang, Cirebon, Bandar Lampung, Pangkal Pinang).

Data Collection and Methodology: The experts based their analysis on field evidence and official documents and conducted a minimum of twelve interviews per city. The researchers also organized four focus group discussions for each city gathering at least twenty stakeholders and local officials from the cities' different departments (Kota), local disaster agencies (BPBD), civil society organizations and public decentralized administrations (BAPPEDAS), and the Environmental Agency for each focus group. The detailed organizations and their original titles are reflected in Fig. 3**.** Some of these focus groups and interviews took place in Bahasa Indonesia, with a transcript, while others have been organized online and benefited from simultaneous interpretation to English. This article is therefore based on a multi-disciplinary qualitative analysis reflecting on the actions and needs of the cities by the different cities, stakeholders triangulated with the city's available documentation, and consideration of the reports. The study is not solely based on the available documents about policies; It follows empirical research about climate adaptation (Runhaar et al., 2018) and considers the practices, policies, and realities beyond mere conceptualizations.

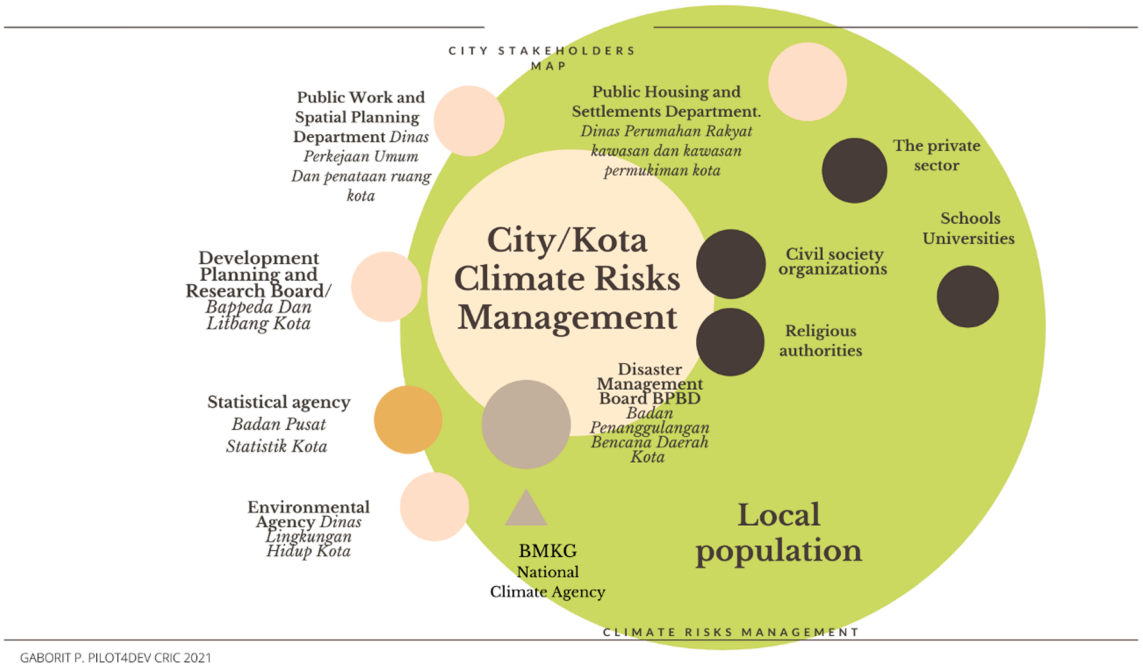

Fig. 3. Mapping the stakeholders involved in cities' climate risk management.

3.2. *Presentation of the 10 case cities*

The table below presents the cities and maps their geographical location on the Indonesian archipelago.
Growing cities exposed to sea level rise and floods.
The information below is based on the qualitative analysis of the urban analysis reports by the CRIC project.

1. **Bandar Lampung** is a large city and a transportation hub in Sumatra. Bandar Lampung is vulnerable to natural disasters, including floods, landslides, droughts, high tides, and tsunamis. Twenty-three disasters, mainly floods, were reported between 2010 and 2019 (Priyadi et al., CRIC Urban Analysis Report 2020). Bandar Lampung experiences annual flooding due to erratic heavy rainfall which worsened by the drainage conditions and damaged dikes. As a recent example, in December 2021, Sub-District *Kecamatan* Rajabasa experienced flooding after just two hours of heavy rainfall, which varied from 20 cm to over a meter in height.[8] Bandar Lampung also experiences seasonal tidal flooding that affects coastal communities including the fisher's village. In November 2021 the water inundation reached about 50 cm and affected 127 households, with the duration of inundation lasting more than 12 h. Local communities responded to this situation by operating pumps and constructing their own simple protections to prevent the water from inundating their houses.
2. **Cirebon** is a coastal city located in West Java. It is developing into a metropolitan area with related challenges, such as spatial planning, density, building regulations, and the conversion of paddy fields into industrial and residential areas. It also faces sea level rise, which puts the clean water at risk as the seawater intrudes into the low groundwater. The illegal dumping of waste is partly responsible for the failure of past restoration programs. Cirebon is in a high disaster risk area. The city is working on drainage for floods and is planning a disaster management program. The development of Cirebon as a metropolitan area is also leading to concerns in land use as the paddy fields are converted into residential and industrial areas, threatening the city's agriculture and food safety.
3. **Gorontalo:** Located in the Maluku region, Gorontalo is an important growing area and a transportation hub, while fisheries remain an important sector. The city is prone to disasters such as earthquakes, floods, droughts, and other extreme weather events like storms. It is categorized as a medium risk area on the national disaster index. The city's urbanization adds more pressure to the agricultural land, which is further threatened by droughts and floods (Dillon et al., CRIC Urban Analysis report 2020). Upstream deforestation is a possible issue.
4. **Kupang**: Located in the South-eastern part of Indonesia (*East Nusa Tenggara*), Kupang city is vulnerable to climate disasters, including strong winds, heavy rainfall, and droughts, which cause well levels to drop. Tropical storms are also expected to increase in frequency and intensity due to climate change. The strong winds affect tourism, food supplies, shipping, property, and housing

[8] Kumparan.com, 10 December 2021, Accessible at: https://kumparan.com/lampunggeh/puluhan-rumah-di-rajabasa-bandar-lampung-terendam-banjir-1x5K6JAhpXv.

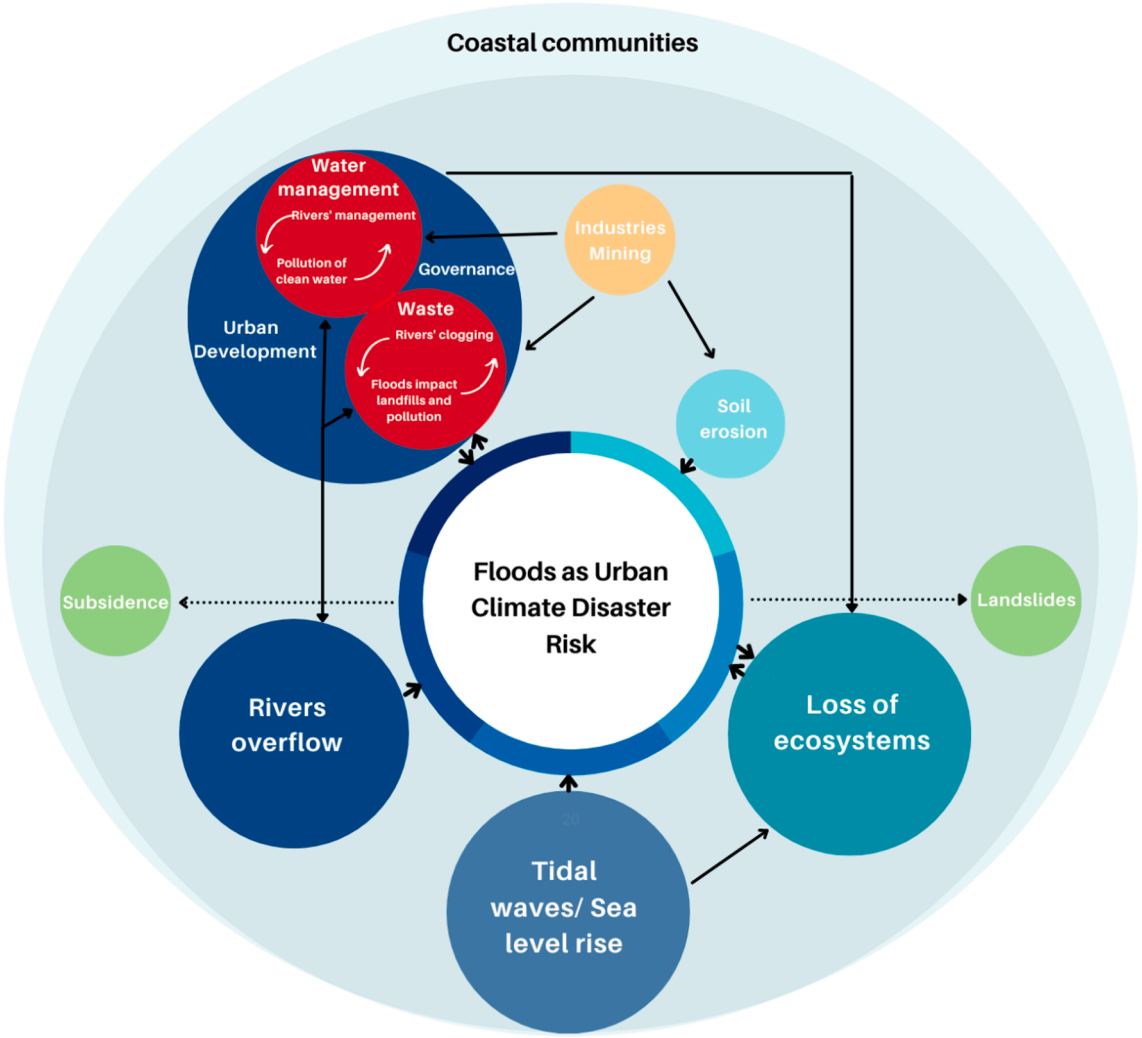

Fig. 4. Mapping the factors' interrelations of floods (climate disasters in cities).

units. Droughts are just as recurrent as the city is also prone to coastal abrasion, floods, and landslides (Ridwansyah et al., CRIC, Urban Analysis Report 2020). The UNDP enacted a local disaster management program in 2015.

5. **Mataram** is a coastal city facing several disaster risks. These risks include sea level rise, extreme waves, abrasion, earthquakes, and droughts. An earthquake in 2018 triggered a tsunami wave and resulted in human casualties, injuries, and damages in several parts of the city, and displacements of the population. The city has a strong potential in tourism, but coastal areas are disaster prone.
6. **Ternate** is an island city spanning eight islands, three of which are uninhabited. Ternate island is the main island. It is a major transportation and trading hub for the province of North Maluku and East Indonesia. Ternate is part of the first six areas with the highest potential for disaster in Indonesia, including volcanic activity, earthquakes, landslides, storms, and floods. The city is undergoing rapid urbanization and requires strategies to accommodate urban growth, disaster management, and infrastructure.

Cities located on river deltas, prone to floods from rivers with exposed riverbank areas.

7. **Banjarmasin**: Located 16 cm below sea level, Banjarmasin is the capital of the province of South Kalimantan and is called the 'City of a Thousand Rivers'. The tidal waves affect the stilt houses of the riverbank areas. The wooden stilt houses are prone to both floods and residential fires. The river's drainage is often clogged by open landfill dumping and upstream mining activities causing overflows (Amri et al., CRIC Urban Analysis Report 2020, Gaborit et al., 2020; Prayitno, 2017). The regeneration of the city and land clearance are at stake, with open questions for the residents and the place's identity.
8. **Pangkal Pinang** is the largest city of the island of Bangka. The city is prone to floods. It recorded 49 events in the year 2019 alone, and around 1497 houses were reported damaged (Mulkhan et al., CRIC Urban Analysis Report, 2020; Tirtariandi el Anshori et al.,

2020; Gaborit et al., 2020). Not only is the pumping of water also leading the city to sink due to subsidence, the dry season aggravates seasonal fires.

Samarinda City is the capital city and most populated city in East Kalimantan. It is located near the possible future capital city of Indonesia. Its population grew 78% between 1990 and 2000. The city is located 10 to 200 m above the sea level but is still prone to floods, droughts, fires, and landslides. The city currently faces challenges linked with rapid urbanization as its surroundings have abundant natural resources such as gas, oil, palm oil, and forests.

Inland city

9. **Pekanbaru:** With a population of over a million, Pekanbaru is a large economic center located in Sumatra. The city faces disaster risks from floods, forest fires, and haze (Mulyana et al., CRIC Urban Analysis Report 2020b, Gaborit et al., 2020). Sustainable urbanization and disaster prevention are considered a priority.

The intensity of rainfall is expected to increase in the upcoming years:

The elevation above or below sea level is also an explanatory factor for hazard occurrence.

The risks can be correlated, cascading, and interacting as detailed in Fig. 1 and in Fig. 4.

Faced with these hazards and risks, local authorities have adopted resilience policies which are detailed in Table 1. They have also identified the needs and constraints to develop better and more efficient policies for climate and disaster risks.

4. Main discussion points

Our discussion points focus on the response part of climate adaptation including policies, planning, and possible resilience local actions and coping strategies of both local governments and local stakeholders. The Diagram (Fig. 2) will structure the discussion. Indeed climate adaptation strategies are challenged by several parameters which are detailed further.

The different discussion points confirm that the priorities are severalfold, and that public authorities, especially cities, will be faced with increasing trade-offs. A trade-off is a situation that necessitates choosing or balancing between one or more desirable but conflicting plans, policies, or measures (Grafakos et al. 2019). In our case, the trade-offs can be: whether to relocate part of the population, whether to develop contingency plans and evacuation routes, selecting the level of alerts, and choosing which areas will benefit from resilience and adaptation actions and which will not.

The discussion points below are structured around the theory framework (Fig. 1) and (Fig. 2) and address the central questions of governance, the involvement of different stakeholders (1) and the decentralization process (2), the socioeconomic pathways including the conflicts created by land use and spatial development (3), the unequal impacts on vulnerable groups (4), the funding and infrastructure difficulties in setting up priorities with limited funding streams (5), and the call for more research categories for further acknowledgement of the climate change impacts (6).

Fig. 2 shows the central role of governance within the socioeconomic political processes. In this article, the challenges of governance are addressed through the cooperation of multi-stakeholders as well as the process of decentralization.

4.1. Governance: The challenges for multi-stakeholder cooperation

A lot has been written about how governance would be key in climate adaptation, and how political ecology would be important in understanding future policymaking (Basset and Fogelman, 2013, Funtowicz, 2020; Koch et al., 2021). There is a consensus that the fight against climate change necessitates a genuine cooperation among all the different stakeholders (Rosenzweig et al., 2018; Wijaya et al., 2020, Gaborit, 2021). International agencies have been active in promoting urban resilience and the involvement of both local governments and community groups in the climate adaptation process (Wijaya et al. 2020). The experience of the CRIC project and the study of the ten pilot cities shows that there is already a consultation process among the stakeholders and a dialogue mechanism in place at the local level (*Musrenbang*) (Fig. 3). The Ministry of the Environment and Forests (MoEF) is also part of the dialogue. The knowledge levels of the different stakeholders on climate issues is particularly important. Knowledge levels are recognized as an important area to prioritize by the Ministry of the Environment and Forests, local and district governments, and local planning boards or *Bappedas* (*CRIC-Urban Analysis Reports*). The CRIC research[9] shows, however, that the local decision-makers and stakeholders currently lack the capacity in terms of infrastructure, funding, and information in real time to tackle climate disasters and further adaptation. The first reason for this is the astounding number of simultaneous challenges to be answered by the city governments: to ensure development planning, increase urban resilience, maintain the continuity of urban ecosystems, reduce the vulnerability of the coastal and exposed areas, decrease potential human and economic losses, and develop contingency and disaster response plans. The second issue hampering stakeholder cooperation is that the different organizations are pursuing different interests in the absence of a strong national cohesive program for each of the concerned cities. The focus group discussions show that the dialogue among stakeholders, including with official representatives, is necessary but presently insufficient when it comes to achieving climate response, adaptation, and resilience action. The case of Pangkal Pinang equally highlights the issue of a lack of trust in the cities'

[9] Through the focus groups, interviews, discussions and reports.

stakeholders and local population towards the capacity of the different organizations to implement climate disaster actions (Mulkhan et al., Urban Analysis Report, CRIC, 2020).

Additionally, the question of climate and weather data transfer in real time and stakeholder anticipation of the risk level has emerged[10] as an equal difficulty in case of climate events like floods. Real-time information transfer is needed between the meteorological agency BMKG and the local disasters agencies BPBD, and also between the local disaster agency and the local population (See Fig. 3). A level of cooperation is also needed to agree on the levels of alerts and the best alert system to set up (broadband systems, SMS, sirens, mosque loudspeakers, etc.). Therefore, advocating for a "multi-stakeholder" cooperation, as response to climate adaptation, is not sufficient and should be accompanied by incentives, coordination with community representatives, information sharing, and transparency to prove efficient. The consultative process and the population's inclusion, including the vulnerable groups, in the decision-making process are also both recognized as necessary, requiring a more efficient disaster risk reduction and management (Ziervogel 2017; Djalante et al., 2017; Gaborit, 2021). The work with community representatives, civil society organizations, and religious authorities amongst other community leaders seem equally important. Transparency and a local engagement process may also confront communities with the lack of available choices. Complications will continue to arise due to necessary trade-offs by the decision-makers' need to choose between different priorities, different levels of alerts, different evacuations routes and contingency plans, possible relocations, and prioritizing which infrastructure and neighbourhoods to protect. The increase in climate events is highlighting the lack of current global available solutions and the lack of land use mechanisms that can be easily activated by the local authorities (Wirawan et al., 2019; Afrizal et al., 2020, Gaborit, 2021). In this context, the distribution of power and competencies between the different government tiers and its evolution is important to understand the cities' real capacities to develop prevention and response to climate disasters through local policies, actions, and land use mechanisms (See Fig. 2). Decentralization is simultaneously both enhancing the role of cities and local governments, without giving them the means to develop adequate strategies with more funding and land use mechanisms.

4.2. *Understanding and muddling through the decentralization process.*

Literature about decentralization in Indonesia highlights that it is a complex phenomenon (Rahayu, 2016; Salim and Hudalah, 2020). The governance of the different jurisdictions is riddled with high levels of complexity, uncertainty, and conflicts (Rahayu 2016' von Korff et al. 2019). Since 1998 and the early 2000 s, though, local authorities and districts were granted not only more autonomy but also more competences over their budget and resources. Although research shows that cities still depend on national funding (Rahayu 2016), cities have been recognized as semi-autonomous actors in many different areas including the provision of local services, water management, waste management, and disaster preparedness. However, land use and ownership are still mainly recognized as state-owned or nationalized in non-constructed areas and cannot be used by cities as leverage to adapt the planning to climate-related events such as floods. The power, local budgets, and responsibilities have partly shifted toward the direction of cities, together with the responsibility to protect the populations and constructions as well as natural areas. However, the cities share the competences in terms of planning and have few leverages in terms of land use. Some authors consider that decentralization in disaster risk reduction (DRR) is an achievement. According to Djalante et al. (2017), 'in line with the decentralization in the development and planning approach, the responsibility for Disaster Risks Reduction, and Disasters Risks Management is shared across different levels of government, from heavy reliance on national governments to greater responsibility of local governments' (Lassa 2013; Djalante et al. 2017). The local research on the ten cities confirms this trend of responsibility transfer but also highlights the difficulties experienced from the local government officials to find the necessary investments for climate adaptation without financial support from the ministries. The focus group discussions especially show that the decentralization process is hampered by a complete dependency on national funding for climate adaptation and inclusiveness programs (such as '*cities without slums*', '*Kampung Iklim*' environmental, and climate-related programs, etc.) The forms of local governments are also complex: cities are referred to as including the local government, the BAPPEDA local planning board, and other agencies such as environmental or local disaster management agencies. Without increased funding mechanisms and investors and capacities to manage the land, cities will face a lack of preparation as well as capacity shortages in implementing possible smart solutions, early warning systems, and adaptive urban planning. Access to real time and accurate data in terms of climate-related events is also a challenge. Indeed, planning in times of uncertainty is most definitely not an easy matter.

The next discussion point will address the question of adaptation and resilience actions (Fig. 2) and reflect on the difficulties for cities' to find a response to all the interrelated priorities, especially in a situation of funding gap.

4.3. *Adaptation and resilience: Priorities and funding*

There are various interrelated problems linked to climate change and adaptation such as water or waste management (for instance, to avoid the clogging of the rivers' drainage systems). Some of the problems are escalating, such as droughts and strong winds, while others, such as flash floods, are repetitive while the question of predictability is complicated. Priorities are severalfold to develop appropriate coping mechanisms as there are many interrelated factors (see Fig. 4). Flash floods and puddles are extremely present in most of the pilot cities, but especially in Banjarmasin, where riverbank areas are regularly flooded, and Bandar Lampung and Pangkal

[10] Within the focus group discussions.

Pinang, due to their urban morphology. Cities are faced with contradictory imperatives: while the ten cities are faced with floods, housing needs are simultaneously rising. Consequentially, the number of buildings is increasing, thus sacrificing many water catchment areas which were also necessary to adapt the floods. Waste management and rivers' drainage, as well as the protection of water reservoirs emerge among other important priorities together with housing, economic needs, social issues and the prevention of further floods. But the capacities and the local funding remain very limited. The Detail Engineering Design Pangkal Pinang, which includes a retention lake in the city center, was approved in 2020 but could not be achieved due to budget constraints. The lack of funding was also reflected in the findings from the focus group discussions of the CRIC project for the ten different pilot cities. This question of funding was indeed very central to the debates, in hope that national and international funding could complement the city's budgets for the programs. It was, however, clear that the different ten pilot cities were confronted with numerous priorities and challenges: waste management (Mataram, Cirebon, Samarinda), early warning systems, and floods (Bandar Lampung, Pangkal Pinang and Ternate), or simply access to water and water management (Banjarmasin, Gorontalo, Kupang). Urbanization, transportation, waste, river clean-up, water, and also economic development and social inclusion were at the forefront of the cities' concerns, together with disaster risk prevention.

In this context, the available city budgets, including the funding of national government programs, would quickly prove insufficient in tackling climate needs. Furthermore, different studies show that mitigation actions, when compared to adaptation actions, receive the main portion of global climate finance flows from international multilateral development aid organizations and development banks (Grafakos et al., 2019). This portion was superior to 96% between 2010 and 2011 and was still 24% in 2019 (Buchner et al., 2012; Chan and Amling, 2019; Tall et al., 2021). In 2019, the MDBs indeed committed 61.5 billion US dollars in climate finance. This included 76% for mitigation and only 24% for adaptation while private investments in this sector are just beginning (Tall et al. 2021). This shows that medium-term investments for the development of local climate adaptation strategies still rely not only on local political will but also on a limited local funding.

This lack of available funding leads to risky trade-offs as leaders focus on what cities can easily tackle, such as domestic waste, to the detriment of more long-term climate adaptation policies that aim to protect populations that are most exposed to hazards, such as contingency plans, evacuation routes, early warnings, and relocation programs, amongst others.

As mentioned earlier, land use mechanisms are also at stake. Indeed, it is increasingly recognized as a source of conflict at the urban level, while the lack of available mechanisms to regulate land use at the local level contributes to increased deforestation, and leads to negative climate impacts. Land use and planning constitute an illustrative point, reflected in the interrelation between factors and impacts (Fig. 2). This is subsequently explained, and detailed more under the following section that approaches urbanization needs, deforestation, and conflicts within the scope of land use, planning and spatial development.

4.4. Land use, planing and spatial development: tools or sources of conflict?

According to recent literature, land use and resources in Indonesia often become sources of conflict (Wollenberg et al., 2009; Wirawan et al., 2019; Afrizal et al., 2020). These conflicts are closely tied to unsustainable planning and the rapid increase in demand for land by a variety of interests, particularly large-scale industrial expansion, palm oil plantations, and growing urbanization. According to other analysts on urbanization and disasters, 'largely uncontrolled urbanization has led to high disaster and climate vulnerability in Indonesia' (Djalante et al., 2017: 2).

The intensity of the demand for land is in stark contrast to continued uncertainty over the legal framework for land use and ownership, as well as ongoing spatial planning efforts (Wirawan et al. in 2019). In this context, land use policies, which would be necessary for the cities to find the best balance or trade-off between urbanization, climate adaptation, and climate mitigation have limited actual authority. National policies over spatial planning are based on broad environmental concerns (such as the protection of forests, ecosystems, and natural buffers to climate disasters). These considerations are reflected in the regulations related to planning, land use, and spatial management (Ardiansyah, 2015, Tombourou 2013, Resosudarmo, 2012). However, in their current implementation, land use policies are subjected to a range of pragmatic adaptation when confronted with economic realities, urbanization needs, and industrial interests (Wirawan et al. 2019; Afrizal et al., 2020). As a result, local authorities cannot rely on clear land use coping mechanisms for climate adaptation, such as redesigning areas for water catchment, building dykes, designing natural buffer areas, or regenerating river banks. Nevertheless, these authorities are often called as mediators in possible land use conflicts, such as between the industry and private owners. This makes it difficult in these circumstances to develop a consistent planning and adaptive approach to cope with the climate adaptation and growing urbanization.

In Banjarmasin, for example, the cleaning of rivers would be necessary to reduce the rivers' overflows. However, this cleaning investment would require anticipatory designation of rivers as public utilities and assets to the city government. As a result of unclear jurisdiction, private land ownership along the riverbanks, and land designation, which entails designation over the rivers, the necessary public works to clean the rivers and reduce the water overflow cannot be implemented. This is an example of barriers related to land use management, which could be leveraged or changed for more successful climate adaptation.

Again considering Pangkal Pinang, the question of trust is critical for the city to act on land use change and to implement adapted local adaptation policies. The interviews performed among the cities' stakeholders and the local population show that a lack of trust will increase the challenges for the public institutions when initiating long term planning and land use change (Mulyana et al., CRIC, Urban Analysis Report 2020a).

As we see from the analysis above, a clearer role of cities in the land use and spatial development could be the necessary tool to find the correct balance and trade-offs between the needs of growing urbanization, like the development of housing, climate adaptation like land clearance in threatened areas, protection of natural buffers such as mangroves, and climate mitigation such as the protection of

forests and seas as carbon sinks. Unfortunately, the current regulations are not specific enough to provide enough competences to the local authorities on this important matter as well as enough control and enforcement authority to the national authorities.

Among the different socio-economic pathways, the impacts of climate change on vulnerable groups is also particularly important.

4.5. Socioeconnomic pathways: Disaster impacts on vulnerable groups

The unequal impacts of climate change on vulnerable communities and the inequity of intervention have been widely documented in the existing research (Marino and Ribot, 2012; Baztan et al., 2020). Within the ten CRIC cities, the populations living in coastal areas are directly exposed to the impacts of climate change. The country's population densities are indeed highest in the coastal regions, which increases the risks of hazards for most of the people living below an elevation of ten meters (Perwaiz et al., 2020). Exposure is clearly related to socioeconomic vulnerability. The growing urbanization needs and the lack of affordable, safe land increases the less affluent communities' exposure to climate hazards. People living in informal settlements are also increasingly at risk, especially with regard to flooding.

The local research in our project demonstrate that the people living on the riverbank areas (Banjarmasin) or the coastal fishers' communities are directly exposed to regular floods and damages (Cirebon, Bandar Lampung, Ternate). In cities like Bandar Lampung, 12.4% of the population lives in informal settlements, while in Banjarmasin, the old city neighborhood depends on wood stilt housing which is more vulnerable to flash floods. In fact, 24% of the population lives below the poverty line[11]. The socioeconomic effects of climate-related impacts are not to be underestimated. Poverty indeed remains a determinant of vulnerability as people have less access to information, knowledge, and recovery facilities. Additionally, droughts, regular floods, and storms may thrust more people into poverty due to lost livelihoods, housing, business, or work facilities and damaged infrastructure. Furthermore, regular floods and droughts have various repercussions on public health (Perwaiz et al. ,2020). Our project's research and interviews show that local governments are aware of the social vulnerabilities in their territories and are investing in slum improvement programs and re-locations. The majority of the ten cities implement the national "cities without slums" program. Nevertheless, the urban analysis reports and focus group discussions highlight that the cities' local governments focus on short-term preparedness and immediate priorities and cannot integrate all socio-economic, cross-boundary, and public health aspects as parameters for long-term policies. The short-term and long-term impacts of climate change on vulnerable groups and public health are additional complexities which could be taken into account both at a research level and when developing future policies.

5. More categories are needed to assess and support climate change adaptation

There is currently an abundant and wide range of international articles about disaster prevention and disaster management in Indonesian cities (Leitman, 2007; Djalante et al., 2017; Perwaiz et al., 2020) including other articles on the adaptation to climate change. However, the research covering both of these aspects within their specific contexts and developments are still lacking. As illustrated by Baztan et al. (2020), 'climate science may need to be linked more directly to local communities, to their capacities, and their contexts of vulnerability' (IPCC, 2014; Vaughan et al., 2016; Baztan et al., 2020). Some authors rightly suggest developing assessment frameworks to integrate the adaptation of different risks into policies, such as an Adaptation-Risk Policy Alignment (ARPA) (Sainz de Murieta et al., 2021). This framework would be used to assess whether and how climate change adaptation policies integrate risk knowledge and information. But this is still a very new approach, and it is currently used mainly to assess the climate adaptation in large, cosmopolitan cities and not yet in coastal, small-, and medium-sized ones. The ACCRN network[12] and the different resilient cities networks are developing matrices on urban resilience which could be used by local governments and practitioners. Their methodology and approach also focus on large cities and equally highlight the necessity of funding and the need for real time information.

The question of real time information is, however, extremely complex for resilience and response policies, such as in the implementation of early warning systems. The project's regular focus group discussions and interviews confirm that current information developed by the climate agencies can be slightly too technocratic to grasp for local communities and stakeholders as it is also illustrated by literature (Klein et al., 2017; Funtowicz, 2020), and may not provide the necessary and timely information needed to reduce or to respond to the risks (Baztan et al., 2020). As we have seen previously, the impacts of climate change affect several areas. Seawater intrusion is polluting the groundwater in many coastal areas, causing possible issues in terms of water scarcity. Landslides are also becoming more frequent as a result of urbanization, as well as floods and climate change (Fig. 4). Several cities also experience seasonal flooding. Yet, as we have seen in the example of the ten pilot cities, other factors also come into play such as the city's morphology, the river pollution from upstream mining activities, or the clogging of the drainage systems due to illegal waste dumping (Fig. 4). Although there is no 'one size fits all solution,' more research is urgently needed to study the impacts and possible solutions for the adaptation of these coastal cities to climate change and to identify the relationships between the different risks and the policies.

6. Conclusion

Coastal cities in Indonesia are faced with a double imperative: to solve urban growth and to protect the coastal areas and riverbanks from floods and other climate-related hazards. They will need to become resilient by adapting to climate change and other changes,

[11] UN Habitat 2012, CRIC Urban Analysis reports 2020.

[12] Asian Cities Climate Change Resilience Network (ACCCRN).

such as subsidence, demographic urban growth, poor land management, unsustainable use of resources, possible social unrest, conflicts, poverty, insecurity, and declining ecosystems. Both growing urbanization and adaptation to the risks related to climate change require time, land planning, financial investment, good governance schemes, and capacities. The repercussions of climate change are very much intertwined with cities' water management, access to clean water, and sustainable waste management. Cities are faced with uncertainty and cascading risks and hazards. To tackle these challenges, it is important to consider the interrelation between the factors and the impacts (Fig. 4). This interrelation is even more important in terms of governance, resilience actions, socioeconomic pathways, and funding (Fig. 2). A multi-stakeholder approach and a sound organization of priorities are both essential. As we have demonstrated, however, the cooperation between stakeholders is complex, and cannot be taken for granted (Fig. 3). Strong incentives for each segment or key stakeholders are needed to achieve impacts beyond technocratic programs. Local governments play a key role in terms of climate adaptation and cities, yet have limited financial capacities. Land use can be an appropriate leverage to find a balance (or trade-off) between the urbanization needs, necessities of climate adaptation, such as natural buffers and land clearance, and efforts towards mitigation, like the protection of carbon sinks such as forests or marine ecosystems. The land use situation remains unclear, however, and generates social conflicts regarding land ownership. Cities are increasingly carrying the burden of finding the right and most appropriate strategies within the decentralization framework. Nevertheless, priorities within the different cities are severalfold. Failures in more generalized and efficient climate adaptation will lead to more disaster impacts, damages, and victims. The populations living in informal settlements as well as coastal areas are more directly exposed. Finally, as illustrated in Fig. 1, Fig. 2 and Fig. 4, more field research is needed to systematically assess climate disaster risk adaptation and resilience, and to properly address the question of uncertainties in light of multiple risks and hazards across disciplines.

1 www.populationstat.com.
2 Mulkhan et al., 2020 CRIC Urban Analysis Report, Pangkal Pinang.
3 In average.
4 78% between 1990 and 2000 in Amri and Jamalianuri, 2020 CRIC urban analysis report Samarinda.
5 Ridwansyah et al., 2021 CRIC Urban Analysis Report Kupang.
6 2019 Dillon H. et al., 2020 CRIC Urban Analysis Report Gorontalo.
7 67,93% over the last 25 years in Dillon et al., 2020 opcit.

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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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