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Urban planning for flood resilience under technical and financial constraints: The role of planners and competence development in building a flood-resilient city in Matola, Mozambique

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ABSTRACT

Today, urban flood resilience constitutes an academic and political discourse as well as a ‘proposed state’ to be achieved within urban management, planning, and development. Matola, a major Mozambican coastal city, has witnessed many floods, mainly caused by rainfall, the most devastating of which happened in 2000. This study analyses the actions the urban planners took during that major flood event, what flood mitigation and adaptation strategies and measures for increased flood resilience they have developed since that flood event, and the contribution of urban planning to building flood resilience under financial and technical constraints. The study is based on interviews with 32 urban planners from Matola and observations in the field. In addition to financial limitations, the main challenge in promoting flood resilience in Matola is the deficient and insufficient coordination in mitigation and adaptation actions among urban planners, political elites, and members of low-income urban communities, who use floodplain areas for purposes that contradict resilience-building actions. During the 2000 floods, mitigation actions were carried out by rescuing people and goods and placing them in accommodation centres. After the 2000 floods, gradual adaptation strategies and measures were carried out, such as hiring and training staff, designing a new urban plan, gradual resettlement, opening drainage channels, and allocating water pumping systems in some areas to promote flood resilience. The study concludes that urban planning contributed significantly to the building and promotion of flood resilience in Matola: the strategies and measures taken so far have contributed significantly to reducing the exposure and vulnerability to flooding of the population, their assets, and urban infrastructure, as well as improving the ecosystem in lowlands and coastal protection wetlands. The study brings a contribution from retrospective and prospective resilience thinking to the debate on building and promoting resilience in urban socio-ecological systems, showing the role of urban planners, and planning and management activity since the 2000 floods, and perspectives on the future. The study demonstrates that the development of competences or technical skills to plan and manage strategies and measures to promote resilience is a key factor in promoting socio-ecological resilience.

Introduction

Urban floods as natural hazards are increasing globally, with the highest and increasing frequency and intensity as well as widest geographic distribution worldwide seen in recent decades [30,49,51,54]. Currently, urban areas accommodate around 55 % of the world’s population ([57]:1) as well as most socio-economic infrastructure, goods, and assets, a scenario that is expected to intensify in coming decades, increasing the number of people exposed to risk of flooding [45,56]. Climate variability with climate change appears to be altering rainfall patterns, resulting in positive anomalies worldwide and consequently generating increasing floods in, for example, Africa, where prolonged heavy rains may increase in volume and occurrence [18,20,29]. Southern Africa has suffered from intense cyclones associated with strong winds and heavy rains, causing flooding in rural and urban areas and calling for improved flood management to reduce flood risk through the promotion and improvement of resilience measures [6,12,20,37,62].

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In the context of flood risk planning and management, there are three different discourses of resilience: engineering, ecological, and social–ecological resilience [8,41,65]. According to ([63]:2), "the discourses of engineering, ecological, and socio-ecological resilience provide distinctive approaches and prescribe different roles for spatial planners". For flood risk planning and management, the engineering resilience discourses promote water control engineering measures such as dams and drainage systems to mitigate flood risk. However, these approaches have been criticized for harming riverine ecosystems of rivers and watersheds and increasing the risk of long-term floods [8,33]. Furthermore, as these infrastructures can withstand only up to the magnitude of the flood stress for which they were prepared, they put cities in a situation of insufficient preparation due to uncertainty about the magnitude of future precipitation. In contrast, ecological resilience theorists advocate adaptive measures to prevent urban expansion in floodplains and even to remove urban infrastructure from flood risk sites, letting these areas perform their floodplain functions of transporting and storing water, providing groundwater recharge, filtering sediments and contaminants, transporting nutrients, and sustaining habitats for some of the most sensitive living resources of the terrestrial and/or aquatic fauna and flora [33,41,63]. The socio-ecological resilience approach advocates the preparation and adaptation of houses and urban infrastructures to allow development through the systemic, dynamic, and integrated interaction between the needs of socio-economic and ecological development [8,41,63]. According to ([22]:439), "two useful tools for resilience-building in social-ecological systems are structured scenarios and active adaptive management. People use scenarios to envision alternative futures and the pathways by which they might be reached". Therefore, resilience from a socio-ecological perspective advocates planning made by people and systematic action to achieve the desired objectives, considering the interaction between social and ecological elements [10]. It is therefore important in this study to reveal how planners' flood management strategies and measures are related to the three different discourses. However, in terms of the three resilience approaches, this study is conducted with theoretical support from the socio-ecological perspective. This theoretical position was chosen because urbanized floodplains are urbanized socio-ecological systems or human-natural systems where climate, socio-economic trends, built systems, and riverine processes affect flood hazards and consequent disasters [8,11,33]. In a socio-ecological system, resilience to urban floods starts with the shock caused by the disastrous event, and continues through mitigation, confrontation, coping, recovery, preparation, learning, and adaptation supported by an urban planning process, whether at the city or municipal level [11,33,50,63], which are at the core of this study.

Studies of flood risk management and resilience building worldwide show that current urban storm water management emphasizes source control, distributed over the watershed to minimize changes in the urban water cycle by proposing integrated solutions within the urban landscape [8,17,44,59]. However, the socio-economic, political, and scientific environment in which resilience theories and urban flood resilience approaches were developed and settled is in the Global North, whose approach is embedded in urban planning and management with a huge allocation to adaptation resources [55]. This helps shape the social geography over time, developing a flood-resilient urban environment through considering demographic aspects as well as housing, transportation, communication, health, and other sectors that support the well-being of residents in flood risk sites [8,19,47,55], contrary to what happens in urban spaces in developing countries.

Many urban flood alleviation strategies in African countries, such as Nigeria, Kenya, Madagascar, Liberia, and Zimbabwe, have not succeeded because of the complex alliances that exist between different actors, especially in informal settlements, which are the most affected by floods. These alliances occur between politicians, parties and their supporters, community organizations, and international NGOs, as well as between landowners, tenants, and government agencies, often around interests contrary to urban flood management plans. These complex alliances whose interests are defended at all costs by those involved lead to a lack of coordination and mutual suspicion and mistrust between those promoting change and those affected by it ([17]:270). Similar challenges also appear to undermine the promotion of flood resilience in Mozambique. Previous studies have shown that a major challenge when promoting flood resilience in Mozambican cities is the inefficiency of and lack of coordination among urban planners[2] (hereafter, 'UP') and managers, politicians, and communities. While some actors, such as UP, take the adaptation agenda seriously, to some extent, although with technical and financial limitations, in everyday practice it becomes mired in politicking and social manipulation as well as competing claims over resources. In turn, communities struggle to maintain their way of life depending on their own capacities and resources to mitigate and adapt to floods [2,5,9,43]. Despite the technical, financial, and political challenges faced by planners working on urban flood resilience in Mozambique's main cities, in the Municipal Council of the City of Matola (hereafter, 'Matola') since the devastating floods of 2000, progress has been made in various ways, for example, by relocating people from floodable to safe areas and building drainage systems. This study sets out to better understand what measures, actions, and competencies have been developed in urban planning and what strategic resilience approaches these measures have built on, during and after the major flooding in 2000. Such insights add to the growing literature addressing how UP perform flood resilience actions and strategies in the Global South, under technical and financial constraints and in socio-political complexities.

Matola is located in Southern Mozambique and emerged in the colonial era as a dormitory city for workers from the Mozambican capital, Maputo, and the Matola port and industrial park. Matola, with an area of 368.4 km^2 and currently over 1,030,000 inhabitants [27], has had an autonomous urban administration responsible for urban planning and development since 1997, the time of the decentralization of urban management in Mozambique and the creation of municipalities. In year 2000, Matola suffered from one of Mozambique's most serious floods in recent decades [24,42,48]. During the 2000 floods, roads were cut and there was partial or total destruction of housing and household goods, basic infrastructure (e.g., hospitals, electrical and telephone lines, and water supply systems), various equipment, etc. [24,48]. While facing flood risk, Matola is also characterized by increasing urban population, urban growth, and land use change, marked by horizontal urban spread [4,58].

Against this background, this study aims to analyse the actions the UP took during the major flood event, what flood adaptation[3] and mitigation[4] strategies they have developed since that flood event, and the contribution of urban planning to building flood resilience under financial and technical constraints and socio-political complexities. The research questions are: What flood mitigation actions were taken during the 2000 floods, and what strategies and adaptation measures were used by UP promote flood resilience in Matola? How have UP, through urban planning, contributed to building and promoting flood resilience in Matola? The knowledge gained contributes to local and global scientific debate on urban planning and resilience to urban floods in the face of constraints.

[2] In this study, urban planners (UP) include technicians from various specialties (e.g., architects, environmental managers, environmental engineers, surveyors, water engineers, and land use planners) who plan and manage the continuous use of urban land.

[3] Adaptation involves "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" [61]:2).

[4] Mitigation includes all activities aimed at reducing harm [51]. In disaster risk management, mitigation is "the lessening or limitation of the adverse impacts of hazards and related disasters"[61]:8).

Urban planning for flood resilience: Three discourses and approaches

In contemporary urban flood disaster planning and management, the study, analysis, and assessment of resilience are theoretical and practical elements. Urban planning is a professional practice of deciding how to achieve a set of objectives, based on a set of factors/contexts, for example, the biophysical characteristics of a territory, policies, socio-economic and community attributes, and technical capacity, constituted and executed to create and enhance the urban fabric [46,63]. These are the factors that inspire and influence social actors and social structures that gather necessary resources and over time build, rebuild, shape, and generate socio-economic transformations with spatial manifestations [34,38], which are relevant to the analysis in this study. When addressing urban planning for flood resilience, besides the biophysical characteristics (e.g., vegetation, fauna, topography, and climate) of the territory, the policies and economic context influence the choice of resilience approaches and the flood risk management agenda, particularly which response measures or actions are implemented in each urban context. The existing technical capacity, such as the people from different specialties who are knowledgeable about urban planning, influences the way resilience to urban flooding is addressed and the effects on the quality of urban life and well-being that follow a disaster [55,63]. Furthermore, the characteristics of a community, in particular local community knowledge of the territory, constitute a source of information that is often relevant to official flood planning and management policies and actions [15,31]. In urban planning for flood resilience, vulnerability,[5] hazard,[6] and risk[7] maps are great sources of information that aid in making better decisions about what actions to take and where in the context of a flood response plan [3]. This allows for the more accurate reform of urban land use and of the types and characteristics of infrastructure for housing, transport, industry, green areas, and urban sanitation, etc., that constitute the urban fabric. The goal is to improve urban development and the urban environment from the social and environmental perspectives, as well as to improve the efficiency of service distribution and the urban economy [3,46,52].

Resilience to natural hazards, with particular attention to urban flooding, constitutes an academic and political approach and, at the same time, a 'proposed state' [11,23,64]. Thus, resilience to urban flooding includes both mitigation and adaptation measures. Mitigation refers to limiting, lessening, or reducing the harm of the impacts of flood hazards. Adaptation implies the adjustment of the natural or human components of urban systems in response to actual or expected flood hazards and their effects to reduce vulnerability. Therefore, urban flood resilience involves planning, structuring, and restructuring solutions to cope with the risks of expected and unexpected flood events, thereby improving living conditions and the functioning of the environment [16,51,53], placing it at the core of this study.

In urban flood risk planning and management, different approaches are based on three different discourses of urban flood resilience found in the literature: the engineering, ecological, and socio-ecological resilience discourses [33,41,63,64]. In the context of flood risk planning and management, the similarities and differences of these discourses can be seen in Table 1. To ([25]:XX), resilience from an ecological perspective "determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb the change of state variable, driving variables, and parameters, and still persist". In the context of urban flood planning and management, the ecologically oriented urban flood resilience approach aims to preserve existing natural areas and protect biodiversity by limiting urban settlement developments to safer areas and impeding urban expansion into floodplains [63,64]. It can also be addressed by removing urban infrastructure from flood risk locations and allowing the areas to perform their floodplain function, or by increasing the percentage of floodable area and decreasing dependence on flood control to reduce exposure for people, infrastructure, and assets [33,63]. Unlike ecological resilience, which focuses on the natural ecosystem, engineering systems are products of intentional human invention. The resilience of an engineering system focuses on ensuring the continuity and efficiency of the system's functioning during and after stress or failure [39,63]. In the case of failure of the system's functioning, the engineering system must quickly recover to normal levels of functionality or bounce back to the original functioning condition when released from the impact and stress [32]. In the context of urban flood planning and management, the engineering resilience approach aims to keep floods away from urban areas [33] or to reduce and avoid flood hazard [64] through structural technical measures such as dams, dykes, spillways, dredging, barriers, embankments, and storm surge barriers. The engineering resilience approach also fits with the use of spatial measures, such as river widening, river basin retention, infiltration areas, water storage, polders, and wetlands, all oriented to flood probability reduction [41,63].

The concept of resilience has evolved in the social sciences and is applied in studies of disasters affecting socio-ecological systems [11]. In the socio-ecological approach to disaster planning and management, resilience is mainly described as the 'capacity' of an actor (i.e., individual, community, organization, or social unit) or system to cope with, absorb, mitigate, recover, adapt to, withstand, or resist the impacts of hazards [1]. Here, people are included as agents of the ecosystem [21] (see Table 1). The resilience of the socio-ecological system is characterized by the interaction between disturbance and reorganization, and

Table 1
Differences between three resilience approaches: engineering, ecological, and socio-ecological.

	Ecological resilience	Engineering resilience	Socio-ecological resilience
Theoretical construct and perspective on resilience	Tolerance and reorganization	Resistance and recovery	Recovery + adaptation and change
Assumption/ paradigm	Multiple equilibria (multiple regimes)	One equilibrium (one regime) and predictability	Integrated systemic cross-scale dynamic interactions
Concerns	Unpredictability and uncertainty	Deviation from the ideal level of system functionality or stable state	Disruption of system functionality and losses
Focus	Persistence, robustness, and/or regime shift	Constancy/ stability/ consistency: recovery returning quickly to the equilibrium	Transformation, adaptive capacity, learning, and innovation
Measurement	Persistence: remaining within the current regime stability landscape	Speed of recovery to the previous stable state	Integrated system feedback
The role of disturbance	The magnitude of disturbance the system can undergo before recovering	Disturbance as threat	Disturbance of the organization and of the interaction that sustains development

Source: Author, drawing on Aldunce et al. [1], Brown [11], Cutter et al. [15], Folke [21], George [23], Liao [33], Vitale et al. [63], and Wamsler & Brink [64].

[5] Flood vulnerability is the extent to which a system is susceptible to floods due to exposure (i.e., perturbation), in conjunction with the system's ability (or inability) to cope, recover, or basically adapt [7].

[6] Hazard is any natural phenomenon or human activity that may cause loss of life, injury, or other health impacts, property damage, social and economic disruption, or environmental degradation [60].

[7] Disaster risk is the likely consequence of the combination of the probability of a hazardous event and its negative consequences [54].

between support and development. The focus is on transformative and adaptive capacity, learning, and innovation unfolding in the context of integrated system feedback and dynamic interactions between different spatial and social scales [11]. Socio-ecological resilience is also characterized by adaptation capacity, in which the individual, community, organization, or social unit adjusts to changes, seeks to moderate the effects of disturbance, and sees dealing with the stress caused by hazards as an opportunity to improve and innovate their local socio-environmental conditions [15]. Here learning and adaptation are key aspects when "reviewing the capacity of people and the structure of organizations associated with disaster risk management, based on what worked and what did not during past disasters" ([1]:11). Resilience is also characterized by anticipation, and it "includes pre-event measures to prevent hazard-related damage and losses and post-event strategies to cope with and minimize disaster impacts" ([15]:600), placing it at the core of this study. A system with high socio-ecological resilience can incorporate one low engineering or ecological approach, or even combine low or medium ecological and engineering resilience, considering the spatial manifestation of socio-economic activities.

The socio-ecological urban flood resilience approach hence emphasizes the role of actors such as citizens or local communities, UP, and policymakers in enhancing flood resilience by redefining land use and building regulations and by making socio-economic adaptability more flexible. It mainly adopts combined technical, structural, and non-structural spatial measures. "Spatial measures, warning systems, adjustments to the built environment, and flood-oriented land use dispositions may all enhance urban flood resilience" ([63]:4). Urban planning and regulations may introduce green infrastructure, waterproof architecture, drainage system improvement, and disaster insurance, or simply no longer conduct urban development in areas prone to flooding. Evacuation to public spaces in an emergency, to facilities such as evacuation centres and temporary shelters whenever flooding occurs, is another strategy for building flood resilience [8,63].

Methodology

Description of the study area: Matola

Matola is located in southern Mozambique and is the capital of Maputo Province. It lies in the Infulene and Matola rivers' catchments and includes the short Maputo Bay coastline (see Fig. 1). Matola has an estimated area of 368.4 km^2 divided into three administrative areas. In year 2000, Matola had an estimated population of 424,662 inhabitants [28] and a population density of 1,152.7 inhabitants/km^2. Currently, Matola has over 1,030,000 inhabitants [27], with a population density of approximately 2,985.9 inhabitants/km^2, which exerts great pressure on land use.

Matola was purposively chosen for this study because, in year 2000, it suffered from the most devastating and destructive floods experienced by the city (Author et al., 2022; [24,48]. According to a flood hazard and risk assessment by Neves et al. [40], using data from the 2000 floods, 61,978 inhabitants at the time lived in areas at medium flood risk and 53,036 in areas at high flood risk. The sum of the results of the flood hazard and risk assessments corroborate the results published during the 2000 floods, indicating that more than 100,000 people were affected by the floods in Matola [24,48]; (see Fig. 2). Furthermore, since 2000, Matola has suffered from cyclical floods. For example, due to the floods that occurred in the rainy season of October to March 2012/2013, in addition to the degradation of infrastructure such as roads, bridges, schools, hospitals, housing, and access roads, several families were displaced and resettled in Maputo Province (including Matola) and Maputo city [13].

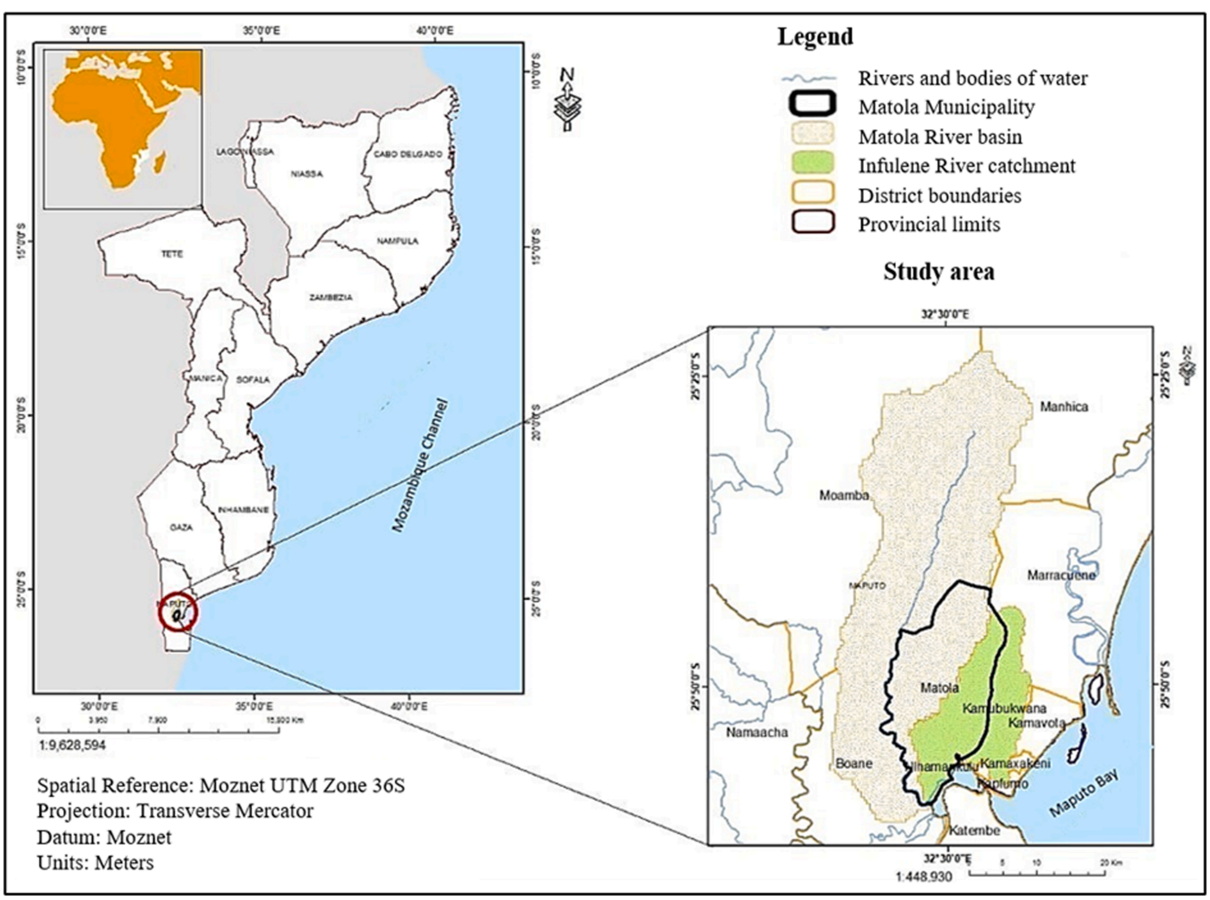

Fig. 1. Location of Matola (source: author).

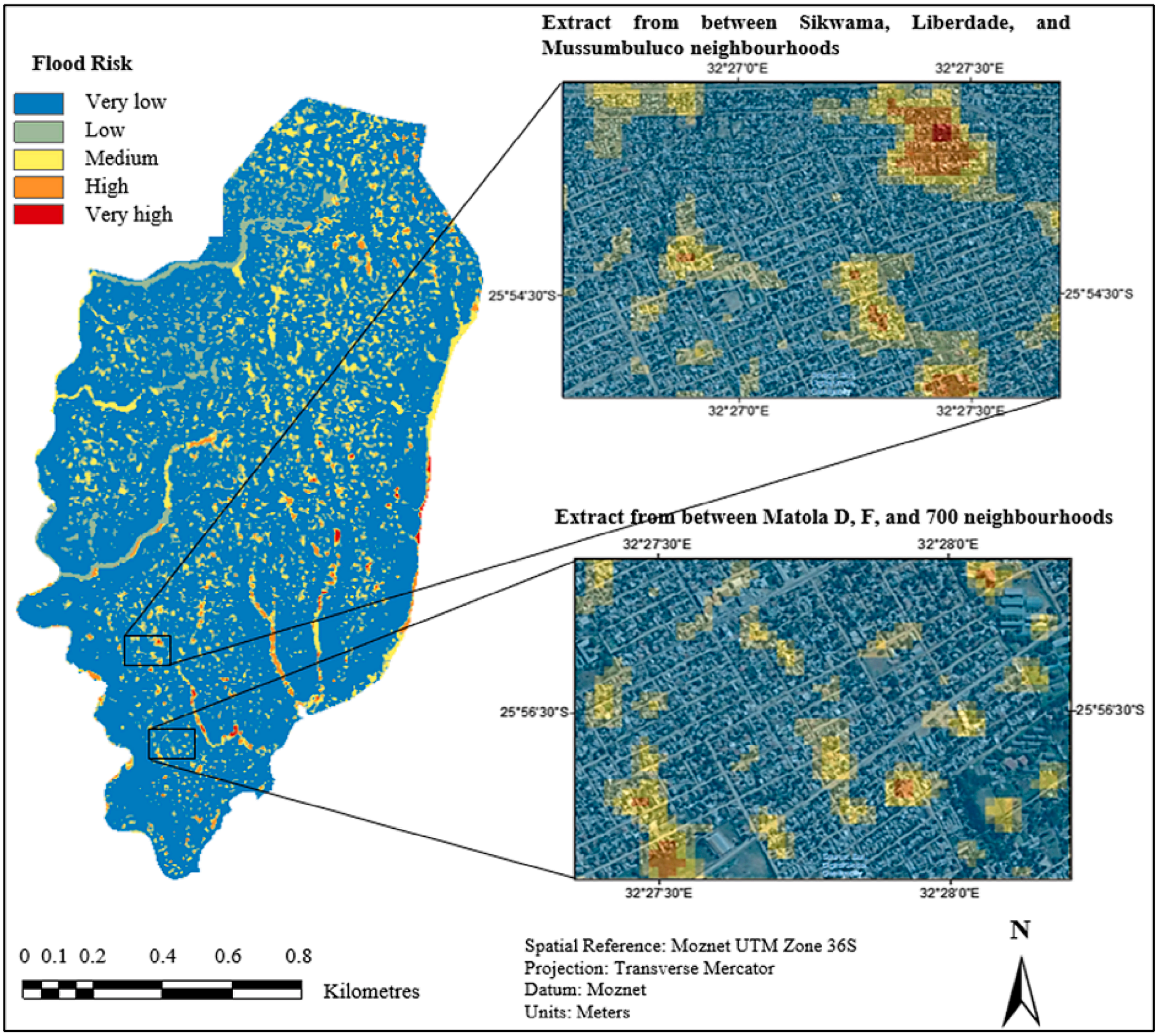

Fig. 2. Flood risk map of Matola and extracts showing flood risk areas combined with satellite images from 2022 ().
Source: [40]

According to INAM [26], in the rainy season of October to March 2021/2022, the province of Maputo, in which Matola is located, rains tended to be above normal. Furthermore, around 413,000 inhabitants currently live in areas vulnerable to flooding, where if floods of the magnitude of those of 2000 occur, people may experience low, medium, and high risks of flooding, which would also cause the degradation of infrastructure and local socio-economic disruption [40]. The flood risk map in Fig. 2 shows the flood situation that Matola experienced in 2000. The areas selected in this risk map, combined with satellite images of these same areas from 2022, show the risk of flooding to which Matola remains exposed. Therefore, in circumstances of high rainfall such as those of 2000, large inhabited areas could become flooded, putting people, infrastructure, and property at risk, and these scenarios highlight the relevance of this study of Matola (see Fig. 2).

Data collection and data analysis methods

From the beginning, this study considered obtaining the main empirical data through interviews. Imaging data captured during direct observation testifying to the problem of flooding and actions to promote resilience were also considered, as were documents providing additional information about the object of study. Interview data were collected through semi-structured interviews with 32 UP in Matola from November 2020 to January 2021. The 32 interviewed members of the urban planning team have diverse specialties and roles important for urban planning and management. As for specialties, the interviewees had the following roles: physical land use planners, water and sanitation engineers, civil construction engineers, environmental engineers, environmental and local development planners, architects, surveyors, cartographers, geographers, and specialists in geographic information systems. The interviewed UP perform roles in designing general and partial urban plans, zoning the territory, plotting the land, and designing proposals for the type of infrastructure to be built in each area (e.g., markets, housing, transport routes, and drainage systems), and monitoring compliance to the urban land use standards in the city, including land use management.

In selecting the interviewees, this study used non-probability sampling, specifically, purposive sampling, to choose informants representing the different experts constituting the urban planning team in Matola, i.e., those who draw maps, formulate land use plans, write spatial strategies, and manage and monitor urban land use. This strategy of choosing interviewees was adopted in order to select informants who had knowledge and experience of the problem of flooding and urban planning for flood resilience in Matola. The interviews were formally authorized by the President of the Municipal Council of the City of Matola. Of the 32 UP, 30 were from the Council of Territorial Planning and Urbanization, one from the Council of Construction and Infrastructure, and one from Municipal Finances. Of the 32 UP, two experienced the 2000 floods in the planning sector, and the rest joined the planning team over time, until 2017. This study maintains the anonymity of its informants or interviewees. The questions asked in the interview were about the mitigation actions during the 2000 floods, and the strategies and adaptation measures from floods after 2000, to promote resilience, as developed by UP, to floods in Matola. It was also relevant to ask the UP about the experience and cause of the 2000 floods in Matola, and their aftermath, and about the UP' perception of Matola's preparedness to face future floods.

Semi-structured interviews were chosen as a data collection technique because they allow unique information to be obtained through open discussion of the research object. They allowed the planners to express their knowledge, experiences, concerns, and opinions about the floods, and about the actions that the urban planning sector carried and carry out to promote and increase resilience to urban floods in Matola. Direct observation was also conducted. This technique was useful for directly visualizing the study area and capturing images showing flooded areas. These images, used in presenting the results (see section 4), show places affected by recent floods that occurred while doing fieldwork as well as adaptation measures implemented at selected locations, according to information previously obtained from interviews with UP. The documentary research was carried out with particular emphasis on the 2010 Urban Structure Plan [14] and national strategic instruments that advocate promoting resilience [35,36]. The data analysis involved the triangulation of differentiated data resulting from the semi-structured interviews with the UP, data from relevant documents, and images from observations. The data were analysed and interpreted using NVivo software. The study uses the conceptual framework of socio-ecological resilience discourse, particularly regarding the learning and adaptation aspects of urban flood resilience approaches to mitigation, coping, responsiveness, and recovery capability. This conceptual framework is used here to explain, analyse, and discuss how urban planning, particularly UP, contributed to promoting flood resilience in Matola, and finally present the conclusions.

Study limitations

The limitations of this study relate to the deliberate methodological approach, which focuses on flood mitigation and adaptation strategies, measures, and action approaches to promote flood resilience, during the floods of 2000 and afterwards. The study participants were UP, the key actors who were interviewed, as they were the ones who led the urban planning process and could address the mitigation and adaptation strategies and actions to promote flood resilience in Matola. No other stakeholders, such as residents, other government officials, and representatives from non-governmental organizations, participated.

Results concerning actions and measures for building flood resilience in Matola

Experiences and causes of flooding

Some of the interviewees experienced the floods in 2000 as UP in Matola, while others experienced them as students or inhabitants living in Matola or Maputo. The UP who were active in Matola during the floods in 2000 stated that Matola was taken by surprise, being completely unprepared to help people evacuate from the flooded sites. There was no early warning system to clarify the magnitude of the rainfall or the intensity and duration of the floods. From 5 to 9 February, daily rainfall in the region averaged 151.9 mm, flooding Matola for a week. The floods affected all 41 neighbourhoods of Matola, at different risk levels. Matola has suffered from almost cyclical floods since then, disrupting the economic and social dynamics of the municipality, although with lower intensity than the year 2000 floods (Fig. 3).

In 2000, Matola did not have drainage systems that could withstand and control the huge precipitation discharge that caused the floods. Consequently, on 6 February, Matola residents woke up to flooding, being surprised at the water in their backyards and houses. Depending on the location, the water could reach a depth of 1.5 m, to the point that houses and other infrastructure were abandoned (Fig. 4).

Technical incapacity at the time of the 2000 floods was one factor affecting the lack of preparation, as planners had long been unable to predict that certain areas that became flooded were 'floodable'. All the planners had similar understandings of the causes of the floods. According to the collected data, the causes of floods have been categorized as physical, socio-economic, technical, and political/governance (see Table 2).

As shown in Table 2, prior to 2000, the existing urban plans identified the lower-lying areas as meriting preservation and did not predict the extent to which Matola was vulnerable to flooding in practice. Financial incapacity was identified as another factor hindering the implementation of actions related to mitigating and/or adapting the forms of land use to urban flooding risk. However, from the planners' testimonies, it is clear that their 2000 flooding experiences awakened them to the need for urban planning that would promote actions to improve flood resilience. The adaptation and/or mitigation measures and the flood management strategies adopted in urban planning in Matola are presented below.

Flood risk mitigation and adaptation measures and/or actions for flood resilience

Participation and incorporation of indigenous knowledge of coping capacity

An immediate measure taken was to ensure the participation of local communities in activities carried out during and after the floods, as highlighted by one interviewee:

Community knowledge was important, as well as community participation in carrying out migration actions during the 2000 floods, and adaptation measures from 2000 and onwards. There was community participation in rescuing families trapped by the floods, identifying and registering families to be resettled, choosing areas for resettlement, helping our teams of planners identify areas for installing drainage, and other activities that needed planners' and community members' cooperation (UP active during the 2000 floods, man, Matola, November 2020).

As a way of mitigating floods in the context of urban planning and management, the forms of participation practised were sensitization/awareness and/or 'consultation' led by UP and political leaders from Matola and by technicians from INGC,[8] now called INGD.[9] There are two types of sensitization: first, when a hazard is forecasted, such as foreseen floods, with the aim of preparing the population and, if necessary, evacuating it to safe areas; second, after a phenomenon that puts residents at risk, such as floods. Then sensitization is done with a view to convincing those affected to move to safe areas or to join the resettlement organized by the municipality and its partners. In turn, a 'consultation' occurs when there is a plan to be executed. When a sustainable plan is being designed, the population of the area covered is informed of the plan's execution and consulted about their experience of the natural characteristics of the area (e.g., the natural channels of running water) and about local knowledge of coping mechanisms. This is a community participation mechanism formally established in Matola.

[8] INGC – National Institute of Disaster Management.

[9] INGD – National Institute for Disaster Risk Management and Reduction

Fig. 3. Recent flooding in 2022 in *Nkobe* and *700* neighbourhoods (photos: author).

Fig. 4. Housing and commercial infrastructure abandoned since 2000 (photos: author).

Emergency evacuation of population and removal of assets

According to the interviewees who were planners in Matola during the floods in 2000, the first mitigation action taken in the face of floods was the evacuation of the population from risk areas to accommodation centres located in safe places considered able to protect them from rain and water, such as schools, markets, and private and government buildings. This activity was carried out in close coordination with agents of INGC. Employees from public and private establishments were mobilized, as well as students who were available as volunteers to support the effort. According to planners who were part of the rescue team in Matola during the floods in 2000,

> rescue activities during the floods consisted of raising awareness of the population's evacuation, rescuing and transporting people, including food and available goods, distributing tents in places of accommodation, distributing food, drinking water, and other consumables, and constructing latrines (UP volunteer during the 2000 floods, woman, Matola, November 2020).

However, according to the interviewees, the rescue action carried out on 6 February 2000 was late and did not immediately reach all the most affected areas. This delay was due to the time required to mobilize human and technical resources, such as boats and cars, and to prepare accommodation sites. During this process, mutual help among community members played an important role, for example, those who were relatively safe hosted those at relatively high risk in their homes, sheltering people and goods until the rescue teams arrived. Community members also helped guide the rescue teams to the places where people might be trapped by the floods. Another activity consisted of installing flood barriers to prevent water from entering places used to accommodate people. A substantial part of the population lost all or part of their homes and others have had their homes permanently flooded, up to the present (Fig. 4). Hence, it was necessary to follow all these activities until people could return to their homes or those who could not were relocated to other safe areas.

Resettlement of affected population

One adaptation measure that immediately followed the 2000 floods was the resettlement of affected populations. This activity took place with the involvement of the affected communities, and extended from the identification of the families to be resettled and choice of resettlement area, to the discussion of the model and size of housing, depending on the household size. Drawing up partial urban plans was immediately started in 1° de Maio, Kongolote, and Nkobe neighbourhoods, previously identified as safe for population resettlement. This activity included diagnosing socio-economic and biophysical conditions and planning for different land uses, such as housing, roads, and health centres. In addition to drawing up partial urban plans, funds were channelled from INGC and international partners of the Government of Mozambique for the construction of emergency housing. Paved roads were built to access these neighbourhoods, electricity and running water were installed, and then new houses were distributed to those whose homes were destroyed and damaged by the floods, especially those whose homes were located in areas considered waterways. This resettlement phase, in the aforementioned neighbourhoods, took place from 2000 to 2002. However, resettlement works are still underway, with areas identified that should eventually be cleared of residential, commercial, and industrial infrastructure. For the construction of the Lingamo drainage channel in 2005, families were relocated to other neighbourhoods. In Matola A neighbourhood, there are still families to

Table 2
Causes of floods in Matola according to the interviewed UP.

		Before 2000	2000 to 2020
Physical		• Exposure to strong cyclones and heavy rains; lowland topography	• Exposure to strong cyclones and heavy rains; lowland topography
Socio-economic		• Inheritance of disordered settlements in the urban periphery of the poor population of the colonial era Occupation of risk areas by needy populations and/or those from rural exodus due to civil war, drought, and famine Financial incapacity: inability to settle and relocate the population in safe areas	• Inheritance of disordered settlements in the urban periphery of the poor population of the colonial era Occupation of risk areas by needy populations and/or those from rural exodus in search of better living conditions in cities Financial incapacity: constraints that limit the implementation of planned actions, e.g., construction of drainage throughout Matola, rapid resettlement of the population, monitoring compliance with environmental and urban land use standards Rapid increase in urban population and urban growth: horizontal urban spread replacing green areas with housing, industrial, and commercial infrastructure Construction of industrial and commercial infrastructure in risky but economically viable locations New formal housing in risky locations
Technical	Population	• Informal and disordered construction in natural waterways and areas vulnerable to flooding	• Construction of some formal and informal infrastructure in natural waterways and areas vulnerable to flooding
	Municipal management	• Formal colonial buildings in areas that were not expected to be flooded Lack of dam systems to control water during flooding times Insufficiency of drainage systems Technical inability: lack of UP to assess the risk and design of urban plans considering the risk of flooding	• Formal colonial buildings in areas that were not expected to be flooded Lack of dam systems to control water during flooding times Difficulties in drain maintenance and in constructing new drainage infrastructure Growth of urban area without accompanying drainage systems Highway infrastructure built with high elevations that impede the flow of water from certain neighbourhoods – engineering failuresNon-compliance with territorial planning instruments (e.g., Urban Structure Plan) ; little mastery of resilience actions
Politics/governance		• Colonial governance system that maintains African residential areas on the periphery in risky areas Post-independence governance system unable to restructure the city and ensure compliance with environmental and urban land use standards	• Delay in implementing resilience actions such as resettlement Difficulty in monitoring and implementing urban plans and compliance with environmental standards Passive and active permission to establish industrial, commercial, social service, and housing infrastructure in flood risk areas Change of leaders and partners: new agendas and interests in urban land

Source: Interviews with UP in Matola.

be resettled. According to one of the UP interviewed:

The resettlement process is being carried out in stages, due to the scarce funds, as there are several families to be resettled dispersed in some critical points in terms of flooding in the different neighbourhoods of Matola. In addition to the families immediately resettled after the 2000 floods, throughout the process of carrying out a territorial diagnosis within the scope of urban planning, over time we identified other families that occupied areas at risk of flooding. The cyclical floods that have occurred during the rainy season have proven that some households must be resettled along the lower Matola River, Lingamo, and families that are close to the coastal protection flood areas. This is one of the reasons why we still have families to resettle (UP active during the 2000 floods, man, Matola, November 2020).

According to the interviewees, in addition to the financial difficulties of relocating the identified families, the activity is complex and requires institutional cooperation since it involves several sectors – for example, electricity, water, and road works – all of which requires effective planning. In addition, Matola's horizontal growth means that there are limitations on the land available for resettlement, so these activities are being carried out in partnership with other territorial jurisdictions, such as the District of Moamba and Boane, which have made safe areas available for resettlement.

Building flood control infrastructure

An important measure was the construction of drainage channels. During the floods of 2000, some channels were opened as a way to direct floodwaters away from some neighbourhoods. From 2005 onwards, concrete drains were built. One example is the Lingamo channel, which has partially solved the flooding problems in some neighbourhoods. The channel runs from Liberdade and passes through Fomento neighbourhood towards Maputo Bay (Fig. 5). However, according to one of the interviewees:

The channel's impact is very small in relation to the magnitude of the existing problems. The channel is insufficient for the water volumes resulting from heavy rains in rainy seasons, leading to overflowing and flooding of the neighbourhoods along its route over a length of approximately 10 km (UP, man, Matola, January 2021).

The interviewees pointed out that Matola Municipality continues to gradually intervene in the construction of drainage in various neighbourhoods (see Fig. 6). The interviewees pointed out that one of the measures recently carried out was a water elevation system using electric pumps. This system removes water from concentration points, ponds, and directs it to sloping areas leading into the Matola River. However, the system's operational capacity has been exceeded, due to large volumes of water that have invaded houses and commercial infrastructure, even preventing the circulation of vehicles, people, and goods in some risk areas.

Training and hiring qualified technicians

As a strategy to address the insufficiency of trained personnel, one important action undertaken by the municipality has been providing training to its staff, as well as increasingly hiring technicians with diverse specialities that are important for urban planning. According to one of the interviewees:

After the floods of 2000, our sector and the municipality in general felt the need to think and plan Matola taking into account this new challenge of promoting sustainability and preventing people, infrastructure, and goods from suffering from flood events in the future. At the time of the 2000 floods, our team of technicians was mainly made up of surveyors, and there was no clear concern for promoting flood resilience. Our concern was to divide up land into plots and distribute it to citizens who needed it for housing and other socio-economic activities. To address this gap, a process began of the internal training and recruitment of technicians with diverse but fundamental specialties for urban planning, and this process is ongoing (UP active during the 2000 floods, man, Matola, December 2020).

In this way, the municipality of Matola has gradually become staffed with qualified and specialized urban planning personnel, with an emphasis on land use planners, environmental managers, local development planners, architects, environmental and construction engineers, and water and sanitation engineers. Although there is still insufficient funding to address urban flood mitigation and/or adaptation measures more efficiently and effectively, with new and qualified personnel, it has been possible over time for the municipality to consciously address various aspects of urban planning, with a concern for developing measures to adapt and/or mitigate urban flooding.

Introducing an early warning system

To prepare urban areas for floods and to reduce vulnerability, Matola benefits from the INAM[10]/DNGRH[11]/INGD early warning system. As a strategy for mitigating and/or adapting to natural hazards and promoting resilience, the Mozambican government, with the support of partners, has sought to equip Mozambican institutions with instruments that help alert communities located in areas at risk of these phenomena. Every day, INAM releases weather forecast information for the next 24 h across the country; in turn, DNGRH informs Mozambicans of the impact of the forecast weather on waters in the national river basins. In the event of a forecast of an extreme flood event, INGD works in cooperation with INAM and DNGRH. These institutions issue their warnings via radio, television, newspapers, and websites. This information provided by INGC and INAM plays an important role in UP' activities, as explained by one of our interviewees:

The information disclosed and provided by INGC and INAM is fundamental to our activity of planning, managing, and monitoring flood control actions. Because, in addition to serving as a warning to the general population, they also serve as a warning to us, and the information serves as a basis for monitoring the flooding situation during precipitation events throughout Matola. In addition to planning, we provide land use suggestions based on data we gather when we travel to the field to check the performance of the infrastructure built so far to drain water, by the Council of Construction and Infrastructure. Throughout the city, we check the situation of settlements in the face of floods, and the capacity of floodplains and green areas to contain and evacuate water to Maputo Bay during the rainy season, between October and March, which is the critical period. It is based on this information that we are able to make proposals, for example, to remove certain families from certain places at high risk of flooding, and to propose the need for drainage infrastructure in certain areas in the different neighbourhoods of Matola (UP, man, Matola, January 2021).

In addition to the information provided by INGC and INAM being useful for monitoring and planning purposes, the interviewees stated that, based on this information, identified field agents travel to the risk areas to disseminate information with a view to sensitizing the population and preparing them for potential flood events, or even to evacuate the population to accommodation centres located in safe places.

Development of an urban structure plan

Ten years after the floods of 2000, Matola Municipality developed its urban structure plan in 2010 [14], considering previous flood experiences. Due to the high risk of flooding at the national level, INGD created instruments for helping to plan and develop the city, inspired by the global environmental sustainability agenda promoted by international non-governmental organizations. The first instrument at the national level was the Vulnerability Assessment Climate Change and Adaptation Strategy 2005 [36] and the second was the National Adaptation Program of Action 2008 [35]. These national instruments pointed out the need to promote flood resilience through mitigation and/or adaptation measures and, over time, have inspired the planners, especially in formulating the 2010 urban plan. According to one of the interviewees:

We designed the plan because we dream of a better, sustainable, and resilient Matola, not only in terms of floods, but also to limit the emergence of informal neighbourhoods, to organize the municipality with well-identified industrial, commercial, and housing areas. This organization prevents other risks such as the spread of fires and diseases in disorderly neighbourhoods with dense occupation and difficult access, which suffer from frequent floods. We also foresee the allocation of basic services such as education, health, security, and green areas, among others, in different neighbourhoods, for better urban development in Matola (UP, woman, Matola, December 2020).

This plan constitutes an instrument intended to regulate the use of urban land, although without details about the different flood risk levels, specifying waterways and areas vulnerable to flooding, green and protected areas, and other urban features [14]. The areas vulnerable to flooding have been mapped and marked by warning signposts across Matola (Fig. 7).

The vision of the municipal urban plan includes clean flood channels, with drainage channels at the centre, surrounded by carefully tended grassy floodplains that can be used for recreation. It incorporates vegetated floodplains with some urban agriculture, providing multiple ecosystem services. These areas are planned and managed by the municipal urban management authority with community involvement, which is important for the urban fabric. In fact, an urban plan in Mozambique has the same status as law: it must be strictly obeyed by both the planners and managers of urban land, by other state institutions

[10] INAM – National Institute of Meteorology, Mozambique.

[11] DNGRH - National Water Resources Management Directorate.

Fig. 5. Lingamo channel (photos: author).

Fig. 6. Drainage being built along roads at Machava-Sede (photos: author).

Fig. 7. Infrastructure being built in places vulnerable to flooding (photos: author).

with interests in the urban space, and by private entities and citizens. However, land can be divided into plots and DUATs[12] allocated in areas vulnerable to flooding by the municipal urban management authority, and various formal[13] and informal[14] infrastructures are sometimes constructed in risky areas. This is because of the illegal occupation of areas at risk of flooding by some community members, especially new low-income citizens, and because of political pressure interfering in the

[12] DUAT – Right to Land Use.

[13] Formal infrastructure: legally built infrastructure with a DUAT and a construction permit in a suitable location.

[14] Informal infrastructure: illegally built infrastructure; illegality may be due to the infrastructure being built without a DUAT, without a construction permit, and in an unsuitable location.

technical aspects of land use planning. According to the interviewees, while the UP present detailed plans, highlighting the areas vulnerable to flooding that must be protected and not occupied, political leaders sometimes force the UP to divide these same areas into plots and assign DUATs. In some cases, vulnerable locations are occupied by housing and commercial infrastructure, and Matola Municipality grants permits for these activities due to their economically viable locations for entrepreneurs, who become legal occupants in unsuitable locations (see Fig. 7). Associated with this is the rotation of political power, with all political leaders seeking to satisfy their own interests and those of their allies during their terms, sometimes infringing on urban planning norms. These actions are contrary to the efforts to promote flood resilience in Matola.

UP' perception of Matola's preparedness for future floods

The interviewees gave their opinion on the preparedness of Matola for future floods considering the mitigation and/or adaptation measures implemented by the Municipality of Matola to build and promote flood resilience supported by urban planning. For those interviewed, Matola is in an ongoing process of recovery, because there are still residents to resettle and there is still a need to build and expand the drainage network and other possible flood solutions. Therefore, if intense rainfall continues during the hot, rainy season, Matola, especially its citizens and infrastructure in floodable areas, may continue to suffer from cyclical floods. If the floods continue to be lower than in 2000, as has been the case so far, Matola will eventually be able to withstand them without losses. However, if the floods equal or surpass the level of the 2000 floods under current conditions of occupation and land use, around 69 % of those interviewed considered it unlikely that Matola would be prepared in advance to deal with floods without losses, and 31 % considered it very unlikely. The interviewees argued that although urban planning has contributed greatly to identifying measures to promote resilience, some of which have been implemented, other factors make it possible still to experience losses in the event of floods of magnitudes equalling or surpassing those of 2000. These factors are the increase in population, which is now more than twice that of 2000, and the accelerated urbanization around Matola, characterized by the horizontal expansion of socio-economic infrastructure. In the case of severe flooding, this infrastructure can serve as a barrier to the passage of water, slowing its flow and worsening the effects of flooding on people, infrastructure, and goods. Furthermore, due to technical and financial constraints in the Municipality of Matola, a time-consuming process of implementing adaptation measures would be necessary for recovery – let alone increasing local social well-being.

Discussion

Without devaluing the actions of various social actors in building or promoting flood resilience, the actions of Matola's UP to deal with floods constitute the object of analysis. In summary, the interviews with the UP showed that five strategic measures have been especially important for understanding and learning about urban flooding, building, and promoting urban flood resilience since 2000: i) community knowledge, ii) formulating partial urban plans for resettlement, iii) increasing the technical capacity of planning staff, iv) formulating new urban plans for all Matola, and v) monitoring the territory for potential flooding. Of the three flood resilience approaches identified in previous literature – i.e., the engineering, ecological, and socio-ecological approaches – it is possible to perceive UP' coping measures and actions in Matola as directly related to the socio-ecological resilience approach that Aldunce et al. [1], Brown [11], Cutter [15] and Liao et al. [31] saw as the foundations for building and promoting resilience in an urban system considering mitigation actions in their coping, responsiveness, recovery capability, learning, and adaptation aspects.

Despite it being challenging for UP due to the intensity and magnitude of the floods and due to financial and technical restrictions, since the floods of 6 February 2000, mitigation actions have been carried out to limit lessen, or reduce the harm caused by the impacts of flooding on residents, assets, and socio-economic infrastructure. The immediate response or coping action in the face of flooding was to evacuate people and goods in flooded areas to safe areas in a joint action between community members and rescue teams. Supporting this mitigation action was *community knowledge* about where people were trapped by the floods, and about the best ways to reach these people and their goods. Community knowledge was also relevant in identifying families to be resettled, in the process of choosing resettlement sites for building houses, and in distributing new plots and houses to flood victims. In this case, UP strategically used community knowledge as Cutter [15] and Liao et al. [31] suggest that helps in the adoption and implementation of measures to deal with flooding as it provides local information often not contained in strategic documents, and can help improve strategies and actions to promote resilience. These important findings of cooperative actions between communities and rescue teams in the 2000 floods in Matola are evidence of coordination activities when dealing with floods.

The flood scenario that damaged urban infrastructure and socio-economic activities and negatively impacted the lives of citizens led to the need to develop strategies and measures to adapt to floods and promote resilience. Structured scenarios of desired alternative futures, the ways in which these can be realized, and adaptive management are the main tools for building resilience in socio-ecological systems [22]. The desired future scenarios can be designed and adaptive activities realized only with the availability of people specialized in the required tasks; in the case of building and promoting resilience to urban flooding, UP are the specialized personnel in charge of planning the city and land use management. The need to promote resilience emphasized to the urban planning sector of Matola the need to restructure general and partial urban plans by identifying floodable and non-floodable areas to adapt their uses for better responsiveness to flood hazards. UP have played an important role in the urban system, as they have been planning the use of urban land and monitoring the implementation of what was planned to guarantee its functionality, without negatively compromising the different elements (e.g., humans, infrastructure, socio-economic activities, and various biophysical components such as air, soil, water, vegetation, and fauna) of the urban system. This was the case when immediately *formulating partial urban plans* for the 1° de Maio, Kongolote, and Nkobe neighbourhoods, previously identified as safe for the resettlement of the population. These actions allowed the immediate resettlement of families permanently threatened by water, giving the resettled communities recovery capability by housing their families in places safe from flooding. Under conditions of available funding, for example, it might be possible to carry out major engineering works for floodwater control, associated with sophisticated housing, commercial, and industrial infrastructure that requires high organizational capacity and large sums of funding for its execution. However, due to the financial constraints, the most used alternatives were the gradual resettlement of the population, removing them from the flood-vulnerable areas. This is an adaptive *spatial measure* in a socio-ecological resilience approach that aims to reduce the flood exposure of infrastructure, people, and assets [55,63]. The permanent removal of communities and urban infrastructure from flood risk sites contributes significantly to the promotion of urban sustainability and flood resilience because it enables these areas to perform their floodplain functions, and the municipality can then gradually build drainage channels in the most critical areas in neighbourhoods. In turn, relocating communities to safe locations allows them to settle safely and carry out socio-economic activities that guarantee their well-being.

One of the main findings of this study was *the increase in the technical capacity of the planning staff* over time in terms of the diversity of specialities that cover aspects relevant to addressing flood problems in the urban planning sector. This interesting practical example of increasing responsiveness suggests that working with resilience is not just a matter of choosing an engineering or ecological approach, but, after a crisis, entails developing competences to better address issues of promoting resilience. Thus, Matola's urban planning sector benefited from the flood crisis, increasing its technical capacity to address not only flooding but also urban planning as a whole. The new technical capacity of trained and contracted staff, the early warning system, and the national strategies and guidelines that address climate change and urban floods contained in instruments produced later in 2005 and 2008 by the Mozambican government [35,36] have supported the *development of new urban plans for Matola in 2010*. In fact, diminishing the apathy regarding disasters and consequently accepting that disasters and change can happen opens up the possibility of framing them as opportunities for improvement and innovation [1]. Another important finding that highlights the relevance of the role of urbanists in Matola concerns having UP monitor the territory for compliance with the urban land use plans standards by citizens. Associated with this task is that of monitoring flood scenarios throughout the city based on the 2010 urban plan, which identifies flood risk areas, with the help of precipitation and flood forecasts provided by the INAM and DNGRH early warning system. This *monitoring activity* is fundamental to flood management, as it allows evaluation of the performance of adaptation measures implemented to date, such as drainage, bridges, and the capacity to accumulate and drain water from floodplains and green areas in the face of heavy rains and floods.

Although Matola still faces flooding, associated with the use of land in floodable areas for socio-economic infrastructure, due to pressure from political elites and new low-income citizens who occupy and use areas vulnerable to flooding for socio-economic activities, it has been possible since 2000 to develop strategies and measures to promote flood resilience in Matola. Strategic measures have been developed, ranging from cooperating with communities and increasing institutional technical capacity by training and hiring technicians, to a gradual approach to measures such as resettlement, drainage construction, and developing an urban plan that identifies areas at risk of flooding to prevent their inappropriate use. However, the use of prohibited floodable areas for industrial, commercial, and housing purposes suggests the need to increase environmental education for citizens, to make them more aware of flood hazards that inappropriate use of urban land brings to their lives, assets, and the urban environment of Matola in general. Therefore, the learning process that UP have engaged in over time with a view to promoting resilience should extend to all local actors, such as politicians, communities (especially those of new low-income citizens), and all urban land users. Environmental education can be implemented through social organization, mobilization, and raising awareness of the need to follow urban land use plans. It should also address the limits and role of areas vulnerable to flooding and other relevant aspects via an education platform that allows different social groups to gain knowledge. The lack of such knowledge leads to little public concern about the health of rivers and low awareness of the role and dynamics of floodable areas, leading to their inappropriate use [31]. Increased monitoring of compliance with environmental standards and urban planning, associated with holding offenders accountable and repairing damage, would contribute to promoting flood resilience in Matola.

Conclusions

The study offers lessons about challenges encountered in promoting flood resilience in Matola, and strategic lessons from the actions of UP in an ongoing effort to promote resilience to urban floods in a context of technical and financial constraints after the 2000 floods. During the 2000 floods, the community's knowledge of where people and goods were trapped by floods and how to best reach them was relevant to supporting rescue actions. *Community knowledge* also helps planners choose resettlement locations and diagnose the needs of families to be re-housed in the resettlement process. The main challenges in promoting flood resilience in Matola since the 2000 floods have been the deficient and insufficient coordination in mitigation and adaptation actions between different structures or actors, namely, political actors, UP technicians, and members of urban communities, and the lack of economic resources. This finding confirms, to a certain extent, the results of previous studies of the promotion of resilience in other Mozambican cities [2,5,9], which point to the inefficiency and lack of coordination between UP and managers, politicians, and communities as well as to technical and financial limitations. In Matola, this gap arises, on one hand, due to political interests in urban land strategically located for the construction of industrial and commercial facilities, but in areas at risk of flooding. On the other hand, the gap arises due to low-income citizens who build their homes in some floodable areas, in a certain way revealing the difficulties they have in accessing urban land in safe areas, which reveals urban poverty. The land interests of politicians and low-income citizens contradict the land use proposals presented by UP in the partial and general urbanization plans of Matola, and harms to a certain extent the agenda of promoting flood resilience.

This study reveals that the experience of coping with the devastating 2000 floods emphasized to Matola's planning sector the need to improve urban planning activity to better respond to the challenge of building and improving resilience to future floods. The *competence development strategy* was therefore adopted through ongoing staff technical training and the hiring of qualified technicians; this proved to be an important strategy, as it increased the capacity to plan the city and monitor the approach to measures promoting flood resilience. The increase in the urban planning technical capacity has allowed the design *of partial plans specifically addressing flooding* issues and a *new urban plan in 2010* addressing, among other aspects of urban development, the problem of flooding, identifying areas vulnerable to flooding and specifying waterways, green and protected areas, and other urban features. Based on this information, it was possible to implement flood resilience spatial solutions, such as removing people from floodable areas and relocating them to safe areas, and specifying areas destined for urban agriculture, housing infrastructure, and the construction of drainage systems, bridges – among other fundamental infrastructure for the urban fabric in the context of promoting flood resilience. Despite existing challenges in building resilience related to inefficient coordination between UP, politicians, and local communities, this study concludes that urban planning, particularly UP, contributed significantly to building and promoting flood resilience in Matola: these actions helped reduce the exposure and vulnerability to flooding of the population, assets, and urban infrastructure, as well as improving ecosystem services (e.g., accumulation of rainwater, rainwater runoff, and recovery of natural flora and fauna habitats) in the low-lying areas and protected coastal wetlands. Urban planning strategically addressed flood resilience by gradually implementing measures, namely: designing partial plans and gradual resettlement, formulating a new urban plan, gradually opening drainage channels, and placing water pumping systems in some areas of Matola, according to technical and financial capacity.

This study shows that addressing flood resilience is challenge that needs to be participatory and adopted by political decision-makers and all social actors, including UP. This needs to be done to overcome obstacles to resilience, such as the imposition of politicians' interests on urban land use that contradict planning suggestions. This can be done by building a common understanding of the threat among policymakers, UP, the affected population, and private actors through environmental education. This entails looking at urban planning not as something limited to technicians and politicians, but as involving all social actors in Matola, regardless of social strata and individual or political interests. This study brings a contribution from retrospective and prospective resilience thinking to the debate on building and promoting resilience in urban socio-ecological systems, as it shows the role of urban planners and planning and management activity since the 2000 floods to the present and perspectives on the future. This study helps expand the scientific understanding of flood resilience by showing in practice, in the case of UP in Matola, the importance of developing competencies and institutional capacity and better and gradually addressing resilience measures.

Note on contributor

José Lourenço Neves has been researching urban flooding and urban planning for flood resilience at the Unit for Human Geography, Department of Economy and Society, University of Gothenburg, Sweden, since 2019. He has taught and worked as a research assistant at the Faculdade de Ciências da Terra e Ambiente da Universidade Pedagógica de Maputo, Mozambique, since 2009, working in the areas of geography, tourism and the environment, territorial and urban planning, and climate change.

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CRediT authorship contribution statement

José Lourenço Neves: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing.

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.

Data availability

The data that has been used is confidential.

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