

Chapter 2

Flood Risk Reduction and Climate Change in Large Cities South of the Sahara

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Abstract In the region south of the Sahara, flooding is the most common natural hazard. Large cities are increasingly affected: 7 in the 1980s, 27 in the 1990s, 37 in the 2000s, and 7 more since 2010. Although many studies link this trend to climate change, our understanding of natural events is still too fragmentary to allow us to appreciate the correlation between precipitation and floods. When attempting to bridge this gap, we should also consider how rainfall affects a city's entire watershed (which can be quite extensive). By contrast, the impact of flooding on places, goods, and people is much better understood. Such effects can be so extreme as to bring the economies of large cities to their knees. Over time, the concept of risk as a product of hazard and vulnerability has expanded to include exposure and climate change adaptation. Mapping flood risk is the first step towards identifying adaptation measures, yet only one of the 11 large cities most affected by floods has a detailed flood risk map. Three of the 11 have adopted climate change adaptation strategies and plans. The remaining eight cities use an array of tools whose impact on flood risk reduction is not yet detectable.

Keywords Flood risk • Risk mapping • Climate change • Local adaptation plans • Sub-Saharan cities

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2.1 Introduction

Floods account for half of the disasters recorded since 1981 in Sub-Saharan Africa, and 78 of them have hit large cities (EM-DAT). This figure alone renders consideration of flood risk a necessity in the context of adaptation to climate change. In addition, flood risk is becoming an increasingly pressing issue for two reasons: firstly, the number of floods is increasing, presumably due to climate change; secondly, large cities south of the Sahara are growing in number. The extent of potential damage is therefore increasing.

This chapter aims to outline the current understanding of the relationship between floods and climate change in an urban context, and to identify the risk mapping methods and main adaptation measures that are slowly being adopted.

In the past, efforts to reduce flood risk have involved at least two different approaches: disaster risk reduction (DRR), which identified exposed areas, mitigation, and post-event measures; and climate change adaptation (CCA), which identified climate change trends (CC) and measures designed to mitigate the impacts of future flooding.

The possibility of combining these approaches has often been suggested (Mitchell and Van Aalst 2008) and, more recently, largely hybridized studies have drawn on both approaches.

The second section reviews what is known about climate change (precipitation and sea level rise) in urban environments. We then move on to consider the present understanding of the flooding that affects large cities in Sub-Saharan Africa in order to highlight existing knowledge gaps. The third section addresses the impact of flooding on large cities in order to determine whether specific adaptation measures are needed in such areas. The fourth section addresses flood risk reduction, with a focus on maps of risk areas, an aspect that is specifically considered in the case studies collected in this publication, as well as adaptation planning.

In order to complete this process, we drew predominantly from the EM-DAT International Disaster Database and maps of flooded areas produced by UNITAR and the ICSMD. The second and third sections proceed on a case-by-case basis, starting with the large cities that are more exposed to flooding, and draw mainly from reports and plans. When considering the actions taken by international donors to promote risk reduction and climate change adaptation, the main source of information is the literature produced by multilateral organizations. We also reconstruct how the definition of risk has evolved over the past two decades.

2.2 Extreme Rainfall and Flood Risk in Large Cities South of the Sahara

Floods are usually caused by the overflowing of large rivers, by flash floods from their tributaries, runoff following intense local rain, and sea level rise, as well as ground water floods and artificial systems failures (Bloch et al. 2012, p. 27).

In the next three decades, temperatures in Southern Africa are expected to rise and rainfall in Eastern Africa is expected to increase (including in the Horn of Africa). Global mean sea level is expected to rise from 18 to 59 cm (according to different temperature change scenarios) over the next 100 years (IPCC 2007, p. 45, 2010).

Detailed studies of climate change and flooding in vast areas are possible, and those that have been carried out have detected—as is the case in South Africa—changes in the intensity of extreme rainfall events (Mason et al. 1999). However, the current understanding of the link between climate change and floods is lacking with respect to individual large cities (Brinkmann and von Teichman 2010). If it were possible to detect variations in the frequency and intensity (mm/hour) of extreme rainfall in large cities, and changes in the duration of the rainy season, we would be able to assert that we are witnessing climate change. Unfortunately, the large cities where rainfall analyses have been conducted are still too few. Moreover, existing analyses are usually limited to annual rainfall over time (Table 2.5). The large cities where the intensity and frequency of heavy rains has been investigated (Addis Ababa, Dar es Salaam, Douala, Maputo) are exceptions to the rule (De Paola et al. 2013) (see Chap. 9). As a result, climate change predictions are formulated only at the national scale, and then presumed to be applicable to individual cities (UN-Habitat 2010a, p. 7). In its *Global Report on Human Settlements 2011—Cities and Climate Change*, UN-Habitat introduces the efforts made by cities to tackle climate change and its impacts, but it does not discuss the changes in precipitation in the watersheds to which they belong or how this contributes to flooding. This information is essential when planning adaptation measures such as drainage canals.

Moreover, urban climate change studies are limited by the lack of weather stations recording atmospheric conditions (Table 2.1). Thus, the link between extreme weather and flooding in urban centers is little understood, and our knowledge of urban flooding is based only on its impact.

2.2.1 Floods in Large Cities

The Emergency Events Database of the CRED EM-DAT Centre for Research on the Epidemiology of Disasters has been recording disasters worldwide in partnership with the WHO and other organizations since 1988, and makes that record available on the Internet. Over the past 33 years, 654 floods have affected 38 million inhabitants and have claimed almost 13,000 lives in Sub-Saharan Africa. This is the number one hazard in terms of frequency and impact in the sub-continent (almost 50 % of disasters are floods).

The same source reveals that 11 % of disasters hit large cities and cause 12 % of total damage. This figure is approximate, as some events are not reported while others involve not only urban areas, but also wider territories that can include smaller cities or towns. It is worth noting that of the 78 floods that have hit large cities, two-thirds have recurred in the same place, including Bangui (7 times),

Table 2.1 Large cities south of the Sahara, 2013: weather station density

City, year	Area		Weather station No.
	Built-up area km ²	Administrative area km ²	
Dar es Salaam, 2011	400	1,690	1
Abidjan, 2009	–	487	1
Accra, 2000	344	3,245	1
Maputo, 2011	182	347	1
Dakar, 2009	156	580	1
Douala, 2013	–	210	1
Niamey, 2013	122	528	2

(Saley et al. 2009; Angel et al. 2005; République du Sénégal 2010) (see Chaps. 5, 11 and 12)

Djibouti (5 times), Accra and Lagos (4 times each), and Bamako, Cape Town, Dakar, Kinshasa, and Luanda (3 times each). The effect of repeated flooding is that it “will reduce the capacity of communities and others to prepare for these events, respond to them, and rebuild in their wake” (UNEP/OCHA 2012, p. 7).

2.2.2 Trends in Flooding

The number of cities hit by flooding is increasing: from 7 in the 1980s, to 27 in the 1990s, to 37 in the 2000s, and in the first two and a half years of the present decade there have already been 7. The number of people affected rose from 310,000 in the 1980s to 3.8 million in the following decade, then fell to 1.2 million in the 2000s, and has dropped to 0.1 million in the past two and a half years.

Maps of the areas flooded following extreme natural events are increasingly available. UNITAR-UNOSAT produces small-scale maps of flooded urban areas. Maps of disasters as they unfold are also produced by the European Union’s Joint Research Centre Global Disaster Alert and Coordination System, as well as by the International Charter on Space and Major Disasters (ICSMD), together with Strasbourg’s SERT.

This documentation does not provide information on the size of flooded areas, though it would be easy to determine using the GIS used to generate such maps, and that information would be extremely useful for planners when estimating damage and preparing for recovery work.

The information gathered on the flooded areas of some particularly exposed cities (Table 2.2) shows that the extent of the areas hit varies enormously from case to case: sometimes it is less than 9 % of the built-up area, while in others it is over 50 %.

In large cities, the flooding of small areas affects tens if not hundreds of thousands of people. The number of homeless people can become a veritable nightmare for local authorities, particularly when one considers that floods are not

Table 2.2 Large cities south of the Sahara: a survey of areas exposed to flooding

	Bangui	Banjul	Dakar	Djibouti	Maputo	Niamey	Ouagadougou	Saint Louis
Year of flood	2009	2009	2009	2001	2011	2012	2009	1997
Built-up (ha)	9,250	4,948	15,560	–	18,240	11,400	21,750	386
Flooded (ha)	800	–	800	1,200	–	2,746	14,878	13
Flood risk (ha)	–	60	–	1,333	5,734	–	–	–
P total (thousands)	1,000	35	...	...	1,100	1,100	308 ^a	...
P flooded (thousands)	181		360	–	70	84	24 ^a	–
Flooded/Built up (%)	9	–	5	48	–	24	68	3
Flood risk/Built up (%)	–	1	–	53	31	–	–	–
P flooded/P total (%)	18		8	–	7	8	8	–

(Nguimalet 2007; Jaiteh and Sarr 2010; Angel et al. 2005; République de Djibouti et al. 2001; Braccio and Tiepolo 2013; Ville de Niamey 2012; République du Burkina Faso 2010; UNITAR 2009) (see Chap. 12)

^a Households

brief episodes: water can often linger for months, and where houses are built of earth (as is still the case in many cities), they collapse.

Over half of the large cities hit by flooding are located along the coast (Fig. 2.1). This means that they are also exposed to the risk of flooding due to a rise in sea level.

There is no connection between the 2013 human development index and the number of people affected by flooding in urban areas, i.e. there is no proof that countries with lower human development suffer more from flooding. This means that even the most developed countries south of the Sahara do not have sufficient adaptation measures in place to reduce the risk of flooding.

2.2.3 Reasons for Flooding

We don't know what natural events cause each of the disasters recorded by the EM-DAT. In some cases, flooding occurs as flash floods, which are intense and last a short time. In many riverside cities, flooding occurs when the river rises above the level of its banks and not because of extreme rains falling on the city, although rains can contribute to the phenomenon. This type of disaster is generated upstream, by intense rains falling on areas that are sometimes hundreds of miles away from the city, affecting vast watersheds and resulting in the swelling of the river far above its usual level. In the Sahel area, flooding occurs due to erosion

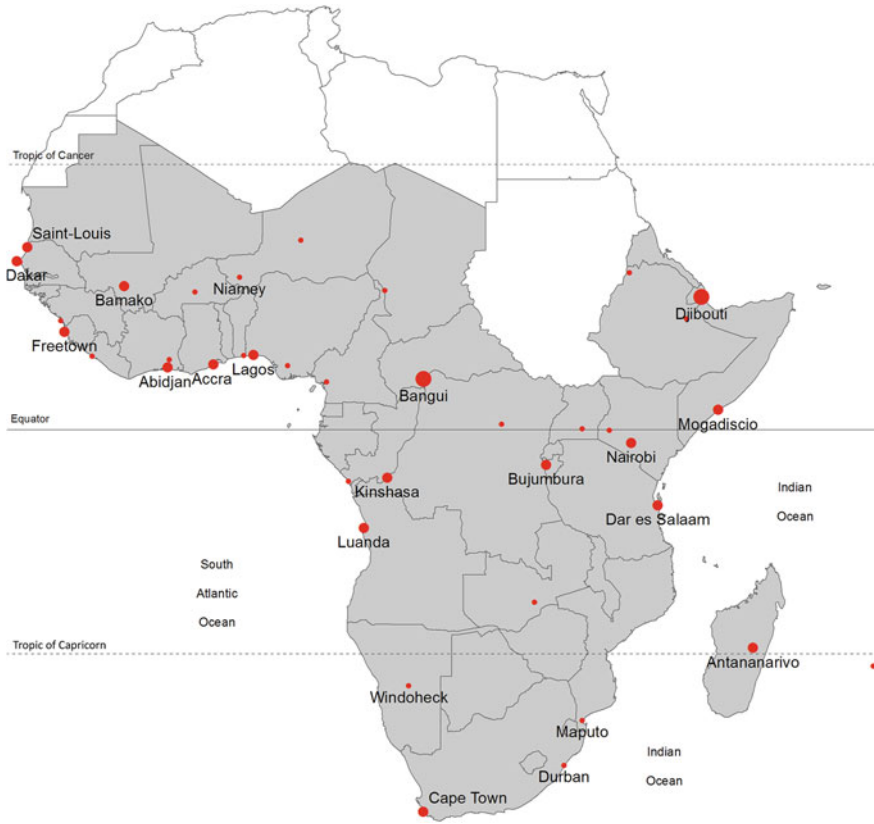


Fig. 2.1 Large cities south of the Sahara, 1981–2013: cities hit by flooding five times or more (*large bullet*), 3–4 times (*medium bullet*), 1–2 times (*dot*). *Source* CRED EM-DAT, formulated by E. Ponte

caused by the reduction of vegetation in higher parts of the watershed (in favor of agriculture and pasture or due to deforestation), which has altered the structure of riverbanks and riverbeds with sand deposits (Mahé 2006). Such was the case with the flooding of Niamey in 2012. Examination of climate change effects on flooding requires an expanded perspective, focusing not only on urban weather stations but considering the network of weather stations throughout the entire river basin upstream of the city, in areas that are, at times, truly vast. The field literature currently available is not an adequate basis upon which to understand such mechanisms.

2.3 The Impact of Urban Flooding South of the Sahara

Flooding has a direct impact on the population, buildings, livestock, crops, and goods, as well as an indirect impact in human, economic, social, financial, political, and institutional terms.

The impact on homes can be devastating if floodwater stagnates. In several parts of Lagos, water from the most recent floods stagnated for a length of time that varied from four to six months (Aderogba et al. 2012, p. 420). Where buildings are made of earth, homes literally melt away. Where they are made of more resistant materials, they remain inaccessible for several days, sometimes weeks. In both cases, properties are devalued (Commissioner for environment 2012). If flooding invades latrines, as in Lusaka (Heat et al. 2010) and in many other cases, the sludge seeps out, contaminating the stagnant water or open fresh water drinking wells, and this can create serious health problems. Indirect problems in this case include the accommodation of displaced persons in camps and their subsequent resettlement.

Another severe impact concerns transport infrastructure such as roads and railways (Adelekan 2000). Their paralysis stops all economic trade, and if petrol distribution is hindered as a result, interruptions in the electricity supply may also occur (UN-Habitat 2011, p. 72).

At other times, flooding can disrupt the provision of drinking water via the municipal supply network (UN-Habitat 2011).

The impact of flooding can be particularly severe in peri-urban agricultural areas (Kolawole et al. 2011), especially in the Sahel, where the great drought of the early 1970s led to the creation of vast irrigation perimeters in order to guarantee food security in urban areas should there be other droughts in future. If high waters exceed the riverbanks and flood the paddy fields, as occurred in Niamey in August 2012, the harvest will be damaged and the country will have to resort to international food aid.

In more general terms, flooding increases the incidence of malaria, can expose the population to toxic substances, harms health, and increases requests for medical assistance.

The impact of flooding on people's livelihoods and goods is potentially huge if settlements are not protected from high water, if they have been constructed in dry riverbeds or if the population has not been warned of the risk of high water with enough warning.

The proliferation of informal settlements with an insufficient number of roads hinders access to relief during emergencies (UNEP/OCHA 2012), increases the impervious surface and therefore runoff, and hinders drainage maintenance (blocked by rubbish). Consequently, an average amount of rainfall may be enough to cause a flood.

The efforts made to react to flooding are greater the more densely populated the exposed area and the more severe the consequences, such as contamination of the clean water supply and treatment centers or the circulation of waste and pollutants

(UNEP/OCHA 2012, p. 17). In any case, it is impossible to evacuate the population of an entire district, especially if there is no contingency plan.

2.4 Flood Risk Reduction in Large Cities

A disaster risk management approach involves the planning, creation, and evaluation of strategies and policies, as well as the organization of measures designed to prepare for, and respond to, emergencies, and to rebuild (IPCC 2012, p. 34).

2.4.1 *Recognizing the Risk*

The first step is always to recognize the risk. Today, risk of disaster is

the likelihood of severe alterations in the normal functioning of a community due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse effects that require immediate emergency response to satisfy critical human needs... (IPCC 2012, p. 32).

The creation of risk maps is considered a priority, and they should be updated and verified in partnership with potentially exposed communities (UNEP/OCHA 2012, p. 11). From the mid-1990s on, risk was mainly calculated as a product of hazard and vulnerability, and it was listed as such in the manuals of the main multilateral organizations until the mid-2000s. At the same time, towards the end of the 1990s, an approach to risk that initially considered exposure, hazards, and vulnerability, and, more recently, capacity, adaptation or preparedness, made headway, and the manual definition of risk evolved accordingly (Table 2.3).

Although there is general agreement on the determinants of risk, each factor may be ascertained using different sets of indicators, depending on the chosen methodology.

The first step in assessing flood risk is identification of flood-prone areas (Table 2.4). This can be achieved using two different methods. The first involves the observation, recording, and mapping of flooded areas. This method is used by local authorities, particularly after flooding, in order to determine the number of people affected for the purpose of distributing compensation. Many such investigations that apply this method have also drawn information from the personal recollections of local inhabitants. Insofar as past flooding is linked to the amount of precipitation in the watershed, these approaches can also be used to identify flood risk areas for preventative purposes. The second type of method is preventative and is based on hydrological models of the areas that could be flooded by heavy rains. This method is not frequently used in Sub-Saharan Africa due to the amount of time needed to gather information, and the cost. Furthermore, it seems to produce rather imprecise results for urban areas characterized by informal

Table 2.3 Different ways of conceiving of risk and some of its applications

Formula ^a	Origins	Multi/bilateral organisation manuals
$R = H * V$	Blakie et al. (1994) Wisner et al. (2003)	UNDHA (1992) GTZ (2002) UN-Habitat (2004) IATF CCDRR (2005) UNDP 2004
$R = Pr * Co$	Jones and Boer 2003	
$R = H, V, E$	Crichton (1999) Granger et al. (1999) Turner 2003 Dilley et al. (2005)	ADRC 2005
$R = H * V * DP$	Villagrán de León (2004)	
$R = H * V * Co$	Kaynia et al. (2008)	
$R = (H * V * Va)/P$	De La Cruz-Reyna 1996 ^a	
$R = H + V + E - Cc$	Davidson (1997)	IADB et al. 2003
$R = H (E + S - A)$		UN-Habitat (2010a)
$R = (H * V)/C$		UN/ISDR 2002 World Bank (2009) USAID (2010)
$R = (H * V * E)/A$	Gotangco and Perez (2010), see Chap. 12	

^a C = Capacity (= adaptation), Cc = Coping capacities, Co = Consequence, DP = Deficiencies in preparedness, P = Preparedness, Pr = Probability, Va = Value threatened. For terms and definitions see UNISDR 2009

Table 2.4 Large cities south of the Sahara: methods used to identify flood-prone areas

Method	Accra	Gwagwalada	Kano	Maputo
Wet area after heavy rains				•
Elevation of flooded area	•	•		
Census enumeration areas nearest stream channels	•			
Stream buffer zone according to slope angles			•	

(Okyere et al. 2012; Rain et al. 2011; Ishaya et al. 2009; Orok 2011) (see Chap. 12)

settlements, which do not lend themselves well to modeling due to the constant changes they undergo (construction work, blockage of the drainage canal network, increasing soil impermeability, etc.).

A hazard as the threat of or potential for adverse effects comes about when a physical event (rain) reaches a human settlement, and this should be expressed as a rain recurrence interval (Table 2.5). However, this is rarely done.

Those exposed to the hazard will be adversely affected by it according to their level of vulnerability, i.e. their ability or inability to cope with the adverse effects

Table 2.5 Large cities south of the Sahara: hazard appreciation

Physical event characteristics	Abidjan	Addis Ababa	Dakar	Dar es Salaam	Kano	Lagos	Maputo	Niamey	Ouagadougou
Yearly rainfall	•	•	•		•	•			•
Monthly rainfall					•				
Daily rainfall				•			•	•	
Years considered in rainfall, n°	29	51	40	53	25	105	46	10	30
Recurrence interval of extreme rains									
Seasonal variation of tides							•		
Sea level rise due to climate change							•		

(Saley et al. 2009; Conway et al. 2004; Da Costa and Kandja 2002; De Paola et al. 2013; Nabegu 2009; World Bank 2009) (see Chaps. 9, 10 and 11)

Table 2.6 Large cities south of the Sahara: indicators used to assess vulnerability to flooding

Sector	Indicator	Accra	Addis Ababa	Maputo	Lagos
Physical	Soil			•	•
	Impervious surface			•	
	Road			•	
	Tree cover	•	•	•	
	Dumping site			•	
	Elevation	•			
	Lack of drainage			•	
	Housing density			•	•
Socio-economic	Poverty			•	•
	Illiteracy	•			
	Casual laborers	•			
Demographic	Fertility	•			•
	Young	•			•
	Migrants	•			
Health	Mortality under 5 years	•			

(Jankowska et al. 2011; Tamru 2002; Adedeji et al. 2012) (see Chap. 12)

of climate change (IPCC 2012). Vulnerability, in turn, can be broken down into sensitivity, adaptive capacity, and resilience (Table 2.6).

Adaptation—understood not as a collection of existing measures, but rather as a combination of future measures—involves a rainwater drainage system in all large cities considered (Table 2.7). Given that drainage systems often do not have the capacity to meet requirements, and are also obstructed by rubbish left in the street and transported downhill by runoff, rubbish removal is an adaptation measure that is often recommended in urban flooding situations. Also common is the use of flood risk assessment, community awareness, and resettlement of the local population residing in flood-prone areas.

2.4.2 Planning Flood Risk Reduction and Adaptation to Climate Change

The abovementioned measures should be coordinated and applied using a timetable. In other words, they should result from a plan. Local authorities should mobilize awareness of such an instrument even at levels above the local sphere.

UN-Habitat is one of the multilateral organizations committed to climate change adaptation in Africa. Since the 2007 *Global Report on Human Settlements*, UN-Habitat has been confronting the issue of disasters and climate change. Rather than being described, climate change is presumed in its various guises (tropical cyclones, heat waves, floods, and sea level rise). Among its noted consequences is

Table 2.7 Large cities south of the Sahara: recommended adaptation measures for flooding

Adaptation measures	Accra	Addis	Bangui	Durban	Lagos	Maputo	Niamey
Flood risk assessment		•		•	•		
Land use zoning					•		
Coastal set back lines				•			
Contingency plan for risk areas				•			
Master drainage plan				•			
Early warning system				•			
Rainfall/runoff projections				•			
Research into CC impact on floods				•			
Disaster relief fund and centers					•		
Protective margins for infrastructure					•		
Drainage	•	•	•			•	•
Drainage maintenance				•		•	
Pumping station to provide drainage					•		
Fight against silting-up of river(s)							•
Soil conservation							•
Slope stabilization/riparian vegetation				•		•	
Reforestation							•
Protecting wetlands					•	•	
Rubbish collection			•			•	•
Industrial waste disposal facilities					•		
Infiltration maximization		•					
Retention ponds upstream		•					
Incentives to leave exposed areas						•	
Resettlement		•	•	•	•	•	
Dwellings built out of durable materials			•				
Community awareness			•	•	•		
Monitoring areas where construction is not permitted			•		•		
Public health			•				
Social insurance schemes		•			•		
Sea walls						•	

(IMWI 2013; Nguimalet 2007; Lewis 2009; Karley 2009; Commissioner for environment 2012; Chap. 13; République du Niger and Ville de Niamey 2012)

migration away from affected areas to cities, which results in an increase in the number of informal settlements in flood-prone city areas. Disaster risk assessment, land use planning, early warning, retrofitting, and formulation of emergency and reconstruction plans were among the first mitigating measures to be proposed (UN-Habitat 2007c). Cities are therefore seen as drivers of climate change through their energy consumption and the release of greenhouse gases. At the same time, the high concentration of poor people makes cities more vulnerable to climate change.

Table 2.8 Large cities south of the Sahara: local assessment tools, strategies, and plans for flood control

Assessment tools, strategies, and plans	Addis Ababa	Bangui	Cape Town	Cotonou	Dakar	Durban	Kampala	Lagos	Maputo	Niamey	Ouagadougou
Loss assessment					•					•	•
CC assessment											
Risk map							•				
Evaluation of needs		•							•		
Strategic agenda for CC adaptation	•										
CC adaptation strategy								•			
Climate adaptation action plan			•			•					
Storm water drainage master plan					•						
CC protection				•							
Local development plan adapted to CC										•	

IMWI 2013; Nguimalet 2007; Mukheibir and Ziervogel 2007; République du Sénégal 2012; Lewis 2009; UN-Habitat 2010b; Commissionner for environment 2012; République du Niger and Ville de Niamey 2012; Ville de Niamey 2012; République du Burkina Faso 2010 (see Chap. 12)

The year following publication of the *Report* saw the launch of the City and Climate Change Initiative in four cities, including Kampala and Maputo in Africa. The initiative was later extended to include Beira, Bobo Djoulaso, Kigali, Mombasa, Saint Louis, Vilankulo, and Walvis Bay (UN-Habitat 2012a).

In the subsequent 2009 *Global Report on Human Settlements*, climate change was recognized as the most important environmental issue (UN-Habitat 2009, p. 5). However, the understanding of climate change in urban environments remained generic in nature. Studies examining Kigali, Maputo, and Mombasa (UN-Habitat 2010) are far from having identified its salient characteristics.

These projects operate within a framework of international agreements that includes the Hyogo Framework for Action (or HFA), which prioritizes early warning systems and measures for reducing specific risks and is supported by the secretariat of the UNISDR (2007).

A system for identifying risk and setting up measures—although its main stages have been defined—remains rather difficult to implement. Mainstreaming flood risk reduction measures into the Millennium Development Goals and into poverty reduction strategies and infrastructure strategies is particularly time-consuming (IPU and UNISDR 2010).

A comparison of 11 large cities particularly exposed to flooding (Table 2.8) allows us to observe the adoption of a wide variety of assessment tools, strategies, and plans for flood risk reduction. Almost every city has some kind of instrument for evaluating damage and mapping risk and needs, and two-thirds of cities have planning tools. On the other hand, the adoption of local planning tools designed to reduce flood risk and facilitate adaptation is a complex process, as shown by the recent survey of promising practices in Africa, which consist entirely of single adaptation measures (UN-Habitat 2012b).

2.5 Conclusion

The connection between climate change and flooding in large cities south of the Sahara is not yet fully understood.

As regards recording and tracking rainfall patterns, a single weather station is not sufficient for vast urban areas such as Abidjan, Dar es Salaam or Maputo. Without multiple data points for a given city, the analysis of annual rainfall cannot be particularly meaningful. Calculation of rainfall recurrence intervals is absolutely essential if we wish to define the hazard (see Chaps. 9 and 12), but this is rarely done, and analysis of rainfall intensity and duration has been carried out in only a very few cases (De Paola et al. 2013). More precise information on daily rainfall (mm/hour) would allow us to understand whether rainfall has intensified over time. Such findings could point to climate change and would, in any case, be pertinent, particularly when planning the scale and location of adaptation measures.

The case studies considered demonstrate that flooding in riverside cities is not caused by local precipitation, but rather by precipitation affecting the entire watershed upstream of the city. This has two important implications: firstly, it is difficult to estimate the impact of future hazards; secondly, adaptation measures to reduce exposure and vulnerability cannot be limited to the urban area, but must also involve rural surroundings. The practical consequence of this observation is that adaptation measures for large cities should actually be adopted to some extent (perhaps to a great extent) outside of their administrative boundaries and agreed to together with other municipalities.

Adaptation assessment is still underdeveloped in Sub-Saharan Africa. Single flood risk reduction measures, including planning tools, are quite dissimilar to each other and do not follow the recommendations issued by the main multilateral organizations that deal with this matter.

The drainage canals in African cities are notoriously ineffective, and current rainfall levels are enough to cause persistent flooding. Resettlement of the entire exposed population exceeds the operating abilities of local governments. The only solution is therefore to ensure that what already exists works properly.

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