Mopping With the Tap Open: The Key Importance of Land Management for Urban Flood Resilience in Houston (Texas) and Accra (Ghana)

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SUMMARY *The recent pandemic of flood disasters has raised key questions about how to mitigate flood damages in cities across the globe. Anticipated extreme weather patterns and ongoing urbanization further exacerbate the problem, and have caused a frantic search for ways to activate cities' resilience from flooding. The focus on urban resilience, however, requires an integrated approach and streamlining of policies of sectoral institutions, that manage different components of the urban built environment: rather than solely relying on large-scale protective infrastructure, the scope of pursued mitigation efforts is expanding to include disaster response and adaptation of the built environment. Based on five years of multidisciplinary research into flood risk mitigation in the 'US' Flood Capital', (Houston, Texas) and a recent World Bank-commissioned study into the flood resilience of Accra (Ghana), we argue that flood resilience is systematically undermined by the land management sector. Despite the different economic and institutional context in both case studies, the flood management and disaster response sectors find themselves to be 'mopping with the tap open': they are unable to keep pace with a land management sector that keeps producing new flood risks. Unless the performance of this key sector is improved – ranging from proper land registration to systematically imposed regulations and building codes at the regional scale – flood losses in these cities will continue to rise.*

1. INTRODUCTION

Cities are particularly vulnerable to natural hazards, due to the large and growing urban population worldwide and the complex patterns of economic assets, infrastructures and services that characterize them. Flood risk has been recognized by established global institutions like the WBG and the UN, and initiatives like the 100 Resilient Cities (100RC) supported by the Rockefeller Foundation, as the key challenge to urban resilience (UN General Assembly, 2015; UNDRR, 2017).

Despite the surge of interest in the concept of urban (flood) resilience, little consensus exists regarding a proper definition (Meerow et al., 2016). However, some key features of the concept are persistent in the debate. First, several studies aimed at defining and operationalizing urban flood resilience, have emphasized the importance of context-dependency (City Strength Diagnostic, 2017; Hallegatte et al., 2018).

A second feature of urban flood resilience is that it may be attained in different ways: as opposed to more traditional infrastructure-based approaches (levees, sea walls, storm water facilities), it includes all measures that mitigate flood losses. The expanded scope and broader concept of flood resilience has the advantage of offering multiple strategies that fit particular governmental and societal contexts. Moreover, it appears that societal preferences for specific

flood resilience measures differ from nation to nation (Kaufman & Wiering, 2017). In particular, nations in Europe that have a dominant flood risk discourse pertaining to high manageability of risks, seem to favor a governance discourse of collectivity and central governance (Ibidem), which may limit the extent of adoptable flood resilience measures (Walker et al., 2014).

A third feature of flood resilience is its relation with the built environment, and the associated notion of interdependency (Jha et al., 2012). Different components of the built environment are managed by different institutions that work with different 'siloed' or disciplinary approaches.

As a rule of thumb, a coordination problem between flood management issues on the one hand and urban development management on the other appears to be prevalent (Remoro-Lankao et al., 2018). This particular challenge has been observed for many nations (Thaler et al., 2016). Emergency response tends to be organized by hazard managers; urban development by spatial planners; and water management of any kind by engineers. Such siloed efforts may lead to frantic efforts to mitigate flooding by one sector in a particular geographic area, while the other sector creates new exposure everywhere (Berke et al., 2018).

In short: despite the globally acknowledged urgency of supporting flood resilience, its interdependent components are not well-understood. This paper addresses this gap by developing a classification of measures that can activate cities' resilience globally, and apply it to two sample case-studies in the US and the Africa. Specifically, this exploratory paper aims at answering questions related to:

- The types of flood resilience measures that are currently pursued (what are the most common ones?), and which institutions pursue them?
- How successful are the institutions in mitigating flood risk? What obstacles do they face, and in particular, how well do they coordinate their actions?

The ultimate purpose of this paper is to provide an *integrated perspective* on urban flood resilience, and use it to identify and discuss the main shortcomings based on the state of the art. First, we describe the main review framework, which includes the identification of measures relevant to flood resilience. We then present the sample of case-studies, and the method that was used to extract information relevant to the study. Afterwards, we present the results of the evaluation. Finally, we discuss the main findings and conclude with recommendations (for future practice and research).

2. METHODS

2.1 Classification of resilience measures

As a first step in this study, we identified and classified possible measures for flood resilience that are relevant for urban areas. Many examples and description of resilience measures are present in the literature (GFFDRFR). However, to the best of our knowledge, a comprehensive classification of typologies of measures has not been developed. Berke et al. (2015) has made an attempt to produce a list of spatial policies that aim to reduce the physical and social vulnerability of communities. However, Berke et al.'s list of spatial policies is focused on explicitly spatial measures like wet- and dry-proofing of constructions, and flood infrastructures. It excludes measures related to disaster- or emergency management.

The Kingdom of the Netherlands (2009) has produced a more extensive perspective on measures to mitigate flood losses, known as the Multilayered Safety Approach (Hoss et al., 2011; Tsimopolou et al, 2015). The MLS-approach builds on an approach known as the Safety Chain, that distinguishes measures based upon the timing of a disaster it targets: before, during, or after (Jongejan et al). For the MLS-approach, the notions of prevention and spatial scale as objectives are added to timing.

First, infrastructures can be built to capture or drain flood waters on a permanent basis; second, vulnerable land uses and/or communities can be expelled from the floodable areas, or structures equipped to temporarily deal with flood waters can be implemented; third, communities can be relocated from the floodable areas during an emergency (Brand et al., 2018). The first option aims to prevent flood water from entering the built environment; the second option aims to minimize economic loss and loss of life; the third focuses on minimizing loss of life only. These three types of measures appear to constitute the full range of flood resilience efforts.

	Measures	**Rationale**
Layer 1	Preventive infrastructures like flood defenses (storm surge gates, levees), storm water reservoirs, drainage systems (sewage, culverts)	Preventing water from entering the built environment; all-inclusive flood loss mitigation
Layer 2	Secondary flood defenses (compartmentalization), designated land uses in the hazard zone, elevation (land or construction), dry- and wet-proofing (construction requirements)	Mitigating flood losses for a selection of sites
Layer 3	Evacuation (protocols), disaster management, awareness programs, early warning systems, contingency plans	Minimizing loss of life only

2.2 Sample case studies

Both case-studies represent rapidly expanding cities that experience rising flood losses.

In the last decade, Greater Houston suffered flood losses by hurricane Ike (2008), the Tax Day flood and Memorial Day flood (2015 and 2016), and hurricane Harvey (2017). The sheer majority of these flood losses were incurred by severe rainfall, that not only caused the 22 bayous in the city to overflow, but also produced 'ponding' (Sebastian et al., 2017). The disastrous evacuation in response to hurricane Rita (2005) claimed many lives, as did the storm surge produced by hurricane Ike. Storm activity is seasonal, with August and September hosting the majority of tropical storms.

Although flooding is a frequent phenomenon in Accra during the rainy season, the city suffered a dramatic flood event in 2015 when compound flooding and clogged drains caused

the Odaw-river to overflow (World Bank, 2017). The majority of the losses were occurred by cascading effects: the explosion of a gas-station where many sheltered from the rising waters.

Large parts of the urban fabric in both case-studies can be defined as flood hazard zones. In Greater Houston, the so-called 500-year flood plain is the administrative boundary for the flood hazard zone since hurricane Harvey. Previously, the 100-year flood plain was used as a standard for both building regulation and flood insurance policies. However, the floodable territory is probably much larger: the flood maps produced by the Federal Emergency Agency (FEMA) are often outdated with properties sustaining losses outside of the registered flood plains (Blackburn, 2017).

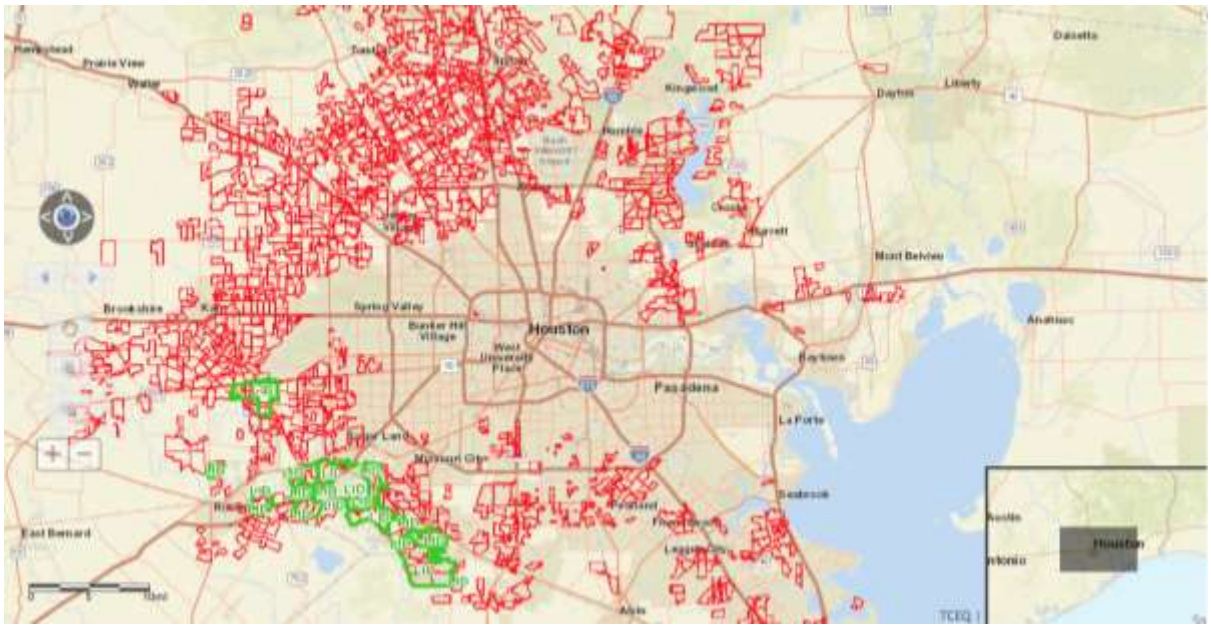

Figure 1: MUDs at the suburban fringe of Houston demonstrate the fragmentation of Texas' institutional landscape. Source: Sebastian et al., 2017.

In Greater Accra Metropolitan Area, the flood hazard area is defined based on elevation: below 34 and 14 meters of elevation respectively (HKV, 2018). For AMA, the historic city center of the metropolis, the implies that at least half of the urban fabric is liable to flood.

Data was drawn for the occasion of this paper from existing research efforts at TU Delft. As a result, the case-studies differ both in spatial breath of data and empirical diversity. No effort has been made to create a statistical or numerical comparison based on these data. Nonetheless, the data allows for a quick exploration and comparison of the trends in flood resilience measures, the institutions that pursue them, and their perceived success.

For Greater Houston, TU Delft has been involved in many, multidisciplinary research efforts that aim to both understand and address flood risk mitigation (Kothuis et al., 2015; Kothuis & Kok, 2016; Sebastian et al., 2017). Many of the data about institutions and their flood risk mitigation efforts has been gathered in 2014, and supplemented for this paper with recent publications (Sebastian et al., 2017; Blackburn, 2017; Blackburn & Bedient, 2018; policy paper 2018).

For Greater Accra, TU Delft was commissioned by World Bank to elucidate the operation of institutions regarding flood resilience, and the correspondence with World Bank's own operation. To do so, a sample was taken from parts of the GAMA metropolitan region: AMA only constitutes one of 23 municipalities within the Greater Accra Metropolitan Area. This limited the scope of efforts and institutions to be captured.

Overall, data drawn from semi-structured interviews was complemented and triangulated with data from existing reports, surveys and papers. As a rule of thumb, Ghana represents a research environment where data is comparatively scarce in comparison with Texas.

Both case-studies represent different economic and institutional contexts. Texas is a classic example of a Republican, 'red' state with a high esteem for personal liberty and property rights, which is in turn associated with a strong antipathy for regulation and taxes (Kothuis et al., 2015). Despite its preference for democratic mayors, the City of Houston is notorious for being the largest north-American city without a zoning regulation – the most basic tool in the US spatial planning kit. The Texas' preference for a lean government with a 'low taxes, low service'-attitude is reflected in both in its decentralized and fragmented institutional system *and* Houston's urban fabric (Sebastian et al, 2017). Larger Houston has a sprawling lay out characterized with car-dependent, low-density development. Outside of the city's fringe, where rapid development is underway, no municipal government exists. Development and the required infrastructure are organized by so-called Municipal Utility Districts that gather funding via bonds and minimal taxes on residents (Basset & Malpass, 2013). Any type of public issue is met with the creation of a special district: an independent, local entity that levies its own taxes. Texas has one of the strongest economies in the US, with a steady growth even during the latest global financial crisis.

Ghana is a former colony of the British empire, and the first to win its independence. Before colonization, the region's institutional system was based on chiefs, clans and territorial tribes, with the Akan-people as the largest unit. The current institutional system is a blend of relatively centralized formal institutions with strong informal ones: the chiefs (City Strength Diagnostic, 2017). Greater Accra is a rapidly expanding metropolis with relatively low density that is serviced by an informal mini-bus (tro-tro) system. The urban fabric of AMA, the historic urban core of Accra, consists of both formal (registered) and informal settlements (Brand et al., 2018). Although not all informal settlements are necessarily slums, the majority is located on lands that are owned by traditional authorities (chiefs). Despite its modest economic growth of the last decade, Ghana is a relatively poor nation with outstanding loans with World Bank (City Strength Diagnostic, 2017).

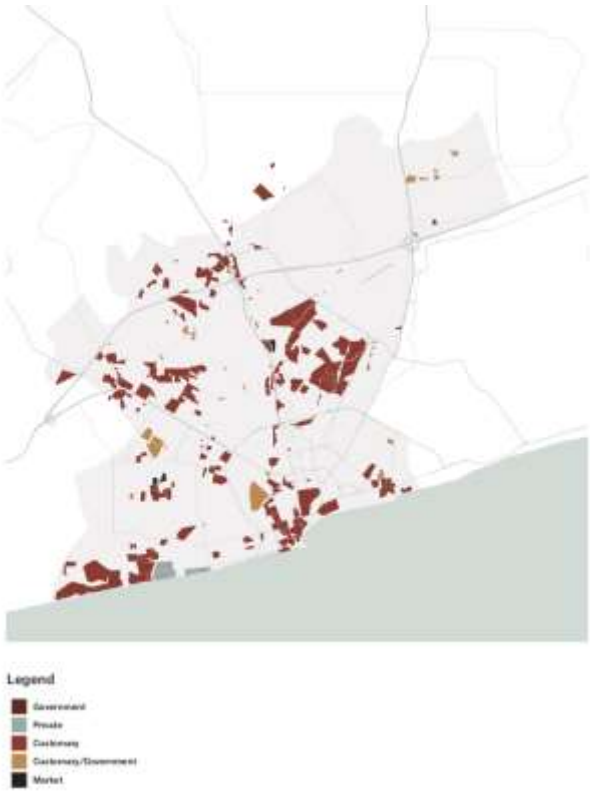

Figure 2: informal settlements within Accra Metropolitan Assembly. The red colour indicates informal settlements located on land owned by customary landowners or 'chiefs'. Source: Brand et al., 2018.

2.3 Analysis of resilience measures

Consistent with the exploratory nature of this paper, after accounting for the largest breath of flood resilience measures, a two-step analysis was performed, using the following guiding questions:

- *Breadth*: how common are the flood resilience measures that are pursued? How widely available are they, to groups or places? Can a certain type of flood resilience measures be identified that is dominant?
- *Institutional*: what is the nature of the organizations that pursue the flood resilience measures? If they are public, what level of government do they represent?
- *Performance*: how well are flood resilience measures implemented? What obstacles for successful implementation exist, in terms of capacities and resources?
- *Trends*: can a trend be identified in the type of flood resilience measures, their implementation success, and/or the institutions that pursue them?

Additionally, we divided the observed resilience measures were divided over sectors according to their safety layer: emergency response, spatial planning & land administration, and flood infrastructure. This allowed for an exploratory comparison of the performance of these sectors.

3 RESULTS

3.1 What types of resilience measures are pursued and which institutions pursue them

Both case studies demonstrate a rise in activities in response to rising flood losses. Moreover, the attempts to mitigate flood losses also appears to diversify.

In Greater Houston, flood losses are mitigated traditionally by (mandatory) flood insurance (NFIP) in the administrative 100-year flood plain, complemented by evacuation assistance provided by the Houston TranStar agency. Both are public services related to the Federal Emergency Management Agency, a federal level institution: FEMA defines the height of location of mandatory flood insurance, and assists local emergency managers in their recovery and response efforts after the US president has signed a federal disaster declaration. After hurricane Rita (2005), evacuation has become more organized based on Zipcode areas, evacuation routes and contra-flow. Building-level adaptation is also fairly common: building codes (elevation) applies to new development in flood plains, and can also result in discounts on insurance premiums of the NFIP. Municipal governments can choose to adopt stricter building codes. On the barrier islands in front of the Texas coast, structures are raised on ever-higher stilts. Compliance is ensured by municipalities or county flood plain management. Since hurricane Harvey, regulations have been extended to the 500-year flood plain. In the absence of comprehensive spatial policy, mandatory hazard mitigation policy is not translated in local development (master) plans. Although the majority of flood resilience efforts take effect during or after a disaster (and can be labeled as recovery-based), preventive infrastructures do exist. In the southwest of Houston, the US Army Corps of Engineers (USACE) operates two storm water reservoirs: Harris and Baker. Last year, a bond-issue was raised by the City of Houston two fund a third reservoir on Kathy Prairie. The Harris County Flood Control District (HCFCD), a special district, manages the bayous in Harris County only. It also assists in buy-outs: the buying and grazing of properties that have been flooded multiple times. Afterwards, building is restricted in such areas – unless the buy-out has been funded by Texas State (which appears to be rare). This practice has experienced a hike after hurricane Harvey, and is (partly) funded by FEMA as well.

In Greater Accra, flood losses are primarily mitigated by storm water drains and sewers that are maintained by infrastructure departments at the municipal (assembly) and national level. Formally, a building ban applies parallel to open waterbodies: this should prevent encroachment of development into floodable areas. Municipal assemblies are required to oversee compliance. Emergency response is organized by NADMO, Ghana's national disaster management agency. The agency also sits in the municipal planning committees, which could theoretically guarantee consideration of flood resilience in all spatial development schemes. NADMO has limited staff, and relies on police- and firemen from the local assemblies. A large amount of non-public organizations assists in emergency response, including religious organizations (Catholic relief, Red Cross) and international ones (UN). Since the 2015 flood event, incremental steps towards diversification and sophistication of flood resilience efforts have been taken. UN has supported the creation of an early warning system, while in Adenta Assembly flood shelters have been built. Currently, Ghana's central government considers a combined flood infrastructure and community upgrading project, that

would capture rain upstream of the Odaw and upgrade or resettle vulnerable communities downstream.

3.2 How successful are institutions in mitigating flood risk?

In Greater Houston, a coordination problem between flood management issues on the one hand and urban development management on the other exists (Sebastian et al., 2017). First, the urban fabric of Greater Houston continues to expand precisely at those sites that do not have a municipal government yet. Such sites are often in Houston's Extra territorial jurisdiction (ETJ) and it is the absence of regulation and sales tax, and the comparatively low fees to be paid to MUDs that makes building attractive (Basset & Malpass, 2013). As a result, development always outpaces the large-scale flood infrastructures required to off-set for the hardened surfaces that prevent the soil from absorbing rainfall. The excess water produced by MUDs ends up downstream, in the City of Houston, which needs to raise funding for storm sewers and reservoirs by voting for bond issues. City nor County can prevent building outside of the City proper, or add building regulations. Moreover, HCFCD is only operational in Harris County (leaving the other counties bare of a special flood management district). Both HCFDC and USACE have difficulty maintaining the safety of their flood infrastructures – demonstrated by the near failure of the reservoirs during Harvey – allegedly due to funding constraints. Houston TranStar operates in the entire metropolitan region, but struggles to warn and evacuate a growing population using a limited regional and national infrastructure network. Despite the increased efforts to mitigate flood losses after Hurricane Harvey, it has been noted that no real policy change has occurred in the region (policy paper).

In Greater Accra, challenges in the urban land management sector undermine other flood mitigation efforts (Brand et al., 2019). This is demonstrated strongly in the continued existence of informal settlements in areas that are liable to flood. Inadequate adherence to land use regulations is allowed, as the local assembly either does not have the resources to enforce compliance, or chiefs successfully request leniency. Moreover, despite many World Bank-funded efforts to introduce a nation-wide land administration-system, lack of clarity on ownership and registration (delays in title/deed registration) undermines and efficient land market. Next to an often-cited structural lack of resources, a coordination problem exists between many institutes within the same sector. Lack of communication between for example the hydrological services department (HSD), the Ministry of Urban Roads, and the local roads department (DUR) has resulted in misaligned culverts and drains that exacerbate flooding. To some extent, this is related to the activities of World Bank: preconditions for loans often contain demands for new institutions and legislation, a phenomenon known as 'institutional proliferation'. Institutions also disappear once projects are finished, resulting in a versatile institutional landscape. In contrast with Texas, local (if not regional) planning schemes exist. For example, a recreation scheme was developed for the lower Odaw-area that expanded the flood plain at the expense of informal settlements. The Old Fadama community was resettled for this purpose, but lack of resources to prevent new settlers from coming in allowed New Fadama to develop. Regular cleaning of drains to prevent clogging is similarly hindered by lack of resources.

4 CONCLUSION & DISCUSSION

The results of this study suggest that, when an integrated perspective to urban flood resilience is adopted, as serious cross-sectoral coordination problems comes into scope. In both cities, rising flood damages are responded to by an increasingly broad range of flood resilience measures, pursued by different sector-based organizations. This suggests, first, that flood resilience is a relatively young policy concern that is still finding its way in the institutional system.

Not all of these resilience measures, however, are easily squeezed into the simplicity of the multilayered flood safety-approach. A key example are flood insurances, that are a key part of flood management in the US. Such resilience measures, for one, do not represent infrastructures. Moreover, that have a real impact on spatial planning and land management.

A key observation is that most flood resilience efforts are taken by the flood management and emergency response sectors, and they face serious obstacles in their effectiveness. We argue that flood resilience is systematically undermined by the 'land management' sector in both cases.

In Texas, land management in the broadest sense is impeded by societal preference for a lean government, which results not only in a lack of spatial planning powers at the regional scale, but also in its decentralized and fragmented institutional system. The Texas-case raises key questions about societal preferences of (de)centralized approaches to flood risk management (Kaufman & Wiering, 2017), and the potential constraints this puts on effectively activating urban flood resilience (Romero-Lankao et al., 2018).

In Ghana, spatial planning powers do exist, but are ineffective because of non-compliance, informal land transactions and interference with mandates. Next to the informal, but more importantly, non-transparent power of chiefs over land in the city, conflict over landownership complicates flood resilient land use planning schemes. That, unfortunately, applies to acquiring lands for upstream reservoirs, and keeping lands downstream free from settlement.

Despite the different economic and institutional context in both case studies, the flood management and disaster response sectors find themselves to be 'mopping with the tap open, as the Dutch saying goes'. They are unable to keep pace with a land management sector that keeps producing new flood risks. Unless the performance of this key sector is improved – ranging from proper land registration to systematically imposed regulations and building codes at the regional scale – it is likely that these cities will continue to flood. Proper land (use) management is a decisive precondition for success. This applies to virtually all types of efforts, ranging from the creation and operation of (preventive) infrastructures to the reallocation or flood-proofing of vulnerable land uses and communities.

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