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NEEDS FOR ADAPTATION OF URBAN FLOOD MANAGEMENT UNDER CLIMATE CHANGE

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ABSTRACT: The problems posed by urban flooding are difficult to confront and manage. Urban centres already comprise over 50% of the total population worldwide and, according to the United Nations, this number is projected to rise to 70% by 2050. The combination of climate change, increasing urbanization, demands for housing and industrial land, and economic development cannot be discounted in urban flood management. The past may no longer be a reliable guide to the future, which particularly concerns urban flood management planning and implementation. Rather than focusing on any one of these issues or one single measure, it is necessary to combine them into a comprehensive planning process. This process requires flexibility and regular validation in order to increase adaptation and enhance community resilience.

The paper examines the key elements of effective urban flood management through the lens of climate change. Addressing these key elements requires an integrated approach that aims to "live with floods" and empower participation of various stakeholders involved in flood management. The paper discusses the major issues and aspects of both urban flood management and climate change adaptation likely to have a significant impact on urban planning. It also explores how current policies, planning and implementation mechanisms can be assessed and evaluated. The paper attempts to answer the question: is the current urban flood management model effective within the context of climate change? Two case studies will showcase and illustrate the application and management of such integrated strategies.

Key Words: Adaptive strategies, climate change, integrated flood management, urban flooding

1. INTRODUCTION

The problems posed by urban flooding are difficult enough to confront and manage. These problems will become even more troublesome with climate change, as the degree and extent of climate variability move in unpredictable ways, and as a high level of uncertainty remains regarding the trends and possible next equilibrium state(s) of the world climate. Urban population already comprises over 50% of the total population worldwide and, according to the United Nations (2011), this number is projected to rise to 70% by 2050.

This paper outlines the key elements of effective urban flood management through the lens of climate change. These elements require integrated approaches that aim to “live with floods” and empower participation of various stakeholders involved in flood management. The paper discusses the major issues and aspects likely to have a significant impact on urban planning. It also explores how current policies, planning and implementation mechanisms can be assessed and evaluated, attempting to answer the question: is the current urban flood management effective within the context of climate change? Two case studies from Jakarta, Indonesia and Malmö, Sweden showcase and illustrate the application and integration of such integrated strategies.

Cities and communities around the world have enough problems with flooding as it is. Climate change will likely not make things any better or easier. It is very possible that present, expected precipitation and flood parameters will change, so will variations about the mean that communities and flood planners have become accustomed to over the past decades. Climate change will bring about alterations in meteorological circumstances lasting for long periods. These alterations will "play themselves out across space and time, owing to differences in infrastructure densities and use, difference in environmental conditions, and the long-term nature of climate change as well as the long-lived nature of the various infrastructure systems" (Kirshen et al., 2006). Climate change will likely complicate the demands imposed on communities, which already face rapid urbanization, industrial expansion and the pressure for economic development.

The underlying principle of climate change effects is both simple and stark: Past history – upon which much of planning and design rest – may no longer be a reliable guide to future performance. Urban flood planners and managers will find it difficult to make planning and investment decisions regarding adaptation to climate change when faced with questions for which there are, as yet, few clear and definitive answers. For example:

- Will floods or droughts be more severe?? Will there be higher intensity rain storms over a shorter period of time? Can this change be quantified?

- Will extreme events happen more frequently with less time for recovery between them?

Designers and planners will have to become more comfortable with uncertainty and learn to deal with a more mobile target when planning flood responses and designing systems. Budgeting for flood planning and response may be even more difficult than it already is. Urban managers and elected officials will have to address vulnerable infrastructure, built with a considerable investment of money and resources, but which is aging and deteriorating with less money being invested to maintain, replace or retrofit it. Everyone involved will have to face the vital, but uncomfortable, question: Is it useful to maintain or retrofit systems to past design standards based on past climate history?

Uncertainty will also play into decisions on adaptation to climate change, as people weigh the costs and benefits of doing so. Stern (2007) points out that "there will be little financial incentive for developers to increase resilience of new buildings unless property buyers discriminate between properties on the basis of vulnerability to future climate". A possible measure could be governments update their building codes. On the other hand, how will prospective purchasers or developers factor in a 100-year flood (or other extreme weather event) if they plan to occupy the property for only 5–10 years (Labadie, 2011)?

2. FACTORS IMPACTING URBAN FLOOD MANAGEMENT

Efforts to manage urban flood water tend to focus on confining the water in restricted channels, preventing it from flowing into certain "high-value" areas, and speeding its transit through the urban areas to somewhere else. These tactics, of course, don't solve the problem; they merely shift the problem, and the deleterious effects, to a different location or part of the city or to the next downstream urban area (WMO, 2009a). Operations and maintenance of drainage systems and flood control measures are important, especially when these systems intersect or overlap with other infrastructure elements and operations. Poor maintenance of roads and culverts can negatively affect the effectiveness of flood control measures.

Communities and their agencies must always be on guard to ensure that trash and debris do not clog drainage channels, therefore, reducing their carrying capacity. Operation of sewage treatment systems, along with combined sewer overflow elements, must be emphasized in order to protect public health. Storms, heavy rainfall events, and flood events should be considered in the design of drainage systems, sewer systems and treatment plants so that they are not overpowered and can function during extreme events.

Long-lasting (or more frequent/intense) rainfall events can lead to saturation of the soil, leading to increased surface flow, destabilization of slopes, and landslides – all of which can damage infrastructure elements, whether installed above ground or below the surface. Migrants to urban areas build shelters on marginal or unimproved land because they cannot afford to live elsewhere. Their shelters are built of bamboo, tin, cardboard, scrap metal or other light materials that are more vulnerable and will not withstand flood waters. In many cases residents of informal settlements fill in natural drainage channels with dwellings or waste materials, preventing normal rainwater flow and causing the water to spread out into the residential area. Pathways and (unpaved) streets that reflect the travel patterns of the residents are beaten flat and impervious, affording no means for infiltration and soil absorption of precipitation, but providing a free passage of surface runoff and flood water into homes and businesses. This exacerbates exacerbate the situation, particularly as no primary and secondary stormwater management or comprised system has been considered.

The direct impacts of urban flooding are clear and easily observed: inundation of buildings and residences, damage to structures, washing away of belongings and vehicles, destruction of public infrastructure, mud and mold everywhere – not to mention injuries and loss of life. Less obvious are the backup of sewage into homes and buildings and the release of untreated sewage from damaged treatment plants. In addition, hazardous chemicals and fuels may be spread by flood waters from damaged production facilities or storage areas. Both untreated sewage and toxic chemicals can pose significant threats to public health and the water supply.

Other impacts are often overlooked in planning for, responding to and recovering from urban floods. The ability to earn a livelihood may disappear for some time. The ability to travel to work may be seriously compromised. Schools and other community centers or services may be closed for days or weeks, and commercial businesses that provide food and necessary items may be damaged or inaccessible. At the same time, flood waters and related flood damages may reduce the amount of vital supplies that can be transported into the city, lengthen the travel time or even stop the movement of supplies altogether. The various direct and indirect impacts may severely harm a city's economy and hinder recovery. Thus, one flood event can adversely affect potential preparedness and mitigation measures prior to the onset of the "next" event.

3. URBAN FLOOD MANAGEMENT AND CLIMATE CHANGE ADAPTIVE STRATEGIES

The policies and practices of urban flood management are firmly embedded in the social, economic, financial, cultural and ethical circumstances of the community. Choosing a particular course of action in flood management will bring and require changes in all the other factors – and vice versa. Climate change effects, and the need to adapt to those effects, could have a profound impact on all aspects of a community's life. It is necessary, therefore, to integrate urban flood management decisions considering adaptive strategies to cope with climate change allowing the greatest benefit for the community, not only in short-term solutions but also in long-term planning. This integration of strategies will enhance capacity to adapt and will support economic development and recovery.

Urban flood management must deal directly and explicitly with drinking water supply, sewage and wastewater disposal, and surface runoff disposal, while managing both stormwater quantity and the effects of stormwater on water quality (WMO, 2009b). In so doing, urban flood managers must also work within the framework of Integrated Flood Management so as to meet the larger issues of effectiveness, socioeconomic equity, and long-term positive outcomes. The urban flood zone lies within a larger watershed and floodplain area, and its flood hazard and experience cannot be divorced from the management of the hydrology of the entire system.

Many urban centres have developed flood management plans and approaches that share a common feature: a unique focus on the hydraulic and engineering aspects of flood management. This focus ignores the very real environmental, political and socioeconomic aspects of flood management as well as

any other options that could provide more optimal solutions. It is impossible to control or totally eliminate floods. Instead, planners and practitioners need to concentrate on enhancing the resilience of the population to flood risks. Tucci (2007) puts it most succinctly:

> *Flooding is controlled by a combination of structural and non-structural measures enabling the riverside population to minimize its losses and continue to live in harmony with the river. These include engineering and social, economic and administrative measures. Planning of protection against flooding and its effects involves research into the ideal combination of these measures. (Tucci, 2007)*

Implementing urban flood management as an adaptive strategy goes well beyond the traditional, structural approaches, and it includes a great number of issues and practices that are not usually considered in flood management.

> *Adaptation is a process by which individuals, communities and countries seek to cope with the consequences of climate change, including climate variability. It should lead to harmonization with the country's or community's pressing development priorities such as poverty alleviation, food security, disaster management of economic development. It can be undertaken in a pro-active mode: through strategic planning in incremental stages; or autonomous mode where ad-hoc tactical adjustments are made as the events and situations unfold. (WMO, 2009b)*

The basis for any urban flood management plan is a comprehensive assessment of current and potential flood risks that identifies all the possible flood-related hazards. This assessment also includes how hazards develop in the future as a consequence of further urbanization, urban development, land-use changes or climate change. An "acceptable risk" assessment entails ():

- Understanding projected climate scenarios and potential impacts and the limitations of the projections,
- Identifying the most vulnerable groups, areas, sectors, and urban systems and how they may be affected,
- Identifying the range of factors that systematically combine to make them vulnerable, including both direct (e.g. exposure to hazards) and indirect (e.g. regional or international food security) factors,
- Assessing of existing capacities to adapt, and
- Assessing scenarios of structural and non-structural solutions that mitigate the impacts.

The application of technical, non-structural methods greatly extends the traditional approach to urban flood management. Land-use management policies and processes are a natural companion for urban flood management, and both contribute significantly to Integrated Flood Management and Integrated Water Resources Management. Building codes provide specifications for the design, operation and maintenance of buildings and infrastructure facilities. Municipal drainage and stormwater codes regulate the operation of stormwater systems, covering what can legally go into the system, how the system must be managed and operated, and what is allowed to exit the system – whether into a treatment plant or into a water body. Urban development plans must also he developed to show the sufficiency of primary and secondary stormwater management systems.

4. THE IMPORTANCE OF COMMUNITY PARTICIPATION IN URBAN FLOOD MANAGEMENT

Community participation addresses the practical aspects of managing floods, and it is essential in urban areas, where population density is high and space for flood mitigation and emergency measures is limited. It is vital to identify and integrate the involved stakeholders' needs and concerns from the beginning, not only to raise awareness of potential risks and actions to be undertaken in the event of a flood (e.g. evacuation routes). Like this, community participation contributes to building consensus among planners and the community, and ensures acceptance and effectiveness of basin-wide planning and decision-making.

Each stakeholder and community has different perceptions of risk. Various communities, individuals and groups have different vulnerabilities and capacities to cope with and recover from flooding. This said, many factors need to be considered, such as age, gender, class, source of livelihoods, ethnicity, language, religion and physical location

Urban communities often live in the riskiest environments, such as flood plains, unstable slopes, and coastal areas. These are also usually the sites most at risk from the adverse impacts of climate change. Adaptation and urban flood management will likely be driven by arguments about equity and fairness: Who sets the priorities for recovery? How are the needs of low-income residents balanced with the needs of those who are better off? Who decides what will be rebuilt where? Whose home or business gets flooded when levees are breached to relieve flood water buildup? Who gets displaced when new facilities are constructed during recovery?

5. CASE STUDIES

5.1 Malmö, Sweden

An excellent example of integrated planning and implementation occurred in the neighborhood of Augustenborg (Malmö, Sweden). Augustenborg has experienced periods of socioeconomic decline in recent decades and has frequently suffered from floods caused by overflowing drainage systems. In 1999-2001, the City of Malmö initiated a Sustainable Urban Drainage Systems (SUDS) as part of an effort to combat flooding, improve waste management and enhance biodiversity.

> *Due to recurring flooding problems it was proposed that stormwater from Augustenborg should be disconnected from the existing combined sewer, and drained by means of an open system. The main intention was to reduce flooding by 70%, eliminating combined sewer overflow completely, by both lowering the total volume of stormwater reaching pipes and reducing the peak flow rates. This has been achieved by reducing the impervious areas and the associated runoff, preserving and enhancing green spaces, and managing stormwater to reduce total runoff. (Kazmierczak and Carter, 2010)*

As a result of this project, the stormwater system is now able to handle runoff volumes locally. The implementation of this system has improved both stormwater management in the area, and the performance of the combined sewer system. The volume of stormwater draining into the combined system is now negligible, and this system now drains almost only wastewater. This type of integrated planning takes into account not only the outcome of flood risk mitigation, but also of the resulting economic and environmental impacts.

5.2 Jakarta, Indonesia

Jakarta is located on the north coast of Java, Indonesia, and is one of the world's largest and rapidly developing urban areas. Flood risk in Jakarta can be characterized as a result of coastal and riverine flooding. This risk is aggravated by land subsidence as a consequence of excessive deep groundwater extraction for water supply.

The Jakarta Coastal Defence Strategy (JCDS) is an example of an integrated approach that combines flood risk reduction with urban development and spatial planning. Because flood risk is a function of many factors, its solution includes traditional flood protection but also aims to solve drinking water supply problems, water pollution and traffic jams. The overall aim of JCDS is to protect Jakarta against coastal flooding. To do this, a strategic plan has been developed that "integrates effective technical solutions to prevent flooding (livable dikes, retention ponds, pumps) with additional measures to make the technical solutions sustainable (piped water supply, sewerage and sanitation, resettlement), and with investment opportunities to make the overall plan financially feasible based on internal cross-subsidies and public-private partnership (land reclamation, toll roads, and deep seaport) (WMO, 2013). An important aspect of the plan is integration. Future plans further push the approach of coastal development incorporating aspects of coastal defense in its overall design, aiming to decrease subsidence and reclaim land from the sea.

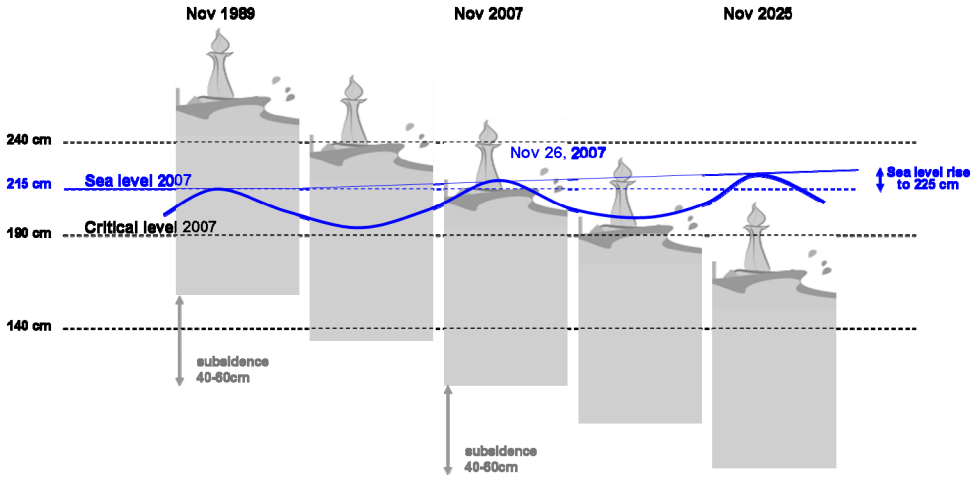

Figure 1: Land subsidence in Jakarta compared to a flood event in 2007. The upper blue line is the expected effect of sea level rise (WMO, 2013)

As structural measures alone cannot provide adequate risk management, an integrated approach requires their combination with non-structural measures.

- Measures taken at the community level include the participation of communities to reduced flood risk and address sanitation aspects. Health risk is particularly high during flood events. As a result, community action plans were initiated, with the aim to raise awareness on recycling, canal cleaning and maintenance, and solid waste management. Both capacity and awareness building required the involvement of and support from already existing groups and stakeholders to ensure the effectiveness of risk reduction measures.

- When water levels rose off the coast of Jakarta in June 2008, precise and timely predictions contributed to the protection of large parts of the city from being flooded. Timely flood warnings allowed emergency managers to build provisional water defences from sandbags and bamboo, and to start pumping operations in time. The result was a dramatic limitation of flood damages.

6. CONCLUSIONS

Urban flood management is a continuous process that must recognize social, economic and environmental aspects in striving for an acceptable solution. It is imbedded within integrated flood management, which lies within integrated water resources management on a basin-wide basis. All of these processes must be responsive to the likely – but as yet uncertain – effects of climate change. At the same time, population growth and related social dynamics, livelihood requirements, economic development, land use development, environmental protection and so on interact to influence the hydrological circumstances of a river basin and floodplain.

Each of these forces is dynamic and continues to evolve, as do the direct and indirect pressures they exert on flood management policies and practices. One cannot create a comprehensive picture of the future by examining each of these factors independently. They interact in various expected and unexpected ways and must be addressed holistically.

The uncertainty inherent in climate change projections may mean that risk-centered approaches and risk-based analysis (including cost-benefit analysis) are no longer as applicable or robust as they once had been. The combination of climate change, increasing urbanization, demands for housing and industrial land (often in the floodplain), economic development and rising expectations must be considered in urban flood management. The past may no longer be a reliable guide to the future, especially when it comes to urban flood management planning and implementation. Rather than focusing on any one of these issues, it will be necessary to combine them – and their many stakeholders – into a comprehensive planning process for increasing adaptation and enhancing community resilience.

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