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Review

Flood risk inevitability and flood risk management in urban areas: A review

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The increasing probability of flood risk in terms of its magnitude and frequency in urban areas prompted man to act for flood mitigation measures. Various flood risk control measures were carried out in different parts of the world but flood events persisted. This paper assessed the main causes of flood risk in urban areas and the various flood risk management measures for flood control so as to come out with a sustainable flood risk mitigation measures for urban areas. Related theories and empirical studies were reviewed as a method to acquire relevant information for analyzing the factors of flood risk and the trend in flood risk mitigation measures. The result points out the inability of both structural and non-structural measures to completely stop flood occurrences. Hence, an integration of the current measures and a partial systematic conversion of land use to its natural state can sustainably reduce flood risk in urban places.

Key words: Flood risk, flood risk management, urban areas, flood mitigation.

INTRODUCTION

Flood risk is one of the most devastating natural hazards that cause loss of lives, damage to properties, resources and environmental degradation in urban areas (Forkou, 2011). Over 3,000 flood disasters occurred in a span of twenty years from 1990-2010 and are responsible for the death of 200,000 people and making 3 billion people homeless in the world (Smith, 2013). It is estimated that on average almost 200 million people in more than 90 countries are exposed to catastrophic flood events every year and it is expected to rise in future due to climate change and the steady demographic growth, as well as of urbanization (UNESCO, 2008). A crucial concern for world natural hazards is the generation of efforts, strategies, policies and programs of the global governments at various levels to mitigate the flood occurrences.The persistence incidence of flood events besides the measures undertaken indicates the inability of flood control measures to adequately control floods. A sustainable flood risk management requires flood risk assessment to identify forces and factors causing potential flood risk. This paper reviewed various theoretical and empirical literatures as a method for collecting information regarding causes of flood risk in urban areas and the corresponding flood mitigation measures so as to discover a sustainable flood risk management measures for urban areas.

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Some literatures attributed flood risk to climatic change. For example, Karley (2009) claimed that the main causes of flooding in Ghana are intense rainfall that generates massive run-off that causes floods. Criss (2009) asserted that the increasing frequency of flood events could not be unrelated to climatic change.Others researchers argued that the increasing flood events was not only due to the extreme climate changes, but a continued encroachment of people and properties in areas at risk of flooding leading to an increasing potential damage (Hooijer, et al., 2004). In essence flood risk is generally assumes as the probability of hazard (climatic change), and the exposure and vulnerability of the elements at risk. A clear understanding of the three elements that create the risk gives the necessary information for factoring in most flood related aspects in the overall management of flood risks and at the same time contribute substantially to the development and wellbeing of the people (WMO, 2009).

Since flood risk is defined as a function of probability of flood hazard and the potential damage, most flood reduction measures aimed at reducing the probability of flooding and minimize the potential damage (Hooijer et al., 2004). Therefore, options available to manage flood hazards include structural (dyke, dams, reservoirs, relief channels, embankments). For instance Sultana, et al. (2007) asserted that structural measures like embank-ments can provide protection against many types of flooding.

A second perspective on flood mitigation emphasizes the integration of water resource management, land-use management, hazard management and changes the Flood Risk Management (FRM) paradigm from defensive to pro-active, from ad-hoc to integrated flood manage-ment. It focuses on managing and living with floods, balancing floods for sustainable development, and approaching the decision-making process differently by learning to manage risk and live with the floods (WMO, 2009). Whether responses to flood hazard take a structural or a combination of both structural and non-structural measures, there remains a need for public involvement of communities at risk in decision making for flood risk management sustainability in urban areas.

Besides all the measures above the review discover flood occurrence and frequency persisted in urban areas and it became apparent that total prevention from flood risk is inevitable. The paper also find out that, a gradual systematic land use conversion to its natural state could sustainably decreases flood risk and flood frequency (Scilling et al., 2014).

LITERATURE REVIEW

Theoretical basis for flood risk inevitability

There is no doubt for an increasing concern on flood risk in various towns and cities around the world especially river floods that account for almost half of the deaths and one-third of all economic losses from natural hazards worldwide (UNESCO, 2008). In a span of twenty years from 1990-2010 floods are responsible for 200,000 deaths and affected 3 billion people by making them homeless (Smith, 2013). Continuous rising of flood incidence globally and the increasing flood risk led environmental scientist pondering on what could be the possible factors behind this environmental problem and what are the possible measures against it. Many different perspectives exist explaining the main reasons for flood risk and these are examined below.

The climatic factors

Many urban flood risk research works have different findings regarding factors responsible for flood risk, although disaster problems may sit at the interface of the natural and social environment. In essence flood risk has been conceptualized as a function of the changing climate, the socio-cultural environment and some time a combination of both climate and the built environment.

Some environmental researchers argues that global warming and climate change is directly and or indirectly increasing the amount of rain and ice melting and thereby increasing the magnitude of runoff and subsequent flooding. For instance flood disasters in Zimbabwe are related to two different phenomena: localized heavy seasonal rainfall causing rivers overflowing and the cyclone induced floods leading to frequent and seasonal flood (Ghimbi, 2007). According to Karley (2009) the common causes of flooding in Ghana are intense rainfall leading to run-off, dam-burst and tidal waves, and spread flooding was a result of Cyclone Eline in 2000 over Mozambique, South Africa, Zimbabwe, Malawi, Botswana and Namibia (Vaz, 2000). Criss (2009) asserted that the increasing frequency of flood events could not be unrelated to climatic change.

However, flood hazard and its risk could not be accounted as the only one factor responsible for flood risk; therefore more factors are needed to give adequate insight and understanding of the process.

The socio-cultural factors

The second perspective claimed cultural activities have significantly affects the working of the physical natural environment and that the environment is only responding to these actions.Of all land uses changes affecting hydrology of an area, urbanization is by far the most forceful bringing changes in peak flow characteristics, changes in total run off, changes in quality of water and changes in hydrological amenities (Leopold, 1968).The increasing human population in the urban areas and the encroachment and modification of the flood plains of river

systems are contributing factors to the increasing damages and risk causes by the floods (Samarasinghe et al., 2010).The volume of runoff is governed primarily by infiltration characteristics and is related to land, slope, soil type and vegetation. It is thus directly related to the percentage of an areas cover by roofs, streets and other impervious surfaces at time of hydrograph rising during storms (Leopold, 1968). The increase in impervious surface such as the effect of increasing flood peaks during storm period and decreasing low flows between storms (Leopold, 1968). For example removal of vegetated land cover by replacing it with concrete surfaces in urban areas increases impermeable surfaces, thereby causing increase in overland flow and reduces infiltration, bypassing the natural storage and attenuation of the subsurface leading to quick runoff and flooding. Therefore urbanization increases the volume and rate of surface runoff through alteration of natural drainage system and modification of runoff to streams. The end result is a greater volume of runoff, discharging in a shorter period of time and potentially leading to dramatically increase in flood peaks (Smith, 2013).For instance empirical studies shows that climate has not been a consequential factor in the observed increasing flood damages in Africa according to a study by Baldassare et al. (2010) on flood fatalities in Africa. The actions include but not limited to poor planning of the physical environment, poor management of wastes, inadequate drains for the built up areas but also occupation of the floodplain areas. Hooijer, et al., (2004) examines that the impact of 30 years of urbanization on two sub-catchments of the Thames, showing a clear increase in flood frequency with urbanization, followed by a reduction in storage. Daniel (2012) also claimed that the general notion of heavy rainfall as been the major cause of urban flood is refuted, but lack of urban infrastructures play a major role for flood disaster in Gombe metropolis, Nigeria.

This perspective theorized based on empirical studies that the increasing flood risk is not only cause by climate change but the increasing build-up environment affecting how the environment works as the main reason for floods. Subsequent progress in flood studies combined the two factors for flood incidence around the global.

Combined impact of climate and socio-cultural factors

Pielke (2000) argue that, there is a weak relationship between hydrological factor and the damaging floods, because the damaging floods occur from a combine effect of physical and societal processes, and floods result from a combination of meteorological and hydrological extremes (WMO/GWP, 2008).The flood risk is increasing not only because of climate change but also due to continued encroachment of people and properties in areas at risk of flooding resulting in an increasing potential damage (Hooijer et al., 2004). Criss (2015) concluded that flood levels rises as a result of climatic change and in-channel structures.

According to the above perspectives, flood risk can be perceived as a function of exposure, vulnerability and hazard (Wisner et al., 2004). The climatic change could be seen as the hazard and the socio-cultural context could be regarded as the exposure to hazard and the vulnerability of people in the hazard place. Therefore, in order to fully understand the concept of urban flood risks, it became necessary to examine the different kind of components encompasses the risks for efficient flood management for survival of man in his urban setting. Hence, flood risk hazard can be characterized by climatic change leading to probability and intensity of high river flows that causes inundation in an area. Exposure and vulnerability refers to the question of whether or not people or values are in range of flood waters and is the population and assets located in hazardous zone.

Therefore, flood risk can be seen as a cross-cutting combination of vulnerability, exposure and hazard and if any of these three elements increases or decreases, then the risk increases or decreases accordingly. As such understanding flood risk concept could be an efficient measure for risk reduction.

Sustainability models for flood risk management (FRM)

Understanding the distinction between the three elements that create risk; hazard, exposure and vulnerability - gives the necessary information for factoring in most flood related aspects in the overall management of flood risks and at the same time contribute substantially to the development and wellbeing of the people (WMO, 2009). The models available for flood risk mitigation include the traditional structural measures (dyke, dams, reservoirs, relief channels, embankments) and integrated non-structural (land use planning, flood warning systems, evacuation, preparedness and insurance) options at the individual, institutional and government level (Correla et al., 1998).

The first component is the hazard and the structural model targets mostly the flood hazard. The traditional structural flood risk reduction measures have been primarily on river training, construction of embankment and retention by reservoirs, aimed at reducing the flood hazard, i.e. the probability of flooding. For instance, Sultana et al. (2007) asserted that structural measures like embankments can provide protection against many types of flooding. Urban water management in most industrialized nations of Europe and America is characterized by large margins of safety involving huge infrastructure and technical facilities (Pielke, 2000). In recent time flood control measures may include flood-

proofing measures such raising the plinths or foundations for homesteads, keeping space for livestock in flood shelters (Sultana et. al., 2007). The measure has been on defense and control rather than on management.

Secondly, other models considered flood risk in a different angle by integrating exposure and vulnerability aspects of the flood risk. Since, it is recognized that structural flood control alone does not solve the flood risk and hazard problems, because flood control measures have been usually planned in isolation from other development. Therefore, they are reactive rather than proactive, by focusing on structural measures, and sought solutions from mono-disciplines (Shresha, 2012). Gilbert White was the first to argue that flood control measures should be integrated with non-structural methods, like land use planning to produce a more comprehensive flood management (Smith, 2013). Hence the paradigm shift from post-disaster response and relief centric approach to pre-disaster proactive preparedness and mitigation centric approach focusing on disasters as direct concern and a common understanding of the concept of vulnerability as important for developing a central notion. However, a sustainability and efficiency require a shift from the traditional structural flood defense to a more comprehensive Flood Risk Management (FRM) approach that include prevention, protection, preparedness, response and recovery. The most efficient and sustainable reduction of flood risks could be achieved by reducing the potential damage (vulnerability) in flood-prone areas through adapted land use and spatial planning. For example more recently, a pronounced paradigm shift in this respect can be seen in Netherlands where the design of flood plains and floating houses practices became more efficient to cope with a highly unpredictable environment (Wostl, 2005). Also in 1977 a major storm that caused 20,000 deaths in the East Coast of India, but after this catastrophe, an early warning system was established when the same area was hit with the same flood magnitude, in 1996 and 2005, the number of fatalities was 1000 (UNESCO, 2008). The major aim of urban FRM is to minimize human loss and economic damages, while making use of the natural resources for the benefit and wellbeing of the people.

The third perspective argued that flood hazards tend to be better understood by the local people involves, because their proximity the waterways acts as constant reminders of the risks to which they are exposed to. Hence, their willingness to participate in the flood management planning is essential (Correla et al., 1998). Whether responses to flood hazard take a structural, non-structural or mixed measures, there remains a need for a mechanisms for public involvement in decision making for flood risk sustainability. This is because measures to mitigate flood hazard may include what can be done to reduce vulnerability and this can be done through increasing the resilience and coping capacity of communities affected by the flood.

Sustainable FRM approach integrates water resource management, land-use management, and hazard management and changes the flood mitigation and control paradigm from defensive to pro-active, from ad-hoc to integrated flood management and focuses on managing and living with floods, balancing floods for sustainable development, and approaching the decision-making process differently by learning to manage risk and live with the floods. This is because urban flood is inevitable in as much as urban development continued plus the increasing flood hazard globally.

RESULT AND DISCUSSION

Based on the prevailing literature there are three perspectives to envisage the factors responsible for flood risk in urban areas. The climate change is viewed as one of the factor for flood hazard and its risk. And the second perspective hold the view that socio-cultural activities such as development of urban structures greatly reduces the infiltration capacity and thereby generating more runoff and the subsequent flood evens. Furthermore, proximity of urban structures to areas liable to flood led to the devastating flood risk in urban environment. The last view combines both climatic and the socio-cultural factors as the main reasons for urban flood events. Thereby flood risk generally encompasses three elements; hazard, exposure and vulnerability.Climate is the basic source of flood hazard and occupation of the floodplains by people and their socio-economic conditions increases exposure and vulnerability of flood risk.To efficiently mitigate flood risk, understanding these three elements is necessary. Structural flood measures targets the hazard, while non-structural measures aim at exposure and vulnerability elements. And current FRM advocates a holistic approach of both structural and non-structural measures with community involvement of elements at risk for efficient and sustainable FRM in urban environment. A critical examination of the available flood risk measures, the paper discovers that a gradual systematic conversion of urban land use to its natural state could sustainably decrease flood risk and flood frequency in urban areas (Scilling et al., 2014).

Conclusion

With the trend in rapid human and urban development and the increasing flood risk in urban areas environmental researchers realized that absolute flood security is in most cases in entirely inevitable. Therefore, flood risks cannot be entirely avoided but can only be reduced to a desired level; as such FRM does not strive to eliminate flood risks completely in urban areas but only try to conceptualize measures to mitigate them, to an acceptable level. And this is done by integrating, structural,

non-structural measures with community involvement. And finally, a systematic gradual conversion of urban land use to its natural stage could be an efficient sustainable measure for flood risk in urban areas.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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