SGVU J CLIM CHANGE WATER
Vol. 10, 2023 pp. 1-9
ISSN: 2347-7741

Analysis of Urban waterlogging Risk in Bangladesh; Causes Effects and sustainable remedies: A Review

Saima Akbar [1],

[1]Centre for Climate Change and Water Research, SGVU, Jaipur, India

*E-mail: Saimaakbardm11@gmail.com

ABSTRACT

This paper focuses on the analysis of rainfall-induced flooding which is caused by high intensity storms, rainfall, and runoff in the city area that is inundated due to lack of proper drainage system and inefficient management. This review points out the causes and impacts of urban waterlogging on the urban environment of the city. This waterlogging becomes a burden for the inhabitants of Khulna City in Bangladesh and creates adverse social, physical, economic, and environmental impacts, Such as disruption of traffic movement and normal life, damage to structures, and infrastructure, and loss of income potential, etc. The stormwater becomes polluted as it mixes with solid waste, clinical waste, silt, contaminants, domestic wastes, and other human activities that increase the number of waterborne diseases. As per the literature study, waterlogging due to heavy rainfall has become a serious problem in urban areas due to rapid urbanization activities and poor drainage systems, which poses a great threat to livelihood and other structures. Also, the Global climate has changed a lot in the past decades, due to which extreme weather conditions are becoming more frequent which led to severe waterlogging events around the world in recent years. So, we need sustainable sound planning and the introduction of new techniques to address this problem in the near future. In this review, we have explained the causes, impacts, and provision of some of the important remedial measures available in the literature based on particular areas for managing this hazard to a great extent keeping in view some sustainable solutions.

Key Words: Waterlogging, sustainable, Urban area, Precipitation, drainage, hazard, global warming.

INTRODUCTION

Bangladesh is experiencing environmental degradation due to rapid urbanization, increase in population, and industrialization. The process of urbanization is linked with economic development, which makes an increasingly higher contribution to the national economy. However, when the growth of the urban population takes place at an exceptionally rapid rate, most cities and towns are unable to cope with changing situations due to their internal resource constraints and management limitations (Bari and Hasan, 2001). Khulna is the third largest metropolitan city in Bangladesh which has a population of about 1.2 million with a growth rate of 4.5% per annum (BBS, 2003). The city is facing a number of environmental problems. Water logging, solid waste disposal, and black smoke from vehicular and industrial emissions, air and noise pollution, pollution of water bodies by industrial discharge. All these are the regular problems of the city. Waterlogging like rain-fed floods is considered a natural calamity. These hazards affect economically leaving a prolonged and wide range of negative impacts. About 80% of the annual rainfall in Bangladesh occurs from June to September when the rivers flow at a high stage due to a huge inflow of water from catchments outside the country. As a result, drainage is impeded. Besides this, high-intensity and long-duration rainfall causes local flooding when the local river cannot drain quickly.

It has now become a menace in urban areas in today's era due to the uncontrollable growth of population, unplanned urbanization, rapid industrialization, and other developmental activities in cities and towns. Unplanned urbanization and poor drainage systems create panic for local people and the administration. Urban water logging is caused by two main factors, which are meteorological and geological factors, both have led to extreme precipitation events in the last few years and waterlogging has become a major environmental issue, especially severe waterlogging could lead to property damage and other negative effects on people’s economic development residing in hazard-prone areas. But nowadays more and more researchers are paying more attention to urban waterlogging.

During monsoon, rivers tend to swell in their flood plains, Lakes and wetlands retain excess surface runoff, while forested

lands help in soil retention, but in urban areas, waterlogging happens mainly and frequently during rainy seasons. Even a moderate to heavy downpour will submerge or inundate various parts of the area such as lanes, highways, housing societies, shops, markets, transport or traffic movement and communication, etc. Disaster due to urban waterlogging is a key problem that restricts the development of urban ecology. The sharp increase in impermeable surface ratio leads to a decrease in rainfall infiltration and an increase in surface runoff.

Causes of waterlogging and human inference: Urban waterlogging is a common problem in many cities around the world and can be caused by a combination of natural and human factors.

Here are some of the primary causes of urban waterlogging.

Poor drainage system; inadequate drainage systems, including clogged or undersized stormwater drains and sewer systems, can lead to water accumulation during heavy rainfall.

Urbanization and Impervious Surfaces; Rapid urbanization often results in the replacement of natural permeable surfaces (like soil and vegetation) with impervious surfaces (like concrete and asphalt). This reduces the ability of the land to absorb rainwater, increasing surface runoff and waterlogging.

Deforestation: The removal of trees and vegetation in urban areas reduces the capacity of the land to absorb and retain water, leading to increased surface runoff and waterlogging.

Climate Change: Climate change and Global warming cause extreme weather events such as heavy rainfall and storms leading to variations in the total amount of precipitation throughout the year, causing serious problems for social development and people's lives

Land Use Planning and Zoning: Poor urban planning and zoning practices can result in the construction of buildings and infrastructure in flood-prone areas, exacerbating waterlogging issues.

Infrastructure Development: Construction projects that alter the natural flow of water, such as road construction, can disrupt the natural drainage patterns and contribute to waterlogging.

Encroachment of Water Bodies: Unauthorized construction near lakes, rivers, and ponds can reduce their capacity to hold excess water during heavy rains, leading to

waterlogging.

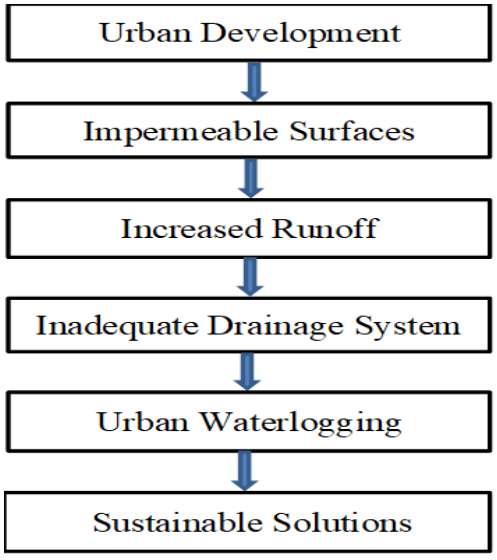
Inadequate Maintenance: Lack of regular maintenance of drainage systems and waterways can lead to blockages and reduced efficiency in managing rainwater.

Urban Heat Island Effect: Urban areas tend to be warmer than surrounding rural areas due to heat-absorbing surfaces and human activities. This can intensify rainfall, leading to more runoff and waterlogging.

Poor Solid Waste Management: Improper disposal of solid waste can clog drains and culverts, preventing the efficient flow of rainwater.

Geological Factors: Certain geological conditions, such as a high-water table, impermeable bedrock, or clayey soil, can contribute to waterlogging problems in specific areas.

METHODOLOGY FLOW CHART



RESULTS AND DISCUSSION

Water logging is said to be the major problem in most urban areas and needs to be addressed, to overcome this problem there is an immediate need to minimize the impact of waterlogging on the urban environment by taking necessary mitigation measures for risk reduction in a sustainable manner. We must adopt standardized monitoring, assessments, modeling, and mapping methodologies/procedures to improve the waterlogged area. We should follow the NDMA guidelines on urban flood management in India so that we can plan and design a stormwater Drainage system for other urban areas. Maintenance and cleaning of drains shall be done at regular intervals and all kinds of illegal and existing useless structures should be removed. There is an immediate need for a dynamic strategy to cope with the changing nature of the floods in future. We can also adopt the concept of sponge city in urban areas for effective management of this hazard. Further research should be done on integrated approaches of various measures discussed for the proper solution to this hazard. Identifying a problem using GIS/geospatial techniques and other sustainable ways can be used to identify waterlogged areas and manage them in

different urban areas of the world. Significant improvement is needed for the prevention of waterlogging in urban areas. Identification of the most vulnerable assets, areas, and potential risks for the formation of urban waterlogging in detail and provision of some preventive measures but People are ignoring the concept of sustainable development. This review believes in the introduction of new techniques like LID and the construction of a sponge city, green technology, e.g., green rainwater infrastructure by moving from grey to blue and green environments. Sponge city policies are a set of nature-based solutions that use natural landscapes to catch, store, and clean water; the concept has been inspired by the ancient wisdom of adaptation to climate challenges, particularly in the monsoon world. Which will later on result in an increase in absorbency ratio and thereby reduction in damage loss due to urban waterlogging as far as possible, This would solve the problem of urban waterlogging effectively in the near future and also will help in the free-flowing of water. This could be useful for the policymakers, and engineers to take possible mitigation plans for sustainable urban planning.

This paper mainly introduces the situation, causes, experiences, problems, and suggestions for urban rainstorm waterlogging disaster risk management under the background of climate change. Nowadays more attention needs to be paid to urban waterlogging hazards and groundwater recharge.

CONCLUSION

Rapid population growth and its growing demand for housing in Khulna City are encouraging the real estate business and private developers to grab and encroach on wetlands, lowlands, water bodies, and natural drainage systems for housing, roads, and commercial activities. Due to such activities, the natural drainage pattern and flood retention areas are destructed creating unprecedented waterlogging. Waterlogging in Khulna City is the consequence of unplanned development. So, day by day the amount and areas of waterlogging are increasing. Due to rapid urbanization with unplanned construction, most of the stormwater drainage have been encroached, filled up, diverted, and led to obstruction to the smooth flow of water to the outfall-rivers, creating severe water-logging in the city every year during monsoon incurring huge loss in terms of adverse social, physical, economic and environmental costs. No doubt with the help of GIS technology the acquisition of recent

information about water logging studies aimed at solving urban and environmental problems but by using the concept of sponge city as followed by many urban areas like China and other metropolitan cities, this problem could be solved effectively. This review paper is of great significance for a comprehensive and scientific understanding of urban rainstorm waterlogging disasters in urban areas and provides crucial information for long-term sustainable planning and high-quality construction of safe cities in the future.

The main conclusions are as follows.

1. Due to global warming and rapid urbanization, urban rainstorm waterlogging in urban areas is becoming more serious, and the situation is not optimistic.
2. The main causes of urban rainstorm waterlogging in urban regions are caused by the joint action of many aspects that is, global warming leads to the increase of urban rainstorm frequency and intensity; urban construction planning does not follow the original natural geographical pattern; rapid urbanization construction processes bring many adverse aspects;
3. The strategies for urban rainstorm waterlogging control at home and abroad are different. Although the systems, names, and emphases vary in different regions, the core concepts are mainly rainwater source control, rainwater recycling, and rainwater multi-functional storage. Construction of Sponge City still needs to learn from foreign experience to serve local urban waterlogging control.
4. To improving disaster monitoring, early warning, and forecasting systems; and vigorously strengthening the response of the metropolis. Concerning the construction of a catastrophe capacity plan, the awareness of long-term, sustainable, and institutionalized urban planning of decision-makers at all levels should be enhanced, and The awareness of disaster risk prevention and cross-regional disaster risk coordination of all people in the whole region (at all times) should be strengthened.

REFERENCES

1. Allan, R.P.; Sodden, B.J. Atmospheric Warming and the Amplification of Precipitation Extremes. *Science* **2008**, *321*, 1481–1484.
2. Behrouz, M.S.; Zhu, Z.; Matott, L.S.; Rabideau, A.J. A new tool for automatic calibration of the Storm Water Management Model (SWMM). *J. Hydrol.* **2020**, *581*, 124436.

3. Bari, F. M. and M. Hasan. 2001. Effect of Urbanization on Storm Runoff Characteristics of Dhaka City. Tsinghua University Press. XXIX IAHR Congress. Beijing, China.
4. BBS, 2003. National Population Census 2001, Preliminary Report, Bangladesh Bureau of Statistics. The government of Bangladesh. University Press Limited, Dhaka, Bangladesh
5. Chen, C.-F.; Liu, C.-M. The definition of urban stormwater tolerance threshold and its conceptual estimation: An example from Taiwan. *Nat. Hazards* **2014**, *73*, 173–190.
6. Dainik Loakshamaj, 2004. The daily newspaper published on 16th September 2004, Jessore, Bangladesh.
7. Du, S.; Van Rompaey, A.; Shi, P.; Wang, J. A dual effect of urban expansion on flood risk in the Pearl River Delta (China) is revealed by land-use scenarios and direct runoff simulation. *Nat. Hazards* **2015**, *77*, 111–128.
8. Dainik Pourbanchal, 2005. The daily newspaper published on 07 July 2005, Khulan, Bangladesh.
9. Dai, Y.; Jiang, J.; GU, X.; Zhao, Y.; Ni, F. Sustainable Urban Street Comprising Permeable Pavement and Bio Retention Facilities. A Practice. *Sustainability* **2020**, *12*, 8288.
10. Dai, Y.; Chen, L.; Shen, Z. A cellular automata (CA)-based method to improve the SWMM performance with scarce drainage data and its spatial scale effect. *J. Hydrol.* **2020**, *581*, 124402.
11. Environmental Mapping and workbook for Khulna city, 1999. Urban and rural Planning Discipline, Khulna University, Khulna, Bangladesh.
12. Gosaba Island, Sundarbans, India. Spatial Information Research, 28, 709-721.
13. Girona's, J.; Roesner, L.A.; Ross man, L.A.; Davis, J. A new applications manual for the Storm Water Management Model (SWMM). *Environ. Modell. Softw.* **2010**, *25*, 813–814.
14. Huang, Y., Ma, Y., Zhang, S., Li, Zhen, Huang, Y. (2021). Optimum allocation of salt-discharge areas in land consolidation for irrigation districts by SahysMod. Agricultural Water Management. 256. https://doi.org/10.1016/j.agwat.2021.107060
15. Hou, J.; Du, Y. Spatial simulation of rainstorm waterlogging based on a water accumulation diffusion algorithm.*Geomat. Nat.Hazards Risk* **2020**, *11*, 71-87.
16. Imran, H.; Akib, S.; Karim, M.R. Permeable pavement and stormwater management systems: A review. *Environ. Technol.* **2013**, *34*, 2649–2656.
17. Jamali, B.; Bach, P.M.; Deltaic, A. Rainwater harvesting for urban flood management integrated modeling framework. *Water Res.* **2020**, *171*, 115372.
18. Konukcu, F., Gowning, J.W., Rose, D.A. (2006). Dry-drainage: A sustainable solution to water logging and salinity problems in irrigated areas Agricultural Water Management. 83; 1-12.
19. Kuruppu, U.; Rahman, A.; Rahman, M.A. Permeable pavement as a stormwater best management practice: A review and discussion. *Environ. Earth Sci.* **2019**, *78*, 327.
20. Kader, M.A., Senge, M., Mojid, M.A., Ito K. (2017a). Recent Advances in Modifying mulching materials and methods for Modifying Soil Environment. Soil Tillage Res.; 168:155-166.

21. Longobardi, A.; D'Ambrosio, R.; Mobilia, M. Predicting Stormwater Retention Capacity of Green Roofs: An Experimental Study of the Roles of Climate, Substrate Soil Moisture, and Drainage Layer Properties. *Sustainability* **2019**, *11*, 6956.
22. Liu, Y.; He, S.; Wu, F.; Webster, C. Urban villages under China's rapid urbanization: Unregulated assets and transitional neighborhoods. *Habitat Int.* **2010**, *34*, 135–144. [CrossRef]
23. Porrini, D.; Schwarz, R. Insurance models, and European climate change policies: An assessment. *Eur. J. Law Econ.* **2014**, *38*, 7–28.
24. Park, K.; Lee, M.-H.; Park, L. The Development and Application of the Urban Flood Risk Assessment Model Reflecting upon Urban Planning Elements. *Water* **2019**, *11*, 920.
25. Quan, R.-S. Rainstorm waterlogging risk assessment in the central urban area of Shanghai based on multiple scenario simulation. *Nat. Hazards* **2014**, *73*, 1569–1585.
26. Sun, S.; Zhai, J.; Li, Y.; Huang, D.; Wang, G. Urban waterlogging risk assessment in well-developed region of Eastern China. *Phys.Chem. Earth Parts A/B/C* **2020**, *115*, 102824.
27. Su, B.; Huang, L.; Li, Y. Integrated simulation method for waterlogging and traffic congestion under urban rainstorms. *Nat.Hazards* **2016**, *81*, 23–40.
28. Wu, Z.; Shen, Y.; Wang, H. Assessing Urban Areas' Vulnerability to Flood Disaster Based on Text Data: A Case Study in Zhengzhou City. *Sustainability* **2019**, *11*, 4548.
29. Wang, K., Wang, Z., Liu, K., Cheng, L., Wang, L., and Ailing, Ye. (2019). Impacts of the Eastern Route of the South-to-North Water Diversion Project emergency operation on flooding and drainage in water-receiving areas: an empirical case in China. Nat. Hazards Earth Syst. Sci. 19, 555-570.
30. Y, X.; Beiqun, L.; Zaiwu, G. Real-time identification of urban rainstorm waterlogging disasters based on Weibo big data. *Nat.Hazards* **2018**, *94*, 833–842.