

The Role of Unplanned Urbanization in Water Scarcity and Drainage Problems: A Review in Bangladesh Perspective

1. Mst. Farhana Yeasmin

Assistant Professor of Sociology
Department of General Education
Northern University of Business & Technology Khulna, Bangladesh
E-mail: alinnub@gmail.com

2. Sadia Tasneem

Assistant Professor of Economics
Department of General Education
Northern University of Business & Technology Khulna, Bangladesh
E-mail: sadiatasneem9@gmail.com

3. Fatema Tuz Zohora Jui

Lecturer
Northern University of Business & Technology Khulna, Bangladesh
E-mail: juifatematuzzohora@gmail.com

4. Ashraful Islam

Lecturer
Northern University of Business & Technology Khulna, Bangladesh
E-mail: ashrafullaw92@gmail.com

Abstract

Rapid urbanization and population growth in Bangladesh, are increasing vulnerability to hazards like floods, earthquakes, fires, and water logging. This has led to social, physical, economic, and environmental consequences, such as disruption of life, water scarcity, infrastructure damage, and extinction of wildlife. This study examines the impact of unplanned urbanization on water scarcity in Bangladesh's rapidly growing cities, assesses its effect on drainage systems, and proposes strategies for mitigation. This study conducted a comprehensive analysis of unplanned urbanization in Bangladesh, examining its effects on population, water sources, and drainage systems. The research assessed the interconnections between urbanization, water scarcity, and flooding by drawing on secondary data from various sources. Additionally, it proposed strategies to mitigate these challenges and promote sustainable urban development. Finally, some possible and practical solutions for managing urbanization have been suggested to tackle water scarcity and drainage problems in Bangladesh.

Key Words: Unplanned urbanization, Water scarcity, Drainage problem

1. Introduction

Urbanization is often seen as a sign of economic progress and development, but when unplanned and poorly managed, it can lead to significant environmental and infrastructural challenges. Bangladesh, as one of the most densely populated countries in the world, has experienced rapid urbanization over the past few decades, particularly in its major cities like Dhaka and Chittagong. Unfortunately, much of this urban growth has been haphazard, leading to a range of issues, including water scarcity and drainage problems.

Unplanned urbanization refers to the expansion of cities without adequate infrastructure, planning, or environmental considerations. In Bangladesh, this phenomenon is particularly pronounced due to a combination of factors, including population growth, rural-urban migration, and economic pressures. As urban areas expand without proper land use planning, they encroach on wetlands, rivers, and natural drainage systems, exacerbating water-related problems.

Bangladesh is one of the most densely populated countries globally, where urban populations have been steadily increasing due to migration from rural areas to the industrial and service sectors in search of employment and better living conditions. Between 2000 and 2010, low-income countries like Bangladesh experienced a significant demographic shift, as urban population growth outpaced that of rural areas for the first time. Despite this, Bangladesh cannot be considered an 'urban nation,' as only 28.4% of its population lived in urban areas in 2011, compared to the global urbanization rate of 52.1% (Bapari et al., 2016).

Urbanization describes the movement of people from rural areas to urban centers, coupled with a gradual shift in the industrial structure from primary industries to secondary and tertiary sectors (Zhang et al., 2022).

Unplanned urbanization is a significant global concern, particularly in the rapidly expanding megacities of developing countries. The rapid and uncontrolled growth of Dhaka City exposes its residents to numerous health risks.

The expansion of cities and the urbanization of the world are among the most remarkable phenomena of modern times, bringing about significant changes in nearly every aspect of social life. Urbanization is an inevitable and evolving process. Although cities and towns have existed for centuries, the modern phase of urbanization began with the Industrial Revolution in England and later spread across all continents. The 21st century is increasingly becoming an urban age. Urbanization refers to the growing proportion of people living in urban areas, such as cities and towns. Urban growth is an inevitable component of this process. In recent times, the trend of people settling in and around cities in Bangladesh has been steadily rising (Lipi & Hasan, 2021).

With planned urbanization, Bangladesh is poised to reach its goal of sustainable urban development. In 2008, humanity passed a significant socio-demographic milestone for the first time, with half of the global population residing in urban areas (UNFPA, 2007).

Water scarcity generally refers to the disparity between the availability of water and its demand. Prolonged water scarcity can lead to significant issues, including rising river levels, groundwater depletion, and a declining water table (Kummu et al., 2016; Jiang, 2009). A thorough understanding of the underlying causes of water scarcity can help in devising effective strategies to address and mitigate this issue (Majumder, 2015).

Currently, a significant portion of the world's urban populations is experiencing water scarcity. Population growth, urbanization, and socioeconomic advancements are anticipated to drive a 50–80% increase in urban industrial and domestic water demand over the next 30 years. Urban water scarcity is usually managed through engineering solutions and infrastructure development. Reservoirs are often employed to collect and store water during times of surplus, ensuring a steady supply to cities and preventing shortages during dry periods (He et al., 2021).

While it is known that urbanization and industrialization degrade groundwater quality, the specific mechanisms and timeline of contamination remain unclear. This is mainly due to the absence of baseline data on groundwater quality in many cases, making it difficult to assess changes after industrialization. To track the changes in groundwater quality caused by human activities, gathering and analyzing all relevant data is essential (Khan et al., 2022).

An urban drainage system is typically described as a network designed to collect and transport storm water runoff from urban areas efficiently, with the primary goal of preventing flooding. These systems, known as separate drainage systems, are commonly employed in Australia and North America. Our limited understanding of the effects of climate change and urbanization poses a significant obstacle to developing an effective integrated urban drainage plan. To address failures in drainage systems, it is crucial to accurately forecast hydrological factors influenced by climate change, including annual and extreme rainfall, prior soil moisture, sea level rise, and variations in groundwater levels throughout the lifespan of drainage infrastructure (Yazdanfar & Sharma, 2015).

The United Nations (UN) projects that the global population will hit 8 billion by November 2022, with around 55% (4.46 billion as of 2021) residing in urban areas. By 2050, it is expected that nearly 70% of the global population will live in cities. The sustainability of urban development is crucial to humanity's future. However, urbanization rates vary across nations due to differences in socioeconomic progress. Bangladesh, a lower middle-income nation, is among the most densely populated countries, with around 170 million people and a population density of 1,265 individuals per square kilometer. The country has experienced significant urban growth in recent years. The urban population grew from 5.1% in 1974 to 32.8% in 2013, and by 2040, over half of Bangladesh's population is expected to reside in urban areas. (Mamun et al., 2022).

Water scarcity, both in terms of quantity and quality, has become a pressing issue in many urban areas in Bangladesh. The over-extraction of groundwater, pollution of surface water bodies, and loss of natural water retention areas have all contributed to the growing crisis. Additionally, poor drainage systems, coupled with increasing instances of heavy rainfall due to climate change, have led to frequent urban flooding. These problems are further aggravated by the lack of proper waste management, which clogs drainage systems and contaminates water sources.

The intersection of unplanned urban growth, water management issues, and inadequate infrastructure poses significant risks to public health, the environment, and the sustainability of urban development. Addressing these challenges requires a holistic approach, involving improved urban planning, sustainable water management, and community engagement to create resilient and livable cities.

The aim of this study are: To analyze the impact of unplanned urbanization on local water scarcity in rapidly growing urban areas, to assess how unregulated urban expansion affects the efficiency and effectiveness of drainage systems, to propose strategies for mitigating water scarcity and improving drainage in cities experiencing unplanned urban growth in Bangladesh

Overall, the study provides critical insights into how unplanned urban growth affects water resources and infrastructure, offering practical solutions for managing urbanization in a way that promotes sustainability and resilience.

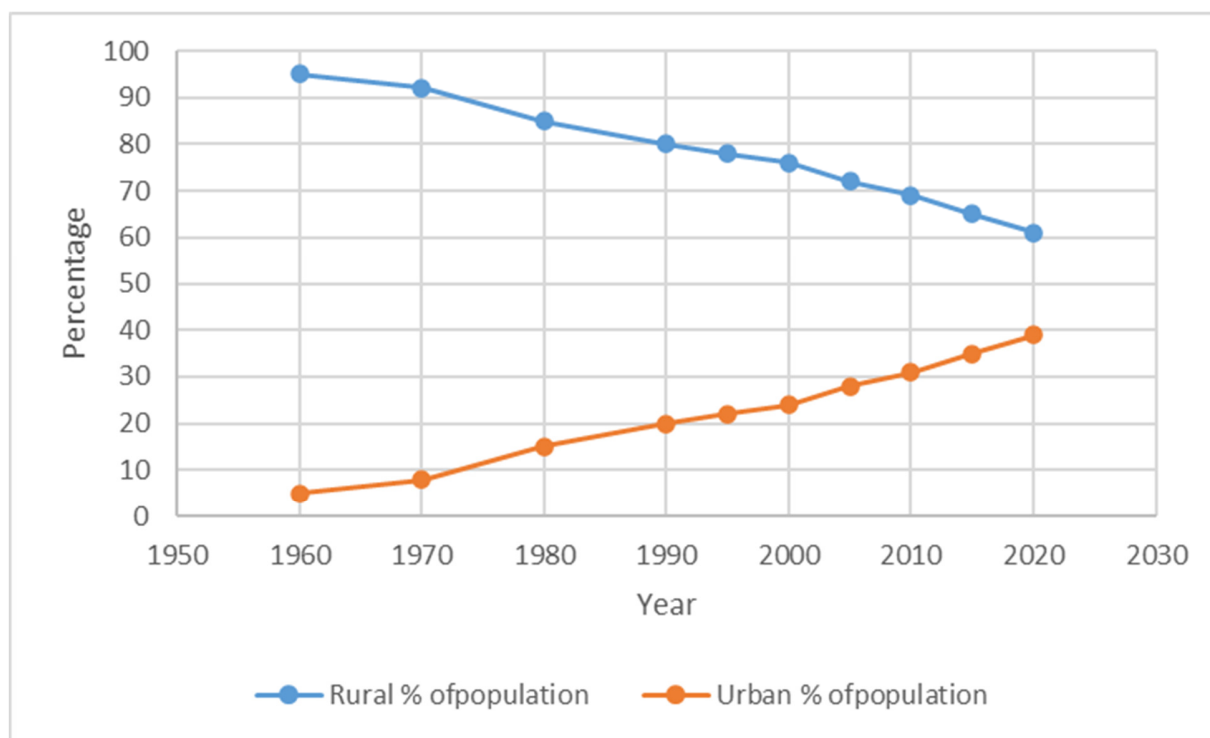
2. Methodology

This research was carried out using a comprehensive descriptive and analytical methodology. The secondary source served as its primary foundation. Secondary data was gathered from a variety of published sources, including World Bank, United Nations, Worldometer, and pertinent scholarly articles. To assess Bangladesh's urbanization patterns and investigate the relevant issues associated with urbanization, data spanning the years 1950 to 2020 was examined. To guarantee a thorough examination, additional sources are explored as well, including policy documents, government reports, and previous literature. The ethical approval for this study was not necessary because it entailed a methodical assessment and analysis of previous studies. All authors and sources received due recognition and acknowledgment.

3. Unplanned Urbanization and its Impact

3.1 Unplanned Urban Growth

Urbanization, characterized by the expansion of built environments and population growth, often leads to negative environmental consequences. Unregulated urban development contributes to the loss of vegetation cover, resulting in increased land surface temperatures and the prevalence of impervious surfaces (Mamun et al.,2022). This phenomenon is particularly prevalent in lower- and middle-income countries, where a lack of urban planning and enforcement of regulations exacerbates these issues. The consequences of unplanned urban growth are far-reaching. Trends in urban and rural populations are shown in Figure 1.



Source: Worldometer, 2020

Figure 1: Trend in Urban and Rural Population

Population Momentum and Urbanization

Urbanization is a dynamic process where human settlements and economic activities cluster in specific areas (Yadav et al., 2024). Population momentum, the continued growth of a population even after fertility rates have declined, is a significant factor shaping demographic trends globally. Urbanization plays a crucial role in this process. As more people migrate to cities, the urban population grows, contributing to overall population expansion. The extent of urbanization can be measured by comparing the urban population to the total population or by analyzing the rate at which the urban share of the population is increasing. According to the United Nations, the global population in 2018 was 7.6 billion, with 4.2 billion living in urban areas. By 2050, the global population is projected to reach 9.7 billion, and 68% of the population will be urban (Sun et al., 2020).

Inadequate Urban Planning and Its Consequences on Population

The lack of proper urban planning has significant implications for populations, particularly in developing countries. In Bangladesh, for example, more than 18 lakh people (approximately 20% of the total population) reside in slums (Rahaman et al., 2023). This is a direct consequence of inadequate urban planning and development. High natural population growth in urban areas often occurs through the expansion of urban settlements and the migration of people from rural to urban areas. If this trend continues unchecked, unplanned urbanization will become even more pronounced. This can lead to a variety of problems, including overcrowding, inadequate infrastructure, and increased poverty.

Public Health Impacts of Unplanned Urbanization

Unplanned urbanization can have significant negative consequences for public health. The lack of adequate infrastructure, such as parks, recreational facilities, and public spaces, can contribute to physical and mental health problems. According to the World Health Organization (WHO), air pollution is a major public health concern, causing nearly 7 million premature deaths annually (Campbell-Lendrum et al., 2023). Unplanned urbanization often leads to increased air pollution due to factors like traffic congestion and industrial emissions.

Furthermore, unplanned urbanization can result in the development of unhygienic markets, educational institutions, and other public facilities. This can create health risks and make it difficult to access essential services. The COVID-19 pandemic highlighted the vulnerabilities of densely populated urban areas. The virus disproportionately affected high-density cities and the urban regions, emphasizing the importance of effective urban planning and public health measures (Havarian-Garmsir et al., 2021). Unplanned urbanization, water scarcity, and drainage problems are interrelated and form a cycle. It is shown in Figure 2

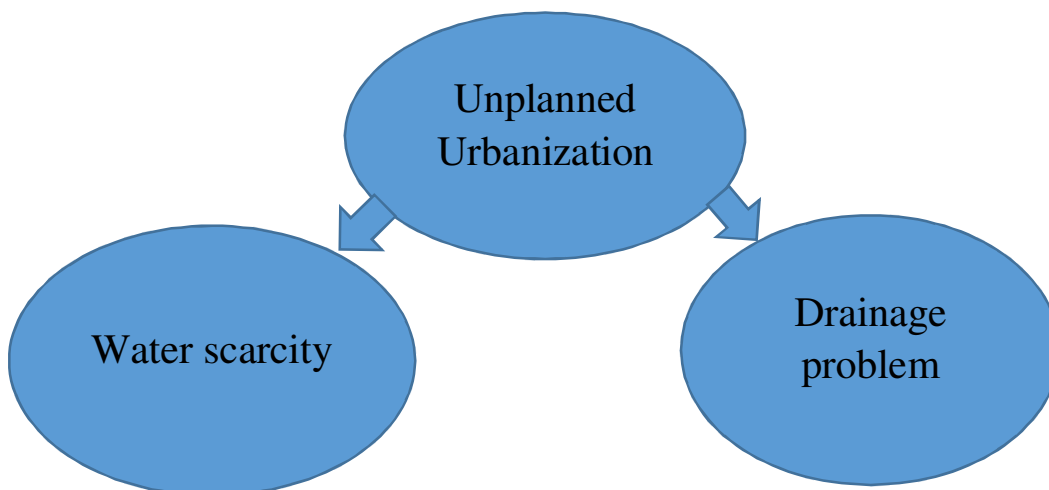


Figure 2: Interconnection Between Unplanned Urbanization, Water Scarcity, and Drainage Problems

3.2. Water Scarcity and Its Impact Due to Unplanned Urbanization

One of the most pressing challenges of urbanization is the deterioration of water quality. As cities grow and develop, the increased demand for water resources strains existing supplies. Since the 1990s, water quality has declined significantly, posing a growing threat to human health, the environment, and overall sustainability (du Plessis, 2023). According to the “World Cities Report 2020” currently 56.2 % of people are living in urban areas (Li et al., 2023). Urbanization leads to a significant increase in the demand for water. This growing demand, combined with limited water resources, has made water scarcity a pressing issue for sustainable and healthy urban development. Developing cities, in particular, are often major consumers of water and can contribute to the contamination of freshwater ecosystems (Kassay et al., 2023). The impact of urbanization on drinking water quality is a major challenge that requires comprehensive solutions. A well-designed urban plan must prioritize both the quantity and quality of water resources. Implementing advanced water treatment technologies and addressing infrastructure deficiencies are essential steps to ensure the long-term sustainability of urban water supplies.

Over-extraction of groundwater and shrinking surface water sources

Groundwater, the Earth's largest freshwater resource, plays a crucial role in sustaining Eco hydrological processes and providing domestic, agricultural, and industrial water supplies worldwide. However, unregulated over-extraction disrupts this balance, leading to severe impacts on water availability and microenvironments, which ultimately contribute to climate change. In deltaic regions, the extraction of groundwater and hydrocarbons frequently causes subsidence, leading to increased flooding and coastal erosion (Chen et al., 2022). The interplay between water extraction and climate change has become a significant global issue. This problem is increasing day by day due to unplanned urbanization. Groundwater accounts for approximately 89% of the Earth's freshwater, excluding polar ice caps. Given the well-documented global water scarcity, managing these valuable groundwater resources is crucial. (Sharma et al., 2021).

Water demand impacts on health

In 2017, over 785 million people worldwide did not have access to basic water services, and more than 884

million people consumed unsafe water (Utami et al., 2024). As a result of urbanization, there is an increased risk of water flow changes, water shortages and water pollution in urban areas. Solving water scarcity is not easy. So water supply policies should be taken and implemented strictly to address the situation. Urban water scarcity has often been managed through engineering and infrastructure solutions. Reservoirs are a common strategy to capture and store water when it's plentiful, ensuring a steady supply to cities during times of drought (He et al., 2021).

Pollution of Water Sources

A major difference between rural and urban water supply systems is the large infrastructure in city areas, which is absent in rural environments. In rural areas mainly hand pumps, artesian wells, ditch wells, rivers, and sewage are used as fresh water sources (Singh et al., 2024). Water pollution can originate from various sources, but a primary point source of contamination is sewage and wastewater treatment facilities. Water scarcity is increasingly becoming a significant threat to urban water security globally (Yang et al., 2024).

Industrial and household waste contaminating rivers, canals, and water bodies

Based on scientific evidence, approximately 70.9% of Earth's surface is covered by water and of this, 96.5% is saltwater found in oceans and seas, while only 1.7% constitutes freshwater, which includes glaciers, groundwater, and surface water. (Singh et al., 2022). Industrial waste consists of materials generated during manufacturing processes, such as chemicals, metals, plastics, and other byproducts, particularly from urban areas. Often hazardous, this type of waste necessitates specialized handling, treatment, and disposal methods to avoid environmental contamination. The concern of urban solid waste management is gaining importance in global environmental priorities, as the volume of waste increases with population and consumption growth (Hidalgo-Crespo et al., 2024). Waste management is a challenging task in the present scenario in urban areas, as there are various sources of waste such as medical waste, household waste, industrial waste etc. (Gautam et al., 2024). These various types of waste have toxic effects on the environment and human health and the accumulation of waste damages the environment and endangers human health.

Impacts on safe drinking water and aquatic ecosystems

Fresh water is becoming a global challenge nowadays (Mishra, 2023). Unplanned urbanization has multiple impacts on safe drinking water and aquatic ecosystems. Cities are closely related to ecosystems as the city is also an ecosystem with people as its main component (Newman & Jennings, 2012). Ecosystems, on the other hand, are the objective basis for human activities and urban development. Based on rivers and lakes, canals, urban aquatic ecosystems are characterized by water spaces, aquatic environments and aquatic organisms. The aquatic ecosystems are suffering from unplanned urbanization. For this reason, the deficiency of safe drinking water is becoming acute. Access to electricity can enable the use of electric pumps for irrigation, which can increase agricultural productivity and water availability (Terang & Baruah, 2023).

3.3 Drainage Problems and Their Impacts Due to Unplanned Urbanization.

Due to unplanned rapid urbanization, most of the storm-water drainage systems are confined, filled, diverted and obstructed in the river, causing severe flooding in the city every year during the monsoon season. (Ahammad, 2018). Like many urban areas in developing countries, the Dhaka region has expanded by approximately 70% over the past 30 years and during the last 15 years, around 15.64 km² of wetland has

been encroached upon, which has compromised the effectiveness of the existing drainage network (Halder & Majed, 2023). As a result, there is no end to the suffering of the people of the city. So authorities should take care of these during urbanization.

Insufficient Drainage Infrastructure

Inadequate drainage systems can cause transportation disruptions, soil erosion and health hazards due to mosquito breeding in stagnant water. They also contribute to water pollution, property damage and flooding, which can destroy infrastructure and ecosystems. A research in Addis Ababa showed that approximately 35.5% and 28.6% of failure causes are debris and various solid wastes for cross- and longitudinal drainage structures with correlation coefficients of 0.93 and 0.95, respectively (Jemberie et al., 2023). Addressing these issues through sustainable water management and efficient drainage practices is essential to mitigating these adverse impacts.

Inadequate drainage systems in rapidly growing cities

To avoid the risk of urban flooding, rainwater drainage systems are required (D'Ambrosio & Longobardi, 2023). Urbanization is causing climate change. And the timing and amount of rainfall is also changing. This requires adequate infrastructure to deal with sudden rains and floods. Urban flooding is caused in various cities due to the associated risks of climate change in increasing the frequency of extreme rainfall events and the intensification of urban settlements. (Dharmarathne et al., 2024). Urbanization has resulted in the conversion of natural surface areas into residential areas, roads and other paved surface areas, which have significantly impacted urban areas and caused variations in the urban water cycle. Therefore, current and future land use policy should also be managed.

Blockages caused by poor waste management and informal settlements

Poor waste management in informal settlements leads to infrastructure blockages, flooding, and isolation, exacerbating environmental and health problems. Informal settlements foster social cohesion and act as a platform for addressing inequality and alleviating housing shortages and high rents (Kirabo, 2023). Addressing these issues requires formal urban planning, enhanced waste management, and community engagement in sustainable practices. Waste management is very crucial in urban areas. In informal settlements of Sub-Saharan African cities, waste management practices like open burning and burying are driven by limited access to collection services and low awareness of environmental impacts (Muheirwe et al., 2023).

Encroachment on Natural Waterways

Encroachment on natural waterways, driven by urbanization, mining, and climate change, leads to significant environmental issues such as biodiversity loss, water pollution, and altered hydrological cycles (Mukherjee et al., 2023). Research revealed that the encroachments which are mostly in the form of buildings started over two decades ago became more alarming (Agyen-Brefo, 2012). Unplanned urbanization affects the natural water flow, resulting in urban flooding and inundation. Addressing these challenges requires comprehensive strategies including protective legislation, sustainable practices, restoration projects, and public education.

Filling up of ponds, canals, and rivers for construction

Filling ponds, canals, and rivers for construction involves raising ground levels by excavating soil and materials, facilitating urban development. This practice can cause environmental harm, including habitat loss, ecosystem disruption, and increased flood risks. In Haiti, the swift urbanization and extensive deforestation have intensified the risk of flooding, leading to significant disasters in November 2012, 2016, and 2022. (Jean et al., 2024). Ponds and wetlands are crucial for flood management in both modern green infrastructure and historical urban settings. (Zhang & Kondolf, 2024).

Impacts on natural water flow, leading to urban flooding and waterlogging

Urban waterlogging is a globally burning question and a widely recognized issue. Research indicates that floods, along with drought, are among the most damaging abiotic stresses, annually affecting 17 million km² of land (Kaur et al., 2020). The urban areas experience continuous or heavy rainfall in a short period that exceeds the capacity of their drainage systems, and then water logging occurs. Dumping of wastes seriously affects the flow of water. The flow velocity of waterlogging is also a key concern in waterlogging. Land features, infrastructure etc. are also responsible for waterlogging. Specifically, in flood protection hydraulic design, a vital parameter in the sizing of drainage structures is the design flow rate. Wang et al. (2024) suggested the implementation of green infrastructure to reduce the risk of urban flooding in Beijing, China. This hinders the natural flow of water and contributes to flooding. It can lead to the spread of waterborne diseases such as cholera, typhoid etc. It also leads to soil erosion, water pollution, and damage to ecosystems. Floodwaters carry pollutants and debris, impacting water quality and harming aquatic life. To solve this problem solid waste management should be implemented.

Urban flooding during monsoon seasons

Urban flooding during monsoon seasons is a significant problem in rapid-growth cities. This issue, characterized by the flooding of streets, homes, and infrastructure, poses serious risks to public safety and disrupts economic activities. Flood is a devastating environmental hazard, responsible for 44% of all disasters and impacting 1.6 billion people globally between 2000 and 2019, regardless of geography, climate, or development level (Manandhar et al., 2023). Using Yamane's sampling method, a survey of 370 samples revealed that houses and parks were most frequently damaged, with common issues including roof collapse, house fires, seepage, and wall dampness. (Zia et al., 2023).

Health risks due to stagnant water and poor sanitation

Urbanized areas have been facing multiple challenges both in environmental and public health areas. Due to stagnant water and poor sanitation people are suffering from various diseases. Sanitation situation is not so good in most of the developing cities and it is a big global issue. Research showed that, in 2016, only 6% of households had access to a basic sanitation facility, and 40% of households had no handwashing facilities in Ethiopia (Girma et al., 2024). In the world, diarrhea causes 1.6 million deaths annually, including 525,000 children. (Dickson-Gomez et al., 2023). To face this problem, have allowed people to use their existing toilets, through temporary repairs to broken sewers and sewage treatment works.

5. Discussion and Conclusion

Drainage problems can severely impact public health, infrastructure, the environment, and economic stability. Studies showed that, existing drainage systems cannot manage the expected flooding risks caused by a slight change in future rainfall intensity under each climate model. (Bibi et al., 2023). Effective

management and improvement of drainage systems are crucial to mitigating these adverse effects and ensuring overall societal well-being. The process of determining the appropriate spacing for drains involves understanding unsteady groundwater flow, which is described by the linear Boussinesq equation (Tzimopoulos et al., 2023).

Unplanned urbanization in Bangladesh has significantly contributed to water scarcity, leading to various environmental and social challenges. The following Table 1 outlines some key impacts:

Table 1: Impact of Unplanned Urbanization on Water Scarcity in Bangladesh

Impact	Explanation
Reduction in water bodies	Rapid construction of buildings and infrastructure has led to the filling of ponds, lakes, and wetlands, reducing the overall water storage capacity.
Pollution of water sources	Industrial effluents, sewage, and waste disposal have contaminated rivers, groundwater, and other water bodies, making them unsuitable for consumption and use.
Increased demand for water	The growing population in urban areas has led to a higher demand for water for domestic, industrial, and commercial purposes, straining existing water resources.
Reduced groundwater recharge	The loss of natural water bodies and the sealing of the ground surface have hindered the recharge of groundwater, leading to depletion of aquifers.
Climate change impacts	Unplanned urbanization has exacerbated the effects of climate change, including irregular rainfall patterns, droughts, and sea-level rise, further contributing to water scarcity.

Bangladesh, with its rapid urbanization, has faced significant challenges related to drainage systems. Unplanned development has exacerbated these issues, leading to waterlogging, flooding, and pollution. Impacts of unplanned urbanization on drainage system are shown in Table 2.

Table 2: Impact of Unplanned Urbanization on Drainage Systems

Impact	Consequences
Waterlogging	Flooding of homes, businesses, and public areas, causing property damage and disruption of daily life.
Public Health Risks	Waterlogging can create breeding grounds for mosquitoes and other disease-carrying insects.
Economic Loss	Flooding can lead to business closures, loss of jobs, and damage to infrastructure.
Environmental Degradation	Pollution of water bodies can harm aquatic ecosystems and biodiversity.
Social Disruption	Flooding can displace communities and disrupt social cohesion.

Table 3 summarizes the key aspects of urbanization and ideal urban planning.

Table 3: Key aspects of urbanization and ideal urban planning

Key Point	Explanation
Urbanization and Health	Urbanization is a major global trend that has a substantial impact on public health.
Population Growth in Cities	The World Health Organization predicts that by mid-century, more than 70% of the global population will reside in cities.
Unplanned Urban Growth	Cities are growing too quickly and without proper planning, making it difficult for municipalities to maintain healthy environments, harming residents' well-being.
Ideal Urban Environment	Features of a well-planned, healthy urban environment.
Transport	Public transport should be within 500 meters, with regular services, accessible via wheelchair-friendly, paved footpaths.
Food and Goods	Shops should be located within 500 meters.
Green Space	Parks should be accessible within 500 meters.

Key Point	Explanation
Access to Opportunities	Employment, education, and cultural opportunities should be within 30 minutes by public transport; safe paths to schools.
Housing	Diverse housing options using sustainable designs and providing both good indoor and outdoor air quality.
Social Cohesion	The neighborhood should foster community bonds, tolerance, and safety.

Source: Haque et al., 2014.

Unplanned urbanization in Bangladesh has created significant challenges for water management and urban infrastructure, especially regarding water scarcity and drainage systems. Rapid population growth in cities, coupled with insufficient urban planning, has led to the over-extraction of groundwater, reduction of natural water bodies, and a deterioration in water quality. This, in turn, has exacerbated water shortages, particularly during the dry season, and put immense pressure on the urban drainage infrastructure, making cities vulnerable to frequent flooding during the rainy season. The absence of sustainable urban planning has contributed to haphazard construction, reduced open spaces, and a lack of proper drainage systems. This has resulted in frequent waterlogging, worsened by the climate change impacts that intensify rainfall and make water management more difficult. Poor waste management has further clogged drainage systems, turning urban centers into hotspots for water-related issues.

To mitigate these challenges, urgent measures are required, such as strengthening urban planning policies, restoring and preserving natural water bodies, promoting rainwater harvesting, and improving drainage and waste management infrastructure. A multi-stakeholder approach involving the government, private sector, and community is crucial to ensure long-term, sustainable solutions to water scarcity and drainage problems in Bangladesh. In conclusion, addressing the issues of unplanned urbanization is critical not only for the well-being of urban residents but also for fostering a more resilient and sustainable urban future in Bangladesh. The solutions lie in comprehensive planning, improved infrastructure, and effective governance.

6. Policy Recommendations

There are some possible recommendations for decreasing unplanned urbanization in Bangladesh.

1. To improve urban public service delivery, Local Government Institutions (LGI) should be empowered with the necessary power, financial, human resources, and technical capabilities to efficiently manage urban utilities and services, overcoming challenges in finance and human resources.
2. Addressing gaps in urban governance laws and policies is crucial. Revise regulatory frameworks, assign coordination to authorities, ensure accountability through transparency, and prepare, amend, and update policies to eliminate ambiguities and inconsistencies.
3. Bangladesh's urban local bodies face central government control, leading to gaps in coordination, accountability, and efficiency. Strengthening local governments can improve resource mobilization and innovative investment strategies.
4. Urban policies should prioritize inclusivity and community participation, implementing best practices from other cities, and designate specific areas for street vendors to cater to low-income groups and consumers.

5. The integration of Sustainable Development Goals (SDGs) in urban planning is crucial for inclusivity and quality of public services, especially for low-income and left- Behind individuals. Clear mechanisms and citizen engagement are essential for monitoring progress and prioritizing vulnerable groups.

References

Agyen-Brefo, R. (2012). The effects of encroachment on sustainable public land management: a case study of the Owabi catchment area in Kumasi (Doctoral dissertation).

Ahammad, M. (2018). Analysis of stormwater runoff for a selected catchment of eastern Dhaka using hydrologic model.

Bapari, M. Y., Haque, M. E., Chowdhury, M. K. I., & Islam, M. J. (2016). Impacts of unplanned urbanization on the socio-economic conditions and environment of Pabna Municipality, Bangladesh. *Journal of Environment and Earth Science*, 6(9), 105-114.

Bibi, T. S., Reddythta, D., & Kebebew, A. S. (2023). Assessment of the drainage systems performance in response to future scenarios and flood mitigation measures using stormwater management model. *City and Environment Interactions*, 19, 100111.

Campbell-Lendrum, D., Neville, T., Schweizer, C., & Neira, M. (2023). Climate change and health: Three grand challenges. *Nature Medicine*, 29(7), 1631-1638.

Chen, G., Xu, B., Bidom, B., & Burnett, W. C. (2022). Effects of Groundwater Extraction and River Regulation on Coastal Freshwater Resources. In *Blue Economy: An Ocean Science Perspective* (pp. 123-152). Singapore: Springer Nature Singapore.

Dharmarathne, G., Waduge, A. O., Bogahawaththa, M., Rathnayake, U., & Meddage, D. P. P. (2024). Adapting cities to the surge: A comprehensive review of climate-induced urban flooding. *Results in Engineering*, 102123.

Dickson-Gomez, J., Nyabigambo, A., Rudd, A., Ssentongo, J., Kiconco, A., & Mayega, R. W. (2023). Water, sanitation, and hygiene challenges in informal settlements in Kampala, Uganda: a qualitative study. *International Journal of Environmental Research and Public Health*, 20(12), 6181.

Gautam, A. K., Pingua, N., Chandra, A., & Arya, R. K. (2024). Domestic Waste Management and Their Utilization. In *From Waste to Wealth* (pp. 1371-1398). Singapore: Springer Nature Singapore.

Girma, M., Hussein, A., Norris, T., Genye, T., Tessema, M., Bossuyt, A., ... & Samuel, A. (2024). Progress in water, sanitation and hygiene (WASH) coverage and potential contribution to the decline in diarrhea and stunting in Ethiopia. *Maternal & Child Nutrition*, 20, e13280.

Halder, A., & Majed, N. (2023). The effects of unplanned land use and heavy seasonal rainfall on the storm-water drainage in Dhaka metropolitan city of Bangladesh. *Urban Water Journal*, 20(6), 707-722.

Haque, S. E., Tsutsumi, A., & Capon, A. G. (2014). Sick cities: a scenario for Dhaka City. *Our World*, n-a.

havarian-Garmsir, A. R., Sharifi, A., & Moradpour, N. (2021). Are high-density districts more vulnerable to the COVID-19 pandemic?. *Sustainable Cities and Society*, 70, 102911.

He, C., Liu, Z., Wu, J., Pan, X., Fang, Z., Li, J., & Bryan, B. A. (2021). Future global urban water scarcity and potential solutions. *Nature Communications*, 12(1), 4667.

He, C., Liu, Z., Wu, J., Pan, X., Fang, Z., Li, J., & Bryan, B. A. (2021). Future global urban water scarcity and potential solutions. *Nature Communications*, 12(1), 4667.

Hidalgo-Crespo, J. A., Velastegui-Montoya, A., Soto, M., Amaya Rivas, J. L., Zwolinski, P., Riel, A., & Rivas-García, P. (2024). Improving urban waste management: A comprehensive study on household waste generation and spatial patterns in the Grand Guayaquil Metropolitan Area. *Waste Management & Research*, 0734242X241262714.

Jean Louis, M., Crosato, A., Mosselman, E., & Maskey, S. (2024). Effects of urbanization and deforestation on flooding: Case study of Cap-Haïtien City, Haiti. *Journal of Flood Risk Management*, e13020.

Jemberie, M. A., Melesse, A. M., & Abate, B. (2023). Urban drainage: The challenges and failure assessment using AHP, addis ababa, ethiopia. *Water*, 15(5), 957.

D'Ambrosio, R., & Longobardi, A. (2023). Adapting drainage networks to the urban development: An assessment of different integrated approach alternatives for a sustainable flood risk mitigation in Northern Italy. *Sustainable Cities and Society*, 98, 104856.

Karmakar, G., Sarkar, A., Chouhan, P., & Rahaman, M. Impact of Urban Growth on Land Surface Temperature Pattern of Urban Landscape Using Space-Borne Images. In *Disaster Risk, Resilient Agriculture and Livelihood* (pp. 269-281). Routledge India.

Kassay, A. B., Tuhar, A. W., & Ulsido, M. D. (2023). Integrated modelling techniques to implication of demographic change and urban expansion dynamics on water demand management of developing city in Lake Hawassa Watershed, Ethiopia. *Environmental Research Communications*, 5(5), 055012.

Kaur, G., Singh, G., Motavalli, P. P., Nelson, K. A., Orłowski, J. M., & Golden, B. R. (2020). Impacts and management strategies for crop production in waterlogged or flooded soils: A review. *Agronomy Journal*, 112(3), 1475-1501.

Khan, M. R., Hasan, F., Islam, M., Chowdhury, M., Sadeak, S., Amin, A., ... & Ahmed, K. M. (2022). Potential impacts of industrialization on coastal fresh groundwater resources in Bangladesh. *Sustainability*, 14(14), 8704.

Kirabo, H. (2023). A framework for improvement of informal settlements in Kampala City, Uganda (Doctoral dissertation).

Li, R., Zhu, G., Lu, S., Sang, L., Meng, G., Chen, L., ... & Wang, Q. (2023). Effects of urbanization on the water cycle in the Shiyang River basin: Based on a stable isotope method. *Hydrology and Earth System Sciences*, 27(24), 4437-4452.

Lipi, A. I., & Hasan, N. (2021). Urbanization in Bangladesh: Emerging challenges and the way forward. *Bangladesh Journal of Multidisciplinary Scientific Research*, 3(1), 33-44.

- Majumder, M. (2015). *Impact of urbanization on water shortage in face of climatic aberrations*. Springer.
- Mamun, S. A. A., Islam, M. M., Okely, A. D., & Hossain, M. S. (2022). Rapid and unplanned urbanization in the least developed districts of Bangladesh: a case study from Jamalpur using geospatial techniques. *Discover Sustainability*, 3(1), 42.
- Mamun, S. A. A., Islam, M. M., Okely, A. D., & Hossain, M. S. (2022). Rapid and unplanned urbanization in the least developed districts of Bangladesh: a case study from Jamalpur using geospatial techniques. *Discover Sustainability*, 3(1), 42.
- du Plessis, A. (2023). Water resources from a global perspective. In *South Africa's Water predicament: Freshwater's unceasing decline* (pp. 1-25). Cham: Springer International Publishing.
- Manandhar, B., Cui, S., Wang, L., & Shrestha, S. (2023). Urban flood hazard assessment and management practices in south asia: a review. *Land*, 12(3), 627.
- Mishra, R. K. (2023). Fresh water availability and its global challenge. *British Journal of Multidisciplinary and Advanced Studies*, 4(3), 1-78.
- Muheirwe, F., Kihila, J. M., Kombe, W. J., & Campitelli, A. (2023). Solid waste management regulation in the informal settlements: A social-ecological context from Kampala city, Uganda. *Frontiers in Sustainability*, 4, 1010046.
- Mukherjee, S., Rizvi, S. S., Biswas, G., Paswan, A. K., Vaiphei, S. P., Warsi, T., & Mitran, T. (2023). Aquatic Eco-Systems Under Influence of Climate Change and Anthropogenic Activities: Potential Threats and Its Mitigation Strategies. *Hydrogeochemistry of Aquatic Ecosystems*, 307-331.
- Rahaman, M. A., Kalam, A., & Al-Mamun, M. (2023). Unplanned urbanization and health risks of Dhaka City in Bangladesh: Uncovering the associations between urban environment and public health. *Frontiers in Public Health*, 11, 1269362.
- Sharma, R., Kumar, R., Agrawal, P. R., & Gupta, G. (2021). Groundwater extractions and climate change. In *Water conservation in the era of global climate change* (pp. 23-45). Elsevier.
- Singh, N., Poonia, T., Siwal, S. S., Srivastav, A. L., Sharma, H. K., & Mittal, S. K. (2022). Challenges of water contamination in urban areas. In *Current directions in water scarcity research* (Vol. 6, pp. 173-202). Elsevier.
- Sun, L., Chen, J., Li, Q., & Huang, D. (2020). Dramatic uneven urbanization of large cities throughout the world in recent decades. *Nature communications*, 11(1), 5366.
- Terang, B., & Baruah, D. C. (2023). Techno-economic and environmental assessment of solar photovoltaic, diesel, and electric water pumps for irrigation in Assam, India. *Energy Policy*, 183, 113807.
- Tzimopoulos, C., Samarinas, N., Papadopoulos, K., & Evangelides, C. (2023). Fuzzy Unsteady-State Drainage Solution for Land Reclamation. *Hydrology*, 10(2), 34.
- UNFPA. (2007). *State of world population 2007: Unleashing the potential of urban growth*. <https://www.unfpa.org/publications/state-world-population-2007>

Utami, R. R., Geerling, G. W., Salami, I. R., Notodarmojo, S., & Ragas, A. M. (2024). Mapping domestic water use to quantify water-demand and water-related contaminant exposure in a peri-urban community, Indonesia. *International Journal of Environmental Health Research*, 34(1), 625-638.

Wang, Y., Peng, L., Yang, L. E., Wang, Z., & Deng, X. (2024). Attributing effects of classified infrastructure management on mitigating urban flood risks: A case study in Beijing, China. *Sustainable Cities and Society*, 101, 105141.

Yadav, P. K., Mishra, V. N., Kumari, M., Kumar, A., Kumar, P., & Bhatla, R. (2024). Spatially Explicit Simulation and Forecasting of Urban Growth Using Weights of Evidence Based Cellular Automata Model in a Millennium city of India. *Physics and Chemistry of the Earth, Parts A/B/C*, 103739.

Yang, Y., Yu, H., Su, M., Chen, Q., Wen, J., & Hu, Y. (2024). Urban water resources accounting based on industrial interaction perspective: Data preparation, accounting framework, and case study. *Journal of Environmental Management*, 349, 119532.

Yazdanfar, Z., & Sharma, A. (2015). Urban drainage system planning and design—challenges with climate change and urbanization: a review. *Water Science and Technology*, 72(2), 165-179.

Zhang, L., & Kondolf, G. M. (2024). Ponds and Wetlands Landscapes of Flood Management in the Cities of the Lower Yellow River Floodplain—The Case of Huaiyang, China. *Water*, 16(5), 703.

Zhang, T., Zhou, Y., Li, M., Zhang, H., Wang, T., & Tian, Y. (2022). Impacts of Urbanization on Drainage System Health and Sustainable Drainage Recommendations for Future Scenarios—A Small City Case in China. *Sustainability*, 14(24), 16998.

Zia, A., Rana, I. A., Arshad, H. S. H., Khalid, Z., & Nawaz, A. (2023). Monsoon flood risks in urban areas of Pakistan: A way forward for risk reduction and adaptation planning. *Journal of Environmental Management*, 336, 117652.