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Land Use Change and Surface Water Runoff Dynamics of Chattogram Metropolitan Area

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Abstract: *Urbanization-driven land use cover changes significantly affect hydrological processes. This can alter the surface water runoff patterns. This research explores the relationship between land use changes and surface runoff water issues focusing on the study city Chattogram Metropolitan Area (CMA), the most significant port city in Bangladesh. The rapid urban development in Chattogram causes increased incidents and severity levels of waterlogging and urban flood in several parts of the city. The decadal Land Use and Land Cover (LULC) change was analyzed by supervised image classification of twenty years' (from 2003 to 2023) Landsat time-series data. It was determined considering five land use classes: agriculture, buildup area, bare land, vegetation, and waterbody classes. The Natural Resources Conservation Service (NRCS) curve number method was also applied to estimate the surface runoff water. The research found that, the LULC has significantly decreased in waterbodies by 30.29%, vegetated areas by 30.29%, and agriculture by 12.09% in the CMA. The buildup area, on the other hand, has been reflected to have the biggest shift, increasing by 55.99%. The estimated surface runoff has likewise experienced a sharp change, rising from 1.25 km^2 of high runoff in 2003 to 272.92 km^2 in 2013 and 419.00 km^2 of very high runoff in 2023. Pearson correlation analysis shows a consistently strong and highly significant positive correlation between LULC and surface runoff. This emphasizes the influential role of LULC dynamics in shaping hydrological patterns in CMA.*

Keywords: Land use and land cover (LULC), Surface runoff, natural resources conservation service (NRCS) curve number.

Introduction

The global increase in population and economic growth has led to significant changes in land use worldwide (Marques et al., 2019). In the last few decades, rapid urbanization has increased paved surfaces, resulting in increased surface runoff and altered hydrological regimes (Jin et al., 2023). The geographical distribution and

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composition of land cover have impacts on surface rainwater runoff by influencing factors like infiltration rates, evapotranspiration, and soil erosion (Jin et al., 2023). Land use changes can influence the hydrological processes. The change in land use patterns commonly arises from different anthropogenic activities such as urbanization, deforestation, agricultural growth, and industrialization. These alterations have far-reaching effects on the natural equilibrium of ecosystems, especially in the context of surface area water runoff dynamics (Islam & Mahmood, 2017). Urbanization changes absorptive surface areas with impervious structures, resulting in enhanced overflow and modified hydrological routes (Dwarakish & Ganasri, 2015). Deforestation may lower evapotranspiration rates, impacting the balance between rainfall and overflow (Islam & Mahmood, 2017). Understanding the impact of global land use changes on external water circulation is crucial due to recurring global changes.

In recent times, Chattogram Metropolitan Area (CMA), one of the prominent port cities in Bangladesh has faced many waterlogging problems. It is causing annual economic losses of Tk 1,000 crore by affecting local businesses and residents, causing significant hardships (Yousuf, 2021). The CMA is one of the megacities in Bangladesh that confronts a lot of challenges due to rising urbanization. Few research has been performed on the effects of land use changes on surface area water overflow in Chattogram. While researchers have documented the general results of urbanization on hydrology in other regions, the special geographical context of Chattogram demands a focused examination. The city's uneven terrain, thick settlements, and closeness to the Bay of Bengal develop an intricate hydrological system. This research contributes to the understanding of the troubles that is triggered by shifting land use patterns and resulting increased surface runoff water.

The CMA is the second-largest and most densely populated city in Bangladesh. The city is experiencing very rapid and unplanned urbanization that has resulted in significant changes in LULC over the last few decades (Bajracharya & Sultana, 2022). It lies within the Bay of Bengal coastline (Figure 1) and hence is under the threat of the impact of climate change manifested as sea-level rise, storm surge, or heavy rainfall (Bajracharya & Sultana, 2022). It has experienced recurrent waterlogging problems in many low-lying areas (*Agrabad, Halishahar, Bakalia, etc*.) due to inadequate drainage capacity, poor maintenance of canals, and encroachment of wetlands (Bajracharya & Sultana, 2022).

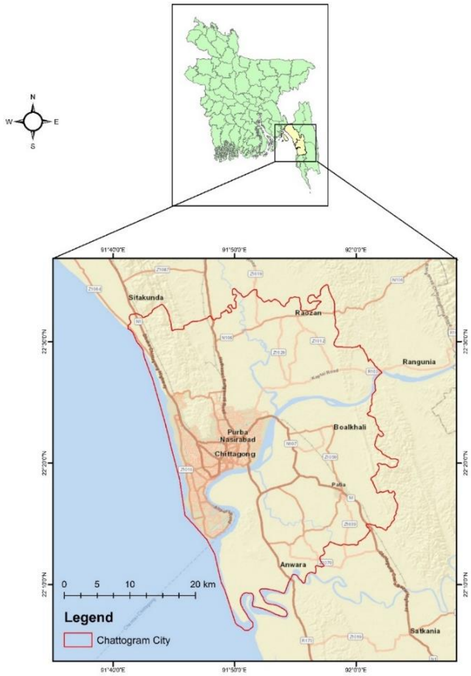


Figure 1: Location of Chattogram in Bangladesh.
Source: Authors, 2024.

This research aims to provide understandings of the geo-physical reasons for intensive waterlogging and flooding in the CMA. To achieve this, this research systematically quantifies the decadal changes in LULC (objective 1) and surface water runoff patterns (objective 2) in the CMA. Moreover, the novelty of this research is to establish their relationships (objective 3), which can provide valuable insights for sustainable urban planning practices, flood mitigation strategies, and improved water resource management. Some significant factors like rainfall, hydrological soil type, and LULC patterns are observed to evaluate the relationship between LULC and surface runoff.

Conceptual Framework

Increased surface water run-off creates waterlogging and floods. The Surface Runoff is the dependent variable in this research. The independent variables include land use, hydrological soil group, and rainfall. Agriculture, buildup area, waterbody, bare land, and vegetation are the five key land use types (Hütt, 2023). This research used this classification of land use for providing a comprehensive understanding of Land Use and Land Cover (LULC) changes. Rainfall amount fluctuates over time; hence this variable can influence the Surface Runoff outcome over a certain period.

Land use refers to the totality of setups, activities, and inputs carried out on a specific land cover type, while land cover refers to the physical terrain of an area, including forests, open water, and agricultural land (Thiery, 2020). Surface runoff is the portion of liquid that occurs when rainfall, snowmelt, or irrigation water goes into surface streams, rivers, or sewage systems without being managed by a dam upstream. It is influenced by meteorological factors, physical characteristics, and river systems (Water Science School, n.d.). The control variables are land use change and rainfall, which indicates that surface runoff can alter if one of those variable's changes. Thus, given all of those variables, it is possible to determine the possible effect of the dependent variable due to thechanges in the independent variables . Figure 2 is the conceptual framework that shows how different types of land use, combined with rainfall and soil properties, contribute to the surface runoff patterns in the CMA.

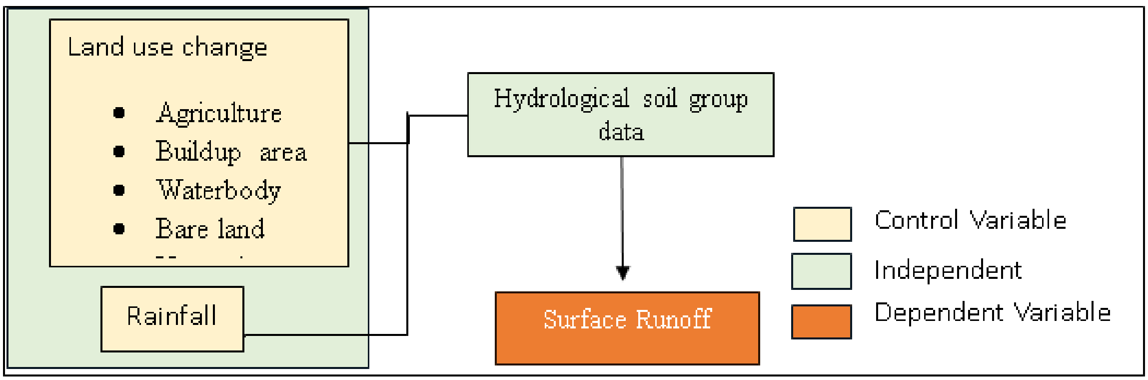


Figure 2: Conceptual framework, Source: Authors, 2024

Methodology

This research utilizes a deductive and quantitative approach. Multiple secondary data sources were required to determine the trend of LULC and surface water runoff, and their interrelations. Table 1 depicts the sources of data required for the research and the analysis process.

Table 1: Data Variable Matrix

Objectives	Variables	Data sources	Method of analysis	Tools
To analyze and quantify the decadal changes in land use andland cover (LULC) patterns in the CMA.	LULC change (Saponaro & Tarantino, 2022).	Landsat 8 and Landsat 5 satellite images from USGS Earth Explorer.	Supervised Image Classification	ArcGIS 10.8
To analyze and quantify the decadal changes in surface runoff patterns in the CMA area.	Curve Number Value (Moglen et al., 2022).	United States Department of Agriculture website	Data extraction	Excel
	Hydrological Soil Group Data (Moglen et al., 2022).	NASA Earth-data	Spatial clipping	ArcGIS 10.8
	Rainfall data (Moglen et al., 2022).	BD Meteorological Department	Aggregation	Excel and ArcGIS 10.8
	Surface runoff	Calculations	NRCS-CN Method	Excel and ArcGIS 10.8
To understand the relationship between land use change and surface water runoff in the CMA.	LULC, Surface runoff (Saponaro & Tarantino, 2022).	Mentioned before	Correlation Analysis	SPSS

Source: Authors, 2024.

For exploring two decadal changes in LULC, three years of data were used: 2003, 2013, and 2023. The 20-year timeframe is chosen for investigation because a 20-year span gives a large dataset for these models to analyze trends and anticipate accurately (Mazur et al., 2022). To determine the LULC, Supervised image classification was used. It requires a selection of representative samples for each class of interest. Afterward, it is used to set a classifier that can assign classes to the remaining pixels (Gunasekara et al, 2018). 30m spectral resolution Landsat 5 images are utilized for 2003, whereas 30m spectral resolution Landsat 8/9 images are used for 2013 and 2023.

Surface runoff modeling is a very complicated real-world phenomenon in hydrologic engineering. Because, it is dependent on classes of LULC, soil types, antecedent soil moisture conditions, and rainfall intensities (Moniruzzaman et al., 2020). Surface runoff was estimated using the Natural Resources Conservation Service (NRCS) curve number approach. Because it is more suitable for hydrological modeling, straightforward, predictable, and sensitive to the main factors that produce runoff, including land use, rainfall, and soil type. (Garen & Moore, 2005). The method uses a parameter called the Curve Number (CN), which ranges from 0 to 100 and represents the potential maximum retention of rainfall by the watershed (Moglen et al., 2022). A higher CN means less retention and more runoff, while a lower CN means more retention and less runoff (Moglen et al., 2022). The NRCS-Curve method is widely used for hydrologic and hydraulic design, and to assess the impacts of land-use change on runoff (Moglen et al., 2022). The CN is determined by considering the following variables, which are explained later:

- LULC and their corresponding CN values,
- Hydrologic soil group (HSG), and
- Antecedent moisture condition (AMC)

Table 2: LULC and their Corresponding CN Values

Class Name	CN Value according to HSG			
	A	B	C	D
Agriculture	67	77	83	87
Buildup	98	98	98	97
Bare land	77	86	91	93
Vegetation	55	72	81	86
Waterbodies	100	100	100	100

Source: Moglen et al., (2022)

Table 2 depicts a clear picture of which CN value was used for specific LULC classes. The CN value for the NRCS-CN technique is a parameter that stands for the runoff capacity of a catchment location based on its land use, soil types, and antecedent moisture conditions. HSG are soils with similar runoff potential under similar conditions. It is influenced by soil properties that affect infiltration rates for bare soil after prolonged wetting and freezing (Soil Survey Manual, 1993). AMC is a term that describes the relative wetness or dryness of a watershed or a sewer shed before a rainfall event (Farran & Elfeki, 2020). After defining the CN value for corresponding LULC, HSG, and AMC for the CMA, final runoff estimations were done by Equation 1.

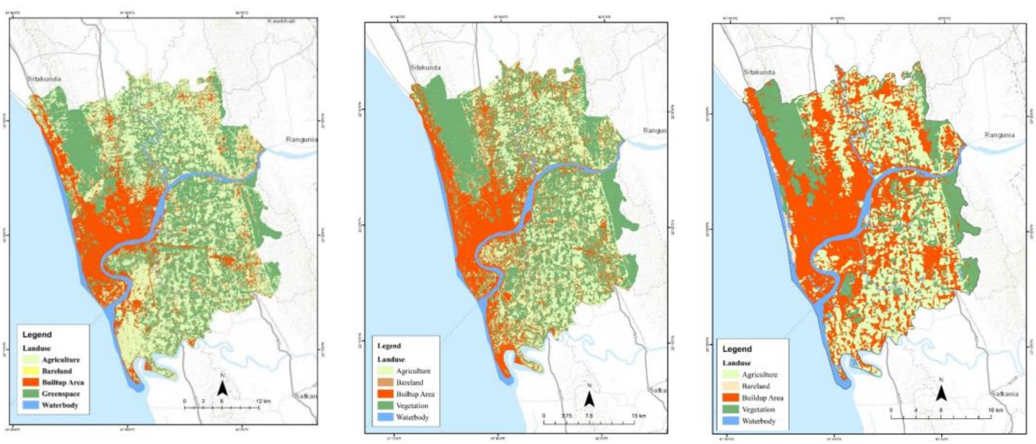
The Runoff equation is: $$Q = \frac{(P - I_a)^2}{(P - I_a + S)}$$ .... Eq. 1.

$$S = \frac{25,400}{CN_{II}} - 254 \; and \; I_a = 0.2S.$$

Where,
Q = Runoff,
P = Rainfall,
I = Initial abstraction, and it was assumed that I = 0.2S, meaning initial abstraction is 20% (Lim et al., 2006), and
S = Maximum retention capacity.

The amount of runoff water flows was measured by the NRCS-CN approach . Finally, a Pearson correlation analysis was done to find out the relationship between land use and surface runoff. . Correlation Analysis was used to estimate the influence of land use change on surface runoff.

Land Use and Land Cover Dynamics of Chattogram
This section presents the findings of the analysis and decadal changes on LULC in the Chattogram Metropolitan Area (CMA). The selected five LULC classes can be seen clearly in the Chattogram City LULC map for the years 2003, 2013, and 2023. It is also visible how much space each type of land occupies (Figure 3).



2003 **2013** **2023**

Figure 3: LULC Map of the CMA During 2003, 2013, 2023).
Source: Authors, 2024

Over the past two decades, the metropolitan area has experienced a noticeable transformation in its land use patterns. Figure 3 provides a visual representation of the LULC comparison of the last 20 years for the CMA. Back in 2003, agriculture was the most significant land use, covering 36.52% (424.44 km²) of the metropolitan area. Ten years later, by 2013, agricultural land was still prominent, but slightly decreased to 35.36% (410.78 km²). This trend continued into 2023, when agricultural areas shrank further to 32.13% (373.08 km²). These gradual reductions likely point to the shifts toward more urban and buildup spaces as the metropolitan area has expanded and modernized.

One of the biggest changes has been in the buildup areas. In 2003, buildup regions covered 24.47% (284.45 km²) of the land. By 2013, this area had increased modestly to 26.55% (308.45 km²). However, the jump from 2013 to 2023 was more significant, with buildup spaces growing to 38.22% (443.81 km²). This rapid increase highlights the CMA's urban expansion, as the demand for space for housing, businesses, and industries has surged over recent years. Vegetation cover has also shifted, though at a slower rate. Green areas occupied 27.17% (315.76 km²) in 2003, decreasing slightly to 26.42% (306.99 km²) by 2013. By 2023, vegetation had declined more noticeably to 21.81% (253.35 km²). This reduction aligns with urban development trends as natural spaces gradually give way to buildupbuildup zones. Waterbodies, including rivers, lakes, and ponds, also show a reduction in size over this period. In 2003, they accounted for 10.74% (124.87 km²) of the metropolitan areas. This decreased to 9.85% (114.45 km²) by 2013, and then to 7.49% (87.05 km²) by 2023. The shrinking area of waterbodies may reflect both natural changes and increasing land requirements for other uses. Lastly, bare land, though a smaller category, showed interesting fluctuations. In 2003, bare land covered 1.09% (12.67 km²) of the area, which increased to 1.81% (21.08 km²) by 2013. By 2023, however, bare land had reduced to 0.34% (4.01 km²), possibly converted into other uses like residential or commercial spaces over time.

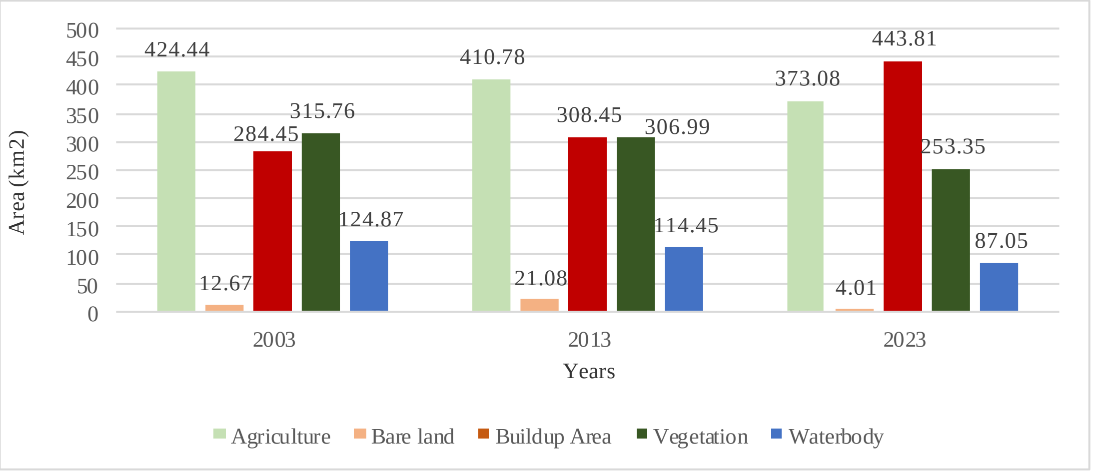


Figure 4.: Decadal Comparison of LULC Changes.
Source: Authors, 2024

The CMA's LULC comparison during the 20 years is shown graphically in Figure 4. The amount of agricultural land in the city is decreasing. The fact that the amount of vegetation is declining quickly between 2013 and 2023. Additionally, the fast growth of the buildup area is a sign of rapid urbanization. In terms of land use type, the buildup area has established itself as the most predominant land type in 2023 after previously ranking third.

In summary, these changes reveal a gradual shift in Chattogram from a largely agricultural landscape towards a more urbanized one. The expansion of buildup areas and reduction in agricultural, vegetative, and water spaces reflect a city responding to modern demands, reshaping its land use to meet the needs of a growing urban population.

Decadal LULC changes of the CMA for the timeframe of 2003, 2013, and 2023 have been presented in Figure 4. It shows that positive values imply increasing land types, while negative values represent decreasing land area for that given land type. The table depicts the dramatic shifts in LULC during 2003-2013 and 2013-2023 across different land use types. Agriculture showed a consistent decline, (falling by 3.22% and 9.18%) in the respective periods. Bare land showed a contrasting pattern, with a significant increase of 66.38% in 2003-2013 and a considerably larger reduction of 80.98% in 2013-2023. Buildup areas grew continuously, increasing by 8.44% and 43.88% in each decade. Vegetation declined by 2.78% initially, followed by a more significant reduction of 17.47%. Waterbodies experienced declines of 8.34% and 23.94% in both times. These findings provide direct insights into the changing landscape, demonstrating the dynamic character of land use changes across the specified periods. Within a twenty-year timeframe, agriculture experienced a decline, bare land experienced a boost, buildup areas expanded, vegetation experienced a decline, and waterbodies experienced a decrease.

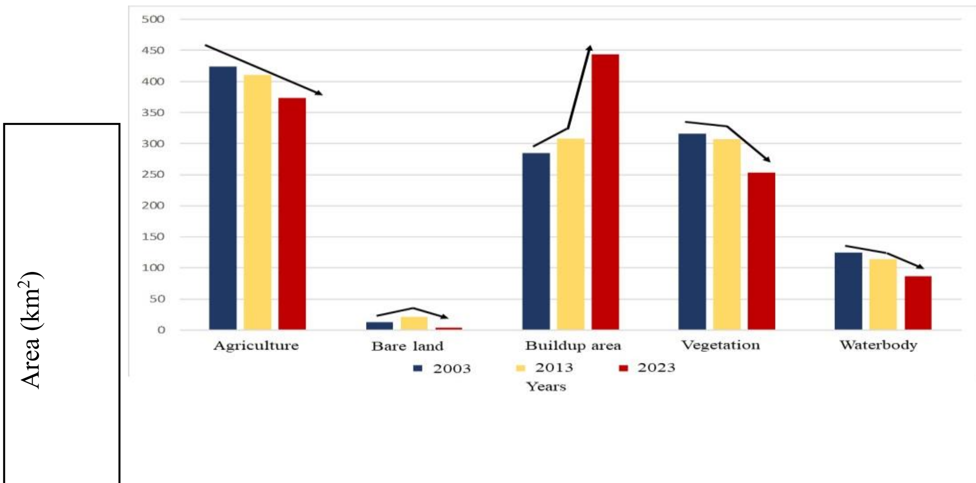


Figure 5: Decadal Changes in each LULC class.
Source: Authors, 2024.

The rapid urbanization is evident in the rapid increase in in the buildup area. These findings highlight the dynamic nature of land use changes. From figure 5 decadal changes in each LULC class can be seen. Agriculture land use is facing depreciation in terms of land a rea. That means a transformation of agricultural land is occurring. Although it appears that bare land has reduced over the past ten years, bare land areas increased between 2003 and 2013. The buildup area is boosting in terms of both land area and intercity. In the last decade, buildup areas have faced rapid boosts which caused almost 40% increase. Among land types, vegetation is the most declining. The amount of vegetation is declining quickly. The waterbody is likewise getting smaller.

Surface Runoff Dynamics of Chattogram

The section presents the findings of decadal changes in surface run-off pattern in the CMA by NRCS-NS approach in the Chattogram metropolitan area (CMA) utilizing the HSG and AMC. The soil classification map of the city is created from NASA's hydrological soil group data and presented in Figure 6. This figure consists of specialized type of soil map that provides information about the water-related characteristics of soils in a particular area. Four types of HSG are found in Chattogram city from Table 3-soil group C, D, C/D, D/D. Each of HSGs of this city has a distinct potential for runoff.

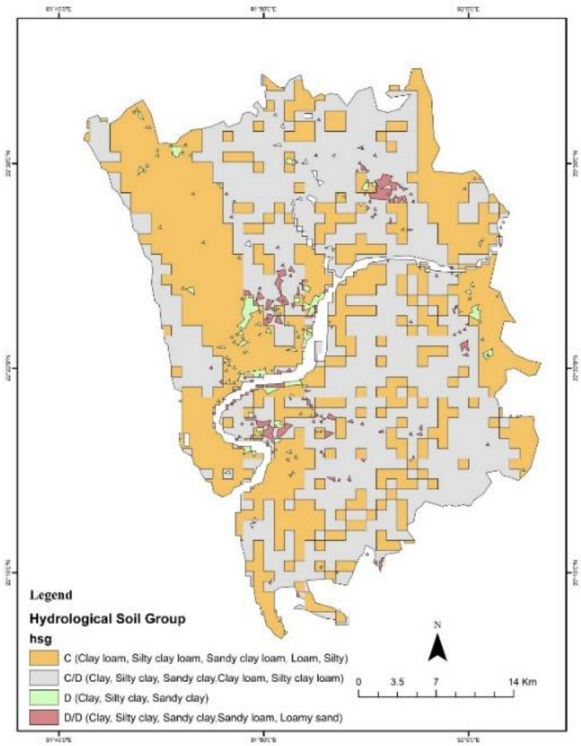
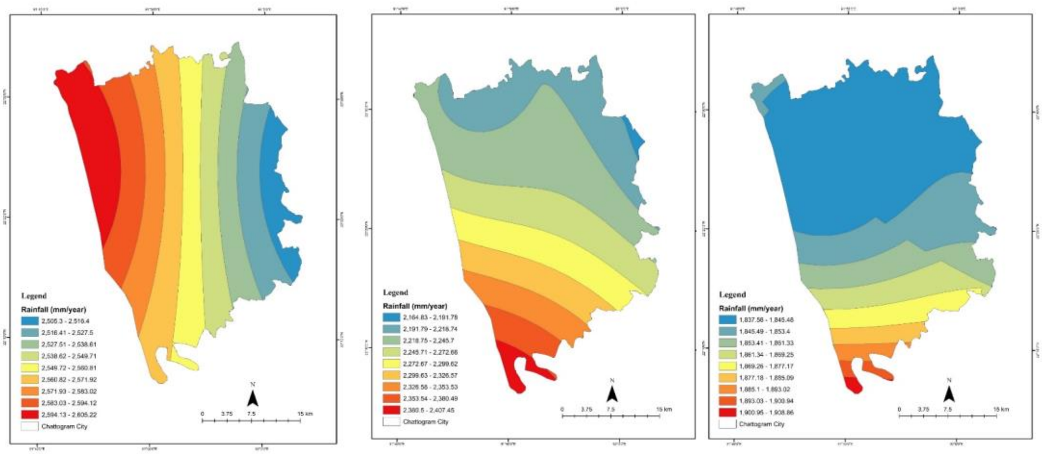


Figure 6: Hydrological Soil Group (HSG) Map of Chattogram City,
Source: Authors, 2024.

The rainfall distributions of three distinct years, 2003, 2013, and 2023, were investigated to estimate surface runoff water. This was done by the aggregation method. Daily rainfall data is clustered into annual totals to create a summarized representation, which is shown in the annual rainfall map. Thus, the rainfall distribution of the CMA over twenty years and the overall changes in the rainfall pattern, were investigated.

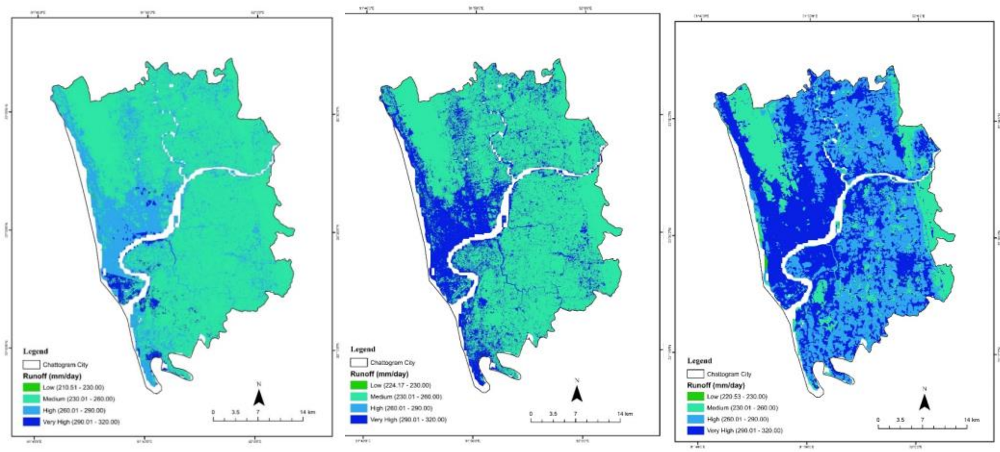


2003 **2013** **2023**

Figure 7: Rainfall Distribution Map of Chattogram.
Source: Authors, 2024.

Rainfall in the CMA has varied tremendously over the years, showing quite an observable trend in the years 2003, 2013, and 2023. The average annual rainfall of the city in the year 2003 was about 3000 mm, though there is a wide variation in the regional receipt. While the northeastern parts comprising *Hathazari* and *Sitakunda* receive over 4000 mm, the southwestern parts comprising *Patenga* and *Anwara* receive less than 1500 mm. This was about 2300 mm on average in 2013, fairly well distributed in the metropolitan area. However, it is over the central parts of *Chandgaon* and *Pahatali*, with over 2400 mm; *Hathazari* and *Anwara* receive less than 2200 mm. Continuing its trend of a downward spiral in the year 2023. The averages have taken a further spin with 1800 mm and happen to be distributed inequitably within the city. Whereas in the northeast, rainfall was over 1900 mm, it was below 1600 mm in the southwest. This comparison for two decades means a decline of about 1200 mm in annual rainfall in two decades and increased inequality in its distribution across different parts of the city.

The surface run off data is measured the Runoff equation (1) by the LULC classes with its HSG data,.with the assigned CN value for different land classes, and the rainfall data. The runoff intensity is divided into four classes: Low (210-230 mm/day), medium (230-260 mm/day, high 260-320 mm/day), and very high (290-320 mm/day) (Figure 8).



2003 2013 2023

Figure 8: Runoff Map of Chattogram Metropolitan Area, Source: Author, 2024

The surface runoff of Chattogram has been changing a lot in recent times compared to 2003 and2013, reflecting change in various respects. In 2003, the average was about 250 mm/day. The overflow in the southeastern parts, such as *Patenga* and *Anwara* area, was above 320 mm/day. The runoff in *Hathazari* and *Sitakunda* areas was below 210 mm/day. The mean runoff reached about 2400 mm/day by 2013. The most intensive drainage took place in the central parts of the area: more than 290 mm/day in *Chandgaon* and *Pahartali*, while the lowest less than 230 mm/day was in the northeast and southwest parts of the zone. By 2023, runoff was 2300 mm/day on average, but quite unequal. It indicates that the most critical overflows (above 320 mm/day) are concentrated in the southwestern areas of *Patenga* and *Anwara*, while the lowest values are in *Hathazari* and *Sitakunda*, below 220 mm/day. During the years, the moderate levels of runoff (between 220 mm/day and 290 mm/day) remained stable for the central, eastern, and western parts of the city, indicating various but repetitive hydrological problems.

The intensity of each class of runoff, along with the accompanying runoff values in millimeters per day and the total runoff area in square Kilometer (sq. km.), are listed in Table 5.

Table 5: Runoff Intensity and Area Distribution

Class	Intensity	Runoff (mm/day)	Total runoff area (sq. km·)		
			2003	2013	2023
1	Low	210-230	1.25	1.33	2.43
2	Medium	230-260	816.29	801.29	210.35
3	High	260-290	246.43	14.87	458.65
4	Very High	290-320	1.25	272.92	419.00

Source: Authors, 2024.

Table 5 provides the magnitude of each category of runoff, together with the corresponding runoff values expressed in millimeters per day (mm/day) and the total area of runoff in sq. km. The low run off surface area in 2023 was 2.43 sq. km. The medium runoff, varying between 230 and 260 mm/day, encompassed a total area of 210.35 sq. km. The runoff class was classified as very high, reaching its highest level, covering an area of 458.65 sq. km. The very high runoff displayed the highest magnitude in comparison to all other classifications. The high runoff exhibited a significant magnitude of 419.00 sq. km, ranking as the second greatest value.

Decadal comparison of runoff patterns

Decadal comparison of the maps in Figure 8 shows that the typical surface runoff for the CMA increased by 700 mm/day from 2003 to 2023. The runoff distribution came to be more unequal in 2023, with even more variants amongst various locations in the city.

The northeastern part of the city, which had the most overflow in 2003 and 2013, had low runoff in 2023. The southwestern part of the city, which had the highest runoff in 2003 and 2013, had the very high overflow in 2023. The main part of the city, which had modest runoff in 2003 and the greatest runoff in 2023, had moderate overflow in 2013. The eastern, western, and north-western part of the city, which had modest or high runoff in 2023 and 2013, had moderate runoff in 2013.

Figure 8 shows that in 2003, surface runoff is predominantly labeled as being in the moderate category, with minimal low and very high runoff. This would indicate good water absorption. By 2023, high and very high runoff areas expand, indicating more impervious surfaces and higher flood and erosion hazards.

Relationship Between Land Use Change and Surface Water Runoff

This section explains the correlations between land use change and surface water runoff in the CMA through comparison of them in figures and Pearson correlation analysis. The comparative scenario of the LULC and surface runoff of the Chattogram for two decades is shown in Figure 9.

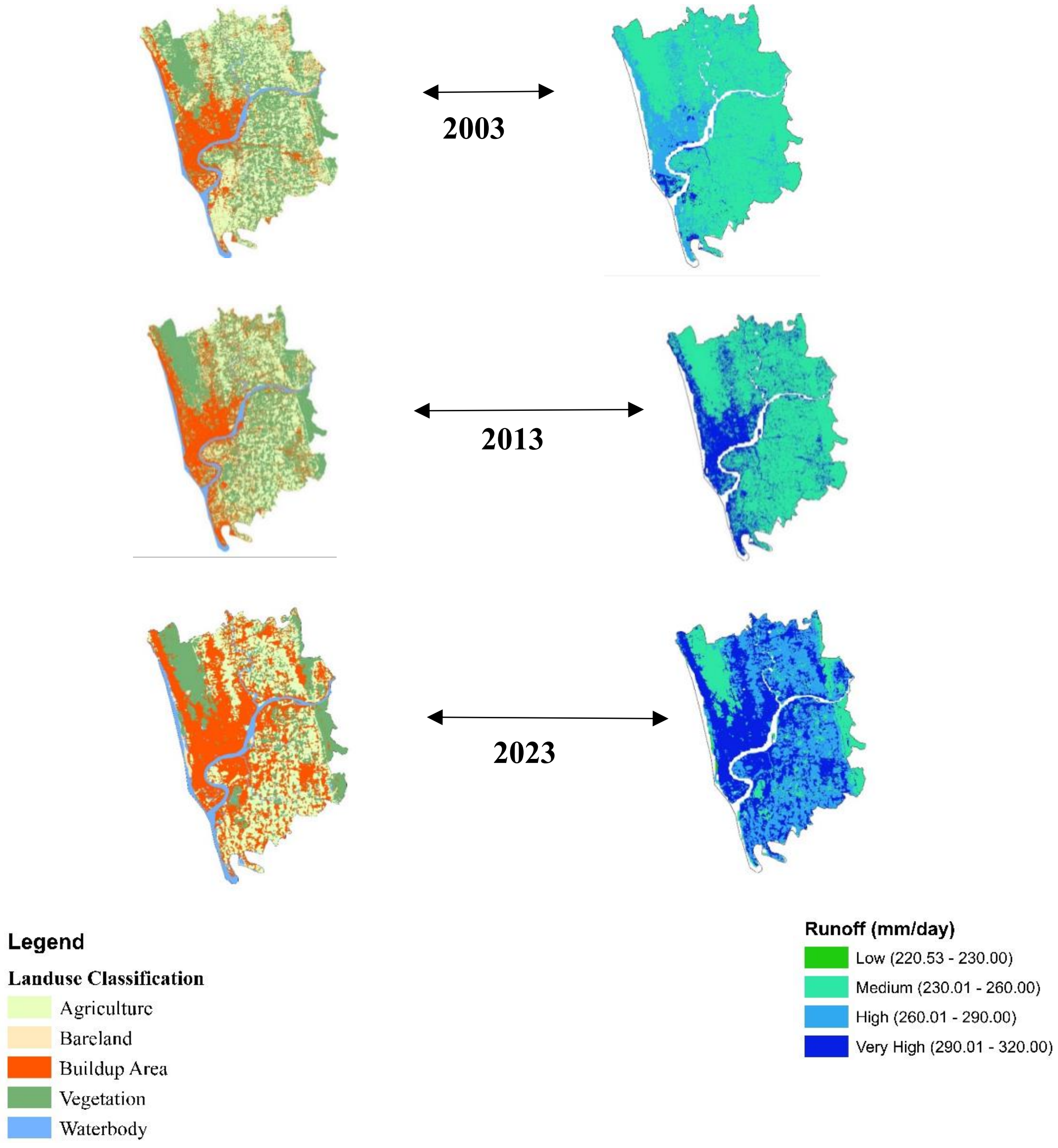


Figure 9: Decadal runoff comparison in Chattogram, Source: Authors, 2024

Figure 9 shows the land use and surface runoff composition for the years 2003, 2013, and 2023. The LULC has a significant impact on the surface runoff of a particular area. Over the course of each decade, there have been significant changes in land use. The variation in rainfall leads to varying runoff patterns for each grid value, specifically with the land use variable. Based on the maps, it is evident that the CMA is rapidly urbanizing. Simultaneously, it is reasonable to conclude that the city's surface runoff is expanding.

Table 6: LULC and total runoff comparison

LULC classes	2003			2013			2023		
	Area(km^2)	Average Runoff (mm/day)	Total Runoff (mm/year)	Area(km^2)	Average Runoff (mm/day)	Total Runoff (mm/year)	Area(km^2)	Average Runoff (mm/day)	Total Runoff (mm/year)
Agriculture	424.44	255	108232.2	410.78	265	108856.7	373.08	270	100731.6
Bare land	12.67	220	2787.4	21.08	220	4637.6	4.01	230	922.3
Buildup Area	284.45	290	82490.5	308.45	300.2	92596.69	443.81	305	135362.1
Vegetation	315.76	247.5	78150.6	306.99	250	76747.5	253.35	255	64604.25
Waterbody	124.87	285	307248.7	114.45	300.5	34392.23	87.05	300	26115

Source: Authors, 2024

Agricultural areas reduced with time and the total runoff was slightly reduced. The bare land was extended in 2013, then shrunk by 2023. The buildup areas grew greatly with the increased runoff that reflecting more impermeable surfaces and higher flood risks. The vegetation cover was reduced, which means less water could be absorbed. The shrinkage of waterbodies with time and tampering with the capacity to retain water were responsible. The general tendency of changing natural and agricultural lands to urban areas increases runoff and enhances the susceptibility of surface overflow.

Statistical relationship between LULC and surface runoff

It was performed Pearson correlation analysis to evaluate the relationship between LULC and surface runoff in the CMA. In the correlation analysis for the year 2003 between LULC area and surface runoff, the Pearson relationship coefficients show a solid and statistically significant favorable direct relationship between the two variables. The correlation coefficient of 0.881 recommends a solid favorable correlation between LULC and surface runoff. The Pearson connection coefficient of 2013 is 0.991 demonstrating an almost perfect positive correlation. Similar results were found in 2023, where the correlation coefficient was 0.993. The research indicates a robust and statistically meaningful association between LULC and surface area runoff in the provided dataset for two decades. Consistently strong and highly significant positive correlation between LULC area and surface runoff in the years 2003, 2013, and 2023 emphasizes the influential role of LULC dynamics in shaping hydrological patterns.

Conclusion

It is significant to explore the major reason for an increasing incidence of rainwater runoff in highly developing metropolitan cities. The research extensively analyzed the relationship between land use and surface runoff water overflow in Chattogram Metropolitan area (CMA) over two decades from 2003 to 2023. The decadal comparison of land use land cover (LULC) identified a significant decrease in agricultural land, paired with an exceptional expansion of buildup areas. Simultaneously, surface runoff patterns displayed greater average runoff and enhanced spatial irregularity over the years. The analysis of surface runoff has shown that the runoff intensity and area distribution have significantly changed during the last two decades. In 2003, medium-intensity runoff was predominant, with low and very high runoff classes having the lowest surface areas. In 2023, high and very high runoff areas expanded, posing risks of flooding or erosion. This analysis provides insights into Chattogram city's surface area runoff characteristics, emphasizing land use changes, hydrological soil, and rainfall patterns for effective surface area. The surface area runoff evaluation exposes a significant rise in mean surface area overflow throughout the years. Moreover, it shows an enhanced spatial variability, highlighting the vibrant nature of hydrological patterns. The relationship evaluation constantly demonstrated a substantial favorable relationship between LULC and surface area runoff in 2003, 2013, and 2023. These findings emphasize the enduring impact of land use dynamics on hydrological patterns, highlighting the critical role of urbanization in shaping surface water runoff. The research finding might be affected due to the limitation of lack of this research of not considering factors like wind patterns, temperature, and humidity. Further research could accomplish a better understanding considering these. Moreover, a longer period of study instead of two decades might create more generalizable knowledge.

References

Bajracharya, P., & Sultana, S. (2022). Examining the Use of Urban Growth Boundary for Future Urban Expansion of Chattogram, Bangladesh. *Sustainability, 14*(9), Article 9. https://doi.org/10.3390/su14095546

Dwarakish, G. S., & Ganasri, B. P. (2015). Impact of land use change on hydrological systems: A review of current modeling approaches. *Cogent Geoscience, 1*(1), 1115691. https://doi.org/10.1080/23312041.2015.1115691

Farran, M. M., & Elfeki, A. M. (2020). Evaluation and validity of the antecedent moisture condition (AMC) of Natural Resources Conservation Service-Curve Number (NRCS-CN) procedure in undeveloped arid basins. *Arabian Journal of Geosciences, 13(*6), 275. https://doi.org/10.1007/s12517-020-5242-y

Garen, D. C., & Moore, D. S. (2005). Curve Number Hydrology In Water Quality Modeling: Uses, Abuses, And Future Directions. *Journal of the American Water Resources Association, 41(*2), 377–388. https://doi.org/10.1111/j.1752-1688.2005.tb03742.x

Gunasekara, F. H., Yrle, F. & Kavinda. (2018). QGIS: Basic Training. https://docs.sigro.org/qgis-basic-training/en/

Hütt, C. (2016). Best Accuracy Land Use/Land Cover (LULC) Classification to Derive Crop Types Using Multitemporal, Multisensor, and Multi-Polarization SAR Satellite Images. https://www.mdpi.com/2072-4292/8/8/684

Islam, M., & Mahmood, F. (2017). Analysis of intense rainfall runoff and water logging in recent years due to drainage congestion in Chittagong city using hydrological model. https://doi.org/10.1016/j.ijsbe.2017.01.005

Jin, T., Zhang, X., Xie, J., Liang, J., & Wang, T. (2023). Study on hydrological response of runoff to land use change in the Jing River Basin, China. *Environmental Science and Pollution Research, 30*(45), 101075–101090. https://doi.org/10.1007/s11356-023-29526-1

Lim, K. J., Engel, B. A., Muthukrishnan, S., & Harbor, J. (2006). Effects of Initial Abstraction and Urbanization on Estimated Runoff Using Cn Technology1. *JAWRA Journal of the American Water Resources Association, 42(*3), 629–643. https://doi.org/10.1111/j.1752-1688.2006.tb04481.x

Marques, A., Martins, I. S., Kastner, T., Plutzar, C., Theurl, M. C., Eisenmenger, N., Huijbregts, M. A. J., Wood, R., Stadler, K., Bruckner, M., Canelas, J., Hilbers, J. P., Tukker, A., Erb, K., & Pereira, H. M. (2019). Increasing impacts of land use on biodiversity and carbon sequestration driven by population and economic growth. *Nature Ecology & Evolution, 3*(4), Article 4. https://doi.org/10.1038/s41559-019-0824-3

Mazur, E., Harris, N. & Stolle, F. (2022). 20 Years of Land Cover Data Reveals Important Transformations of Our Planet. Land & Carbon Lab. https://www.landcarbonlab.org/news-updates/land-cover-data-reveals-impacts-climate-nature-people

Moglen, G. E., Sadeq, H., Hughes, L. H., Meadows, M. E., Miller, J. J., Ramirez-Avila, J. J., & Tollner, E. W. (2022). NRCS Curve Number Method: Comparison of Methods for Estimating the Curve Number from Rainfall-Runoff Data. *Journal of Hydrologic Engineering, 27*(10), 04022023. https://doi.org/10.1061/(ASCE)HE.1943-5584.0002210

Moniruzzaman, M., Thakur, P., Kumar, P., Alam, M., Garg, V., Rousta, I., & Olafsson, H. (2020). Decadal Urban Land Use/Land Cover Changes and Its Impact on Surface Runoff Potential for the Dhaka City and Surroundings Using Remote Sensing. Remote Sensing, 13, 1–22. https://doi.org/10.3390/rs13010083

Saponaro, M. & Tarantino, E. (2022). LULC Classification Performance of Supervised and Unsupervised Algorithms on UAV-Orthomosaics. In O. Gervasi, B. Murgante, S. Misra, A. M. A. C. Rocha, & C. Garau (Eds.), Computational Science and Its Applications – ICCSA 2022 Workshops (pp. 311–326). Springer International Publishing. https://doi.org/10.1007/978-3-031-10545-6_22

Soil Survey Manual. (1993). U.S. Department of Agriculture.

Thiery, W. (2020). Land Use, Land Cover and Land Management Change: Definitions, Scenarios, and Role in the Climate System. Obo. https://www.oxfordbibliographies.com/display/document/obo-9780199363445/obo-9780199363445-0103.xml

Water Science School. (n.d.). Runoff: Surface and Overland Water Runoff | U.S. Geological Survey. Retrieved December 26, 2023, from https://www.usgs.gov/special-topics/water-science-school/science/runoff-surface-and-overland-water-runoff

Yousuf, M. (2021, August 3). Mitigating waterlogging in chattogram city: over tk 3,000cr spent, yet no remedy in sight. The Daily Star. Retrieved August 3, 2021, from https://www.thedailystar.net/mycity/chittagong-city-corporation/news/over-tk-3000cr-spent-yet-no-remedy-sight-2143666.