IJARSGIS
Volume 8, Issue 1-4
June & Dec-2022-23, Pp.20-33
ISSN-2394-8698 (P)
ISSN-2395-4388 (O)
www.gssjournals.org

Analysis of Rainfall-runoff relationship in Major Basins of Kanpur District and their relation with Urbanization using Remote sensing and geospatial tools and techniques

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Abstract

In the water cycle rainfall and runoff are important factors. In the Basin rainfall-runoff relationship somehow demarcates the water balance in the basin. Climate change affects the rainfall pattern consequently runoff is much affected by the land use pattern. The rainfall-runoff relationship helps manage resources, flood control, and water utilisation. The rainfall-runoff relationship is directly and indirectly related to the impervious surface. Increased impervious surface causes excess runoff. In this study, we have selected twelve major basins of the Kanpur district and calculated the rainfall-runoff relationship for these twelve basins and consequently their relationship to urbanization. The regression method has been used to find the correlation between the rainfall and runoff. Finally, theoretical and graphical representations have been used to find out their relation to Urbanization. For the Runoff calculation, the SCS-CN method has been used. Finally, there is a strong relationship between rainfall-runoff has been found in the basins and urbanization plays a major controlling factor in runoff. This study provides insights for effective water resource management in the context of increasing urban development.

Keywords: *Rainfall-relationship, Regression, Runoff, SCS-CN.*

1. Introduction

In the hydrological cycle rainfall and runoff are vital factors, rainfall contributes to infiltration and surface flow, and runoff excess reaches the rivers and oceans (Ward & Robinson, 2000; Reddy, 2005). These processes are very crucial for water distribution, especially in monsoon climate regions like India (Singh, 1992; Chitale, 1994). It is very important to understand the rainfall-runoff pattern to understand sustainable water management and flood control (Dingman, 2015). Knowledge of the rainfall-runoff relationship helps manage

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resources, water availability in the area, and flood control plans (Ward & Robinson, 2000; Singh, 1992).

Rainfall-runoff relationship is a crucial phenomenon in hydrology to understand how water flows in the water cycle and how precipitation changes into runoff paying attention to the other contributing factors of landscape and type of land and soil (Dunne & Leopold, 1978; Dingman, 2008). In a watershed basin, a complex relationship has been found between rainfall and runoff. The major contributors to a basin are rainfall and runoff as its transformation which is affected by various factors such as physical and chemical properties and type of land use of the area (Chow et al., 1988). Impervious surfaces such as built-up areas (Urbanization) change the runoff pattern and have high runoff in urban settings (Lehner et al., 2017) and natural landscapes have high infiltration capacity causing low runoff in the area (Zhang et al., 2018). Various methods have been developed for runoff calculation in the basin such as rational and SCS-CN methods based on the rainfall intensity and land use land cover (USDA, 1986). Climate change has a direct impact on rainfall intensity and consequently on runoff patterns. (Huntington, 2006). Modern tools such as geospatial technology and digital elevation models, play important roles in the estimation of the rainfall and runoff relationship and managing the climate change impact on the rainfall and runoff relationship (Beven, 2011; Fang et al., 2008; Wagner et al., 2012).

In urban areas due to the expansion of built-up, impervious surfaces, roads, and building infiltration is very low which causes heavy runoff from the urban area. Heighten runoff causes storms and flooding in urban areas (Novotny, 2003; Ponce, 1989). Fang et. al. in their study "Using the SCS-CN Model with Remotely Sensed Rainfall in Ungauged Catchments." in the year 2008 demonstrated the utilization of the GIS and remote sensing technology in the calculation of the remotely sensed rainfall data and runoff data calculation using SCS curve number in the ungauged catchment. In the study of Vogel et al. in their study entitled "Impact of Urbanization on the hydrology of small watersheds." Emphasize how a small increase in impervious area causes a significant increase in runoff and peak flow consequently causing severe flooding events. In this study, we have concluded the Rainfall-runoff relationship in Major basins of Kanpur district. Twelve major basins have been selected to represent the relationship. Regression methods have been used to calculate the rainfall-runoff relationship. In the end, the relationship between rainfall-runoff and urbanization has been described.

1.1 Study Area

Kanpur District is located in Uttar Pradesh, India. The locational extent of the district is 26° 27' 36.00" N latitude and 80° 19' 48.00" E longitude (Figure 1). The geographical area of the Kanpur district is 3155 sq. km. and the average annual rainfall is 821.90 mm. The major physiographic unit in this area is the Central Ganga alluvial plain. Major drainages of the districts are the Ganga and Pandu rivers. The major soil types of the area are alluvial and sandy. (District Brochure of Kanpur Nagar District, U.P., 2008-2009). May and June are the hottest month in the district. The mean daily maximum temp. in the district is found in May is 41.7 degrees Celsius.

The potential evapotranspiration in the area is 1660.9 mm (District Brochure of Kanpur Nagar District, U.P., 2008-2009). The old name of Kanpur was "Kanhpur" which was then a small village situated on the bank of the Holy Ganga, the Kanpur city was founded by the Hindu Singh, a king of Sachendi State (Brief

Industrial Profile of District Kanpur Nagar, MSMS). The total population of the area is 4581268, of which 2459806 are males and 2121462 are female population. The number of households is 863338 (District Census Handbook, 2011).

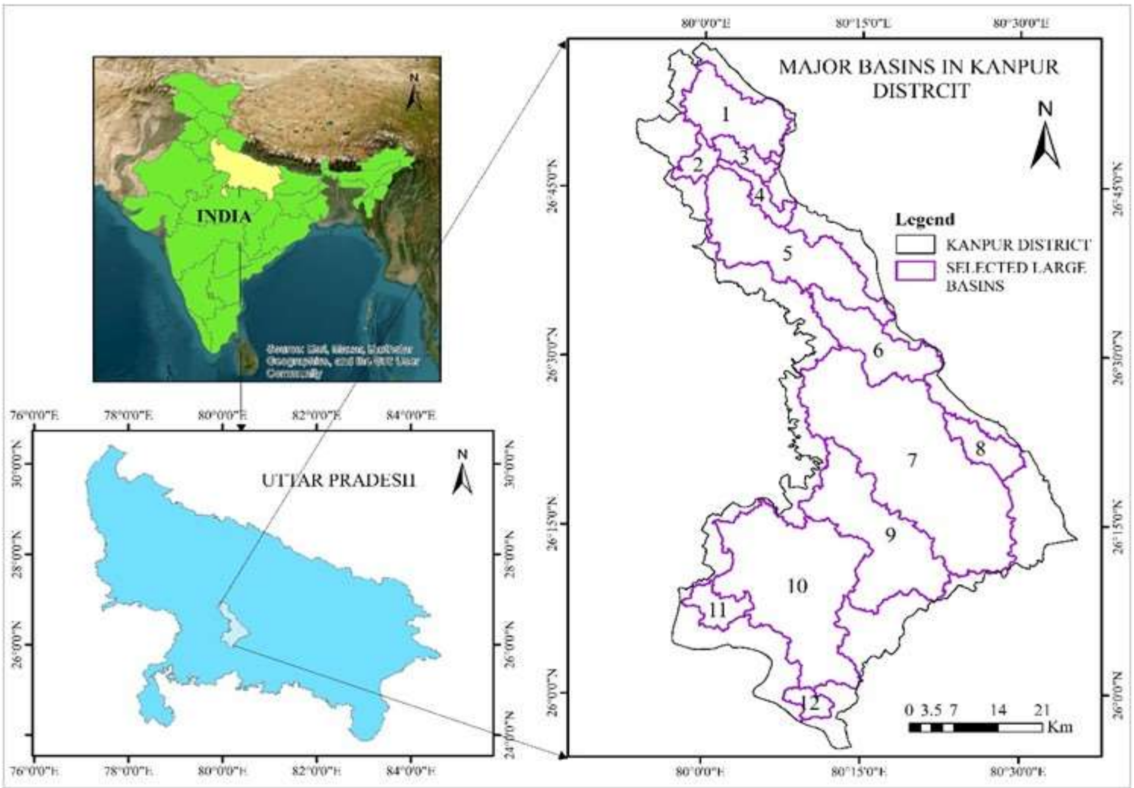

Figure 1: Location map of the study Area.

2. Methodology

2.1 Basin Delineation

A basin has been constructed in the Kanpur district using the DEM data. The basins have been demarcated using the software ArcGIS 10.8. The DEM data of Kanpur District has been added to ArcGIS, and the basins have been constructed by following the command fill >> flow direction >> basin tool (Figure 2). All the basins in the area have been converted into polygons, and large major basins have been extracted from the file.

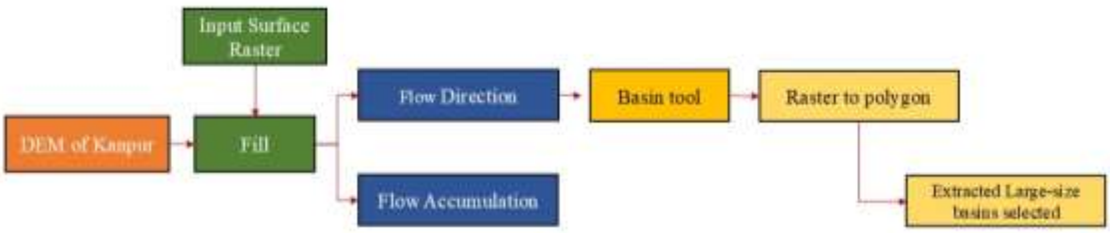

Figure 2: Flow map of the basin delineation

2.2 Land Use Land Cover

The land use land cover of the Major basins in Kanpur District has been calculated for the year 2018. The Land Use Land Cover has been calculated in ArcGIS software using the Support Vector Machine tool following the classified raster. Support Vector Machine (SVM) is a widely used machine learning technique in remote sensing, commonly applied to categorize different land cover types, including water bodies, forests, urban areas, and agricultural lands (Foody & Mathur, 2004). SVM works by finding a clear boundary, or dividing line, that separates different categories based on their unique features, like colors or patterns, in the data (Huang, et al 2002). Unlike other methods, SVM helps prevent overfitting by creating a larger gap between different categories, which helps it make accurate predictions on new data (Mountrakis, et al 2011). In this study Five classes have been delineated: waterbody, Forest, Agriculture, Barren, and Built-up. The built-up as a representative of Urbanization has been extracted from the LULC.

2.3 Rainfall

The rainfall of the area has been collected for two purposes, one is for the rainfall itself and second is the for the runoff delineation. Daily Basis rainfall has been downloaded from the CHRS Center for Hydrometeorology and Remote Sensing, University of California, Irvine, (UCI) Data Portal on real-time global high resolution 4km*4km.

The CHRS is a high-resolution, satellite-derived dataset that captures global precipitation trends. By integrating infrared satellite data with ground-based rainfall measurements, it delivers a more precise and comprehensive understanding of precipitation patterns worldwide, particularly in areas where weather stations are scarce (Funk et al., 2015; Peterson et al., 2013). The daily rainfall data for the whole 2018 year has been downloaded and processed.

2.4 Runoff Calculation

The Runoff calculation has been done basin-wise for all twelve major basins of the Kanpur district. The SCS-CN method has been used to calculate the monthly runoff from the basin using the daily rainfall data. The SCS-CN method is commonly used to estimate how much water will run off during a rainfall event, based on land and soil characteristics. (Hawkins et al., 2009) To use this method, we need data like the amount of rain, soil type, land cover, and how wet the area was before the rain. (USDA, 1986) The Curve Number (CN) shows how much runoff can be expected, based on factors like soil type, plants, and moisture levels. (Ponce & Hawkins, 1996). The CN value can be changed based on how wet the soil was before the rainfall, which is called antecedent moisture conditions (AMC). (Wilson et al., 2000). Things like soil, plants, and land use affect the CN, which in turn influences how much water runs off after it rains. (USDA NRCS, 1997). This method is easy to use, so it’s often chosen for designing water management systems and understanding runoff in an area. (Jha et al., 2009). Following are the equations to compute the runoff using the SCS-CN method (Figure 3).

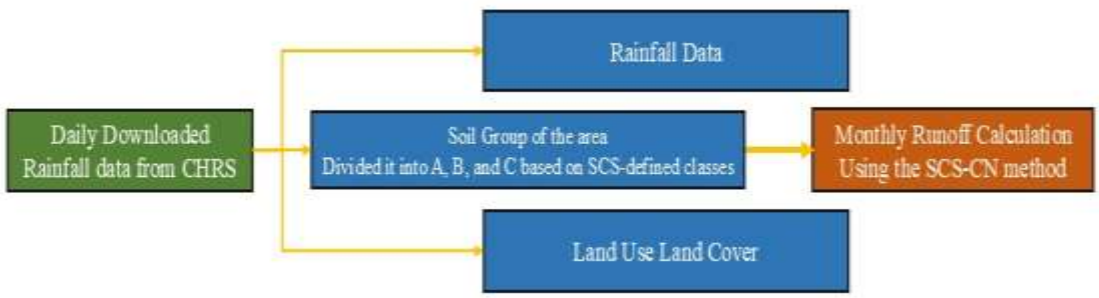

Figure 3: Flow map of the Runoff Calculation

At first, we calculate AMC type based on daily rainfall data (Table 1), further, CN Ⅱ values for all types of Land Use Land cover have been assigned. Based on CN Ⅱ, CN Ⅰ and CN Ⅲ values are calculated based on equations. Then 1 CN value is calculated to quantify the S and finally Q (Subramanya, K. 2013) (equations 1, 2, and 3).

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \quad \text{for } P > 0.2S \qquad \text{eq. 1}$$

Where Q is daily runoff, P is daily runoff, and S is potential maximum retention.

$$S = \frac{25400}{CN} - 254 \quad = \quad 254\left(\frac{100}{CN} - 1\right) \qquad \text{eq. 2}$$

Where CN is the Curve number

$$CN = \frac{25400}{S+254} \qquad \text{eq. 3}$$

CN_{II} is extracted from the table for hydrologic soil cover complexes. (Provided in Ministry of Agriculture, Govt. of India, Handbook of Hydrology, New Delhi, 1972). Further, CN Ⅰ and CN_{II} are calculated by equations 4 and 5.

$$AMC\ \ I : CN_I\ \frac{CN_{II}}{2.281 - 0.01281\ CN_{II}} \qquad \text{eq. 4}$$

$$AMC\ \ III : CN_{III}\ \frac{CN_{II}}{0.427 + 0.00573 - 0.01281\ CN_{II}} \qquad \text{eq. 5}$$

Table 1: Antecedent Moisture Condition to determine CN value.

AMC	Total Rain in Previous 5 Days	
	Dormant Season	Growing Season
Ⅰ	Less than 13 mm	Less than 36 mm
Ⅱ	13 to 28 mm	36 to 53 mm
Ⅲ	More than 28 min	More than 53 mm

(Source: Subramanya, K. 2013).

This rainfall and runoff daily/monthly have been compiled into yearly Rainfall and runoff in each basin for the year 2018.

2.5 Rainfall-Runoff Relationship

Rainfall and Runoff data have been computed separately for twelve major basins of the Kanpur District. The relationship between Rainfall and Runoff has been established using straight-fit regression and coefficient of determination (equations 6,7 and 8) (Subramanya, K. 2013). Regression is a statistical method used to examine the connections between different variables (Kutner et al., 2005). It helps predict the value of one variable based on the known value of another (Gelman et al., 2014). The most basic type, linear regression, assumes a direct, (Field, A., 2013; Sullivan, M., & Sullivan, C., 2016). The straight-fit regression and straight-line relationship between the variables (Belsley et al., 2004). The strength of this relationship is often measured by R^2, which shows the proportion of variation in the dependent variable explained by the independent variables (Freedman, 2009). The coefficient of determination (R^2) in regression shows how much of the variation in the dependent variable can be explained by the independent variable(s). An R^2 value close to 1 means the model closely fits the data, indicating a strong relationship. On the other hand, an R^2 value close to 0 suggests there's little or no relationship between the variables coefficient of determination have been calculated in Excel.

$$R = aP + b \quad \text{eq. 6}$$

Where R is Runoff, P is rainfall, and a and b are regression coefficients.

$$a = \frac{N(\Sigma PR) - (\Sigma P)(\Sigma R)}{N\,(\Sigma P^2) - (\Sigma P)^2} \quad \text{eq. 7}$$

Where N is the Number of observations.

$$b = \frac{\Sigma R - a(\Sigma P)}{N} \quad \text{eq. 8}$$

2.6 Rainfall-runoff and Urbanization Relationship

We have calculated the percentage of Rainfall for each basin using total rainfall in all basins and a similar method has been used for the Runoff and Urbanization to establish a relationship between them. We have adopted percentages and graph representation to demonstrate the relationship between them (equations 9, 10, and 11).

$$\text{Rainfall} = \frac{Rainfall\ in\ ith\ basin}{Total\ rainfall\ in\ all\ Basin} \quad \text{eq. 9}$$

$$\text{Runoff} = \frac{Runoff\ in\ ith\ basin}{Total\ runoff\ in\ all\ Basin} \quad \text{eq. 10}$$

$$\text{Urbanization} = \frac{Urbanization\ in\ ith\ basin}{Total\ Urbanization\ in\ all\ Basin} \quad \text{eq. 11}$$

*The formula has been adopted for each basin value.

3. Result and Discussion

3.1 Land Use Land Cover

Twelve basins are Extracted from the DEM data using the geospatial techniques. The major basins that have flow accumulation greater than 3000 have been selected (Figure 4). Table 2 shows the different Land Use Land cover patterns in each district for the year 2018. In Wetland 1 the waterbody area is 19072835.88 sq. meter, the Forest area is 139212331 sq. meter, the agriculture area is 135210554.3 sq. meter, the Built-up area is 20064209.78 square meters, and 36404683.13 sq. meters. Basin 2 is predominantly covered by forest, with no waterbody, and includes smaller areas of agriculture and built-up land. Specifically, Basin 2 has a waterbody area of 1,864,641.686 sq. meters, no forest area, an agriculture area of 28,096,919.65 sq. meters, a built-up area of 2,474,493.9 sq. meters, and no barren land. The details for Basin 3 are a waterbody area of 6,873.372525 sq. meters, no forest area, an agriculture area of 30,521,178.09 sq. meters, a built-up area of 1,876,030.584 sq. meters, and no barren land. Basin 4 features extensive forest cover along with significant agricultural land and a small amount of barren area, but it has no water body. Specifically, Basin 4 has a waterbody area of 16,318.7813 sq. meters, no forest area, an agriculture area of 33,183,795.74 sq. meters, a built-up area of 4,117,215.486 sq. meters, and a barren area of 2,968,890.378 sq. meters. The breakdown for Basin 5 includes a waterbody area of 24,489,555.72 sq. meters, a forest area of 24,851,296.17 sq. meters, an agriculture area of 250,764,331.2 sq. meters, a built-up area of 251,140,001.7 sq. meters, and a barren area of 47,884,801.19 sq. meters. Basin 6 is characterized by a large agricultural presence, significant forest cover, and a considerable built-up area, with a notable barren land portion as well. Specifically, Basin 6 has a waterbody area of 28,640,649.37 sq. meters, a forest area of 28,349,840.98 sq. meters, an agriculture area of 78,044,966.98 sq. meters, a built-up area of 127,245,148.9 sq. meters, and a barren area of 52,814,580.23 sq. meters. Basin 7 is the largest in the dataset, featuring extensive forest, agriculture, built-up, and waterbody areas, making it highly diverse in land use.

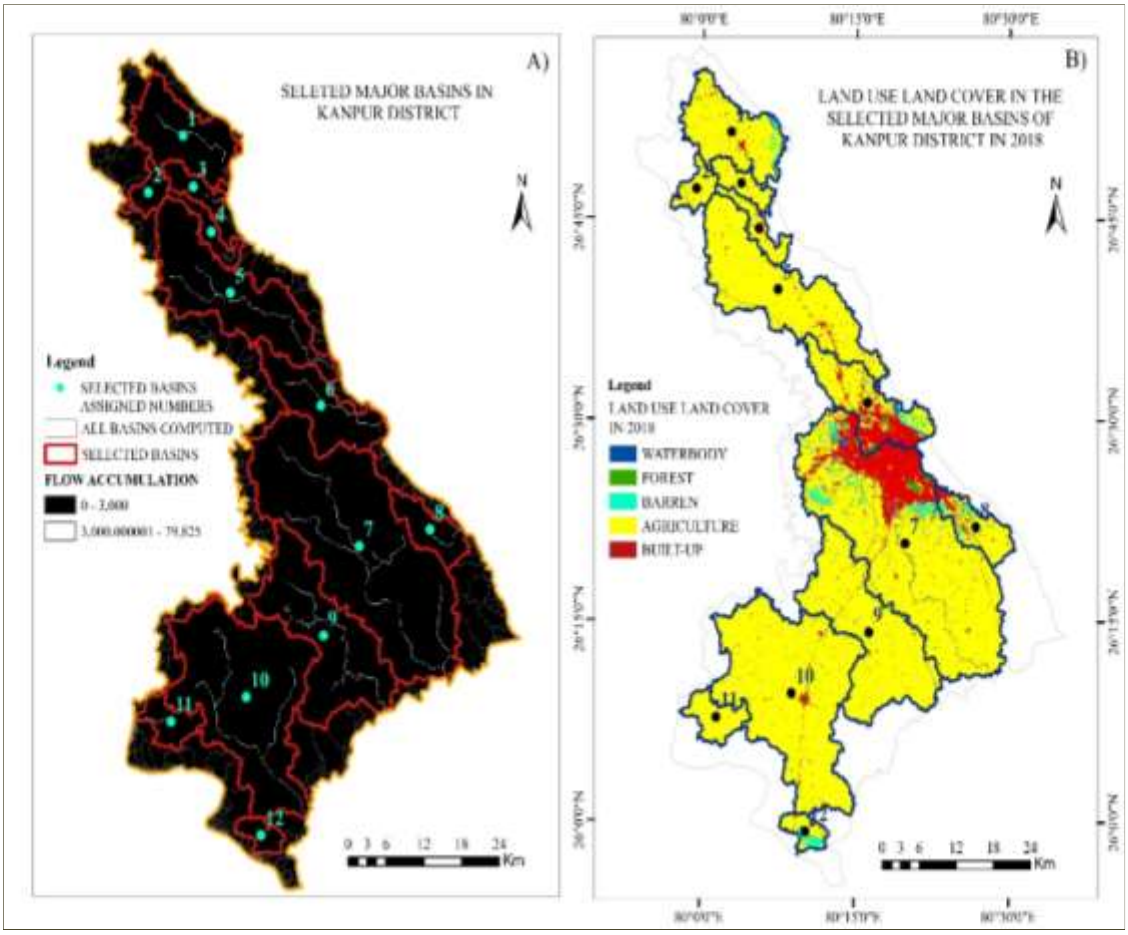

Figure 4: A) Extracted Basins B) Land Use Land Cover for each twelve basins.

The details for Basin 7 are a waterbody area of 191,005,731.2 sq. meters, a forest area of 191,156,518.7 sq. meters, an agriculture area of 590,487,430 sq. meters, a built-up area of 191,562,564.9 sq. meters, and a barren area of 368,541,753 sq. meters. Specifically, Basin 8 has a waterbody area of 170,371.9933 sq. meters, a forest area of 3,333,588.434 sq. meters, an agriculture area of 58,775,627.93 sq. meters, a built-up area of 17,707,123.85 sq. meters, and a barren area of 6,883,679.468 sq. meters. The specifics for Basin 9 include a waterbody area of 19,347,147.31 sq. meters, a forest area of 16,070,715.37 sq. meters, an agriculture area of 265,487,902.7 sq. meters, a built-up area of 19,584,748.13 sq. meters, and a barren area of 25,719,709.36 sq. meters. In Basin 10, the waterbody area is 14,787,428.38 sq. meters, the forest area is 20,983,224.96 sq. meters, and the agriculture area is 412,274,368.8 sq. Meters, the built-up area is 27,268,267.36 sq. meters, and the barren area is 20,628,443.28 sq. meters. Specifically, Basin 11 has a waterbody area of 17,098.66822 sq. meters, a forest area of 1,502,145.921 sq. meters, an agriculture area of 42,482,509.05 sq. meters, a built-up area of 4,627,947.741 sq. meters, and a barren area of 4,137,939.94 sq. meters. Lastly, the details for Basin 12 include a waterbody area of 8,020,749.008 sq. meters, a forest area of 23,556,527.58 sq. meters, an agriculture area of 1,708,850.604 sq. meters, a built-up area of 15,534,710.05 sq. meters, and no barren land (Figure 5). Overall, the data illustrates a diverse range of land use across the 12 basins, with varying balances of forests, agriculture, urban areas, waterbodies, and barren land.

Table 2: Land Use Land Cover in Each Basin of the 2018 year.

					area in sq. meter
Wetland no.	Waterbody	Forest	Agriculture	Built-up	Barren
1	19072835.88	13921231.31	135210554.3	20064209.78	36404683.13
2	1864641.686	0	28096919.65	2712809.251	2474493.9
3	6873.372525	0	30521178.09	1876030.584	0
4	16318.7813	0	33183795.74	4117215.486	2968890.378
5	24489555.72	24851296.17	250764331.2	251140001.7	47884801.19
6	28640649.37	28349840.98	78044966.98	127245148.9	52814580.23
7	191005731.2	191156518.7	590487430	191562564.9	368541753
8	170371.9933	3333588.434	58775627.93	17707123.85	6883679.468
9	19347147.31	16070715.37	265487902.7	19584748.13	25719709.36
10	14787428.38	20983224.96	412274368.8	27268267.36	20628443.28
11	17098.66822	1502145.921	42482509.05	4627947.741	4137939.94
12	8020749.008	0	23556527.58	1708850.604	15534710.05

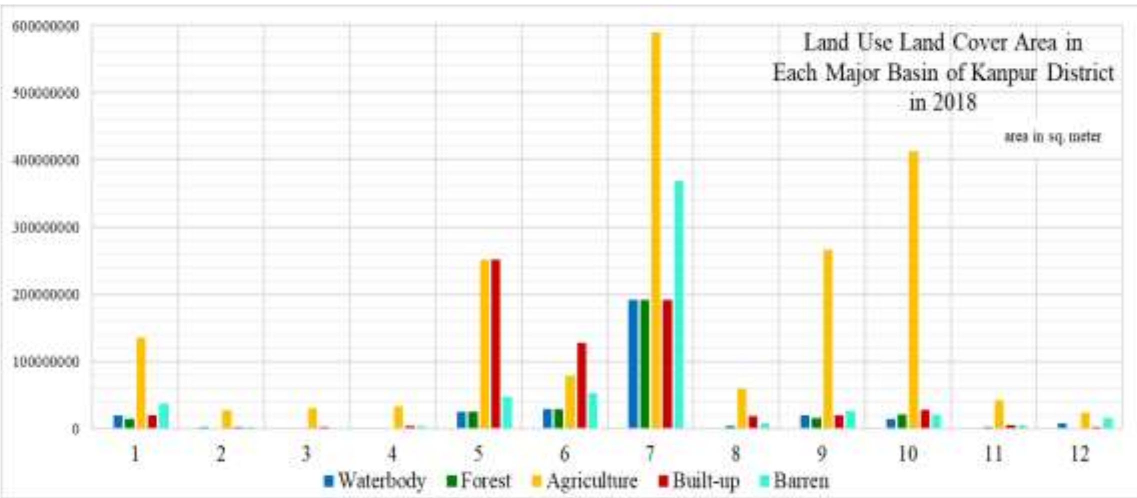

Figure 5: Graphical presentation of the basins' land use land cover area in 2018.

3.2 Annual rainfall and Runoff Distribution in each Basin

Basin 1 receives a yearly rainfall of 221.98 cm with a runoff of 44.32 cm, indicating moderate rainfall and a relatively low runoff rate. Basin 2 experiences higher rainfall at 242.3 cm and a substantial runoff of 111.18 cm, suggesting significant water flow. Basin 3 receives 233.23 cm of rainfall with a runoff of 128.55 cm, reflecting efficient water flow compared to rainfall (Figures 6 and 7). Basin 4 has 237 cm of rainfall and 119.19 cm of runoff, indicating a strong runoff response to rainfall. Basin 5, with 221.5 cm of rainfall and 49.91 cm of runoff, has lower runoff relative to its rainfall. Basin 6 receives 210.78 cm of rainfall, with a runoff of 42.54 cm, indicating low runoff relative to rainfall.

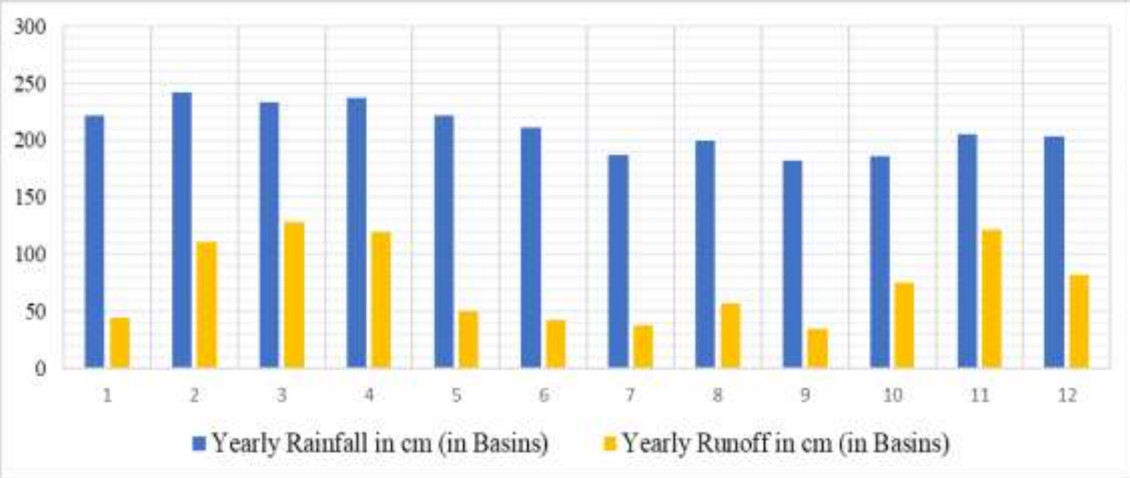

Figure 6: Annual rainfall and runoff from each basin.

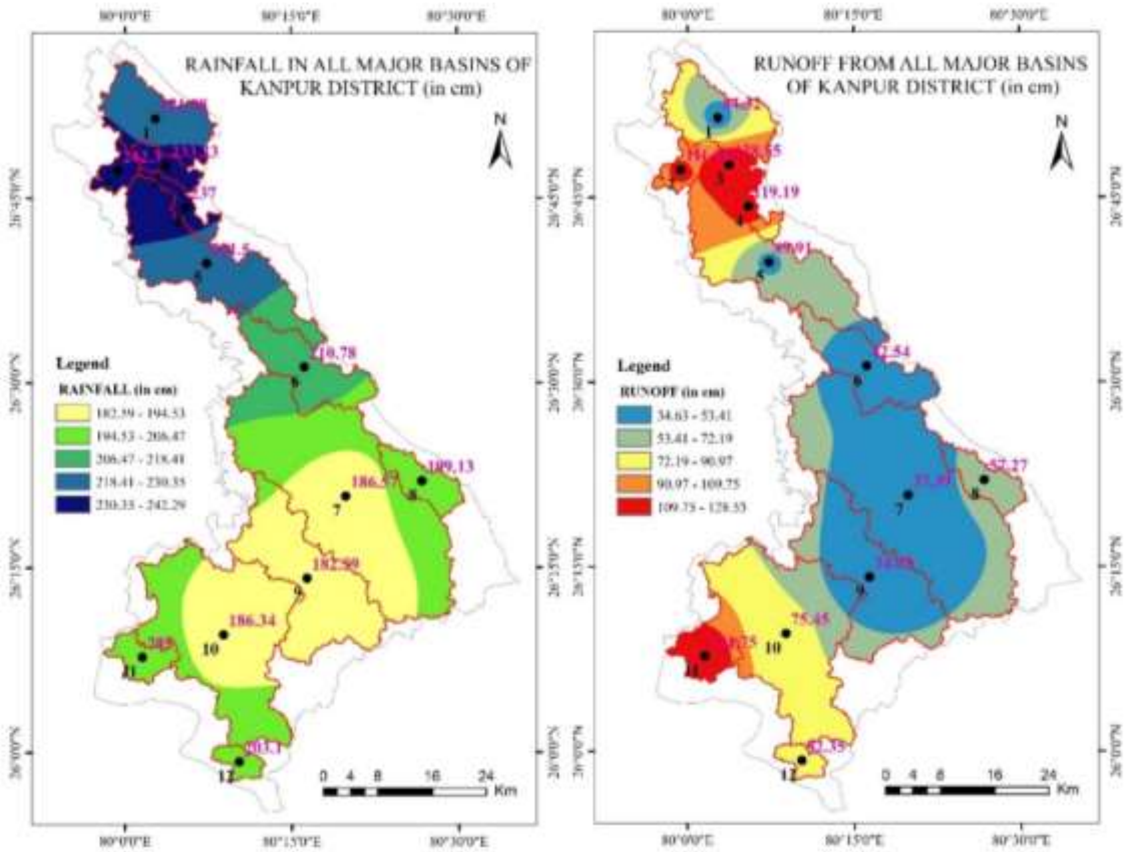

Figure 7: Yearly Rainfall and Runoff Distribution in Selected Major Basins in Kanpur District.

Basin 6 receives 210.78 cm of rainfall, with a runoff of 42.54 cm, indicating low runoff relative to rainfall. Basin 7 experiences 186.57 cm of rainfall and 37.39 cm of runoff, showing a modest runoff response. Basin 8 receives 199.13 cm of rainfall with a runoff of 57.27 cm, suggesting moderate runoff. Basin 9 has the lowest rainfall at 182.59 cm and a runoff of 34.63 cm, reflecting limited water flow. Basin 10 receives 186.34 cm of rainfall with a runoff of 75.45 cm, indicating higher runoff relative to rainfall. Basin 11 experiences 205 cm of rainfall and a significant runoff of 121.75 cm, showing efficient water flow. Basin 12 receives 203.1 cm of rainfall with a runoff of 82.35 cm, reflecting moderate water flow. Overall, the basins show varying rainfall and runoff levels, with Basins 2, 3, and 11 having notably high runoff, indicating effective water flow in these areas.

3.3 Rainfall and Runoff Relationship

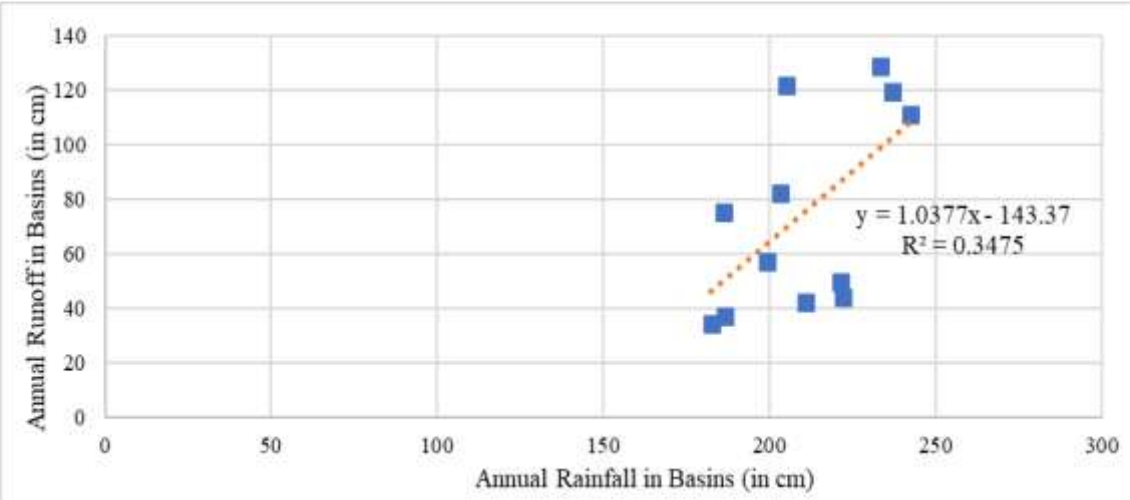

Figure 8: Rainfall-runoff relationship using Regression and coefficient of determination

There is a coefficient of determination between rainfall and runoff, which is 0.3475 which indicates that data is somehow distributed near the straight fit line (Figure 8). The distribution of the data near the straight-fit line shows how strong a linear relationship is between Annual runoff and rainfall. the required rainfall-runoff relationship in the basins is given by the y formula, which is y = 1.0477x-143.37. in this formula, x is the rainfall. This formula helps predict how much runoff we can expect based on different amounts of rainfall. It's important to remember that both rainfall (P) and runoff (R) are measured in centimeters. Understanding this connection can help with planning and managing water resources in the area. Overall, the data shows a clear trend that can be useful for addressing runoff issues.

3.3 Rainfall-runoff and Urbanization Relationship

Basin 1 has a rainfall percentage of the total is 8.78, this wetland has a yearly runoff percentage of the total is 4.90, and urbanization percentage in this basin has a total percentage of 5.21. Basin 1 has a rainfall percentage of 8.78% of the total, indicating a moderate level of precipitation relative to the other basins (Figure 9 and Table 3).This wetland has a yearly runoff percentage of 4.90%. Additionally, the urbanization percentage in Basin 1 stands at 5.21%, reflecting a relatively low level of urban development compared to some of the other basins. Basin 2 shows a rainfall percentage of

9.58%. It has a yearly runoff percentage of 12.29%, suggesting a significant conversion of rainfall into surface runoff. The urbanization percentage in this basin is 4.51%, which is relatively low. Basin 3 features a rainfall percentage of 9.22%, with a notably high yearly runoff percentage of 14.21%, the highest among all basins.

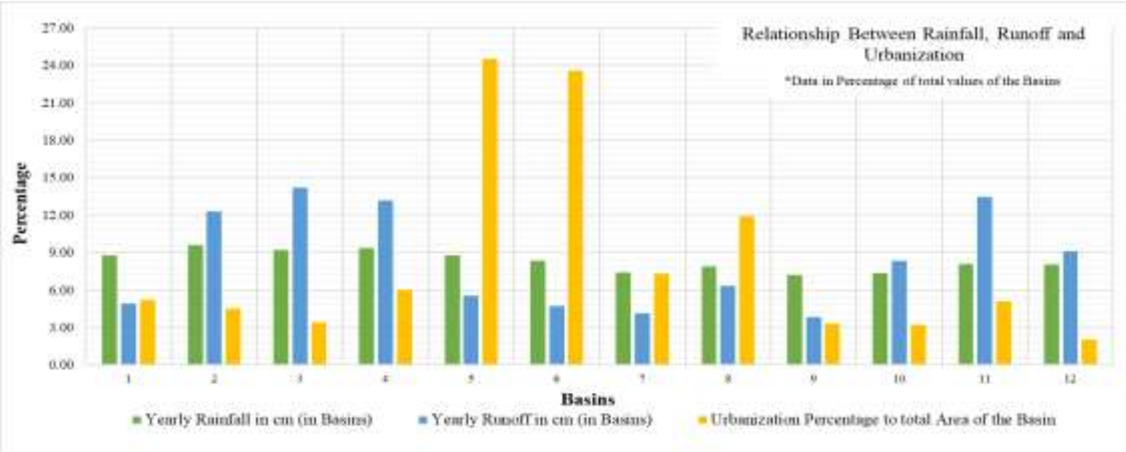

Figure 9: Graphical representation of the Relationship between Rainfall, Runoff, and Urbanization

This indicates that this basin is particularly efficient at converting rainfall into runoff, despite having an urbanization percentage of 3.38%. Basin 4 has a rainfall percentage of 9.37%, alongside a yearly runoff percentage of 13.18%, reflecting a considerable runoff from its rainfall. The urbanization percentage here is 5.97%. Basin 5 records a rainfall percentage of 8.76%, but has a lower yearly runoff percentage of 5.52%. Despite this, it has the highest urbanization percentage at 24.48%, indicating extensive development.

Table 3: Rainfall, runoff, and Urbanization relationship.

Basin no.	Yearly Rainfall in percentage (in Basins)	Yearly Runoff in percentage (in Basins)	Urbanization Percentage to Total Area of the Basin
1	8.78	4.90	5.21
2	9.58	12.29	4.51
3	9.22	14.21	3.38
4	9.37	13.18	5.97
5	8.76	5.52	24.48
6	8.33	4.70	23.58
7	7.38	4.13	7.30
8	7.87	6.33	11.90
9	7.22	3.83	3.30
10	7.37	8.34	3.21
11	8.10	13.46	5.12
12	8.03	9.10	2.04

Basin 6 has a rainfall percentage of 8.33%, with a yearly runoff percentage of 4.70%. Its urbanization percentage is 23.58%, indicating significant urban development. Basin 7 shows a rainfall percentage of 7.38% and a yearly runoff percentage of 4.13%. The urbanization percentage is 7.30%, suggesting a moderate level of urban development. Basin 8 has a rainfall percentage of 7.87%, with a yearly runoff percentage of 6.33%. Its urbanization percentage stands at 11.90%, reflecting a moderate level of development. Basin 9 has a rainfall percentage of 7.22%, the lowest among the basins, and a yearly runoff percentage of 3.83%, indicating minimal surface runoff relative to the rainfall received. The urbanization percentage is 3.30%. Basin 10 displays a rainfall percentage of 7.37% and a yearly runoff percentage of 8.34%, indicating a moderate level of runoff. Its urbanization percentage is 3.21%. Basin 11 has a rainfall percentage of 8.10%, alongside a yearly runoff percentage of 13.46%, reflecting a higher rate of runoff relative to its rainfall. The urbanization percentage is 5.12%. Basin 12 features a rainfall percentage of 8.03% and a yearly runoff percentage of 9.10%, indicating a balanced relationship between rainfall and runoff. The urbanization percentage is the lowest at 2.04%.

4. Conclusion

The study aims to find out the rainfall-runoff relationship and its relation to the built-up area in the basins of the Kanpur district in 2018. The hydrological analysis of twelve basins in the Kanpur district reveals diverse rainfall and runoff patterns. Basin 2 has the highest rainfall at 242.3 cm and a substantial runoff of 111.18 cm, while Basin 3 shows an efficient runoff of 128.55 cm from 233.23 cm of rainfall. Basin 5 shows the highest urbanization at 24.48%. Major basins were identified based on flow accumulation, and land use was classified into five categories for the year 2018: Waterbody, Forest, Agriculture, Barren, and Built-up. The area of each land use type across twelve basins varied significantly, with Basin 1 having the largest waterbody area (19,072,835.88 sq. meters) and Basin 5 showcasing extensive agriculture (250,764,331.2 sq. meters) and built-up land (251,140,001.7 sq. meters). Daily rainfall data was collected to calculate monthly runoff using the SCS-CN method, revealing that Basin 2 experienced the highest runoff of 111.18 cm from a rainfall of 242.3 cm. Regression analysis established a positive correlation between rainfall and runoff. The analysis of the Kanpur district's basins through geospatial techniques has revealed a significant understanding of the relationship between rainfall runoff and urbanization. The delineation of twelve major basins from the Digital Elevation Model (DEM) data using ArcGIS has provided a framework for understanding the hydrological dynamics in the region.

The results indicate different runoff responses to rainfall, but certain basins demonstrate high efficiency in converting rainfall into runoff. Specifically, Basins 2, 3, and 11 presented notable runoff percentages, suggesting that urbanization and land cover types play critical roles in hydrological responses. Overall, the study underscores the complex interactions among land use, hydrology, and urbanization in the region. This relationship between the Rainfall-runoff relationship and urbanization will help in land management, urban planning, and to development of sustainable development practices to mitigate flooding. The study not only contributes to the understanding of hydrological patterns but also emphasizes the importance of continuous monitoring of built-up change and its impact on hydrology. Future research should aim to use these findings to help shape local planning and policies. This can enhance the area's ability to deal with the challenges brought on by urban growth and climate change.

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