



MA CITIES AND GOVERNANCE
TATA INSTITUTE OF SOCIAL SCIENCES, HYDERABAD

STORM WATER ANALYSIS OF GAJWEL MUNICIPALITY

PRESENTED BY-

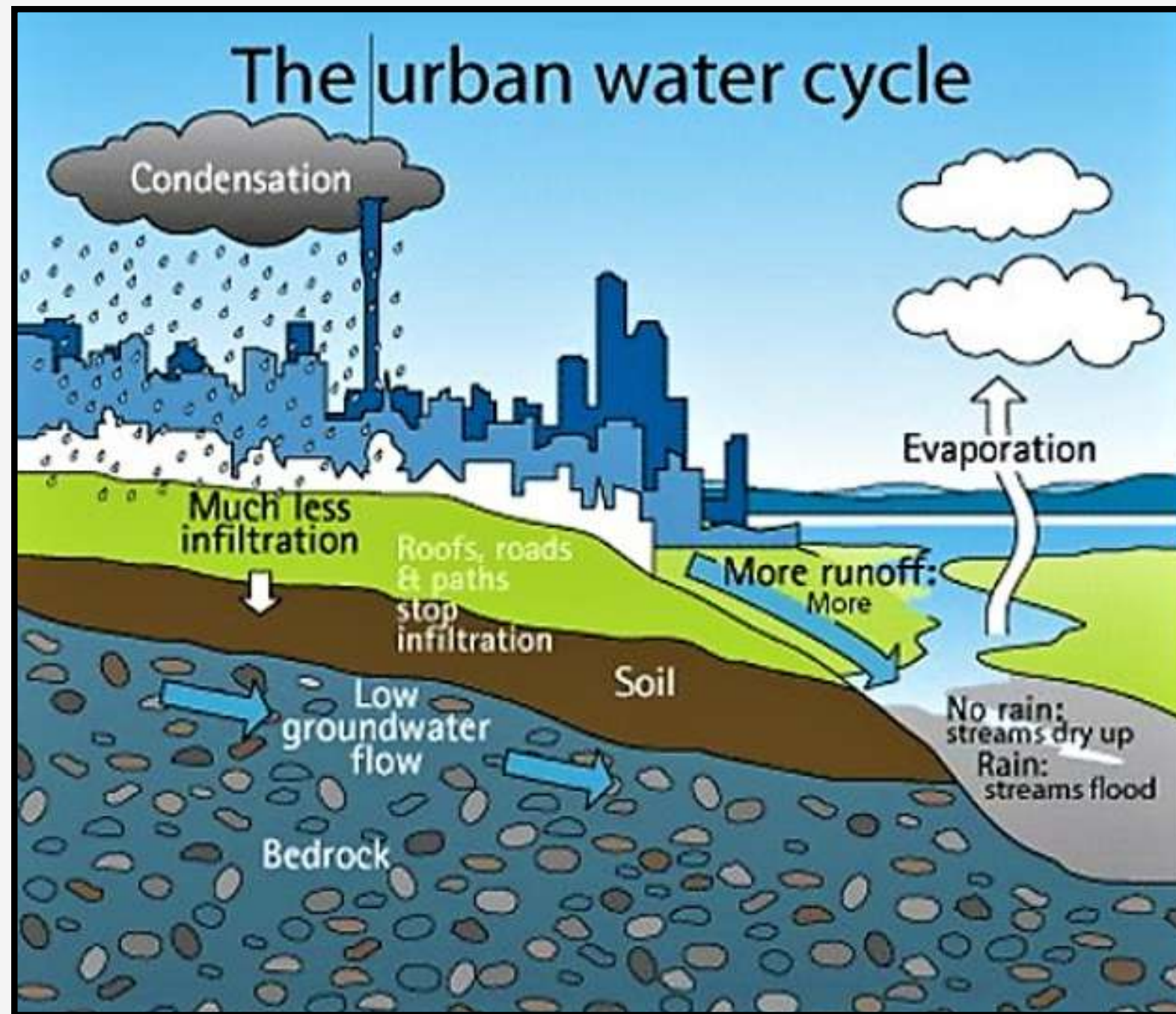
ARAVIND V RAJEEV
DISHA ARORA
KUSHAL PRATAP MALL
MAGARE NAGESH MADHUKAR
MRITYUNJAI SHARAN
NIKETAN AMBADE
PRAJNA KOLISETTI
SHRUTI DUTTA
SRISHTI DUGGAL



Table Of Content

- Storm water analysis
- Land use and land cover analysis
- Calculations of quantity of water
- Methodology
- Total ground water recharge
- Gajwel Town Profile
- Watershed and Stream segment
- Hydrological Soil Groups
- Total run-off
- Recommendations

STORM WATER ANALYSIS



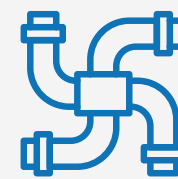
Source: Auckland City Council



Comprehensive evaluation of rainfall run-off within a specified area or region.



Comprehend the interaction of rainfall with the environment, particularly with surfaces such as rooftops, pavements, and roads.

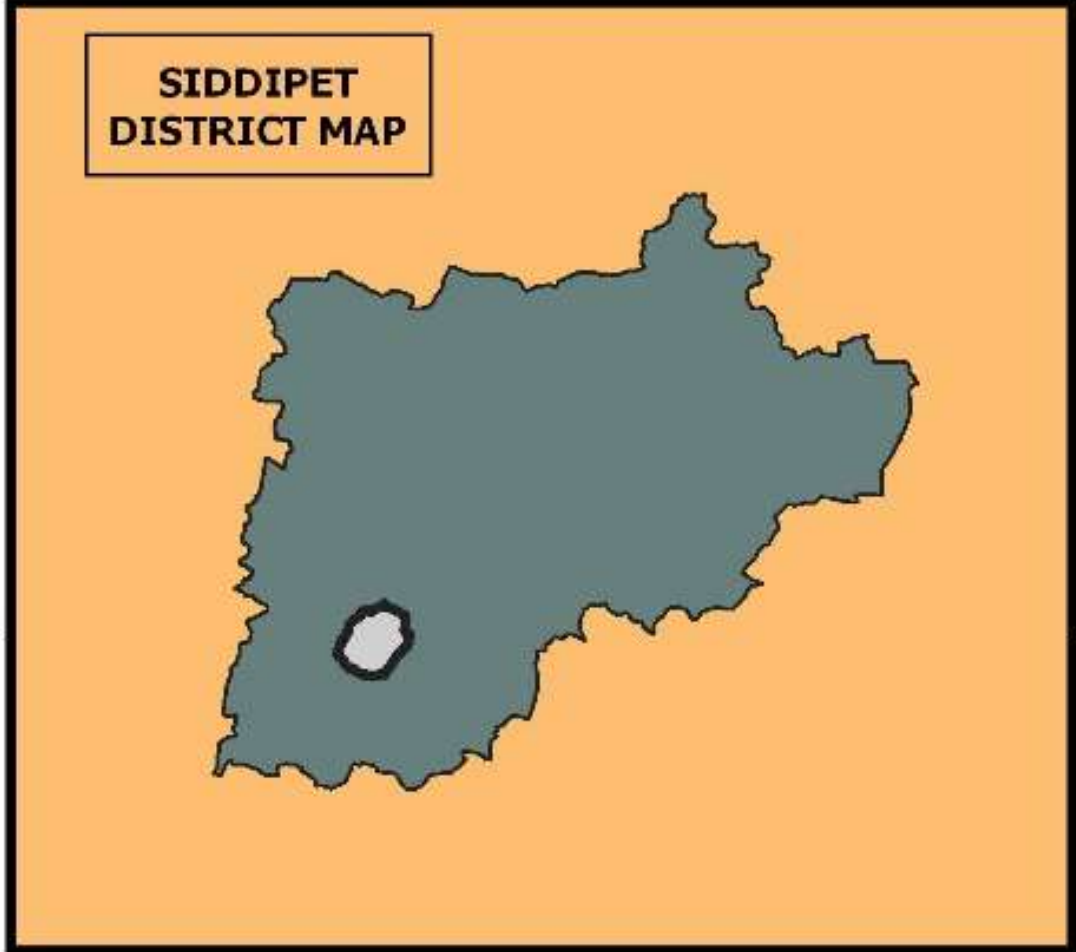
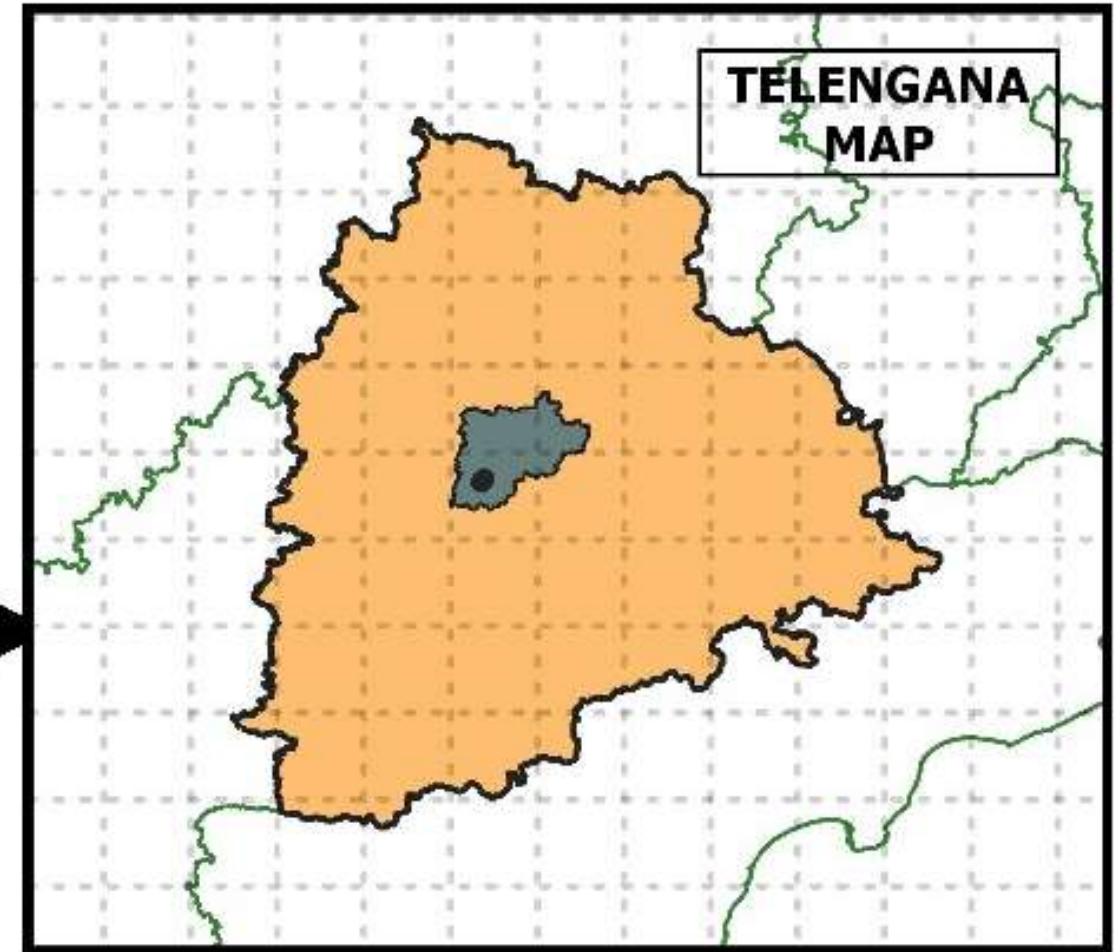
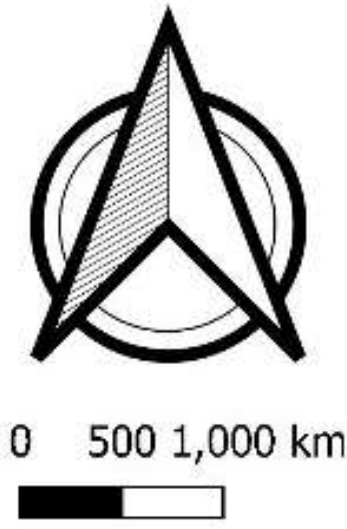
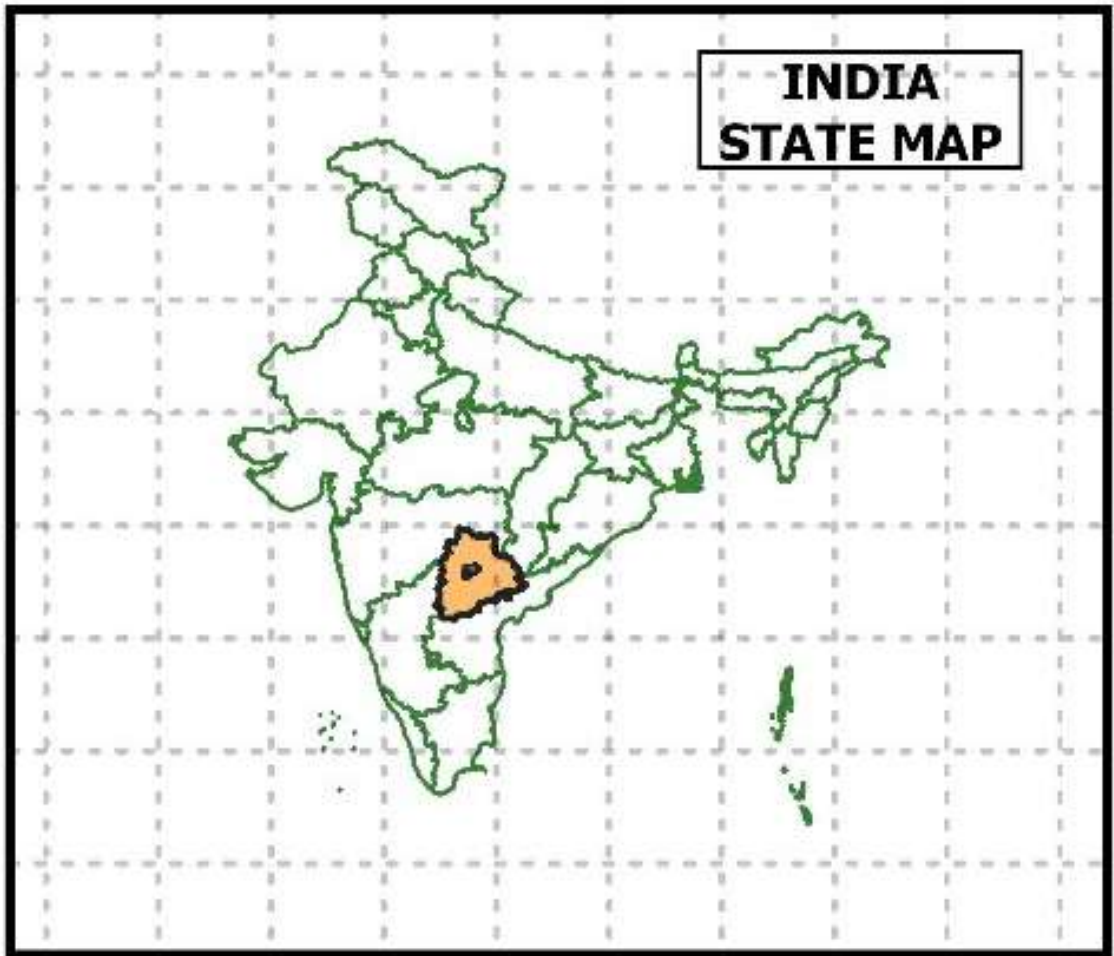


Stormwater management systems encompass a spectrum of infrastructure, including drainage networks, retention ponds, infiltration basins.



It aims prevention of flooding, managing erosion, and safeguarding water quality, particularly in urban environments.

Study Area



GAJWEL TOWN PROFILE



49,330*



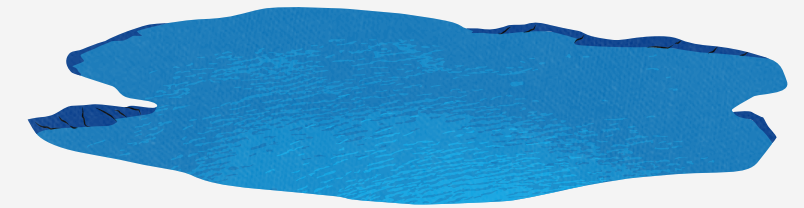
51.9 sq. km



950 person/sq.km



76.4%**



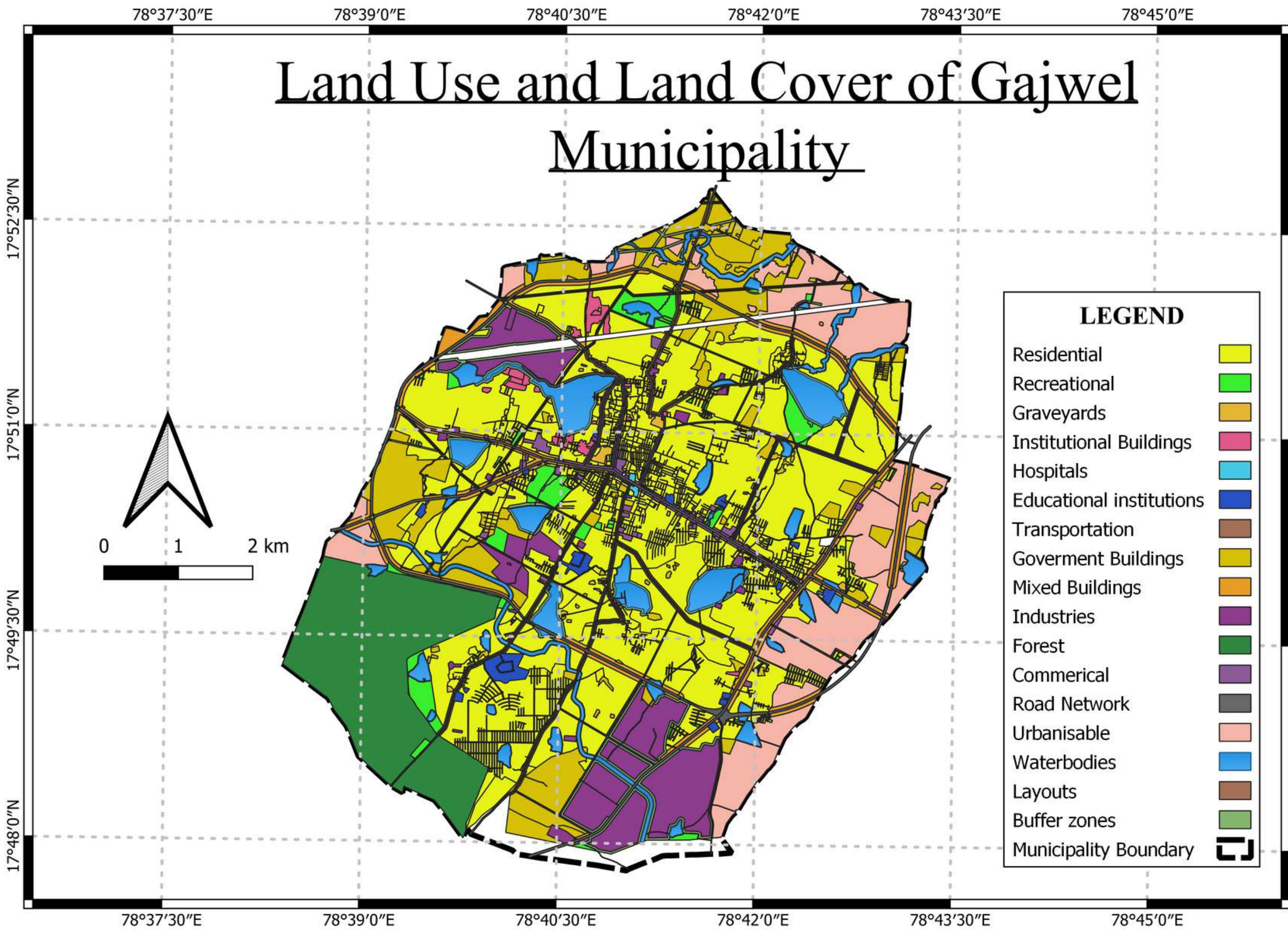
Lake:
Pandavula Cheruvu

Since its inception in 2012, intensive planning projects have been undertaken to fulfill the requirements of urban demands. The town receives an average rainfall of 813.5mm and thus, it becomes important to divert and store surplus water, for which a robust infrastructure of stormwater drainage is a necessity.

*Projected population 2023 from Census 2001 and 2011 with a compound growth rate of 2.7%

** Literacy figures based on Census 2011 data

Land Use and Land Cover of Gajwel Municipality



LEGEND

- Residential
- Recreational
- Graveyards
- Institutional Buildings
- Hospitals
- Educational institutions
- Transportation
- Government Buildings
- Mixed Buildings
- Industries
- Forest
- Commerical
- Road Network
- Urbanisable
- Waterbodies
- Layouts
- Buffer zones
- Municipality Boundary

LULC Layer	Area in sq. km
Buffer	1.836
Roads	5.762
forest	5.128
mixed	2.148
Transportation	0.033
Commercial	0.760
Residential	19.880
Industries	3.511
Recreational	1.153
Urbanisable	4.942
Water bodies	3.195
PS 1- Govt. Buildings	5.057
PS 2- Education Institutions Buildings	0.381
PS 3- Hospitals	0.022
PS 4- institutional buildings	0.321
PS 5- graveyards	0.085
Layout	0.644
Total	54.858

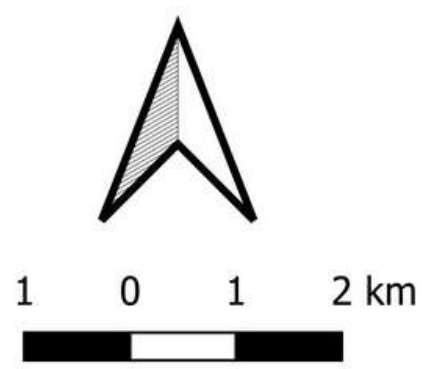
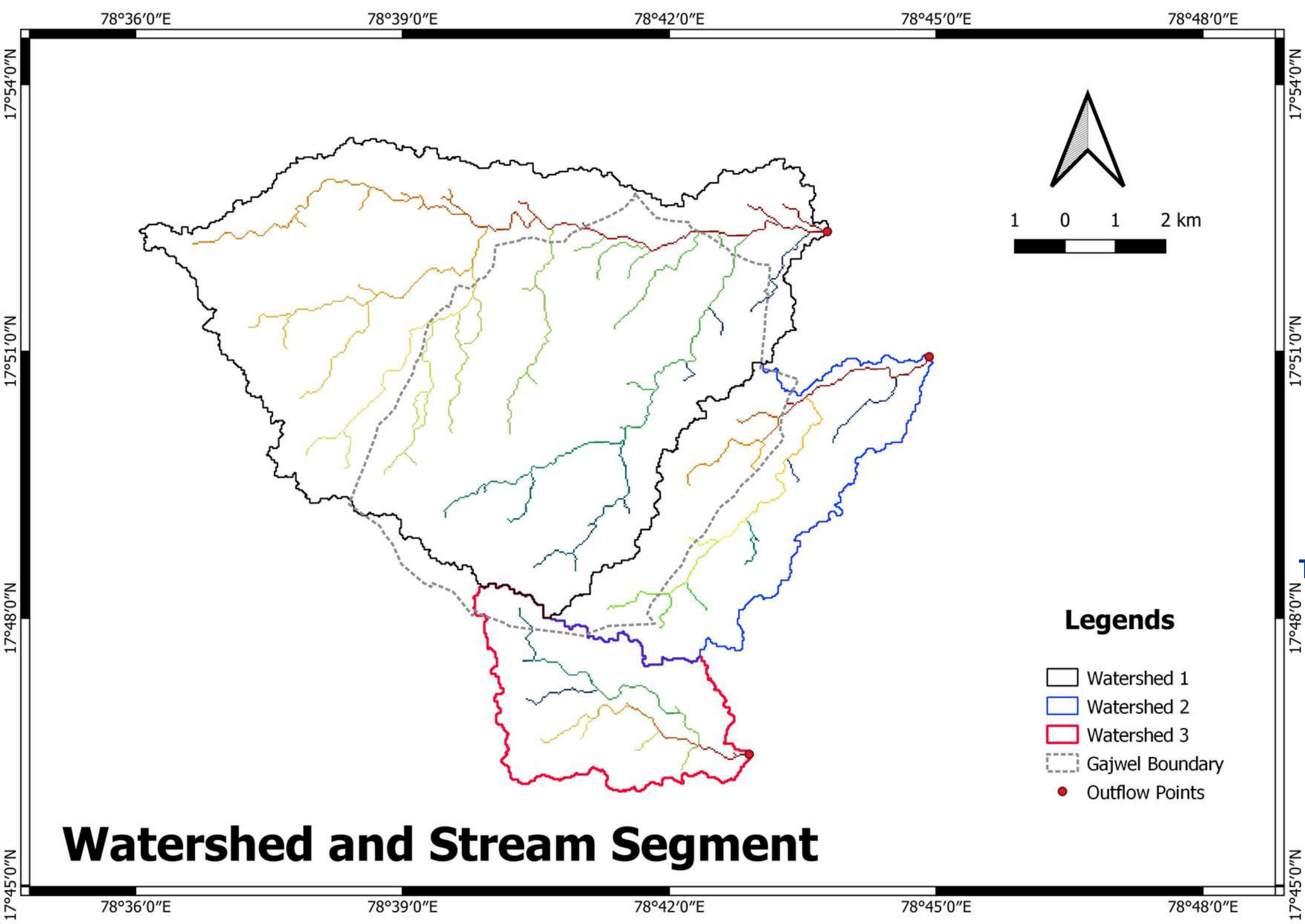


LAND USE AND LAND COVER OF GAJWEL MUNICIPALITY

- **Residential Focus:** Covers 19.88 sq. km, indicating a primary emphasis on housing infrastructure.
- **Environmental Preservation:** Forests span 5.13 sq. km, and water bodies encompass 3.19 sq. km, showcasing a commitment to preserving natural spaces.
- **Administrative & Industrial Zones:** Govt. Buildings occupy 5.06 sq. km, while industries cover 3.51 sq. km, highlighting significant areas allocated for administrative and industrial purposes.
- **Smaller Land Shares:** Transportation, commercial, healthcare, education institutions, and graveyards hold minor land shares, suggesting potential growth areas within the municipality.
- **Diverse Landscape:** Reflects a diverse land use pattern focusing on housing, environmental conservation, governance, and industrial activities, with opportunities for development in smaller sectors.

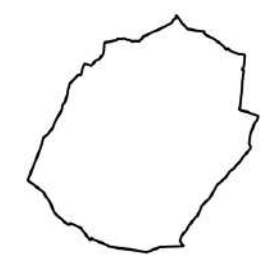
Composition of LULC of Gajwel ULB in km sq.





- Legends**
- Watershed 1
 - Watershed 2
 - Watershed 3
 - Gajwel Boundary
 - Outflow Points

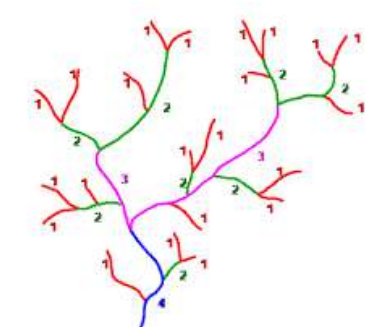
Watershed and Stream Segment



Storm Water doesn't adhere to the ULB or the Administrative Boundary



Watershed 1 Area= 7,91,49,781 sq.m.
Watershed 2 Area= 2,14,15,904 sq.m.
Watershed 3 Area= 1,39,33,875 sq.m.
Total Watershed Area= 11,44,99,560 sq.m.



Strahler Stream Order:
Classification system describing position within the drainage network

CALCULATIONS FOR QUANTITY OF WATER



Actual Rainfall = 1016.6 mm
= 1.0166m

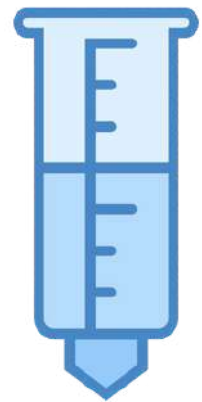


Total Watershed Area =
11,44,99,560 sq.m.

Total Quantity of Rainwater (Q) = Watershed Area(in sq.m.) X Total Rainfall (in m)

Since, $1\text{m} \times 1\text{m} \times 0.001\text{m} = 0.001 \text{ cu.m.} = 1\text{L}$

Therefore, $1\text{m} \times 1\text{m} \times 1\text{m} = 1 \text{ cu.m.} = 1,000 \text{ L} = 1\text{KL}$



Putting the value of Watershed Area and Rainfall value in Formulae -

$$Q = 11,44,99,560 \text{ sq.m.} \times 1.0166 \text{ m}$$

$$Q = 11,64,00,252.7 \text{ cu.m.}$$

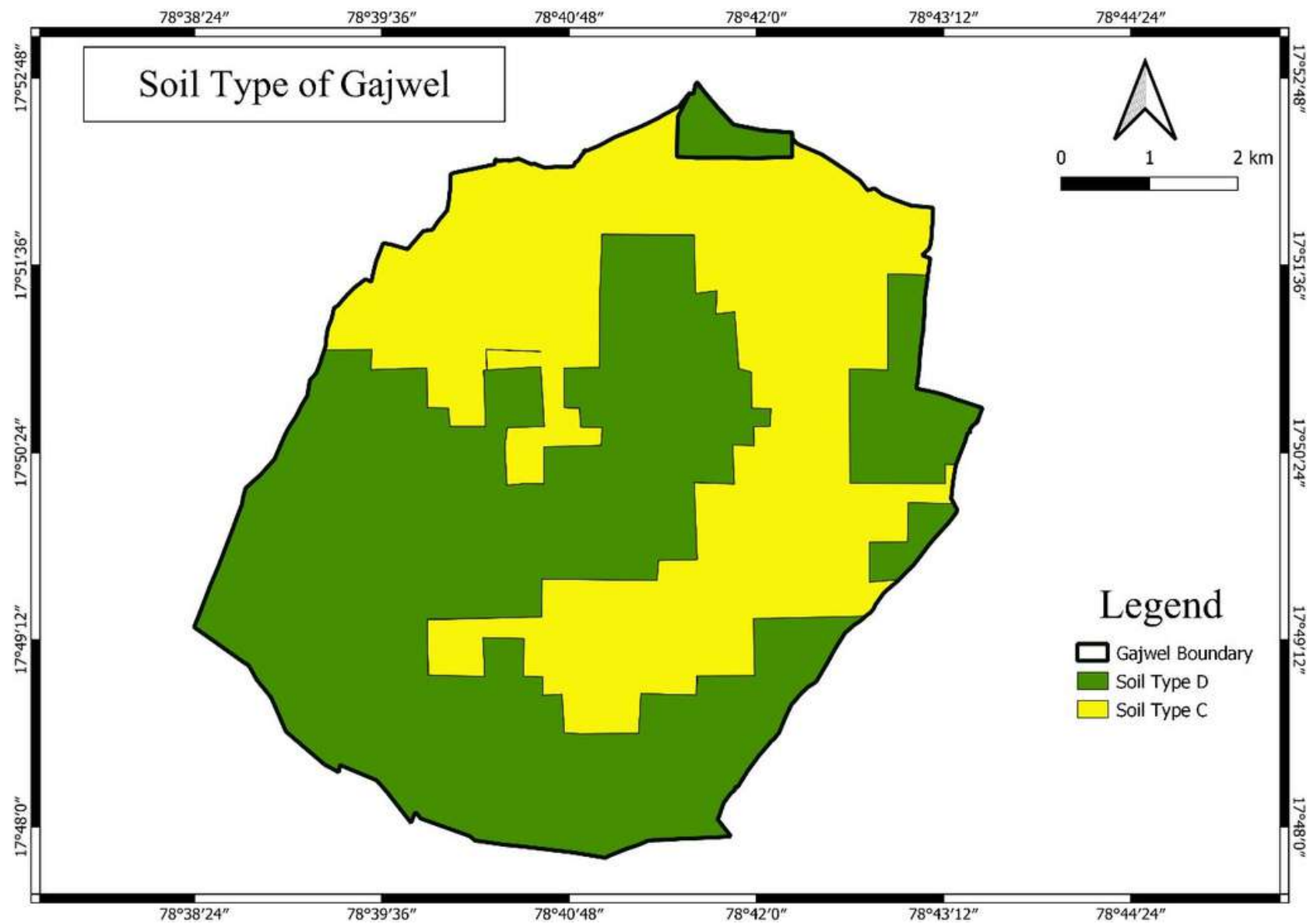
$$Q = 11,64,00,252.7 \text{ KL}$$

Now, converting the amount of water in Million Litre (ML) -

Value in ML = Value in KL / 1,000

$$Q \text{ (in ML)} = 11,64,00,252.7 \text{ KL} / 1,000 = 11,64,00.25 \text{ ML}$$

Q = 1,16,400 ML (Approx.)



HYDROLOGICAL SOIL GROUPS (HSGs)

GROUP A: Sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted.

GROUP B: Silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

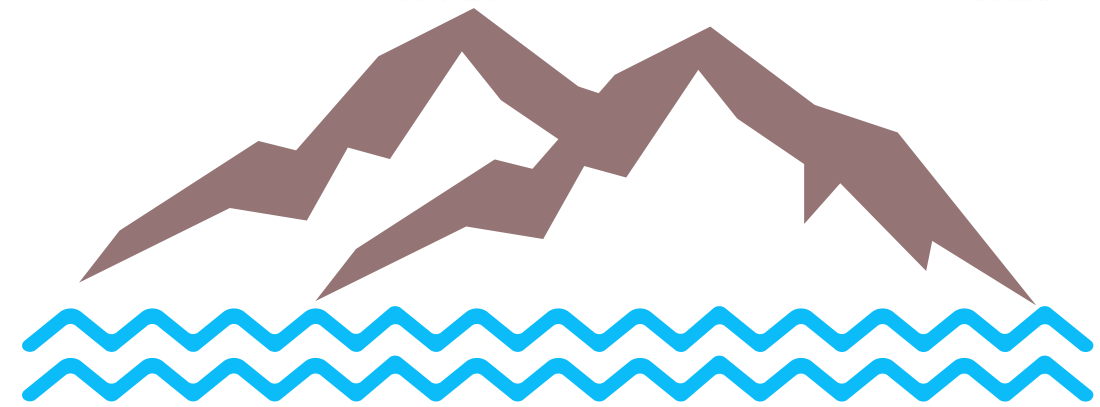
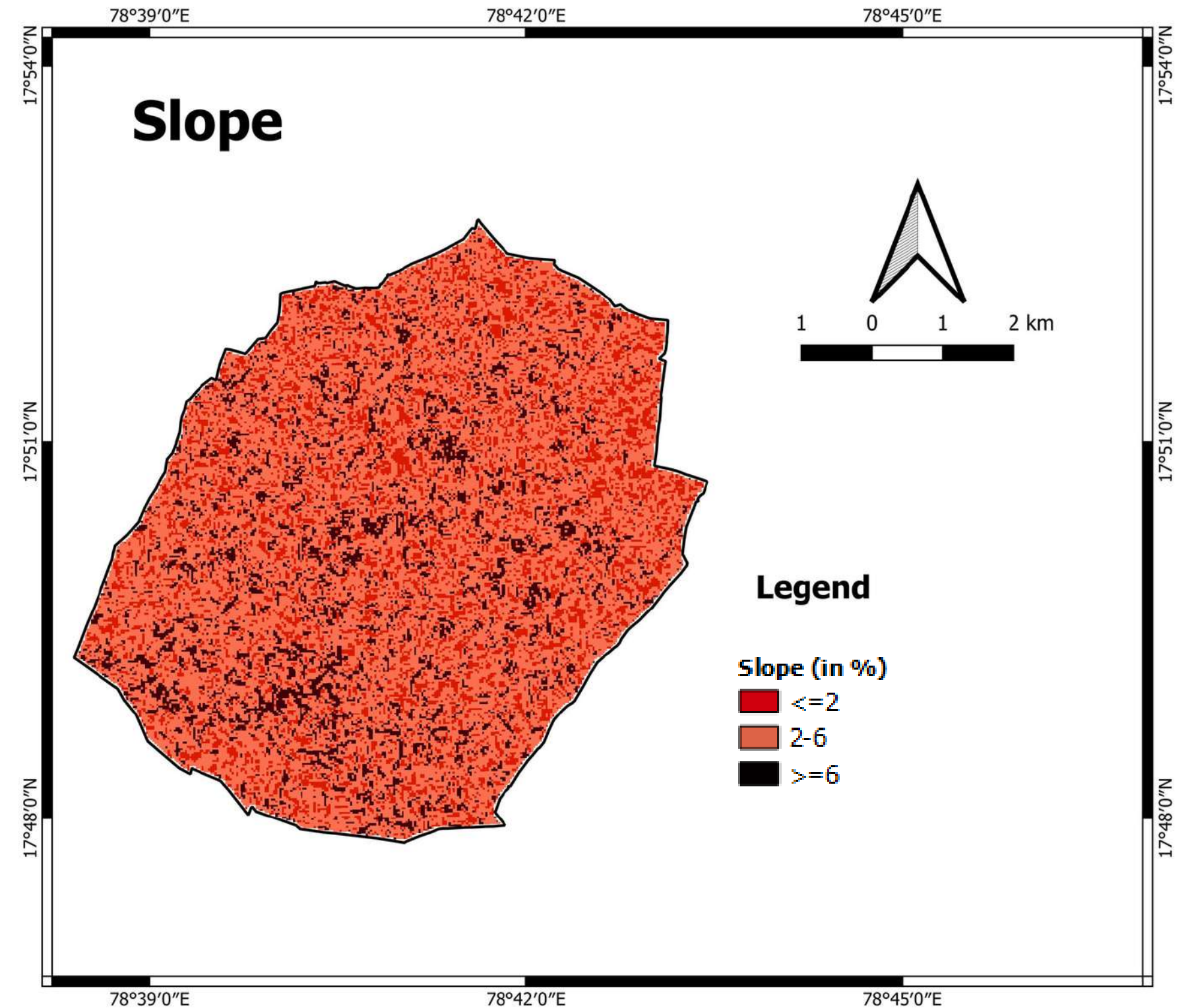
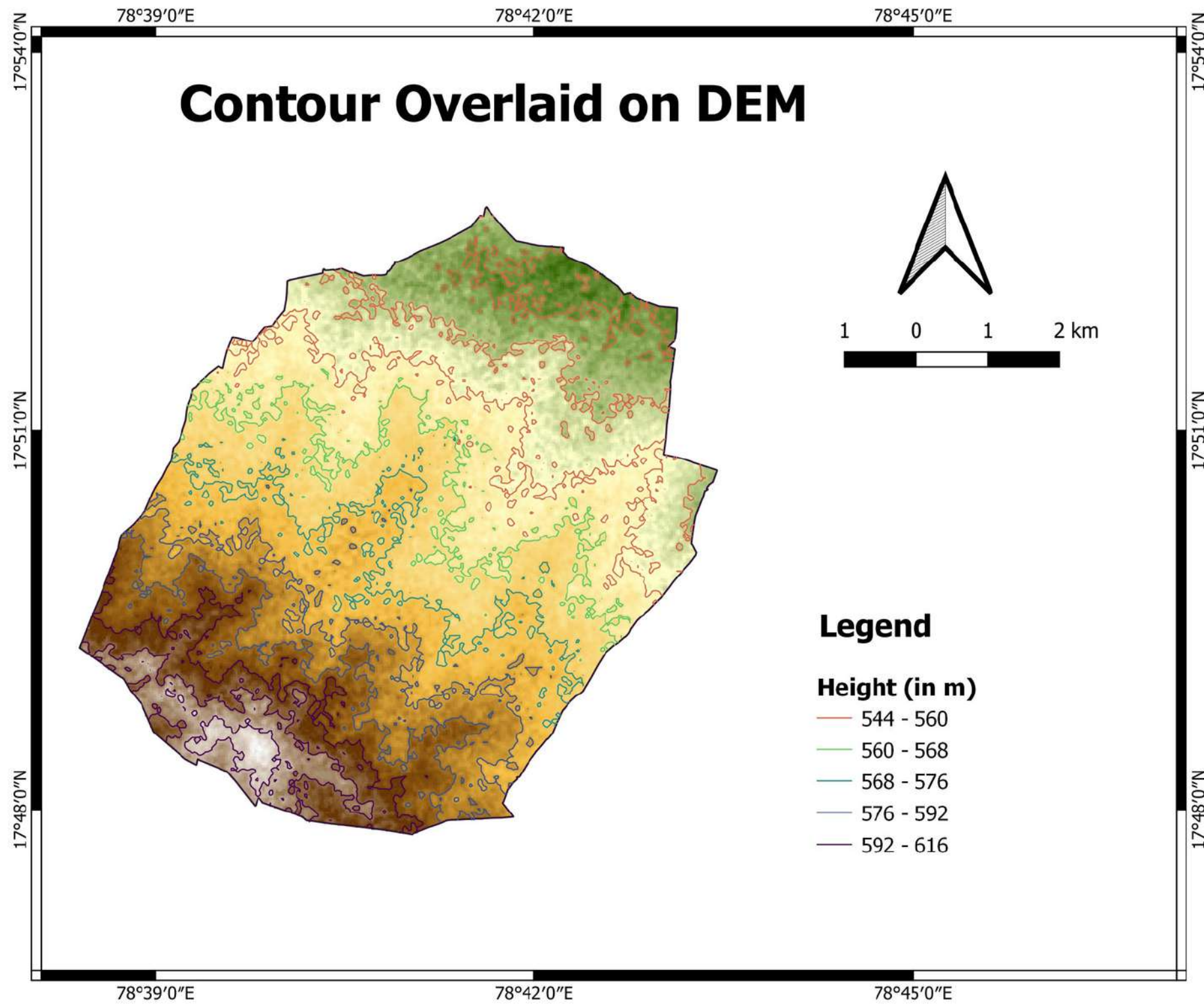
GROUP C: Soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.

GROUP D: Soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This HSG has the highest runoff potential.

Runoff Potential
Lowest A<B<C<D Highest

The study area of Gajwel contains Soil Type C and D

Land use	Soil Group A			Soil Group B			Soil Group C			Soil Group D		
	0-2%	2-6%	>6%	0-2%	2-6%	>6%	0-2%	2-6%	>6%	0-2%	2-6%	>6%
Residential (65% impervious)	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
Residential (30% impervious)	0.19	0.23	0.26	0.22	0.26	0.30	0.25	0.29	0.34	0.28	0.32	0.39
Residential (12% impervious)	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.29	0.35
Commercial	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Industrial	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
Streets	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
Parking	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
Open space	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
Cultivated land	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
Pasture	0.12	0.20	0.30	0.18	0.28	0.37	0.24	0.34	0.44	0.30	0.40	0.50
Meadow	0.10	0.16	0.25	0.14	0.22	0.30	0.20	0.28	0.36	0.24	0.30	0.40
Forest	0.05	0.08	0.11	0.08	0.11	0.14	0.10	0.13	0.16	0.12	0.16	0.20

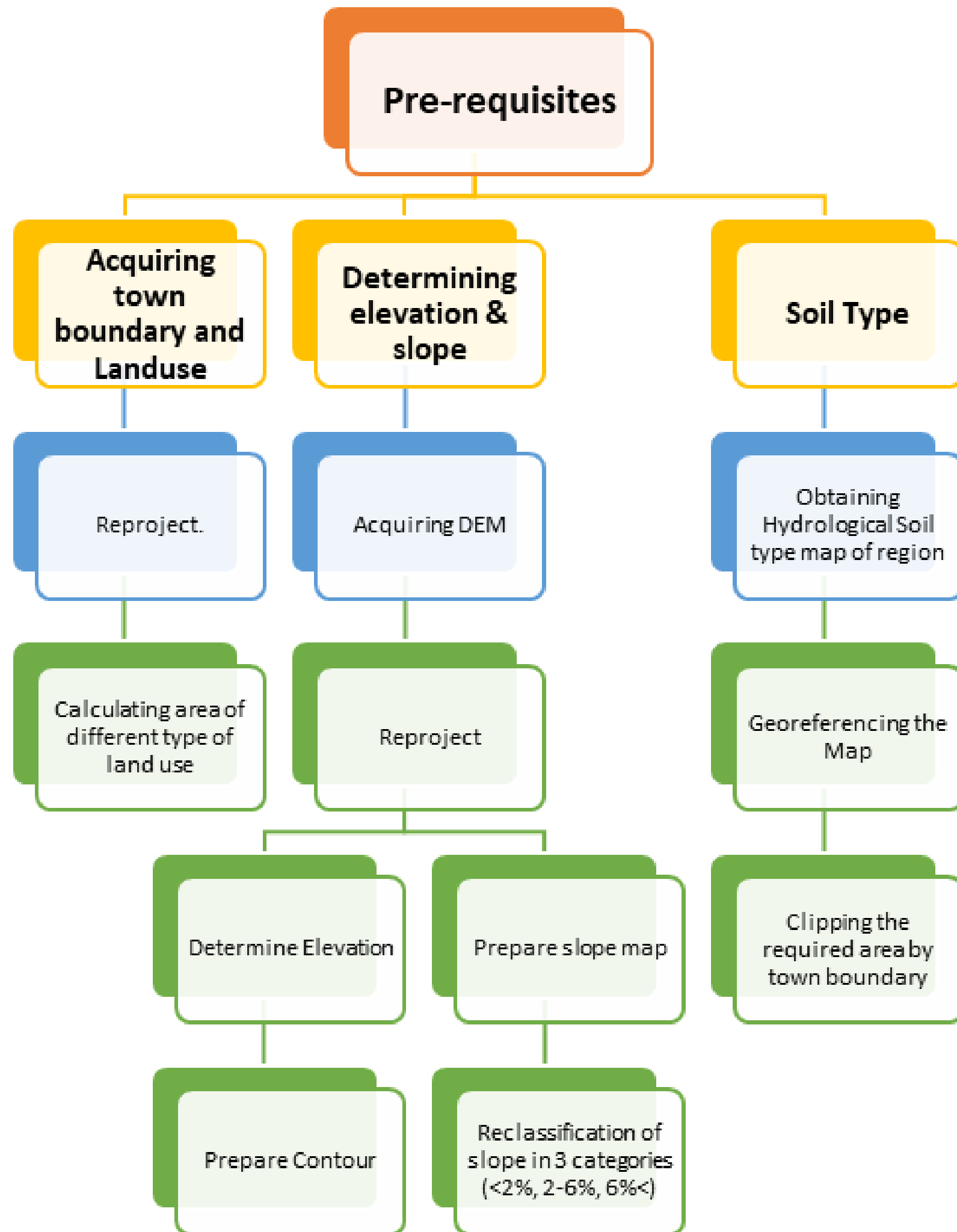


Elevation Range: 544m - 616m

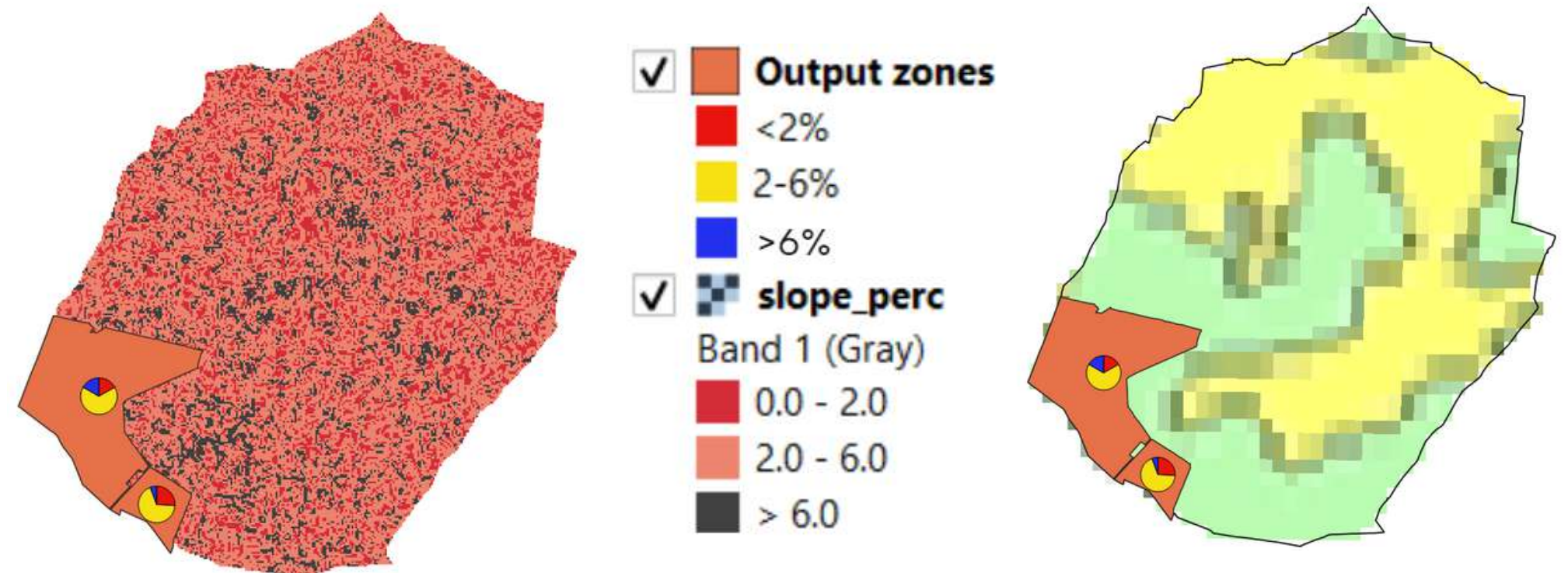


Slope Range: 0 - 29%

Methodology



After acquiring all three pre-requisites we need to know the area under different soil type and varying slope of every land use. For determining the same, we require all three layers (land use shape-file, reclassified slope raster and soil type layer) in QGIS environment. The zonal histogram tool is used to get share of classified slope area (i.e. <2%, 2-6%, 6%<) of a particular landuse. Then, selection tool is used to select all land parcel of that landuse lying within different soil type. This will result in required area of every landuse in varying soil type and slope value.



Total Run-off

$$Total\ Runoff\ (Y) = Total\ Rainfall\ (Q) \times \frac{[Coefficient\ of\ runoff(C1) \times Area(A1) + C2 \times A2 + \dots + Cn \times An]}{Total\ Watershed\ Area(A1 + A2 + \dots + An)}$$

Land Use Type	Considered Land Uses	Area Under Soil Type C			Area Under Soil Type D			Relevant Coeff. Of soil C			Relevant Coeff. Of soil D			Effective Run-off
		0-2%	2-6%	>6%	0-2%	2-6%	>6%	0-2%	2-6%	>6%	0-2%	2-6%	>6%	
Urbanisable	Open Spaces	0.332	0.954	0.170	0.941	2.298	0.247	0.12	0.17	0.24	0.16	0.21	0.28	0.9451
Transportation	Parking	0.003	0.013	0.005	0.002	0.009	0.002	0.85	0.86	0.87	0.85	0.86	0.87	0.0286
Roads	Streets (40 % soil C and 60% soil D)	0.490	1.456	0.360	0.734	2.183	0.540	0.72	0.73	0.76	0.73	0.75	0.78	4.2831
Residential	30 % Residential (65% imperv.)	0.742	2.301	0.535	0.495	1.534	0.357	0.3	0.33	0.38	0.33	0.36	0.42	2.0508
	70 % Residential (30% imperv.)	1.732	5.368	1.249	1.155	3.579	0.833	0.25	0.29	0.34	0.28	0.32	0.39	4.2080
Recreational	80% Open Spaces	0.099	0.268	0.085	0.095	0.321	0.056	0.12	0.17	0.24	0.16	0.21	0.28	0.1758
	20% Residential (12% imperv.)	0.025	0.067	0.021	0.024	0.080	0.014	0.2	0.25	0.31	0.24	0.29	0.35	0.0620
Mixed	20 % Residential (30% imperv.)	0.053	0.166	0.039	0.036	0.110	0.026	0.25	0.29	0.34	0.28	0.32	0.39	0.1299
	40% Commercial	0.107	0.331	0.077	0.071	0.221	0.051	0.72	0.72	0.72	0.72	0.72	0.72	0.6187
	40% Industrial	0.107	0.331	0.077	0.071	0.221	0.051	0.68	0.69	0.69	0.69	0.69	0.7	0.5924
Layout	Open Spaces	0.103	0.335	0.070	0.025	0.087	0.025	0.12	0.17	0.24	0.16	0.21	0.28	0.1152
Industries	Industries	0.270	0.850	0.253	0.411	1.391	0.337	0.68	0.69	0.69	0.69	0.69	0.7	2.4236
Forest	Forest	0.000	0.000	0.000	0.935	3.426	0.767	0.1	0.13	0.16	0.12	0.16	0.2	0.8137
Commercial	Commercial	0.138	0.288	0.058	0.065	0.163	0.048	0.72	0.72	0.72	0.72	0.72	0.72	0.5469
Buffer	Open Spaces	0.141	0.445	0.132	0.215	0.727	0.176	0.12	0.17	0.24	0.16	0.21	0.28	0.3607
PS 1- Govt. Buildings	Residential (12% imperv.)	0.650	1.527	0.232	0.586	1.674	0.388	0.2	0.25	0.31	0.24	0.29	0.35	1.3456
PS 2- Education Institutions Buildings	Residential (30% imperv.)	0.027	0.149	0.080	0.013	0.077	0.036	0.25	0.29	0.34	0.28	0.32	0.39	0.1192
PS 3- Hospitals	Residential (30% imperv.)	0.000	0.001	0.001	0.004	0.016	0.000	0.25	0.29	0.34	0.28	0.32	0.39	0.0070
PS 4- institutional buildings	Residential (30% imperv.)	0.073	0.200	0.033	0.002	0.010	0.002	0.25	0.29	0.34	0.28	0.32	0.39	0.0922
PS 5- graveyards	Open Spaces	0.015	0.027	0.014	0.006	0.018	0.007	0.12	0.17	0.24	0.16	0.21	0.28	0.0161
											Effective Runoff Area		18.9346	
											Total Land-use Area		54.8583	
											Total Quantity of Rain		116400	
											Total Runoff		40176	

The determination of storm water run-off is mainly dependent upon three broad factor. These factors are (i). Total rainfall in the area, (ii). Area under different type land-use alongwith slope variation and (iii). The coefficient of run-off of respective landuse under different slope value. The total run-off in the Gajwel area is 40,176 Million Litre (ML).

Total Ground Water Recharge

$$\text{Total Recharge (R)} = \text{Total Rainfall (Q)} \times \frac{[\text{Coefficient of recharge (R1)} \times \text{Area (A1)} + \text{R2} \times \text{A2} + \dots + \text{Rn} \times \text{An}]}{\text{Total Watershed Area (A1 + A2 + \dots + An)}}$$

Land Use Type	Considered Land Uses	Area	Relevant Coeff.	Effective Groundwater Recharge
Urbanisable	Open Spaces	4.942	0.1	0.4942
Transportation	Parking	0.033	0.02	0.0007
Roads	Streets	5.762	0.02	0.1152
Residential	30 % Residential (65% imperv.)	5.964	0.04	0.2386
	70 % Residential (30% imperv.)	13.916	0.05	0.6958
Recreational	80% Open Spaces	0.922	0.1	0.0922
	20% Residential (12% imperv.)	0.231	0.06	0.0138
Mixed	20 % Residential (30% imperv.)	0.430	0.05	0.0215
	40% Commercial	0.859	0.02	0.0172
	40% Industrial	0.859	0.02	0.0172
Layout	Open Spaces	0.644	0.1	0.0644
Industries	Industries	3.511	0.02	0.0702
Forest	Forest	5.128	0.1	0.5128
Commercial	Commercial	0.760	0.1	0.0760
Buffer	Industrial	1.836	0.02	0.0367
PS 1- Govt. Buildings	Residential (12% imperv.)	5.057	0.06	0.3034
PS 2- Education Institutions	Residential (30% imperv.)	0.381	0.05	0.0191
PS 3- Hospitals	Residential (30% imperv.)	0.022	0.05	0.0011
PS 4- institutional buildings	Residential (30% imperv.)	0.321	0.05	0.0160
PS 5- graveyards	Open Spaces	0.085	0.1	0.0085
Effective Recharge Area				2.8146
Total Land-use Area				54.8583
Total Quantity of Rain				116400
Total Runoff				5972.11

Recharge Matrix	
Commercial	0.02
Industrial	0.02
Streets	0.02
Parking	0.02
Residential (12%)	0.06
Residential (30%)	0.05
Residential (65%)	0.04
Forest	0.1
Open Spaces	0.1

Note - The recharge matrix is prepared based on assumption. The coefficient of recharge mostly vary between 0.02 - 0.1 in soil type C&D. The coefficient of different landuse are based on assumptions.

The determination of ground water recharge is mainly dependent upon three factors. These factors are (i). Total rainfall in the area, (ii). Area under different type land-use and (iii). The coefficient of recharge. The total groundwater recharge estimated in Gajwel area is 5,972.11 Million Litre (ML).

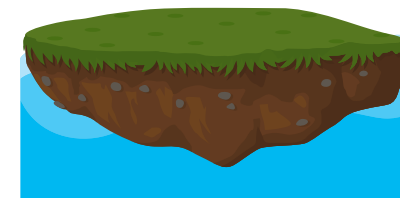
Future Run-off and Ground Water Recharge

Land Use Type	Considered Land Uses	Area Under Soil Type C			Area Under Soil Type D			Relevant Coeff. Of soil C			Relevant Coeff. Of soil C			Effective Run-off
		0-2%	2-6%	>6%	0-2%	2-6%	>6%	0-2%	2-6%	>6%	0-2%	2-6%	>6%	
Urbanisable	40 % Residential (30% imperv.)	0.133	0.382	0.068	0.376	0.919	0.099	0.25	0.29	0.34	0.28	0.32	0.39	0.6051
	15% Commercial	0.050	0.143	0.026	0.141	0.345	0.037	0.72	0.72	0.72	0.72	0.72	0.72	0.5337
	15% Industrial	0.050	0.143	0.026	0.141	0.345	0.037	0.68	0.69	0.69	0.69	0.69	0.7	0.5114
	20% Roads	0.066	0.191	0.034	0.188	0.460	0.049	0.72	0.73	0.76	0.73	0.75	0.78	0.7336
	10% Open Space	0.033	0.095	0.017	0.094	0.230	0.025	0.12	0.17	0.24	0.16	0.21	0.28	0.0945
Transportation	Parking	0.003	0.013	0.005	0.002	0.009	0.002	0.85	0.86	0.87	0.85	0.86	0.87	0.0286
Roads	Streets (40 % soil C and 60% soil D)	0.490	1.456	0.360	0.734	2.183	0.540	0.72	0.73	0.76	0.73	0.75	0.78	4.2831
Residential	50 % Residential (65% imperv.)	1.237	3.835	0.892	0.825	2.556	0.595	0.3	0.33	0.38	0.33	0.36	0.42	3.4180
	50 % Residential (30% imperv.)	1.237	3.835	0.892	0.825	2.556	0.595	0.25	0.29	0.34	0.28	0.32	0.39	3.0057
Recreational	60% Open Spaces	0.074	0.201	0.063	0.071	0.241	0.042	0.12	0.17	0.24	0.16	0.21	0.28	0.1318
	40% Residential (12% imperv.)	0.049	0.134	0.042	0.047	0.161	0.028	0.2	0.25	0.31	0.24	0.29	0.35	0.1241
Mixed	20 % Residential (30% imperv.)	0.053	0.166	0.039	0.036	0.110	0.026	0.25	0.29	0.34	0.28	0.32	0.39	0.1299
	40% Commercial	0.107	0.331	0.077	0.071	0.221	0.051	0.72	0.72	0.72	0.72	0.72	0.72	0.6187
	40% Industrial	0.107	0.331	0.077	0.071	0.221	0.051	0.68	0.69	0.69	0.69	0.69	0.7	0.5924
Layout	70% Residential (65% imperv.)	0.072	0.234	0.049	0.017	0.061	0.017	0.3	0.33	0.38	0.33	0.36	0.42	0.1525
	20% Roads	0.021	0.067	0.014	0.005	0.017	0.005	0.72	0.73	0.76	0.73	0.75	0.78	0.0949
	10% Open Space	0.010	0.033	0.007	0.002	0.009	0.002	0.12	0.17	0.24	0.16	0.21	0.28	0.0115
Industries	Industries	0.270	0.850	0.253	0.411	1.391	0.337	0.68	0.69	0.69	0.69	0.69	0.7	2.4236
Forest	Forest	0.000	0.000	0.000	0.935	3.426	0.767	0.1	0.13	0.16	0.12	0.16	0.2	0.8137
Commercial	Commercial	0.138	0.288	0.058	0.065	0.163	0.048	0.72	0.72	0.72	0.72	0.72	0.72	0.5469
Buffer	Industrial	0.141	0.445	0.132	0.215	0.727	0.176	0.68	0.69	0.69	0.69	0.69	0.7	1.2674
PS 1- Govt. Buildings	Residential (12% imperv.)	0.650	1.527	0.232	0.586	1.674	0.388	0.2	0.25	0.31	0.24	0.29	0.35	1.3456
PS 2- Education Institutions Buildings	Residential (30% imperv.)	0.027	0.149	0.080	0.013	0.077	0.036	0.25	0.29	0.34	0.28	0.32	0.39	0.1192
PS 3- Hospitals	Residential (30% imperv.)	0.000	0.001	0.001	0.004	0.016	0.000	0.25	0.29	0.34	0.28	0.32	0.39	0.0070
PS 4- institutional buildings	Residential (30% imperv.)	0.073	0.200	0.033	0.002	0.010	0.002	0.25	0.29	0.34	0.28	0.32	0.39	0.0922
PS 5- graveyards	Open Spaces	0.015	0.027	0.014	0.006	0.018	0.007	0.12	0.17	0.24	0.16	0.21	0.28	0.0161
											Effective Runoff Area	21.7011		
											Total Land-use Area	54.8583		
											Total Quantity of Rain	116400		
											Total Runoff	46045.94		

Land Use Type	Considered Land Uses	Area	Relevant Coeff.	Effective Groundwater	
				Recharge	
Urbanisable	40 % Residential (30% imperv.)	1.977	0.05	0.098840506	
	15% Commercial	0.741	0.02	0.014826076	
	15% Industrial	0.741	0.02	0.014826076	
	20% Roads	0.988	0.02	0.019768101	
	10% Open Space	0.494	0.1	0.049420253	
Transportation	Parking	0.033	0.02	0.000663522	
Roads	Streets	5.762	0.02	0.115247521	
Residential	50 % Residential (65% imperv.)	9.940	0.04	0.397606377	
	50 % Residential (30% imperv.)	9.940	0.05	0.497007971	
Recreational	60% Open Spaces	0.692	0.1	0.069159176	
	40% Residential (12% imperv.)	0.461	0.06	0.02766367	
Mixed	20 % Residential (30% imperv.)	0.430	0.05	0.021483255	
	40% Commercial	0.859	0.02	0.017186604	
	40% Industrial	0.859	0.02	0.017186604	
Layout	70% Residential (65% imperv.)	0.451	0.04	0.01803704	
	20% Roads	0.129	0.02	0.00257672	
	10% Open Space	0.064	0.1	0.0064418	
Industries	Industries	3.511	0.02	0.070223066	
Forest	Forest	5.128	0.1	0.5127625	
Commercial	Commercial	0.760	0.1	0.075961905	
Buffer	Industrial	1.836	0.02	0.0367223	
PS 1- Govt. Buildings	Residential (12% imperv.)	5.057	0.06	0.303420689	
PS 2- Education Institutions Buildings	Residential (30% imperv.)	0.381	0.05	0.019067491	
PS 3- Hospitals	Residential (30% imperv.)	0.022	0.05	0.001116056	
PS 4- institutional buildings	Residential (30% imperv.)	0.321	0.05	0.016027137	
PS 5- graveyards	Open Spaces	0.085	0.1	0.008512562	
				Effective Recharge Area	2.43175498
				Total Land-use Area	54.8583
				Total Quantity of Rain	116400
				Total Runoff	5159.77



Total Run-Off = 46,045.94 ML



Recharge = 5,159.77 ML

With the increasing urbanization and concretization over time, the landuse patterns are expected to change. So, for future runoff and recharge prediction calculations, the considered land use are changed which is ultimately resulting in higher surface runoff and lower groundwater recharge. The surface runoff is expected to cross more than 46,000 ML of water in coming 10 to 15 years whereas the groundwater recharge is expected reduce by 800 ML.

What is a storm drainage system?

A series of drainage pipes used to remove excess water from streets, alleys, ditches, etc.

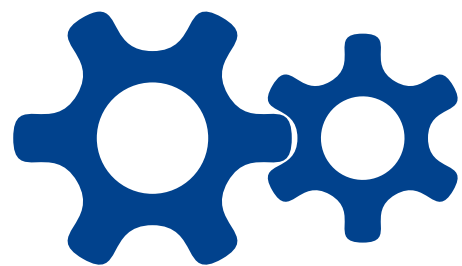
Why are they important?

Without them, our ground and surface waters would become contaminated as well as the overall environment and how it affects public health and safety.

What is an illegal discharge?

Any item an individual disposes of which can contaminate the water system such as trash, debris, chemicals, and any other pollutants.

RECOMMENDATIONS FOR TACKLING STORM WATER IN GAJWEL



MINIMUM CONTROL MEASURES



POLICY PROPOSALS



OBJECTIVES SET FOR ENGINEERS



BEST PRACTICES

MINIMUM CONTROL MEASURES

Illicit Discharge Detection and Elimination

- Litter Collection
- Illicit Discharge Legal Authorities
- Maintain Outfall Inventory
- Hazardous Material Response

Construction Site Storm Water Runoff Control

- Site Inspection
- Construction Plans Review
- Regulatory Mechanism Review
- Community Submitted Information

Post Construction Storm Water Management in Areas of New Development and Redevelopment

- Long Term Operations and Maintenance
- Post-Construction Structural/Non-Structural Controls

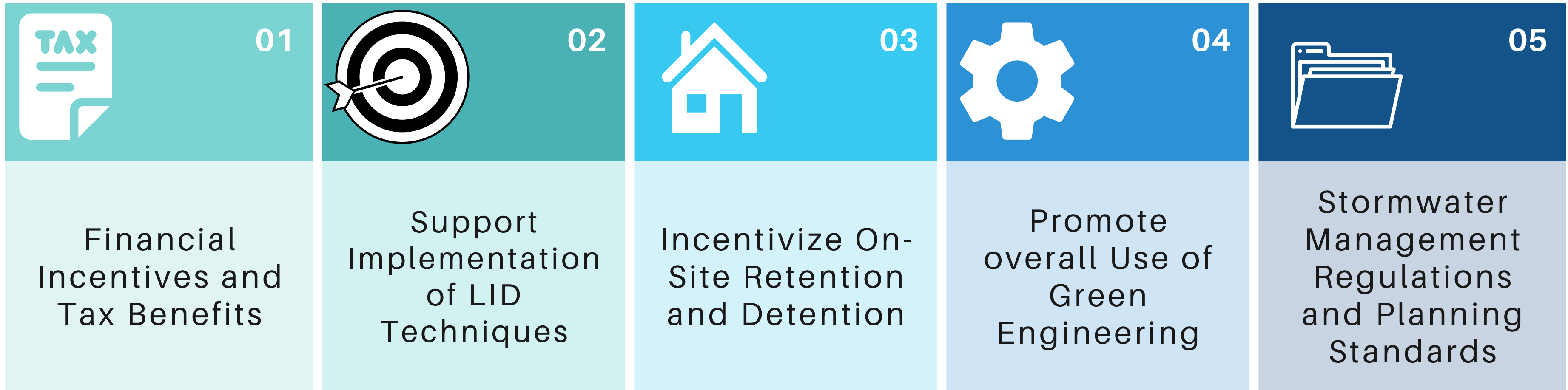
Pollution Prevention/Good Housekeeping for Municipal Operations

- Litter Collection
- Waste Collected During Maintenance of Storm Water Structural Controls
- Spill Prevention Plan

Public Education, Outreach and Involvement

- Community Clean-Up Events
- Public Websites
- Flyers/Brochures

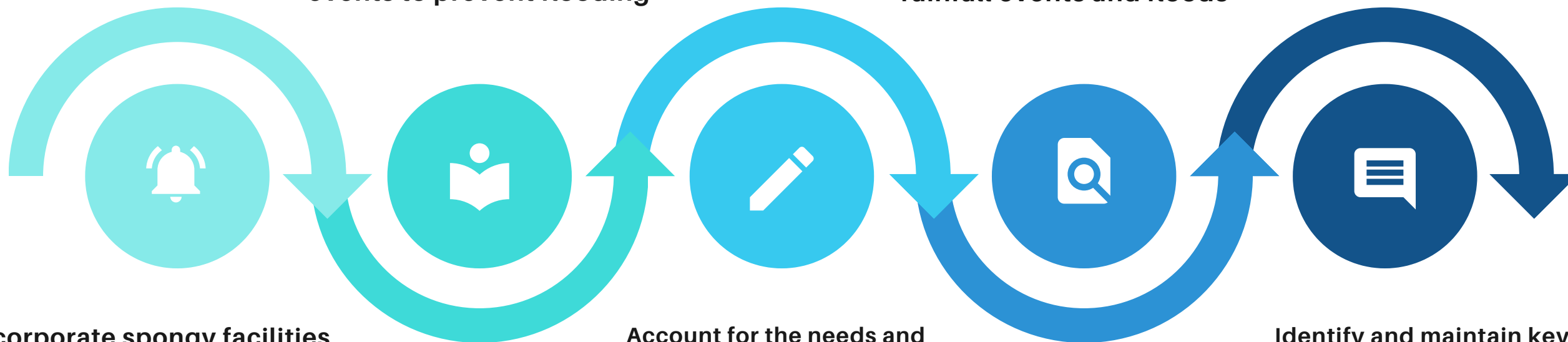
POLICY PROPOSAL



Design outflow lines with sufficient capacity to handle peak flows during heavy rainfall events to prevent flooding

Develop emergency response plans designating staff responsibilities to manage heavy rainfall events and floods

OBJECTIVES FOR ENGINEERS



Incorporate spongy facilities such as bio-retention cells and stormwater gardens to absorb and infiltrate more runoff onsite

Account for the needs and infrastructure of old residential areas when designing community-level outflow systems

Identify and maintain key operating points like pump stations and drains for heavy rainfall response

BEST PRACTICES

Green Roof

- Reduces overall runoff of storm water from buildings.
- Improves quality of collected water by percolation and infiltration through plants.
- Installation of extensive green roofs can reduce roof runoff by 65% and intensive runoff can reduce it by 85%

Projects

- 1) ONGC Dehradun
- 2) Chicago City Hall, Pilot Project



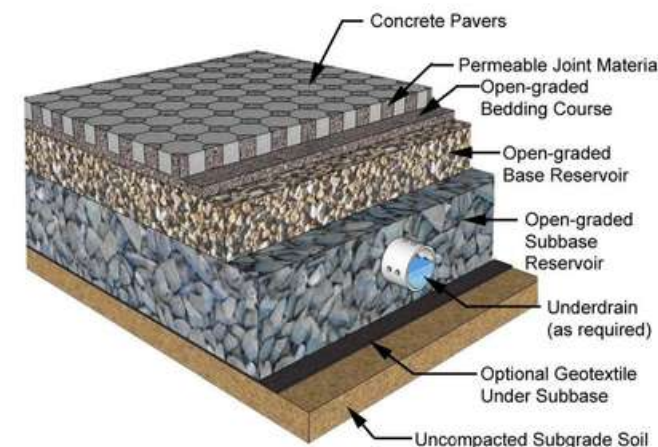
Source: Cutmasters, Garden Placed On Chicago Building Rooftop, 2013, Digital Image

Permeable Pavements

- Usage of porous materials for constructing pavements (such as gravel, grass pavers, etc) instead of asphalt or concrete.
- Plays a huge role in replenishing groundwater by increasing underground recharge rate, thus reducing runoff

Projects

- 1) Katedan Sports Complex, Hyderabad
- 2) Chicago City Hall, Pilot Project



Source: New Indian Express Online News

Artificial Wetlands

- Water storages created at a lower gradient where runoff gets accumulated and is filtered through natural elements like plants, greens, sediments
- Very efficient in controlling flooding in lower ends of slopes.
- Low cost, effective filtration of water

Projects

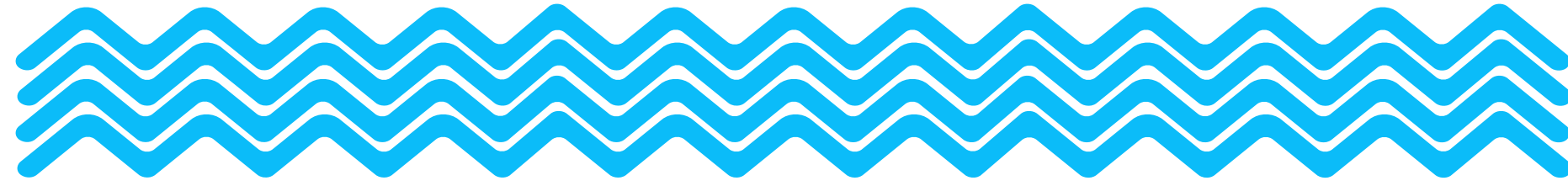
- 1) Haiderpur Wetland, Uttar Pradesh
- 2) Harike Lake, Punjab



Source: Hindustan Times

References and End Notes

- Anuraga, T. S., Ruiz, L., Kumar, M. M., Sekhar, M., & Leijnse, A. (2006). Estimating groundwater recharge using land use and soil data: A case study in South India. *Agricultural water management*, 84(1-2), 65-76.
- CHAPTER 2 - SOIL AND WATER. (n.d.).
<https://www.fao.org/3/r4082e/r4082e03.htm>https://stat.atlas.tsdps.telangana.gov.in/administrative_2022.html
- Chapter 7 hydrologic soil groups - USDA. (n.d.). <https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba>
- Deutsch, B., Whitlow, H., Sullivan, M., & Savineau, A. (2005). Re-greening Washington DC: a green roof vision based on environmental benefits for air quality and stormwater management.
- Grismer, M. E., & Shepherd, H. L. (2011). Plants in constructed wetlands help to treat agricultural processing wastewater. *California Agriculture*, 65(2), 73-79. <https://doi.org/10.3733/ca.v065n02p73>
- McCuen, R. H. (1998). *Hydrologic analysis and design*.
- Moglen, G. E., McCuen, R. H., & Moglen, R. L. (2018). Consequences of changes to the NRCS rainfall-runoff relations on hydrologic design. *Journal of Hydrologic Engineering*, 23(8), 04018032.
- Mohammed, A. M., Thatiparthi, V. L., Pyla, K. R., & Maryada, A. (2020). Estimation of Surface Runoff in an Ungauged Basin Using SCS-CN Method, A Case Study of Manair River Basin in Telangana, India. *Applied Ecology and Environmental Sciences*, 8(6), 340-350.
- Runoff coefficients for different soil groups and slopes runoff coefficients for different soil groups and slopes. Runoff coefficients for different soil groups and slopes - Minnesota Stormwater Manual. (n.d.).
https://stormwater.pca.state.mn.us/index.php?title=Runoff_coefficients_for_different_soil_groups_and_slopes
- Storm Water Management Program. UTPB. (2018). <https://www.utpb.edu/university-offices/ehs/storm-water>



*Thank
You*

