Teaching Water Supply and Sanitation Design in Engineering: A Pedagogical Experiment

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Global South Academic Conclave on WASH and Climate 2025

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Faculty of Technology, CEPT University

Established in 1982 as the 'School of Building Science and Technology', the faculty has following programs-

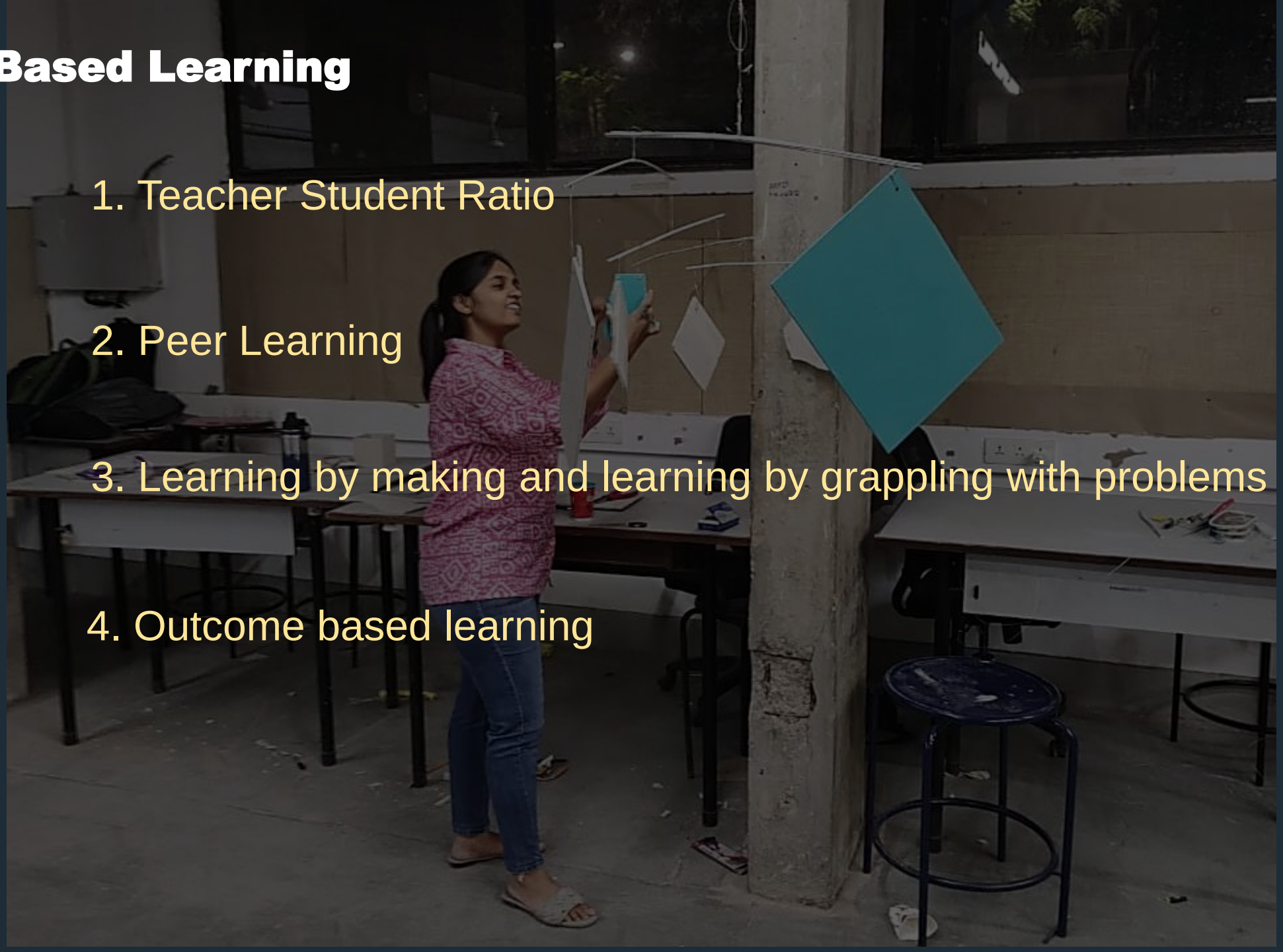
UG:

- Bachelor's in Civil Engineering

PG:

- Master's in Construction Engineering and Management
- Master's in Geomatics
- Master's in Building Energy performance
- Master's in Structural Engineering Design

Studio Based Learning



1. Teacher Student Ratio

2. Peer Learning

3. Learning by making and learning by grappling with problems

4. Outcome based learning

Studio Based Pedagogy (2016)

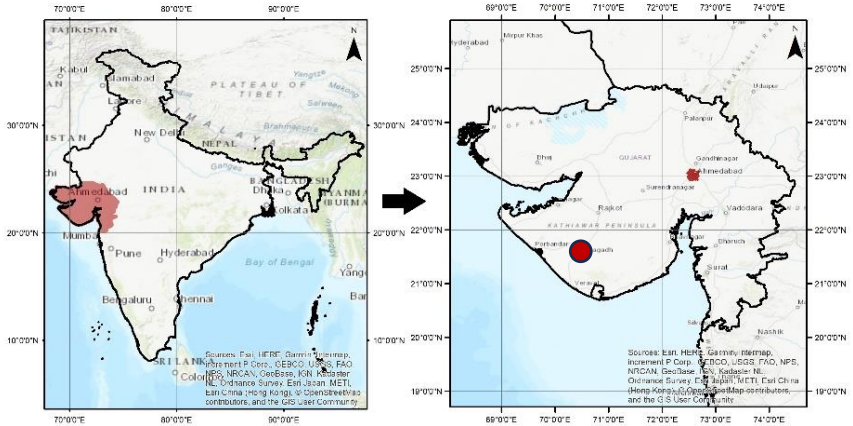
	Construction	Structures	Services	Management and Advances
L2 Studios	Concrete Studio	Form and Structure : Steel	Plumbing Design Studio	
	Exploring the Indigenous Construction Techniques	Geotechnical Parameters: Influencing Foundation Systems	Planning and Design of Road Infrastructure	
	Industry 4.0 Construction Technology	Deployable Structures - Concepts and Explorations	Network Design for Water Systems	
		Designing Spaces in Reinforced Concrete		
L3 Studios	Construction of Mass Housing Projects	Pedestrian Bridge Design	Engineering Urban Water Systems	Engineering Project Procurement Management
	Waste Management Through Application in Construction	Cantilevered Structures- Form, Material, Design and Construction	MEPF: Services, Design and Coordination	Engineering Sustainability: Impact of Design, Materials and Technologies
			Urban Road Intersection Analysis and Design	

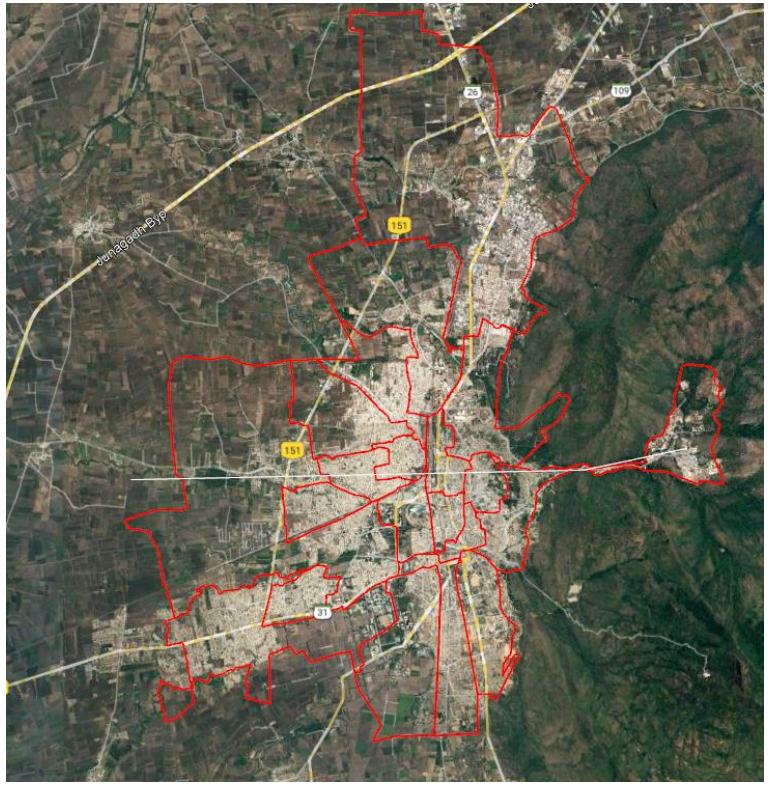
Engineering Urban Water Systems Studio

- Challenge is to design water supply, sewerage and stormwater network for a Junagarh.

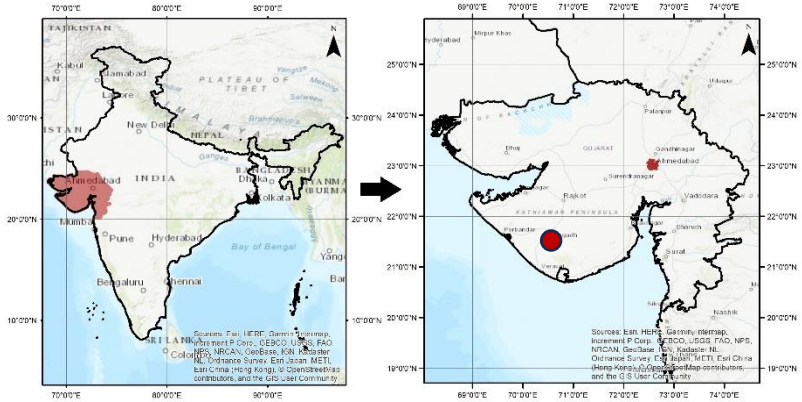
- Students are given a zone of Junagarh for design of these systems.

    - Selection of the study area
    - Population Projections
    - Demand Projections
    - Water Supply Design
        - Storage Sizing
        - Network Design
        - **Design and Cost Optimizations**
    - Sewerage Design
        - Zoning
        - Network Design
        - **Design and Cost Optimizations**





Junagarh



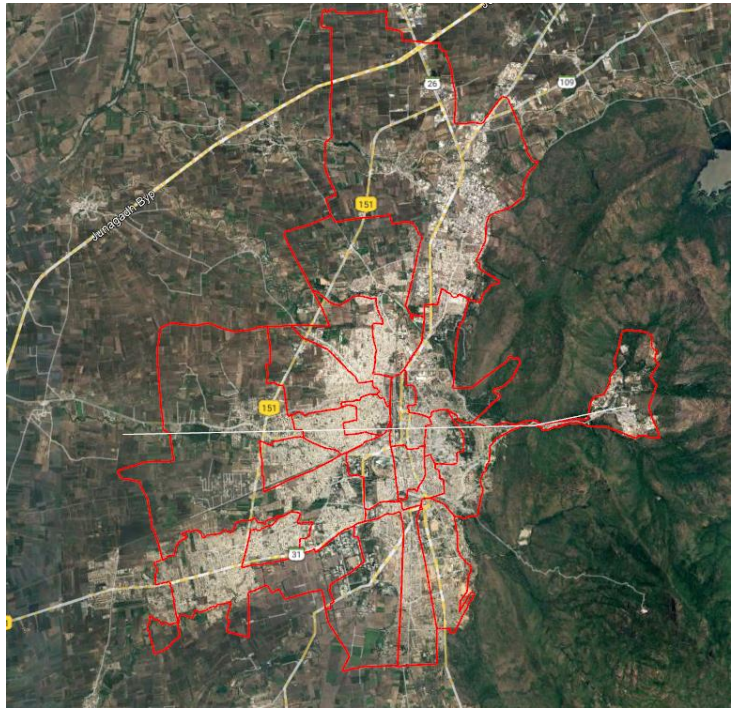


Fig. Location of Junagarh

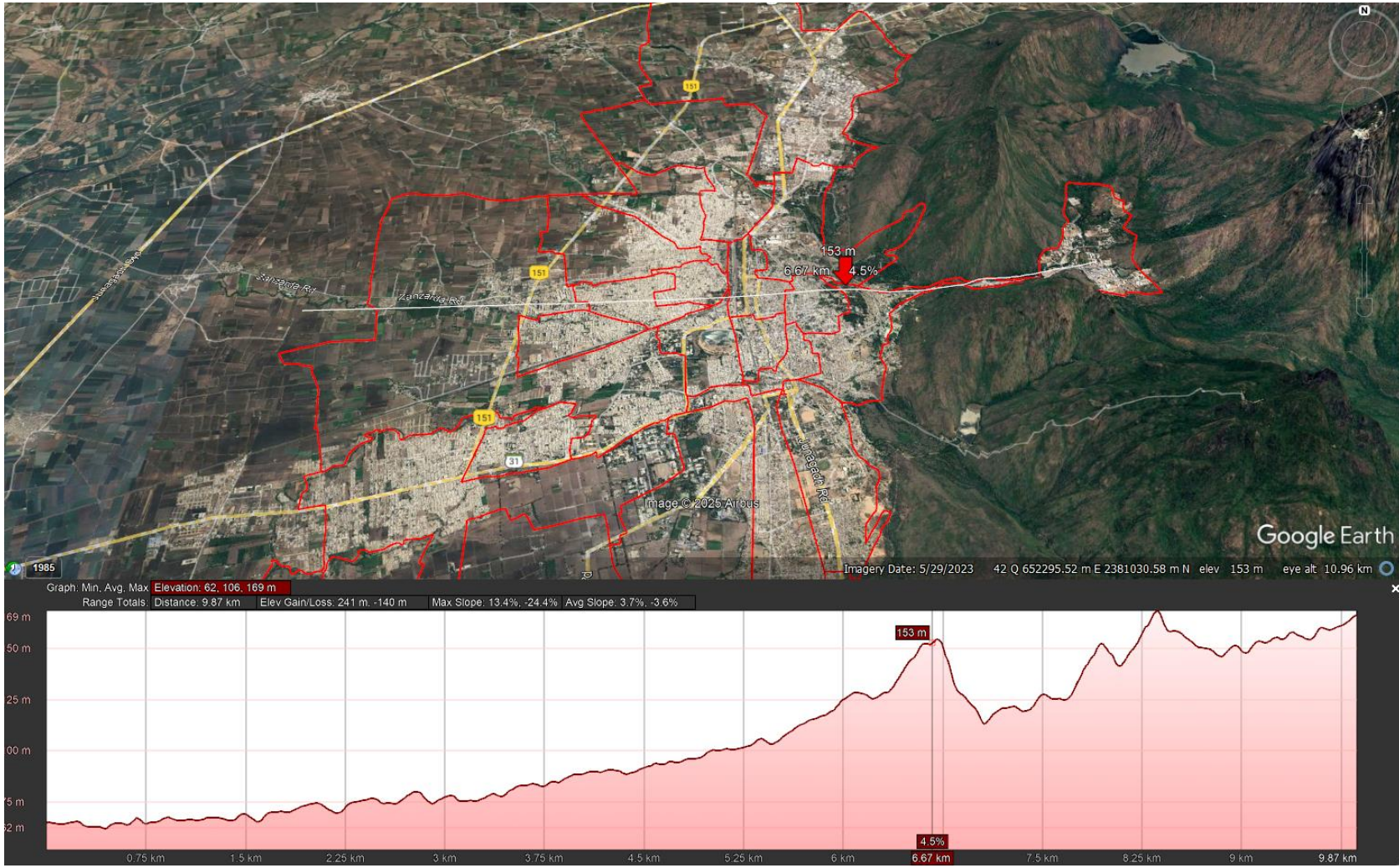


Fig. Elevation changes in site

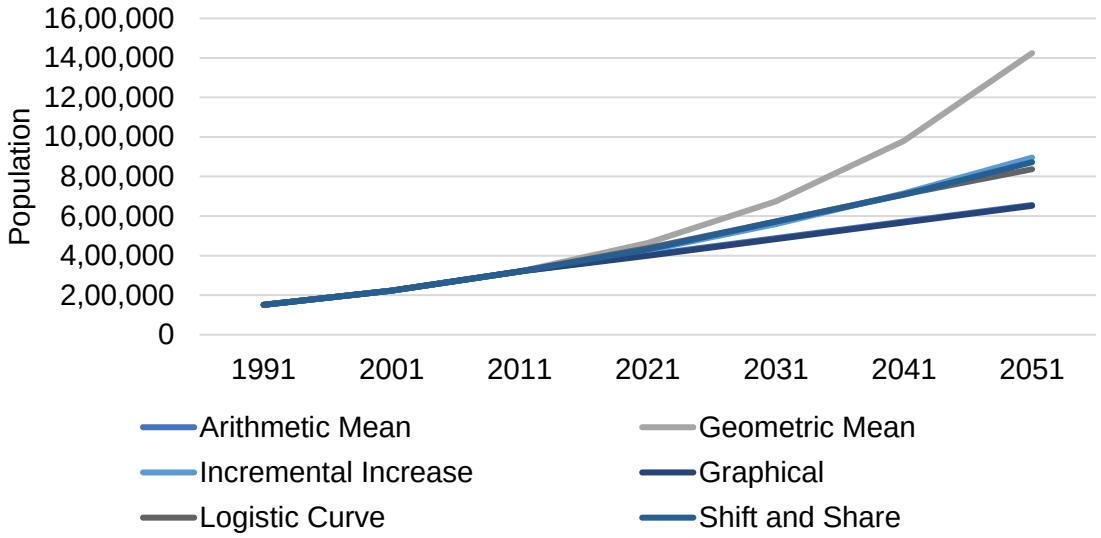
Average 106 m, Max 169m, Min 62m

Description of Exercises

Exercise 1: Population Projection and Demand Estimation

1. Population Projection Using Different Methods for Junagarh and the zone

Students are independent to choose any of the methods but have to provide an argument for method selection.



Comparison of different population projection methods.

2. Demand Projection for water and sewage

After the population projection demand estimations were done based on CPHEEO manuals.

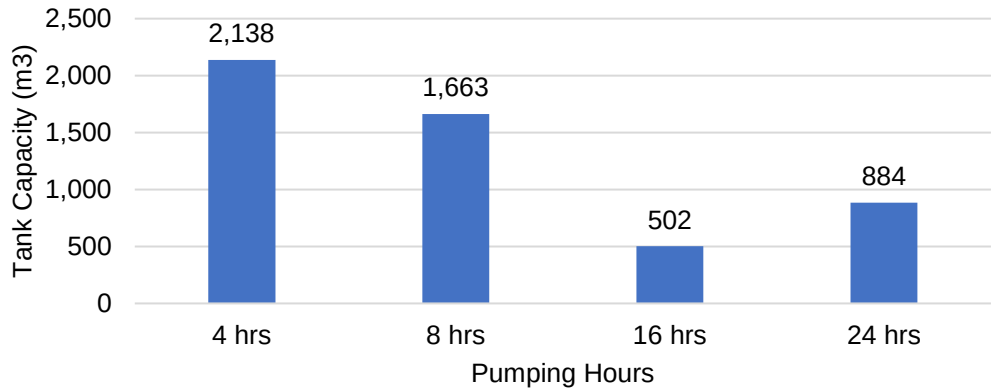
The table shows demand estimations up to year 2051. The assumptions for Demand are used from CPHEEO manuals.

Year	Zone Population	Water Demand (lpcd)	Water Demand (L/d)	UFW (@15%) (L/day)	Fire Demand (L/day)	Total Water Demand (MLD)	Sewage Generation (MLD)
2021	9980	135	1347300	202095	315911	1.9	1.5
2031	14502	135	1957770	293666	380815	2.6	2.1
2041	21073	136	2865928	429889	459053	3.8	3.0
2051	30622	137	4195214	629282	553371	5.4	4.3

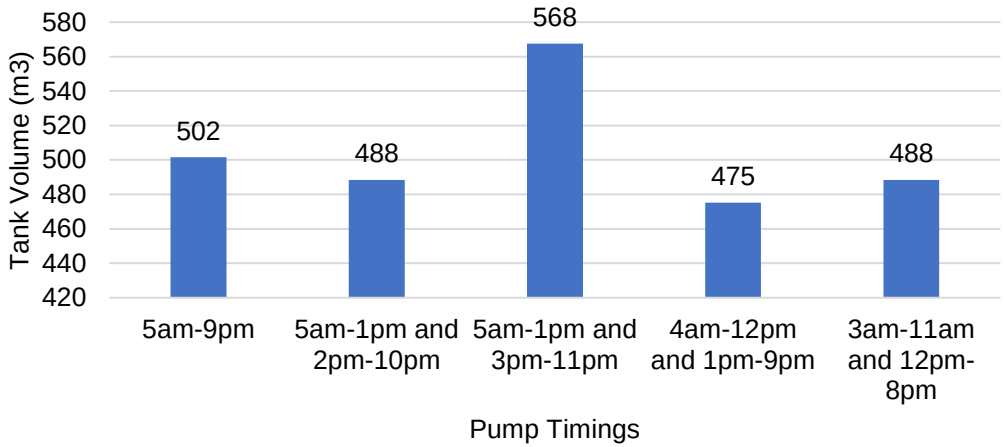
Exercise 2: Water Supply Design

2. Tank Sizing

Students decide the optimal size based on different iterations as per the example below.



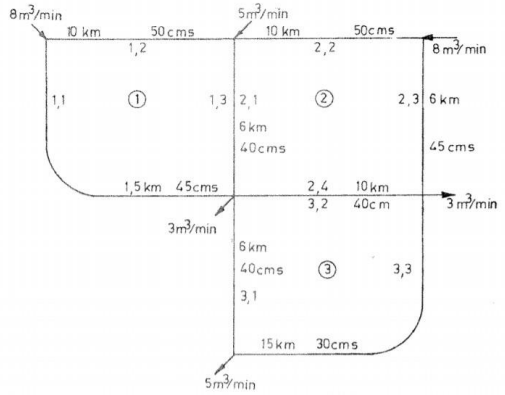
The graph shows requirement of different tank capacity for pumping hours.



The graph shows tank size optimization by operating at different times.

4. Designing using basic principles

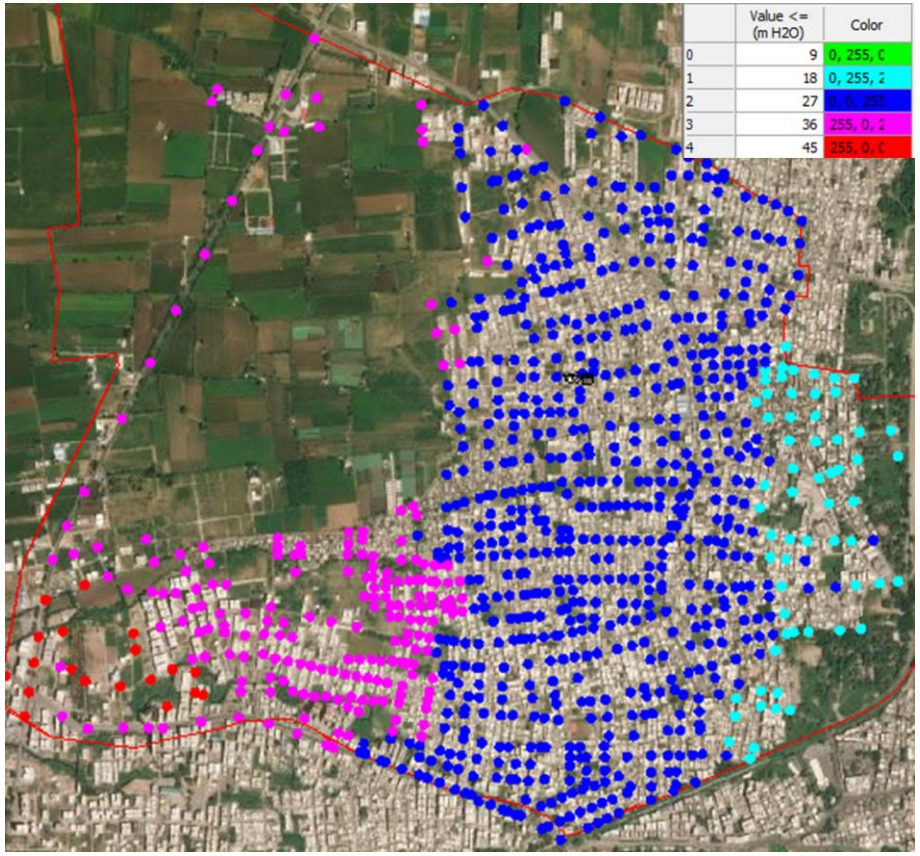
Solving networks through hardy cross method.



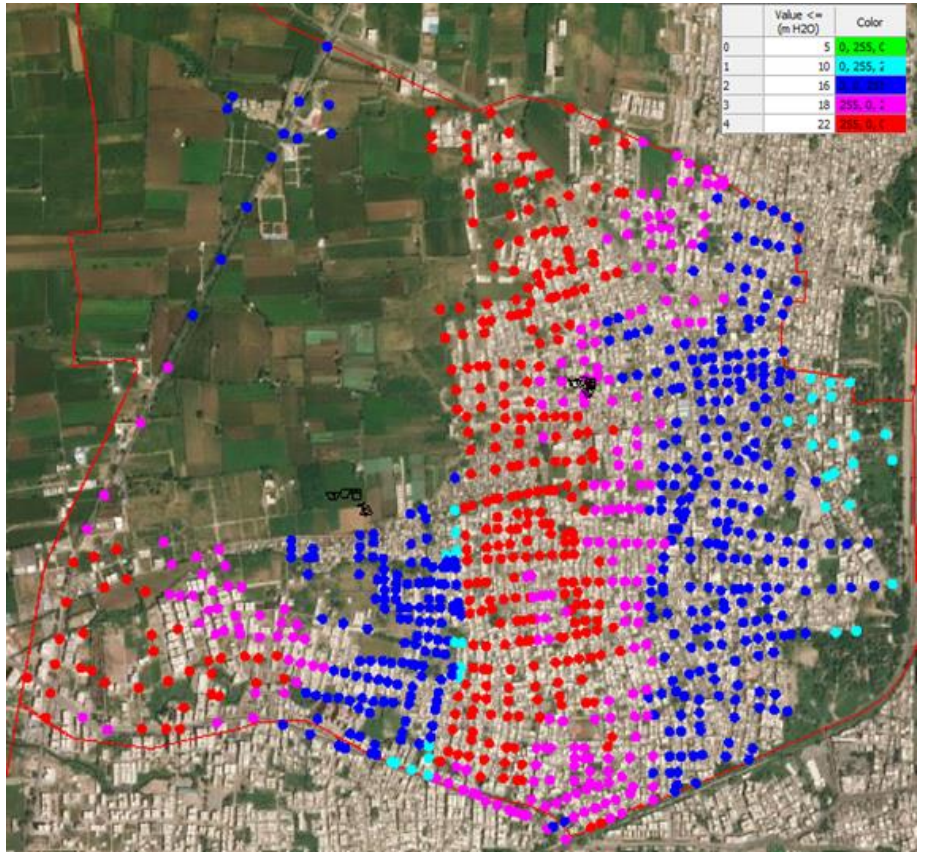
The table shows solving loops in excel sheets.

PIPE	length (m)	Diameter (mm)	Q(m³/s)	K	Head loss (m)	2H/Q	▲Q	Corrected flows
Loop 1								
1	10000	0.5	4.50	3.0871E+10	5.00769E+11	2.22443E+11		4.5254
2	6000	0.4	2.34	5.4914E+10	2.64727E+11	2.26437E+11	0.022905	2.3611
3	15000	0.45	-3.50	7.7356E+10	-7.86074E+11	4.495E+11		-3.4746
Σ					-20577802049	8.9838E+11		
Loop 2								
2	6000	0.4	-2.34	5.4914E+10	-2.64727E+11	2.26437E+11		-2.34707
4	10000	0.5	-3.34	3.0871E+10	-2.87749E+11	1.72398E+11		-3.34707
5	6000	0.45	4.66	3.0942E+10	5.35324E+11	2.29664E+11	-0.00887	4.65293
6	10000	0.4	0.48	9.1524E+10	23599666312	98128495973		0.47212
Σ					6447205049	7.26627E+11		
Loop 3								
6	10000	0.4	-0.48	9.1524E+10	-23599666312	98128495973		-0.48481
7	15000	0.3	1.13	5.5734E+11	7.0216E+11	1.23964E+12	-0.00382	1.12902
8	6000	0.4	-3.87	5.4914E+10	-6.72123E+11	3.47605E+11		-3.87098
Σ					6437560147	1.68538E+12		
					3.77252E+12			

Design Optimization

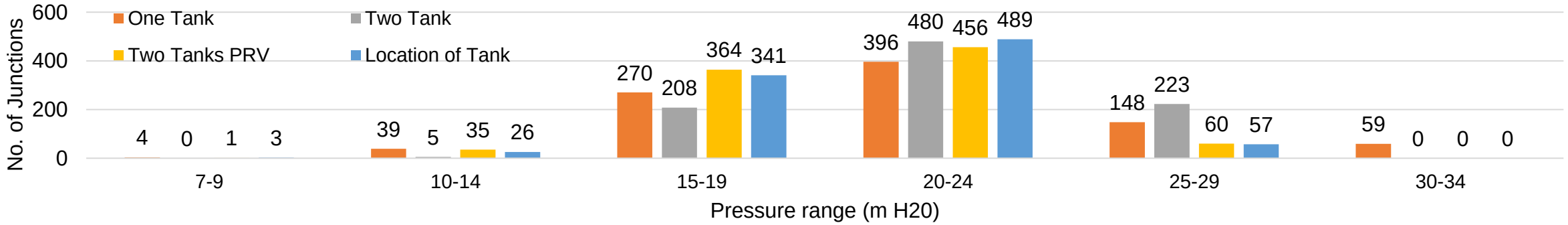


a. Iteration 1 for water supply



b. Iteration 2 for water supply

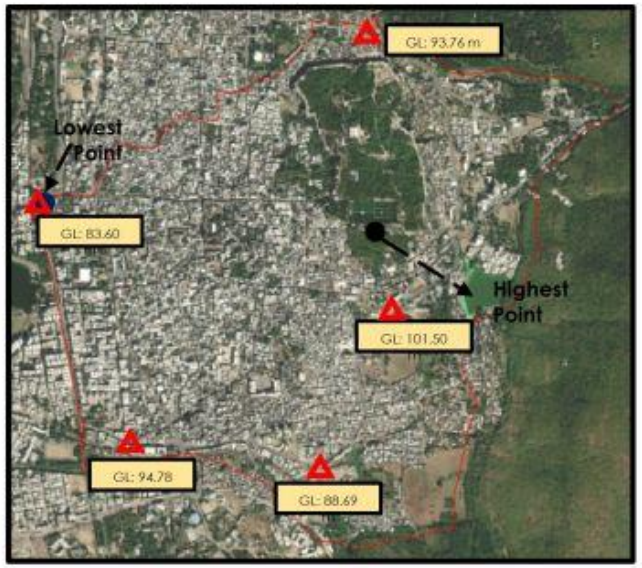
System performance is measured by change in number of junctions in different pressure ranges in different design iterations. As the iterations proceed the pressure becomes optimal.



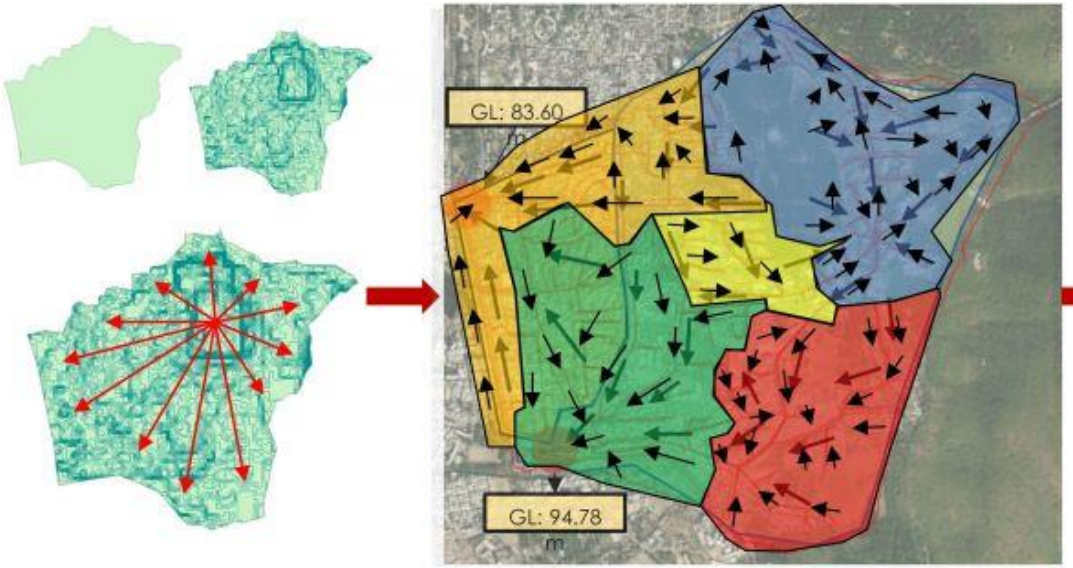
Sewerage Design

1. Understanding the design principles and Designing Sewers

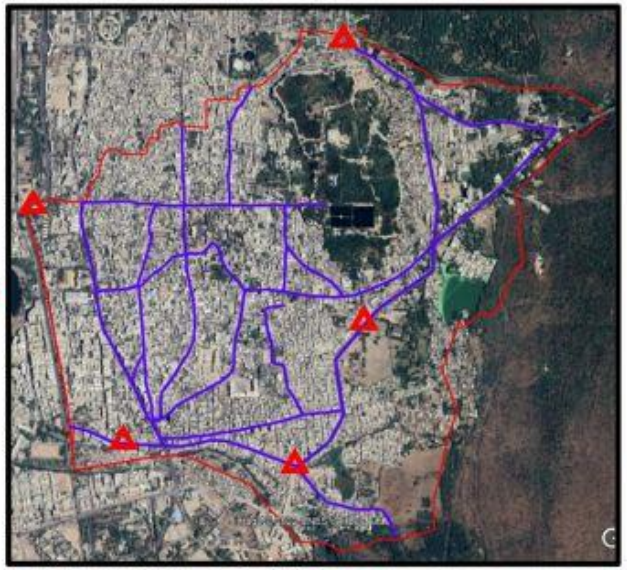
In this exercise, we started first with design principles and design using excel and then shifted to SewerGEMS. The process of design is highlighted below for one student.



Identifying the existing outfalls and contour of the study area



Dividing into zones on the basis of more refined contour of the zone



Laying Sewer as per the existing road network of the zone

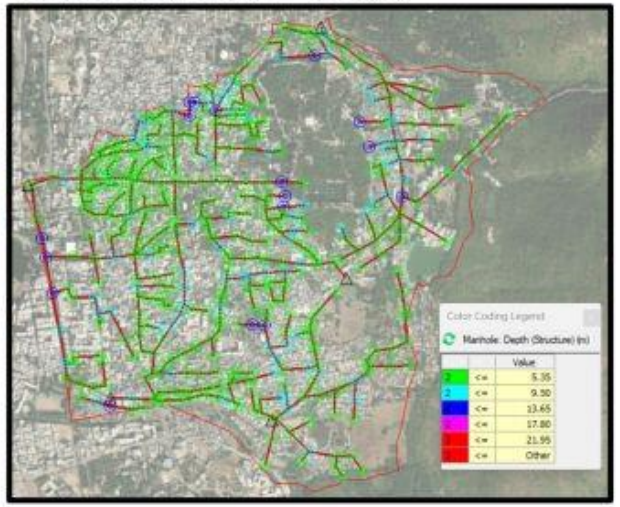
2. Cost estimation of SEWERGEMS model Iterations

Sr. No.	Item	Iteration 1	Iteration 2	Iteration 3	Iteration 3.1
1	Excavation	₹ 13,29,40,103	₹ 4,68,15,051	₹ 4,68,07,385	₹ 4,55,78,118
2	Backfilling	₹ 1,31,49,245	₹ 54,37,678	₹ 54,44,044	₹ 53,19,369
3	Bedding	₹ 7,45,367	₹ 5,52,185	₹ 5,63,810	₹ 4,75,963
4	Providing NP4 pipe & LLJ for same	₹ 3,30,44,974	₹ 2,43,44,063	₹ 2,49,12,302	₹ 1,81,54,002
5	M.H. Frame & Cover	₹ 27,52,800	₹ 27,50,506	₹ 22,94,000	₹ 22,94,000
6	M.H. Brick Masonry & Plastering	₹ 10,40,32,490	₹ 7,01,18,265	₹ 6,76,52,903	₹ 7,09,09,822
7	Total	₹ 28,66,64,980	₹ 15,00,17,749	₹ 14,76,74,445	₹ 14,27,31,273

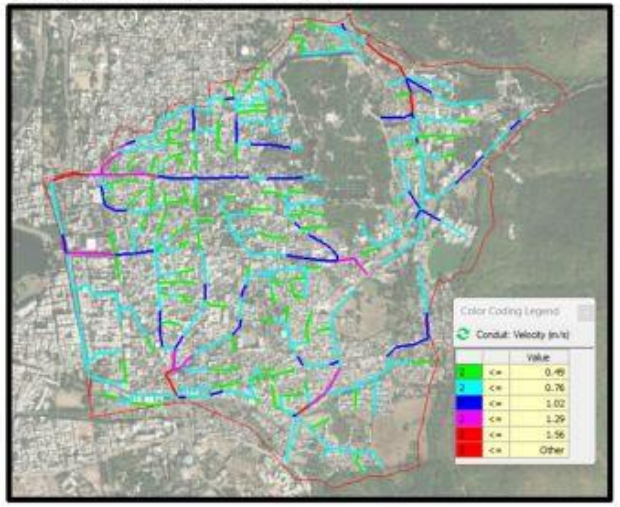
Cost Per

Sr. No.	Item	Iteration 1	Iteration 2	Iteration 3	Iteration 3.1
1	Cost per MLD	₹ 1,99,07,290	₹ 1,04,17,899	₹ 1,02,55,170	₹ 99,11,894
2	Cost per Capita (2057)	₹ 2,574	₹ 1,347	₹ 1,326	₹ 1,282
3	Cost per Length	₹ 9,876	₹ 5,235	₹ 5,155	₹ 4,983

Depth of Structure - Results



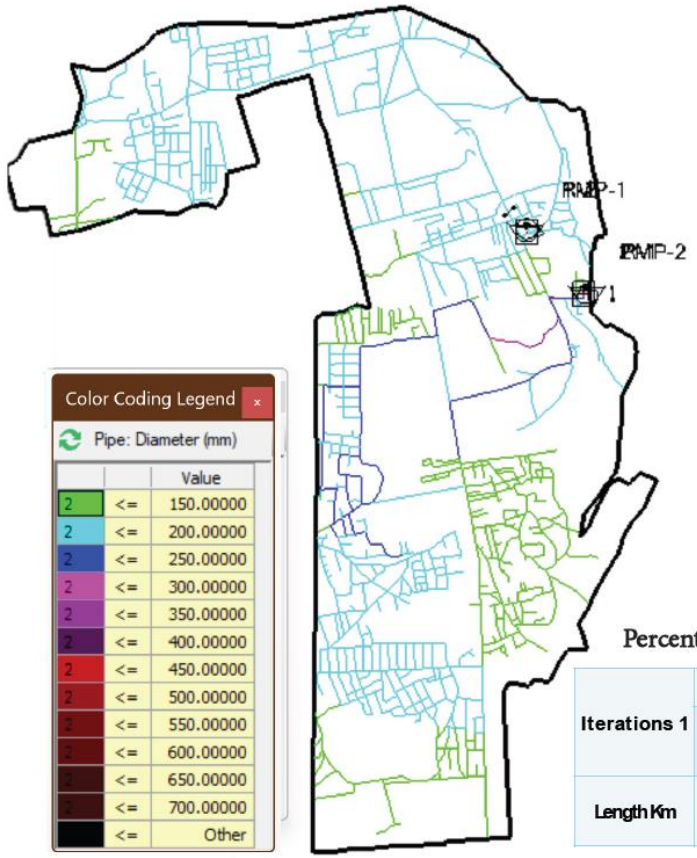
Velocity in Pipe - Results



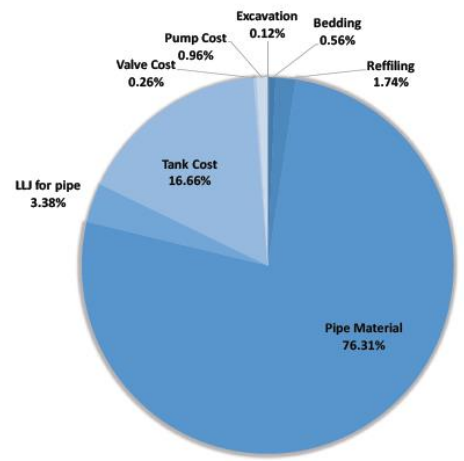
Key Take Aways

- Students question the codes (Is a lesser pipe diameter more efficient for undulating terrains?)

INITIAL ITERATION (150 mm pipe Ductile Iron pipe diameter used)



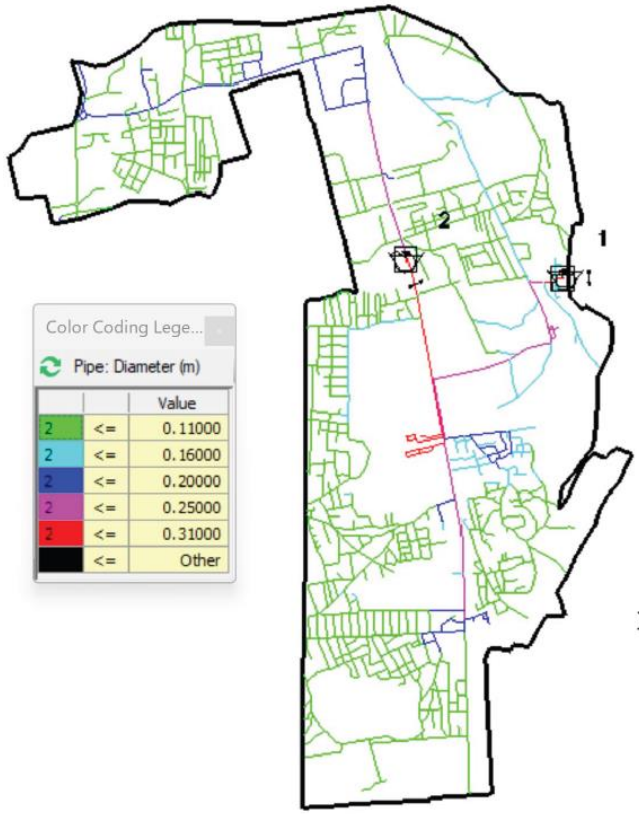
Total Cost for Initial Iteration: ₹ 17,30,00,000



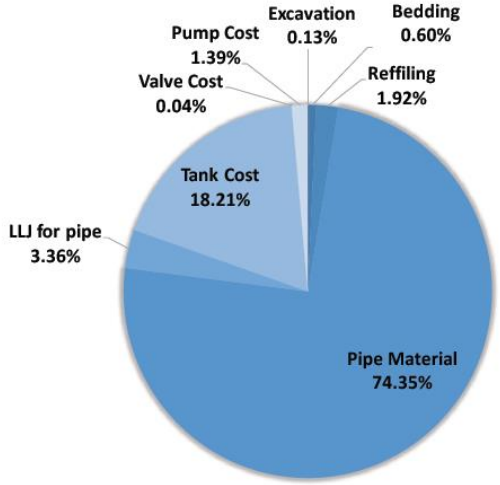
Percentage of Pipe having velocity greater than 0.6m/s= 18%

Iterations 1	Diameter (mm)									
	150	200	250	300	350	400	450	500	600	700
Length Km	17.76	38.26	4.39	0.08	0.14	0.22	0.06	0.05	0.01	0.04

FINAL ITERATION (110 mm HDPE pipe dia used)



Total Cost for Initial Iteration: ₹ 6,15,00,000



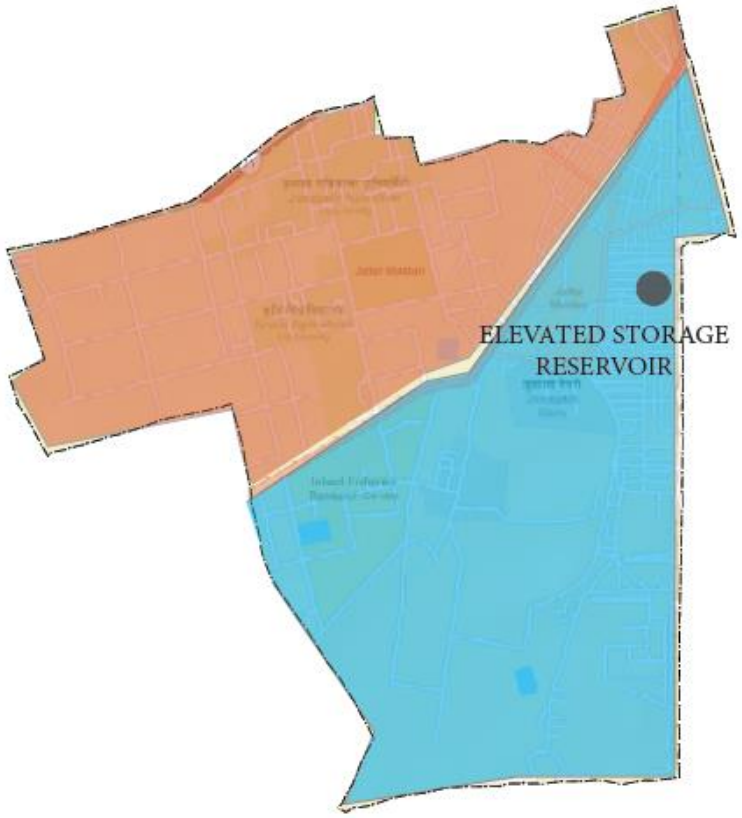
Percentage of Pipe having velocity greater than 0.6m/s= 27%

Iterations 1	Diameter (mm)				
	110	160	200	250	310
Length Km	45.70	5.5	5.00	2.54	1.50

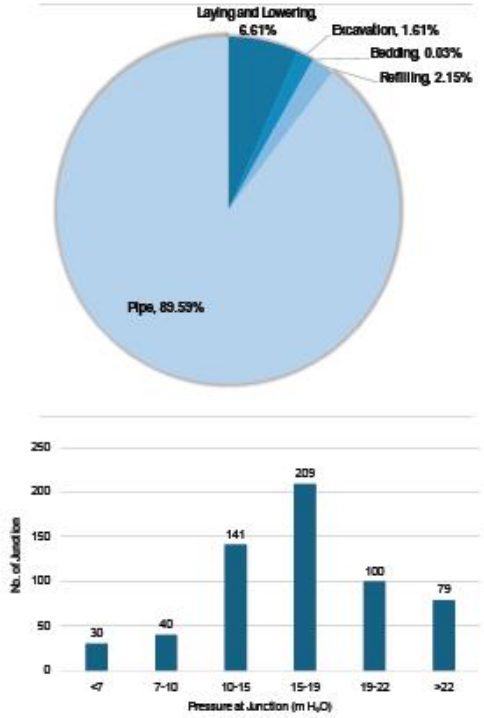
Key Take Aways

- Increased understanding of design and operations

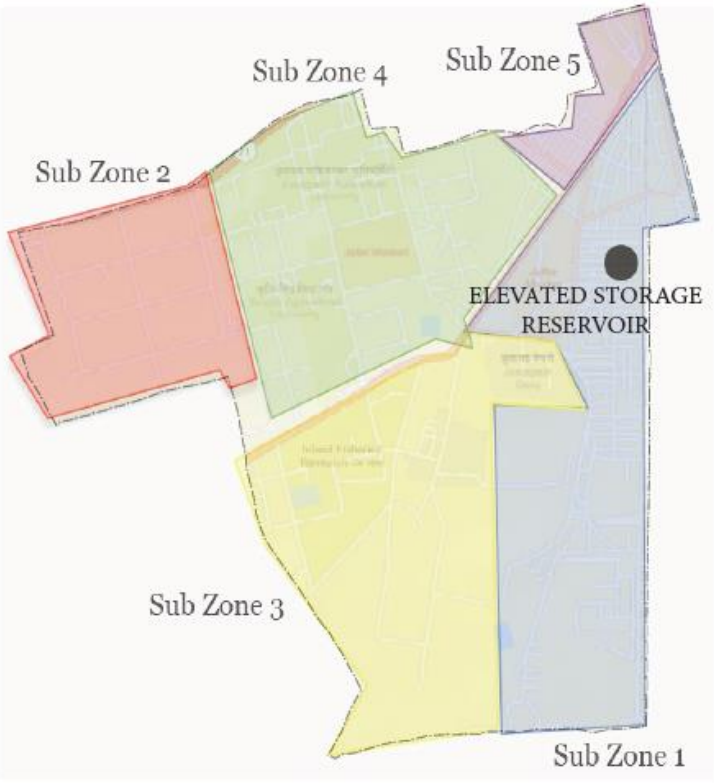
INITIAL ITERATION (Zone-2 is divided into sub-zones on the basis of highway passing through it)



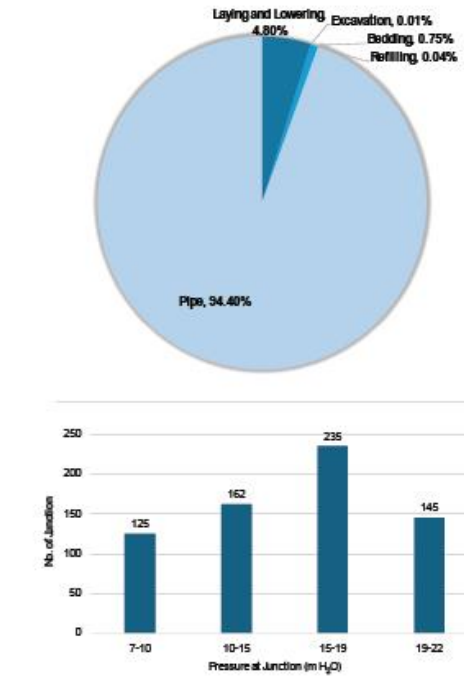
Total Cost for Initial Iteration: ₹ 25,12,00,000



FINAL ITERATION (Zone-2 divided into subzones as per elevations)

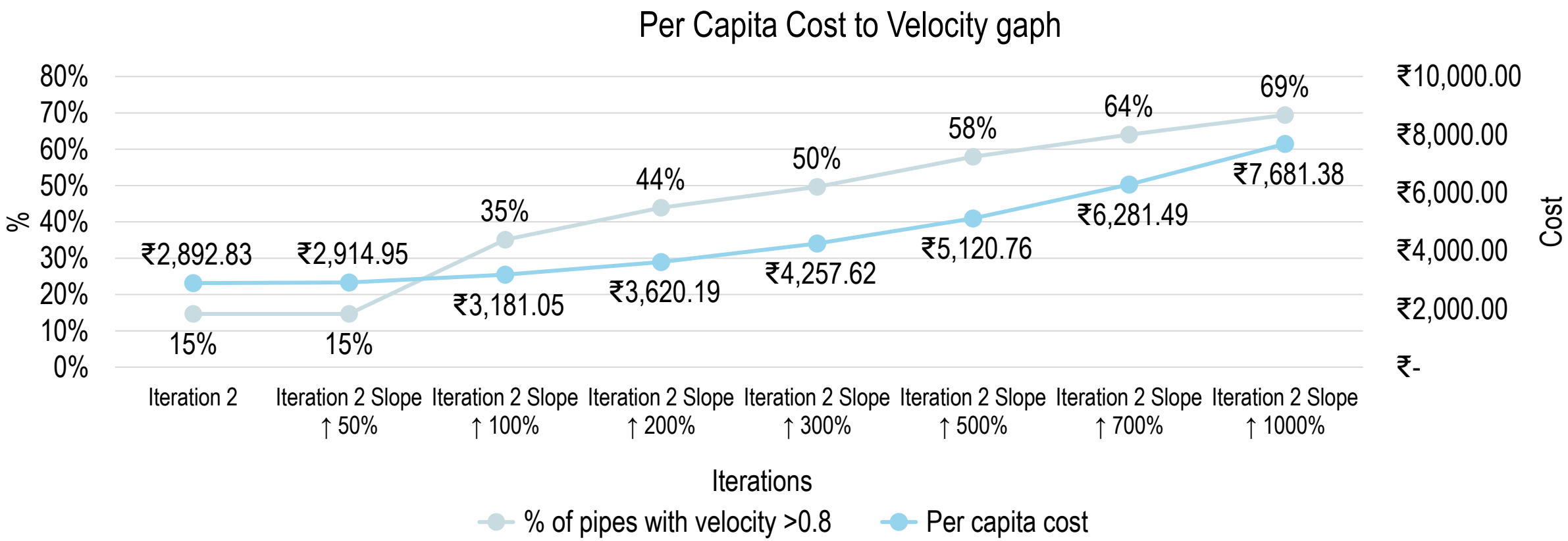


Total Cost for Initial Iteration: ₹ 21,95,00,000



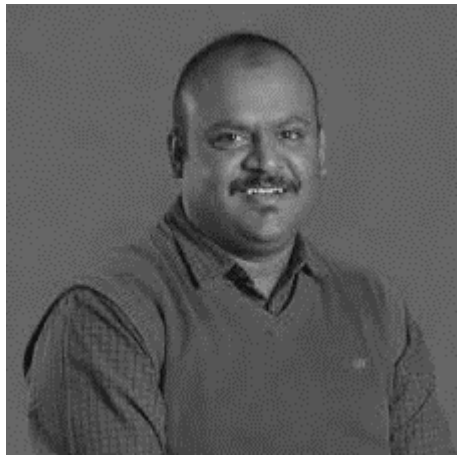
Key Take Aways

- Understanding and appreciating decision dilemmas: Cost Vs Velocity



Team

Tutors and TAs



Tushar Bose

Janki Jethi

Abhinav Ahuja

Jigar Patel

Thank You!

Thank You

Global South Academic Conclave on WASH and Climate 2025

CWAS CENTER FOR WATER AND SANITATION
CRDF CEPT UNIVERSITY
CEPT UNIVERSITY FACULTY OF PLANNING
Gates Foundation
viega foundation