

Urban Stormwater Management: Quantifying Stormwater Reuse Potential in Darjeeling

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Darjeeling Town Population:

2011: 118805 (Census, 2011)
2024: 148538 (Arithmetic Method)
2050: 208004 (Arithmetic Method)



Introduction

- India, home to 18% of the global population, has access to only 4% of the world's freshwater resources (National Water Policy, 2012; World Bank, 2023). This limited supply is unevenly distributed, leading to severe water challenges in several regions and difficulties in meeting national water supply benchmarks.
 - Darjeeling exemplifies this paradox. Despite high precipitation levels, the town struggles with water scarcity, further compounded by a mostly non-functional sewerage system. According to CPHEEO guidelines, the town requires 70 litres per capita per day (LPCD), with an additional 15% for leakage, totalling 80 LPCD (assuming the town has 100% coverage of OSS). However, residents currently receive only 20 LPCD, (Konar, wt.al.; 2021) translating to a water supply requirement of approximately 3 MLD for the current population, far below the recommended benchmarks.
 - Recognizing these urban water challenges, Darjeeling's water challenges can be addressed through AMRUT 2.0 for urban water supply, NAFCC for climate-resilient strategies, and Mission Amrit Sarovar for water body rejuvenation, ensuring sustainable water security. The challenges are further exacerbated by climate change, as observed by the Indian Meteorological Department (IMD), which notes shifting precipitation patterns likely to persist. However, effective stormwater management presents an opportunity to mitigate Darjeeling's water scarcity and address its pressing needs.
- Therefore the study attempts to answer the following question-
- How can Stormwater reuse into the existing water supply system can potentially enhance Darjeeling's overall per capita water supply?

Results and Discussion

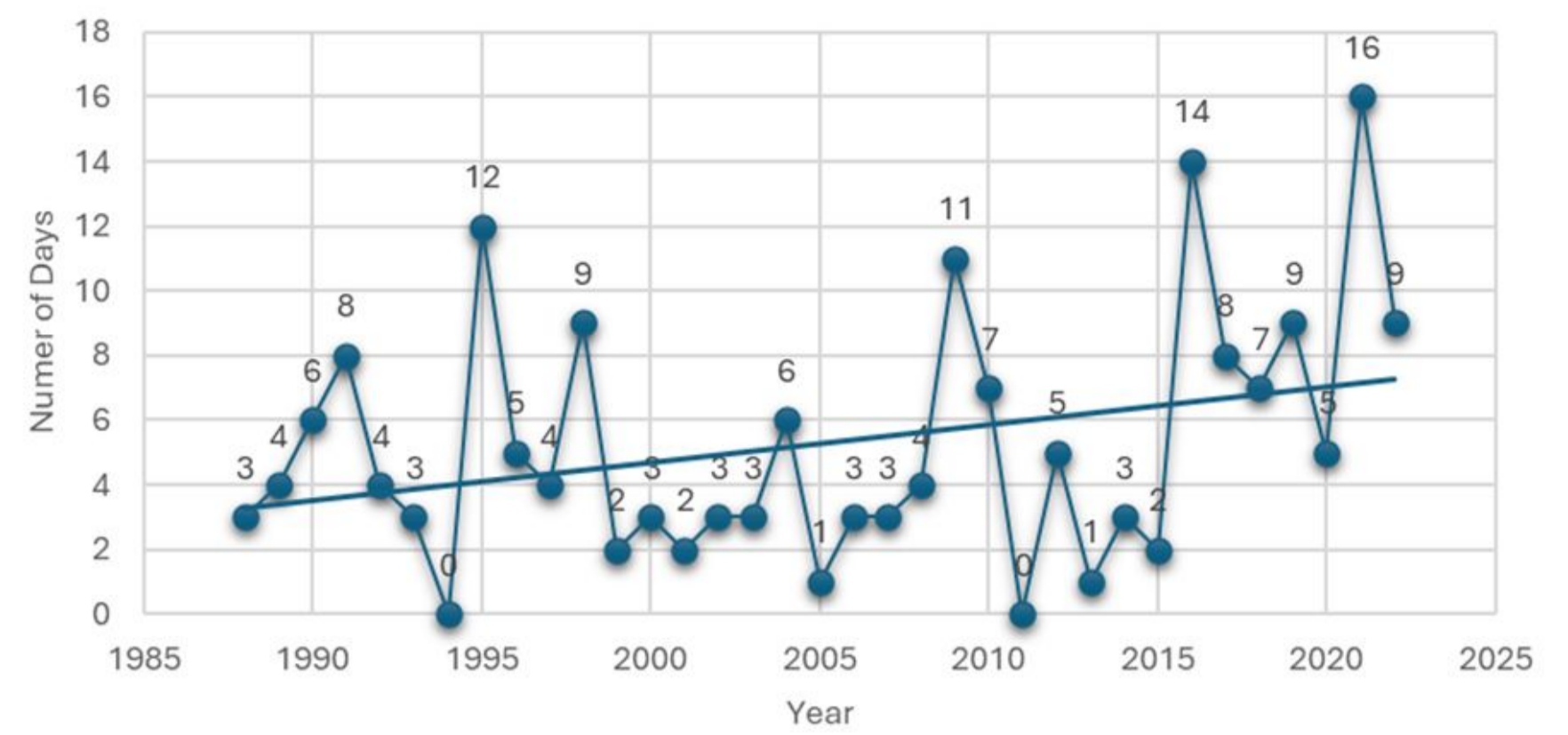


Figure 1 illustrates the increasing trend in the number of Heavy Rainfall Days (64.5–115.5 mm/day) in Darjeeling over the past 35 years (1988–2022), highlighting the impact of climate change. This trend, while indicative of heightened climatic variability, also presents an opportunity to develop stormwater harvesting infrastructure in the town.

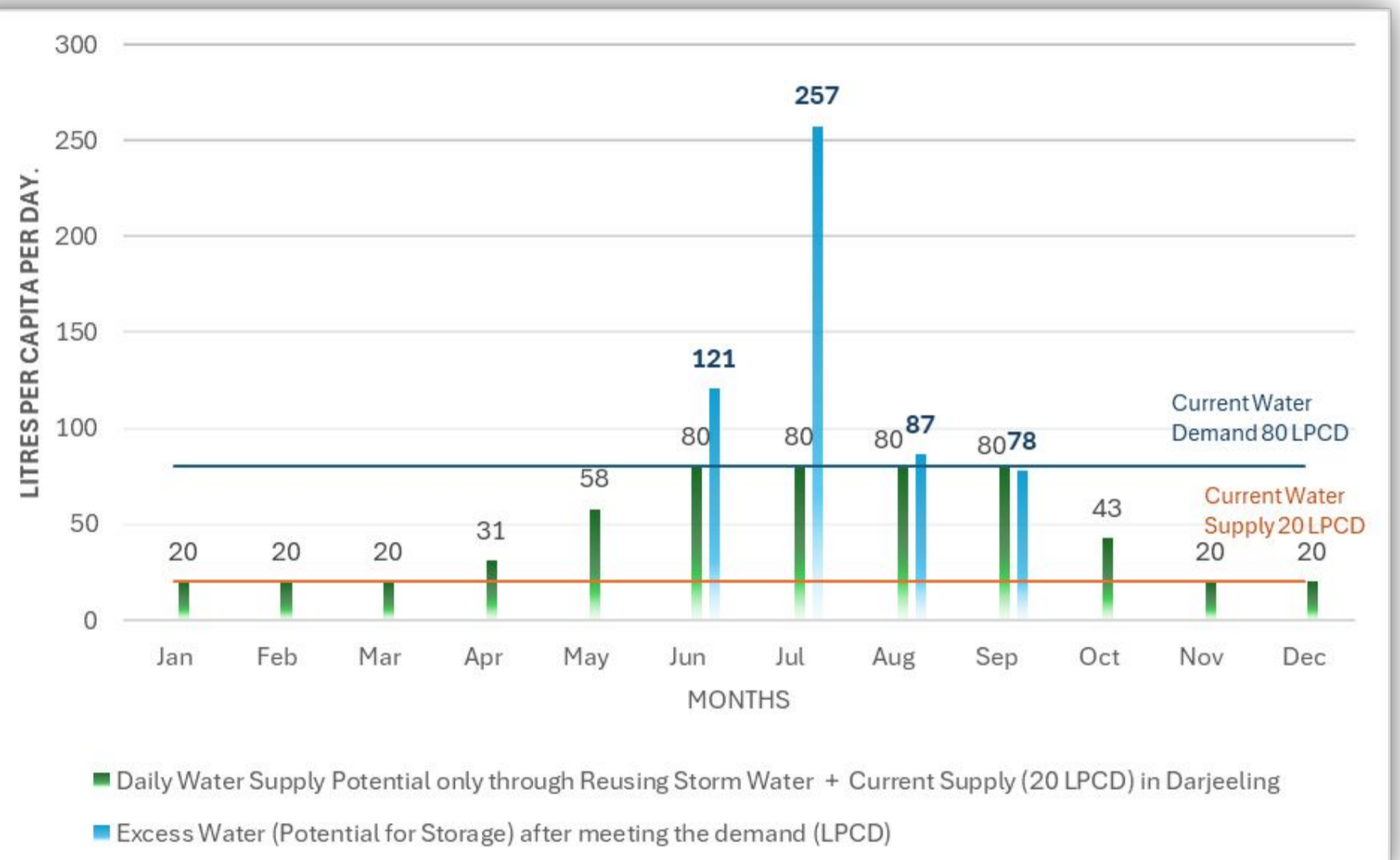
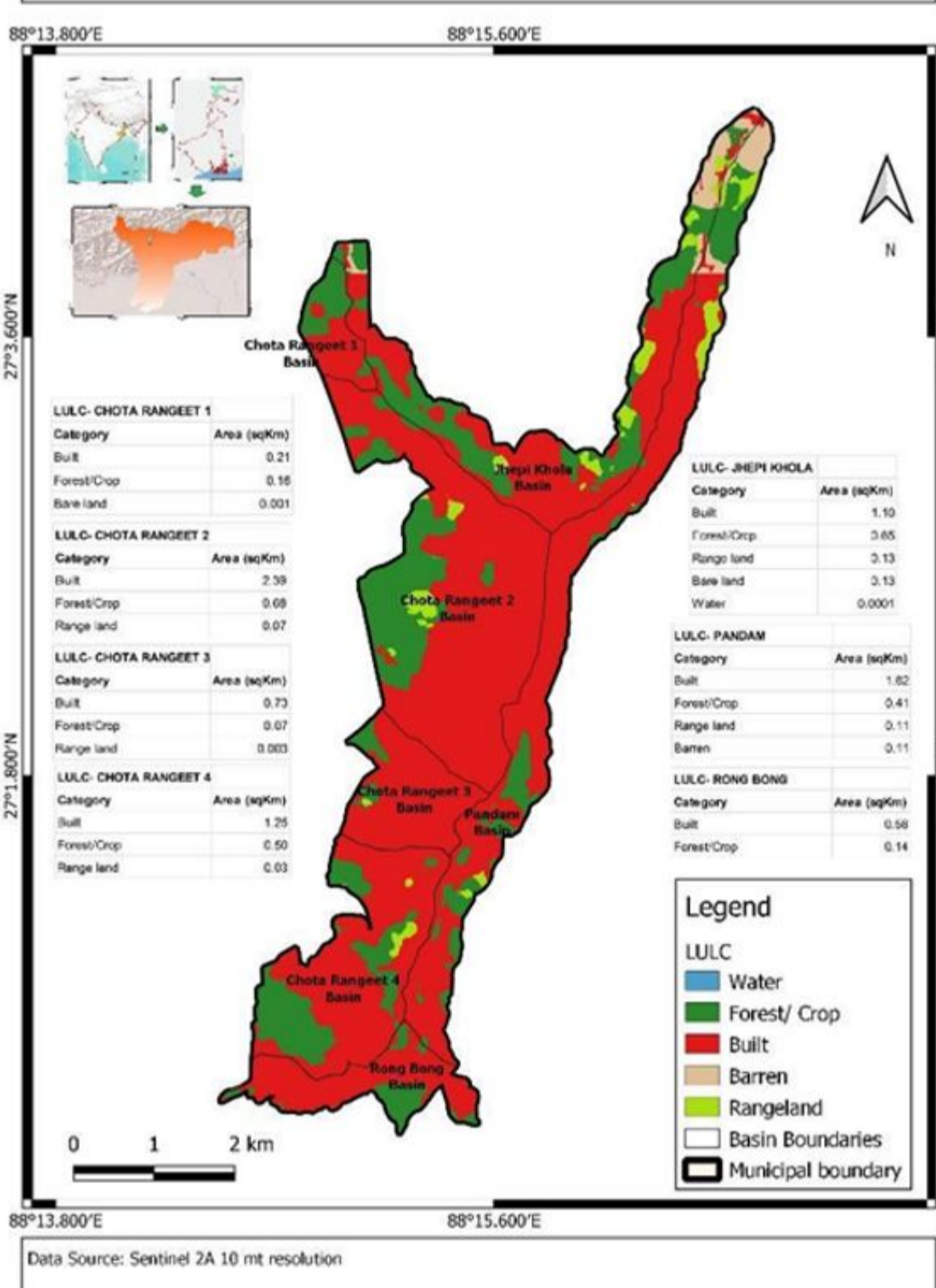


Figure 2: Illustrates how integrating stormwater management with the existing water supply system can enhance water-related service delivery in Darjeeling.

Land Use Land Cover of Sub-basins (2023)



LULC- Weighted CN Number of Darjeeling

Category	Area (sqkm)	SCS - CN Number (as per USDA)
Built	7.8848	0.93
Forest/Crop	2.6105	0.86
Rangeland	0.3438	0.89
Bare land	0.0239	0.91
Water	0.0001	0.99
Total Area	10.8631	CN value Weighted Average 0.912

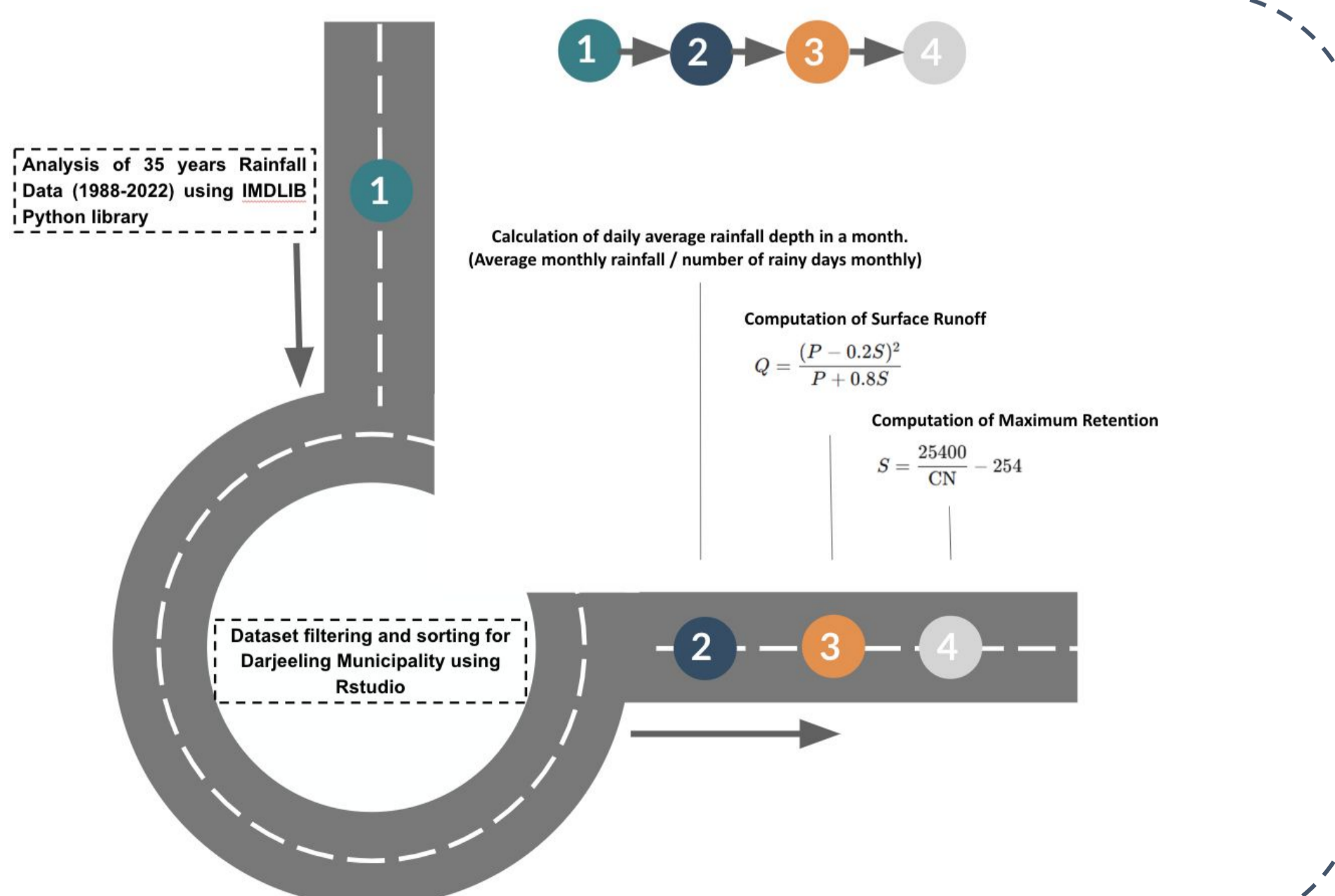
$$\text{Weighted CN} = \frac{\sum(\text{Area} \times \text{CN})}{\sum \text{Area}}$$

While Darjeeling continues to explore sourcing water from distant locations like the Balasan River, the city holds immense potential to augment its water supply through innovative stormwater management measures. Integrating stormwater reuse into our current water supply system is a strategy that elevates service delivery without relying on heavy, hard-engineering solutions as an immediate solution and improving storage capacity as a long term solution.

Today, with water demand soaring at 80 LPCD against a mere 20 LPCD supply, this forward-thinking approach can meet at least 50% of the demand from May to October through effective sub-basin wise decentralized storage. National Missions like AMRUT offer critical financing, enabling the city to develop storage solutions that capture the surplus water during months of heavy rainfall and distribute it during drier periods—ensuring a steady, year-round water supply.

Even more striking, during the monsoon months (June to September), water availability exceeds total demand by an additional 87–266 LPCD. This surplus is not just a number; it represents a vital opportunity to mitigate seasonal shortages and build resilience into our water infrastructure.

Enabling Environment for improving water supply through improved stormwater management



Data Sources: imdlib Python library, Rainfall data - IMD, LULC map - Sentinel-2A with a 10-meter resolution. Population data - census 2011 and projected to 2024 and 2050. City administrative boundary - Darjeeling Municipality.