# Water and Wastewater Visioning for Large, Dense Unplanned Urban Settlements in an Era of Climate Risk

## A CASE STUDY OF SANGAM VIHAR, DELHI

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**Production:** Rakesh Shrivastava and Gundhar Das

The Centre for Science and Environment is grateful to the Swedish International Development Cooperation Agency (Sida) for their institutional support.

BILL & MELINDA GATES *foundation*

This Protocol is based on research funded by the Bill & Melinda Gates Foundation. The findings and conclusions are those of the authors and do not necessarily reflect positions or policies of the foundation.

**Valuable inputs were received from R.S. Tyagi (Ex-Member Drainage, Delhi Jal Board), Ankit Shrivastava (Ex-Delhi Development Commission Consultant), Satyendra Dabas (Executive Engineer, DJB), L.L. Meena (Dy SE, DJB), Ramesh Shrivastava (DMRC), Pratima Joshi (Secretary, Shelter Associates), Dhawal Patil (Ecosan Services Foundation), Pranav Singh (Co-founder, Janya Collectives), Suraj Kumar (Co-founder, Innpact Solutions), Prof. Dr Hina Zia (Dean and HoD, Jamia University), and several others, including Hira Pandit (Pradhan, Block E, Sangam Vihar), Vinay Rawat (Parshad representative, Block C, Sangam Vihar) and the RWA members of Sangam Vihar. Special thanks to the residents of Sangam Vihar whose invaluable cooperation greatly facilitated the survey process.**




Maps in this report are indicative and not to scale.

**Citation:** Umra Anees and Depinder Kapur 2024, *Water and Wastewater Visioning for Large, Dense Unplanned Settlements in an Era of Climate Risk Era: A Case Study of Sangam Vihar*, Delhi, Centre for Science and Environment, New Delhi

**Published by**
**Centre for Science and Environment**
41, Tughlakabad Institutional Area
New Delhi 110 062
Phone: 91-11-40616000
Website: www.cseindia.org

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# Foreword

Increasing urbanization in the Global South is accompanied by the emergence of acute water and wastewater challenges because the nature of our urbanization is predominantly unplanned and informal. With climate change, we are witnessing increasing variability, alternating flooding and water scarcity in our cities, which is felt more acutely by residents of our unplanned and informal settlements.

Based on designing solutions for an aggregation of total population and per capita water supply and wastewater generation of a city, large centralized systems of water supply and wastewater treatment are preferred. This has resulted in sub-optimal outcomes for our unplanned and informal settlements. The *Sewerage Manual* (2013) of the Ministry of Housing and Urban Affairs highlights the challenges of centralized sewerage systems for India, with high capital cost of underground sewerage infrastructure, high cost of sewage pumping and maintenance costs that our small towns cannot afford, and above all the severity of water scarcity that many Indian cities face that negates the viability of water- and flushing-based sewer systems. According to Census 2011, sewerage coverage was less than 33 per cent of the urban Indian population. Faecal sludge management has emerged as a solution, currently implemented in around a 500 towns of India.

The urban water supply and sanitation systems discourse has recently been confined to a narrow contestation between sewered and non-sewered sanitation systems on the one hand, and a normative techno-managerial 'water-sensitive cities' framing on the other. While there is merit in promoting non-sewered sanitation systems and in adopting frameworks that define what a city should do for becoming water-sensitive, what does this mean for large-populated, informal and unplanned settlements of our cities? The what and how of achieving appropriate water supply, sanitation systems and storm-water management in these settlements is missed out.

Can half a million, or a million-plus unplanned settlements with 50–100 MLD of wastewater generation be served with non-sewered sanitation (NSS) systems, solid-free sewer systems or shallow sewers? Will retrofitting solutions of connecting unplanned settlements with large volumes of wastewater generation to existing main sewers work? Given the increasing water stress, how can water supply be augmented and storm water managed in a way that is equitous and climate-risk proof?

This study attempts to address the above questions. The case study of Sangam Vihar, an unplanned settlement of about a million-plus in about 5 sq. km in southeast corner of Delhi shows the need for a good nuanced understanding of water-related challenges and a direction in which we must proceed to explore solutions.

The study is unique for the following three reasons:

- Its primary-research-based findings and conclusions for large, dense unplanned settlements addresses all the three critical aspects (water supply, sanitation and wastewater, and storm-water challenges);
- It offers a conceptual understanding for two critical elements, unplanned settlements and urban planning, and links this to water and sanitation; and
- It breaks the dichotomy of sewered versus non-sewered approach to urban sanitation, highlighting decentralized systems (water supply, sanitation and storm water) as the future pathway, and as a climate risk mitigation strategy.

Unplanned and informal settlements define the challenges of water supply, sanitation and storm-water management of all our cities. We hope this study with its recommendations for decentralized planning of water-related infrastructure will be useful in defining the agenda of urban water related policy and programmes as well as frameworks and actions.

The primary study with its research methodology, rich data sets included in this report, and the findings and recommendations will be useful for students, researchers, universities, water and sanitation professionals, practitioners, experts and policymakers.

**Depinder S. Kapur**
Director
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# Executive summary

Informal and unplanned settlements now dominate the urban landscape of most developing countries of Africa and Asia, especially in the metro cities. Such settlements are close to 50 per cent or more in the large metropolitan cities of India. Some of these unplanned settlements are very large and house half a million or more people, and are cities within a city. While overall access to clean water, sanitation and storm-water management in large cities of the Global South is increasing, this improvement is neither just nor equitable—in terms of equitable access, adequacy, and quality or affordability of water and sanitation services. On top of this is the climate change impact on our cities and intensification of the water cycle, causing alternating water scarcity and flooding challenges that are evident in Bengaluru and Chennai.

There are very few studies addressing water supply, storm-water and sanitation challenges of unplanned urban settlements with large populations in India and elsewhere in the Global South. The few examples that exist are solid-free sewers in Brazil and the exemplary Orangi Pilot Project of Karachi.

Sangam Vihar, spread over an area of 5 sq. km and with a population of more than a million, is representative of such large, dense unplanned settlements. It is often in news for its 'water mafia' and poor sanitation and storm-water issues.

Can we talk about 'water-sensitive cities' or 'climate-resilient cities' if we ignore large, dense unplanned settlements? What is their status of water supply, sanitation and storm-water management? Can one-off projects of green and blue development establish that a city is moving towards being a water-secure or water-sensitive city? Can ad-hoc retrofitting solutions for water supply, sewers and sanitation, and storm-water management, work in unplanned settlements?

A reimagining of urban water supply, sanitation and storm-water management, in the era of climate change is an urgent imperative for ensuring justice and equity for the water future of our cities.

This study is a continuation of the Global South water-sensitive cities framework developed by CSE,[1] which attempts to situate the water-sensitive design thinking in the concrete context of Global South cities.

## KEY FINDINGS

Generating data for what is not documented was the first challenge of this study, followed by an analysis of the data to assess whether retrofitting solutions for water supply, sewerage and storm-water would work. The situation of water supply, sanitation and storm-water management in Sangam Vihar is critical and needs urgent attention.

**Water:** At 45 litre per capita a day (LPCD) water supply in Sangam Vihar is critically low. Residents are paying up to Rs 1,000 a month or more for purchase of potable and non-potable water. Out of the three water supply sources (tankers, borewells and piped supply), reliance is more on tankers and borewells.

There is inequity in water supply among the residents of 13 blocks of Sangam Vihar. A correlation is observed for economic status of residents, water supplied and potable water purchased. Blocks (I, F, L and M), which have low water supply, also cannot afford to purchase potable water.

**Sanitation:** Non-sewered sanitation systems of sealed underground septage tanks exist in almost every property (approx. 60,000 properties). The majority of these tanks are perforated at the bottom, leading to seepage of septage and groundwater pollution.

The research has identified that more than 200 kilolitre a day (KLD) of septage desludging happens every day in Sangam Vihar. Half of this amount is dumped into the sewage pumping station in Daskhinpuri and carried forward for co-treatment at Sarita Vihar sewage treatment plant (STP). The rest is dumped indiscriminately outside. Delhi Jal Board is implementing a sewerage network in Sangam Vihar. Nearly half of the area now has sewers laid out, but it is still to start operations after which only we will know whether this retrofitted sewerage system will work.

**Grey water:** All the wastewater (from washing, bathing and kitchens) flow is captured and conveyed through the street-level drains. This grey water is partially connected to the main sewer on the Mehrauli-Badarpur (MB) Road and partially to the storm-water drain of Dakshinpuri.

**Storm water:** There are no open spaces inside Sangam Vihar and no unpaved areas for rainwater to recharge groundwater, hence generating high in-situ run-off during rain. The street drains that carry grey water also work as storm-water drains, conveying all such water to the MB Road main sewer and leading to flooding conditions and sewage spillover after even a short 15-minute rainfall episode.

## RECOMMENDATIONS

### 1. Reimagining decentralized water supply and its urgent augmentation priority for Sangam Vihar

The inadequate and uncertain water supply in Sangam Vihar has translated into residents building large underground and over-ground water-storage tanks. The underground water tanks are built next to or close to the underground sealed

septage holding tanks that are perforated at the bottom, which is a major health risk hazard. This needs to change. It requires an enhancement and assured water supply of at least a doubling of the current supply level of 45 lpcd.

Groundwater supply is the predominant source of water in most blocks of Sangam Vihar. Any drop in groundwater levels in the near future can lead to severe water scarcity and high economic burden for the residents. The recent Bengaluru groundwater crisis this year is a warning signal.

Augmenting water supply needs a reimagination of decentralized water supply options. Alternative decentralized water supply options need to be explored for Sangam Vihar. Delhi has 1,045 listed waterbodies. These need to be mapped and matched with sewage treatment plants with which they can be connected for refilling with treated wastewater. Four large lakes lying within a 15-km radius of Sangam Vihar have been identified, which also have STPs nearby for recharging with treated wastewater. They can be used for recharge and serve as water supply sources (with secondary and tertiary treatment) for nearby colonies, planned and unplanned. This way Sangam Vihar water security can also be enhanced with an assured nearby water supply from nearby recharged lakes, instead of depending on high-cost pumping from centralized water-treatment plants.

## 2. Reimagining sanitation systems—combining centralized and decentralized sanitation systems

Estimated total wastewater generated in Sangam Vihar is. approximately 36 MLD. There is an ongoing retrofitting of a sewerage pipelines in Sangam Vihar, connecting to a 20-year-old main sewer line on MB Road. A part of the dense unplanned settlement of Sangam Vihar can and should be connected to the main sewer line, but if the entire sewage of a million plus population is suddenly connected to only one main sewer line, the chances of choking and breakdown are high.

The sewerage retrofitting may worsen the existing system of non-sewered sanitation-based septage-management system within Sangam Vihar. There is further risk of the entire main sewer line also getting choked, resulting in a major breakdown of the main sewer system.

A combination of centralized (retrofitting half of the 13 blocks of Sangam Vihar with existing infrastructure) and decentralized sanitation systems (creating additional decentralized STPs in the periphery of Sangam Vihar) is recommended.

## 3. Addressing urban storm-water management for recharge of groundwater and discharge to prevent in-situ urban flooding

No storm-water management planning or infrastructure is currently proposed for Sangam Vihar, other than a large storm-water drainage channel. A 15-minute

episode of normal rainfall can lead to more than 11million litre of storm water spilling out of Sangam Vihar.

The responsibility of storm-water management of Sangam Vihar now rests with the Delhi Metro Rail Corporation (DMRC). DMRC is sceptical about what to do and are only considering developing a large drainage channel for the storm water of Sangam Vihar. But where to take this water is beyond their means and powers to suggest or implement.

For large metros and several other state capitals, there is an urgency to initiate storm-water management as a nature-based solution initiative. Finding open spaces for groundwater recharge and flood mitigation should be the first priority, followed by creating infrastructure for drainage of storm water for both the purpose of recharge as well as for drainage/discharge.

## THE WAY FORWARD

Mere infrastructure retrofitting solutions for water supply, sanitation and storm-water management will not solve the problems of large populated dense unplanned settlements.

While calling out for a new policy, programme or mission to address such settlements looks attractive, what is really needed is that these settlements are integrated into a reimagined city-wide water supply, sanitation and storm-water management.

With limited potential for in-situ water conservation in these large, dense unplanned settlements, there will need to be decentralized ex-situ water supply augmentation, sanitation and storm-water management solutions. This will require a relook at how we manage water supply at the city level in our large metro cities, how we reuse treated wastewater for groundwater recharge, identifying where and what decentralized systems will work along with centralized systems, and how we address both water conservation as well as drainage to prevent urban in-situ flooding. This entire gamut of water-related planning will define a meaningful 'water-sensitive city' ambition, which the CSE framework of Global South water-sensitive cities has outlined.

It will also require an appropriate institutional makeover of urban water utilities and their engagement and oversight on water issues with other departments that manage buildings, roads, forests, lakes and waterbodies, canals, parks, etc., and creating relevant institutional mechanisms to address water management at the city level and its linkages beyond the city.

A techno-managerial implementation approach by borrowing ideas from frameworks of water and cities of Western developed countries will not work for Global South cities and their water futures. Equity and justice should form the aim

of planning for any water-sensitive city. Infrastructure upgradation, its inclusive access, and who pays and who benefits from green and grey infrastructure development cannot be ignored. Formal urban planning provides legislative entitlements to the less privileged for the development of cities. It needs to be strengthened and not diluted in the name of reforms and cannot be done from a water utilities sectoral planning and forecasting perspective. Formal urban planning needs to incorporate the reimagined perspective of managing water supply, wastewater and storm water, both at the city level and at the regional-planning level.

Chapter 1

# Introduction

## BACKGROUND AND JUSTIFICATION

Developing countries of Asia and Africa are experiencing historically unparalleled rapid urban growth and expansion of cities in an unprecedented unplanned manner (except perhaps in China). Inequity is magnified as never before.

- A vast majority of current and future residents of these cities will reside in congested unauthorized settlements (that are later regularized and then measures are explored to provide them with water supply, sewerage/septage management and storm-water infrastructure and services).
- Most cities do not have adequate infrastructure for water supply, sewerage/septage management and storm-water drainage. Where such infrastructure does exist, its operations and functionality remains a challenge.
- Cities are precariously poised in terms of addressing their growing dependence on water supply from far-off rivers and reservoirs and addressing the issue of their waterbodies (lakes and rivers) turning into large sewers. Groundwater sources are polluted and drying up at alarming rates. Small rivers and waterbodies are also drying up on account of increased extraction of water.
- Less than 10 per cent of our towns (census and statutory towns together totaling 7,924 as per 2011 Census) have sewerage systems and sewage treatment plants (that too with mostly partial coverage).

Almost all our cities now have a large percentage of populations residing in such dense formal or informal, unplanned, settlements that are outside planned urban settlements. These were never developed by an urban development authority, with provision of roads, water and sewerage, public amenities and land use. A dense unplanned settlement may have an 'unauthorized' illegal status or it could have been 'formalized' or 'regularized' over course of time, but remains a dense unplanned settlement.

### Low prioritization of water and wastewater management in urban planning

In the Master Plans of cities, water and sanitation exist as chapters and are not integrated with other parts of planning for urban subsectors. However, less than 10 per cent of statutory urban towns of India have a Master Plan. Modern planning practices considered land as the most valued resource and paid little attention to water systems and resources. In contemporary practices, spatial master plans deal with optimization of street networks and land use. We are yet to see Regional

Plans deal with issues of water, sanitation and storm-water planning, even as our cities are expanding and urban agglomerations are increasing.

### Absence of research

While there are studies that address the lack of infrastructure and service delivery in small unplanned settlements, there is no desk research or a field-based study of water, storm water and sanitation services for very large, dense, unplanned settlements of our cities that define the problem of infrastructure augmentation needed.

### Limitations of frameworks

The prevailing normative discourse of water sensitive urban design and planning (WSUDP) or 'sponge cities' and 'water-sensitive cities' ignores the problem of large dense unplanned settlements where lack of basic water related infrastructure and service provision is the main challenge.

The Global South water-sensitive cities framework[2] developed by CSE brought the focus of equity and justice upfront and identified a four-point index for ensuring that any intervention to justify itself as a contributor to a city becoming water sensitive must show measurable progress against the following four critical 'index' parameters:

- **Functional infrastructure and services:** Fix all existing non-functional water, sanitation and storm-water infrastructure and services to improve efficacy and treatment outcomes.
- **Functional and inclusive infrastructure for unserved areas:** Additional grey infrastructure and services may be needed for unserved informal urban settlements that now dominate the urban landscape of cities of the Global South.
- **Substantial reuse of treated wastewater and biosolids:** Reduce wastewater footprint and increase the reuse of treated biosolids and treated wastewater in a manner that is just and equitable.
- **Mitigating in-situ urban flooding:** Conserving rainwater wherever possible and keeping it as contamination free as possible.

The Sangam Vihar study provides a good practical ground for testing the value of this framing.

## WHY SANGAM VIHAR?

Sangam Vihar is considered one of the largest unplanned settlements of Delhi. The settlement extends on the north of the Mehrauli-Badarpur Road and encompasses an area of 5 sq. km. The entire area suffers from poor water supply, sanitation and storm-water management infrastructure.

For all 13 blocks of Sangam Vihar, the estimated population is more than a million and the population density is amongst the highest in Delhi. A sewerage

infrastructure is being laid out in Sangam Vihar. There was a need to understand if such retrofitting solutions will work or if there is a need to conceptualize and look for a completely different approach to addressing the water-related challenges in such dense unplanned settlements.

The starting block for any solution hunting or perspective building is good data-based research. Being an unplanned informal settlement, there is no official data of what constitutes Sangam Vihar in terms of number of properties, population and a delineated colony/area:

- There is no assessment of per capita water supply.
- There is no assessment of grey-water and black-water generation (this was made possible only when CSE did the per capita water supply estimation through a block-wise survey).
- There is no assessment of desludging frequency of underground sealed septage holding tanks and their disposal.
- There is no assessment of storm-water generation, its drainage or potential for conservation.

Water supply and sewerage infrastructure augmentation by Delhi Jal Board (DJB) has been ongoing since 2017:

- A water supply network of Delhi Jal Board is being laid under five projects, out of which three projects worth Rs 20 crore have been completed while two projects worth Rs 9.50 crore are still in progress and likely to be completed by March 2024.
- Sewerage work is in progress and sewerage lines have been laid out. Approximately 50 per cent of the residents of Sangam Vihar are supposed to have been covered with lateral sewer lines. Outfall/peripheral sewer lines have been installed on main Devli Road and Ratiya Marg, which is connected with the trunk sewer line on MB Road which finally terminates into Okhla SPS through Sarita Vihar SPS.

## OBJECTIVES OF THE STUDY

### 1. Understanding water supply, used water and storm-water challenges of large populated, dense unplanned urban settlements

The study aims to develop a disaggregated understanding of urban water, sanitation and storm-water management challenges, with a focus on large densely populated unplanned settlements of large metro cities, taking Sangam Vihar of Delhi, with its million plus population as a case study. This understanding is largely missing in any

existing research, and find little mention in the formal urban planning instruments of Regional Plans, the City Master Plans (Delhi Master Plan 2041) and even Zonal Plans.

On the basis of a household survey, this study analyses the existing status of water supply, sanitation and storm-water issues in Sangam Vihar. It brings out the community perspective along with an assessment of the potential success or otherwise of the ongoing sanitation/sewerage infrastructure being installed in Sangam Vihar and what needs to be done to meaningfully address the water supply and storm water challenges of this settlement.

## 2. Contributing to the Global South water-sensitive cities framing

The research is a follow-up of the CSE framing of the Global South water-sensitive cities, which defined what water-sensitive cities should be in the context of the Global South. It aims to test the framework developed by CSE for strengthening the case for moving away from a normative and techno-managerial application of what a water-sensitive city can be.

The study explores if retrofitting solutions for water supply, sanitation and storm water can work for such settlements, and reimagines and explores decentralized sanitation and storm-water management solutions that are firmly anchored on principles of circular economy, equity and justice.

## METHODOLOGY

In the absence of data of unplanned settlements, the following steps were undertaken initiate this research:

- Delineating the research area. For the purpose of this study we picked up a 5 sq. km area comprising 13 blocks of Sangam Vihar where Delhi Jal Board has proposed to provide a sewerage system.
- We then proceeded to identify the population of the 13 blocks through a block-wise household survey.
- We estimated per capita water supply/consumption on the basis of population and water supply from different sources.
- Sewage generation and the feasibility/ capacity of the DJB sewerage lines

*Household survey being conducted by CSE team*

**Figure 1: Methodology followed in conducting the study**


*Consultation meeting with sector experts and RWA members*

(dimension of pipes and their conveyance capacity) were estimated.
- The in-situ storm water run-off from Sangam Vihar and its outfall impact were estimated on the basis of approximately 5 sq. km of study area of 13 blocks.

Based on the findings an analysis was done for potential long-term and immediate interventions for ensuring sustainability of sewerage retrofitting initiative of Delhi Jal Board (DJB), storm-water management and augmentation of water supply.

In addition, extensive secondary research was also carried out from:
- Data and reports on urban planning with focus on Delhi, including the Delhi Master Plan, Delhi Jal Board, websites of DDA, MCD, etc., and
- Field-based surveys and formal meetings with experts, officials and local resident representatives of DDA, DJB, PWD, DMRC, MCD, RWA, etc.

Four field survey teams were constituted to undertake a household survey and Focused Group Discussions (FGDs) in the 13 blocks of Sangam Vihar. Detailed research questions for water, sanitation and storm water have been annexed to the report (see *Annexure 1*) and the detailed block-wise analysis have also been annexed (see *Annexure 2*).

Primary data collection for this research took place in July–November 2023. The CSE team and four interns covered a total sample of 222 households in the 13 blocks of Sangam Vihar, on a random basis, to collect individual household-level data on aspects of demography, population, water supply, sanitation and storm water. A total of 22 Focus Group Discussions were also held to arrive at a community-level understanding of some of the more complex issues relating to water, sanitation and storm water. Block-wise data was then analysed before arriving at the overall 13-block analysis of Sangam Vihar. Block-wise data is enclosed in this report as Annexure 2. Two consultation meetings were organized—one with experts and NGOs, and another with local leaders and representatives from Sangam Vihar.

Chapter 2

# Informal and unplanned settlements of Delhi

## GLOBAL SCENARIO

Urbanization is one of the four 'demographic mega-trends' identified by the United Nations,[3] together with population growth, ageing and international migration.

According to an Asian Development Bank (2019) report, the world's urban population has dramatically increased from 751 million people in 1950 (30 per cent of the world's population) to 4.2 billion people in 2018 (55 per cent of the world's population). This number will rise to 5.2 billion in 2030 (60 per cent of the overall population), and 6.7 billion in 2050 (68 per cent of the total population). It also points out that increased urbanization has the potential to pave the way for heightened income disparities, alongside an expanding contrast in job prospects between individuals residing in formal and informal sectors of urban economies. The Report on Urban Competitiveness at a Global Scale (2021),[4] says that numerous urban regions face formidable challenges in accessing clean water, adequate sanitation, healthcare facilities, and educational opportunities.

## INDIA SCENARIO

The urban population of India (as per the 2011 Census), increased from 27.7 per cent in 2001 to 31.1 per cent (377.1 million) in 2011, growing at a rate of 2.76 per cent annually. However, since the 1990s, the urbanization trend has shifted from large Tier 1 towns to medium and smaller towns. Over 2001–11, the urban growth rate of 1.9 per cent was seen in the Delhi, while the district of Gurugram had an annual growth rate of 4.5 per cent.

**Table 1: Reasons for migration in India**

| | 2001 (%) | 2011 (%) |
|---|---|---|
| Works/employment | 14.7 | 10.22 |
| Business | 1.2 | 0.96 |
| Education | 3 | 1.77 |
| Marriage | 43.8 | 49.35 |
| Moved after birth | 6.7 | 10.57 |
| Moved with household | 21 | 15.39 |
| Other reason | 9.7 | 11.74 |

Source: Census of India, 2011.

Migration contributes to urbanization and reasons for the same have been assessed for marriage, employment, education, security, lack of security, and push and pull factors.

Table 1 shows the interstate migration data. Interestingly, marriage is identified as one of the main reasons. Migrating populations will occupy land where it is available, and these end up being informal settlements and unplanned colonies developed by small builders.

Slum populations represent the lowest-income urban populations, and in large metros—such as Mumbai, Delhi or Bengaluru—where buying land from small builders is not possible, slums are more endemic. According to a recent (2022) article by the *Times of India*, there are 2,400 and 675 slums in Maharashtra and Delhi respectively.

## DELHI SCENARIO

According to the Census of India 2011, the urban population of Delhi was 16.3 million, with a decadal growth rate of the population of 21.2 per cent during 2001–11.[5] Out of 16.3 million urban population, 7.22 million were migrants.[6]

With the continuation of the present population trend, the total population of NCTD by the year 2021 would be 22.5 million.[7]

In 2014, the Delhi government carried out a survey of slums and jhuggi jhopri (JJ) colonies, estimating that 0.33 million households (approximately 1.7 million people) lived there, which is around 10 per cent of Delhi's total population. Out of this 0.33 million, about 0.30 million are migrants.[8]

According to 2017 research,[9] the majority of people who migrate from Uttar Pradesh, Bihar, Haryana, Rajasthan, Punjab, etc. to Delhi do so in search of better-paying jobs—this process is known as inter-state migration. In contrast, some individuals especially farmers migrate to Delhi during their off seasons in search of employment—this phenomenon is known as seasonal migration.[10] As per Census of India 2011, 2,029,489 people migrated to Delhi in the process of seasonal migration.[11] The extent of large scale of urban informal settlements and informal work force was evident during the first wave of Covid (in 2020), when a large-scale return of migrants from Mumbai, Delhi and other cities was visible.

### Informal and unplanned settlements

Urban settlements in India are broadly classified into planned and unplanned settlements. Planned settlements are those which have been constructed and developed by government agencies or by housing societies on the basis of duly approved plans. Physical, social, economic and many other considerations are taken into account for the development of such colonies. On the other hand unplanned settlements are those which have come up illegally either on the government

land or private land in a haphazard manner. They have both permanent or semi-permanent and temporary structures edging the city drains, railway tracks, low-lying flood-prone areas, occupying agriculture land and green belts in and around the city.

A significant number of the residents of unplanned settlements work in informal sector which would not be paying them adequately, thus out of compulsion they tend to settle in areas where basic amenities are either lacking or are completely unavailable with a hope of reducing their living costs, including rent, in areas like slums, JJ clusters, unauthorized colonies, etc.[12] Once established, unplanned settlements continue to expand without any supervision from the government, posing further spatial problems.

Informal and unplanned settlements are considered illegal and denied formal services of water supply and sanitation. An outbreak of cholera and gastroenteritis as late as 1988 reportedly claimed more than 150 lives in East Delhi slums, leading to improved municipal supply of water and eventually to sewerage.[13]

Delhi's large number of unplanned settlement is due to the large imbalance between the supply and demand of land, housing, and related infrastructure. Policies and urban planning frequently ignore the demands of the urban poor, which results in an unfair distribution of resources between residents of formal and informal cities[14].

As per Master Plan of Delhi (MPD, 2021) the goal of providing housing for everyone by 2022 required construction of or improvement of 4.8 million houses. The proportion of these houses designated for Economically Weaker Sections (EWS) would be 54 per cent of the overall total. Delhi required 2.4 million fresh housing units by the year 2021 as per the Master Plan of Delhi (MPD-2021) with adequate infrastructural facilities like water and sanitation.

## Three contrasting critiques of urbanization failure

Formal urban planning and planned urbanization has been undertaken in India since Independence by the constitution of Urban Development Authorities in each state and city. The Delhi Development Authority (DDA), in the case of Delhi, was created in 1957 by an Act of Parliament as one of the first such bodies.

**The first critique** is a defense of urban planning as a statutory minimum legal entitlement of the urban poor.[15] It puts forth how by berating urban planning and its formal instruments like the City Master Plan (called Development Plan) as a planned disaster, we take away the only legal safeguard that the urban poor and middle class have against the all private builder-led urban development witnessed in India in the last few decades. The violation of urban planning norms has eventual resulted in evicting slum dwellers on one hand, and giving away prized land (that was formerly under factories or remaining public lands of the river and forests), to

high-end elite commercial and housing use. What the City Master Plan provides is a statutory legal entitlement—the City Master Plan is a legal document—for all residents of a city to the development rights and benefits of a city. It can be legally enforced, unlike welfare schemes and programmes.

**The second critique**[16] blames both the DDA for its idealistic land-use planning for urbanization, and ignored how the low-income sections and poor would find their place in a city like Delhi. It also blames the emergence of 'bourgeoise environmentalism' in the 1990s that led to eviction of both informal workers and informal settlements in Delhi under the narrative of pollution of air and the Yamuna River.

Unhindered urban development, with minimal urban planning by state agencies in the form of basic grid-based land use, no restrictions on allocation of land for different uses and minimal restrictions on construction, defines a neo-liberal market-led urbanization model as **the third critique**[17] of urbanization failure. It builds on the critique of blaming formal urban planning instruments, and seems to be based on the Town Planning Scheme (TPS) first implemented in Ahmedabad. The premise of the Town Planning Scheme premise seems to be based on land value appreciation accruing to land owners, their voluntary surrender of 40 per cent of their land for this purpose to the TPS Authority, and the TPS providing for 10 per cent land use for low-cost housing.

Can the TPS replace City Master Planning for the whole city and not just its peripheral areas for specific purpose housing development? Can it translate into planned urban development outcomes for not only the urban poor (refer to the Delhi Master Plan 2021, which mentions 54 per cent of the new housing should be for economically weaker sections) but also for provision of other public land use for?

It is important to understand why City Master Planning came into existence and what other option we had post-Independence for a planned urban development in terms of spatial land use planning. Why did it fail? Was it an intrinsic fault of Urban Planning or the political-economy of urban land capture by the elite?

*'One can think of role of Master Plan in relation to urban land as one would think of the role of expenditure budget for family income. Both can help but not guarantee efficient and equitable distribution of resources for everyone's needs and wants . . . Mere existence of Master Plan will not stop the powerful from squandering precious urban land to build unnecessary unplanned cyber parks or world-class shopping complexes as monuments to themselves'*

*—Gita Dewan Verma*[18]

It is true that the urban poor who have been denied access to formal housing and water supply and sanitation services, who were victims, became villains of environmental activism in Delhi.

*'In all cases where rural poor have been successful in asserting their rights to resources, they have done so by mobilizing a counter-narrative about their superiority of their conservationist ethics and practices, often performing the role of 'virtuous peasant' or ecologically nodal savage. Organizations of urban poor find it very difficult to Marshall similar moral claims that marry ecology with justice.'*

*—Amita Baviskar*[19]

What is clear is that unplanned urbanization has become a norm for most Indian cities. It has taken the form of gated communities and slums. Provision of water, sanitation and storm-water management are challenges everywhere now. It impacts the economically poor residents of dense unplanned settlements, more than others.

**Table 2: Informal settlements in Delhi (2001)**

| Category | Estimates as per DIEIIP, 2001 | |
|---|---|---|
| | Population (in millions) | Per cent of total population |
| Jhuggi jhopri clusters/squatters | 2.07 | 14.82 |
| Designated slum areas | 2.66 | 19.05 |
| Unauthorized settlements | 0.74 | 5.30 |
| Regularized unauthorized colonies | 1.78 | 12.75 |
| Resettlement colonies | 1.78 | 12.75 |
| Rural villages | 0.74 | 5.30 |
| Urban villages | 0.89 | 6.37 |
| Planned colonies | 3.31 | 23.71 |
| Total | 13.96 | 100.00 |

Source: DUEIIP—Status Report for Delhi 21, GOI & MoE&F, January 2001 and Amitabh Kundu, 'Provision of tenurial security'

## Housing typology

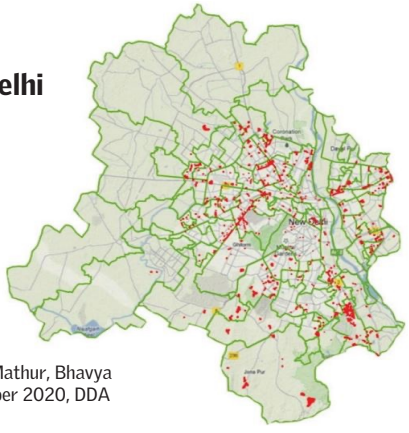
As per the Economic Survey of Delhi (2002), human settlements have been classified into eight different types. The categories are as follows:

Less than 25 per cent of its housing was planned colonies in 2002. The situation would not have changed much, given the large expansion of unplanned settlements since then.

## Informal and unplanned population of Delhi

The Economic Survey of Delhi 2021–22 and Delhi Urban Shelter Improvement Board estimtes that more than 30 per cent of Delhi's urban population resides in unauthorized colonies.[21]

Sangam Vihar is part of the 1,731 unauthorized colonies (affluent unauthorized colonies are excluded) in Delhi as per the gazette notification of October 29, 2019.

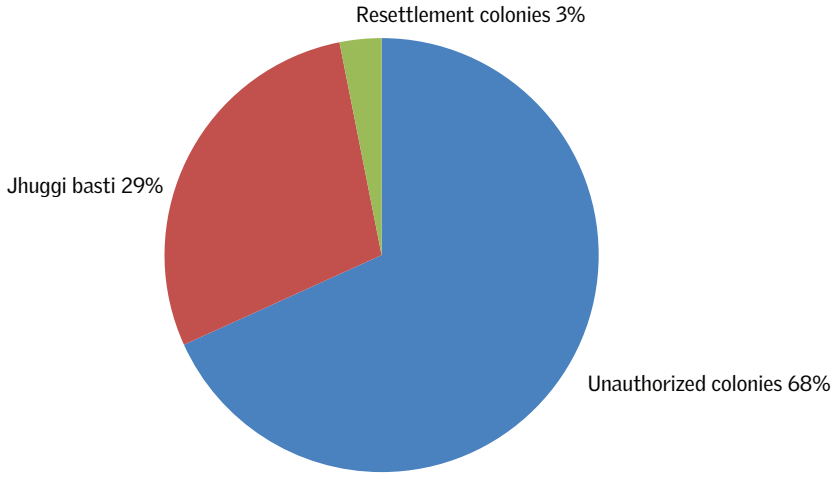
| | | |
|---|---|---|
| Jhuggi basti | Jhuggi basti is also known as jhuggi jhopri clusters/ squatters settlement on 'public land' owned by agencies such as DDA, Railways, CPWD, GNCTD, or Municipal Corporations of Delhi, which have been occupied and built on without permission.[20]<br>According to the Economic Survey of Delhi 2022–23, there are 675 slum and JJ bastis in Delhi with more than 3 lakh jhuggis with a population of about 15 lakh.<br>According to the Economic Survey 2019–20, 30 per cent of Delhi's slums are situated on state government land, with the remaining 70 per cent being on the Central government land.<br>**Map 1: Slums in Delhi**<br>  <br>Source: Singhai, Aakriti and Mathur, Bhavya (2020). HUDCO Shelter October 2020, DDA | 755 jhuggi basti in Delhi with total population of 1.7 million. |
| Resettlement colonies | According to the Centre for Policy Research (CPR) 2014, resettlement colonies are settlements in India that are developed to house residents who are evicted from informal settlements, such as slums or jhuggi-jhopri clusters (JJCs). These colonies are typically located on the periphery of cities and towns | 82 colonies in Delhi |
| Unauthorized colonies | Unauthorized colonies are unplanned settlements not included in the development area of the Master Plan and/or not marked under the residential land use. Their development generally evades building bylaws and planning norms. These unauthorized colonies lack proper roads, open spaces, sanitation and water facilities and are hubs of illegal and unsafe construction. | 1,800 (69 UCs inhabited by affluent section + 1,731 UCs inhabited by non-affluent section) colonies in Delhi with a total population of 40 lakh. |
| Notified slums | A slum that has been officially recognized by the government is called a notified slum. This implies that the government is aware of the slum and is accountable for providing basic services to the individuals residing there. (CPR, 2014) | 2,423 notified slums with a population of approximately 2 million |
| Urban village | Urban villages in India are dense, mixed-use neighborhoods that have evolved organically over time. They are typically characterized by a mix of housing, businesses, and public spaces. | 135 urban villages |

## Table 3: Distribution of unplanned dwelling units and population

| (1) | (2) | (3) |
|---|---|---|
| Unauthorized colonies | Colonies 1,797<br>Population 40 lakh | Illegal colonies in violation of Master Plans, no clear land title |
| Jhuggi basti | JJ basti 755 (dwelling units required about 0.3 million); population 1.7 million | Encroached on public land<br>State government: 30% Central government: 70% |
| Resettlement colonies | Colonies 82 (45 + 37); plots 267,859; population not specified | Incorporated within the expanded city with good shelter consolidation without adequate services |

Source: https://delhiplanning.delhi.gov.in/sites/default/files/Planning/chapter_14_0.pdf

**Graph 1: Percentage of unplanned settlements in Delhi**




## House ownership

According to the 2011 census, almost 68 per cent of households in Delhi have their own houses. The distribution of owned houses varies by district.

Northeast district of Delhi has the most owned houses, i.e. 75.3 per cent; Northwest Delhi has 72.5 per cent, while Southwest Delhi has the most rented houses, i.e. 38 per cent.

Resettlement colonies also do not have adequate infrastructure of water supply and sanitation.

**Table 4: District-wise house ownership**

| District | Ownership status | |
|---|---|---|
| | Owned house | Rented house |
| NCT of Delhi | 68.2 | 28.2 |
| Northwest | 72.5 | 24.1 |
| North | 69.2 | 26.4 |
| Northeast | 75.3 | 23.3 |
| East | 68.3 | 28.6 |
| New Delhi | 13 | 56.6 |
| Central | 70.7 | 24.7 |
| West | 73.1 | 23.4 |
| Southwest | 58.1 | 38 |
| South | 63.5 | 32.8 |

Source: Economic Survey of Delhi 2022–23. Census of India. 2011

Chapter 3

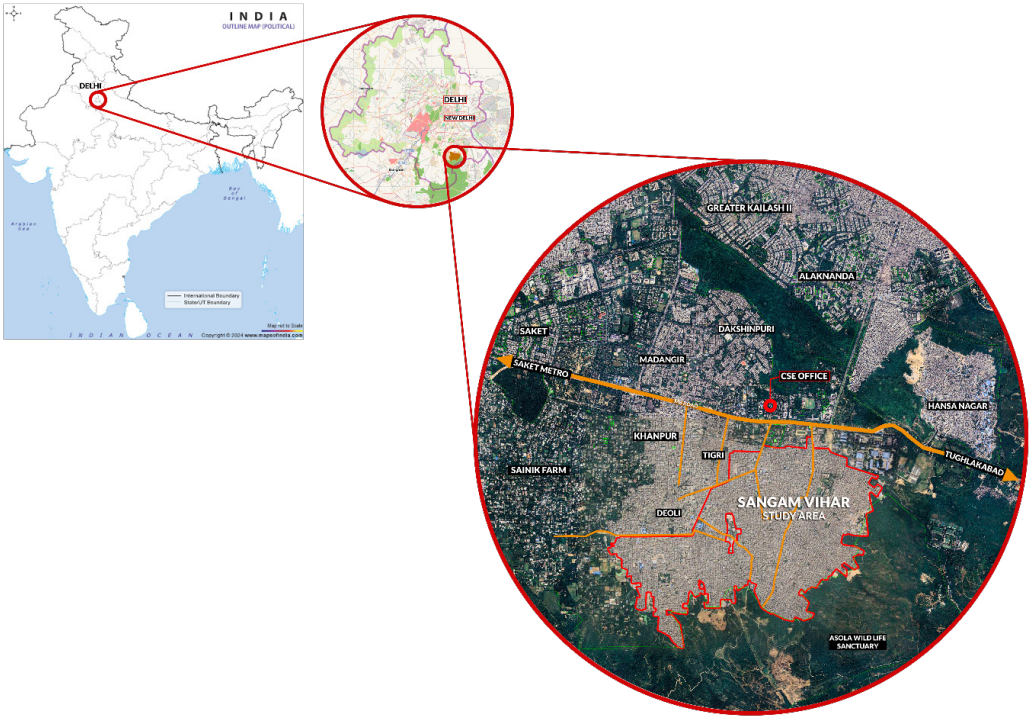
# Introduction to Sangam Vihar

Sangam Vihar is located on the outer edges of the Southeast district of Delhi. Since it is an unplanned settlement, and its legal status is that of an 'unauthorized' colony. Sangam Vihar has other unauthorized colonies of Sainik Farms, a posh upper-class colony and also other working-class unauthorized colonies of Khanpur. It is bound by the Mehrauli-Badarpur (MB) Road on the north and Asola Wildlife Sanctuary on the east and southeast.

Since it is an unauthorized colony, there is no formal colony boundaries other than the electoral wards and the block-wise boundaries by SDMC and DDA. For the purpose of this study, we have taken a residential area comprising 5 sq. km (or approx. 500 hectares), consisting of 13 blocks.

As per the primary survey conducted by CSE, the total population of Sangam Vihar is approximately 1 million. Only a census of all properties can yield data on the number of families. CSE's primary survey considered a property-wise

**Map 1: Location map of Sangam Vihar**




Source: CSE

assessment. Each property can have more than one floor and more than one family. Each property/dwelling unit is estimated to have six to twelve people residing in it (varying with each block). The density of the settlement has increased substantially over the years.

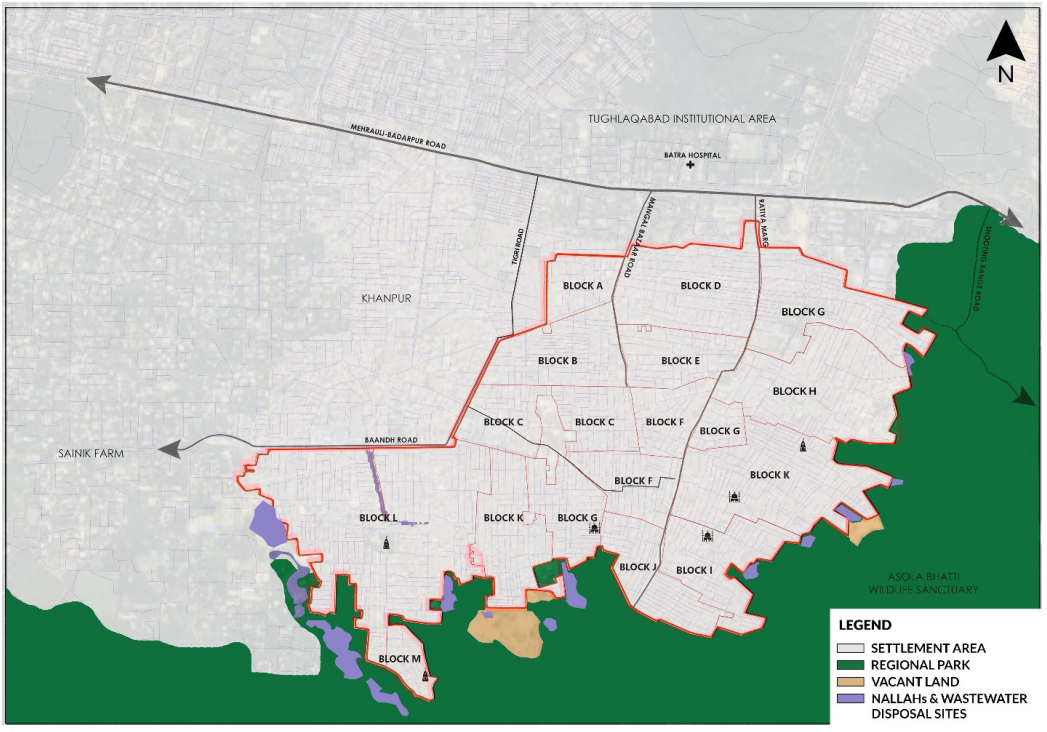
The majority of the population (80 per cent) residing here is Hindu, followed by Muslims (16 per cent), Sikhs (3 per cent) and very few having other religious beliefs.

The 13 blocks of Sangam Vihar, the area of this study, have only two entry points—two main roads, Ratiya Marg and Mangal Bazaar Road—that run north to south from the Mehrauli-Badarpur Road. It is on these roads that all the retrofitting solutions of sewer and water lines are being done. It can take an hour to go from any location in Sangam Vihar to the major Mehrauli-Badarpur route during rush hour due to the severe traffic. Sangam Vihar does not have any public transport, and the nearest bus stops are at the intersections of these two major roads. To get around the settlement, residents use bicycles, cycle rickshaws, motorbikes, scooters, and auto rickshaws.

**Table 5: Block-wise population of Sangam Vihar**

| Block | Total number of households | Population |
|---|---|---|
| Block A | 2,840 | 17,040 |
| Block B | 5,184 | 31,104 |
| Block C | 10,880 | 62,280 |
| Block D | 7,884 | 47,304 |
| Block E | 3,834 | 46,008 |
| Block F | 5,218 | 62,616 |
| Block G | 14,482 | 86,892 |
| Block H | 10,860 | 65,160 |
| Block I | 5,488 | 65,856 |
| Block J | 4,760 | 28,560 |
| Block K | 19,900 | 157,608 |
| Block L | 27,588 | 331,056 |
| Block M | 1,916 | 22,992 |
| | **120,834** | **1,024,476** |

**Map 2: Map showing all the blocks of Sangam Vihar**




Source: Map developed by CSE based on the block boundaries found from DDA and SDMC website

## EVOLUTION

Sangam Vihar is located on hilly terrain. While it was initially a forest, people from Uttar Pradesh, Haryana, Bihar and Rajasthan migrated here and practiced agriculture by clearing out forest. Later they made plots of those agriculture land and sold it as a residential unit. The settlement sits largely on agricultural land that originally belonged to villages of Tigri, Deoli, Khanpur and Tughlakabad.[22] Although Sangam Vihar came into existence in 1979, its evolution can be traced to before Independence (to approximately 80 years ago).

The first Delhi Master Plan (1962) shows Sangam Vihar as a forested area with a small habitation (Deoli village). Early settlers of Sangam Vihar were labourers who arrived in Delhi from Uttar Pradesh, Haryana, Bihar and Rajasthan.[23]

These workers moved to Delhi to Okhla Industrial Areas for construction work during the Asian Games (1982) for which they required affordable housing. Sangam Vihar is now home to migrants from all across India, but the majority of migrants are from Uttarakhand, Uttar Pradesh, and Bihar.[24]

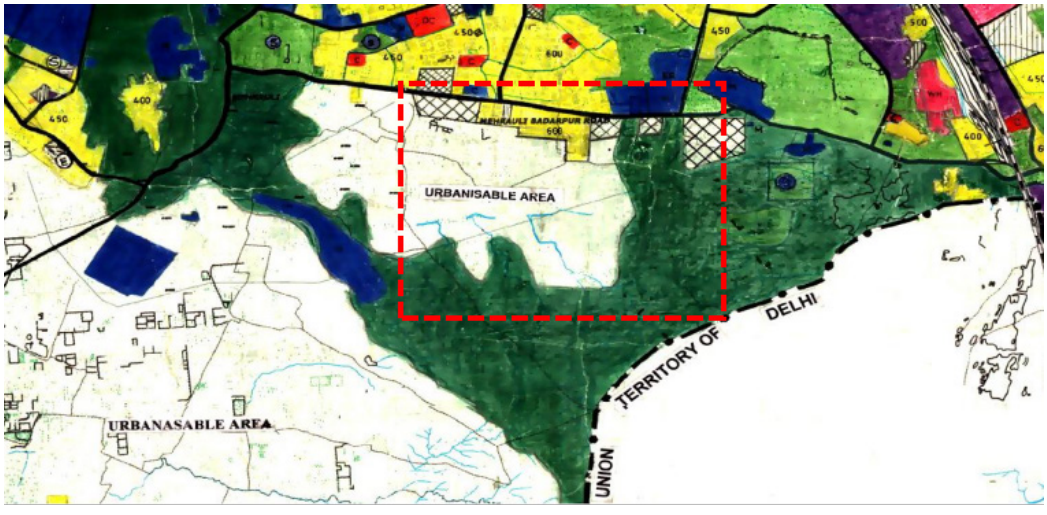
In the Master Plan 2021, Sangam Vihar colony was not demarcated under any land use; it had been shown **as urbanizable area,** which indicates that the area was available for development. However, as per the Zonal Plan, Sangam Vihar fell under residential-designated land use.

In the Master Plan Delhi 2041, Sangam Vihar colony has been demarcated as an **unauthorized colony.** It can be seen in the above map that one-third of the area of the Sangam Vihar has been built on forestland.

Regularized certificates have been provisionally distributed to the following blocks of the Sangam Vihar unauthorized colonies: A block, B block (including B1), C block (including part 1 and 2), E block, F block (including F1, F2 and F3), G2 block, I block, J block (including J1, J2 and J3), K block (including K1 and K2), L block (including L1 and Church Colony) and M block (including M1 and M2).

**Map 3: Master Plan Delhi 1962**

**Map 4: Master Plan Delhi 2021**



**Map 5: Master Plan Delhi 2041**


## CONSTITUENCIES

There are three constituencies in the entire area, namely Deoli, Sangam Vihar and Ambedkar Nagar. The population of each of constituency as per Electoral Commission 2020 data can be seen in the below table along with the area coverage of each constituency. Sangam Vihar has been a parliamentary constituency since 2008 since its present boundaries came into existence due to the Delimitation Commission of India constituted in 2002.

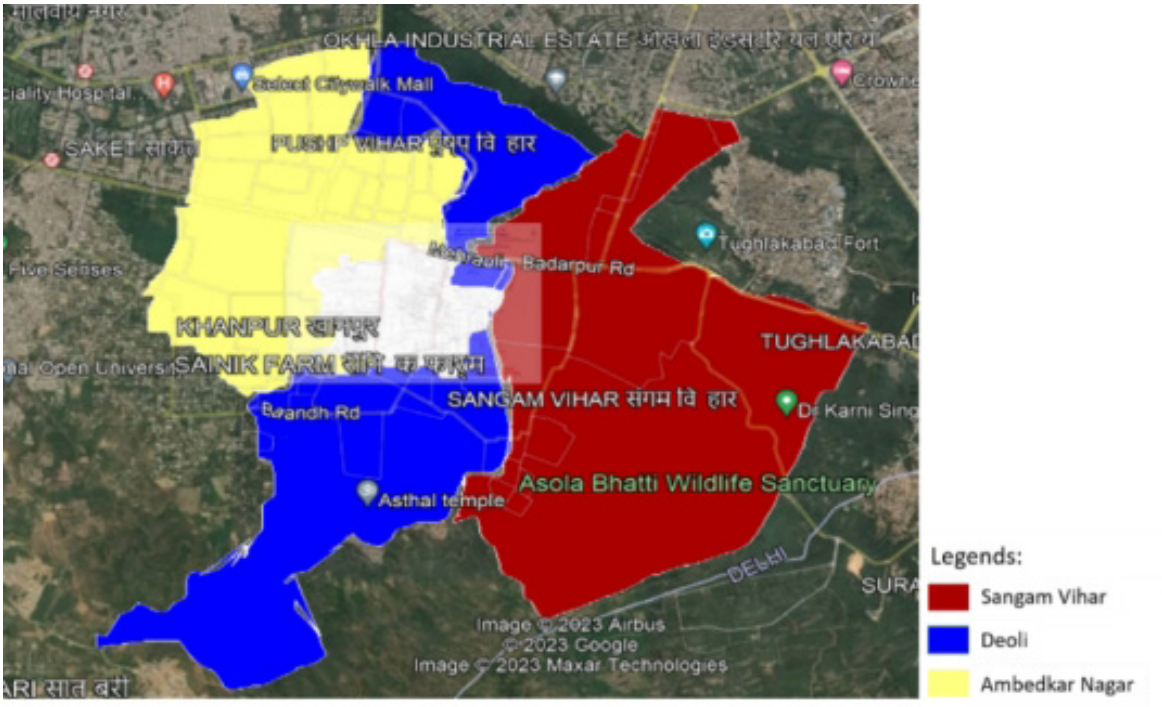
As per Table 7, the total voting population residing in the entire area (see Map 6) the population in the yellow + blue + red portions is approximately 8.5 lakhs. Out of the total area of 22.5 sq. km (including the area of all three constituencies) the area of Sangam Vihar (the study area) is only 5 sq. km. This area was chosen for the study because it has an ongoing sewer line construction by Delhi Jal Board and therefore we wanted to understand the water supply, sanitation and storm water management in this defined unit area and population.

**Table 7: Population of each of constituency of Sangam Vihar (as per Electoral Commission 2020)**

| S. no. | Constituency | Voters (as of May 20, 2020) | Constituency area* |
|---|---|---|---|
| 1. | Sangam Vihar | 260,446 | 9.5 sq. km (perimeter: 16.9 km) |
| 2. | Deoli | 346,844 | ~ 7.2 sq km (perimeter: ~25.6 km) |
| 3. | Ambedkar Nagar | 238,979 | ~ 5.85 sq. km (perimeter: 12.3 km) |
| | TOTAL | 8,46,269 | 22.5 sq. km |

* calculated from Google Earth by overlapping maps

**Map 6: Map showing the constituencies in Sangam Vihar and Delhi Jal Board sewerage project**




## SOCIOECONOMIC PROFILE

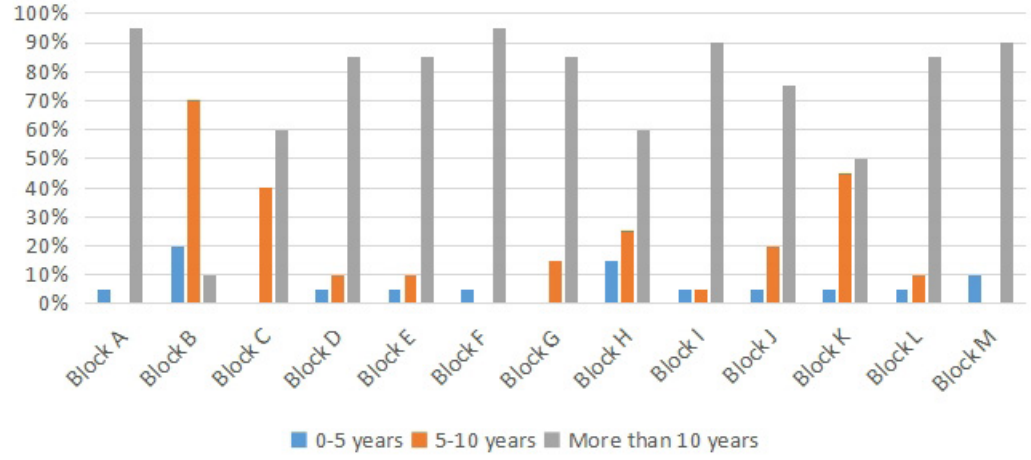
Each of the 13 blocks of Sangam Vihar have a large majority of its residents who have been living there for more than ten years (see *Graph 2*). In blocks B and K, the residential population has substantially increased in recent years. This is perhaps based on access to the main road in some blocks.

The average size of a dwelling is less than 50 sq. m. The settlement is dense, with many small dwellings but with a population per dwelling being less than five in most instances. Blocks at the very end of Sangam Vihar, farthest from the main road—blocks M and L—have a relatively higher number of residents per property/ dwelling block (see *Graph 3*).

The dense unplanned settlement has all the characteristics of a city within a city. There are a large number of informal workers and daily wage workers, petty businesses, grocery and other work (see *Graph 4*).

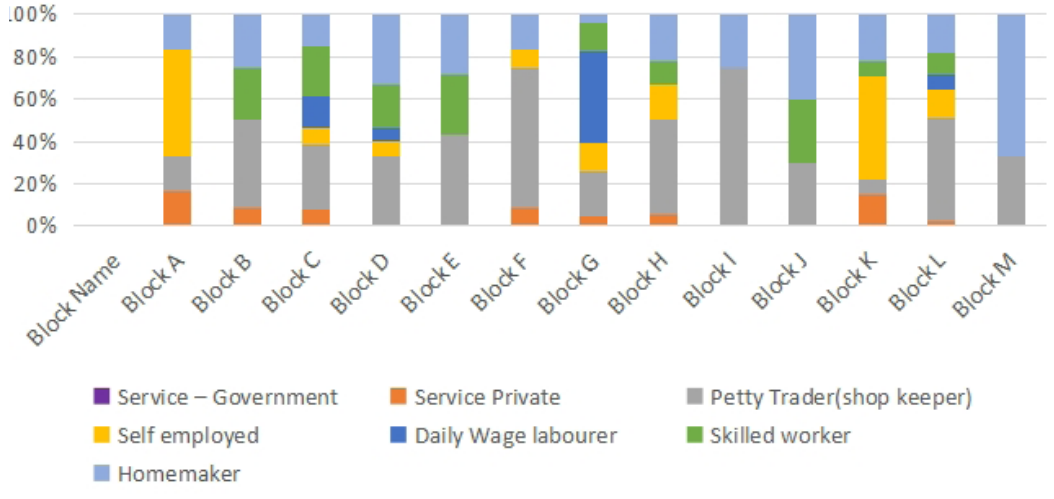
Sangam Vihar represents a working class or a lower-middle-class settlement. Half the respondents reported earning less than Rs 20,000 per month (see *Graph 5*). Given that the majority are in informal work, an assessment of incomes is difficult. Large conspicuous consumption and stores selling expensive consumer goods are not visible in the colony, nor is expensive house construction.

## Graph 2: Duration of residence in Sangam Vihar

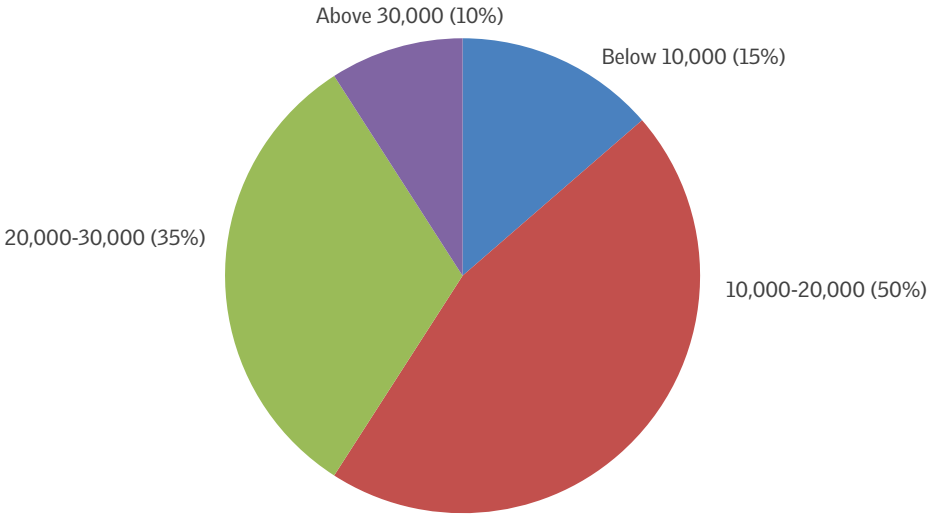



## Graph 3: Number of members in one dwelling unit


## Graph 4: Occupation of residents in Sangam Vihar



**Graph 5: Income levels of residents in Sangam Vihar**

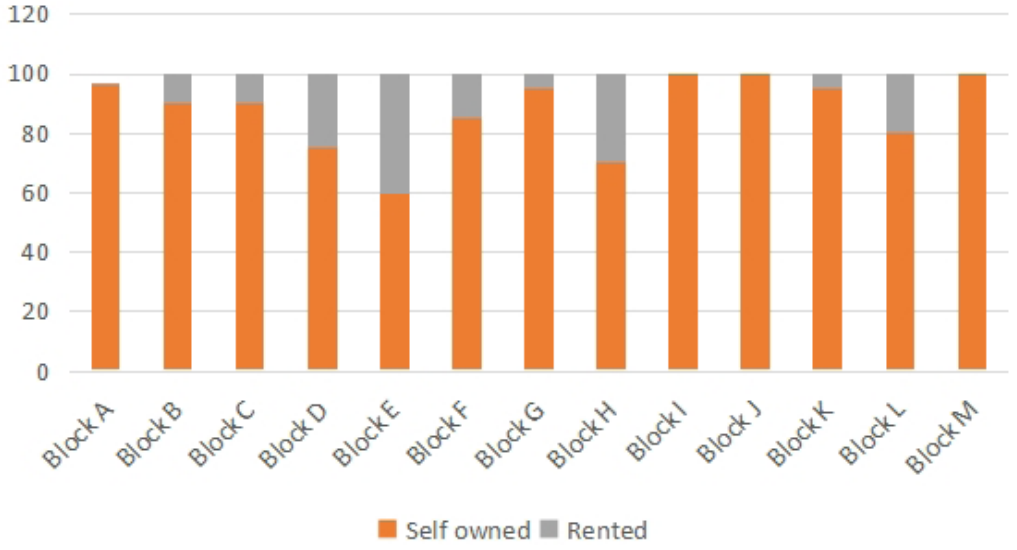



## HOUSING TYPOLOGY

The majority of the houses are self-owned by the residents but they are unauthorized constructions. Only a small fraction of the houses are rented, mostly by migrant workers.

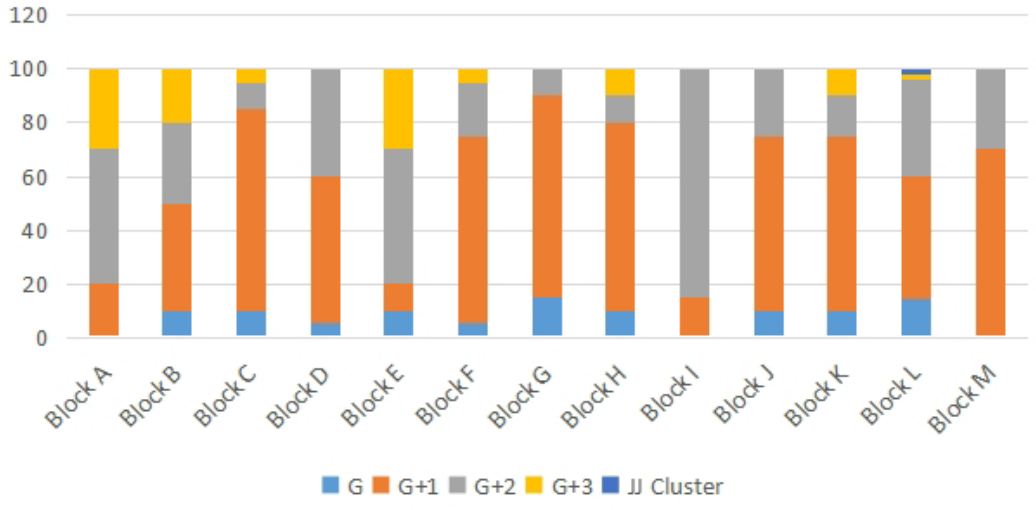
The majority of housing in Sangam Vihar is G+1 height (ground plus one floor), followed by housing in the G+2 category, while very few are single storey (G) or have a G+3 construction (see *Graph 7*). This suggests a prevailing trend of moderate housing patterns with a few variations in the area.

**Graph 6: Ownership type of buildings in Sangam Vihar**



*Properties with varying heights in Sangam Vihar*

**Graph 7: Height of buildings in Sangam Vihar**

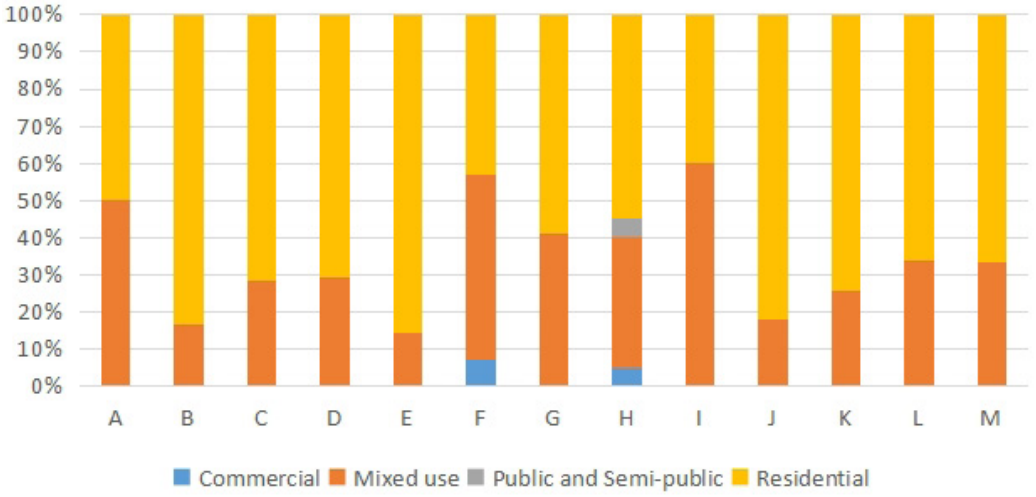



Mixed-use purpose housing dominates the landscape. General stores, iron and wood crafts, eateries, small manufacturing, boutiques, and more form the ground floor or more in most properties.

Residents of Sangam Vihar believe that despite being an unauthorized colony, they do not face the risk of eviction.

This sense of security is rooted in the fact that Sangam Vihar has been established for over 40 years, is a million-plus strong, and there is the affluent Sainik Farms unauthorized colony sharing a border with them.

**Graph 8: Type of properties in Sangam Vihar**




Lack of recreational areas: There are no open areas or playgrounds for children, who mostly play on the streets.


*Children playing on dumping grounds*

Different blocks of Sangam Vihar have specific places where people can gather during public or religious occasions. A common feature, however, is that most blocks utilize religious places and open lanes for these types of occasions. Few parts of K block are the only places with sufficient space for people to celebrate festivals and other occasions. Ram Leela Maidan and Pracheen Chhat Ghat Parisar are the designated places for such events.

## People's perspective

*The biggest problem the community living here faces*

- Water supply is the first major issue. For the majority of the residents, the primary water sources are borewells and bottled water.
- Other issues include waterlogging, inadequate roads and irregular waste collection.
- Theft, drug and alcohol consumption is prevalent in blocks M, K, K2 and I, which are near forest areas.

### People belonging to the same caste or religion tend to live together

All blocks except for M, K, L and I responded that people of all castes and religions live together in their respective neighborhoods.

- In K block, the respondents claimed that individuals with similar religious beliefs, socioeconomic backgrounds, etc. tend to reside in the same neighborhoods. For instance, the Muslim community resides near the Rehmaniya Masjid, the Gupta community occupies a separate lane, and the Sikh community lives close to the Ram Leela Maidan.
- In L block, the respondents indicated that individuals from the same village tend to reside in the same area.
- The respondents in I Block stated that people tend to be more at ease with those who share similar mindsets and religious beliefs. While the majority of residents near the Khuda Masjid are Muslims, this does not imply that individuals from other faiths are excluded from residing in the vicinity.

## Delhi Jal Board Sewerage Project

In March 2022, Delhi Jal Board (DJB) announced a plan to lay 575 km of sewer lines in various unauthorized colonies of Delhi. Out of this, a 25.5 km-long sewer line was proposed for 11 or 12 blocks of Sangam Vihar. This was named Phase 1 (see *Map 2*: DJB sewer line project Phase 1 [white boundary]).

The dimensions of Phase 1 of the project is 1.41 sq. km. Just one block of Sangam Vihar (the study area) lies in the Phase 1 of this project.

**Map 2: DJB sewer line project Phase 1 (white boundary)**


Source: CSE

Chapter 4

# Water

## URBANIZATION AND WATER—GLOBAL SCENARIO

Urban population worldwide increased from 0.8 billion (29.6 per cent) to 4.4 billion (56.2 per cent) between 1950 and 2020, and is expected to reach 6.7 billion (68.4 per cent) by 2050.[25] Over the next 30 years, the demand for urban industrial and domestic water is anticipated to increase by 50–80 per cent as a result of urbanization, population growth and socioeconomic development.[26] The demand for water across the globe is continuously rising. Water use has been increasing worldwide over the past four decades by around 1 per cent per year.[27] Based on the patterns of socioeconomic development, shifting consumption habits and population growth, it is predicted to continue to rise at a similar rate through 2050.

## SOUTH ASIA SCENARIO

It is estimated that 80 per cent of the global population facing water stress lives in Asia, specifically in northeast China, India and Pakistan.[28] About 933 million (32.5 per cent) urban dwellers worldwide lived in water-scarce regions in 2016. The majority of urban population facing water scarcity till 2016 lived in India (222 million) and China (159 million). The rise in India's urban population in water-scarce areas will be substantially higher than that of other nations, projected to rise from 222 million (in 2016) to 550 million in 2050, comprising 26.7 per cent of the global urban population experiencing water scarcity.[29]

## URBAN INDIA SCENARIO

As per the 2011 Census, there are 1.3 billion inhabitants in India, of which 91 million people (6 per cent) lack access to clean water while 600 million (46 per cent) experience high to severe water stress.

As per the Central Public Health and Environmental Engineering Organisation (CPHEEO), norms for urban water supply in India is 150 litre per capita per day (lpcd) for metro cities (with full sewerage systems coverage), 135 lpcd for non-metro towns (with full sewerage systems coverage), 70 lpcd for towns and cities (without sewerage systems), and 40 lpcd for the population who rely on public standpipes of drinking water supply. On average, the duration of water supply duration in Indian cities is one to six hours.[30] No city yet provides a regular uninterrupted water supply, even if the per capita availability as stated is 90–120 litres per day.[31]

Service-level benchmarks for water and sanitation have been prescribed for cities.

**Table 8: Performance indicators for water supply in India**

| S. no. | Indicator | Benchmark (CPHEEO, MoHUA) |
|---|---|---|
| 1. | Coverage of water supply connections | 100% |
| 2. | Per capita supply of water | 135 lpcd (cities) |
| 3. | Extent of metering of water connections | 100% |
| 4. | Extent of non-revenue water (NRW) | 20% |
| 5. | Continuity of water supply | 24 hours |
| 6. | Quality of water supplied | 100% |
| 7. | Efficiency in redressal of customer complaints | 80% |
| 8. | Cost recovery in water supply services | 100% |
| 9. | Efficiency in collection of water supply-related charges | 90% |

Source: https://cpheeo.gov.in/upload/uploadfiles/files/Handbook.pdf

Delhi's data deficiency related to the urban water sector is evident across various fronts. It lacks data for its service-level benchmarks (SLBs), Performance Assessment System (PAS) and Composite Water Management Index (CWMI), hindering effective evaluation and water management.

### Scenario in uplanned settlements in India

Unplanned settlements include both unauthorized settlements that comprise lower-income (e.g. Sangam Vihar) and high-income settlements (e.g. Sainik Farm). These are not covered under the government classification of slum settlements. Unfortunately we don't have disaggregated data for unplanned settlements, only for slums. As per the National Sample Survey (NSS) 69th Round (2012), 94.1 per cent households living in slum areas had improved sources of drinking water. The proportion was more than 75 per cent in almost all the states, with some notable exceptions like Delhi (53.4 per cent) and Jharkhand (67.6 per cent).[32]

Lower-income households spend a significant part of their already limited income on water purchased from private or publicly contracted suppliers.[33] Unclean drinking water causes diarrheal illness in children living in unplanned settlements. Contaminated water is responsible for 15.9 lakh deaths each year, mostly among children under the age of five.[34]

An estimated 65 million people live in India's 33,510 urban slums.[35] India's poor ultimately pay more than the middle class does for basic water services because of forced bribes and being disproportionately affected by direct taxes on consumption.

## DELHI SCENARIO

As per the Master Plan of Delhi, Delhi is a water-scarce city. There are visible accounts of decline in groundwater levels, heavy pollution in the Yamuna River

and instances of frequent waterlogging across Delhi. Delhi is predominantly dependent upon external sources for freshwater, and the continuous increase in future demand may outperform the supply.

The water supply and distribution in Delhi is largely managed by the Delhi Jal Board (DJB). In areas under the New Delhi Municipal Council (NDMC) and Delhi Cantonment, DJB supplies water in bulk while NDMC and Delhi Cantonment manage the distribution. In areas not covered by the distribution system, DJB provides water through tanker services.

The Delhi Master Plan 2021 commits to a 60 gallons per capita a day (GPCD). **The present water demand is estimated to be 1,380 MGD as per the projected population of 23 million for 2021.** The Master Plan for 2041 has reduced the per capita water supply from 60 to 50 GPCD and brought down the requirement to 1,455 MGD water supply target for 2041 (see *Annexure 3* for water supply capacity).

National missions, such as the Swachh Bharat Mission-Urban (SBM-U 2.0) and Atal Mission for Rejuvenation and Urban Transformation (AMRUT 2.0) also lay emphasis on the reuse of wastewater and state that cities should meet 20 per cent of their water demand through recycled water.

**Table 9: The estimated water demand for Delhi**

| Year | Population (in millions) | Demand criteria* (GPCD) | Availability from all sources (MGD) | Total demand (MGD) | Deficit (MGD) |
|---|---|---|---|---|---|
| 2020 | 19 | 60 | 935 | 1,140 | 141 |
| 2021 | | 60 | 935 | 1,380: 23 million pop. (MPD 2041)<br>1,260: 21 million pop. (ES 2022–23) | - |
| 2031 | 29.1 | 60 | - | 1,746 | - |
| 2041 | 29.1 | 50 | - | 1,455 | - |

* Includes domestic, commercial, industrial demand and that for fire services, etc.
Source: MPD 2041 and Economic Survey of Delhi 2022–23

**Table 10: Details of water requirement norms—Delhi Jal Board**

| S. no. | Details | Requirement of water |
|---|---|---|
| 1. | Domestic | 172 LPCD |
| 2. | Industrial, commercial and comunity requirement based on 45,000 litre per hectare per day | 47 LPCD |
| 3. | Fire protection based on 1% of the total demand | 3 LPCD |
| 4. | Floating population and special uses like hotels and embassies | 52 LPCD |
| Total | | 274 LPCD (60 GPCD) |

Source: Economic survey of Delhi 2022–23

## Sources of water supply in Delhi

As per DJB, about 93 per cent households of Delhi now have access to piped water supply. The quantity and quality of this water supply varies. Water is supplied to a population of about 20 million in Delhi through an existing water supply network comprising 15,383-km long pipelines and more than 117 underground reservoirs (UGRs). As per the Economic Survey of Delhi 2022–23, the sources of water supply for Delhi are:

**A.** Delhi Jal Board receives raw water from Haryana through CLC, DSB canals and the Yamuna River course as per detailed below:

- Link canals: 719 cusec (387 MGD) releases at Munak/683 (368 MGD) cusec receipt at Delhi.
- Delhi sub-branch: 330 cusec at Delhi
- Yamuna River course 120 cusec

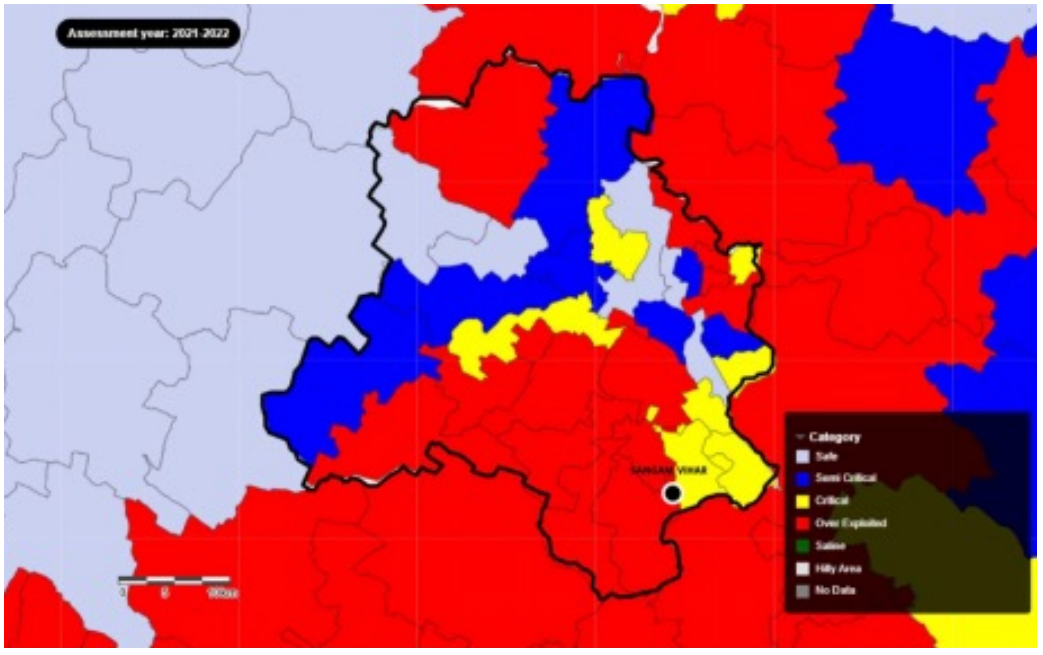
Total = 1,133 cusec (612.5 MGD)

**B.** Ganga water is supplied through Ganga Canal/Murad Nagar Regulator for Bhagirathi (200 cusec) and Sonia Vihar (270 cusec) water treatment plants.
Total = 470 cusec (254.08 MGD)

**C.** 117 MGD groundwater is supplied through Ranney wells/tube wells installed in the Yamuna Flood Plains and other areas at Delhi.

A total of 397 new water tankers with stainless steel containers fitted with GPS have been engaged in improving the water tanker supply delivery system in the

### Map 7: Groundwater extraction situation in Delhi, 2022




Source: https://ingres.iith.ac.in/

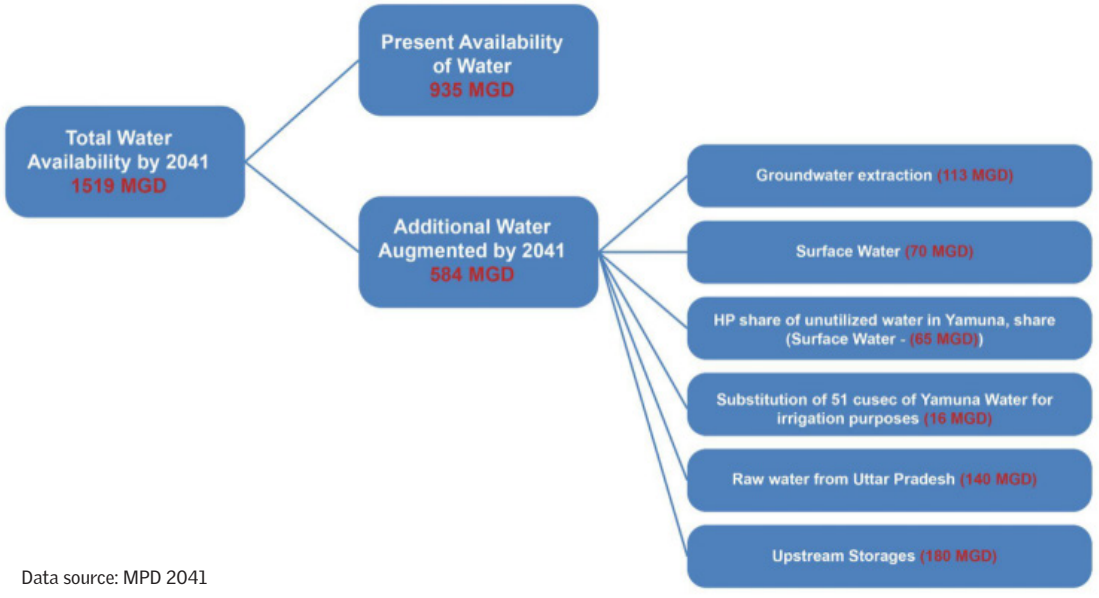
city. Apart from approximately 596 MS (mild steel) hired tankers (during peak summer), 250 newly purchased SS (stainless steel) tankers are being added to the existing fleet to supplement water supply in water-deficit areas. As per the Economic Survey of Delhi 2022–23, the installed capacity of DJB has been augmented by 13 per cent during the last 10 years. The capacity, which was 836 MGD in 2013, has been increased to 921 in 2021. This has further increased to 943 MGD in 2022.

Map 7 shows the extent of water extraction in Delhi, highlighting the most critical areas in red. As per Central Ground Water Board, 44 per cent of area in Delhi falls in the overexploited category, which includes South Delhi along with few parts of North Delhi. The study area, Sangam Vihar, also lies in the overexploited category. Overall, the total current annual groundwater extraction in Delhi is 0.36 billion cubic metre (bcm) and stage of groundwater extraction is 98.16 per cent.

A twin-pronged strategy for water supply in the future focuses on the augmentation of both groundwater and surface water resources, while also emphasizing the need for increased wastewater treatment and reuse, rainwater harvesting initiatives, restoration of waterbodies, etc.

As indicated from the chart above, the additional water demand for Delhi will be met from various sources according to the Water Augmentation Plan 2041. Taking the present water availability is 935 MGD, additional water augmented by 2041 is equal to 584 MGD. The total water availability by 2041 will be 1519 MGD,[36] taking in consideration a population of 30 million (3 crore).

**Figure 2: Water augmentation plan for Delhi, 2041**




Data source: MPD 2041

### Water losses in Delhi

Delhi has a network of about 15,383 km of water supply mains of which a significant portion is old and prone to higher leakage losses. Normally, water losses are calculated by water billed or consumed subtracted from the water produced, called non-revenue water (NRW). NRW does not only include water distribution losses but also water supplied to slums and unauthorized colonies that is not billed for.

According to Delhi Jal Board estimates, NRW is about 58 per cent of the total water supplied. This figure is quite high compared to 10–20 per cent in the developing countries.

### Water tariff in Delhi

The tariff is based on the principle of 'use more pay more'. Present water tariff policy acts as a deterrent for consumers consuming excessive water or having wastage of water. Existing water tariff has two parts: one is the service charge and the other is the volumetric water consumption charge, applicable w.e.f December 1, 2004 and April 1, 2005 respectively.

The Delhi government ensured free lifeline water of up to 20 kilolitres to every household that has a metered water connection. Around 21.39 lakh consumers have benefitted under this scheme since its inception.

## SCENARIO IN UNPLANNED SETTLEMENTS OF DELHI

Piped supplies in unplanned settlements are made available either through individual household connections or public hydrants. Tankers (portable tankers) are also used to supply water by the public water utility Delhi Jal Board (DJB). Water supplied by the DJB is considered safe under normal circumstances, but contamination is common where joints/valves lie close to sewers. Problems also arise in areas where water pipes have become old and corroded. A large number of inhabitants living in slums and unauthorized colonies and squatters depend on shallow hand-pump water, which in most cases is contaminated and thus unfit for drinking.[37]

Delhi is dotted by different types of settlements, which differ from each other in legality, tenure and formality. As per a report published in 2001 by the Delhi Urban Environment and Infrastructure Improvement Project (DUEIIP), only one typology is described as 'planned' settlement and hosted just 23.7 per cent of the population in 2001. The Delhi Jal Board provides water in bulk to planned areas such as NDMC and cantonment areas.[38]

The seven settlement types that lie in the 'unplanned' category host 76.3 per cent of the population in Delhi. The areas that are not provided with regular water supply fall mainly in the category of unplanned settlements such as JJ clusters, slums, unauthorized colonies, regularized unauthorized colonies, JJ resettlement colonies, resettlement colonies, and urban villages.

**Slums and JJ clusters:** Most of the JJ slums depend on tankers for water supply, and since government tankers are mostly incapable of meeting the overall demand for the slums, private water-dealers engage in illegal ways of procuring and supplying water to the slum dwellers.

As per the Delhi government, nearly 44 per cent of the residents of Delhi slums depend on bottled water for drinking purposes, while around 76 per cent of households in the city have piped-water connections.

**Unauthorized colonies:** Unauthorized colonies in Delhi consist of both affluent and non-affluent colonies. Affluent colonies such as Sainik Farms comprise houses with individual borewells while non-affluent unauthorized colonies depend upon community borewells and water tankers for meeting their water requirements.

**Resettlement colonies:** These colonies depend on borewells and water tankers for their daily water needs. Water contamination is a major issue in such areas. For instance, Bhalswa Resettlement Colony faces risks due to groundwater contamination. The study revealed that the groundwater from the hand pumps located in the vicinity of the landfill show increased concentrations of contaminants. The water samples had high levels of TDS, COD as well as specific contaminants such as lead and zinc. Some of the water samples were faecal contaminated.

**Urban villages:** As per DJB, the urban villages have already been provided with water supply. The major source of water provision is water treatment plants. Some areas like South Delhi's Sarita Vihar receives piped water supply from the Sonia Vihar plant.

## RESEARCH QUESTIONS

### Water supply/consumption level

In the absence of data on population and water supplied from formal sources, the first research aim was to get an understanding of per capita water supply in Sangam Vihar.

This required an assessment of population and how much water was being consumed by residents from several sources of supply.

### How is water supplied? Who controls it?

How was the water being supplied, and finding out who controls the water supply was the next challenge, given that water supply is contested and there was a 'water mafia' reported.

**Water quality and pricing/affordability** were assessed through a primary household survey.

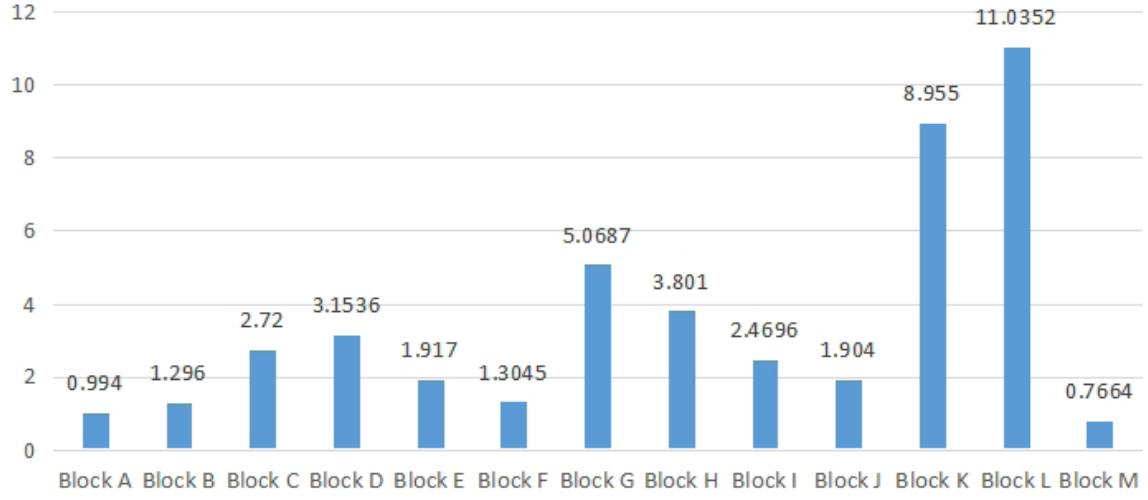
**Meta-analysis of water supply challenges of dense unplanned settlements.** Based on the data generated from the primary household survey, a meta-analysis of water issues was possible. This is done in the section on Conclusions (Chapter 7).

## SCENARIO IN SANGAM VIHAR

The total water consumption in Sangam Vihar is **45,385,000 litre** (**45.39 MLD**) (see *Graph 9*). Water consumption is calculated on the basis of information received from residents, sources of water supplied in the blocks and average monthly spending of households on water purchase for non-potable and potable purposes.

Graph 10 highlights the huge gap between the total water demand and the supply of water available to the residents of Sangam Vihar. Taking 135 lpcd as the

**Graph 9: Total daily water consumption (in MLD)**




**Graph 10: Water consumption and demand in Sangam Vihar (in MLD)**

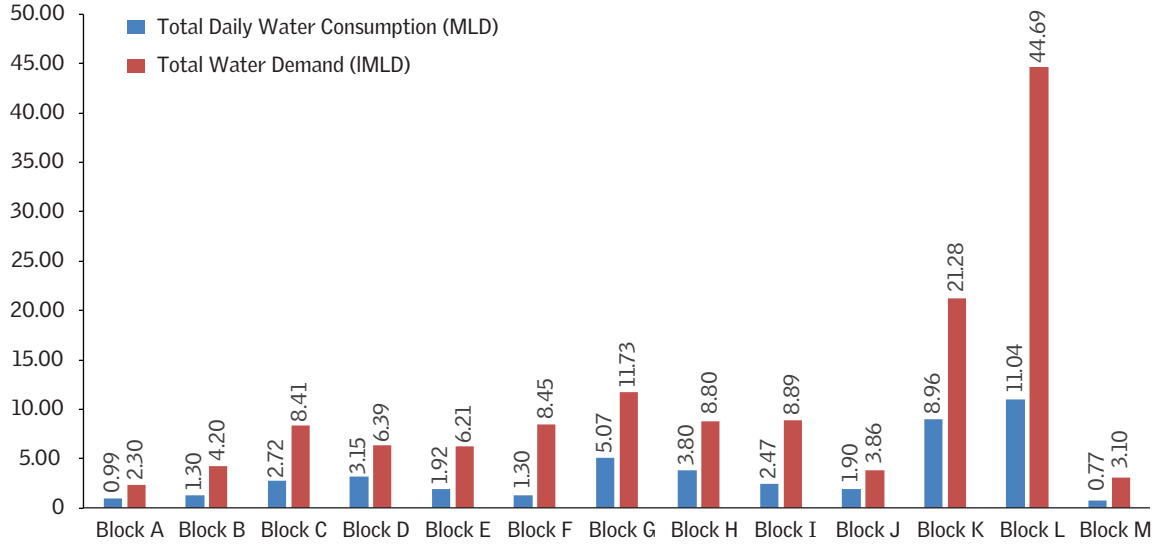


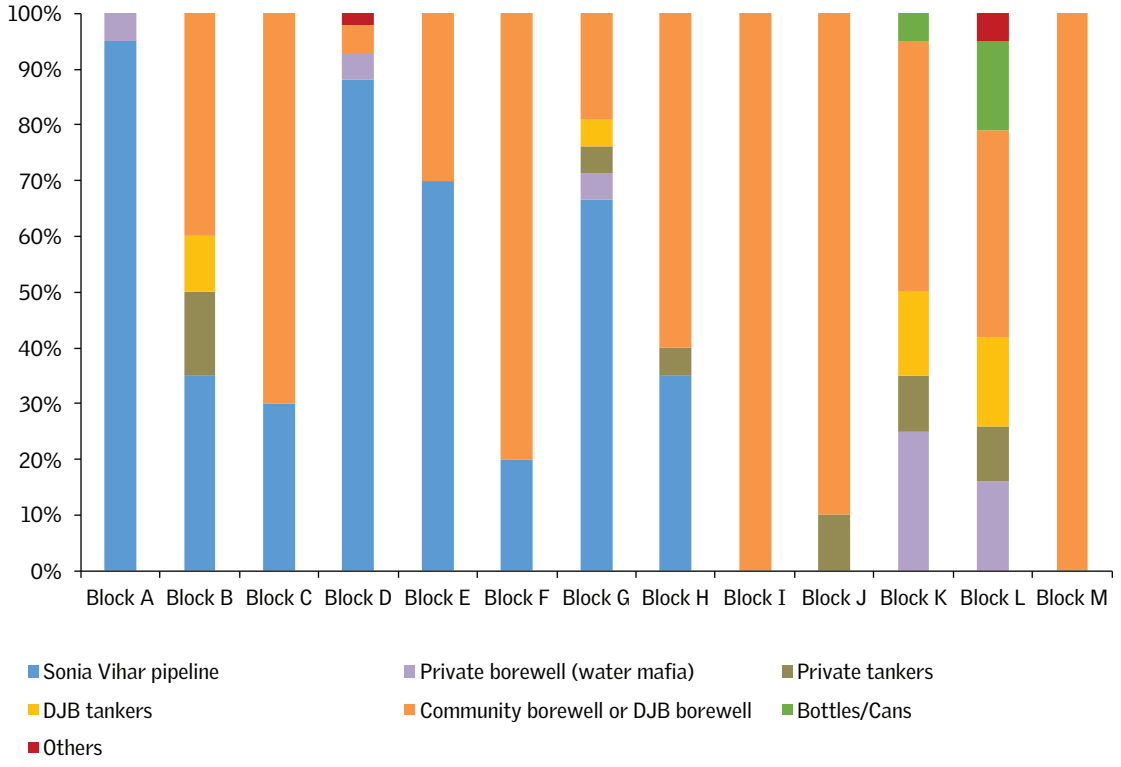
**Table 11: Daily water consumption and water supply gap**

| Block | Total property | Population | Average water consumption per property (lpd) | Water consumption per capita | Total daily water consumption (in MLD) | Total water demand (in MLD) | Gap in water supply (in MLD) |
|---|---|---|---|---|---|---|---|
| Block A | 2,840 | 17,040 | 350 | 58.33 | 0.99 | 2.30 | 1.31 |
| Block B | 5,184 | 31,104 | 250 | 41.67 | 1.30 | 4.20 | 2.90 |
| Block C | 10,880 | 62,280 | 250 | 43.67 | 2.72 | 8.41 | 5.69 |
| Block D | 7,884 | 47,304 | 400 | 66.67 | 3.15 | 6.39 | 3.23 |
| Block E | 3,834 | 46,008 | 500 | 41.67 | 1.92 | 6.21 | 4.29 |
| Block F | 5,218 | 62,616 | 250 | 20.83 | 1.30 | 8.45 | 7.15 |
| Block G | 14,482 | 86,892 | 350 | 58.33 | 5.07 | 11.73 | 6.66 |
| Block H | 10,860 | 65,160 | 350 | 58.33 | 3.80 | 8.80 | 5.00 |
| Block I | 5,488 | 65,856 | 450 | 37.50 | 2.47 | 8.89 | 6.42 |
| Block J | 4,760 | 28,560 | 400 | 66.67 | 1.90 | 3.86 | 1.95 |
| Block K | 19,900 | 157,608 | 450 | 56.82 | 8.96 | 21.28 | 12.32 |
| Block L | 27,588 | 331,056 | 400 | 33.33 | 11.04 | 44.69 | 33.66 |
| Block M | 1,916 | 22,992 | 400 | 33.33 | 0.77 | 3.10 | 2.34 |
| | **120,834** | **1,024,476** | | | **45.39** | **138.30** | **92.92** |

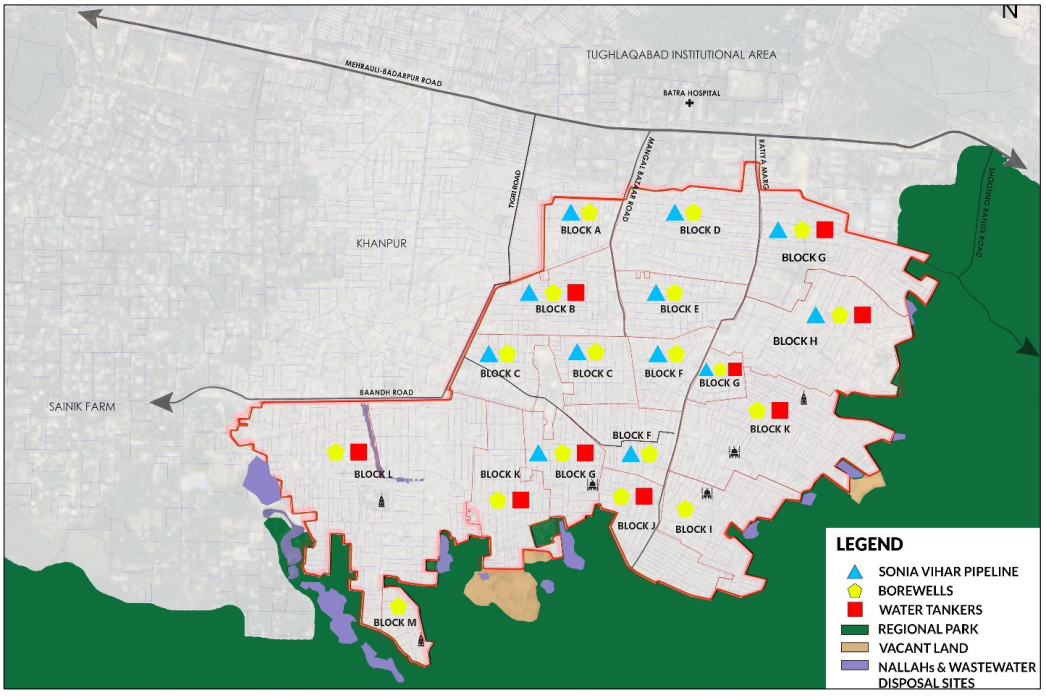
benchmark, the **daily water demand is estimated to be 138.3 MLD**. Therefore, **the total gap is of approximately 92.9 MLD** (see *Table 11*). In larger blocks like block L where the population is high, the gap between the total water demand is more than three times the water available for use.

Even if we take 100 lpcd as a reduced and efficient way of water consumption, the gap will still be 55 MLD. This gap in water supply needs to be urgently augmented, given that the daily water requirements for a large majority of working class residents of Sangam Vihar will be more than what middle-class residents consume, their physical work entailing more bathing and washing requiremnts for water. To meet the extensive water demand, a diverse range of water sources are available in Sangam Vihar, catering to both potable and non-potable usage. Non-potable usage is predominantly met by the Sonia Vihar pipeline (Delhi Jal Board supplies water in this pipeline) and community borewell or DJB borewells (see *Graph 11* and *Map 8*). Blocks that are closer to the main Mehrauli-Badarpur Road (MB) Road, such as blocks A, D, E and few parts of block G, were found to have more than 70 per cent coverage of the Sonia Vihar pipeline for non-potable water usage. The poorest residents of Sangam Vihar reside in the farthest blocks—Blocks I, F, L and M—where water supply is very poor.

## Graph 11: Sources of water supply



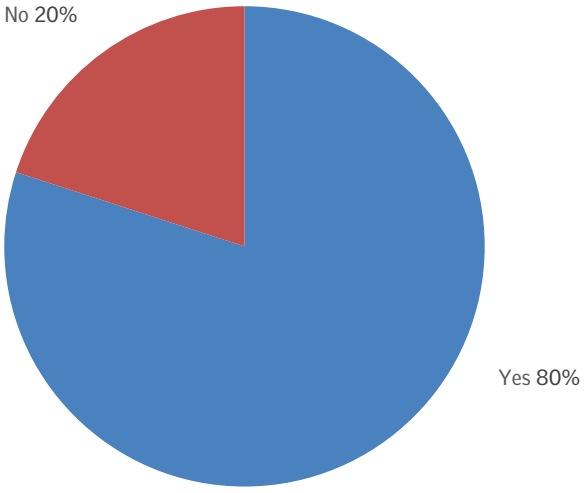

## Map 8: Water supply sources of Sangam Vihar




Source: Primary survey by CSE in 2023


*Varied water supply sources in Sangam Vihar*

**Graph 12: Do residents purchase RO water?**




A substantial majority—more than 80 per cent—of households of Sangam Vihar rely on RO purified water (see *Graph 12*) for potable water, which is typically acquired through daily purchases of 20L bottles and cans from private distributers.

There is inequity in water supply among the residents of 13 blocks. A correlation is observed for economic status of residents, water supplied and potable water purchased. The same blocks (I, F, L and M), which have low water supply, also cannot afford to purchase potable water.

The main sources of water supply during social gatherings are mostly private tankers or DJB tankers, bottles, cans and/or community or DJB borewells. However, residents highlighted that at times bottles or cans they purchase from private players is not RO water but water extracted from the borewell and wrongly labelled as RO water and sold to the people.

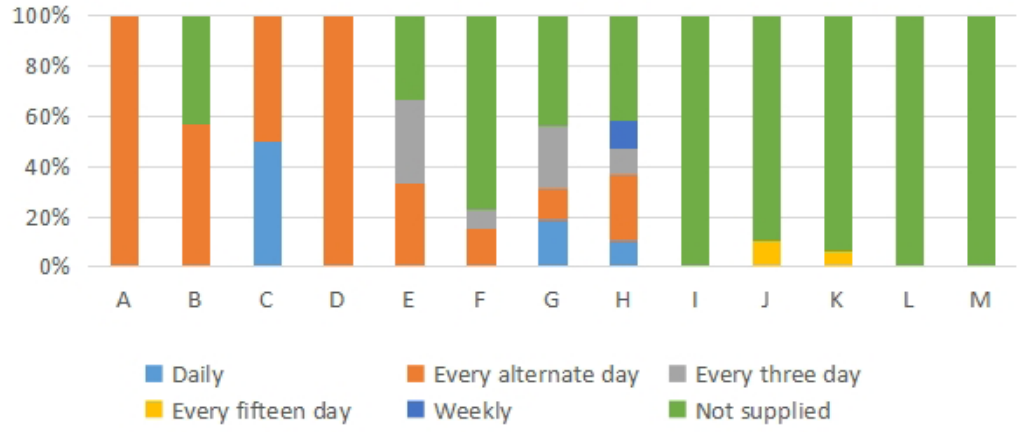
Another resident informed that her family purchases bottled water for drinking but they used borewell water for cooking as it gets boiled while cooking. She did

not see it as a problem as her family had adapted to the taste of the water taste. This is due to the high cost of repurchasing bottles at a regular interval (two to three bottles every alternate day).

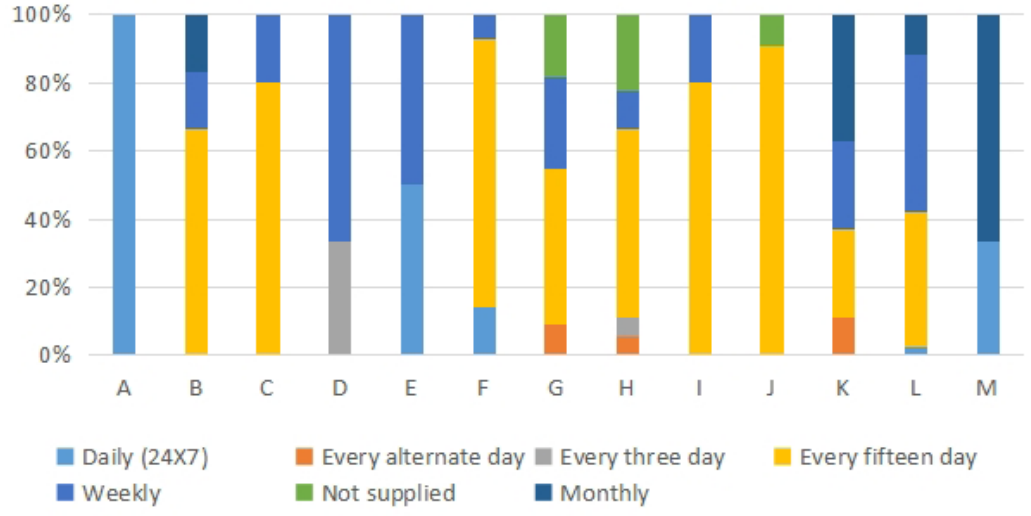
Most of the blocks do not have water pipelines laid. Only a few of the blocks have an operational pipeline (Sonia Vihar pipeline) that supplies water every two to three days to residents. Residents from blocks A and D receive water from Sonia Vihar pipeline, which is supplied every alternate day to them (see *Graph 13*).

However, the water from community borewells is more frequently available to the residents, but this also varies significantly block-wise (see *Graph 14*). For example, in block K, there are areas where the borewell water is available every alternate day, every 15 days, and even on monthly basis.

**Graph 13: How often water is supplied through Sonia Vihar pipeline?**



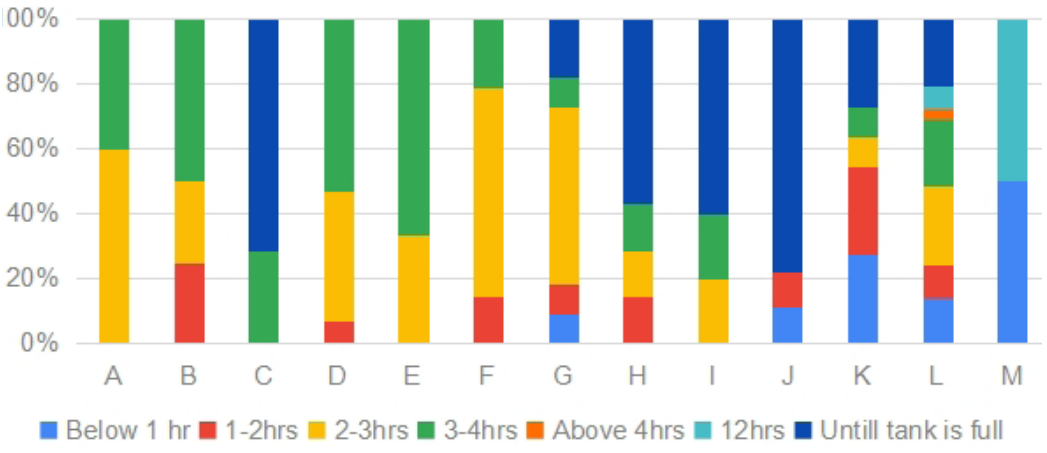

**Graph 14: Frequency of water supplied through borewell**



Power politics over control of borewells in Sangam Vihar defines the 'water mafia' issues of Sangam Vihar. This power and control is exercised over private and public borewells, leaving a large majority of residents at the mercy of high-cost water supply.

Households prefer to store the water due to its infrequent rate of supply. When the water is supplied, residents tend to fill the storage tanks completely so that the water can be used whenever required. This practice is found more in the blocks in southeast Sangam Vihar, namely blocks H, I, J, etc. In blocks A, D, E, water supply is not much of an issue, as residents receive water daily for two to four hours, which they store and use as per their convenience (as informed by residents) (see *Graph 15*).

**Graph 15: Duration of daily water supply: Sonia Vihar pipeline/borewell**

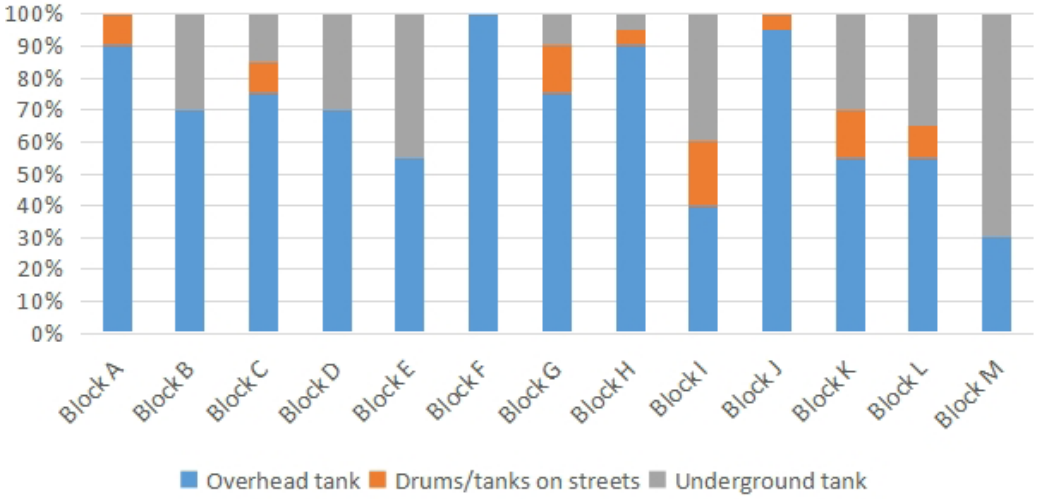



*The residents were asked about their perception on the level of water supplied in Sangam Vihar. The majority responded that they are not very satisfied with the volume of water supplied, which means the water supplied is very little and people are dependent on purchased water to meet their daily needs.*

The data in Graph 16 indicates that approximately 80 per cent of the households use overhead tanks for water storage, while others use underground tanks, highlighting a prevalent preference for overhead tanks within the community. People even store water in drums in a few blocks, indicating that the water is not easily available and they need to store it. Use of drums was more prominent in blocks G, K, I and L. Underground tanks more in the scarcity hit Block M.

In blocks facing water shortages, it was found that the capacity of the water storage tanks was as high as 18,000 litre. The tanks in these blocks are mostly of higher capacity, i.e. of more than 2,000 litre.

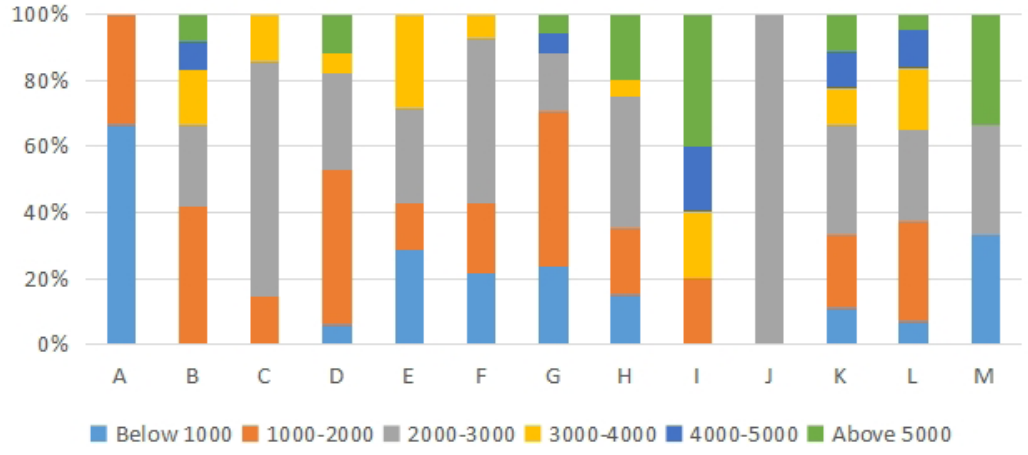
**Graph 16: Type of water storage**



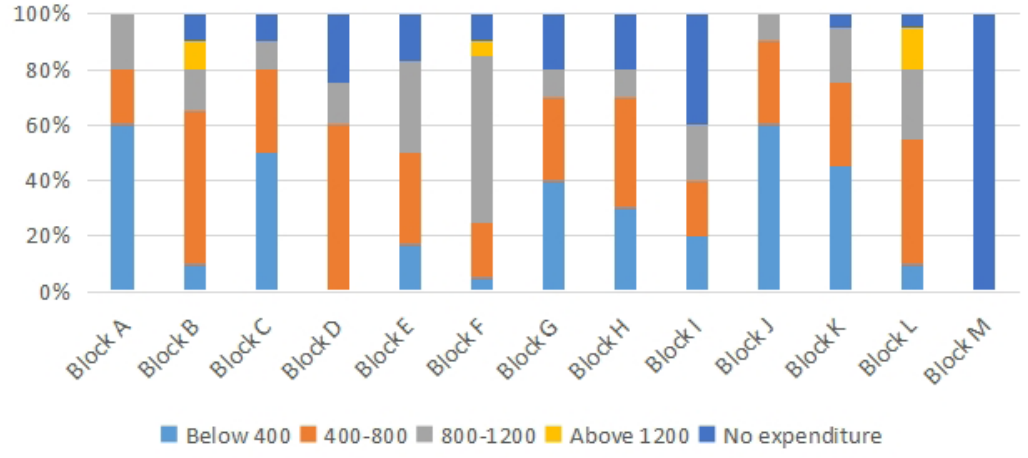



*Water scenario in Sangam Vihar*

**Graph 17: Storage capacity of storage tanks**




**Graph 18: Average monthly spending on potable water**

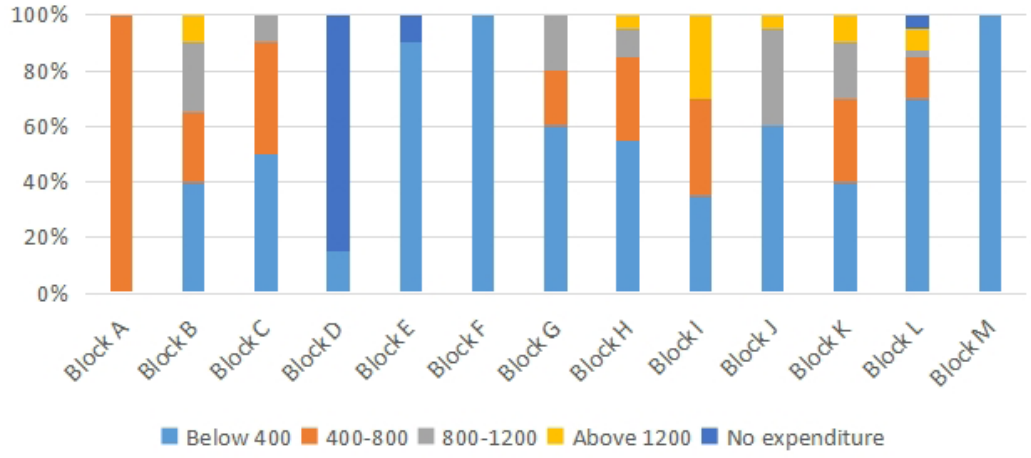



A worrying aspect was that underground water tanks are built next to or close to the underground sealed septage holding tanks, a major health-risk hazard of Sangam Vihar.

In blocks with adequate water supply (e.g. Block A), the capacity of storage tanks was found to be lower, mostly below 2,000 litre (see *Graph 17*).

The primary survey revealed that most of the families paid approximately Rs 400–800 monthly for potable water while a few families even paid Rs 800–1200 as per their usage and water demand. Some families even reported that there was no monthly expenditure on purchase of drinking water (see *Graph 18*). This indicates differing levels of expenditure and highlights potential disparities in access to affordable and reliable water sources within the community.

**Graph 19: Average monthly spending on non-potable water of a household**




For non-potable water, most of the families pay below Rs 400 monthly (in blocks F and M, each household pays below Rs 400 monthly while a few families even pay Rs 400–800 depending on their usage and water demand. This reflects diverse spending patterns on non-potable water needs within the community.

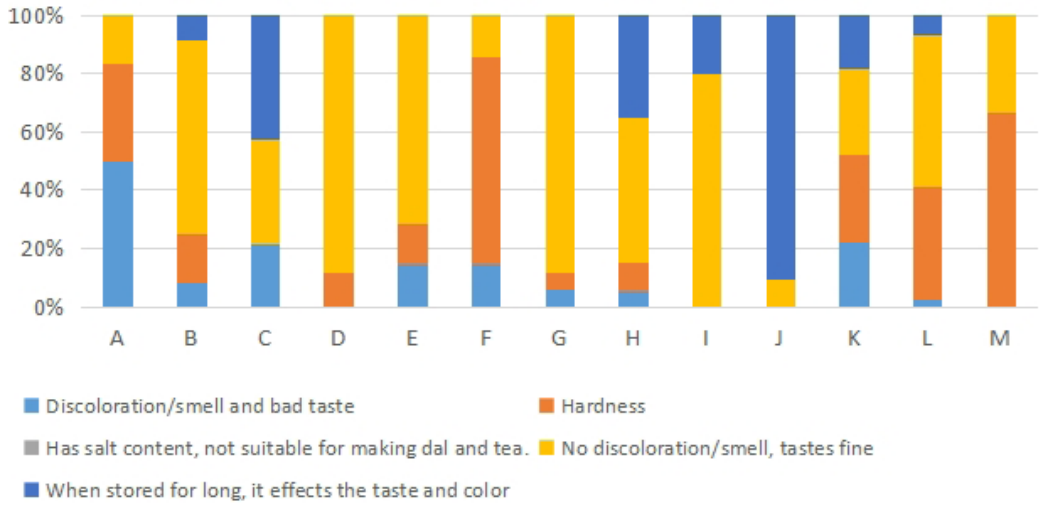
In block D and very few parts of block E and L, however, it was reported by the residents that there is no monthly expenditure on purchase of water. In blocks D and E, this could be due to adequate supply of water from Sonia Vihar pipeline (DJB supplied), as more powerful and affluent people of the society reside in this block they can even afford ROs to purify the pipeline water and use it for potable use as well. But in Block L, this can be due to the unavailability of funds with residents as marginalized population stays there.

*The residents were asked about their perception on the level of affordability of water services in Sangam Vihar, to which majority of them responded that the services are not very affordable to them, a major portion of their income is spent on purchasing water for potable as well as non-potable and usage.*

The residents from many blocks informed that they face no issue of foul smell, no discoloration and the taste is also fine as per them (see *Graph 20*). Residents of a few blocks such as blocks C, J and H, however, added that if the water is stored for a long period of time, then it does affect the taste and colour. In a few blocks such as blocks A, C and K, it was found that the issue of smell and bad taste is prevalent.

In addition, the presence of complaints regarding water hardness in blocks such as blocks F, L and M indicates potential concerns about water treatment or purification.

**Graph 20: Quality of water supplied**




It was reported by the residents that the water contamination levels in both potable and non-potable water sources is low because rarely any water borne diseases can be recorded. This suggests a favorable health environment within the community, with no immediate concerns regarding water borne health issues.

*The residents were asked about their perception on water quality of the non-potable water supplied in Sangam Vihar, to which majority of them responded that the quality varies throughout the blocks. It is very poor in some blocks and moderate in the others.*

**Q. In your area, do you get contaminated water? If yes, what impacts do you see usually?**

*Residents:*

*A: As our main source is from the community borewell, sand particles are seen with hardness and dissolved minerals making it unfit for drinking. Even if we store the water in tanks for long periods, stickiness and microorganisms formation is observed. We use this water for only bathing, washing, and other household purposes. But there have been instances where people have reported skin-related problems as they used the water for bathing.*

*B: Yes, Sonia Vihar water is contaminated so we also have a community borewell connection as the primary source of water. Sonia Vihar pipeline's water is of no use to us.*

**Q. Is contamination seen throughout Sangam Vihar or in certain pockets only?**

*Residents:*

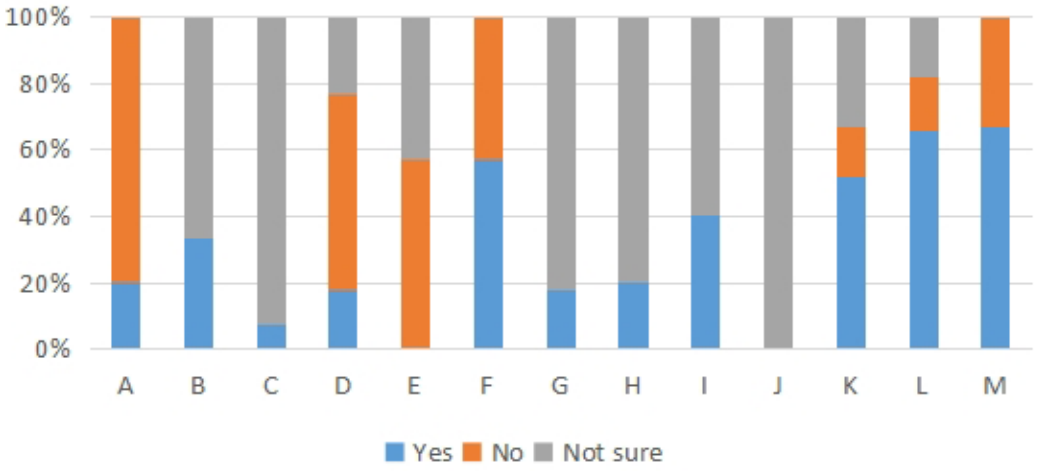
- *Across Sangam Vihar, wherever people are using bore-well water, a white layer can be seen on the top of water. Some believe that it is the salt content which is due to the unlined bottom of septic tanks.*
- *Residents of blocks F, J and most part of block L informed that they face this issue.*
- *The retention pond in the Ramleela Maidan is filled with wastewater and solid waste. The vacant plots are also filled with solid waste, during rainfall the overflowing water from open drains is soaked from the plots filled with solid waste and storm water.*

## Water mafia

Through the secondary and primary survey, the presence of a water mafia was observed in many blocks of Sangam Vihar. Only a moderate percentage of respondents (especially from the blocks facing more water shortages as compared to the other blocks such as blocks F, K and L) confirmed the presence of a water mafia, highlighting an issue of unauthorized control and exploitation of water resources, leading to additional financial burdens for some households.

The survey revealed that the Delhi Jal Board tankers were directly sent to few powerful personalities in the locality, where all the water was transferred for free after which these powerful personalities further sell this water to the residents at around Rs 15–20 per bottle. A few residents from blocks M, B, K, L and I stated that some borewells are controlled by a private party, and they supply water whenever you require it. However, every visit needs to be paid for, the amount in the range of Rs 100–300 depending on the blocks. Additionally, one's own water containers need to be provided.

**Graph 21: Is there a water mafia operating?**



**Q. Do you think water-tanker drivers sometimes stops the tanker near households that pays them more?**

*Resident: In Blocks such as B, C, G, H and I, the respondents said that the water tanker stops near the influential and wealthy people. A Resident's Welfare Association (RWA) member from B block said that there had been instances where the DJB tanker driver takes money and provides the whole tanker to a specific affluent individual. For example, a 5,000-litre tanker should be distributed equally, i.e. 1,000 litre to five families, but the DJB tanker driver sells the water to a specific person who pays for the whole tanker.*

## People's perspective on water-supply conditions in Sangam Vihar

When facing extreme water shortage, do you visit the RWA or any political party for help? Do you get the appropriate solution?

- Except for Blocks M, D and I, all other blocks have reported seeking assistance from either the RWA or political parties.
- Respondents from Blocks B, C, G, H and L stated that the RWA or political parties provide assistance on one or two occasions but are unable to offer a long-term solution.
- Respondents from Blocks F and I indicated that they receive no help from the RWA or political parties. Meanwhile, respondents from Blocks K2 and J reported receiving adequate support from the RWA or political parties.

What should be the top priority when addressing water-related challenges in Sangam Vihar?

- Securing water quality;
- Ensuring adequate supply of water for every household;
- Providing Sonia Vihar pipeline and repairing the existing pipeline network to improve water pressure and water quality; and
- Ensuring affordability of water

Chapter 5

# Sanitation

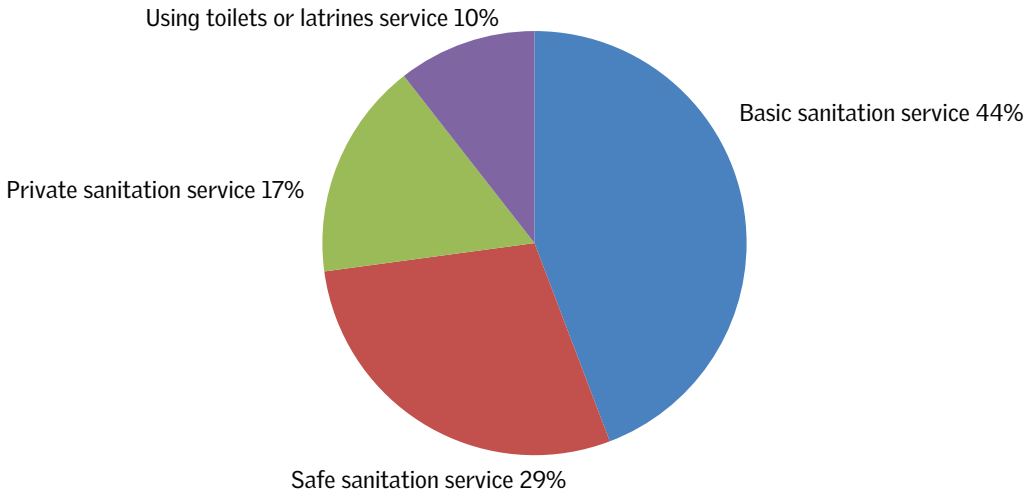
## GLOBAL SCENARIO

The world's population increased from 6.1 billion to 8 billion people between 2000 and 2022.[39] According to WHO, in 2022, 57 per cent of the world's population (4.6 billion people) used safe sanitation services; 33 per cent (2.7 billion people) used private sanitation facilities connected to sewers from which wastewater was treated; 21 per cent (1.7 billion people) used toilets or latrines where excreta was safely disposed of in situ; and 88 per cent (7.2 billion people) used at least a basic sanitation service.[40]

The number for rural, urban and overall estimates for securely managed sanitation has increased the most in low- and lower-middle-income nations.[41]

Lack of sanitation holds back economic growth. Poor sanitation costs billions to some countries, amounting to the equivalent of 6.3 per cent of the GDP in Bangladesh (2007), 6.4 per cent of GDP in India (2006), 7.2 per cent of GDP in Cambodia (2005), 2.4 per cent of GDP in Niger (2012), and 3.9 per cent of GDP in Pakistan (2006). It is predicted that at present rates of improvement, only 67 per cent of the world's population will have access to clean sanitation by 2030.[42]

**Graph 21: Situation of global sanitation services**



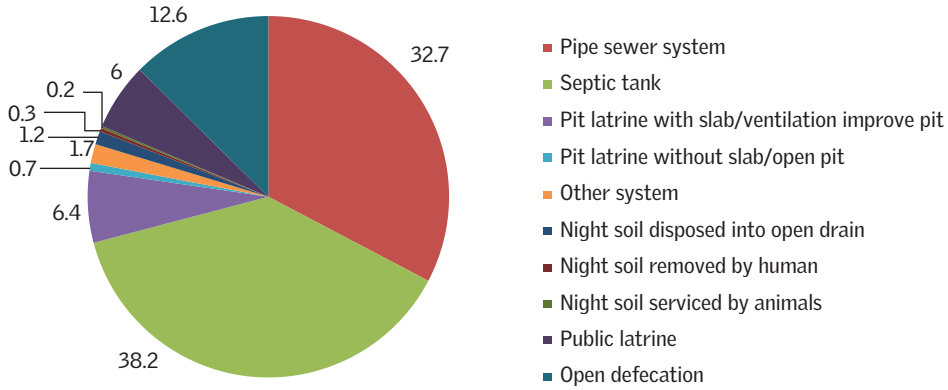

Source: https://cdn.who.int/media/docs/default-source/wash-documents/jmp-2023

## URBAN INDIA SCENARIO

India has the world's largest urban population, with over 377 million people living in cities. A vast majority has access to only basic sanitation facilities through non-sewered systems (only 32.7 per cent had sewerage connectivity as per 2011 Census).

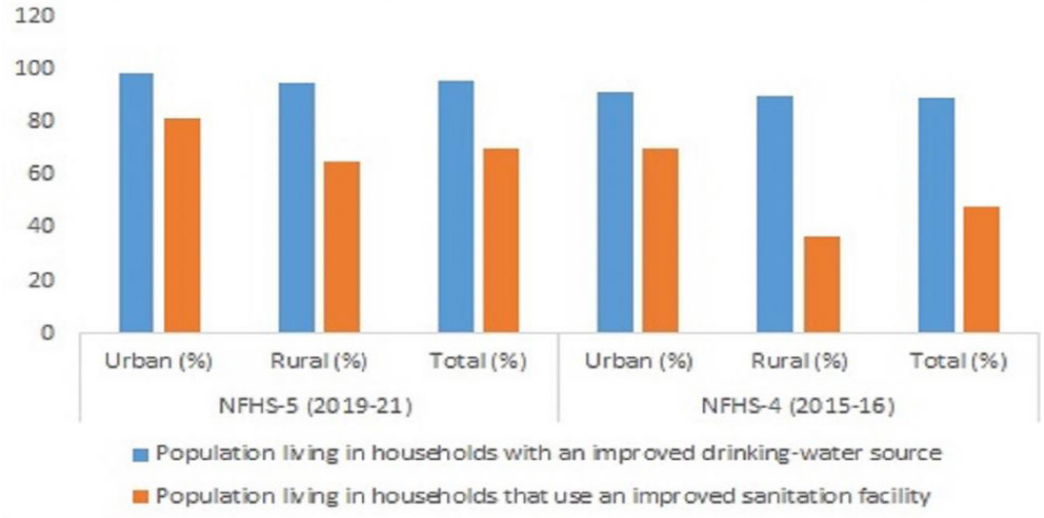
India has made significant progress in improving access to sanitation in the past 20 years. According to the National Family Health Survey (NPHS 5, 2021), urban population with access to improved sanitation facilities was 82 per cent while those with improved drinking water source was 98 per cent.

**Graph 22: Distribution of facilities in urban households of India, 2011**




Source: Census 2011

**Graph 23: Percentage of population living in households with improved drinking-water source and improved sanitation facilities**




Source: Union Ministry of Health and Family Welfare

## SCENARIO IN UNPLANNED SETTLEMENTS IN INDIA

Data for water supply and sanitation services for unplanned settlements at an all-India level, or even at state and city level, is not available. Residents of unplanned low income settlements often rely on a combination of market solutions and community governance to meet their basic sanitation demands.[43]

According to National Sample Survey Organisation (NSSO, 2018), only 43 per cent of households of informal settlements in India have access to a toilet.

### Norms, polices and guidelines

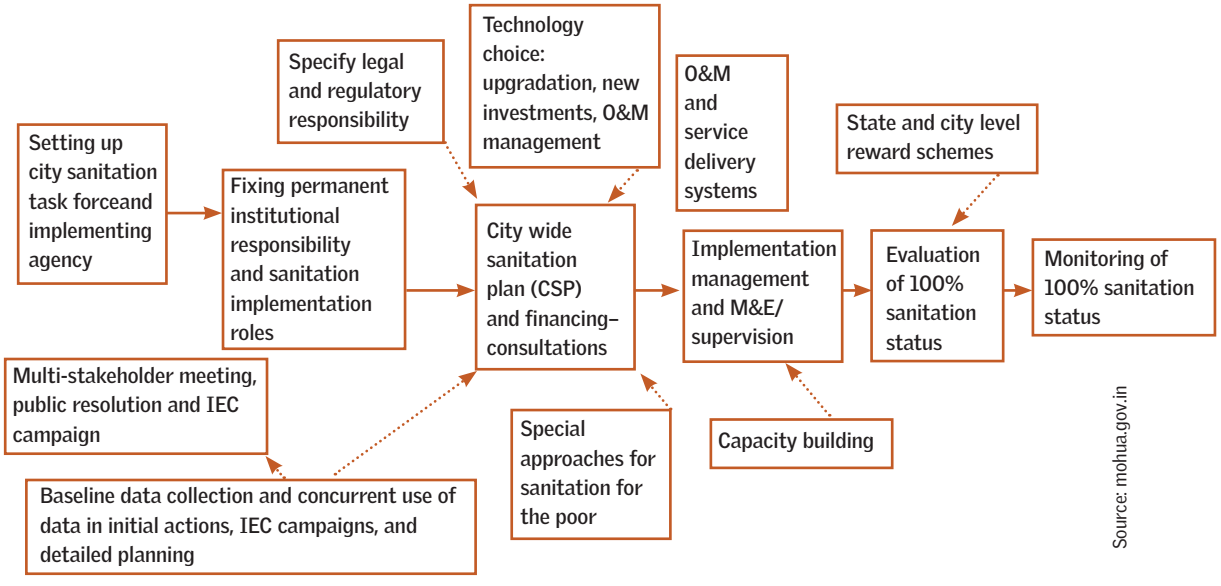
In 2008, the City Sanitation Planning (CSP) was adopted as a framework for urban sanitation planning by the then Ministry or Urban Development (MoUD).

The value of CSP was looking at the entire city as a unit for sanitation planning and not just on individual project planning. A consultative stakeholder mapping of the city with active involvement of city officials, citizens and NGOs is crucial. To identify the existing sanitation challenges in terms of 'sanitation hotspots' in the city where interventions needed to be prioritized and planned.

## DELHI SCENARIO

Sanitation services in slums of Delhi are largely through community toilets. Norms for community toilets provide one seat for 50 users, or one seat per 10 households. Community toilets are to be linked to septic tanks or underground sewerage where networks are available. Community toilets are also to provide bathrooms as per

**Figure 3: Generic elements of planning, implementation and M&E of city-wide sanitation**



one bathroom for 100 persons or one bathroom per 20 households. Unfortunately, within Sangam Vihar, not a single community or public toilet currently exists.

## Sewerage and drainage

According to the Economic Survey of Delhi 2022–23, the sewage treatment capacity of the Delhi Jal Board (DJB) is currently 943 MGD (in 2022).

The projected total generation of wastewater is estimated to reach approximately 1,200 million gallon per day (MGD) by 2041. Delhi's sewerage network consists of 8,107 km of peripheral sewers and 200 km of trunk sewers, supported by 58 pumping stations. According to Delhi Master Plan 2041, approximately 45 per cent of the city lacks sewerage coverage.[45] This existing sewerage network serves as the primary means for collecting wastewater, including sewage and grey water, and transporting it to 35 dedicated sewage treatment plants (STPs) at 20 locations in the city.[46]

## Solid waste

Solid waste is an important factor that contributes to the choking of storm water drains and also of sewerage systems of Delhi. Delhi generates approximately 16,500 tonne of municipal solid waste daily. Projections indicate a significant increase, with estimates in the range of 19,000–25,000 tonne per day by the year 2030.

## Reuse of treated wastewater

As per Ministry of Housing and Urban Affairs, the benchmark for reuse and recycling of wastewater is 20 per cent.,[47] Delhi currently only reuses an underwhelming **12 per cent** of its generated wastewater. This translates to 89 MGD (million gallons per day) reused out of a total 720 MGD generated.[48]

*Dump of solid waste outside the dhalao*

## SOLID WASTE MANAGEMENT NORMS

The Central Public Health and Environmental Engineer Organization (CPHEEO) manual prescribes one sweeping staff per 500 persons.

In addition Corporation norms include:

- One dhallao per 10,000 people;
- One space (of 200 sq. m) for segregation of non-biodegradable waste per 10,000 people;
- 2 cu. m (2,000 litre) container per 500 kg of waste;
- In slums, community bins of suitable sizes ranging from 0.04 to 0.1 cu. m (40–100 litre) provided in suitable locations and adequate quantities; and
- Enough vehicles or carts to transport to landfill sites the quantity of waste produced each day.

The three municipalities were recently merged into a single Municipality of Delhi (2020).

**Table 11: Overview of solid waste management infrastructure in Delhi**

| S. no. | Facility | Location | Capacity | Managed by |
|---|---|---|---|---|
| 1 | Composting plants | Okhla | 200 TPD | IL&FS |
| | | Bawana | 1,500 TPD | Delhi MSW Solutions Ltd |
| 2 | Waste-to-energy plants | Bawana | 2,000 TPD | North DMC |
| | | Okhla | 1,800 TPD | SDMC |
| | | Ghazipur | 1,300 TPD | EDMC |
| 3 | C&D processing plants | Burari | 2,000 TPD | North DMC |
| | | Shastri Park | 500 TPD | EDMC |
| | | Ranikhera | 150 TPD | DMRC |
| 4 | Landfills | Bhalaswa | 60 acre | North DMC |
| | | Ghazipur | 70 acre | EDMC |
| | | Okhla | 32 acre | SDMC |
| | | Bawana | 40 acre | North DMC |

Source: Action committee report for SWM Delhi 2019

Delhi Jal Board is operating wastewater treatment plants (WWTPs) at 20 locations and the total installed capacity of the plants is 617 MGD, the current quantity of treated sewage is 530 MGD against 490 MGD in 2019. In 2019, 90 MGD treated effluent was reused for various non-potable purposes by different agencies.[49]

Estimated sewage generation is approximately 3,491 MLD (768 MGD) (80 per cent of 960 MGD water supply) for population in 2023.

Details of sewage treatment plant:

- Existing number of operational STPs of DJB : 35 STPs (at 20 locations)
- Installed treatment capacity of 35 operational STPs : 2,874 MLD (632 MGD) (82.3 per cent of estimated sewage generation)

- Capacity utilization of existing STPs : 2,407 MLD (530 MGD, March 2023) (83.86 per cent of installed capacity) [now 580 MGD in April 2023]
- Gap in treatment capacity: 618 MLD (136 MGD) (17.7 per cent)[50]

### DJB work on lake and groundwater rejuvenation

Delhi Jal Board has initiated the proposed revival and rejuvenation of 155 waterbodies owned by the Revenue Department or other government agencies in Delhi. The aim of this prestigious initiative is to clean the existing waterbodies, restoring its ecological values and putting in management regimes that are sustainable for long term.

Action plan for rejuvenation of river Yamuna[51] says the work of rejuvenation of 22 waterbodies is already awarded. Proposals for award of revival of 24 waterbodies is to be placed before next board meeting. Tenders for rejuvenation of 13 waterbodies have been received and are under evaluation. DPRs of 11 waterbodies have been received and are under approval and 19 water body DPRs due to be received from CSIR/NEERI.[52]

## SCENARIO IN UNPLANNED SETTLEMENTS OF DELHI

Delhi's population is expected to reach 36 million by 2025. The numbers and access to water and sanitation services of unplanned settlements, unauthorized and JJ slum clusters, and some resettlement colonies is not known. Various estimates of population of unplanned and informal settlements exist. These include the Slum-Free City Action Plan (SFCAP) finalized by the Delhi Urban Shelter Improvement Board (DUSIB), according to which 22.30 per cent of the 255,435 households living in 589 surveyed jhuggi-jhopri (JJ) clusters in Delhi defecate in the open.

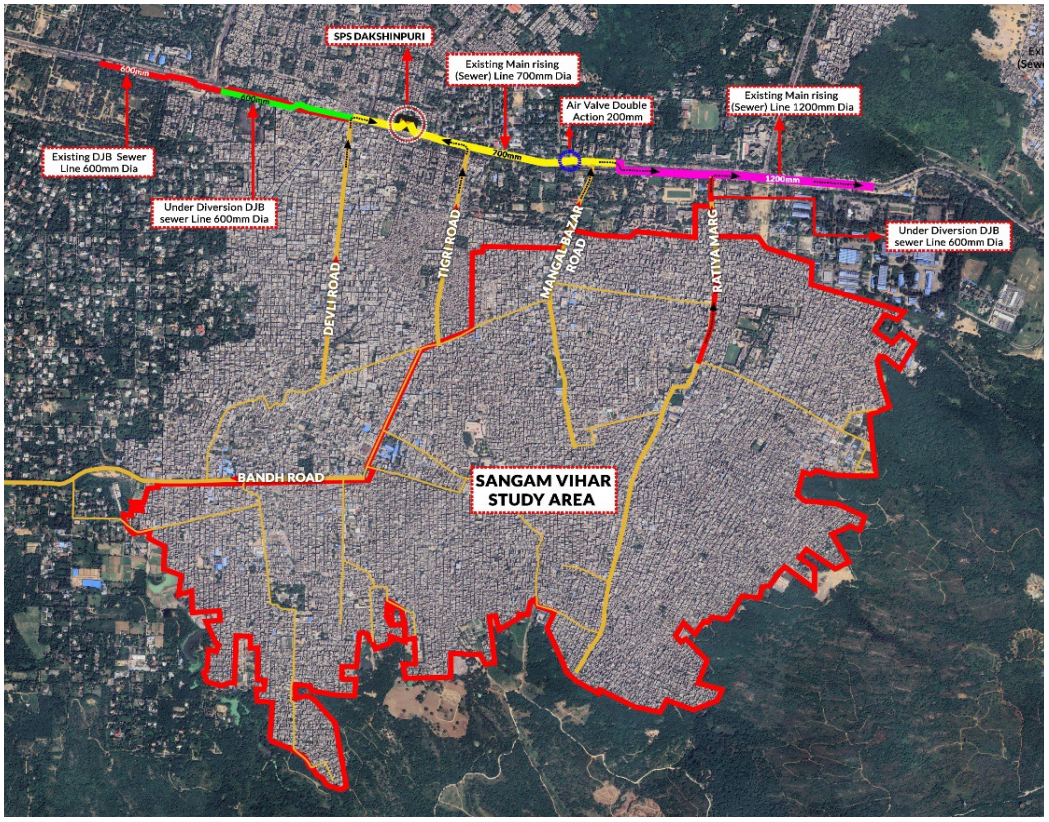
Delhi needed to build and upgrade around 4.8 million houses by 2022, to house a third of its population that lives in substandard housing (which also implies the need for upgrading sanitation systems).[53]

## SCENARIO IN SANGAM VIHAR

This section contains findings and analysis from the household surveys and focused group discussions carried out in Sangam Vihar. The non-sewered sanitation system of Sangam Vihar is getting transformed into a centralized sewer system with connection to the Okhla Sewage Treatment Plant through a retrofitting connectivity with the main trunk sewer line on MB Road (see Map 9).

Estimated total wastewater generated in Sangam Vihar is. approx. 36 MLD. This is based on a low per capital estimate of water supplied per household in Sangam Vihar (45 LPCD only). Out of this total wastewater, 25 per cent is the black water content and 75 per cent is the grey water, which mean the total black

## Map 9: Main truck line on MB Road




Source: Primary survey by CSE

water generated is 9.08 MLD and the total grey water generated is 27.23 MLD (see *Table 13 in Chapter 7*). This is again based on the household survey and the survey of household per capita water consumption/supply.

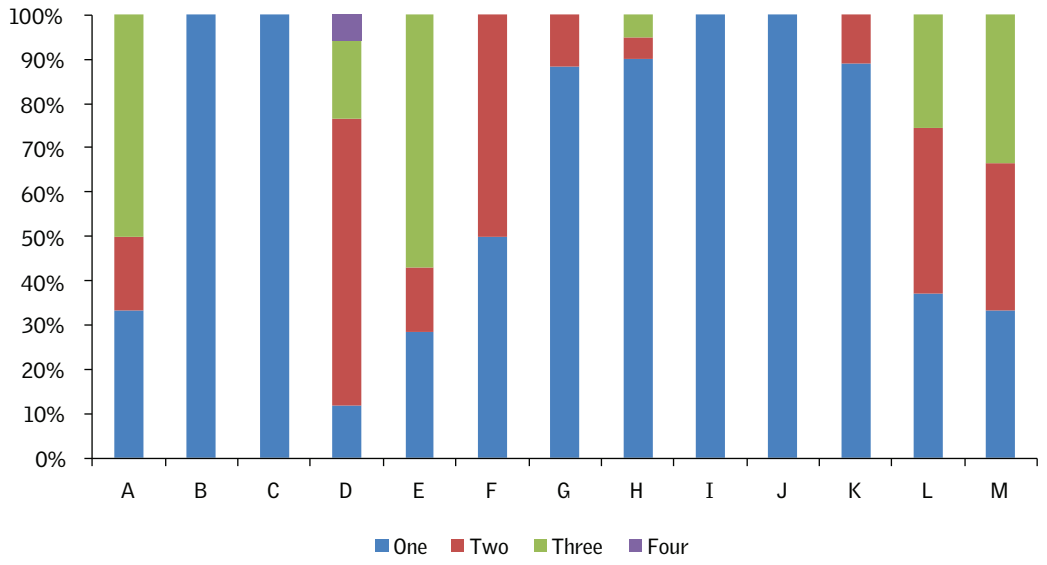
The majority of Sangam Vihar has one or a maximum two toilets per property (that may have more than one family) (see *Graph 24*). If there are more than one floors, all the faecal waste from toilets of all floors is connected to one underground sealed septage holding tank per property.

Even though housing ownership is high in Sangam Vihar, there is not a single community public toilet in the 5 sq. km of dense settlement.

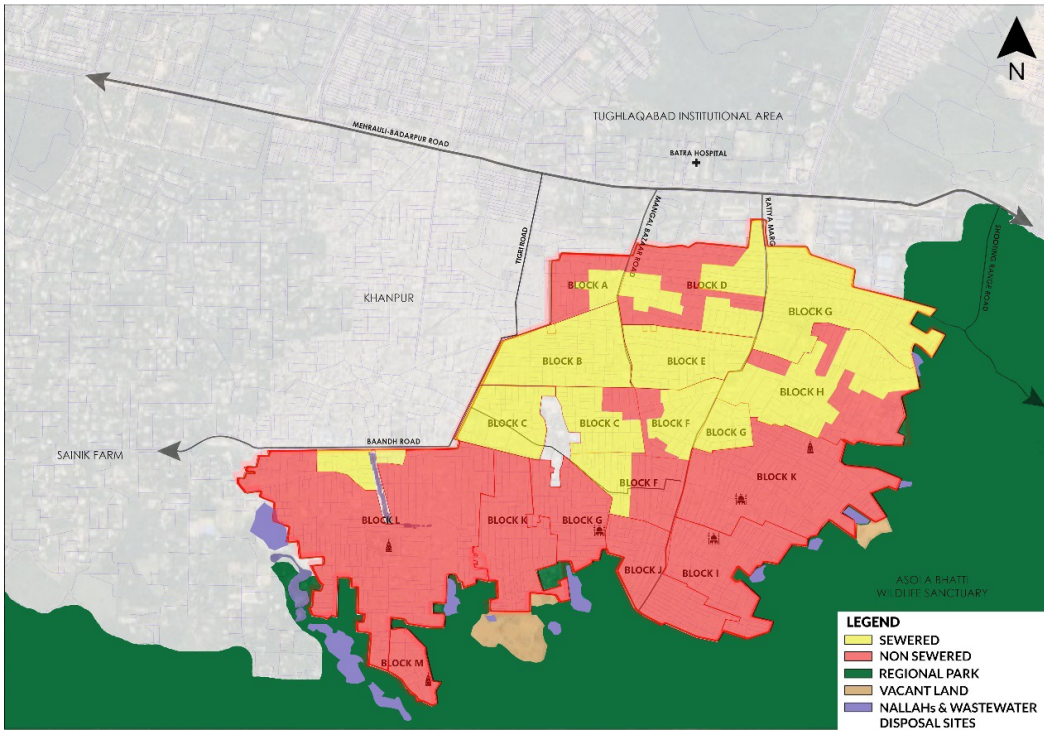
### Faecal sludge containment—Septage holding tanks

Non-sewered sanitation systems dominate all the 13 blocks of Sangam Vihar (see *Map 10*). All the faecal waste from toilets is collected in underground sealed septic tanks that are essentially underground sealed septage holding tanks, with no outfalls. In most cases these are unlined at the bottom for maximizing seepage and reducing desludging frequency and cost associated with it. Of all the tanks

## Graph 24: Number of toilets per property

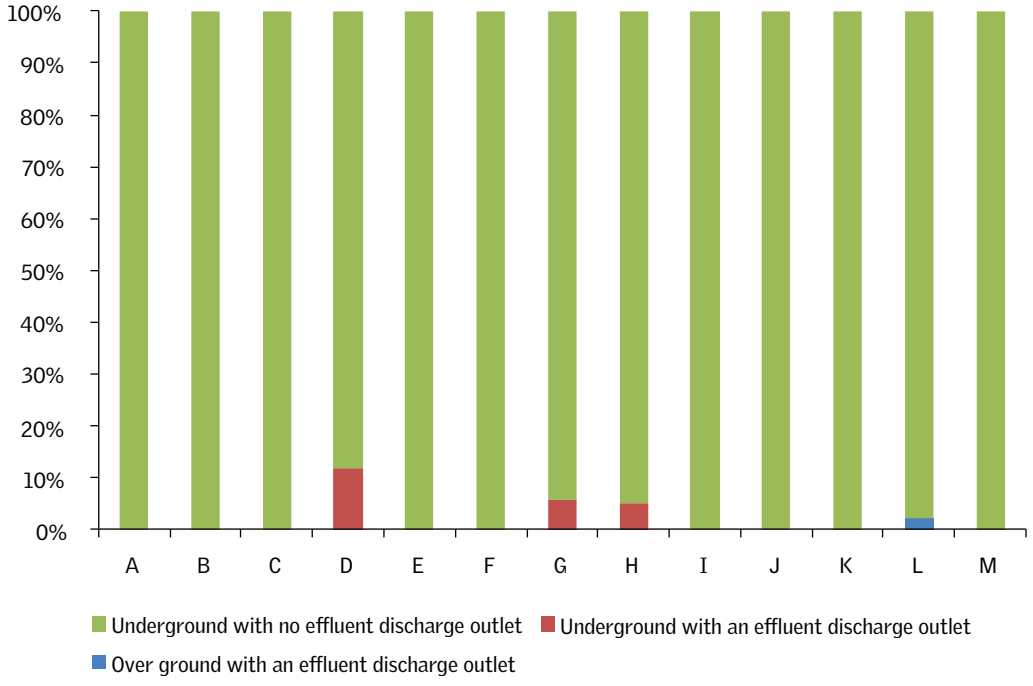



## Map 10: Sewer line coverage in Sangam Vihar




Source: Primary survey by CSE in February 2024

**Graph 25: Types of septic tank**




in Sangam Vihar, 95.5 per cent are constructed underground, with no effluent discharge outlet. This is deliberately done to ensure that effluent from septic tanks do not create odour and bad smell by consensus among all residents.

This system of sealed underground septage holding tanks with unlined bottom, has evolved in Sangam Vihar (see *Graph 25*) due to the lack of sewerage systems and the desire of residents to separate their black water from grey water and storm water flows so that that both the systems don't intermingle.

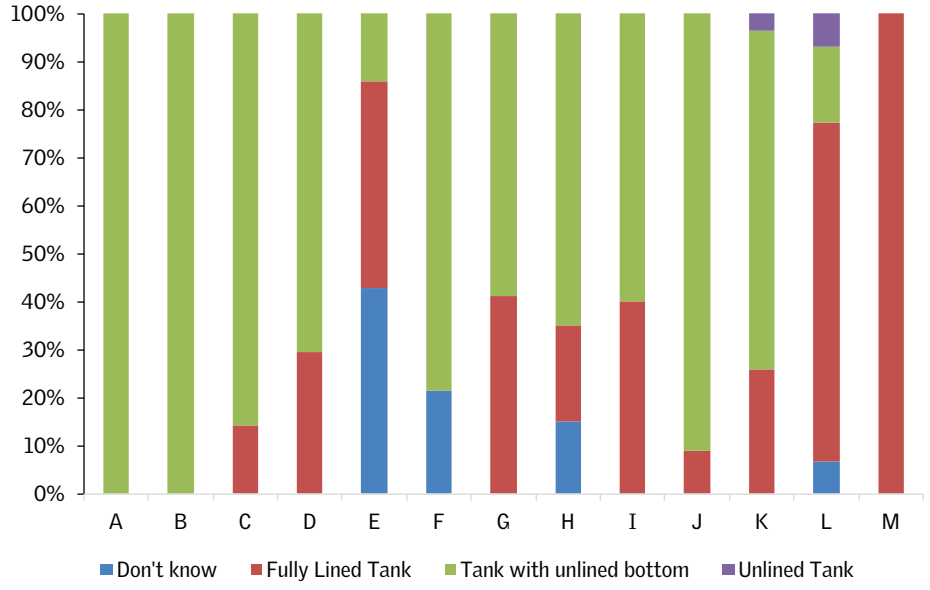
All the kitchen and bathroom water flows out from the houses to the side drains that also carry rainwater or storm water. A natural south to northward sloping topography ensures that a densely populated 5 sq. km area is able to manage their grey water and black water in this manner.

Our household survey found that of all the septic tanks constructed in Sangam Vihar, more than 70 per cent are tanks having unlined bottoms. Fully lined tanks are only 27 per cent (see *Graph 26*).

This was confirmed in a meeting with a sludge tanker operator who said, '10 per cent of the toilets discharge in open drains, 70 per cent toilets have unlined bottom lining and about 20 per cent only are fully cemented and sealed at the bottom' (see *Graph 26*).

As DJB is building a sewer network inside Sangam Vihar, the sealed underground septage holding tanks pose another implication/challenge for household sewerage

**Graph 26: Construction of the septic tank**




connectivity - how to convert the interior plumbing that was designed for the toilets to be connected to the underground sealed septage holding tank, to now get connected to the sewage collecting chamber outside the house? And for the grey water (bathing, washing and kitchen) to also connect to the sewage collection chamber outside each house. This will require internal plumbing fixes and where the houses are multi floors this will be expensive to do.

## Underground containment tanks/septic tanks type

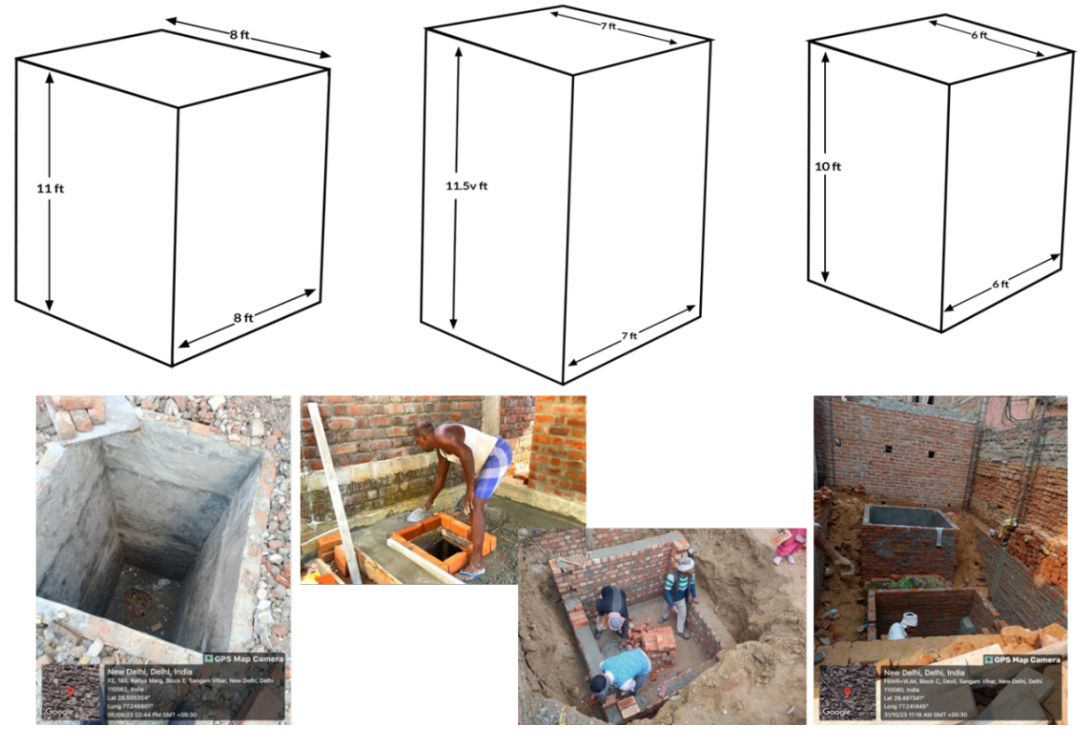
The first variant, measuring 8 feet in length, 8 feet in width, and 11 feet in depth revealed itself as a robust and sizable receptacle. The second type, with dimensions of 7 feet in length, 7 feet in width, and 11.5 feet in depth, showcased a slightly different configuration. This design suggested a careful calibration, perhaps tailored to the specific needs of a larger household.

In contrast, the third type of septic tank unveiled dimensions of 6 feet in length, 6 feet in width, and 10 feet in depth. This smaller configuration hinted at a household with more modest requirements, where efficiency and space utilization took precedence over sheer volume. It underscored the adaptability of sanitation solutions to the diverse socioeconomic landscape of Sangam Vihar.

## Faecal sludge emptying

Desludging frequency of household septic tanks varies from block to block but is on an average relatively short (even twice a year in many instances) (see *Graph 27*), given the sealed nature of the underground tanks, with no effluent outlets.

## Figure 4: Dimensions of septic tanks




Source: CSE

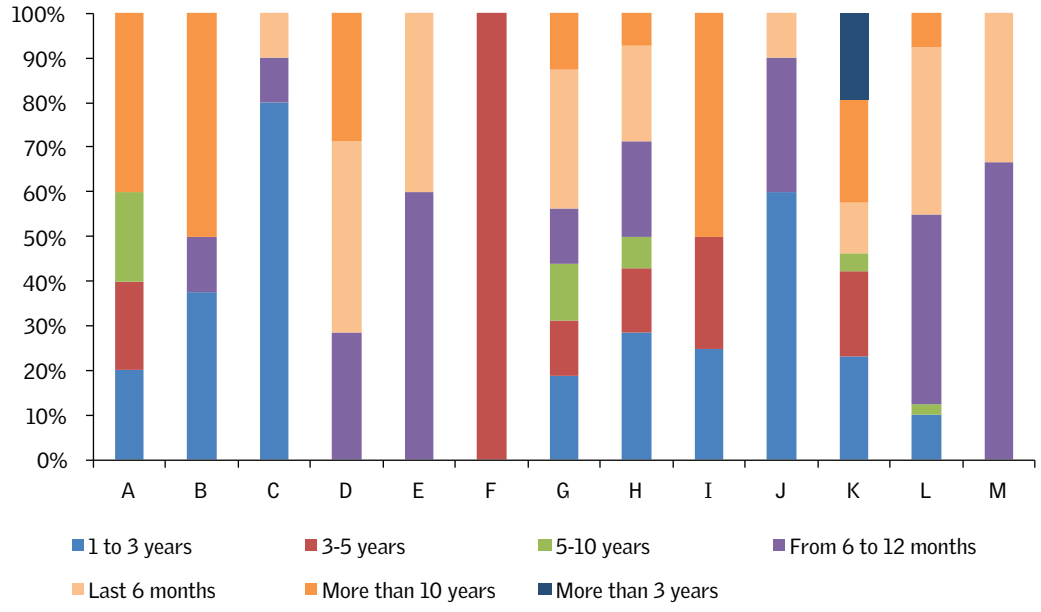

*Desludging trucks in Sangam Vihar*

Source: CSE

Source: Study by CURE in block I of Sangam Vihar

*Sewage channels discharging into plots of land*

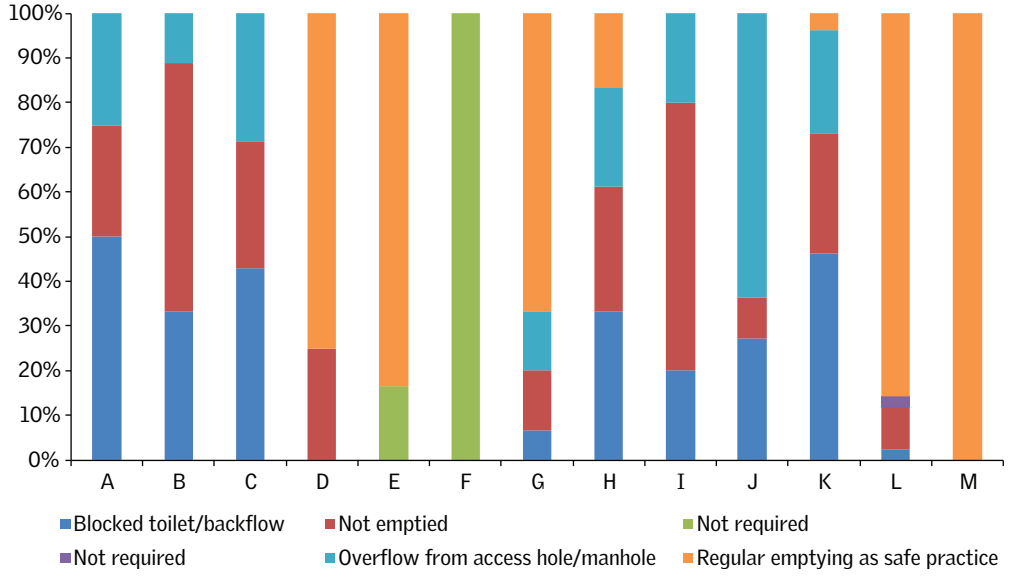
**Graph 27: Last time when septic tank was emptied**




Unlike purchase of bottled drinking water that is price sensitive, emptying of septage tanks cannot be postponed because these are sealed underground tanks. They will back-flow if not emptied.

The majority of the residents informed that the septic tanks are emptied at a regular interval however some informed that it is emptied only when there is a blockage, backflow or overflow issue (see *Graph 28*).

**Graph 28: Reason for emptying the septic tank**



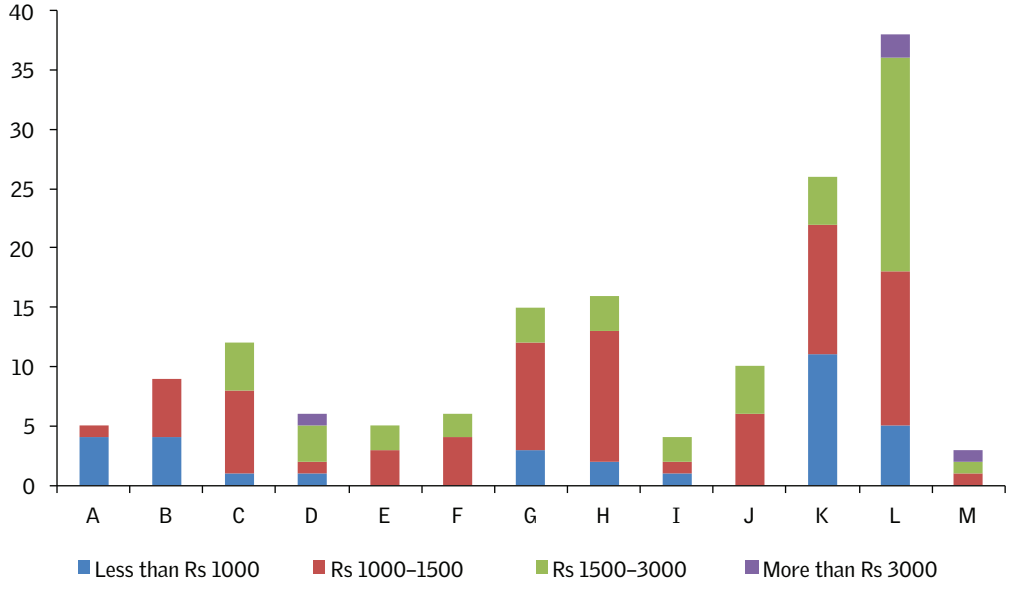
## Affordability of septage tank emptying

Desludging is expensive in Sangam Vihar, where a large number of residents belong to the lower-middle class and working class. The cost is on average Rs 1,000–2,000 per desludging and could be higher as well (see *Graph 29*).

This is high, considering that this is an annualized cost of desludging of a septage holding tank, not one in three years.

More than one trip may be required to fully desludge the large underground septage holding tanks in Sangam Vihar. Residents reported the need to have more than one trips of a desludging tanker to de sludge one septage holding tank.

**Graph 29: Annual cost of emptying the septic tank**



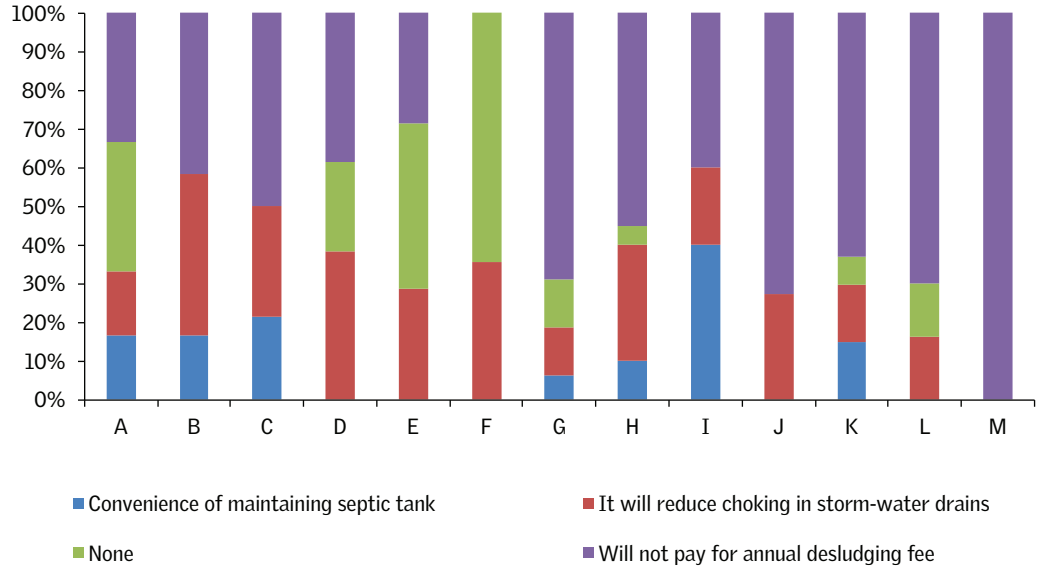

## Centralized sewerage system

A new sewerage system is being laid out in Sangam Vihar (since 2017). The challenge of retrofitting a sewerage system for an unplanned settlement is that the lateral and peripheral sewers cannot be designed as per desired flow rates and velocity—they will need larger pipe dimensions and/or sewage pumping stations.

All the 13 blocks with population of more than a million are relying on two peripheral sewer lines passing through the main roads of Tigri and Ratia Marg. All the sewage of the million-plus settlement must be conveyed through these two sewer lines.

Blocks A, B, C, D, E, and F and one part of G have full or partial peripheral sewer lines adjacent to their households.

**Graph 30: People's perspective on the benefit of new sewer line**




Source: CSE

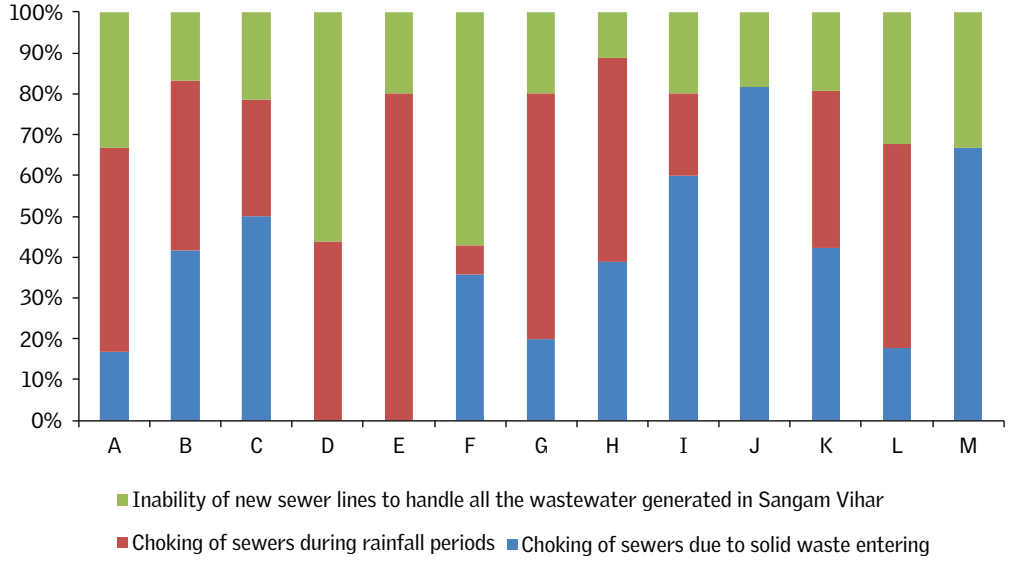
The incentive for people to connect to the sewerage system is that they will not have to pay for desludging and emptying of their septic tanks.

Many residents believed that the sewers might be inadequate to convey the entire sewerage of one million plus population of Sangam Vihar (see *Graph 30*), when the sewerage system reaches the last of Blocks M and L.

They also feared that the sewerage system will choke during the rainy season even if the area receives normal intensity rains (see *Graph 31*).

The unplanned settlement of Sangam Vihar with a population of a million-plus does not have a single community or public toilet.

**Graph 31: People's perspective on major risk they see in the functionality of new sewer line**




Source: CSE

Chapter 6

# Storm water

## GLOBAL SCENARIO

Storm-water management is a key issue in line with global problems of urbanization and climate change. In comparison to the developed countries, developing countries have generally inadequate or non-existent storm-water management practices. Where they exist, storm-water collection systems serve only the most central or wealthiest areas and at other areas either it is not there or if there then in extremely poor condition. In absence of storm-water drains, water runs along natural slopes and collects at low lying areas attracting pollutants (wastewater, trash, sediment) and pose a significant public health, economic and environmental risk.[54] This is a very common problem in developing countries which are typified with large areas of informal settlements. These often do not adhere to official planning guidelines, building regulations and construction standards and, as they are not officially recognized by local authorities, are rarely provided with adequate infrastructure and services.[55] Nonetheless, the vulnerability of these settlements results in part from the exclusion of their residents from the very governance structures that should address their vulnerability.[56]

In this post-millennial period, informal settlements are gaining greater attention from actors in the urban realm in low- and middle-income countries. Storm-water drainage is an important component of the infrastructure that needs to be improved in informal settlements. State-led service delivery and development routes have not effectively reached the urban poor, who are often located in informal settlements.

## URBAN INDIA SCENARIO

As per 2011 census, the coverage of storm water drainage network stands at around 20 per cent of road network in India. The Ministry of Urban Development survey carried out for 13 states storm-water drainage in 2010–11 revealed that 56 of the 104 large cities had coverage below 50 per cent (a level termed by the ministry as needing 'immediate action for improvement') and 93 had coverage below 75 per cent ('caution for improvement') of road network.[57] Besides it, urban centres in India suffer from poor storm-water management due to climate change and changing land use and land cover as Indian rapidly urbanizes.

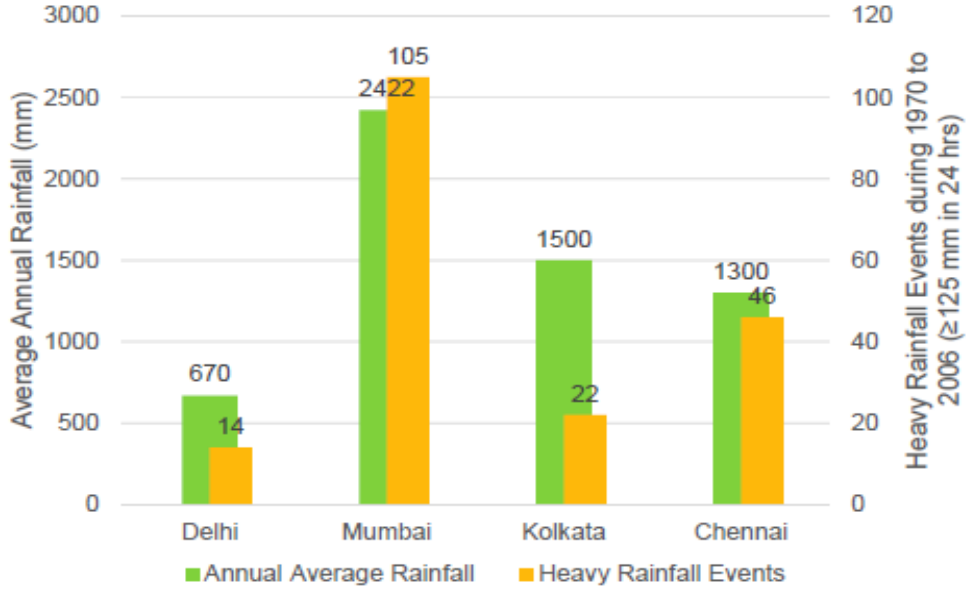
In Indian cities, the conventional design system primarily focuses on the minor drainage system, which is easily recognizable and convenient. It involves the construction of drains, channels, roadside drains, channelization, rehabilitation,

rectification, enlargement of existing storm-water drainage networks, and the provision of cross drainage works. These systems often end up collecting not only storm water but also wastewater from domestic, commercial and industrial activities.

Urbanization in densely populated settlements leads to changes in land use patterns, resulting in the creation of impermeable spaces, the loss of lakes and wetlands, reduced groundwater recharge, the disappearance of storm-water storage systems, increased runoff volume, more frequent and intense peak flows, altered flow patterns, and shorter time to peak flow due to the use of storm drain systems. In addition to storm-water, the drains and channels in typical Indian cities also carry wastewater, as well as solid waste. The lack of preventive maintenance exacerbates the situation further.

The encroachment on green and blue areas and rampant construction in many large cities has resulted in the diversion or damage of storm-water drainage channels. These cities are experiencing shorter but intense periods of heavy rainfall, particularly during the monsoon season, with cities like Mumbai receiving an annual average rainfall of around 2,932 mm. The Indian Meteorological Department (IMD) collects rainfall data through its 6,955 rain gauges across the country, but they do not provide spatially disaggregated data specifically for urban areas.[58] However, it is crucial for cities to have such data in order to design drainage infrastructure effectively, as rainfall distribution within a city is not uniform. This problem is more severe in unplanned densely populated settlements where there is a lack of infrastructure for regular rainfall monitoring, resulting in a lack of data on storm-water discharge.

**Graph 32: Rainfall data of four metropolitan cities in India**



## DELHI SCENARIO

The National Capital Territory (NCT) of Delhi is one of the largest urban agglomerations in the world faced with a complex water crisis. The groundwater table is 40 metre below ground level in as much as 30 per cent of the city. Yamuna River is at its most polluted, within the urban limits of Delhi; innumerable water bodies have been encroached upon and are vanishing; and the water supply in the city is dwindling. Every monsoon, even during moderate rainfall, the city faces urban flooding. Annual average rainfall in New Delhi is 797.3 mm with 39.1 number of rainy days and maximum rainfall intensity of 112 mm/hour (1969–2005). The urban water cycle of Delhi is broken and in dire need of a paradigm shift to address vital issues related to urban water management.[59]

Delhi has a total drainage of 426.55 km of natural drainage lines and about 3,311.54 km of engineered storm water drains which are managed by 11 different agencies.[60]

The drainage of storm water in Delhi, especially in densely populated unplanned urban areas, poses a significant problem. Encroachment on natural drainage streams, retention ponds, and catchment areas, flood plains has occurred, converting once permeable areas into impermeable surfaces. This issue is particularly prevalent in unplanned urban areas where there is a lack of development control regulations. Private builders and even statutory development authorities like DDA, prioritize land value capture over proper registration with development authorities, disregarding the land's topography and the need for essential infrastructure to support the community.

The capital city of Delhi is still operating on the 1976 drainage master plan even though the population has increased manifold and no new drainage master plan has been drawn up and implemented by the concerned agencies ever since. Over the years, Delhi's drainage system has fallen prey to encroachment and poor planning as well. The Master Plan Delhi (2041) does not mention responsibility of drainage infrastructure in unplanned settlements. The Public Works Department (PWD) estimates that the old drainage system can accommodate 50 mm of rainfall only.

According to Delhi Jal Board, at present 81 per cent of Delhi is covered under Sewerage system. In the remaining 19 per cent of the area including 1,800 unauthorized colonies, network is being extended in a phased manner.[61]

### Master Plan Delhi (2041) and focus on storm water

For construction of new drains in the sub cities to be planned under Master Plan 2041, following recommendations are made with regard to planning/construction of drainage system:

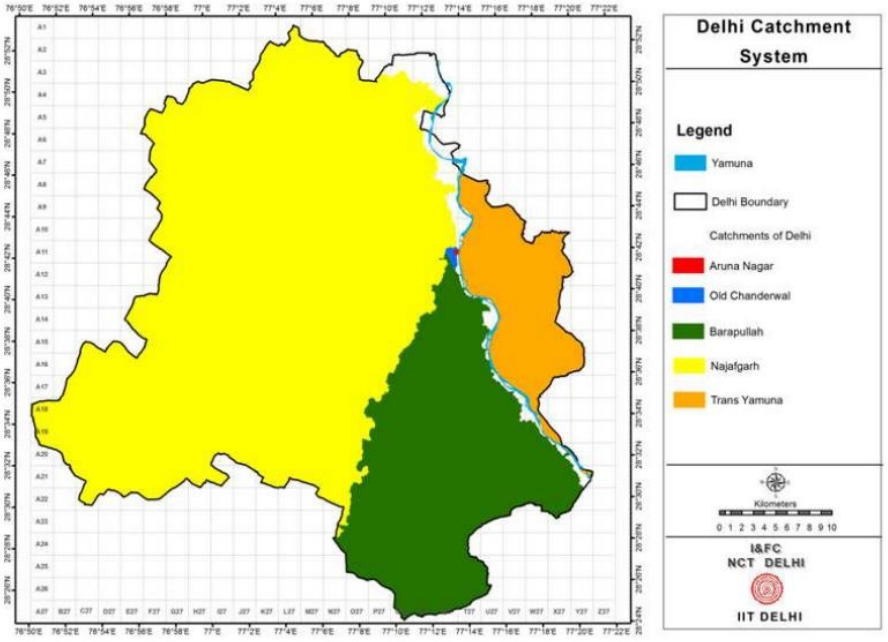
1. The existing drainage network of Irrigation and Flood Control Department may be remodeled within the limits of the feasibility, to integrate the drainage

network of sub-cities to be planned under Land Pooling Policy/MPD-2041, whenever, the relevant details are shared with I&FC Department in consultation with all stakeholders.

2. Provision should be made for continuous green lines along the entire course of the drains on both sides.
3. A separate provision for the services lines like sewer, water, electric, communication etc. should be made outside the drain boundary areas.
4. A separate provision for land for collection, processing, transportation, shifting and disposal should be made for MSW as well as C&D waste.
5. New development should be made in such a way that overall runoff from the area does not increase with the proposed urbanization. For that necessary measures in form of ponds, parks, porous pavements, green belts, artificial lakes/ or other rainwater harvesting and storage structures etc. may be adopted.
6. The officers involved in drainage and flood management should be given exposure to International best practices, so as to adopt the same to the National Capital City of Delhi.

Master plan Delhi 2041 does not mention the responsibility of Drainage infrastructure in unplanned settlements within the Delhi NCT. It does not recommend how we can conserve and use storm water better. By building infrastructure to capture and convey storm water to places where it can be used to recharge ground water and also prevent flooding.

**Map 11: Delhi catchment system**



### Major basins of Delhi-NCT

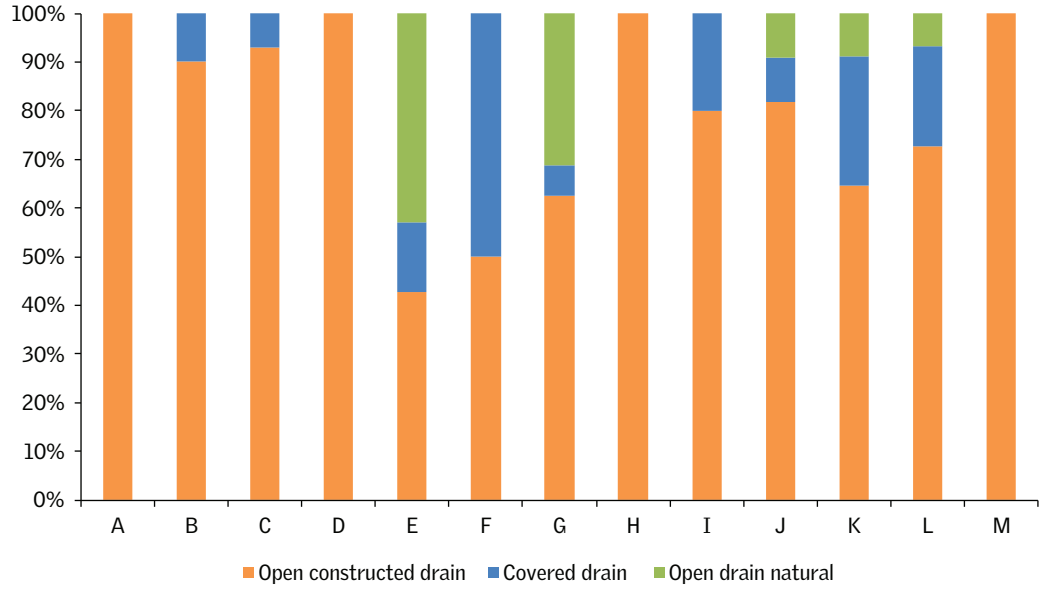
Delhi's catchment system is divided into three major basins: Barapullah, Najafgarh and Trans-Yamuna (see *Map 11*), Najafgarh being the largest one. The study area lies in the Barapullah basin.

## SCENARIO IN SANGAM VIHAR

Almost all of the households in each block rely on a combined drainage system for storm water and grey-water discharge. The drains found in Sangam Vihar are mostly constructed open drains (92 per cent) both natural and constructed while very less numbers have covered drains which were majorly observed in blocks F and K (see *Graph 33*). Many households in affluent blocks (like block D) have illegally covered the drains which are outside their houses, they have acquired that area for activities like parking of vehicles. The drains mostly receive a mix of storm water and grey water. Grey water comprises used water generated from

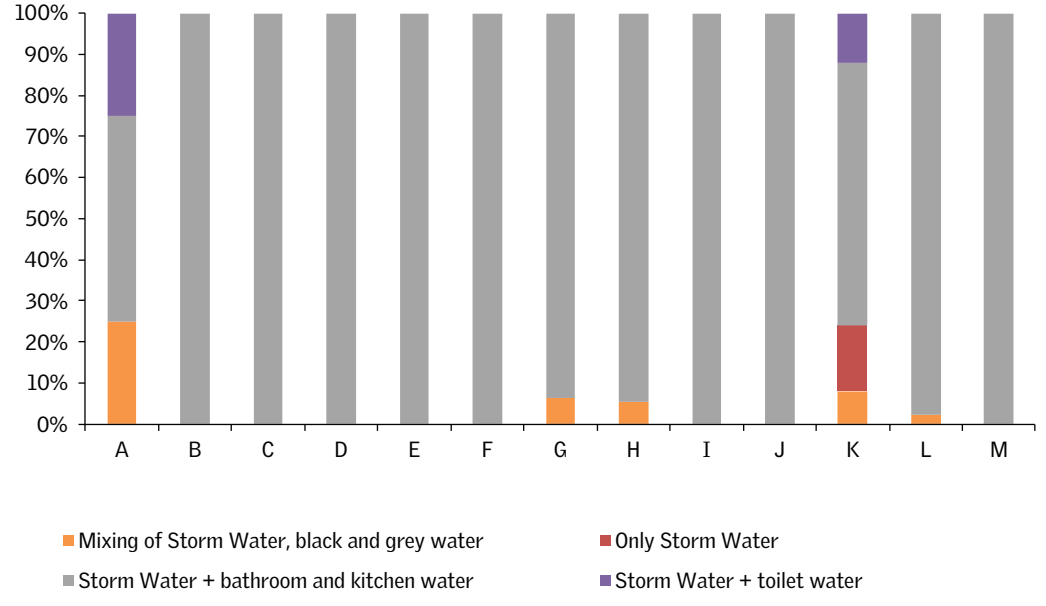

*Types of drains in Sangam Vihar*

**Graph 33: Type of drains**

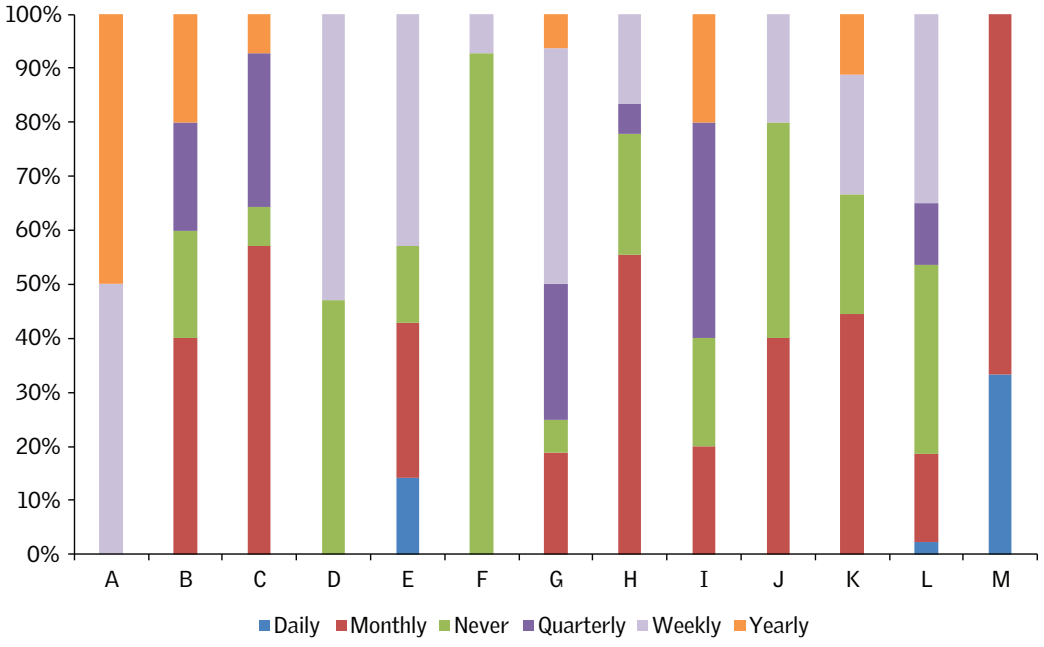



bathrooms and kitchens. Very few residents have informed of the disposal of black water into the drains; more than 95 per cent of the drains are found without any black-water discharge (see *Graph 34*). The responsibility of cleaning of drains is with the MCD, but at places where the MCD is not able to reach, private players are hired. Many residents have informed that cleaning is done on an extremely irregular basis ranging from once in a week to one in a month.

**Graph 34: Type of water flowing into the drains**



**Graph 35: Frequency of drain cleaning**




The outfall of the total storm water is directly flows on to the Mehrauli-Badarpur Road, from where it overflows southwards into Dakshinpuri drain, which then connects it through the Andrewsganj area to the Barapulla main drain entering the Yamuna. There are no water harvesting potential sites inside Sangam Vihar.

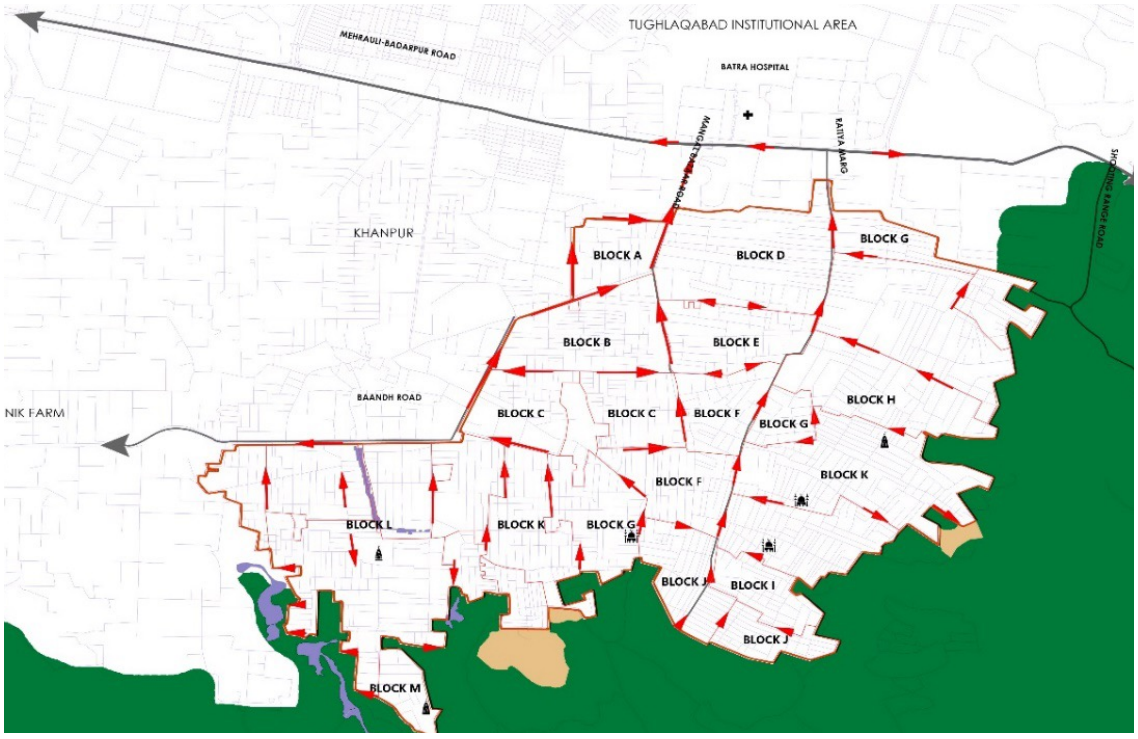
Directional flow of storm water within the 13 blocks of Sangam Vihar of the settlement is mostly in south to north direction, on the MB Road. While few blocks discharge its water in the south-east direction (towards the open land and nallah towards Sainik farms) and in the west direction (towards Asola sanctuary) (see *Map 12*).

## Flooding

While 50 per cent of residents reported no stagnant storm water on the roads near their homes, the remaining 50 per cent revealed a different story (see *Graph 36*). This suggests that a significant portion of the population faces the issue of stagnant water on the streets after rainfall.In more than 80 per cent part of Sangam Vihar, it takes 30 minutes to three hours for stagnant water to be drained away from the streets after heavy rainfall. However, at times it takes around six hours or more to get the water drained (see *Graph 37*).

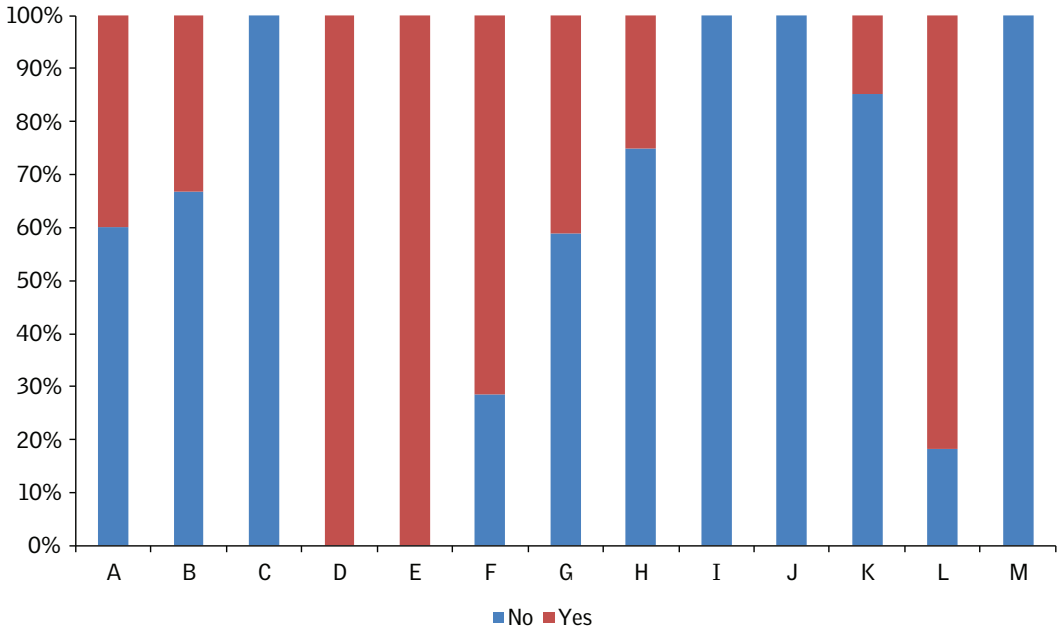
Residents believe that if a new sewer line is laid in Sangam Vihar, storm-water management would become easier and waterlogging and flooding could improve. However, 20 per cents of residents believe that a new sewer line might not resolve the existing issues (see *Graph 38*).

## Map 12: Storm-water outfall in Sangam Vihar



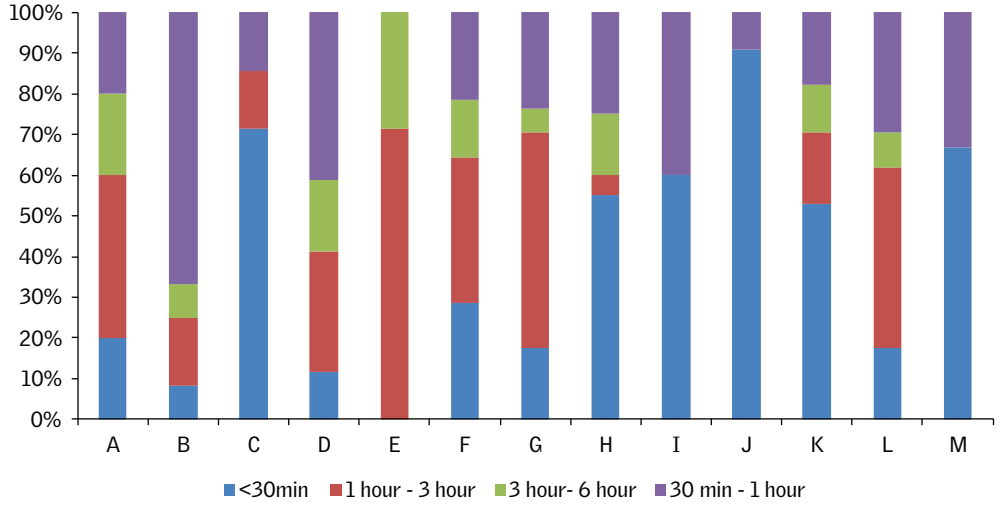

Source: Primary survey by CSE in 2023

## Graph 36: Water stagnating on roads

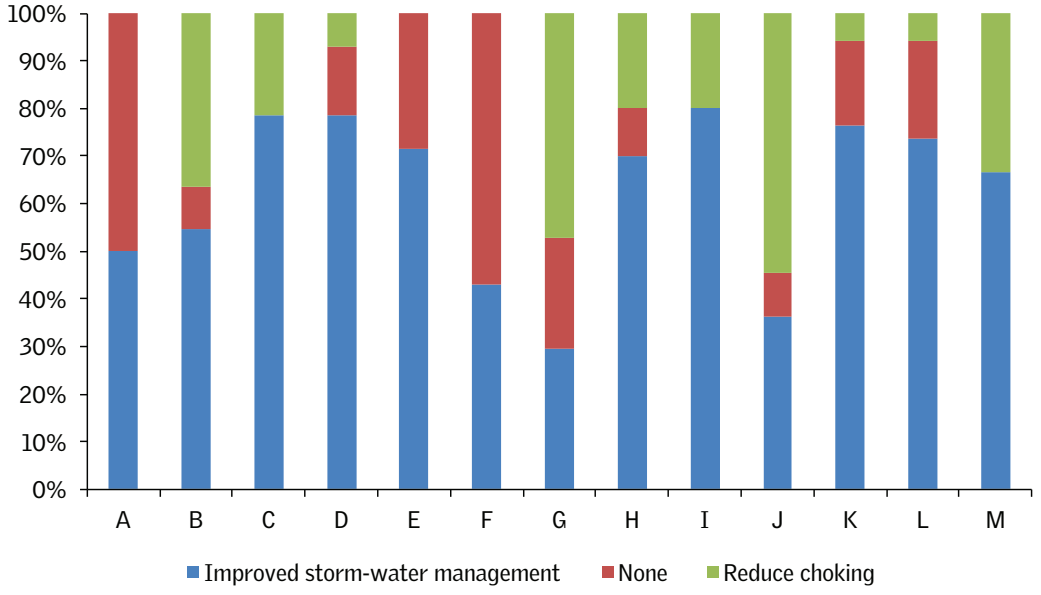


*Overflow of drains due to blockage and rains*

## Graph 37: Time taken for water to drain from streets



**Graph 38: People's perspective on benefit of new sewer line**




**CSE surveyor: What do you think needs to be done to improve storm-water management in Sangam Vihar?**

***Residents:***

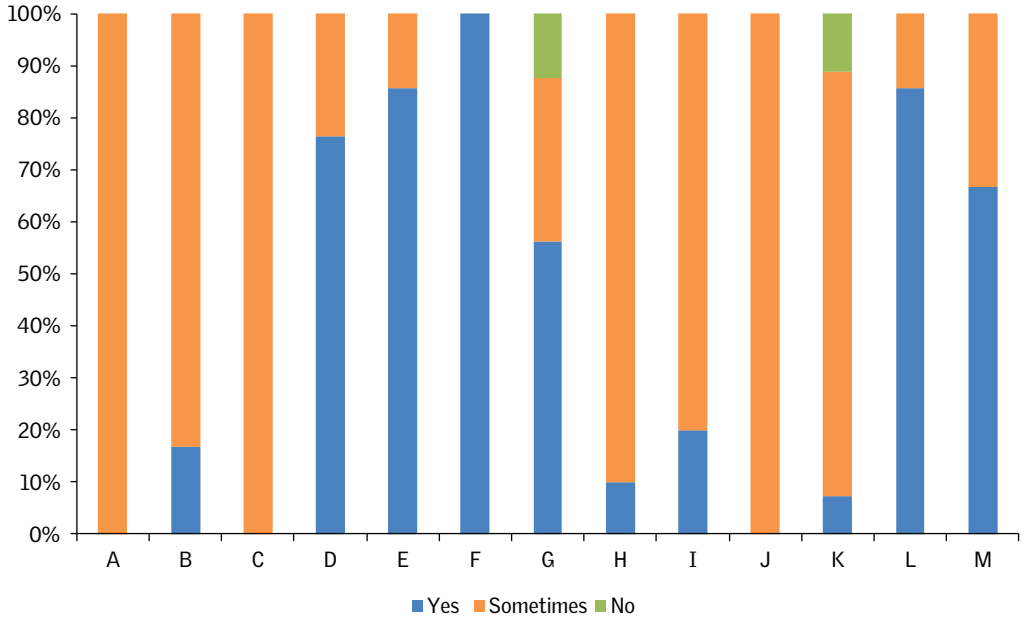
- *Proper roads and drains should be constructed. The drains should be built along the natural flow to easily discharge and manage the storm water.*
- *Sewer lines should be operational and should be designed in such a way that it can solve the issue of flooding in this area.*
- *Residents are in favour of sewer lines being laid, but they are sceptical about its functionality in such unauthorized colonies.*

## SOLID WASTE

As per the field observations and the information received from the residents, it was found that solid waste is trapped into majority of the drains in Sangam Vihar (see *Graph 39*). This waste is a mix of biodegradable and non-biodegradable items coming mostly from households and commercial shops. This is despite the fact that the residents claim that effective door-to-door collection is practised in the area by MCD or private players on a very minimal charge.

*Solid waste dumped in drains*

## Graph 39: Solid waste trapped in drains



Chapter 7

# Water-sensitive city framing

Informal and unplanned settlements now dominate the urban landscape of most developing countries of Africa and Asia, especially in the metro cities. Most of the research work and projects have focused on smaller-sized unplanned and informal settlements, where the population can be easily integrated into the existing water supply and sewerage infrastructure of the city.

Water conservation and septage management can be addressed in smaller towns and smaller peri-urban settlements and slums, through measures of in-situ groundwater recharge and through non-sewered sanitation systems. However there is little good research that tests the potential for large, densely populated unplanned settlements with populations of half a million or more.

Can existing problems of low per capita water supply and high volumes of grey water, black water and storm water from such large, dense unplanned settlements be addressed with retrofitting solutions? Is sewerage-based retrofitting to existing main sewer lines possible for a large settlement of one million-plus? Can its water supply deficit be met by ad hoc augmentation of supply from uncertain and unreliable sources? Can storm water and flooding challenges by addressed as a drainage challenge? If not, what is required to tap this as a water conservation resource?

Very few primary research-based studies address all the three aspects of water supply, storm water and sanitation together for heavily populated unplanned settlements in urban areas.

This research was possible only after identifying the unit areas of research as the 13 blocks of Sangam Vihar. Why? Because this is a contiguous area surrounded by several other unplanned settlements. In thee 13 Blocks DJB has been implementing a sewerage project since 2017.

The first challenge for this study was to document the existing status of water supply, sanitation and storm-water systems.

Enumerating the population and their per capita water supply was the first step, followed by the estimation of existing and desirable infrastructure of water supply, grey- and black-water generation and storm water. The likely success of ongoing sewerage system was then assessed based on the estimated grey- and black-water generation and the dimensions of the sewer pipe to convey this volume of wastewater through only two peripheral sewer lines to the main sewer line on the MB Road.

In this section, we analyse and explore, based on the findings from primary data of Sangam Vihar, the possible solutions for water supply, sewage and storm-water

drainage that may require reimaging and looking beyond the confines of Sangam Vihar and its peripheral areas.

## AUGMENTING WATER SUPPLY

Water is a basic requirement for life. It is the first priority of both rural and urban settlements and is usually provided by civic authorities in some form, even for unplanned settlements. However, beyond just water supply provisioning, it is the quality of water supply, the frequency and timing of supply, adequacy in terms of quantity and need, and its affordability that really determines whether the water supply is adequate and safe.

The current sources of water supply in Sangam Vihar (13 blocks) are:

1. Sonia Vihar pipeline
2. Community/DJB borewells
3. Private tankers and
4. Packaged water (bottled/cans)

### Existing scenario

- The existing water supply, based on household interviews and cross referencing with data, shows that only **45.39 MLD of water is being supplied/consumed** by the 1 million residents of the dense unplanned settlement of Sangam Vihar. This amounts to a low supply of just 45 LPCD (litres per capita per day), far below the 135 LPCD norms of CPHEEO, Government of India.
- **As against the current supply, the desirable water supply is 138.3 MLD.** This is a normative minimum supply/consumption estimate based on a conservative estimation of total population of Sangam Vihar (a large number of informal workers whose water demand will be higher than what middle class residents consume). Since working class requirements for daily washing and bathing is usually much higher.
- Based on the existing water supply and a normative demand, there is a gap of **92.92 MLD of water supply in Sangam Vihar.**

### Findings of the study

- **There is a huge gap in water demand and water supply**:
  - The Sonia Vihar Water Supply plant of Delhi Jal Board (DJB) provides water to only a few blocks of Sangam Vihar. The quality of this piped water supply is considered poor and unfit for drinking, perhaps because it is punctured at several places on the way.
  - The majority of the 13 blocks in Sangam Vihar are dependent on borewells and water tankers (both private and government).

**Table 12: Water consumption in Sangam Vihar**

| Block | Average water consumption per property (lpd) | Water consumption per capita | Total daily water consumption (in MLD) | Total water demand (in MLD) | Gap in water supply (in MLD) |
|---|---|---|---|---|---|
| Block A | 350 | 58.33 | 0.99 | 2.30 | 1.31 |
| Block B | 250 | 41.67 | 1.30 | 4.20 | 2.90 |
| Block C | 250 | 43.67 | 2.72 | 8.41 | 5.69 |
| Block D | 400 | 66.67 | 3.15 | 6.39 | 3.23 |
| Block E | 500 | 41.67 | 1.92 | 6.21 | 4.29 |
| Block F | 250 | 20.83 | 1.30 | 8.45 | 7.15 |
| Block G | 350 | 58.33 | 5.07 | 11.73 | 6.66 |
| Block H | 350 | 58.33 | 3.80 | 8.80 | 5.00 |
| Block I | 450 | 37.50 | 2.47 | 8.89 | 6.42 |
| Block J | 400 | 66.67 | 1.90 | 3.86 | 1.95 |
| Block K | 450 | 56.82 | 8.96 | 21.28 | 12.32 |
| Block L | 400 | 33.33 | 11.04 | 44.69 | 33.66 |
| Block M | 400 | 33.33 | 0.77 | 3.10 | 2.34 |
| | | | 45.39 | 138.30 | 92.92 |

Source: CSE

  - The gap in water supply and water quality leads to high households spending on purchase of non-potable (Rs 400 a month) and potable water (Rs 400 to Rs 800 a month)
- **Water storage and pumping**: Given the uncertain and intermittent water supply, each household invests in more than one storage tanks, or large tanks of 2,000 litres, and pump set. The old houses all had underground water storage tanks, built close to the underground sealed septage holding tanks with perforated bottom.
- **Drinking water**: Bottled water is preferred and used by those who can pay for it. The price being high, only partial requirement of most people is met though this source, defeating the very purpose.
  - Bottled water supply quality is perceived to be better by residents. However the source of this supply is private suppliers, it varies from borewells to partial or fully filtered water that is considered Reverse Osmosis (RO) treated water and thus safe.
- **'Water mafia':** Sangam Vihar has a notorious water mafia in the water supply aspect. The aim of the study was not to expose this as it is already well known. Several respondents answered in the affirmative when asked if a water mafia existed in Sangam Vihar, and whether it operated in various ways from controlling some of the community borewells, to controlling some of the DJB tankers, with implications on cost burden arising from rent seeking.

- Residents of few blocks highlighted the issue of **water quality** in the visible form of water hardness, salt content and discoloration. More unseen pollution elements may also exist.
- There is **no water augmentation plan.** Residents were not aware if there is any major infrastructure plan to address the massive water shortages in Sangam Vihar.
- **A major grey infrastructure push** for water supply augmentation is required. A water-sensitive city framing is therefore not possible without first augmenting water supply infrastructure.

  Alternative decentralized water supply and management options will require looking a city wide re-imagining of how water supply systems can augment the use of treated waste water and its percolation and filtration based secondary treatment followed by tertiary treatment to make it fit for drinking water standards and supplied to planned and unplanned colonies.

## APPROPRIATE SANITATION SYSTEMS

The existing non-sewered sanitation (NSS) system in Sangam Vihar, of underground sealed septage-holding tanks, with no effluent coming out into drains on the streets, was an effective measure adopted by residents of Sangam Vihar when the colony was established nearly four decades ago. It ensured that in the absence of a sewerage system for a large, dense unplanned settlement like Sangam Vihar, with a population of more than a million, the effluent discharge from septic tanks into the open drains outside the houses did not lead to foul odour.

The residents built their internal plumbing in such a way that the grey water flowed into the street drains and not in the underground septage holding tanks. Only the toilets were connected to the septage holding tank. This ensured that their septage holding tanks would not need emptying often.

With a low per capita water supply, and a slop that is unidirectional, the grey water generated was also low and manageable with the street-level open-drainage system.

Regular desludging is needed to get rid of the accumulated faecal sludge in the holding tanks and the frequency of desludging varied from six months to three years. More than 70 per cent septage holding tanks of Sangam Vihar have unlined bottoms, allowing for increased soaking.

The Dakshinpuri Sewage Pumping Station of Delhi Jal Board reports a daily intake of more than 200 kilolitre of sludge (more than 50 tankers a day on an average, 4,000 litre each). In a month, decanting of around 400 sludge tankers takes place in Daskhinpuri SPS alone. Desludging of an additional equal number (400 tankers) takes place in open areas and storm-water drains.

Since 2017, Delhi Jal Board has initiated retrofitting of a sewerage system of

lateral and peripheral sewers in Sangam Vihar. This measure has been welcomed by residents of Sangam Vihar, who see in this the benefit of elimination of the recurrent cost of desludging of their sealed septage-holding tanks.

Added to this is the cost of internal sanitary retrofitting to connect toilets to the sewerage system and not through the septage-holding tank, and closing the septage-holding tank.

## Assessing the ongoing sewerage system capacity to handle all used water

The primary survey of CSE estimated that the total wastewater generated in Sangam Vihar, at the current level of water supply of 45 LPCD for a population of 1 million households, is approximately 36.31MLD (see *Table 13*).

Out of this total used water, if we take 25 per cent as black water content and 75 per cent as grey water, the total black water generated is 9.08 MLD and the total grey water generated is 27.23 MLD.

Many Sangam Vihar residents expressed concerns about whether the new sewerage system will work or if it would fail. The apprehension was regarding the large population of Sangam Vihar and the seemingly small sized/dimension sewer pipes being laid out.

CSE assessed the design of the sewerage system, its capacity to convey and carry the sewage. We found that it broadly meets the requirements at the current low

**Table 13: Wastewater generated in Sangam Vihar**

| Block | Total households | Total wastewater generation (in MLD) | Black water (25% of WW) (in MLD) | Grey water (75% of WW) (in MLD) |
|---|---|---|---|---|
| Block A | 2,840 | 0.80 | 0.20 | 0.60 |
| Block B | 5,184 | 1.04 | 0.26 | 0.78 |
| Block C | 10,880 | 2.18 | 0.54 | 1.63 |
| Block D | 7,884 | 2.52 | 0.63 | 1.89 |
| Block E | 3,834 | 1.53 | 0.38 | 1.15 |
| Block F | 5,218 | 1.04 | 0.26 | 0.78 |
| Block G | 14,482 | 4.05 | 1.01 | 3.04 |
| Block H | 10,860 | 3.04 | 0.76 | 2.28 |
| Block I | 5,488 | 1.98 | 0.49 | 1.48 |
| Block J | 4,760 | 1.52 | 0.38 | 1.14 |
| Block K | 19,900 | 7.16 | 1.79 | 5.37 |
| Block L | 27,588 | 8.83 | 2.21 | 6.62 |
| Block M | 1,916 | 0.61 | 0.15 | 0.46 |
| | **120,834** | **36.31** | **9.08** | **27.23** |

Source: CSE

level of 45 lpcd (litre per capita a day) of water supply and subsequent wastewater generation.

For a settlement of a million-plus, with no planned sewerage system in place, the best retrofitting possible is being attempted by the Delhi Jal Board. There are two main roads in Sangam Vihar where peripheral sewers of a maximum of 700 mm diameter have been installed. Lateral sewers of diameter 200–300 mm are being installed in the lanes.

At the current low level of water supply, the retrofitted peripheral sewers will be able to handle the 36 MLD of black and grey water.

However, if the water supply in Sangam Vihar is doubled or increased to 135 lpcd, this sewerage system will fail and will not be able to handle this quantity (see *Annexure 4*).

A retrofitting solution (connecting the sewage generation of the entire one million-plus residents to an existing main sewer line laid 20 years ago) looks infeasible.

Till the end of 2023, sewer lines have been laid out in less than half of the 13 blocks of Sangam Vihar, connecting to the main sewer trunk line on MB Road.

We therefore recommend that instead of trying to cover the rest of Sangam Vihar with the sewerage system, DJB should consider alternative decentralized STPs in the periphery of Sangam Vihar. The sewerage system can be designed to take all the grey and black water, estimated at more than 25 MLD at the current low per capita supply, to at least three to five decentralized STPs in the southern periphery of forest areas.

This will ensure that retrofitted sewerage system for half of Sangam Vihar will not come under stress and provide assured service to half the residents. The alternative decentralized STPs in the periphery will provide treated wastewater that can serve as a valuable blue resource to recharge small waterbodies around Sangam Vihar, contributing to groundwater recharge and its use in the settlement.

## STORM-WATER PLANNING AND INFRASTRUCTURE

A 15-minute moderate rainfall leads to flooding of the Mehrauli-Badarpur (MB) Road as a large area of Sangam Vihar unplanned settlement slope is in one direction—from south to north on MB Road, south being the forest area. The slope ensures most of the flooding happens in the blocks facing MB Road and not the blocks that are higher in elevation.

An analysis by CSE on storm water incidence and its drainage (see *Annexure 5*) in Sangam Vihar shows the following:

- The total catchment of the storm water shed of Sangam Vihar study area is approximately 5 sq. km. Total storm-water runoff generated:

- Normal intensity rainfall: 52 million litres in a 15-minute spell of rainfall
- High intensity rainfall: 117 million litres in a 15-minute spell of rainfall

Currently there is no storm-water infrastructure augmentation plan for Sangam Vihar. There is no plan for considering taking out the 117 million litre of storm-water runoff from Sangam Vihar to a place where it can be conserved and used for groundwater recharge.

From a water-sensitive city perspective, storm-water management is considered an important component of a city's blue-green infrastructure planning and as a climate-resilient and livable city mandate.

Storm water management will need to be done for each city, based on a differentiation and integration basis. Small spatial land unit area based planning(varying for different typologies of cities of global south – arid, semi arid, coastal, hilly, large, medium and small, etc.), within sub drainage basins, is a must. Where all the storm water from that unit area(say 1sqkm or 10 sqkm) will need to be mapped and appropriate storage and recharge, as well as drainage and discharge quantification will need to be assessed. And then integrated for sub basin and then basin level of the city. This has not been done in the Drainage Master Plan for NCT of Delhi(2018)

## WATER-SENSITIVE URBAN PLANNING

Delhi stares at an imminent water and climate crisis. We also have more frequent flooding of the Yamuna River. Heat island impacts are also on the rise. Delhi's dependence on water from neighbouring states reaches higher and higher levels of unsustainability and risk of climate change and politically induced shortages threatens all the other lofty economic and social development aims.

The Delhi Master Plan 2041 makes the following commitments, which are all very good:

- **Water supply rationalization to address water scarcity:** Water supply in new developments under the various policies of this Plan will be controlled to minimize additional stress on water resources;
- **Treated wastewater for non-potable uses:** 100 per cent treatment and maximum reuse of wastewater shall be encouraged in existing developments and mandatory in new developments;
- **Low water consumption plumbing fixtures;**
- **Optimizing bulk reuse of wastewater generated in the city;**
- **Maximizing retention of storm water; and**
- **Improving efficiency of water systems.**

However these strategies are lacking in prioritization. What each of these strategies will contribute to augmenting what percentage increase/substitution of water availability for Delhi to achieve its target of 1,500 MGD is also not clear.

## DRAFT WATER POLICY FOR DELHI, 2016 (DELHI JAL BOARD)

Water supply in Delhi is highly iniquitous.

"Zonal water distribution is highly variable with Delhi Cantt. Getting 509 LPCD, NDMC area pegged at 440 LPCD, and areas of outer Delhi getting as little as 40 LPCD. As such there is a need for spatial equity in distribution."

Re use of treated water was accorded a top priority:

Delhi is bound to return 250 MGD to River Yamuna under the Upper Yamuna Water Sharing Agreement. High Court has directed the installation of decentralized STPs [package units] in about 189 villages of Delhi and thus a decentralized, unquantified but substantial resource would be available for recharge purposes. Under National Green Tribunals orders of January, 2015.

NCT Delhi will progressively use recycled wastewater to meet its water requirement and thereby decrease its freshwater footprint. Will frame targets to increase its recycled wastewater use:

- to 35% by 2019
- to 70% by 2024
- to minimum 80% by 2026

New urbanization will be built around decentralized small footprint STPs located close to points of generation, treating upto tertiary level

Sewage [black and grey water combined] from unsewered areas will be treated to tertiary levels at suitable locations, used directly for some non-potable activities, but mainly for indirect groundwater recharge, after which it can be recovered and reused for all purposes after treatment. Treated discharge of existing STPs would be reused to the extent possible by users located in their command areas

Source: https://delhijalboard.delhi.gov.in/sites/default/files/Jalboard/universal-tab/water_policy_21112016_0.pdf

There is no follow-up direction in the Master Plan towards the strategies to be prepared while developing the Zonal Plans.

The estimated water requirement for Delhi in 2041, as per the Master Plan, is estimated to reach 1,500 MGD (million gallons a day). This estimate is based on increase in population from 2020 and by reducing the per capita water supply; hence there is a risk that this may not be achieved.

In absolute terms, it is not clear how increasing the 2021 level of water supply by 50 per cent (in 2041), primarily from water supplied by Himachal, Uttar Pradesh and Haryana, can be justified as a worthy strategy to achieve water security for Delhi or make Delhi water-sensitive.

There is more than a 100 million litre of storm water (from just one high-intensity rain episode) just from Sangam Vihar, which currently cannot be tapped.

Instead, the Delhi Master Plan 2041 makes only pedantic declarations of intent: *'The Master Plan advocates an integrated urban water management approach and provides inter-connected strategies in the three major water-related infrastructure sectors, namely water supply, sewerage and drainage. While interventions under this approach can incrementally move the city towards being water secure continued efforts shall be made by concerned authorities to procure raw water through inter-state agreements for meeting the city's requirement.'*

These 'inter connected strategies' for the water supply-sewerage-drainage sectors are nowhere to be seen in the Delhi Master Plan of 2041 or in directions it gives for the Zonal Planning stage. The Master Plan is silent on:

- What is the strategy for drainage improving ground water recharge, by how much?
- How will the demand for raw water be reduced by improved sewerage system efficiency, while simultaneously expanding sewerage connectivity (given that current sewerage connectivity of Delhi is close to 60 per cent only) and the related increased demand for water? How to monitor and measure this?
- What is the 'incremental water security' what is the quantification for the same?

Sangam Vihar is one among several unplanned settlements of Delhi. They feature nowhere in the Master Plan thinking of Delhi, as part of the above mentioned strategies. Unless this is done, we cannot talk of water-sensitive or climate-resilient cities framing for Delhi or for any of our large metro cities.

## RECOMMENDATIONS

### 1. Reimagining decentralized water supply and its urgent augmentation priority for Sangam Vihar

Water supply deficiency of Sangam Vihar is as high 67 per cent (as against a formal supply-norm of 135 lpcd).

Low volume of per capital water supply, affordability and water quality issues have all contributed to the rise of a 'water mafia' that extracts rent in the water supply distribution networks. The so-called 'water mafia' in Sangam Vihar exists in all the three water supply sources—borewell, tankers and piped-water supply. It can be eliminated by augmenting piped-water supply.

Not only is water supply very low (45 lpcd), it is highly dependent on groundwater from borewells. Any drop in groundwater levels can lead to severe water scarcity and high economic burden.

A significant enhancement (at least doubling of the current 45 lpcd water supply) is required for Sangam Vihar. This will also be required if we are planning

any sewerage system.

### *Decentralized water supply augmentation*

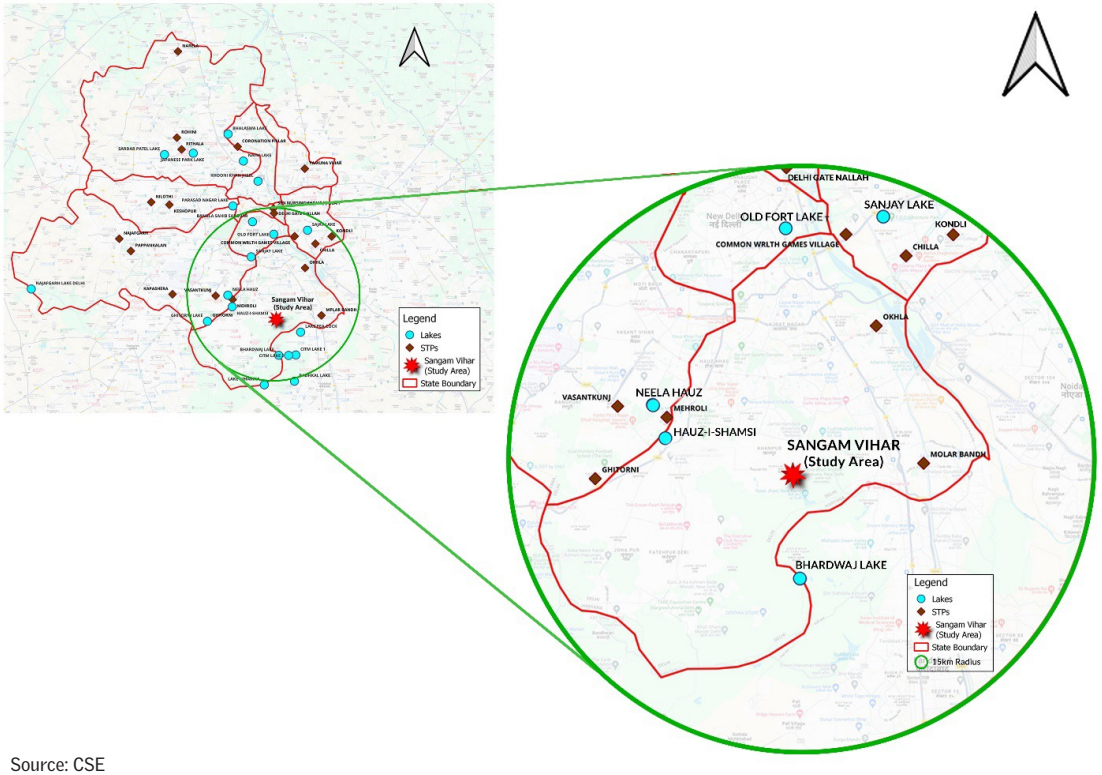
The 5 sq. km of 13 blocks of Sangam Vihar is highly concretized and built up, it does not allow for much in situ groundwater conservation and recharge. The forest areas on its peripheral boundary, with small water bodies, provide opportunity for groundwater recharge.

If decentralized STPs around Sangam Vihar (in the periphery forest and open areas) are built, the treated wastewater and storm water from Sangam Vihar itself can be used to fill the existing waterbodies to recharge the groundwater, thereby assuring groundwater supply for non-potable purposes.

A reimagined city-wide decentralized water supply system using treated wastewater for recharge of a few big lakes, and allocating them for water supply for nearby areas needs to be adopted as a strategy for a large metro city like Delhi. STPs in the vicinity of these lakes, including some big lakes near Sangam Vihar, can be a good option for assured water supply for DJB, with very little pumping cost.

Delhi has 1,045 listed waterbodies. These need to be mapped and matched with sewage treatment plants (STPs). Map 13 (on the left, Delhi map) shows 20

**Map 13: STPs and lakes surrounding Sangam Vihar**




Source: CSE

locations within Delhi where 35 sewage treatment plants (STPs) of the city are operational. Additionally, 20 lakes within or near Delhi with varied sizes have been highlighted.

Moving to the map on the right, attention is narrowed to a 15-km radius around Sangam Vihar, Delhi. Within this zone, we've depicted the spatial distribution of sewage treatment plants (STPs) and notable lakes exceeding 2 hectare (ha). Lakes meeting this size criteria are represented by blue circles—these are Haus-I-Shamsi Lake (2.85 ha), Neela Haus Lake (3.65 ha), Old Fort Lake (5.30 ha), Bhardwaj Lake (11.8 ha) and the largest lake Sanjay Lake (74.5 ha).

This visual depiction aims to locate the areas from where the treated wastewater can be attained. The bigger lakes which can be used for recharge and water supply (with secondary and tertiary treatment) to nearby colonies, planned and unplanned, have been highlighted. This way Sangam Vihar water security can also be enhanced with an assured nearby water supply from recharged lakes, instead of depending on high-cost pumping and supply from faraway sources.

## 2. Reimagining sanitation systems—combining centralized and decentralized sanitation systems

Non-sewered sanitation systems with sealed underground household-level septage holding tanks define the toilet typology of Sangam Vihar. The vast majority of these holding tanks (70 per cent) have perforated bottom linings to allow seepage and hence reduced frequency of desludging. The research has identified that more than 200 kilolitre a day (KLD) of septage desludging happens every day in Sangam Vihar. Half of this is dumped into the sewage pumping station in Dakshinpuri and carried forward for co-treatment at Sarita Vihar STP. The rest is dumped indiscriminately outside.

Sewerage systems have been installed in Sangam Vihar since 2017. These are a retrofitting solution and their current pipe dimensions may not be able to handle a full discharge from 60,000 residential dwellings when supplied with double of the existing supply of 45 LPCD of water.

The sewerage system may not get choked for low water conveyance velocity since it is a congested settlement. It may however not be able to handle more sewage than the current amount. The main trunk sewer connecting to the existing Okhla STP may not be able to handle more than the current 50 MLD of sewage generated from Sangam Vihar.

There is a risk that the existing functional non-sewered system of septage management, which is at least able to separate black water from grey water at the household level, may also break down when the entire wastewater is connected to the retrofitted sewerage system.

### *What is possible?*

The dense unplanned settlement with a population of a million-plus cannot be fully

served with a retrofitted sewerage system as is currently being tried out in Sangam Vihar. A combination of centralized (retrofitting with existing infrastructure) and additional decentralized sanitation systems for large dense unplanned settlements can be a way forward.

There is scope for a decentralized sewerage system and smaller-sized STPs to treat sewage emerging from Blocks K, L and M. Decentralized STPs can be planned around the periphery of the Sangam Vihar southern boundary in the forest area to handle at least half the sewage.

Done together, one half of Sangam Vihar connected to the existing sewerage system and another to a decentralized system, will ensure a safe, sustainable and climate-risk-proofing water and sanitation solution.

## 3. Addressing urban storm-water management for both recharge of groundwater and for discharge, to prevent in-situ urban flooding

No storm-water management planning or infrastructure is proposed for Sangam Vihar. At the street level there are small storm-water drains that currently carry grey water from households. These drains enter the three main streets of Sangam Vihar and from there to Mehrauli-Badarpur (MB) Road (for some blocks, the street drains drain into the forested areas, forming wastewater ponds).

A 15-minute mild rainfall leads to flooding on MB Road. There is no plan to utilize an estimated 117 million litre of storm water generated in a high-intensity rainfall episode in Sangam Vihar.

In the absence of any storm-water management plan, the current administrative arrangement is geared towards managing storm water only on roads where 'those who own the road, manage the storm-water drains'. The Delhi Metro Rail Corporation has been handed over this responsibility of MB Road where the new metro rail line is coming up.

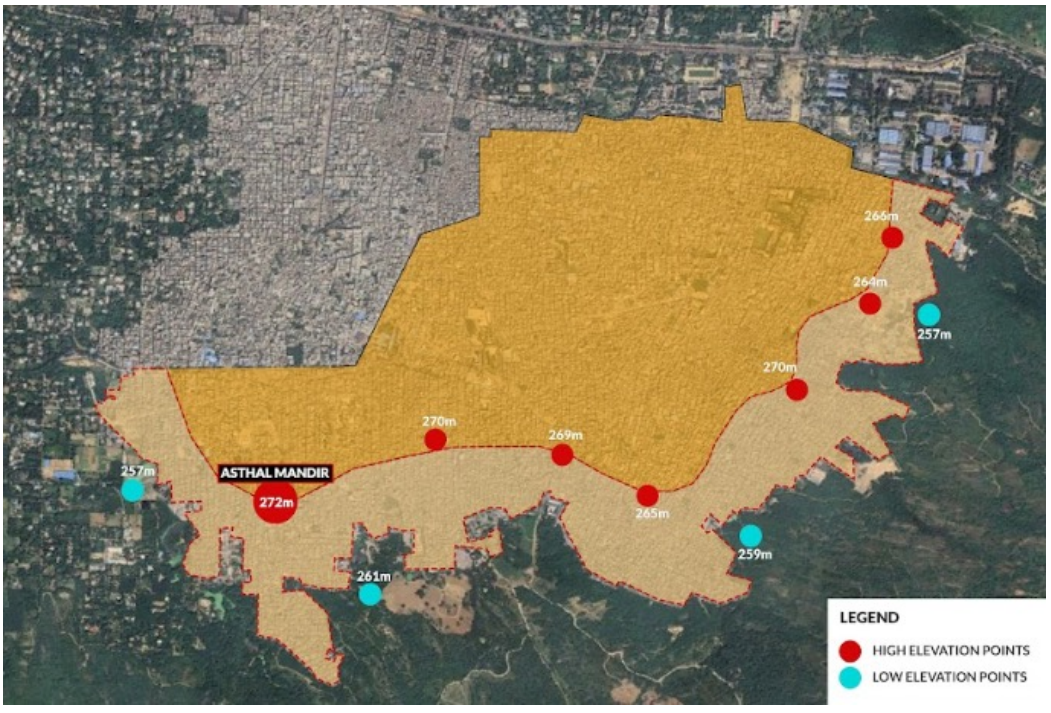
DMRC is not a suitable agency to plan for storm-water management, but it is capable of constructing larger storm-water drains and diverting the storm water to an area in the forest for groundwater recharge—which also prevents flooding—or it can divert the storm water to the Yamuna River.

For large metros and several other state capitals, there is an urgency to initiate storm-water management as a nature-based solution initiative to address high in-situ storm water runoff due to high built-up areas in these cities. To find open spaces for groundwater recharge and flood mitigation is the first priority.

The highest elevation points in the 13 blocks of Sangam Vihar have been marked (see *Map 14*).

By strategically channelling and redirecting both internal sewage (black and grey water) from the blocks, as well as storm water, on the periphery of Sangam

**Map 14: Highest elevation points in Sangam Vihar**




Source: Primary survey by CSE

Vihar (where sewer lines have not yet come) to at least four decentralized STPs can offer a long-term sustainable, climate-proof and equitable solution.

Treated wastewater from the decentralized STPs will in turn help recharge groundwater and improve water security of Sangam Vihar by diverting the water to shallow waterbodies, reducing flooding risk on the MB Road and also reducing the risk of breakdown of the retrofitted sewer lines.

This approach would alleviate pressure on MB Road infrastructure and effectively address the management of total wastewater and storm water in Sangam Vihar.

## *Centring equity and justice in the framing of a water-sensitive cities discourse and practice*

The research confirms that no city in the Global South can claim to move forward towards becoming a 'water-sensitive', 'climate-resilient' or 'sponge city' if it ignores its large, dense unplanned settlements water supply, wastewater and storm-water challenges. The four pillars of the CSE framework for 'Global South water-sensitive cities' are based on equity and justice as the goal of any intervention. It provides a guiding framework for further research on addressing emerging challenges of water in Global South cities—here a copy-paste approach of concepts will not work.

The research offers valuable insights into doing similar research studies in other dense unplanned settlements on how to identify the water, wastewater and storm-

water challenges, and a perspective of addressing infrastructure augmentation using a combination of centralized and decentralized solutions (that can be partly retrofitting and partly new infrastructure augmentation).

## SUMMARY

1. **Understanding the scale of challenges of water supply, wastewater and storm-water management in dense unplanned settlements** and applying a justice, equity and circular economy-based approach to address them
    a. Cities, especially the large metro cities are **at increasing climate-risk-induced water stress and flooding**. Large dense unplanned urban settlements, already facing a crisis of water supply, wastewater and storm-water management, will bear the brunt of climate change impact. Any approach to a 'water-sensitive' cities thinking cannot ignore a large chunk of urban population in our large metros residing in dense unplanned settlements.
    **b. Non-sewered sanitation systems** represent an effective way to address urban sanitation challenges. For large populated, dense, unplanned settlements in our metro cities, however, these systems will not be able to handle and treat the large volumes of black and grey water generated (nearly 36 MLD at the current low per capita water supply), nor address the health and safety issues of leaking underground septage tanks and the high dependence on groundwater sources of drinking water supply.
2. **Retrofitting solutions may not work for large, dense unplanned urban settlements water and sanitation infrastructure solutions** (connecting to existing sewer main lines or storm- water drainage systems). It may worsen the existing situation/system of grey and black-water management and increase the risk of failure of new retrofitted sewer pipes being unable to handle all the wastewater generated and its connectivity to the main trunk sewer line, leading to choking and spillage.
3. **Reimagining a combination of decentralized and centralized water supply, sanitation and storm-water management systems to e**nable water recharge and reuse of treated water for lakes and recharge of waterbodies, with a mix of retrofitting and decentralized STPs for dense unplanned settlements. Maximizing the scope for decentralized treatment of sewage will reduce the cost of pumping and operations that centralized systems incur by using the treated waste water to fill up localized bodies and green infrastructure.
4. **Addressing storm-water management for both conservation and discharge**. In the absence any storm-water management infrastructure, there is flooding of the main road and downstream colonies of Sangam Vihar. Delhi Metro Rail Corporation is the custodian of storm-water management on the

Mehrauli-Badarpur Road. Solutions to storm-water management will require creating drainage infrastructure and finding recharge points close to Sangam Vihar and addressing administrative and jurisdiction challenges.

5. **A significant enhancement of water supply is needed to bridge the current water-supply deficit of Sangam Vihar**. This will also be required for the working of a sewerage system.
6. **Enhancing groundwater security through ex-situ water conservation**. Not only is the water supply very low (45 lpcd) in Sangam Vihar, it is highly dependent on groundwater from borewells. Any drop in groundwater levels can lead to severe water scarcity and high economic burden. A large built-up area of the 5 sq. km area of 13 blocks of Sangam Vihar does not allow for in-situ groundwater conservation and recharge. The forest areas perhaps provides, on its peripheral boundary, the recharge of the Sangam Vihar groundwater table. This needs to be studied and recharge points identified and waterbodies created around them for improving groundwater recharge.
7. **New policy and mission for dense unplanned settlements?** While calling out for a new policy, programme or mission to address water supply, sanitation and storm-water challenges for large, densely populated urban settlements looks attractive, what is really needed is a reimagined city-wide water supply as well as and sanitation and storm-water management of large metro cities, which is exacerbated by climate change and the diminishing capacity of the cities to conserve water. These are too large settlements and finding solutions will need a city-wide approach. Ex-situ water-supply augmentation and ex-situ storm-water management solutions for blue-green infrastructure will require a relook at how we manage water supply at the city level, how we can reuse treated wastewater for groundwater recharge, where and what decentralized solutions will work along with centralized systems, and how we address both water conservation as well as drainage to prevent urban in-situ flooding. Appropriate institutional makeover of Water Utilities and other departments will be required for this to take place.

# ANNEXURES

## ANNEXURE 1: RESEARCH QUESTIONS

Research questions were developed theme-wise (water, sanitation and storm water along with social aspects) to better formulate the study methodology. Each research question has a set of sub-questions, which have been elaborated in the survey questionnaires.

### Water

The key research questions formulated in the water aspect are as follows:

1. What are the different water sources available in Sangam Vihar? What is the percentage share of a particular water source in meeting the water needs of residents in Sangam Vihar?
2. What are the current challenges and obstacles people are encountering in accessing and using this specific water source?
3. To what extent is the major portion of the population in dense urban settlements dependent on groundwater as their primary source of water for various domestic purposes?
4. What are the people's perspectives on the effectiveness of government initiatives addressing water challenges in Sangam Vihar?
5. How do social factors, such as community dynamics, gender roles, and socioeconomic status, influence water access, usage patterns, and perceptions of water quality in unauthorized settlements similar to Sangam Vihar?

### Sanitation

The key research questions formulated with regard to the sanitation aspect are as follows:

1. What is the status of existing household-level sanitation systems—septic tanks and internal plumbing—the current desludging systems and economy?
2. What are the potential benefits and challenges (at household level and for the entire Sangam Vihar) of connecting the household sanitation systems with the sewer systems being installed by the Delhi Jal Board?
3. Will the planned augmentation of sewered systems address the load of all grey and black water?
4. Will the benefits be inclusionary for the most marginal communities of Sangam Vihar?
5. Will the existing main sewerage infrastructure of the Okhla STP sewerage system be able to handle the Sangam Vihar sewerage load?

## Storm water

The key research questions formulated for the storm-water aspect are as follows:

1. Understanding the present condition of:
    i. Street-level storm-water drainage
    ii. Catchment area drainage: all blocks of Sangam Vihar
    iii. Combined-sewer drainage in some areas

What is the status? How the ongoing sewerage augmentation in Sangam Vihar addressing storm water drainage?

2. Undertaking a drainage mapping of Sangam Vihar to understand current and future storm-water drainage challenges;
3. Identifying existing storm-water drainage manual norms and plans for all cities and for Delhi; and
4. Identifying potential opportunities, if any, for harvesting storm water for conservation and recharge around and within Sangam Vihar or at distant places with the support of augmented grey infrastructure.

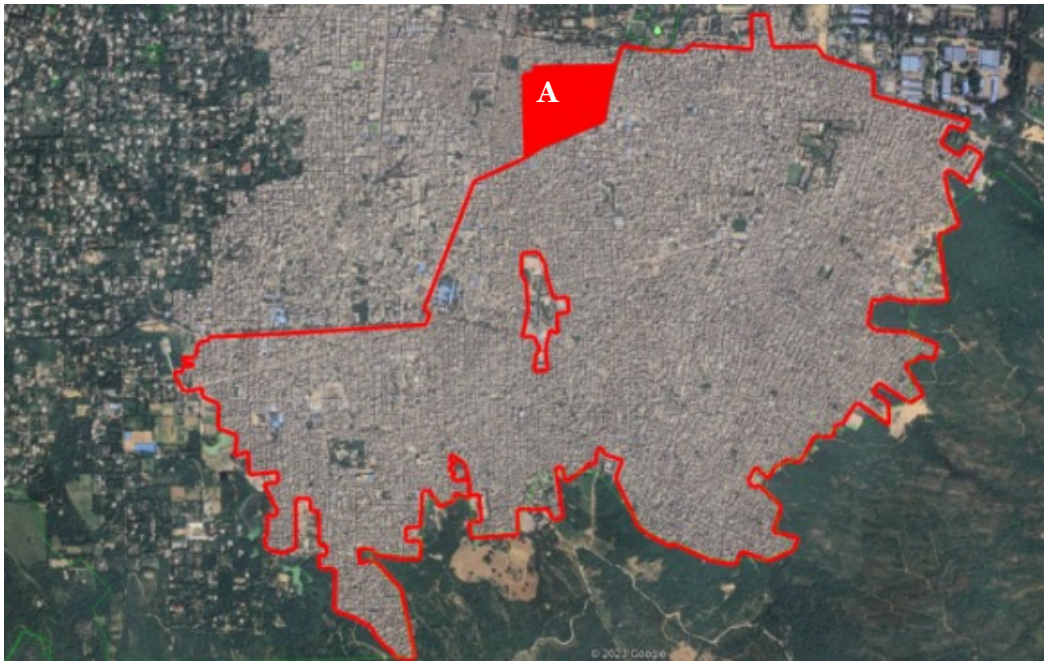
## ANNEXURE 2: BLOCK-WISE ANALYSIS

**Annexure 2:** Block-wise analysis (Block A to Block M of Sangam Vihar)

### BLOCK A

Block A is situated in the north of Sangam Vihar and is spread over an area of 27.5 acre. It accommodates a total of 2,840 households, with a population of 17,040 individuals, the majority of which are Hindu, comprising approximately 83 per cent of the population. Muslims constitute around 17 per cent of the religious demographic.

A significant portion of the population, the majority, has been residing in the area for more than a decade, indicating long-standing residency. A smaller segment of the population, however, is also estimated to have been residing for a duration of five to ten years, suggesting a recent influx of residents into the community.




*Map showing Block A of Sangam Vihar*

| SOCIOECONOMIC PROFILE | |
|---|---|
| Population | 17,040 |
| Area | 27.5 acre |
| Number of households | 2,840 |
| Population residing in Sangam Vihar | 17%: 5–10 years<br>83%: more than 10 years |

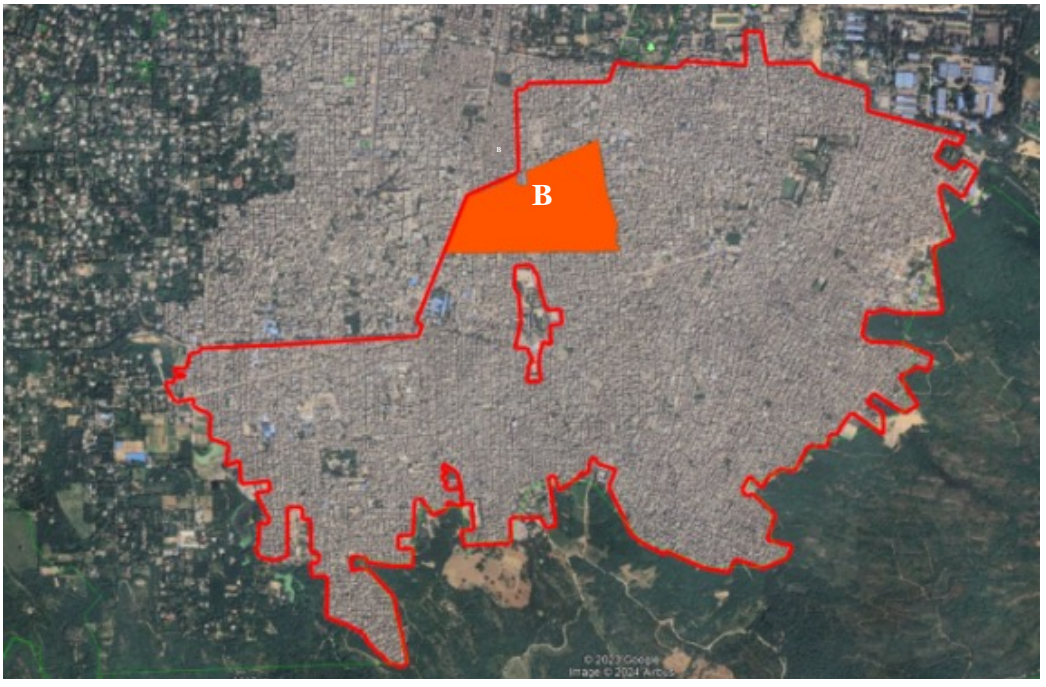
| | |
|---|---|
| No. of residents per dwelling unit | 34%: 0–5 members<br>33%: 5–10 members<br>33%: more than 10 members |
| Different types of occupation | 33%: Shopkeeper<br>17%: Wood contractor<br>50%: Self-employed |
| Monthly income distribution | 17%: Rs 25,000–50,000<br>83%: Not disclosed |
| Housing typology | Self-owned but unauthorized: 50%<br>Self-owned but authorized: 50% |
| Height of the building | 17%: Ground floor;<br>50%: G+1<br>33%: G+2 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties. |
| WATER SUPPLY | |
| Total water consumption | 994,000 litre (as per CSE's analysis) |
| Total water demand | 2,300,400 litre (as per CSE's analysis) |
| Water deficit | 1,306,400 litre (as per CSE's analysis) |
| Primary sources of non-potable water | 56%: Sonia Vihar pipeline<br>31%: community bore-wells<br>7%: private tankers<br>6%: DJB tankers |
| Primary source of potable water | 58% of the population purchases bottled water |
| Drinking water treatment facilities | 88% households lack such facilities.<br>12% of the households have invested in RO systems |
| Frequency of water supply through borewell | 13%: Every alternate day<br>13%: Weekly<br>62%: Every 15 days<br>12%: Not supplied |
| Sonia Vihar pipeline water supply timing | 10 minutes to three hours daily or on alternate days |
| Borewell pipeline water supply timing | Two to four hours |
| People's perspective: How satisfied are you with the level of water supply? | Highly satisfied: 58%<br>Moderately satisfied: 36%<br>Not satisfied: 6% |
| Total storage capacity of the storage tanks on the property (in per cent) | 80% overhead tanks<br>5% underground tanks<br>15% drums or tanks located on streets |
| Total storage capacity of the storage tanks of the property (in litre) | 2,000 L: 70%<br>3,000 L: 18%,<br>5,000 L: 6%<br>6,000 L: 6% |
| Water level in block A | 400–500 feet |
| Average monthly spending on potable water of your household (in Rs) | Below 400: 44%<br>400–800: 31%<br>800–1,200: 12%<br>Above 1,200: 13% |

| | |
|---|---|
| Average monthly spending on non-potable water of your household (in Rs) | Below 400: 41%<br>400–800: 23%<br>800–1,200: 24%<br>Above 1200: 12% |
| Quality of water supply | No discoloration or smell, tastes fine: 88%<br>Discoloration and/or smell and bad taste: 6%<br>Hardness: 6% |
| People's perspective: How affordable do you find the water supply? | Highly satisfied: 17%<br>Moderately satisfied: 34%<br>Not satisfied: 50% |
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet: 95%<br>Underground septic tanks with an effluent discharge outlet: 5% |
| Types of septic tank construction | Unlined bottoms: 60%<br>Fully lined: 40% |
| Septic tank outfall is connected to | No outfall: 69%<br>Soak pit without outfall: 31%<br>Soak pit with outfall – 0% |
| Septic tank emptying duration | 6–12 months: 44%<br>1–3 years: 19%<br>More than 10 years: 37% |
| Reason(s) for emptying the septic tank | Not emptied: 23%<br>Blocked toilet/backflow: 6%<br>Overflow from access hole: 12%<br>Regular emptying as safe practice: 59% |
| Annual cost of emptying the septic tank | Less than 1,000: 29%<br>1,000–1,500: 53%<br>1,500–3,000: 18% |
| Sewer line near households | Most sewer lines are approximately a year old, with some being newly laid and completely unavailable in other parts of Block A |
| Benefits of new sewer line | Will not pay for annual desludging fee: 65%;<br>It will reduce choking in storm-water drains: 12%:<br>Convenience of maintaining septic tank: 6%;<br>None: 17% |
| People's perspective: Do you see any major risk in the functionality of new sewer line? | Choking of sewers during rainfall periods: 70%;<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 18%;<br>No answer: 12% |
| **STORM WATER** | |
| | |
| Type of drain | Combined drainage system in 77% of the block<br>o Open-constructed drains: 85%<br>o Covered drains: 15% |
| Frequency of cleaning of open/covered drains | Weekly: 44%<br>Quarterly: 25%<br>Monthly: 19%<br>Never: 12% |

| | |
|---|---|
| Outfall of the storm water from property | Adjacent drain and nearby sewer line |
| People's perspective: Do you see storm water stagnating on the road near your household? | 70% of residents reported experiencing stagnant storm-water near their homes<br>30% did not |
| Duration of water being drained out from streets | 30 minutes to 3 hours |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm water management: 29%<br>Reduced choking: 47%<br>None: 24% |
| People's perspective: Do you see solid waste stagnating on the road near your household? | 30% of solid waste trapped in drains near their homes<br>70% of solid waste in drains near their homes |
| People's consent: Do you give consent for using all the information for analysis | Yes |

## BLOCK B

Block B is situated in the northwest of Sangam Vihar and has an area of 59.8-acre area. It accommodates a total of 5,184 households, with a population of 31,104 individuals, the majority of which are Hindu, comprising approximately 98 per cent of the population. The Sikh population around 2 per cent of religious demographic. A significant portion of the population, presumably the majority, has been residing in the area for more than a decade, indicating long-standing residency. There is also a smaller segment of the population, estimated to be residing for less than five or five to ten years, suggesting a recent influx of residents into the community.




*Map showing Block B of Sangam Vihar*

| **SOCIOECONOMIC PROFILE** | |
|---|---|
| Population | 31,104 |
| Area | 59.8 acre |
| Number of households | 5,184 |
| Population residing in Sangam Vihar | 33%: 0–5 years<br>17%: 5–10 years<br>50%: more than 10 years |
| No. of residents per dwelling unit | 70%: 0–5 members<br>20%: 5–10 members<br>10%: more than 10 members |
| Different types of occupation | Fruit seller: 12%<br>Carpenter: 11%<br>Martial arts: 11%;<br>Petty trader (shopkeeper)<br>Bakery; 11%<br>Kabadi shop: 11%<br>Grocery shop: 11%<br>Tailor: 11%<br>Service private: 11% |
| Monthly income distribution | 8%: 10,000–25,000<br>58%: not disclosed<br>34%: no idea |
| Housing typology | Self-owned but unauthorized: 91%<br>Rented: 9% |
| Height of the building | 8%: ground floor<br>42%: G+1<br>33%: G+2<br>17%: G+3 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties. |
| **WATER SUPPLY** | |
| Total water consumption | 1,296,000 litre (as per CSE's analysis) |
| Total water demand | 4,199,040 litre (as per CSE's analysis) |
| Water deficit | 2,903,040 litre (as per CSE's analysis) |
| Primary sources of non-potable water | 33%: Sonia Vihar pipeline<br>42%: community borewells<br>17%: private tankers<br>8%: DJB tankers |
| Primary source of potable water | 57% of the population purchases bottled water |
| Drinking water treatment facilities | 90% of the households have invested in RO systems |
| Frequency of water supply through borewell | 8%: weekly<br>55%: every 15 days<br>10%: monthly<br>27% : not supplied |
| Sonia Vihar pipeline water supply timing | Three to four hours daily or on alternate days |
| Borewell pipeline water supply timing | Two to four hours |
| People's perspective: How satisfied are you with the level of water supply? | Highly satisfied: 31%<br>Moderately satisfied: 34%<br>Not satisfied: 35% |

| | |
|---|---|
| Total storage capacity of the storage tanks on the property (in per cent) | 88%: overhead tanks<br>12%: underground tanks |
| Total storage capacity of the storage tanks of the property (in litres) | 2,000 L: 42%<br>3,000 L: 25%<br>4,000 L: 17%<br>5,000 L: 8%<br>6,000 L: 8% |
| Water level in block B | 400–500 feet |
| Average monthly spending on potable water of your household (in Rs) | Below 400: 8%<br>400–800: 25%<br>800–1,200: 50%<br>Above 1,200: 17% |
| Average monthly spending on non-potable water of your household (in Rs) | Below 400: 25%<br>400–800: 33%<br>800–1,200: 25%<br>Above 1,200: 17% |
| Quality of water supply | No discoloration or smell, tastes fine: 67%<br>Discoloration and/or smell and bad taste: 8%<br>When stored for long, taste and colour affected: 8%<br>Hardness of water: 17% |
| People's perspective: How affordable do you find the water supply? | Highly satisfied: 16%<br>Moderately satisfied: 50%<br>Not satisfied: 34% |
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet: 77%<br>Underground septic tanks with an effluent discharge outlet: 23% |
| Types of septic tank construction | Unlined bottoms: 77%<br>Fully lined: 23% |
| Septic tank outfall is connected to | No outfall: 46%<br>Soak pit without outfall: 45%<br>Soak pit with outfall: 9% |
| Septic tank emptying duration | 6–12 months: 12%<br>1–3 years: 38%<br>More than 10 years: 50% |
| Reason(s) for emptying the septic tank | Not emptied: 56%<br>Blocked toilet/backflow: 33%<br>Overflow from access hole: 11% |
| Annual cost of emptying the septic tank | Less than 1,000: 33%<br>1,000–1,500: 42%<br>No answer: 25% |
| Sewer line availability near households | Most sewer lines are approximately a year old, with some newly laid. They are completely unavailable in other parts of Block B |
| Benefits of new sewer line | Will not pay for annual desludging fee: 42%<br>It will reduce choking in storm water drains: 42%<br>Convenience of maintaining septic tank: 16% |
| People's perspective: Do you see any major risk in the functionality of a new sewer line? | Choking of sewers during rainfall periods: 83%<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 17% |

| STORM WATER | |
|---|---|
| Type of drain | Combined drainage system in 77% of the block<br>o Open-constructed drains: 75%<br>o Covered drains: 25% |
| Frequency of cleaning of open/covered drains | Weekly: 50%<br>Quarterly: 20%<br>Monthly: 20%<br>Never: 10% |
| Outfall of the storm water from property | Adjacent drain and nearby sewer line |
| People's perspective: Do you see storm water stagnating at road, near to your HH | 50% of residents reported experiencing stagnant storm-water near their homes<br>50% did not |
| Duration of water being drained out from streets | 30 minutes to 2 hours |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm-water management: 50%<br>Reducd choking: 33%<br>None: 17% |
| People's perspective: Do you see solid waste stagnating on the road near your household? | 45% of solid waste trapped in drains near their homes<br>55% of solid waste in drains near their homes |
| People's consent: Do you give consent for using all the information for analysis? | Yes |

## BLOCK C

Block C is situated in the northwest of Sangam Vihar over an area of 68.8 acre. It accommodates a total of 10,880 households, with a population of 62,280


*Map showing Block C of Sangam Vihar*

individuals, the majority of which are Hindu, comprising approximately 50 per cent of the population. Muslims comprise 22 per cent, Sikh 7 per cent, Christian 7 per cent, and not disclosed around 14 per cent of the religious demographic.

A significant portion of the population, presumably the majority, has been residing in the area for more than a decade, indicating long-standing residency. There is, however, also a smaller segment of the population estimated to be residing for five to ten years, suggesting a recent influx of residents into the community.

| **SOCIOECONOMIC PROFILE** | |
|---|---|
| Population | 62,280 |
| Area | 68.8 acre |
| Number of households | 10,880 |
| Population residing in Sangam Vihar | 43%: 5–10 years<br>57%: more than 10 years |
| Number of residents per dwelling unit | 40%: 0–5 members<br>30%: 5–10 members<br>30%: more than 10 members |
| Different types of occupation | Labour supplier: 7%<br>Self-employed: 7%<br>Homemaker: 15%<br>Shopkeeper: 22%<br>Kabadi shop: 7%<br>Auto mechanic: 7%<br>Service private: 7%<br>Tailor: 7%<br>Driver: 7%<br>Retired: 7%<br>Carpenter: 7% |
| Monthly income distribution | 7%: 10,000–25,000<br>86%: not disclosed<br>7%: no idea |
| Housing typology | Self-owned but unauthorized: 81%<br>Rented: 19% |
| Height of the building | 14%: ground floor<br>65%: G+1<br>14%: G+2<br>7%: G+3 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties |
| **WATER SUPPLY** | |
| Total water consumption | 2,720,000 litre (as per CSE's analysis) |
| Total water demand | 8,407,800 litre (as per CSE's analysis) |
| Water deficit | 5,687,800 litre (as per CSE's analysis) |
| Primary sources of non-potable water | 35%: Sonia Vihar pipeline: 65%: community borewells |

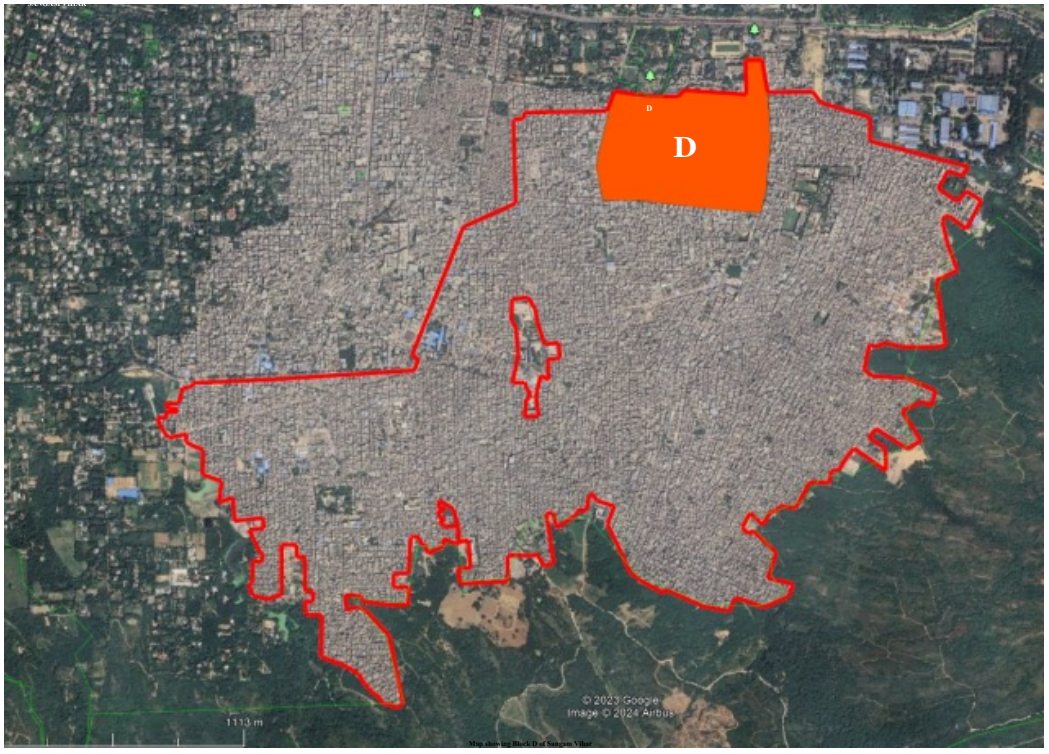
| | |
|---|---|
| Primary source of potable water | 60% of the population purchases bottled water |
| Drinking water treatment facilities | 10% of households have invested in RO systems |
| Frequency of water supply through borewell | 25%: weekly; 75%: every fifteen days |
| Sonia Vihar pipeline water supply timing | Three to four hours daily or until tank full |
| Borewell pipeline water supply timing | Two to four hours |
| People's perspective: How satisfied are you with the level of water supply? | Highly satisfied:10%<br>Moderately satisfied: 20%<br>Not satisfied: 70% |
| Total storage capacity of the storage tanks on the property (in per cent) | 65% overhead tanks<br>15% underground tanks<br>20% drums or tanks located on streets |
| Total storage capacity of the storage tanks of the property (in litre) | 2,000 L: 15%<br>3,000 L: 70%; 4,000 L: 15% |
| Water level in block C | 400–500 feet |
| Average monthly spending on potable water of your household (in Rs) | Below 400: 55%; 400–800: 35%;<br>800–1,200: 10% |
| Average monthly spending on non-potable water of your household (in Rs) | Below 400: 45%<br>400–800: 40%<br>800–1,200: 15% |
| Quality of water supply | No discoloration or smell, tastes fine: 36%; Discoloration, smell or bad taste: 45%;<br>When stored for long, it effects the taste and colour: 19% |
| People's perspective: How affordable do you find the water supply? | Highly satisfied: 63%<br>Moderately satisfied: 17%<br>Not satisfied: 20% |
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet: 98%; underground septic tanks with an effluent discharge outlet: 2% |
| Types of septic tank construction | Unlined bottoms: 85%; fully lined: 15% |
| Septic tank outfall is connected to | No outfall |
| Septic tank emptying duration | Last six months: 28%; one to three years: 72% |
| Reason(s) for emptying the septic tank | Not emptied: 22%<br>Blocked toilet/backflow: 60%<br>Overflow from access hole: 18% |
| Annual cost of emptying the septic tank | Less than Rs 1,000:10%<br>Rs 1,000–1,500: 60%<br>Rs 1,500–3,000: 30% |
| Sewer line near households | Yes |

| | |
|---|---|
| Benefits of new sewer line | Will not pay for annual desludging fee: 45%<br>It will reduce choking in storm water drains: 30%<br>Convenience of maintaining septic tank: 25% |
| People's perspective: Do you see any major risk in the functionality of the new sewer line? | Choking of sewers during rainfall periods: 65%<br>Choking of sewers during rainfall periods: 20%<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 15% |
| **STORM WATER** | |
| | |
| Type of drain | Open-constructed drains: 90%<br>Covered drains: 10%. |
| Frequency of cleaning of open/covered drains | Quarterly: 15%<br>Monthly: 55%<br>Never: 15%<br>Yearly: 15% |
| Outfall of the storm water from property | Adjacent drain and nearby sewer line |
| People's perspective: Do you see storm water stagnating at road, near to your household? | No |
| Duration of water being drained out from streets | 30 minutes to three hours |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm-water management: 80%<br>Reduced choking: 20% |
| People's perspective: Do you see solid waste stagnating on the road near your household? | Sometimes |
| People's consent: Do you give consent for using all the information for analysis? | Yes |

## BLOCK D

Block D is geographically situated in the north of Sangam Vihar and spread over an area of 85.9 acre. It accommodates a total of 14,482 households, with a population of 86,892 individuals, the majority of whomn are Hindus, comprising approximately 88 per cent of the population. Muslims constitute around 12 per cent of the religious demographic.

A significant portion of the population, presumably the majority, has been residing in the area for more than a decade, indicating long-standing residency. However, there is also a smaller segment of the population, estimated to be residing for a duration of five to ten years and less than five years, suggesting a recent influx of residents into the community.




*Map showing Block D of Sangam Vihar*

| **SOCIOECONOMIC PROFILE** | |
|---|---|
| Population | 86,892 |
| Area | 85.9 acre |
| Number of households | 14,482 |
| Population residing in Sangam Vihar | 5%: 0–5 years; 10%: 5–10 years; 85%: more than 10 years |
| No. of residents per dwelling unit | 35%: 0–5 members; 40%: 5–10 members; 25%: more than 10 members |
| Different types of occupation | Auto-rickshaw driver: 11 %<br>Driver: 11%:<br>Kabadi shop: 5%<br>Dhobi: 5%<br>Dairy: 5%<br>Petty trader (shopkeeper) 45%<br>Daily wage labourer: 6%<br>Retired: 6%<br>Unemployed: 6% |
| Monthly income distribution | 29%: Rs 10,000–25,000<br>71%: not disclosed |
| Housing typology | Self-owned but unauthorized: 70%<br>Self-owned but unauthorized: 5%<br>Rented: 25% |

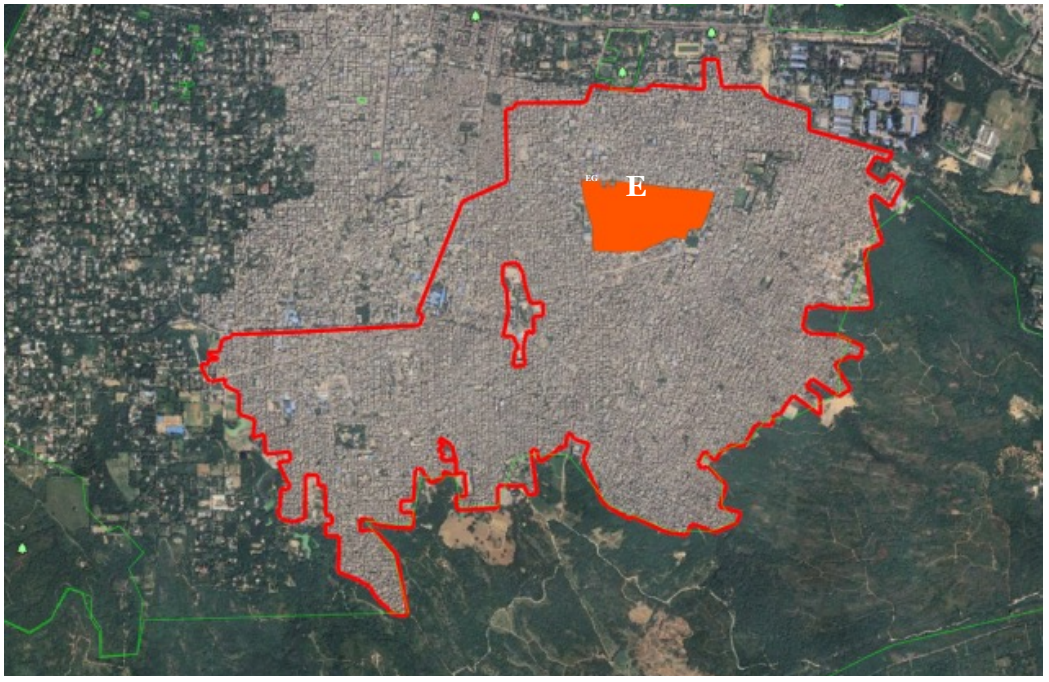
| | |
|---|---|
| Height of the building | 6%: ground floor<br>53%: G+1<br>41%: G+2 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties |
| **WATER SUPPLY** | |
| Total water consumption | 3,153,600 litre (as per CSE's analysis) |
| Total water demand | 6,386,040 litre (as per CSE's analysis) |
| Water deficit | 3,232,440 litre (as per CSE's analysis) |
| Primary sources of non-potable water | 53%: Sonia Vihar pipeline; 29%: community borewells; 6%: private tankers; 6%: DJB tankers: 6%: private borewell |
| Primary source of potable water | 70% of the population purchases bottled water |
| Drinking-water treatment facilities | 35% of the households have invested in RO systems |
| Frequency of water supply through borewell | 30%: every alternate day; 70%: weekly |
| Sonia Vihar pipeline water supply timing | 10 minutes to three hours daily |
| Borewell pipeline water supply timing | Two to four hours |
| People's perspective: How satisfied are you with the level of water supply? | Highly satisfied: 68%; moderately satisfied: 22%; not satisfied: 10% |
| Total storage capacity of the storage tanks on the property (in per cent) | 60%: overhead tanks<br>40%: underground tanks |
| Total storage capacity of the storage tanks of the property (in litre) | 2,000 L: 70%<br>3,000 L: 15%<br>5,000 L: 10%<br>25,000 L: 5% |
| Water level in block D | 400–500 feet |
| Average monthly spending on potable water of your household (in Rs) | 400–800: 65%<br>800–1,200: 35% |
| Average monthly spending on non-potable water of your household (in Rs) | Below 400: 30%<br>Not spending: 70% |
| Quality of water supply | No discoloration or smell, tastes fine: 75<br>hardness: 25% |
| People's perspective: How affordable do you find the water supply? | Moderately satisfied: 34%<br>Not satisfied: 66% |
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet: 70%<br>Underground septic tanks with an effluent discharge outlet: 30% |
| Types of septic tank construction | Unlined bottoms: 72%<br>Fully lined: 28% |
| Septic tank outfall is connected to | No outfall: 62%<br>Soak pit without outfall: 30%<br>Soak pit with outfall: 8% |
| Septic tank emptying duration | Last six months: 58%<br>6–12 months: 22%<br>More than 10 years: 20% |

| | |
|---|---|
| Reason(s) for emptying the septic tank | Not emptied: 23%<br>Regular emptying as safe practice: 77% |
| Annual cost of emptying the septic tank | Less than Rs 1,000: 5%<br>Rs 1,000–1,500: 30%<br>Rs 1,500–3,000: 55%<br>More than 3,000: 10% |
| Sewer line near households | Yes: 60%<br>No: 40% |
| Benefits of new sewer line | Will not pay for annual desludging fee: 39%<br>It will reduce choking in storm water drains: 39%<br>None: 22% |
| People's perspective: Any major risk you see in the functionality of new sewer line | Choking of sewers during rainfall periods: 42%<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 58% |
| **STORM WATER** | |
| Type of drain | Open-constructed drains are available. |
| Frequency of cleaning of open/covered drains | Weekly: 55%<br>Never: 45% |
| Outfall of the storm water from property | Adjacent drain and nearby sewer line |
| People's perspective: Do you see storm water stagnating on the road near your household? | Yes |
| Duration of water being drained out from streets | 30 minutes to three hours |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm-water management: 75%<br>Reduced choking: 10%<br>None: 15% |
| People's perspective: Do you see solid waste stagnating on the road near your household? | Yes: 80%<br>Sometimes: 20% |
| People's consent: Do you give consent for using all the information for analysis | Yes |

## BLOCK E

Block E is situated in the central part of Sangam Vihar and spread over an area of 43.3 acre. It accommodates a total of 3,834 households, with a population of 46,008 individuals, the majority of whom are Hindu, comprising approximately 85 per cent of the population. Muslims constitute around 15 per cent of the religious demographic.

A significant portion of the population has been residing in the area for more than a decade, indicating long-standing residency. There is also a smaller segment of the population, estimated to be residing for a duration of five to ten years, suggesting a recent influx of residents into the community.




*Map showing Block E of Sangam Vihar*

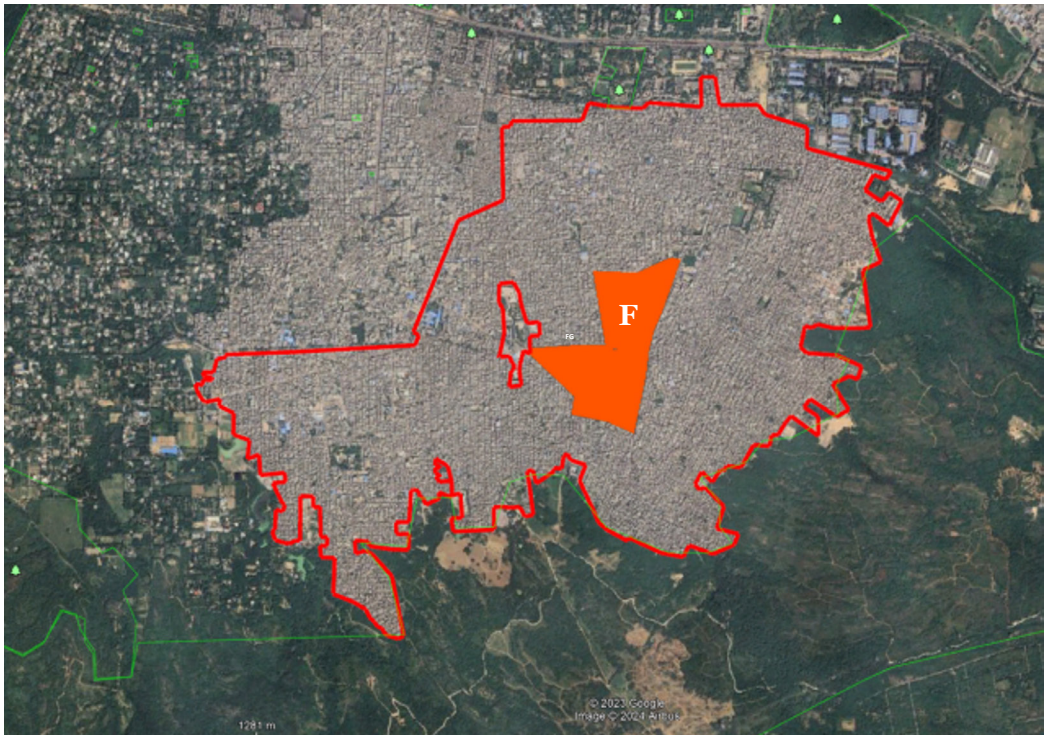
| **SOCIOECONOMIC PROFILE** | |
|---|---|
| Population | 46,008 |
| Area | 43.3 acre |
| Number of households | 3,834 |
| Population residing in Sangam Vihar | 0–5 years: 14%<br>5–10 years: 29%<br>More than 10 years: 57% |
| Number. of residents per dwelling unit | 0–5 members: 10%<br>5–10 members: 65%<br>More than 10 members: 25% |
| Different types of occupation | Shopkeeper: 57%<br>Vegetable seller: 14%<br>Tailor: 29% |
| Monthly income distribution | 14%: no idea<br>86%: not disclosed |
| Housing typology | Self-owned but unauthorized: 60%<br>Rented: 40% |
| Height of the building | 14%: Ground floor<br>14%: G+1<br>43%: G+2<br>29%: G+3 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties. |
| **WATER SUPPLY** | |
| Total water consumption | 5,068,700 litre (as per CSE's analysis) |

| | |
|---|---|
| Total water demand | 11,730,420 litre (as per CSE's analysis) |
| Water deficit | 6,661,720 litre (as per CSE's analysis) |
| Primary sources of non-potable water | 70%: Sonia Vihar pipeline; 30%<br>Community borewells |
| Primary source of potable water | 75% of the population purchases bottled water |
| Drinking water treatment facilities | 15% of the households have invested in RO systems |
| Frequency of water supply through borewell | 50%: daily<br>50%: weekly |
| Sonia Vihar pipeline water supply timing | 10 minutes to three hours daily or on alternate days |
| Borewell pipeline water supply timing | Two to four hours |
| People's perspective: How satisfied are you with the level of water supply? | Highly satisfied: 60%<br>Moderately satisfied: 35%<br>Not satisfied: 5% |
| Total storage capacity of the storage tanks on the property (in per cent) | 60% overhead tanks<br>40% underground tanks |
| Total storage capacity of the storage tanks of the property (in litre) | 2,000 L: 55%<br>3,000 L: 30%<br>5,000 L: 15% |
| Water level in block E | 400–500 feet |
| Average monthly spending on Potable water of your Household (in Rs) | Below Rs 400: 20%<br>Rs 400–800: 45%<br>Rs 800–1,200: 35% |
| Average monthly spending on non-potable water of your household (in Rs) | Below 400: 80%<br>No expenditure: 20% |
| Quality of water supply | No discoloration or smell, tastes fine: 90%<br>Discoloration, smell or bad taste: 5%<br>Hardness: 5% |
| People's perspective: How affordable do you find the water supply? | Moderately satisfied: 29%<br>Not satisfied: 71% |
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet |
| Types of septic tank construction | Unlined bottoms: 10%<br>Fully lined: 45%<br>Don't know: 45% |
| Septic tank outfall is connected to | No outfall: 85%<br>Soak pit without outfall: 15% |
| Septic tank emptying duration | Last six months: 45%<br>6–12 months: 55% |
| Reason(s) for emptying the septic tank | Not emptied: 20%<br>Regular emptying as safe practice: 80% |
| Annual cost of emptying the septic tank | Rs 1,000–1,500: 62%<br>Rs 1,500–3000: 38% |
| Sewer line near households | Available |
| Benefits of new sewer line | Will not pay for annual desludging fee: 22%,<br>It will reduce choking in storm water drains: 20%<br>None: 58% |
| People's perspective: Do you see any major risk in the functionality of a new sewer line | Choking of sewers during rainfall periods: 78%,<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 22% |

| STORM WATER | |
|---|---|
| Type of drain | Open-constructed drains are 50%<br>Covered drains are 10%<br>Open drain natural 40% |
| Frequency of cleaning of open/covered drains | Daily: 15%<br>Weekly: 40%<br>Monthly: 30%<br>Never: 15% |
| Outfall of the storm water from property | Adjacent drain and nearby sewer line |
| People's perspective: Do you see storm water stagnating on the road near your household? | Yes |
| Duration of water being drained out from streets | Three to six hours |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm-water management: 68%<br>None: 32% |
| People's perspective: Do you see solid waste stagnating on the road near the household? | Yes: 85%<br>Sometimes: 15% |
| People's consent: Do you give consent for using all the information for analysis? | Yes |

## BLOCK F

Block F is situated in the central part of Sangam Vihar. The block has an area of 71.4-acre area; it accommodates a total of 5,218 households, hosting a population of 62,616 individuals the majority of this population are Hindus, comprising




*Map showing Block F of Sangam Vihar*

approximately 90 per cent of the population. Muslims constitute around 10 per cent of the religious demographic.

A significant portion of the population, presumably the majority, has been residing in the area for more than a decade, indicating long-standing residency. There is, however, also a smaller segment of the population estimated to have been residing in the block for five to ten years, suggesting a recent influx of residents into the community.

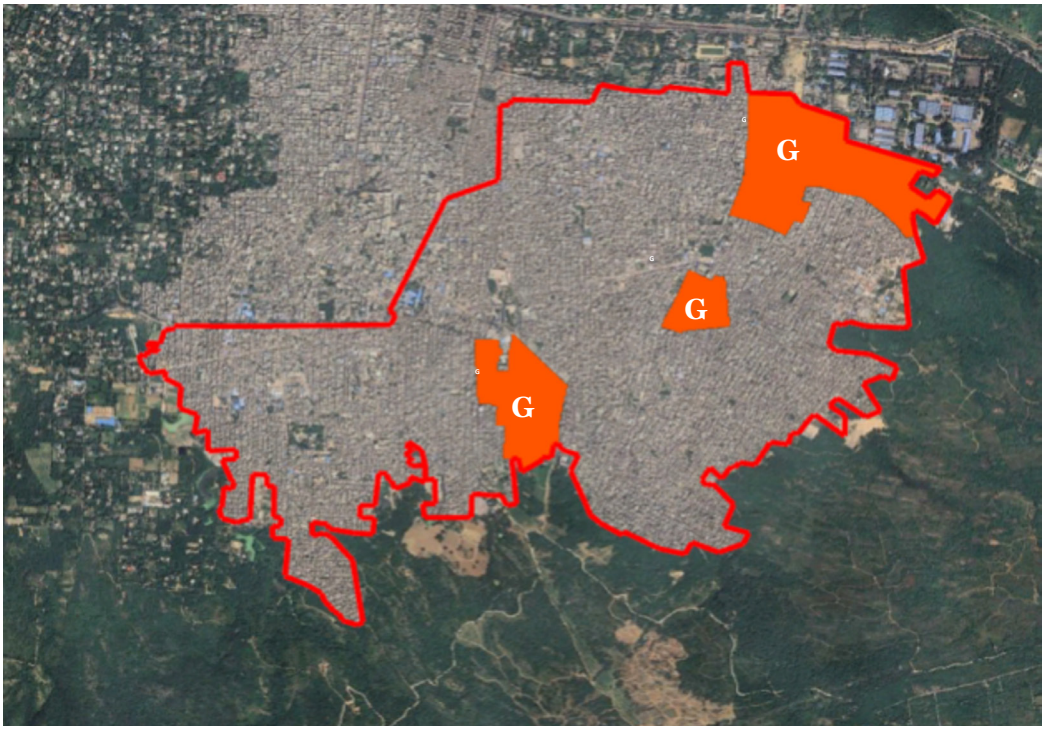
| **SOCIOECONOMIC PROFILE** | |
|---|---|
| Population | 62,616 |
| Area | 71.4 acre |
| Number of households | 5,218 |
| Population residing in Sangam Vihar | 0–5 years: 7%<br>More than 10 years: 93% |
| No. of residents per dwelling unit | 0–5 members: 11%<br>5–10 members: 14%<br>More than 10 members: 75% |
| Different types of occupation | Petty trader (shopkeeper): 58%<br>Unemployed: 14%<br>Vegetable seller; 7%<br>Maid; 7%<br>Cashier; 7%<br>Tea-seller: 7% |
| Monthly income distribution | Rs 1,000–25,000: 7%<br>Rs 25,000–50,000: 7%<br>Not disclosed: 86% |
| Housing typology | Self-owned but unauthorized: 85%<br>Rented: 15% |
| Height of the building | 7%: ground floor<br>64%: G+1<br>22%: G+2<br>7%: G+3 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties |
| **WATER SUPPLY** | |
| Total water consumption | 1,304,500 litre (as per CSE's analysis) |
| Total water demand | 8,453,160 litre (as per CSE's analysis) |
| Water deficit | 4,981,808 litres (as per CSE's analysis) |
| Primary sources of non-potable water | 22%: Sonia Vihar pipeline; 78%: community borewells |
| Primary source of potable water | 85% of the population purchases bottled water |
| Drinking water treatment facilities | 10% of the households have invested in RO systems |
| Frequency of water supply through borewell | 23%: weekly; 77%: every 15 days |
| Sonia Vihar pipeline water supply timing | 10 minutes to two hours alternate days or weakly |

| | |
|---|---|
| Borewell pipeline water supply timing | Two to four hours |
| People's perspective: How satisfied are you with the level of water supply | Highly satisfied: 62%<br>Moderately satisfied: 24%<br>Not satisfied: 16% |
| Total storage capacity of the storage tanks on the property (in per cent) | Overhead tanks |
| Total storage capacity of the storage tanks of the property (in litre) | 2,000 L: 35%<br>3,000 L: 55%<br>5,000 L: 10% |
| Water level in block F | 400–500 feet |
| Average monthly spending on potable water of your household (in Rs) | Below Rs 400: 10%<br>Rs 400–800: 25%<br>Rs 800–1,200: 40%<br>Above Rs 1,200: 10%<br>No expenditure: 15% |
| Average monthly spending on non-potable water of your household (in Rs) | Below Rs 400: 85%<br>No expenditure: 15% |
| Quality of water supply | No discoloration or smell, tastes fine: 15%<br>Discoloration or smell and bad taste:17%<br>Hardness: 68% |
| People's perspective: How affordable do you find the water supply? | Highly satisfied: 57%<br>Moderately satisfied: 28%<br>Not satisfied: 15% |
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet |
| Types of septic tank construction | Unlined bottoms: 76%<br>Don't know: 24% |
| Septic tank outfall is connected to | Soak pit without outfall |
| Septic tank emptying duration | Three to five years: 88%<br>More than 10 years: 12% |
| Reason(s) for emptying the septic tank | Not required |
| Cost of emptying the septic tank | Rs 1,500 per emptying |
| Sewer line availability near households | Yes |
| Benefits of a new sewer line | It will reduce choking in storm-water drains: 42%<br>None: 58% |
| People's perspective: Any major risk you see in the functionality of new sewer line | Choking of sewers due to solid waste entering: 24%<br>Choking of sewers during rainfall periods: 18%<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 58% |
| **STORM WATER** | |
| Type of drain | Open-constructed drains are 52%<br>Covered drains are 48% |
| Frequency of cleaning of open/covered drains | Monthly: 12%<br>Never: 88% |
| Outfall of the storm water from property | Adjacent drain and nearby sewer line |

| | |
|---|---|
| People's perspective: Do you see storm water stagnating at road, near to your household? | Yes: 70%<br>No: 30% |
| Duration of water being drained out from streets | 30 minutes to six hours |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm-water management: 55%<br>None: 45% |
| People's perspective: Do you see solid waste stagnating at road near to your household? | Yes |
| People's consent: Do you give consent for using all the information for analysis | Yes |

## BLOCK G

Block G is divided into three parts, which are geographically situated in the north, south and central part of Sangam Vihar respectively. The block has an area of 94.5 acre. It accommodates a total of 14,482 households, with a population of 86,892 individuals, the majority of whom—comprising approximately 75 per cent of the population—are Hindu. Muslims constitute around 20 per cent, while Sikhs make up about 5 per cent of the religious demographic. A significant portion of the population, presumably the majority, has been residing in the area for more than a decade, indicating long-standing residency. However, there is also a smaller segment of the population, estimated to be residing for a duration of five to ten years, suggesting a recent influx of residents into the community.




*Map showing Block G of Sangam Vihar*

| SOCIO- ECONOMIC PROFILE | |
|---|---|
| Population | 86,892 |
| Area | 94.5 acre |
| Number of households | 14,482 |
| Population residing in Sangam Vihar | 15%: 5–10 years<br>85%: more than 10 years |
| No. of residents per dwelling unit | 60%: 0–5 members<br>40%: 5–10 members |
| Different types of occupation | Vegetable seller: 6%, Carpenter: 6%<br>Working in mobile repairing shop: 6%<br>Self-employed: 11%, Auto-rickshaw driver: 12%<br>Retired: 6%, Grocery shop: 23%<br>Unemployed: 12%, Tea seller: 6%<br>Daily-wage labourer: 6%, Gas refill attendant: 6% |
| Monthly income distribution | Rs 10,000–25,000: 6%<br>No idea: 23%<br>Not disclosed: 71% |
| Housing typology | Self-owned but unauthorized: 95%<br>Rented: 5% |
| Height of the building | 23%: ground floor<br>65%: G+1<br>12%: G+2 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties. |
| **WATER SUPPLY** | |
| Total water consumption | 5,068,700 litre (as per CSE's analysis) |
| Total water demand | 11,730,420 litres (as per CSE's analysis) |
| Water deficit | 6,661,720 litres (as per CSE's analysis) |
| Primary sources of non-potable water | 53%: Sonia Vihar pipeline; 29%: community borewells; 6%: private tankers; 6%: DJB tankers; 6% private borewell |
| Primary source of potable water | 58% of the population purchases bottled water |
| Drinking water treatment facilities | 12% of the households have invested in RO systems |
| Frequency of water supply through borewell | 13%: every alternate day<br>13%: weekly<br>62%; every 15 days<br>12%: not supplied |
| Sonia Vihar pipeline water supply timing | 10 minutes to three hours daily or on alternate days |
| Borewell pipeline water supply timing | Two to four hours |
| People's perspective: how satisfied are you with the level of water supply | Highly satisfied: 58%<br>Moderately satisfied: 36%<br>Not satisfied: 6% |
| Total storage capacity of the storage tanks on the property (in per cent) | 80% overhead tanks<br>5% underground tanks<br>15% drums or tanks located on streets |

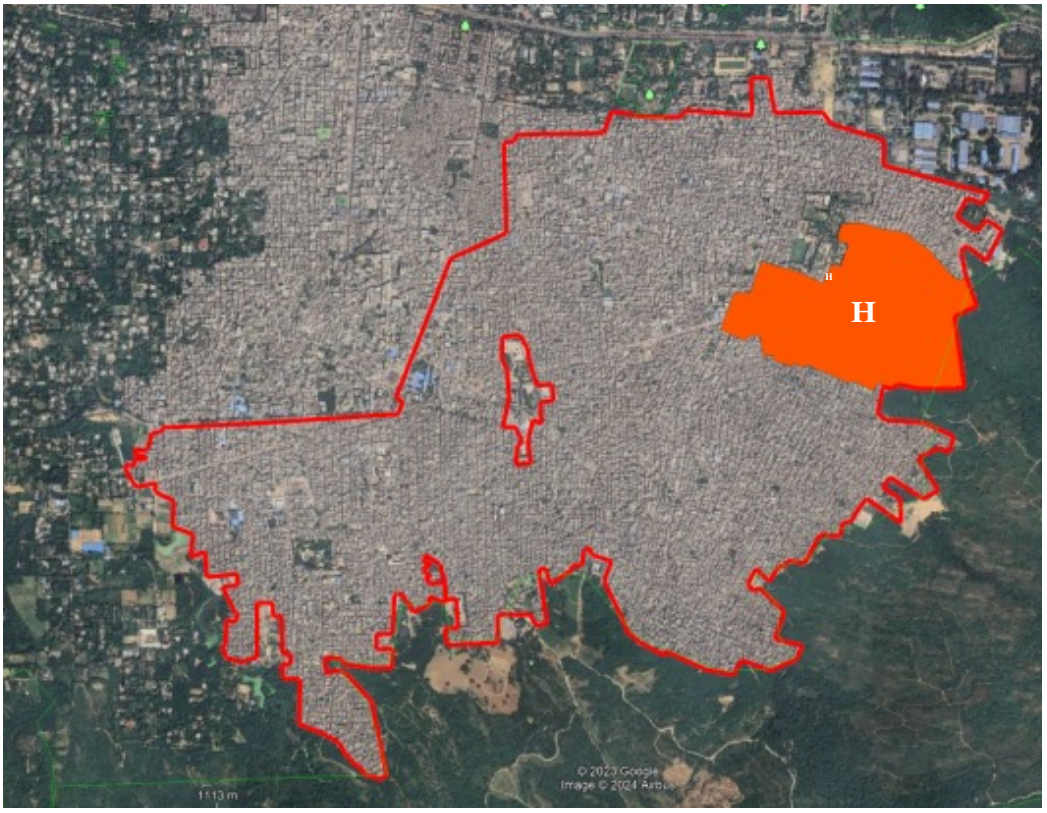
| | |
|---|---|
| Total storage capacity of the storage tanks of the property (in litre) | 2,000 L: 70%<br>3,000 L: 18%<br>5,000 L: 6%<br>6,000 L: 6% |
| Water level in block G | 400–500 feet |
| Average monthly spending on potable water of your household (in Rs) | Below Rs 400: 44%<br>Rs 400–800: 31%<br>Rs 800–1,200: 12%<br>Above 1200: 13% |
| Average monthly spending on non-potable water of your household (in Rs) | Below Rs 400: 41%<br>Rs 400–800: 23%<br>Rs 800–1200: 24%<br>Above Rs 1,200: 12% |
| Quality of water supply | No discoloration or smell, tastes fine: 88%<br>Discoloration, smell or bad taste: 6%<br>Hardness of water: 6% |
| People's perspective: How affordable do you find the water supply? | Highly satisfied: 23%<br>Moderately satisfied: 22%<br>Not satisfied: 55% |
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet: 95%<br>Underground septic tanks with an effluent discharge outlet: 5% |
| Types of septic tank construction | Unlined bottoms: 60%<br>Fully lined: 40% |
| Septic tank outfall is connected to | No outfall: 69%<br>Soak pit without outfall: 31% |
| Septic tank emptying duration | 6–12 months: 44%<br>1–3 years: 19%<br>More than 10 years: 37% |
| Reason(s) for emptying the septic tank | Not emptied: 23%<br>Blocked toilet/backflow: 6%<br>Overflow from access hole: 12%<br>Regular emptying as safe practice: 59% |
| Annual cost of emptying the septic tank | Less than 1,000: 29%<br>Rs 1,000–1,500: 53%<br>Rs 1,500–3,000: 18% |
| Sewer line availability near to household | Yes: 15%<br>No: 85% |
| Benefits of new sewer line | Will not pay for annual desludging fee: 65%;<br>It will reduce choking in storm-water drains: 12%;<br>Convenience of maintaining septic tank: 6%<br>None: 17% |
| People's perspective: Do you see any major risk in the functionality of a new sewer line? | Choking of sewers during rainfall periods: 70%<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 18%<br>No answer: 12% |

| STORM WATER | |
|---|---|
| Type of drain | Combined drainage system<br>o Yes: 77%<br>o No: 23%<br>Open constructed drains: 85%<br>Covered drains: 15% |
| Frequency of cleaning of open/covered drains | Weekly: 44%<br>Quarterly: 25%<br>Monthly: 19%<br>Never: 12% |
| Outfall of the storm water from property | The storm water from property in various parts starts from adjacent drain and nearby sewer line. |
| People's perspective: Do you see storm water stagnating on the road near your household? | 70%: yes<br>30%: no |
| Duration of water being drained out from streets | 30 minutes to three hours |
| Benefits of a new sewer line of DJB to Sangam Vihar locality | Improved storm-water management: 29%<br>Reduced choking: 47%<br>None: 24% |
| People's perspective: Do you see solid waste stagnating on the road near to your household? | 30% of solid waste trapped in drains near their homes<br>70% of solid waste in drains near their homes |
| People's consent: Do you give consent for using all the information for analysis? | Yes |

## BLOCK H

Block H is situated in the northeast of Sangam Vihar, over an area of 104 acre. It accommodates a total of 10,860 households, with a population of 65,160 individuals, the majority of whom—comprising approximately 60 per cent of the population—are Hindu. Muslims constitute around 35 per cent, while Sikhs make up about 5 per cent of the religious demographic.

A significant portion of the population, likely the majority, has been residing in the area for more than a decade, indicating long-standing residency. However, there is also a smaller segment of the population, estimated to be residing for a durations of five to ten years (20 per cent), less than five years (20 per cent), and more than 10 years (60 per cent), suggesting a recent influx of residents into the community.




*Map showing Block H of Sangam Vihar*

| **SOCIOECONOMIC PROFILE** | |
|---|---|
| Population | 65,160 |
| Area | 104 acre |
| Number of households | 10,860 |
| Population residing in Sangam Vihar | 15%: 0–5 years<br>25%: 5–10 years<br>60%: more than 10 years |
| No. of residents per dwelling unit | 70%: 0–5 members<br>25%: 5–10 members<br>5%: more than 10 members |
| Different types of occupation | Auto mechanic: 6%<br>Vegetable seller: 7%<br>Petty trader (shopkeeper): 38%<br>Grocery shop: 6%<br>Unemployed: 6%<br>Skilled worker: 6%<br>Works in bakery: 13%<br>Works in stationery: 6%<br>Works in clothes shop: 6%<br>Self-employed: 6% |
| Monthly income distribution | Not disclosed |

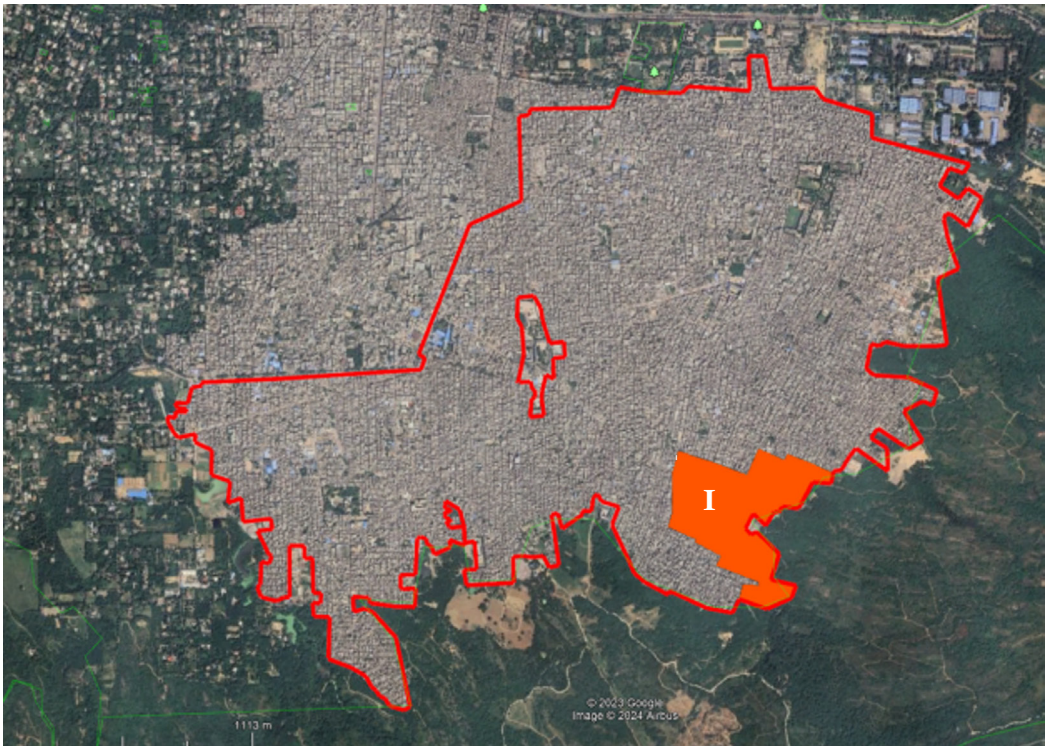
| | |
|---|---|
| Housing typology | 70%: self-owned but unauthorized<br>30%: rented |
| Height of the building | 10%: ground floor<br>70%: G+1<br>10%: G+2<br>10%: G+3 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties. |
| **WATER SUPPLY** | |
| Total water consumption | 3,801,000 litre (as per CSE's analysis) |
| Total water demand | 8,796,600 litre (as per CSE's analysis) |
| Water deficit | 4,995,600 litre (as per CSE's analysis) |
| Primary sources of non-potable water | 35%: Sonia Vihar pipeline; 60%: community borewells; 5%: private tankers |
| Primary source of potable water | 75% of the population purchases bottled water |
| Drinking water treatment facilities | 20% of the households have invested in RO systems |
| Frequency of water supply through borewell | 3%: every three days<br>6%: every alternate days<br>12%: weekly<br>57%: every fifteen days<br>22%: not supplied |
| Sonia Vihar pipeline water supply timing | 55%: 10 minutes to 3 hours daily<br>45%: until the tank and utensils are full |
| Borewell pipeline water supply timing | Two to four hours |
| People's perspective: How satisfied are you with the level of water supply? | Highly satisfied: 30%<br>Moderately satisfied: 30%<br>Not satisfied: 40% |
| Total storage capacity of the storage tanks on the property (in percent) | 90% overhead tanks<br>5% underground tanks<br>5% drums or tanks located on streets |
| Total storage capacity of the storage tanks of the property (in litre) | 2,000 L: 40%<br>3,000 L: 45%<br>5,000 L: 5%<br>15,000 L: 10% |
| Water level in block H | 400–500 feet |
| Average monthly spending on potable water of your household (in Rs) | Below Rs 400: 44%<br>Rs 400–800: 31%<br>Rs 800–1200: 12%<br>Above Rs 1,200: 13% |
| Average monthly spending on non-potable water of your household (in Rs) | Below Rs 400: 41%<br>Rs 400–800: 23%<br>Rs 800–1,200: 24%<br>Above Rs 1,200: 12% |
| Quality of water supply | No discoloration or smell; tastes fine: 88%<br>Discoloration, smell and/or bad taste: 6%<br>Hardness of water: 6% |
| People's perspective: How affordable do you find the water supply? | Highly satisfied: 40%<br>Moderately satisfied: 25%<br>Not satisfied: 35% |

| **SANITATION** | |
|---|---|
| Type of septic tank | Underground septic tanks with no effluent discharge outlet: 90% underground septic tanks with an effluent discharge outlet: 10% |
| Types of septic tank construction | Unlined bottoms: 60%<br>Fully lined: 20%<br>Don't know: 20% |
| Septic tank outfall is connected to | No outfall: 77%<br>Soak pit without outfall: 20%<br>Open drain – 3% |
| Septic tank emptying duration | Last six months: 35%<br>6–12 months: 10%<br>One to three years: 35%<br>Three to five years: 10%<br>More than 10 years:10% |
| Reason(s) for emptying the septic tank | Not emptied: 25%<br>Blocked toilet/backflow: 30%<br>Overflow from access hole: 22%<br>Regular emptying as safe practice: 23% |
| Annual cost of emptying the septic tank | Less than Rs 1,000: 15%<br>Rs 1,000–1,500: 65%<br>Rs 1,500–3,000: 20% |
| Sewer line availability near households | Yes: 20%<br>No: 80% |
| Benefits of new sewer line | Will not pay for annual desludging fee: 57%<br>It will reduce choking in storm-water drains: 20%<br>Convenience of maintaining septic tank: 10%<br>None: 13% |
| People's perspective: Any major risk you see in the functionality of new sewer line | Choking of sewers due to solid waste entering: 30%<br>Choking of sewers during rainfall periods: 60%<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 10% |
| **STORM WATER** | |
| Type of drain | Open constructed drains |
| Frequency of cleaning of open/covered drains | Weekly: 20%<br>Quarterly: 12%<br>Monthly: 65%<br>Never: 23% |
| Outfall of the storm water from property | Adjacent drain and nearby sewer line |
| People's perspective: Do you see storm water stagnating on the road near your household? | 80% of residents reported experiencing stagnant storm-water near their homes, while 20% did not. |
| Duration of water being drained out from streets | 30 minutes to six hours |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm-water management: 64%<br>Reduced choking: 22%<br>None: 14% |
| People's perspective: Do you see solid waste stagnating on the road near your household? | 65% of solid waste trapped in drains near their homes<br>35% of solid waste in drains near their homes |
| People's consent: Do you give consent for using all the information for analysis? | Yes |

## BLOCK I

Block I is situated in the south of Sangam Vihar. The block has an area of 57.3 acres area; it accommodates a total of 5,488 households, hosting a population of 65,856 individuals. The majority of this population are Hindus, comprising approximately 90 per cent of the population. Muslims constitute around 10 per cent of the religious demographic.

A significant portion of the population in Sangam Vihar Block I, comprising 60 per cent of the residents, have been residing in the area for more than a decade. This indicates long-standing residency among the majority of inhabitants. Additionally, a smaller segment, accounting for 20 per cent of the population, is estimated to have been residing in Block I for five to ten years.




*Map showing Block I of Sangam Vihar*

| SOCIOECONOMIC PROFILE | |
|---|---|
| Population | 65,856 |
| Area | 57.3 acre |
| Number of households | 5,488 |
| Population residing in Sangam Vihar | 5%: 0–5 years<br>5%: 5–10 years<br>90%: more than 10 years |

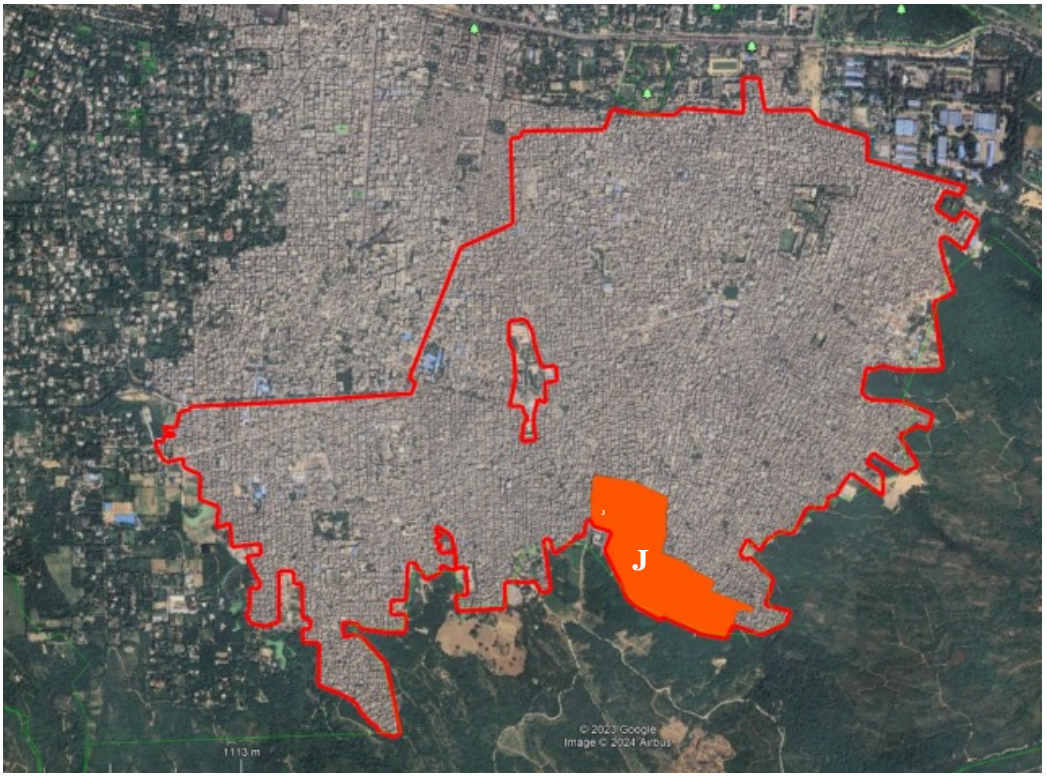
| | |
|---|---|
| No. of residents per dwelling unit | 45%: 0–5 members<br>55%: 5–10 members |
| Different types of occupation | Shopkeeper: 40%<br>Rag picker: 20%<br>Working restaurant: 20%<br>Working in bakery: 20% |
| Monthly income distribution | 20%: Rs 10,000–25,000<br>20%: Rs 25,000–50,000<br>60%: not disclosed |
| Housing typology | Self-owned but unauthorized |
| Height of the building | 15%: G+1; 85%: G+2 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties. |
| **WATER SUPPLY** | |
| Total water consumption | 2,469,600 litre (as per CSE's analysis) |
| Total water demand | 8,890,560 litre (as per CSE's analysis) |
| Water deficit | 6,420,960 litre (as per CSE's analysis) |
| Primary sources of non-potable water | Community borewells |
| Primary source of potable water | 90% of the population purchases bottled water |
| Drinking water treatment facilities | 62% of the households have invested in RO systems |
| Frequency of water supply through borewell | 35%: weekly<br>65%: every 15 days |
| Sonia Vihar pipeline water supply timing | Three to four hours or until full |
| Borewell pipeline water supply timing | Two to four hours |
| People's perspective: how satisfied are you with the level of water supply | Highly satisfied: 60%<br>Moderately satisfied: 20%<br>Not satisfied: 20% |
| Total storage capacity of the storage tanks on the property (in per cent) | 40% overhead tanks<br>40% underground tanks<br>20% drums or tanks located on streets |
| Total storage capacity of the storage tanks of the property (in litre) | 2,000 L: 25%<br>5,000 L: 35%<br>10,000 L: 40% |
| Water level in block I | 400–500 feet |
| Average monthly spending on potable water of your Household (in Rs) | Below Rs 400: 33%<br>Rs 400–800: 33%<br>Rs 800–1,200: 34% |
| Average monthly spending on non-potable water of your household (in Rs) | Below Rs 400: 37%<br>Rs 400–800: 36%<br>Above Rs 1,200: 27% |
| Quality of water supply | No discoloration or smell, tastes fine: 72%<br>When stored for long, taste and colour are affected: 28% |
| People's perspective: How affordable do you find the water supply? | Highly satisfied: 40%<br>Moderately satisfied: 20%<br>Not satisfied: 40% |

| | |
|---|---|
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet |
| Types of septic tank construction | Unlined bottoms: 50%<br>Fully lined: 50% |
| Septic tank outfall is connected to | No outfall: 80%<br>Soak pit without outfall: 20% |
| Septic tank emptying duration | One to three years: 10%<br>Three to five years: 15%<br>More than 10 years: 75% |
| Reason(s) for emptying the septic tank | Not emptied: 50%<br>Blocked toilet/backflow: 25%<br>Overflow from access hole: 25% |
| Annual cost of emptying the septic tank | Less than Rs 1,000: 10%<br>Rs 1,000–1,500: 25%<br>Rs 1,500–3,000: 75% |
| Sewer line availability near households | No |
| Benefits of new sewer line | Will not pay for annual desludging fee: 35%<br>It will reduce choking in storm water drains: 10%<br>Convenience of maintaining septic tank: 35%<br>None: 20% |
| People's perspective: Do you see any major risk in the functionality of a new sewer line | Choking of sewers during rainfall periods: 22%;<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 68%<br>No answer: 10% |
| **STORM WATER** | |
| Type of drain | Open-constructed drains are 85% and covered drains are 15%. |
| Frequency of cleaning of open/covered drains | Weekly: 20%<br>Quarterly: 40%<br>Yearly: 20%<br>Never: 20% |
| Outfall of the storm water from property | Adjacent drain and nearby sewer line |
| People's perspective: Do you see storm water stagnating on the road near your household? | No |
| Duration of water being drained out from streets | 30 minutes to two hours |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm-water management: 85%<br>Reduced choking: 15% |
| People's perspective: Do you see solid waste stagnating at road, near your households? | 10%: Yes<br>90%: Sometimes |
| People's consent: Do you give consent for using all the information for analysis? | Yes |

## BLOCK J

Block J is situated in the south part of Sangam Vihar over an area of 50.3 acre. It accommodates a total of 4,760 households, with a population of 28,560 individuals. The majority of this population are Hindu, comprising approximately 80 per cent of the population. Muslims constitute around 20 per cent of the religious demographic.

The significant majority of residents in Sangam Vihar Block J, approximately 73 per cent, have been living in the area for over a decade, indicating a long-standing presence in the block. There is also a smaller but notable segment, estimated at 18 per cent, who have resided in the community for five to ten years, suggesting a recent influx of residents. Additionally, about 9 per cent of the population consists of individuals who have been in the area for less than five years. This diverse range of residency durations reflects the dynamic nature of the community.




*Map showing Block J of Sangam Vihar*

| SOCIOECONOMIC PROFILE | |
|---|---|
| Population | 28,560 |
| Area | 50.3 acre |
| Number of households | 4760 |

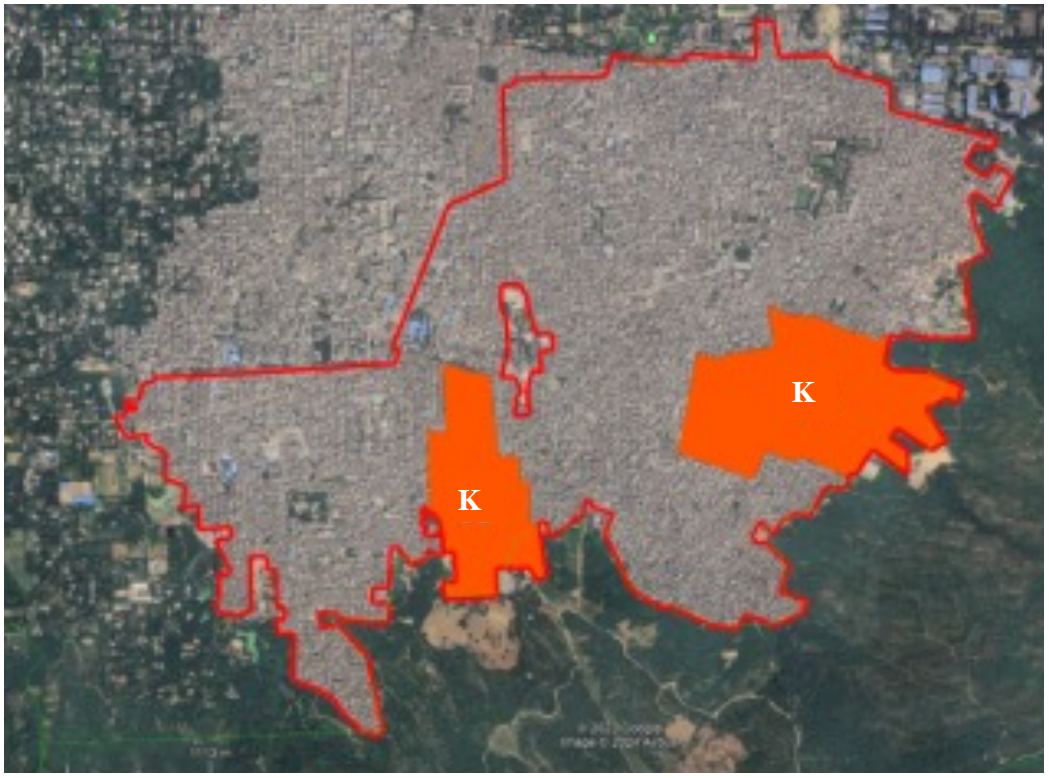
| | |
|---|---|
| Population residing in Sangam Vihar | 9%: 0–5 years<br>18%: 5–10 years<br>73%: more than 10 years |
| No. of residents per dwelling unit | 90%: 0–5 members<br>10%: 5–10 members |
| Different types of occupation | Shopkeeper: 55%<br>Auto-rickshaw driver: 9%<br>Grocery shop: 9%<br>Fruit seller: 9%<br>Bore-well operator: 9%<br>Carpenter, kung fu master: 9% |
| Monthly income distribution | Not disclosed |
| Housing typology | Self-owned but unauthorized |
| Height of the building | 9%: ground floor<br>64%: G+1<br>27%: G+2 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties. |
| **WATER SUPPLY** | |
| Total water consumption | 1,904,000 litre (as per CSE's analysis) |
| Total water demand | 3,855,600 litre (as per CSE's analysis) |
| Water deficit | 1,951,600 litre (as per CSE's analysis) |
| Primary sources of non-potable water | 90%: community bore-wells; 7%: private tankers |
| Primary source of potable water | 100% of the population purchases bottled water |
| Drinking water treatment facilities | 100% of households have invested in RO systems |
| Frequency of water supply through borewell | 95%: every 15 days<br>5%: not supplied |
| Sonia Vihar pipeline water supply timing | 20%: every 15 days<br>80%: not supplied |
| Borewell pipeline water-supply timing | Two to four hours |
| People's perspective: How satisfied are you with the level of water supply? | Moderately satisfied: 78%<br>Not satisfied: 22% |
| Total storage capacity of the storage tanks on the property (in per cent) | 95%: overhead tanks<br>5% drums or tanks located on streets |
| Total storage capacity of the storage tanks of the property (in litre) | Under 4.000 L |
| Water level in block J | 400–500 feet |
| Average monthly spending on potable water of your household (in Rs) | Below Rs 400: 44%<br>Rs 400–800: 31%<br>Rs 800–1,200: 12%<br>Above Rs 1,200: 13% |
| Average monthly spending on non-potable water of your household (in Rs) | Below Rs 400: 41%<br>Rs 400–800: 23%,<br>Rs 800–1,200: 24%<br>Above Rs 1,200: 12% |
| Quality of water supply | No discoloration or smell, tastes fine: 88%<br>Discoloration, smell and/or bad taste: 6%<br>Hardness: 6% |

| | |
|---|---|
| People's perspective: How affordable do you find the water supply? | Highly satisfied: 5%<br>Moderately satisfied: 10%<br>Not satisfied: 85% |
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet |
| Types of septic tank construction | Unlined bottoms: 90%<br>Fully lined: 10% |
| Septic tank outfall is connected to | No outfall |
| Septic tank emptying duration | 6–12 months: 32%<br>One to three years: 52%<br>More than 10 years: 16% |
| Reason(s) for emptying the septic tank | Not emptied: 15%<br>Blocked toilet/backflow: 25%<br>Overflow from access hole: 60% |
| Annual cost of emptying the septic tank | Rs 1,000–1,500: 65%<br>Rs 1,500–3,000: 35% |
| Sewer line availability near to HHs | No |
| Benefits of new sewer line | Will not pay for annual desludging fee: 75%<br>It will reduce choking in storm-water drains: 20%<br>None: 5% |
| People's perspective: Do you see any major risk in the functionality of a new sewer line? | Choking of sewers due to the solid waste entering: 80%<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 20% |
| **STORM WATER** | |
| | |
| Type of drain | Open constructed drains: 75%<br>Covered drains: 10%<br>Open drain natural: 15% |
| Frequency of cleaning of open/covered drains | Weekly: 20%<br>Monthly: 40%<br>Never: 40% |
| Outfall of the storm water from property | Adjacent drain and nearby sewer line |
| People's perspective: Do you see storm water stagnating at road, near to your HH | No |
| Duration of water being drained out from streets | 30 minutes to one hour |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm-water management: 40%<br>Reduced choking: 50%<br>None: 10% |
| People's perspective: Do you see solid waste stagnating on the road near to your household? | Sometimes |
| People's consent: Do you give consent for using all the information for analysis? | Yes |

## BLOCK K

Sangam Vihar Block K is situated in the northeast, with its southern of Delhi. The block has an area of 174.2 acre. It accommodates a total of 19,900 households, with a population of 157,608 individuals. The majority of this population—comprising approximately 67 per cent of the population—are Hindu. Muslims constitute around 27 per cent, while Sikhs make up about 6 per cent of the religious demographic.

A significant portion of the population in the area has been residing for more than a decade, constituting 60 per cent of the residents. This indicates a long-standing residency among the majority of inhabitants. However, there is also a smaller segment estimated to be residing for a duration of five to ten years, accounting for 40 per cent of the population. This suggests a recent influx of residents into the community.




*Map showing Block K of Sangam Vihar*

| SOCIOECONOMIC PROFILE | |
|---|---|
| Population | 157,608 |
| Area | 174.2 acre |
| Number of households | 19,900 |

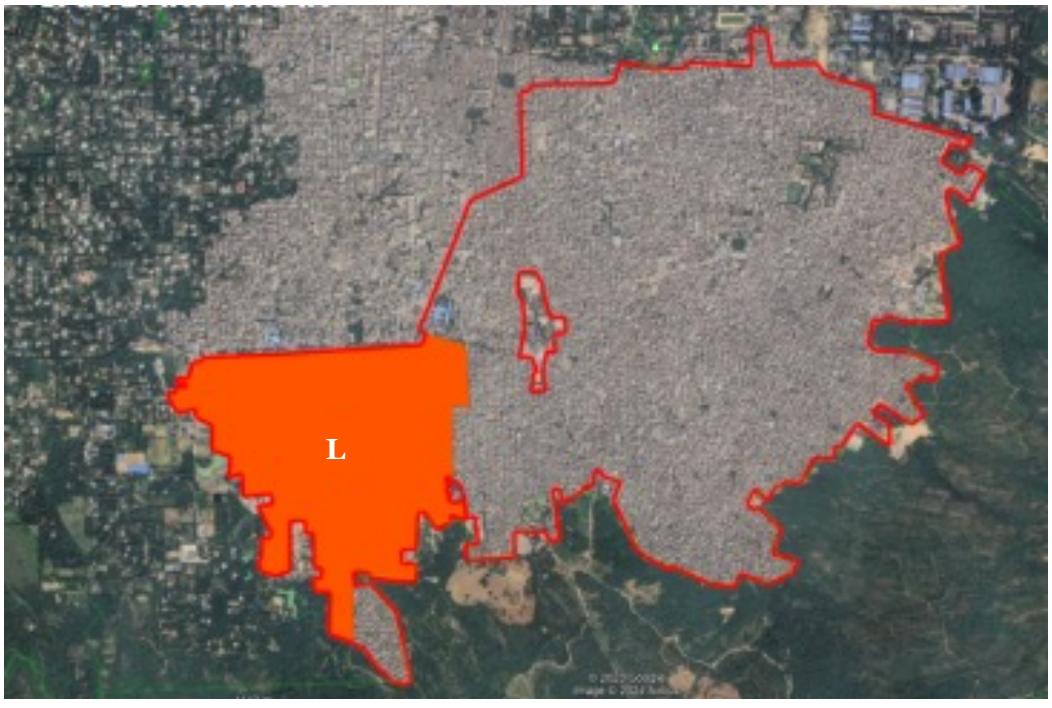
| | |
|---|---|
| Population residing in Sangam Vihar | 5%: 0–5 years<br>45%: five to ten years<br>50%: more than 10 years |
| No. of residents per dwelling unit | 65%: 0–5 members<br>25%: 5–10 members<br>10%: more than 10 members |
| Different types of occupation | 33%: shopkeeper<br>20%: service private<br>47%: self-employed |
| Monthly income distribution | 27%: Rs 10,000–25,000<br>33%: Rs 25,000–50,000<br>27%: no idea<br>13%: not disclosed |
| Housing typology | 95%: self-owned but unauthorized<br>5%: rented |
| Height of the building | 14%: ground floor<br>53%: G+1<br>33%: G+2 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties. |
| **WATER SUPPLY** | |
| Total water consumption | 8,955,000 litre (as per CSE's analysis) |
| Total water demand | 21,277,080 litres (as per CSE's analysis) |
| Water deficit | 12,322,080 litre (as per CSE's analysis) |
| Primary sources of non-potable water | 30%: private borewell<br>45%: community borewells<br>10%: private tankers<br>15%: DJB tankers |
| Primary source of potable water | 95% of the population purchases bottled water |
| Drinking water treatment facilities | 8% of households have invested in RO systems |
| Frequency of water supply through borewell | 25%: every alternate day<br>40%: weekly<br>35%: every 15 days |
| Sonia Vihar pipeline water supply timing | Not available |
| Borewell pipeline water supply timing | Two to four hours |
| People's perspective: how satisfied are you with the level of water supply | Highly satisfied: 37%<br>Moderately satisfied: 35%<br>Not satisfied: 28% |
| Total storage capacity of the storage tanks on the property (in per cent) | 55% overhead tanks<br>30% underground tanks<br>15% drums or tanks located on streets |
| Total storage capacity of the storage tanks of the property (in litre) | 2,000 L: 45%<br>5,000 L: 35%<br>10,000 L: 10%<br>15,000 L: 10% |

| | |
|---|---|
| Water level in block K | 400–500 feet |
| Average monthly spending on potable water of your Household (in Rs) | Below 400: 40%<br>400–800: 30%<br>800–1,200: 20%<br>Above 1200 – 10% |
| Average monthly spending on non-potable water of your household (in Rs) | Below Rs 400: 45%<br>Rs 400–800: 30%<br>Rs 800–1,200: 20% |
| Quality of water supply | No discoloration or smell, tastes fine: 35%<br>Discoloration and/or smell or bad taste: 20%<br>Hardness: 30%<br>Taste and colour affected when stored for long: 15% |
| People's perspective: How affordable do you find the water supply? | Highly satisfied: 33%<br>Moderately satisfied: 35%<br>Not satisfied: 35% |
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet |
| Types of septic tank construction | Unlined bottoms: 70%<br>Fully lined: 25%<br>Unlined tank: 5% |
| Septic tank outfall is connected to | No outfall: 70%<br>Soak pit without outfall: 20%<br>Soak pit with outfall: 5% |
| Septic tank emptying duration | Last 6 months: 5%<br>1–3 years: 20%<br>3–5 years: 15%<br>5–10 years: 30%<br>More than 10 years: 30% |
| Reason(s) for emptying the septic tank | Not emptied: 25%<br>blocked toilet/backflow: 35%<br>Overflow from access hole: 25%<br>Regular emptying as safe practice: 15% |
| Annual cost of emptying the septic tank | Less than Rs 1,000: 35%<br>Rs 1,000–1,500: 45%<br>Rs 1,500–3,000: 20% |
| Sewer line availability near households | Yes: 20%<br>No: 80% |
| Benefits of new sewer line | Will not pay for annual desludging fee: 50%<br>It will reduce choking in storm-water drains: 20%<br>Convenience of maintaining septic tank: 15%<br>None: 15% |
| People's perspective: Do you see any major risk in the functionality of new sewer line | Choking of sewers during rainfall periods: 40% Choking of sewers due to solid waste entering: 40%: Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 20% |

| STORM WATER | |
|---|---|
| Type of drain | Open constructed drains: 55%<br>Covered drains: 35%<br>Open drain natural: 10% |
| Frequency of cleaning of Open/covered drains | Weekly: 20%<br>Monthly: 50%<br>Yearly: 10%<br>Never: 20% |
| Outfall of the storm water from property | Adjacent drain and nearby sewer line |
| People's perspective: Do you see storm water stagnating at road, near to your HH | Yes:80%<br>No: 20% |
| Duration of water being drained out from streets | 30 minutes to six hours |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm-water management:70%<br>Reduced choking: 10%<br>None: 20% |
| People's perspective: Do you see solid waste stagnating on the road near your household? | Yes: 10%<br>Sometimes: 70%<br>No: 20% |
| People's consent: Do you give consent for using all the information for analysis? | Yes |

## BLOCK L

Block L is situated in the southwest of Sangam Vihar. Spread over an area of 226 acre, it is the largest block in Sangam Vihar. It accommodates a total of 27,588




*Map showing Block L of Sangam Vihar*

households, with a population of 331,056 individuals, the majority of whom—comprising approximately 82 per cent of the population—are Hindu. Muslims constitute around 18 per cent of the religious demographic.

A significant portion of the population, presumably the majority, has been residing in the area for more than a decade, indicating long-standing residency. There is, however, also a smaller segment of the population, estimated to have been residing in the area for less than five years, suggesting a recent influx of residents into the community.

| **SOCIOECONOMIC PROFILE** | |
|---|---|
| Population | 331,056 |
| Area | 226 acre |
| Number of households | 27588 |
| Population residing in Sangam Vihar | 5%: 0–5 years<br>10%: 5–10 years<br>85%: more than 10 years |
| No. of residents per dwelling unit | 20%: 0–5 members<br>55%: 5–10 members<br>25%: more than 10 members |
| Different types of occupation | LPG pipeline installation: 5%<br>Jeweller: 5%<br>Petty trader: 42%<br>Self-employed: 5%<br>Auto-rickshaw driver: 6%<br>Tailor: 6%<br>Musician: 6%<br>Maid: 6%<br>Tea-seller: 8%<br>Daily-wage labourer: 11% |
| Monthly income distribution | Rs 10,000–25,000: 24%<br>Not disclosed: 76% |
| Housing typology | Self-owned but unauthorized: 80%<br>Rented: 20% |
| Height of the building | 14%: ground floor<br>46%: G+1<br>36%: G+2<br>2%: G+3<br>2%: JJ cluster |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties. |
| **WATER SUPPLY** | |
| Total water consumption | 11,035,200 litre (as per CSE's analysis) |
| Total water demand | 44,692,560 litre (as per CSE's analysis) |
| Water deficit | 33,657,360 litre (as per CSE's analysis) |

| | |
|---|---|
| Primary sources of non-potable water | 37%: community borewells<br>11%: private tankers<br>28%: DJB tankers<br>24%: private borewells |
| Primary source of potable water | 90% of the population purchases bottled water |
| Drinking-water treatment facilities | 80% of the households have invested in RO systems |
| Frequency of water supply through borewell | 45%: weekly<br>30%: every 15 days<br>20%: every month<br>5%: not supplied |
| Sonia Vihar pipeline water supply timing | Not available |
| Bore-well pipeline water supply timing | Two to four hours |
| People's perspective: How satisfied are you with the level of water supply? | Highly satisfied: 11%<br>Moderately satisfied: 10%<br>Not satisfied: 79% |
| Total storage capacity of the storage tanks on the property (in per cent) | 80% overhead tanks<br>5% underground tanks<br>15% drums or tanks located on streets |
| Total storage capacity of the storage tanks of the property (in litre) | 2,000 L: 32%<br>3,000 L: 28%<br>5,000 L: 35%<br>15,000 L: 5% |
| Water level in block L | 400–500 feet |
| Average monthly spending on potable water of your household (in Rs) | Below Rs 400: 10%<br>Rs 400–800: 45%<br>Rs 800–1,200: 25%; above Rs 1,200: 20% |
| Average monthly spending on non-potable water of your household (in Rs) | Below Rs 400: 70%; Rs 400–800: 15%; Rs 800–1,200: 5%<br>Above Rs 1,200: 10% |
| Quality of water supply | No discoloration or smell, tastes fine: 45%<br>Discoloration and/or smell, bad taste: 5%, Hardness: 40%;<br>Has salt content, not suitable for making dal and tea: 10% |
| People's perspective: How affordable do you find the water supply? | Highly satisfied: 15%;<br>Moderately satisfied: 10%;<br>Not satisfied: 70% |
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet: 95%;<br>Underground septic tanks with an effluent discharge outlet: 5% |
| Types of septic tank construction | Unlined bottoms: 25%<br>Fully lined: 55%<br>Don't know: 5%<br>Unlined tank: 15% |

| | |
|---|---|
| Septic tank outfall is connected to | No outfall: 70%<br>Soak pit without outfall: 20%<br>Soak pit: 10% |
| Septic tank emptying duration | 6–12 months: 35%<br>1–3 years: 10%<br>More than 10 years: 55% |
| Reason(s) for emptying the septic tank | Not emptied: 15%<br>Blocked toilet/backflow: 5%<br>Regular emptying as safe practice: 75%<br>Not required: 5% |
| Annual cost of emptying the septic tank | Less than Rs 1,000: 15%<br>Rs 1,000–1,500: 40%<br>Rs 1,500–3000: 40%<br>More than Rs 3,000: 5% |
| Sewer line availability near households | Yes: 5%<br>No: 95% |
| Benefits of new sewer line | Will not pay for annual desludging fee: 50%<br>It will reduce choking in storm-water drains: 25%<br>None: 25% |
| People's perspective: Any major risk you see in the functionality of new sewer line | Choking of sewers during periods of rainfall: 45%<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 30%<br>Choking of sewer due to solid waste entering: 25% |
| **STORM WATER** | |
| Type of drain | Open constructed drains: 75%<br>Covered drains: 20%<br>Open drain natural: 5% |
| Frequency of cleaning of open/covered drains | Daily: 5%<br>Weekly: 15%<br>Quarterly:15%,<br>Monthly: 20%<br>Never: 45% |
| Outfall of the storm water from property | Adjacent drain and natural nallah |
| People's perspective: Do you see storm water stagnating on the road near your household? | Yes: 80%<br>No: 20% |
| Duration of water being drained out from streets | 30 minutes to six hours |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm-water management: 75% Reduced choking: 5%<br>None: 20% |
| People's perspective: Do you see solid waste stagnating on the road near your household? | Yes: 75%<br>Sometimes – 25% |
| People's consent: Do you give consent for using all the information for analysis? | Yes |

## BLOCK M

Block M is situated in the south of Sangam Vihar over an area of 16.2-acre. It accommodates a total of 1,916 households, with a population of 22,992 individuals. The majority of this population—approximately 95 per cent of the population—are Hindu. Muslims constitute around 5 per cent of the religious demographic.

A significant portion of the population, presumably the majority, has been residing in the area for more than a decade, indicating long-standing residency. There is, however, also a smaller segment of the population, estimated to have been residing in the area for five to ten years, suggesting a recent influx of residents into the community. The majority of households in Sangam Vihar Block M have five to ten family members.


*Map showing Block M of Sangam Vihar*

| SOCIOECONOMIC PROFILE | |
|---|---|
| Population | 22,992 |
| Area | 16.2 acre |
| Number of households | 1,916 |
| Population residing in Sangam Vihar | 10%: 5–10 years<br>90%: more than 10 years |
| No. of residents per dwelling unit | 100%: 5–10 members |
| Different types of occupation | 100%: Shopkeepers |

| | |
|---|---|
| Monthly income distribution | 17%: Rs 25,000–50,000<br>83%: Not disclosed |
| Housing typology | Authorized and self-owned |
| Height of the building | 70%: G+1<br>30%: G+2 |
| Type of property | The majority of residential units also have a notable presence of mixed-use properties. |
| **WATER SUPPLY** | |
| Total water consumption | 766,400 litre (as per CSE's analysis) |
| Total water demand | 3,103,920 litre (as per CSE's analysis) |
| Water deficit | 2,337,520 litre (as per CSE's analysis) |
| Primary sources of non-potable water | Community bore-well and DJB borewell |
| Primary source of potable water | Community bore-well and DJB borewell |
| Drinking water treatment facilities | 100% of households have invested in RO systems |
| Frequency of water supply through borewell | Daily |
| Sonia Vihar pipeline water supply timing | Not available |
| Bore-well pipeline water supply timing | Until tank full |
| People's perspective: How satisfied are you with the level of water supply? | Highly satisfied: 50%<br>Moderately satisfied: 45%<br>Not satisfied: 5% |
| Total storage capacity of the storage tanks on the property (in per cent) | 5% overhead tanks<br>80% underground tanks |
| Total storage capacity of the storage tanks of the property (in litre) | 2.000 L: 50%<br>3.000 L: 40%<br>7,000 L: 10% |
| Water level in block M | 400–500 feet |
| Average monthly spending on potable water of your hHousehold (in Rs) | No expenditure |
| Average monthly spending on non-potable water of your household (in Rs) | Below Rs 200: 70% |
| Quality of water supply | No discoloration; smell and/or taste fine:15%<br>Hardness of water: 85% |
| People's perspective: How affordable do you find the water supply? | Highly satisfied: 35%<br>Moderately satisfied: 20%<br>Not satisfied: 45% |
| **SANITATION** | |
| Type of septic tank | Underground septic tanks with no effluent discharge outlet |
| Types of septic tank construction | Fully lined |

| | |
|---|---|
| Septic tank outfall is connected to | No outfall |
| Septic tank emptying duration | Last six month: 56%<br>6–12 months: 44% |
| Reason(s) for emptying the septic tank | Regular emptying as safe practice. |
| Annual cost of emptying the septic tank | Less than Rs 1,000: 30%<br>Rs 1,000–1,500: 40%<br>Rs 1,500–3,000: 30% |
| Sewer line availability near households | No |
| Benefits of new sewer line | Will not pay for annual desludging fee |
| People's perspective: Do you see any major risk you see in the functionality of the new sewer line? | Choking of sewers due to solid waste entering: 50%<br>Inability of new sewer lines to handle all the wastewater generated in Sangam Vihar: 50% |
| **STORM WATER** | |
| Type of drain | Open constructed drains |
| Frequency of cleaning of open/covered drains | Daily: 40%<br>Monthly: 60% |
| Outfall of the storm water from property | Adjacent drain and nearby sewer line |
| People's perspective: Do you see storm water stagnating on the road near your household? | No |
| Duration of water being drained out from streets | One hour |
| Benefits of new sewer line of DJB to Sangam Vihar locality | Improved storm-water management: 60% Reduced choking: 40% |
| People's perspective: Do you see solid waste stagnating on the road near your house? | Yes: 50%<br>Sometimes: 50% |
| People's consent: Do you give consent for using all the information for analysis? | Yes |

## ANNEXURE 3: CAPACITY OF WATER SUPPLY

Installed capacity of water treatment plants: 2009–22

(As on 31st March 2022)

| S. No. | Name of Plants | Capacity (MGD) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| 1. | Chandrawal Water House I & II | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| 2. | Wazirabad I,II & III | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| 3. | Haiderpur | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| 4. | North Shahdara (Bhagirathi) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 5. | Bawana | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 6. | Nangloi | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| 7. | Sonia Vihar | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 |
| 8. | Ranney Wells & Tube Wells | 100 | 100 | 100 | 100 | 80 | 80 | 80 | 80 | 80 | 80 | 85 | 90 | 95 | 117 |
| 9. | Recycling of Water at Bhagirathi, Haider-pur & Wazirabad | -- | 37 | 37 | 37 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| 10. | Common-wealth Games Village | -- | -- | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11. | Okhla | -- | -- | -- | -- | -- | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 12. | Dwarka | -- | -- | -- | -- | -- | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| | **Total** | **810** | **847** | **848** | **848** | **836** | **906** | **906** | **906** | **906** | **906** | **911** | **916** | **921** | **943** |

*Source: Delhi Jal Board (MGD-Millions Gallons per day)*

https://delhiplanning.delhi.gov.in/sites/default/files/Planning/ch._13_water_supply_and_sewerage_0.pdf

## ANNEXURE 4: CALCULATION OF SEWER CAPACITY

**Cross-checking the dimensions of peripheral sewer provided in the Sangam Vihar in case the water supply is 135 LPCD**

Total population = 1 million

Total water consumption = 1,000,000 x 135 = 135 MLD

Total wastewater generation = 80% of 135 MLD = 108 MLD

Assuming, all three peripheral sewers cater 108 MLD of wastewater to the trunk sewer at MB road. Hence, assuming, each sewer is catering to 36 MLD of wastewater (one-third of total).

Given, discharge (Q) = 36 MLD = 0.832 $m^3$/sec

Assuming, peak hour flow = 12 hours

And maximum velocity (V) = 1.5 m/sec

As per continuity equation –

Discharge (Q) = Area (A) x Velocity (V)

$$0.832 = \frac{\pi D^2}{4} X\ 1.5$$

Hence, required diameter (D) = 0.840 m = 840 mm

The above diameter is required in case of sewer running at full capacity.

Similarly, required diameter (D) in case of sewer running at half capacity = 1.188 m = 1188 mm

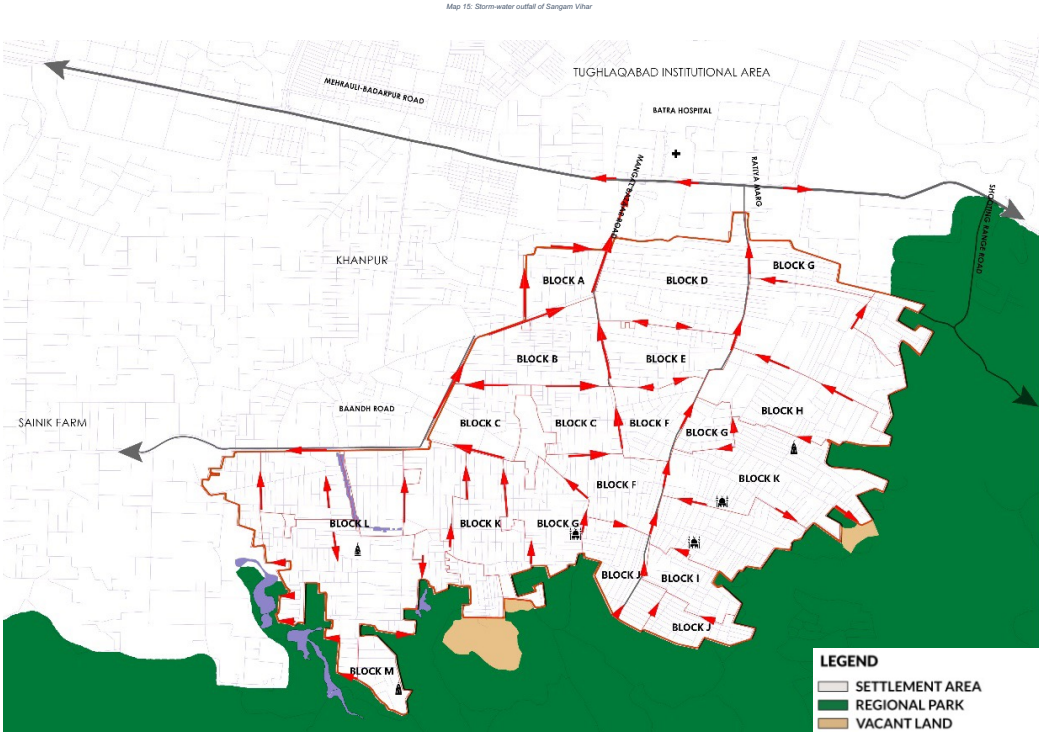
We assume that the diameter of the existing peripheral sewer in Sangam Vihar is 700 mm which is less than the required diameter (in case if water supply is 135 LPCD).

Therefore, the assumed inflow wastewater cannot flow through the existing sewer. The sewer dimensions need to be increased.

## ANNEXURE 5: META-ANALYSIS FOR STORM-WATER MANAGEMENT

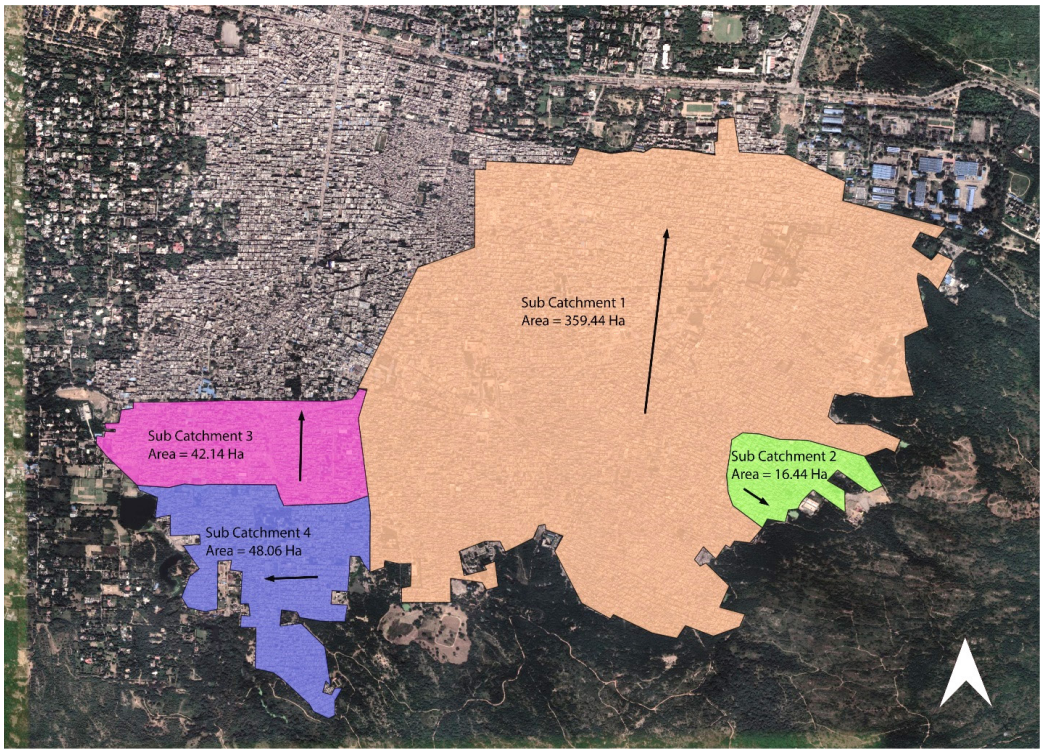
During the primary survey, the flow directions of grey water through drains were mapped. On the basis of this mapping, it is assumed that the storm water will also contribute to the same drains. Based on this assumption, the study area can be divided into four sub-catchments, accumulating, and discharging the flow in four directions (see *Map 15*).

**Map 15: Storm-water outfall of Sangam Vihar**




*Map 16* shows the directional flow of all the sub-catchments. It can be observed that sub-catchments 1 and 3 contribute the flow in the north direction, while sub-catchment 2 discharges its water in the southeast direction. Sub-catchment 4 makes its flow in the west. Sub-catchment 1 is the largest of all four sub-catchments and holds 77 per cent of the total catchment area. The smallest sub-catchment 2 contributes to 3.53 per cent of the total catchment area in the southeast direction.

**Map 16: Flow direction of storm water and grey water in the sub-catchments**




## 1. Calculation of storm-water discharge

The total discharge of storm water through all the sub-catchments of the study area can be understood by considering the rainfall intensity with a return period of five years, area of all sub-catchments and the type of land use land cover in the catchment. All the three parameters have been discussed in the following sections.

To calculate the flow of storm water and grey water in the study area through four sub-catchments, some assumptions have been made, which are discussed as follows:

a. The rainfall intensity is equal in all sub-catchments.
b. The rainfall depth is the same in all sub-catchments.
c. The rainfall has occurred for only 15 minutes in the day.
d. The normal intensity of rainfall is taken to be 50 mm per hour for a duration of 15 minutes.
e. The paved area of the study area of 90 per cent
f. The wastewater generated is 80 per cent of total water consumption per household and grey water is 75 per cent of the total wastewater.
g. All of the grey water generated from the building flows through the sub-catchments to the outfall at different directions as shown in Figure 2.

## *1.1. Area of catchment and sub-catchments*

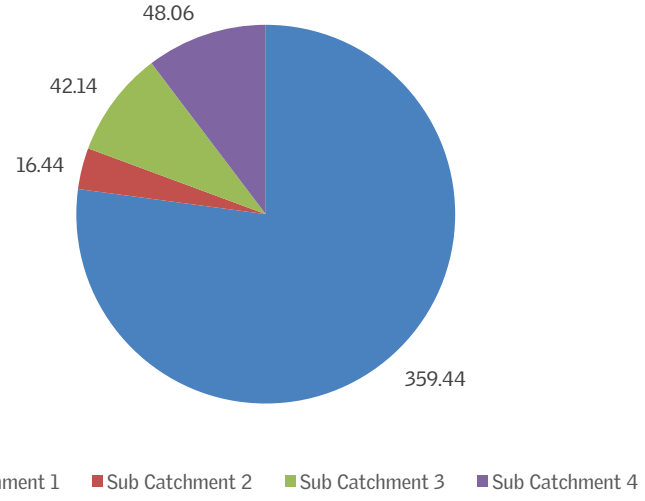
The total area of all catchments is 466.08 hectares. These sub-catchments contribute their flow of storm water and wastewater in different directions (see *Table 14*). The area and percentage of total catchment area of each sub-catchment are shown in *Table 14 and Graph 40*.

**Table 14: Details of catchment and sub-catchments in the study area of Sangam Vihar**

| S. no. | Catchment name | Flow direction | Area | Area | Percentage area |
|---|---|---|---|---|---|
| | | | Square metre | Hectare | Percentage |
| 1. | Sub- catchment 1 | North | 3,594,426 | 359.44 | 77.12% |
| 2. | Sub-catchment 2 | Southeast | 164,411 | 16.44 | 3.53% |
| 3. | Sub-catchment 3 | North* | 421,390 | 42.14 | 9.04% |
| 4 | Sub-catchment 4 | West | 480,559 | 48.06 | 10.31% |
| | Total | | 4,660,786 | 466.08 | 100.00% |

* 90–95% of the flow is towards north, however a very less volume flows in the west direction as well

**Graph 40: Area of sub-catchments in study area of Sangam Vihar**




## *1.2. Peak rainfall intensity*

The rainfall intensity defines the depth of rainfall per unit of time. Here, the rainfall intensity of 112.22 mm per hour of storm with return period of five years and duration equal to 15 minutes is taken for calculation of peak discharge of storm water through the catchments.[62] The reference document illustrates the rainfall data and Intensity-Duration-Frequency (IDF) curve of rain gauge stations at Safdarjung and Palam area of Delhi.

### *1.3. Coefficient of runoff (C)*

Sangam Vihar is a highly densely populated residential area. It is assumed that 90 per cent of the study area is paved with concrete, reducing the infiltration rate and generating more surface runoff. Hence, considering impermeability factor to be 90 per cent, the coefficient of runoff or C is taken as 0.9 for the calculation of peak discharge of storm water. Coefficient of runoff is a constant illustrating the percentage of rainfall converting to surface runoff due to the surface material, where rain falls.

### *1.4. Calculation of peak discharge*

The peak flow defines the maximum flow or discharge during the highest intensity rainfall considered for calculation. The rainfall data for at least 30 years is recorded, and the graph of high intensity rainfalls is plotted against the time (duration) and the return period, which is the frequency of storm occurrence. In this study, it is assumed that the time of concentration for peak discharge in each sub-catchment of the study area is equal to the intensity-duration of the considered rainfall.

To calculate the peak flow, the catchment area of each sub-catchment is multiplied with the rainfall intensity of 112.22 mm/hour and runoff coefficient 0.9 in the rational formula given as below:

**Q = (C I A)/6**

Where,[63]

Q = Peak discharge in cubic meter per min ($m^3$/min)

C = Coefficient of runoff (dimensionless)

I = Rainfall intensity for duration equal to time of concentration in millimeters per hour (mm/hour)

A = Catchment area in hectares (ha)

Using the above formula and data associated, the peak discharges through all the four sub-catchments have been calculated and shown in *Table 15*.

The generated peak discharge (in $m^3$/min) is multiplied with the duration of the rainfall (15 minutes), which gives the volume of storm water generated. It is assumed that the normal rainfall intensity is 50 mm per hour, for 15 minutes duration. Hence, the calculation gives the peak flow and volume of runoff generated (see *Table 15, Table 16, Graph 41 and Graph 42* for the comparison between discharge and flow volume in high and normal intensity rainfall).

## Table 15: Peak discharge and volume of runoff generated for peak and normal rainfall intensity

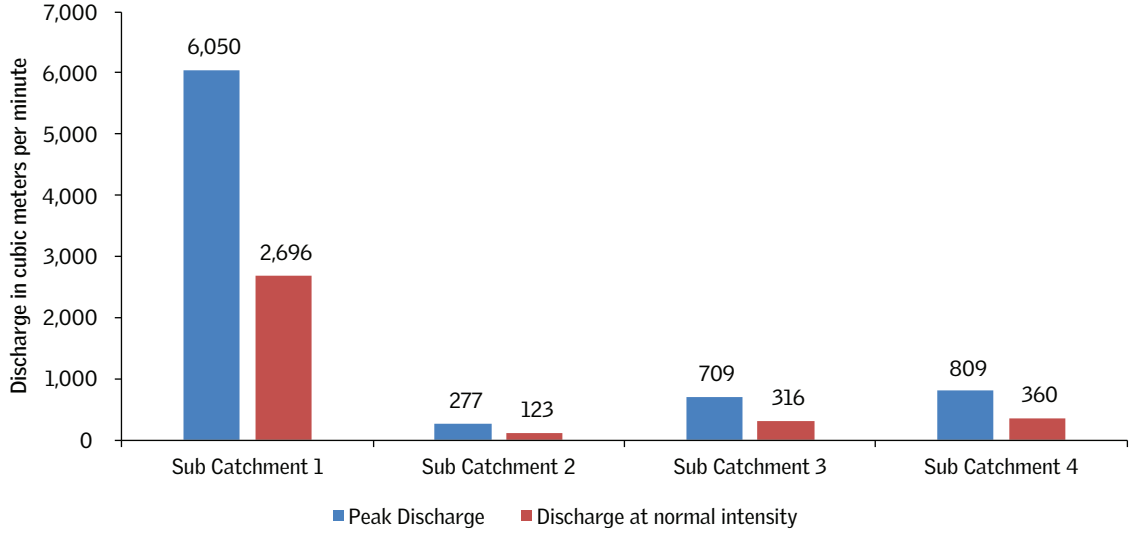
| S. no. | Catchment name | Flow direction | Area | Area | Paved area | Coefficient of runoff (C ) | Rainfall intensity (peak) | Rainfall intensity (normal) | Duration of rainfall | Return period | Peak discharge | Discharge at normal intensity rainfall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | square meter | hectares | % | Dimension-less | mm per hour | | min | years | cubic metre per minute | |
| 1 | Sub-catchment 1 | North | 3,594,426 | 359.44 | 90 | 0.9 | 112.22 | 50 | 15 | 5 | 6,050 | 2,696 |
| 2 | Sub-catchment 2 | Southeast | 164,411 | 16.44 | 90 | 0.9 | 112.22 | 50 | 15 | | 277 | 123 |
| 3 | Sub-catchment 3 | North | 421,390 | 42.14 | 90 | 0.9 | 112.22 | 50 | 15 | | 709 | 316 |
| 4 | Sub-catchment 4 | West | 480,559 | 48.06 | 90 | 0.9 | 112.22 | 50 | 15 | | 809 | 360 |
| | Total | | 4,660,786 | 466.08 | | | | | | | | |

For a duration of 15 minutes of rainfall, the volume of storm water generated is shown in table 3 below.

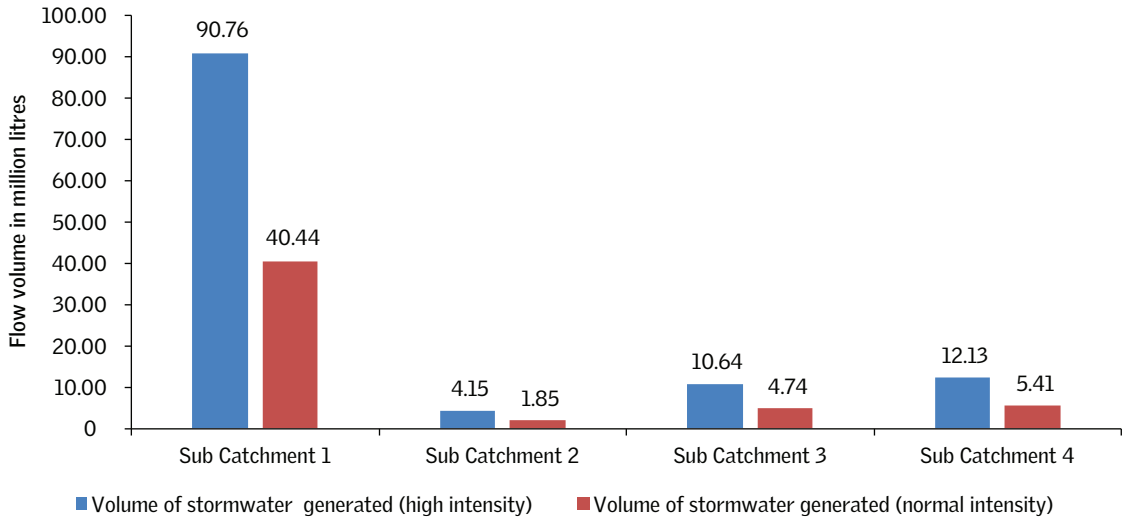
## Table 16: Volume of storm water generated in 15 minutes of rainfall

| Peak discharge | Discharge at normal intensity rainfall | Volume of storm water generated in 15 minutes (high intensity) | Volume of storm water generated in 15 minutes (normal intensity) |
|---|---|---|---|
| Cubic metre per min | | Cubic metre | |
| 6,050 | 2,696 | 90,757 | 40,437 |
| 277 | 123 | 4,151 | 1,850 |
| 709 | 316 | 10,640 | 4,741 |
| 809 | 360 | 12,134 | 5,406 |
| Subtotal | | 117,683 | 52,434 |

## Graph 41: Peak discharge and normal discharge through sub-catchments



**Graph 42: Flow volume of storm water in peak versus normal rainfall intensity**




## 2. Calculation of grey-water discharge through the study area

For the calculation of total grey water generated at the study area of Sangam Vihar, each building or plot has been taken as a unit of study. It is assumed that 80 percent of the water consumed by individuals or families in each building gets converted into wastewater. The grey water amounts to 75 per cent of the total wastewater. The total consumption of water at the building level has been estimated from primary household survey done at the study area.

## 3. Total flow of storm water and grey water through the study area

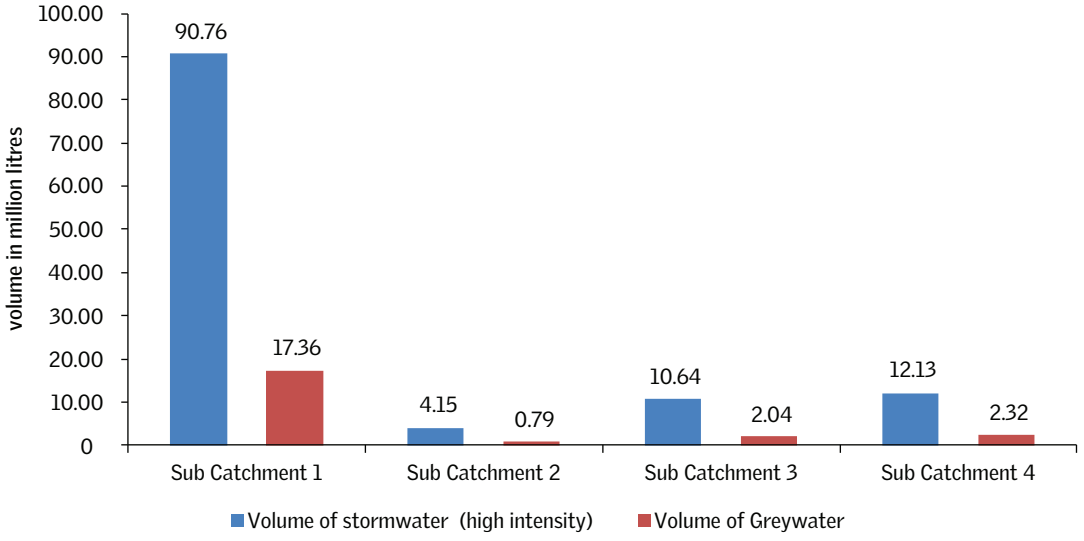
To calculate the total flow of water (storm water and grey water) through the sub catchments, it is assumed that total water flows at the same time during the rainfall, generating heavy load. The grey water from every building gets mixed with the storm water during the heavy rains, increasing the amount of flow. Since we are calculating the mixed flow of grey water and storm water in this case, it is assumed that rainfall has occurred only for 15 minutes in the day, generating the total storm water volume.

The volume of peak intensity storm water for 15 minutes duration and grey water from each sub-catchment has been illustrated in *Graph 43*.

Table 17 shows the total volume of flow for all the catchments by adding the grey water from a building to the storm water.

It must be noted that storm water has been calculated for only 15 minutes of rainfall while the grey water generated from the buildings is for the entire day.

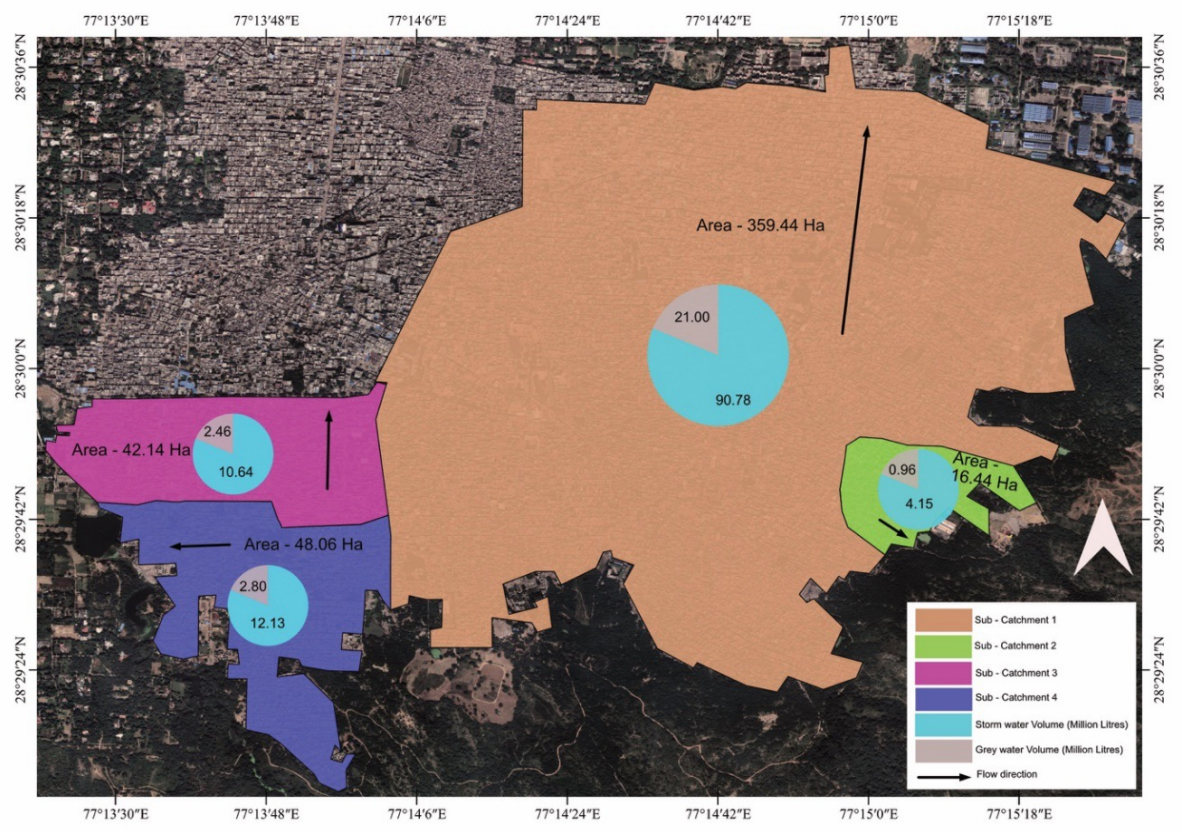
## Graph 43: Volume of storm water and grey water from sub-catchments




## Table 17: Total flow of water (storm water and grey water) in 15 minutes of rainfall

| S. no. | Catchment | Percentage of total catchment | GW through catchment | Volume of storm water generated (high intensity) | Volume of storm water generated (normal intensity) | Total flow volume (storm water + grey water) (high intensity rainfall) | | Total flow volume (storm water + grey water) (normal intensity rainfall) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Percentage | litre | litre | litre | litre | Million litre | litre | Million litre |
| 1 | Sub-catchment 1 | 77.12% | 21,000,710 | 90,757,459 | 40,437,293 | 111,758,169 | 111.76 | 61,438,002 | 61.44 |
| 2 | Sub-catchment 2 | 3.53% | 960,584 | 4,151,296 | 1,849,624 | 5,111,879 | 5.11 | 2,810,208 | 2.81 |
| 3 | Sub-catchment 3 | 9.04% | 2,462,003 | 10,639,887 | 4,740,638 | 13,101,890 | 13.10 | 7,202,641 | 7.20 |
| 4 | Sub-catchment 4 | 10.31% | 2,807,703 | 12,133,874 | 5,406,289 | 14,941,577 | 14.94 | 8,213,992 | 8.21 |
| | Total | 100.00% | 27,231,000 | 117,682,516 | 52,433,843 | 144,913,516 | 144.91 | 79,664,843 | 79.66 |

## Map 17: Flow direction of storm water and grey water in the sub-catchments



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Cities, especially, large metro cities, are at increasing climate risk-induced water stress and flooding. Large, dense, unplanned urban settlements, already facing a crisis of water supply, wastewater and storm-water management, will bear the brunt of climate-change impact.

Sangam Vihar, Delhi, is representative of such a large, dense, unplanned urban settlement. Spread over 5 sq. km and housing a population of more than a million, it is the largest unauthorized colony in Asia.

This research offers valuable insights in terms of approach, methodology and analysis of urban water, wastewater and storm-water challenges of such settlements. It explores whether retrofitting solutions for water supply, wastewater and storm water can work for such unplanned settlements, and reimagines and explores decentralized sanitation and storm-water management solutions that are firmly anchored on principles of circular economy, equity and justice.

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