Rethinking Waste(d) Realities

by
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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public

Acknowledgements

I would like to express my deepest gratitude to the University of Waterloo for providing the academic environment and resources that made this research possible.

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To my family, your love, sacrifices, and constant belief in me have carried me through every stage of this journey.

To my parents, thank you for being my foundation and strength, always reminding me of the bigger picture. This thesis is dedicated to my father, whose life, values, and vision continue to inspire me. He is the reason behind this idea and the motivation that has carried me forward.

Abstract

Keywords:
Landfill Remediation, Dumpsites, Ecological Restoration, Decentralized Waste System, Waste Pickers, Resource Recovery, Urban Resilience, Spatial Justice

Historically marginalized in urban consciousness, waste in the Global South occupies a complex and layered terrain visible in its overwhelming presence, yet systematically excluded from narratives of progress, design, and planning. In New Delhi, this contrast is embodied in Ghazipur's so-called "trash mountain" - a towering monument to systemic negligence and infrastructural collapse. A measure first conceived as a temporary solution has evolved into a permanent fixture, reflecting the city's dependence on centralized, extractive waste systems. The precarious and undervalued labor of informal waste pickers, the toxicity of the air, and the stagnation of land without a future all demonstrate how the silence around waste is not only logistical but deeply spatial, ecological, and political.

This thesis reframes waste as a spatial urban condition and explores overlooked opportunities for renewal. It proposes a decentralized, multi-scalar system where linear waste streams become circular and burdened sites become catalysts of transformation. The transformation of the Ghazipur trash mountain is envisioned as a gradual unmaking rather than erasure. Through temporal and ecological interventions, the site shifts from dumpsite to regenerative landscape. Currently a monument to systemic failure, Ghazipur is reimagined through a multi-scalar strategy consisting of citywide zoning and redesigned waste infrastructure with localized material recovery facility, a neighborhood pilot combining waste infrastructure and public commons, and site-specific remediation of the 70-meter-high landfill through bioremediation, phytoremediation, and constructed wetlands. Together, these interventions restore ecology, recover resources, and reinsert the site into public life, while making visible the labor that sustains it.

Rethinking Waste(d) Realities builds on currents already visible in Indian cities beyond Delhi. Biomining initiatives, decentralized collection systems, and growing legal and civic pressure to remediate landfills point to a real appetite for systemic change. This thesis positions design within that momentum, showing how architecture and landscape can help reorganize waste from crisis to resource.

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Author's Positionality

In writing this thesis, I am conscious of the distances: geographical, experiential, and social - that shape my perspective. Growing up in India, waste was a daily presence, yet the systems and people managing it remained largely invisible. Like many urban residents, I understood waste through its disappearance: quietly collected each morning, never questioned, never traced. I did not know the hierarchies and labor behind its removal.

Design education and architectural research helped me begin to uncover the complex entanglements of caste, informality, and marginalization embedded within waste infrastructures. My understanding has been shaped not only by academic inquiry but also by moments of direct engagement. In 2021, I accompanied a media team to the Ghazipur landfill, where I observed day-to-day activities and had informal conversations with municipal workers and waste pickers. More recently, I volunteered briefly with a grassroots organization active at the site, assisting with public outreach and observing segregation efforts.

While these experiences were limited in duration, they offered perspectives that no textbook or policy report could provide. I do not claim immersion, but these moments have left an imprint. Migration to Canada added another lens: the formal, compartmentalized nature of Western waste systems stands in stark contrast to the chaotic intimacy of those I left behind. This thesis does not claim to speak for waste pickers or communities it references. It does not offer definitive solutions. Rather, it is a design inquiry rooted in curiosity, shaped by privilege, and committed to critical reflection. It seeks to ask better questions, foreground overlooked systems, and imagine new spatial futures, while acknowledging the voices still absent from these pages and the need for future collaborations to bring them in.

Part 1

Introduction

From Waste Crisis to Spatial Opportunity

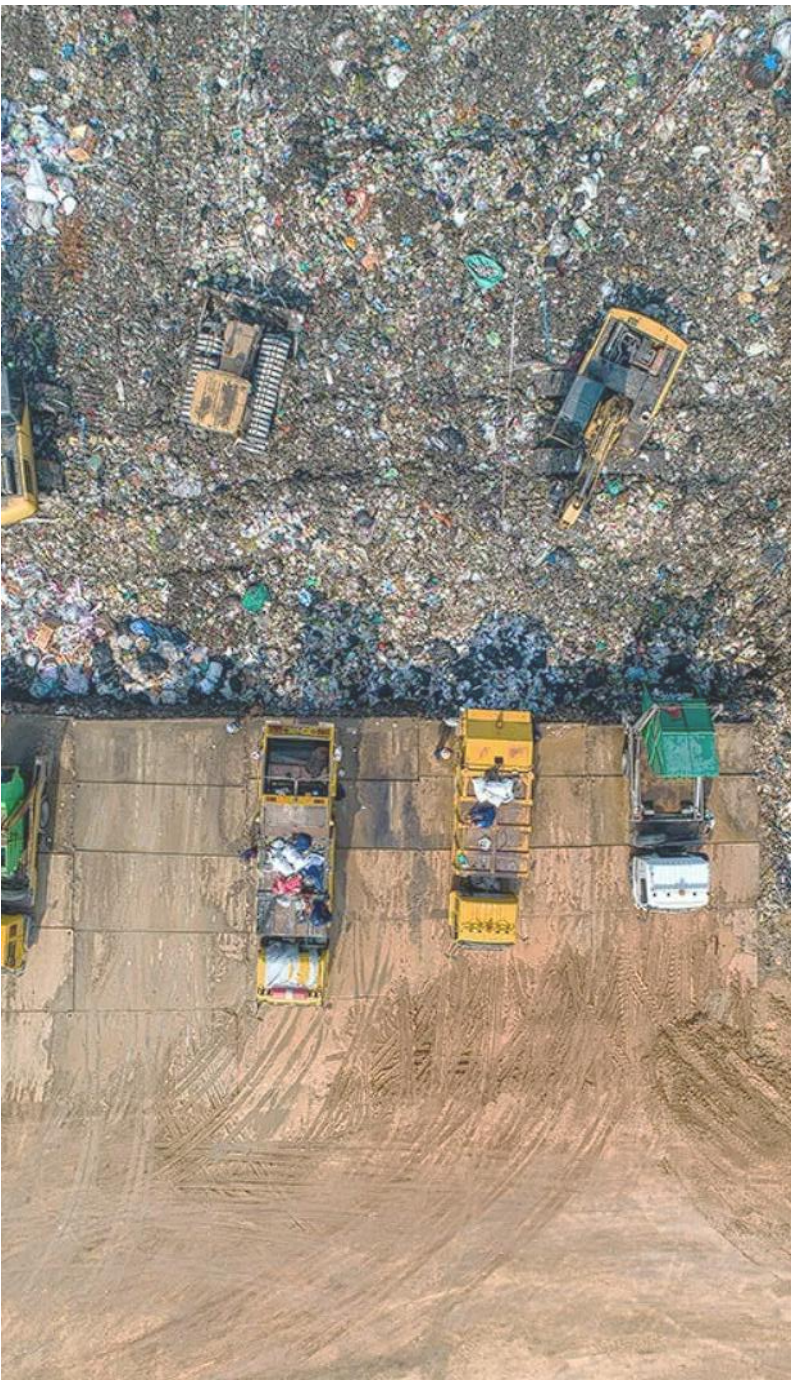


Figure 1: At the edge of the dumpsite, the meeting of waste and machinery marks a seam in the city (Source: Michelman, "Tackling the Waste Crisis")

Overview:

This part reveals how waste, though central to urban life, is made invisible through systems of removal. Linking India's mounting waste crisis to Delhi's overflowing dumpsites, it exposes environmental, social, and spatial failures, and frames architecture as a catalyst for decentralization, restoration, and dignity in waste infrastructure.

1.1 The Hidden Life of Waste

Urban life operates on systems we rarely see. Clean water flows, lights turn on, streets are swept, and trash vanishes each day - quietly, without demanding our attention. This invisibility is by design. Waste systems, more than any other, are constructed to disappear. Pipes, bins, and trucks form a choreography of removal, ensuring that cities remain clean on the surface while shifting the burden to their peripheries. Waste is the byproduct of urban ambition. As cities grow, consume, and discard, waste becomes a sediment of progress- piling up behind the scenes, feeding into landfills, and spilling into informal spaces. Yet, even as its volume explodes, waste remains conceptually and physically marginalized. The 21st century has witnessed a dramatic increase in global municipal solid waste, from 2.01 billion metric tons in 2016 to a projected 3.4 billion by 2050, much of it generated in rapidly urbanizing regions of the Global South[1]. Despite this scale, waste infrastructure remains one of the least designed, least visible, and least dignified components of urban life.



Figure 2: Mixed solid waste dumping on a dumpsite (Source: NDTV – "Fighting India's Garbage Crisis")

Ignoring waste as an architectural and spatial concern carries layered consequences. Environmentally, it contributes to groundwater contamination, methane emissions, and degraded air quality turning unseen systems into slow-

moving ecological threats. Socially, invisibility compounds inequality, reinforcing class-based divisions by relegating waste work to the margins and denying it dignity. Infrastructurally, neglect results in massive, unmanaged dumpsites that not only scar the landscape but also undermine urban resilience, encroach on living environments, and strain already fragile ecosystems. These are not isolated technical failures but symptoms of a deeper cultural and political denial.

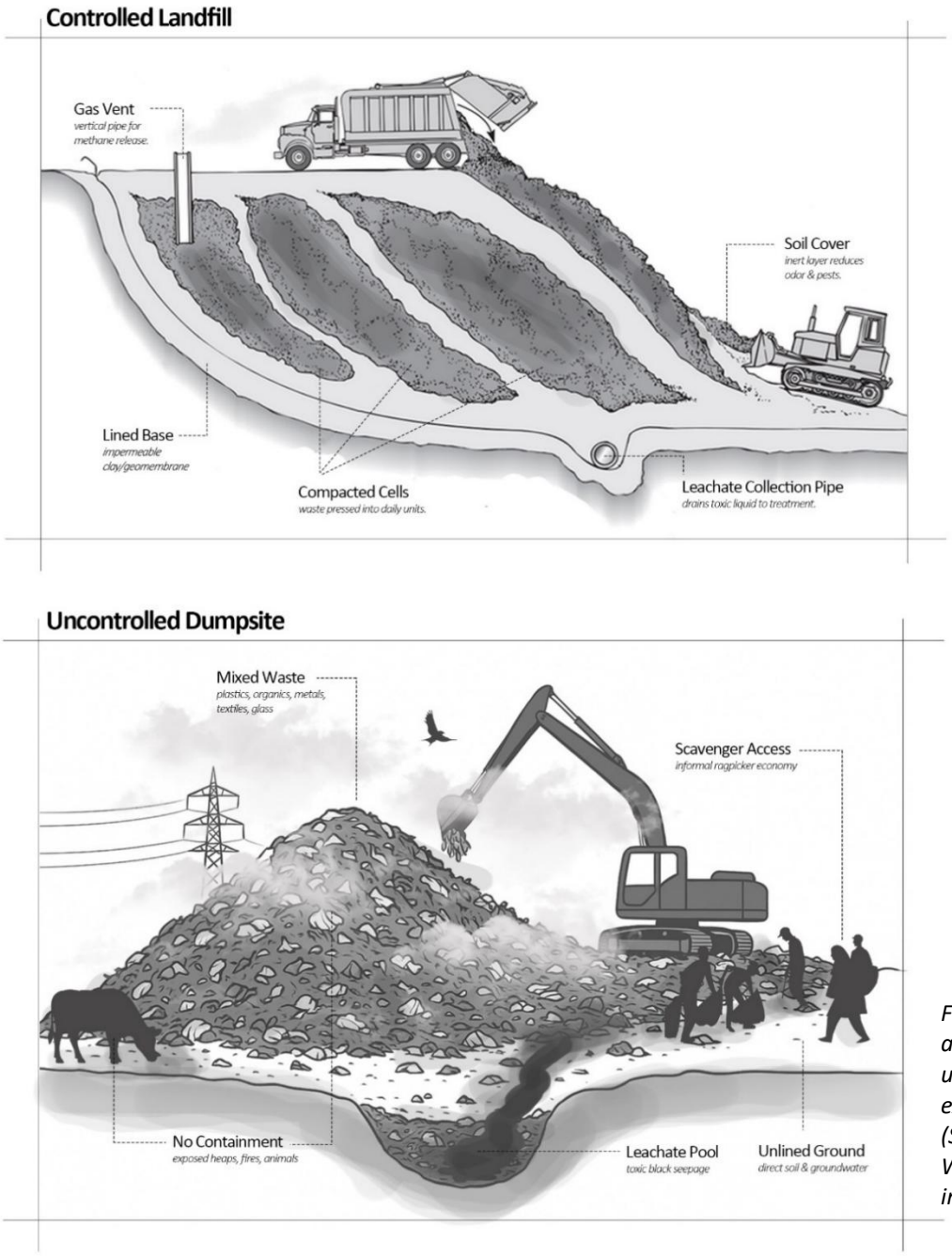


Figure 3: Controlled landfill as buried infrastructure vs. uncontrolled dumpsite as exposed urban void. (Source: Vesilind & Worrell, 2012; Dumpsite interpretation by author)

When waste is excluded from the design and planning imagination, cities may project an image of cleanliness, yet this often masks deeper fragmentation—where formal systems displace burdens onto informal labor and peripheral landscapes rather than resolving them. As Gidwani and Reddy argue, waste is not merely matter out of place, but a political condition that reveals the contested terrains of labor, land, and belonging[2]. To ignore its spatial and social dimensions is to overlook the city's most persistent contradictions.

Dumpsites as Urban Failures and Active Artifacts

Figure 3 illustrates the distinction between a landfill and a dumpsite. A landfill, in theory, is a place to dispose of waste material by burying it and covering it over with soil, especially as a method of filling in or extending usable land[3]. By contrast, a dumpsite is an "unlined and unscientifically designed landfill," accumulating legacy waste and frequently reworked by informal labor- ironically making it sometimes more circular than inert, capped landfills. Legacy waste refers to mixed municipal solid waste: biodegradable matter, plastics, textiles, metals, glass, and more[4]. The country generates over 150,000 metric tons of municipal solid waste per day, with 80% of it remaining unsegregated[5]. More than 3,100 legacy dumpsites cover an estimated 16,000 hectares of land[6]. Most are located at the edge of cities, yet their effects radiate inward- through polluted drains, foul air, and labor networks that reach into every neighborhood. As the Centre for Science and Environment (CSE) notes, India's dumpsites have become "ticking time bombs," generating methane, leachate, and fire hazards while symbolizing a collective denial of consequence[7].



Figure 4: Urban Dumspite in India (Source: Mongabay India)

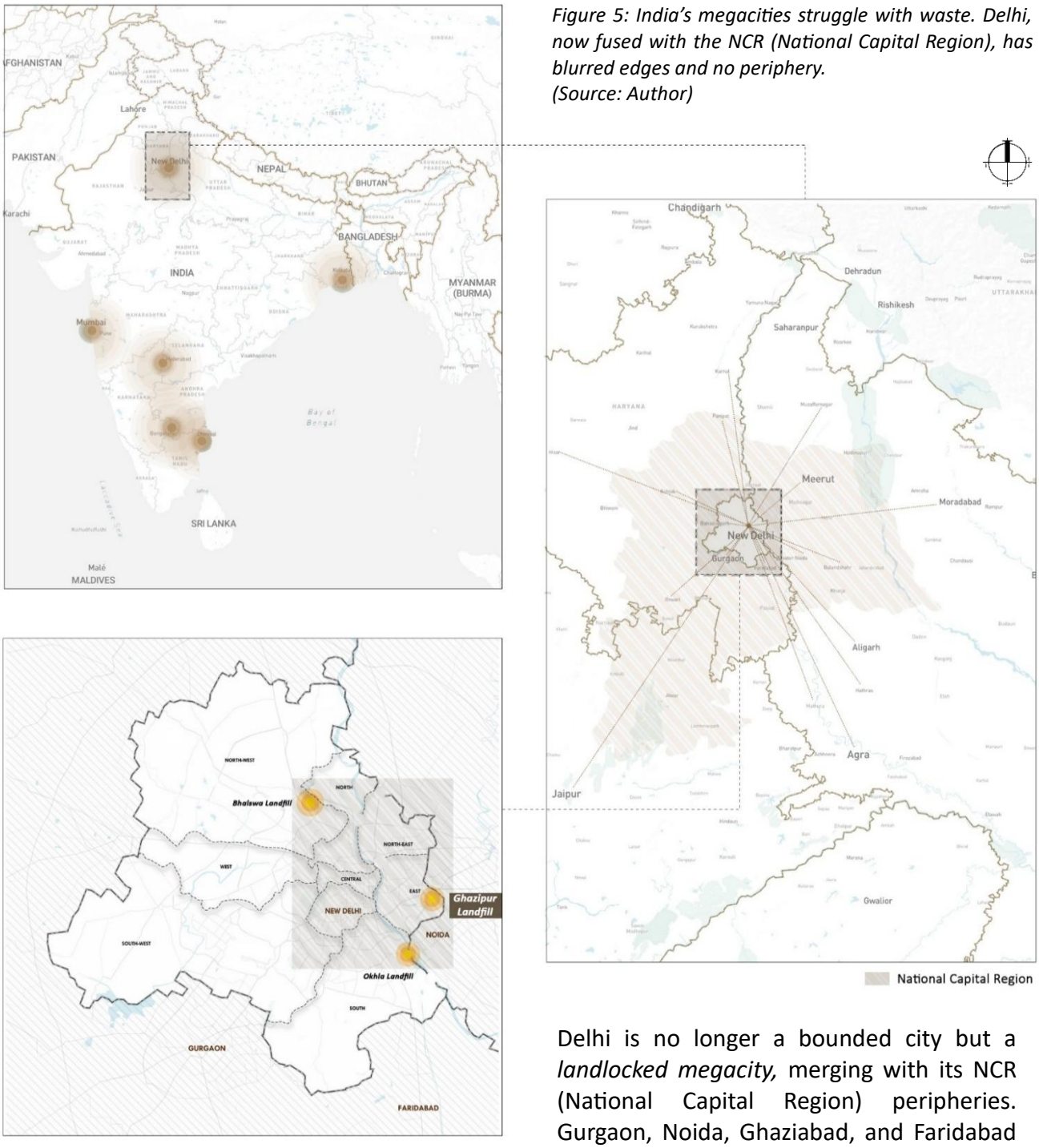


Figure 5: India's megacities struggle with waste. Delhi, now fused with the NCR (National Capital Region), has blurred edges and no periphery.
(Source: Author)

Delhi is no longer a bounded city but a *landlocked megacity,* merging with its NCR (National Capital Region) peripheries. Gurgaon, Noida, Ghaziabad, and Faridabad blur the capital's edge, making land once peripheral: and once hosting landfills, now deeply embedded in dense settlement.

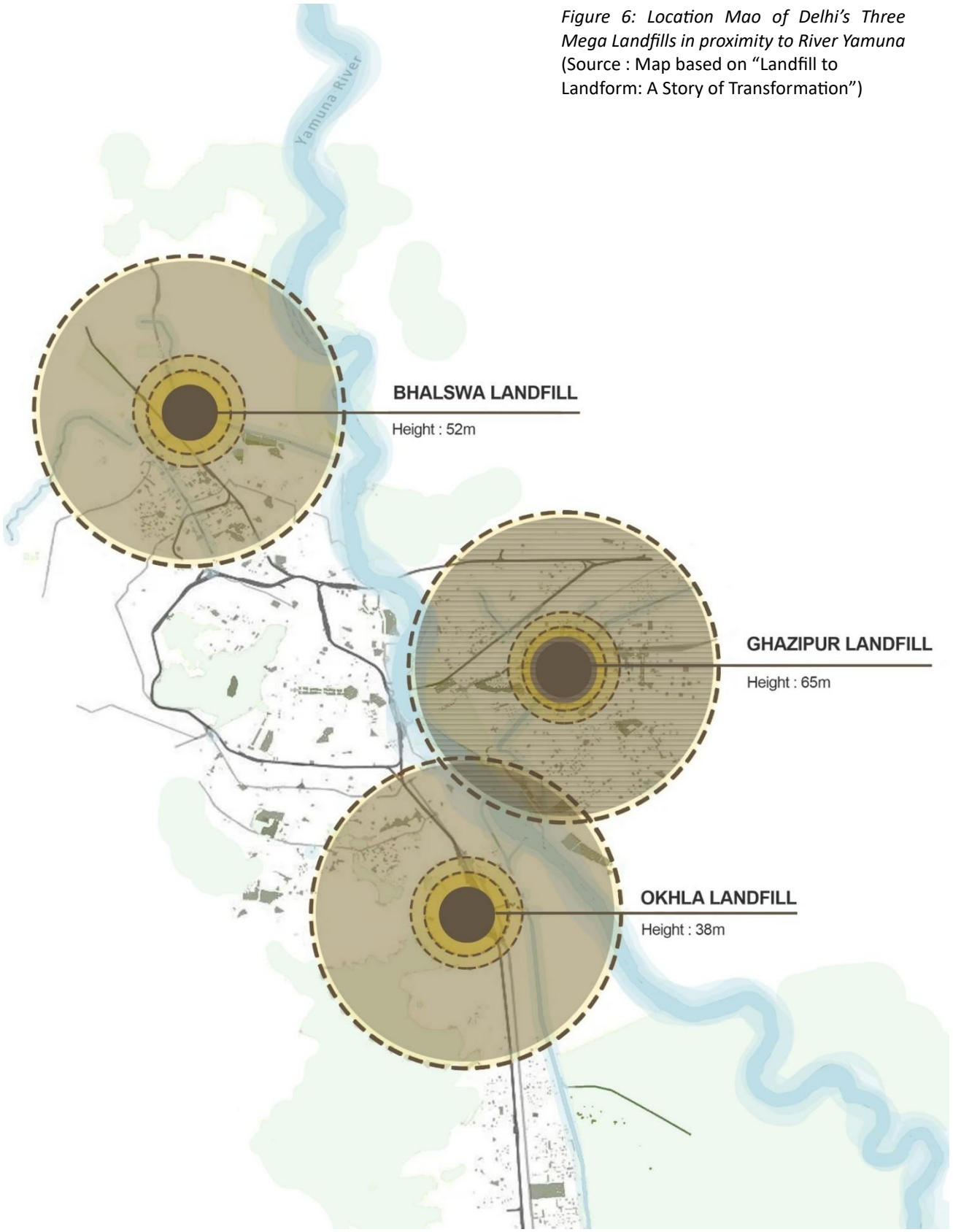


Figure 6: Location Mao of Delhi's Three Mega Landfills in proximity to River Yamuna (Source : Map based on "Landfill to Landform: A Story of Transformation")

1.2 Delhi: Reading the Capital Through Its Dumpsites

Delhi is India's capital, but it is also a condensed map of the nation's urban contradictions. It pairs monumental infrastructure: expansive highways, an extensive metro network, and enclaves of luxury housing with fragile public systems, unregulated sprawl, and chronic shortages of essential services. Nowhere is this paradox more visible than in its waste landscape. It is a city of 34 million people, generating over 11,400 metric tons of waste each day[8]. Much of this waste, still unsegregated, is funneled into three enormous sites: Ghazipur, Bhalswa, and Okhla. All three were declared overcapacity years ago. Yet they continue to receive waste daily, continuously. Each of these landfills represents not only an infrastructural challenge but also a way of reading the city itself.

When they were first established in the 1980s and 1990s, these landfill sites were sited on Delhi's edges, chosen precisely because they were far from the city's core. Ghazipur was placed in East Delhi near the border with Uttar Pradesh; Bhalswa was opened in the low-lying northern wetlands; and Okhla was set up on the then-fringe of South Delhi, near the Yamuna River corridor. At the time, these areas were peripheral, separated from residential neighborhoods by stretches of farmland and open ground. But Delhi's relentless expansion and the growth of the National Capital Region have since engulfed them. What were once margins are now active centers of habitation, trade, and mobility. The city's peripheries have blurred into dense settlement, making the landfills impossible to ignore.

Bhalswa, in North Delhi, began as a dumping ground over a wetland in 1994[9]. The site consumed a water body once used by surrounding settlements, replacing it with a toxic mound of waste that today rises over 60 meters. Leachate from Bhalswa seeps into groundwater and drains, contaminating local water sources. Fires from methane build-up frequently ignite, filling nearby neighborhoods with smoke[10]. For residents, Bhalswa is not an unseen periphery - it is part of daily life, looming above their homes and altering the ecology of the north. Okhla, in South Delhi, is smaller but more contentious. Located within the dense urban fabric, the site sits close to residential colonies, hospitals, and one of the city's largest bird sanctuaries. Its proximity to living neighborhoods has made it a flashpoint for public protest. The Okhla waste-to-energy plant, set up nearby, has been repeatedly criticized for emissions that worsen Delhi's already toxic air[11]. Okhla reveals how the city's waste infrastructure is no longer out of sight but collides directly with urban habitation.



Figure 7: The 65m tall Ghazipur Landfill, Delhi (Source: © 2019 AFP)

Among these landfills, Ghazipur Landfill is the most notorious. Established in 1984 on what was then the periphery of East Delhi, the site was originally intended to function as a controlled sanitary landfill. In practice, however, it became an open dump, absorbing mixed waste with little regulation or long-term planning. What was once low-lying agricultural land has now risen into a 65-meter-high mound of waste[12]. In 2017, a section of the landfill collapsed after heavy rains, killing two people and underscoring its structural instability[13]. A 2025 National Green Tribunal (NGT) report[14] noted ongoing boundary breaches, uncontrolled dumping, and serious risks of slope failure. Ghazipur today stands not only as an environmental hazard but also as a spatial monument to neglect. Yet it is precisely these conditions that make Ghazipur the central focus of this study. Unlike Bhalswa or Okhla, Ghazipur is not hidden at the city's edge. It sits at the nexus of housing, commerce, and infrastructure, where the contradictions of Delhi's growth are most intensely felt. Every day, more than 1,500 informal waste pickers[15] climb its surface to extract recyclables, making the landfill simultaneously a site of danger and of livelihood.

.

Invisible Labor and the Illusion of Removal

The true infrastructure of waste is human. Delhi's waste system is upheld by tens of thousands of informal workers- waste pickers, sorters, and truck loaders. These workers scale landfill slopes daily, sort recyclables with bare hands, and navigate a system that depends on their labor but excludes their presence from policy and design. According to a CSE study[i], Delhi alone is home to 80,000 to 300,000 informal waste workers[16]. This labor force operates in a paradox of visibility: ever-present in the physical landscape yet excluded from institutional recognition. They do not appear in master plans, are not factored into infrastructure design, and lack access to basic workplace rights. Their absence from the architectural imagination is significant; because when design fails to account for the people maintaining a system, it also fails to uphold dignity, safety, or justice in the spaces they occupy. Architecture, when inattentive to informal labor, reinforces hierarchies that keep waste work unseen and undervalued.

Meanwhile, Delhi's model of waste management is centralized in infrastructure but fragmented in labor. While informal workers form the foundation of collection and sorting, official waste flows are organized through distant processing hubs and peripheral landfills. Waste travels long distances from neighborhoods to

[i] CSE: Centre for Science and Environment

dumpsites, severing citizens from the environmental and social consequences of their consumption. This disconnect produces a dangerous illusion; that waste disappears, handled elsewhere, by someone else. Decentralization, where small-scale infrastructures are embedded throughout the city, ecological restoration, where remediation replaces abandonment, and infrastructure dignity, where waste spaces are designed not as voids but as active, humane, and inclusive urban systems, are all urgently required.



Figure 8: Informal waste pickers working at Delhi dumpsites
(Source: (a) Adnan Abidi/Reuters; (b) Reuters; (c) Reuters; (d) Rick Loomis/Los Angeles Times)

(a) Waste pickers sorting through mixed waste as a truck unloads new material.
(b) Workers hauling collected recyclables up unstable waste mounds.
(c) A man walking with a sack balanced on his head across the landfill expanse.
(d) Children carrying large bundles of recyclable waste from the dumpsite.

1.3 The Design Blind Spots

Waste is a spatial problem, yet it is rarely treated as such. Architecture and urban design disciplines usually turn away from waste - its messiness, its materiality, its associations with disorder - leaving it to engineers, sanitation workers, and policy manuals. What emerges is a choreography of neglect: dhalaos[ii] tucked behind walls, transfer stations treated as logistical voids, dumpsites rendered invisible until they erupt into crisis. These are not designed spaces, but afterthoughts - functional and residual. The dominant frameworks remain technical. Management handbooks, CPCB (Central Pollution Control Board)[iii] toolkits, and MSW (Municipal Solid Waste)[iv] regulations emphasize logistics: how much waste is collected, processed, dumped, or burned[17]. These frameworks often overlook questions of form, material, access, labor, and urban experience. Waste, in these accounts, is a number, not a space. Elsewhere, however, other fields have begun to trace waste's human and symbolic dimensions. Further discussed in Part 2, artists, writers, and activists have turned to waste not just as matter, but as metaphor: probing its social hierarchies, tactile economies, and emotional weight. These works do not resolve waste, but reframe it, asking:

Who touches it? Who designs the spaces it moves through? Who gets to forget?

Yet waste continues to shape cities unevenly, removing the burden for some while concentrating its risks on others. This thesis enters that gap, positioning waste not as a side effect of urban life but as a central force shaping its spaces, systems, and inequities. It positions design not as a late-stage fix, but as a practice of reintegration - of stitching waste back into the rhythms of everyday life. It asks how architecture might engage not with the spectacle of disposal, but with the slow work of renewal. *Figure 9* maps this position within the overlapping domains of technical, cultural, and spatial frameworks. It illustrates how current approaches often remain siloed with technical systems focused on logistics, cultural narratives

[ii] *Dhalaos*: small, often enclosed municipal waste collection points in Indian cities, typically serving as neighborhood-level transfer stations where residents and sweepers deposit mixed waste before it is transported to larger processing or disposal sites.

[iii] *CPCB: The Central Pollution Control Board,* under India's Ministry of Environment, Forest and Climate Change, sets environmental standards and issues guidelines for pollution control and waste management.

[iv] *MSW: Municipal Solid Waste*, everyday waste from homes, institutions, and public spaces, including organic, recyclable, and non-recyclable materials.

exploring symbolism, and design disciplines largely disengaged. At their intersection lies the thesis's proposition: an integrated design-led framework that treats waste as both system and civic space, embedding ecological restoration, labor dignity, and public engagement into the urban fabric.

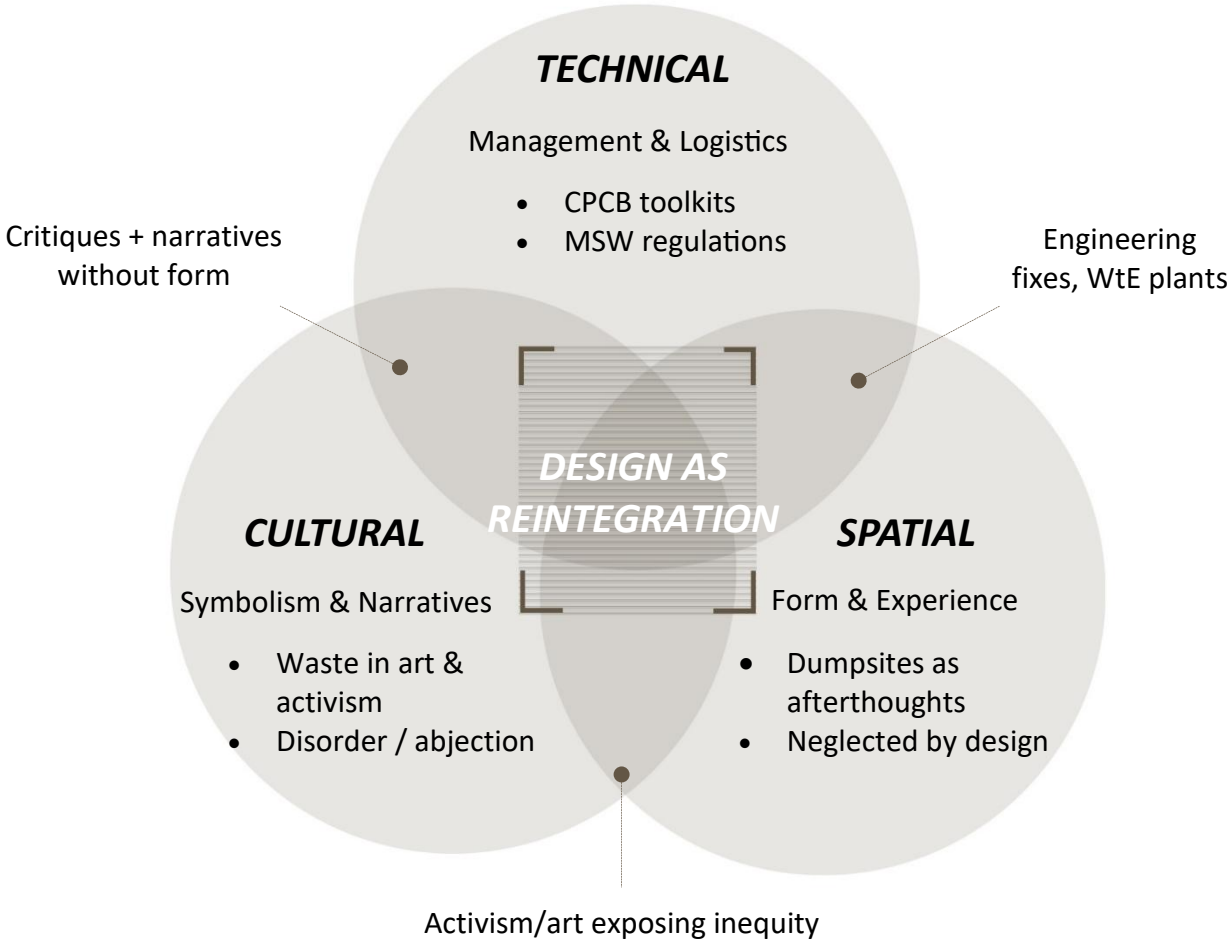


Figure 9: Framework of Waste: Technical – Cultural – Spatial (Source: Author)

1.4 A New Question for Old Practices

This research is guided by a central question:

Can a decentralized, multiscalar, design-led approach to waste management in Delhi reduce dumpsite dependency while restoring land, labor dignity, and public space?

- *Decentralization* means bringing waste processing closer to where it is generated within neighborhoods, markets, and housing clusters. In this thesis, decentralization is explored through the redesign of public waste infrastructure into localized waste nodes embedded with processing systems that reduce the need for distant dumping and processing.

- *Multi-scalar* implies interventions across nested levels: city-wide planning, community-based infrastructure, and the specific case of the Ghazipur dumpsite. The thesis operates across these layers - proposing zoning strategies at the metropolitan scale, a neighborhood pilot in Delhi, and a phased transformation of Ghazipur into a regenerative public landscape.

- *Design-led* asserts the need to integrate architectural strategies with engineering, ecology, and governance, moving beyond policy into space-making. Rather than treating waste as a technical problem alone, the thesis positions design to reimagine neglected typologies into visible, shared systems.

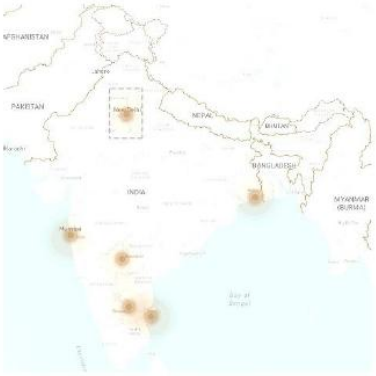
1.5 Research Methodology

To pursue this question, the research adopts a layered methodology that combines critical analysis with spatial and design thinking. Ethnographic sources including NGO publications, field observations, and journalistic accounts offer insight into Delhi's informal waste economy, caste-based labor hierarchies, and the lived experiences of waste pickers. These are paired with a close reading of legal and institutional documents, including India's MSW Rules (2016), CPCB manuals, NGT orders, and international standards on landfill remediation and ecological infrastructure, which establish regulatory frameworks and performance benchmarks that inform the feasibility, sequencing, and environmental safeguards of the proposed design interventions. Spatial inquiry plays a central role. Citywide mapping traces the uneven distribution and condition of infrastructure, revealing how waste infrastructure overlaps with housing typologies, land use, and class-based geographies. Site-specific analysis of the Ghazipur landfill reveals its embeddedness within surrounding ecological systems, infrastructure, and settlement patterns, highlighting how its impacts extend well beyond the site's boundaries. These observations draw from satellite data, ground visits, and historical imagery, allowing the site to be read not just as waste, but as terrain.

Precedents are studied not only for form, but for logic. Projects like Fresh kills Park in New York, Devaguradia in Indore, and the Vellore SLRM (Solid & Liquid Resource Management) model provide reference points for how waste landscapes can be ecologically remediated, spatially reintegrated, and publicly reclaimed. The design process builds from these insights to imagine a system that is both infrastructural and civic: one that unfolds through zoning interventions, neighborhood prototypes, and the reprogramming of Ghazipur from dumpsite to landscape. Alongside technical and spatial analysis, the research employs a comic-style illustrative approach to narrate waste stories. This visual method distills complex infrastructural systems and lived experiences into accessible, sequential narratives that blend factual accuracy with human perspective. The use of layered scenes and metaphor allows the thesis to communicate across disciplinary boundaries making invisible labor visible, and re-situating waste as part of the everyday urban experience rather than a hidden, peripheral condition. In this methodology, waste is not treated as residue to be removed, but as material, space, and condition to be reworked, a lens through which the city's deepest contradictions and most urgent possibilities come into focus.

What Lies Ahead:

The chapters that follow build a structured progression from critique to intervention. The thesis begins by examining global waste systems to uncover how labor, infrastructure, and urban form are entangled in processes of exclusion, especially through the neglect of rag pickers and the absence of spatial imagination in mainstream discourse. It then grounds this critique in the Indian context, with a focus on Delhi's waste management failures and the infrastructural, ecological, and social breakdown evident at the Ghazipur dumpsite. Drawing from a set of global and Indian precedents including decentralized systems, landfill reclamation models, and community-integrated waste typologies: the thesis develops a strategic framework for design. This sets the stage for multi-scalar proposals, spanning city-wide systems, neighborhood interventions, and the phased transformation of Ghazipur from dumpsite to civic and ecological infrastructure. Together, these chapters argue for a design-led response to waste: one that restores material cycles, public space, and labor dignity within the fabric of the city.













Rethinking









Waste(d) Realities

Part 1 Endnotes

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Part 2

Waste, Power, People

A Global Perspective





Figure 10 : Waste Management & People in Global North vs Global South
(Source: WPWMA; Akbar, Basti Suraksha Manch)

Overview:

This part frames waste as a driver of spatial inequality, linking global waste flows to the marginalization of certain geographies and communities. It examines the caste, class, and gendered structures of informal waste labor, critiques architecture's neglect of waste spaces, and calls for design to address waste as a civic, ecological, and social opportunity

"Everyone must be his own scavenger."

- Mahatma Gandhi [18]

2.1 Waste as Infrastructure of Inequality

Modern cities are built on a concealed geography of waste. Behind every act of consumption lies a chain of discards- material flows that must be removed to maintain the illusion of order. But waste is not just the byproduct of urban life; it is a powerful spatial and political force. In the Global South, waste does not disappear- it accumulates in landfills, in informal settlements, and in the bodies and lives of the poor. Waste infrastructure is among the most unevenly distributed systems in the world. According to the World Bank, global municipal solid waste is projected to reach 3.88 billion metric tons by 2050, with over 90% of this growth occurring in low- and middle-income countries[19]. Yet these same regions lack the systems to safely manage it.

In India, more than 60% of solid waste is dumped in open sites without treatment or segregation[20]. These are not mere technical gaps - they are symptoms of systemic environmental injustice. This condition, which environmental historian Marco Armiero refers to as a "geography of sacrifice", highlights how certain communities are structurally consigned to absorb the metabolic costs of urban life[21]. As one landfill expands, another community is erased. Waste follows power. The distribution of waste infrastructure follows what geographer Ruth Wilson Gilmore calls "organized abandonment": a process by which state neglect is not accidental but structurally embedded, rendering certain populations disposable[22]. Dump sites are rarely placed near affluent areas. Instead, they are sited near the urban poor, particularly communities with limited political power. The spatial logic is clear: waste follows power. Their locations reflect what geographer David Harvey calls the "spatial fix"- the tendency of capitalist systems to displace environmental burdens onto marginalized geographies[23].

In contrast, the Global North invests in engineered sanitary landfills, incinerators with pollution control, and formal recycling loops. Germany, for instance, recycles over 65% of its waste[24], while countries like the US and Canada have robust curbside collection systems. The difference is not merely technical- it is infrastructural, cultural, and political. In many parts of the Global South, there is a systemic lack of investment in waste infrastructure, but more critically, a lack of spatial imagination about what role landfills, recycling centers, and composting

facilities could play in the urban fabric. A comparative mapping of some of the world's largest landfills shows this uneven geography in practice. Sites like Apex Regional in Las Vegas (2,200 acres) or Laogang in Shanghai (830 acres) are engineered to absorb vast urban flows, while India's Delhi landfills (500 acres) and Deonar in Mumbai (326 acres) represent the overburdened realities of rapidly urbanizing regions in the Global South. Together, these sites reveal how both high- and low-income cities rely on massive landscapes of disposal, yet under starkly different conditions of governance, investment, and justice.

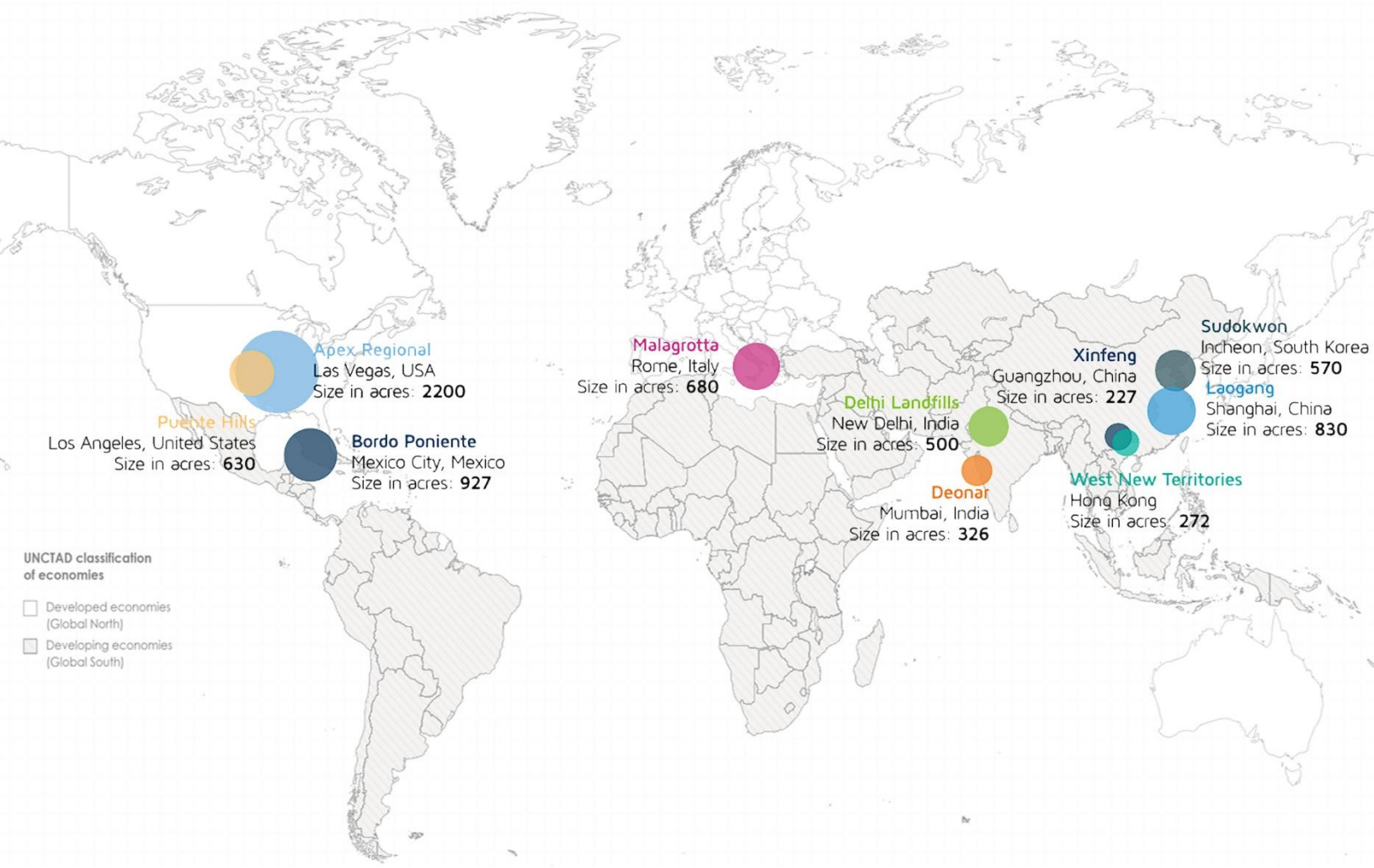


Figure 11: Global Landfills by Scale and Geography:
A Comparative Mapping of Waste Landscapes in the Global North and South
(Source: Author; Data retrieved from www.statistica.com).

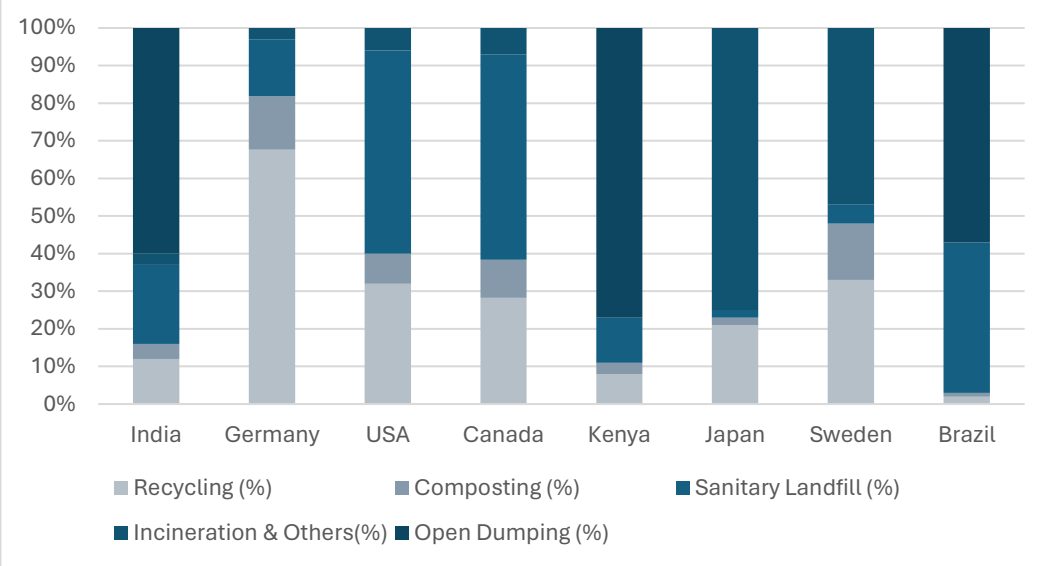


Figure 12 : The chart compares how selected countries handle municipal solid waste, showing the proportion managed through recycling, composting, sanitary landfill, incineration, and open dumping.
(Source: Author; Data retrieved from World Bank 'What a Waste 2.0 Global Waste Statistics 2018)

High-income nations like Germany, USA and Japan rely heavily on engineered systems, including large-scale incineration, while countries like India, Brazil, and Kenya depend on open dumping. The contrast highlights global inequalities in waste infrastructure and the persistence of visible, untreated waste in much of the Global South. Waste is not a side effect- it is a designed condition, deeply embedded in urban form and governance. Similarly, Achille Mbembe's notion of "necropolitics" is useful here: the management of waste and waste labor becomes a technique through which states decide which lives are worth protecting and which can be left to rot[25]. To engage with it as architects means to confront the uneven geographies of disposal, the political structures that sustain them, and the lives entangled in their margins.

2.2 Waste Labor: Caste, Gender, Informality

If waste marks the periphery of urban design, then waste labor exists at the periphery of labor recognition. In many cities of the Global South, it is not the municipality but the informal sector that handles most of the recycling, composting, and reuse. India alone has over 1.5 to 4 million informal waste workers- ranging from itinerant buyers to landfill pickers who sustain material

circulation through labor that is unpaid by the state and largely unprotected by law[26]. This labor is not randomly distributed. It is structured through caste, class, gender, and migration. Waste work in India is historically associated with Dalit communities, who have long been assigned "polluting" labor by the Hindu caste system[27]. As Gopal Guru argues, caste is not just about ritual purity- it is about control over dirty work and the symbolic degradation attached to it[28]. In this light, waste becomes a vehicle through which caste oppression is enforced.

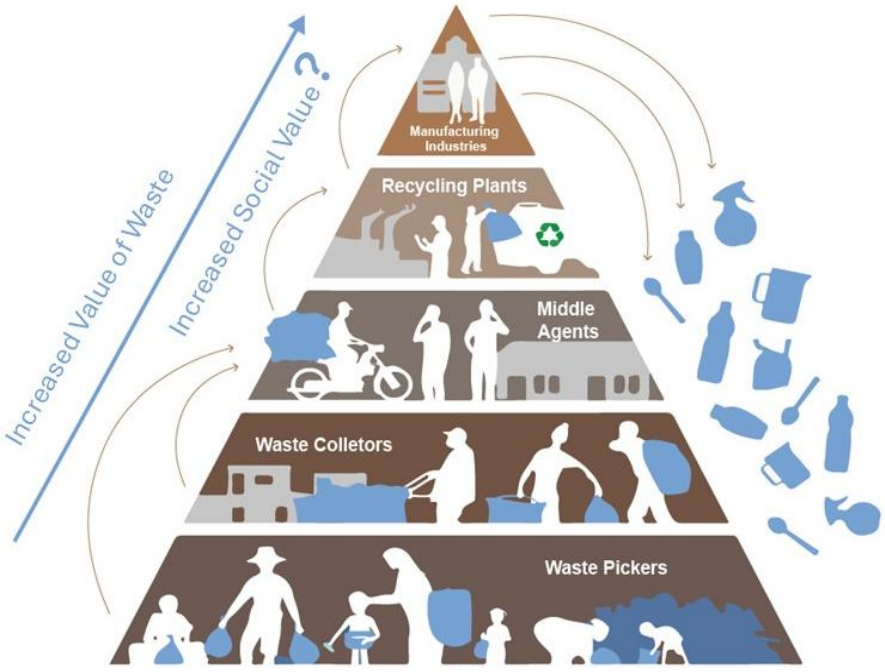


Figure 13 : Socio-economic pyramid of the recycling chain, adapted from Anna Barford (2021) and reminiscent of Lockhoff's Pyramid of Capitalist System (1901).

At the base of recycling pyramid are *waste pickers*, who recover discarded materials under precarious, low-paid, and socially marginalized conditions. Above them, *waste collectors* gather and transport recyclables, often with minimal recognition or protection. *Middle agents* then consolidate and sell these materials to *recycling plants*, where the waste's market value increases significantly. At the apex, *manufacturing industries* transform recycled inputs into new products, capturing the highest economic returns. It also reveals a stark paradox. As waste moves upward, its economic value rises, but so does the social value accorded to those handling it - leaving those at the bottom with the least benefit despite their essential role in sustaining material recovery. This hierarchy highlights the

structural inequities embedded in global and local waste economies, where social status and income are inversely proportional to exposure to risk and environmental harm. This inequity signals the need to design dignified, well-integrated waste infrastructure that bridges informal and formal systems, redistributes value, and reclaims waste spaces as active, civic components of the city's fabric.



Figure 14: Communities surrounding landfills: families, workers, and animals daily lives unfold near waste. (Source: Better Bhalswa)

This labor is also deeply gendered. Women make up most waste pickers across Indian cities. Often, they work under harsher conditions, earn less than their male counterparts, and are more vulnerable to harassment and health risks. As feminist scholar Silvia Federici writes, care labor- including ecological care- is devalued precisely because it sustains life rather than profits[29]. Waste work, which rehabilitates material for reuse and sustains public hygiene, fits squarely in this category. Children and elderly also constitute a significant portion of the workforce. A 2020 Save the Children report estimates that 20% of Delhi's rag pickers are children under 14 [30]. Many are migrants from states like Bihar, West Bengal, and Uttar Pradesh- living in temporary settlements near landfills, without sanitation or state protections.

Despite its contribution, informal waste work is criminalized and stigmatized. Workers are harassed by police, displaced by privatized waste contracts, and excluded from formal spaces of decision-making. The Chintan Environmental Research Group notes that even when waste pickers are integrated into municipal systems, they remain at the lowest rung- paid less, given the dirtiest work, and rarely consulted on policy[31]. This reflects a broader condition of what Nivedita Menon terms "democracy without dignity": the ability to vote without being seen as fully human in civic life[32]. Architecture as a discipline has largely ignored these

realities. Waste labor occurs in spaces not recognized as architectural: back alleys, informal structures, sorting sheds cobbled from scrap. The layered history of, as traced in both field observations and accounts from waste workers, shows how these spaces continue to operate despite infrastructural neglect[33]. These are zones of operation but not of design.

What would it mean to design for waste workers, with them?

Bringing waste workers into the architectural imagination demands new tools, methods, and collaborations. It means designing for people historically left out of urban narratives. It also means challenging architecture's comfort with clean surfaces and disciplinary distance.

2.3 Design: A Cultural and Spatial Blindspot

While urban design has engaged with themes like housing, transportation, and public space, waste remains peripheral. It is treated as a technical backend: handled by engineers, ignored by architects. This omission is not accidental- it reflects a cultural hierarchy of design, where the "clean" is celebrated and the "dirty" is delegated. The design community has allowed waste to become a blind spot, reinforcing what anthropologist Mary Douglas called "matter out of place"[34] - something to be expelled, rather than examined. Architecture has reflected this view. Waste spaces are rendered invisible: dhalaos hidden behind gates, transfer stations treated as back-end infrastructure, and landfills exiled to the periphery. The result is a city designed to forget what sustains it.

The cultural marginalization of waste also produces a *spatial marginalization.* Public spaces such as plazas, parks, and boulevards are framed as worthy of aesthetic and architectural investment, while waste infrastructures are designed for concealment. These facilities often exist as utilitarian containers; bare concrete shells, makeshift sheds, or fenced-off enclosures. Their invisibility is both literal and symbolic: residents rarely enter them, planners rarely draw them, and architects rarely imagine them. In this sense, waste operates as what theorist Rob Nixon has called "slow violence"[35] - its harm accumulates quietly, in leachate, smoke, and disease, without dramatic spectacle or architectural recognition.

Seeing Waste Differently

Yet cultural producers have long filled this void: the neglect of waste in architectural and urban design discourses by reframing it through metaphor, art, and critique. Artists like El Anatsui, Manveer Singh, and Song Dong create monumental installations from discarded objects, reframing waste as memory, migration, and material history. Photographers like Sebastião Salgado and Raghu Rai capture waste pickers not as victims, but as resilient agents within broken systems. The documentary *Waste Land* (2010) shows artist Vik Muniz collaborating with Brazilian catadores[v] to transform trash into portraits of power and self-recognition[36]. Writers like Saumya Roy[37], in *Mountain Tales*, chronicles the daily lives of waste pickers at Mumbai's Deonar landfill, revealing how poverty, urban neglect, and environmental toxicity intertwine in one of Asia's oldest dump sites. Ankur Bisen, in *Wasted*, critiques India's fragmented waste governance and argues that the absence of design thinking has turned sanitation into a social and infrastructural failure[38]. These works reveal a key point: visibility is political. To see waste is to see inequality. To aestheticize it is not to romanticize poverty but to restore the narrative agency of those erased by formal systems.

Some designers have begun to respond. Jennifer Gabrys proposes the idea of "citizen infrastructures"- systems that are co-produced by communities and embedded in the rhythms of daily life[39]. Her work in sensing, monitoring, and engaging with environmental systems challenges the top-down logic of waste planning. Nils Norman argues for infrastructural ecologies: spaces that are both functional and pedagogical, treating waste not as residue but as process[40]. To bring waste into design discourse is to confront the failures of modern urbanism, the lives it devalues, and the landscapes it desecrates. But it is also an opportunity to redefine what architecture values, who it includes, and how it heals.

Waste is not just an object- it is a process that reveals the limits of our imagination.

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[v] In Brazil, informal waste pickers are commonly referred to as *catadores* in Portuguese. People who gather, sort, and sell recyclables from homes, streets, and landfills.

Figure 15: Waste in Culture and Politics. Collage of films, reports, and books that frame waste as central to labor, inequality, and environment. (Source: compiled by author)



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Part 3

Unraveling The Crisis

Waste System Collapse in India, Delhi, and Ghazipur Landfill



Figure 16 : From top of the Ghazipur Landfill Mountain, Delhi (Source: Sky News)

Overview:

This part examines the spatial collapse of waste management in India, focusing on Delhi and Ghazipur Landfill. It explores how urban waste systems in India are marred by outdated, fragmented infrastructure and governance. It highlights the precarious working conditions of informal waste labor and advocates for the reimagining of waste spaces as opportunities for civic, ecological, and social transformation.

3.1 India: Confronting Waste as Urban Condition

India's urban transformation is layered with contradictions. On one hand, it promises globalized skylines, expanding metros, and digital governance; on the other, it masks deteriorating public infrastructure, crumbling drainage systems, and toxic waste accumulations. Nowhere is this split more visible than in the terrain of urban waste. As Indian cities modernize, their waste management systems remain burdened with colonial legacies, fragmented responsibilities, and a culture of invisibilization. The result is an urbanism that conceals its waste while displacing its burdens- spatially, socially, and environmentally.

In India, the siting of landfills in low-income areas is deeply tied to the country's rapid urbanization and growing waste challenges. This study began by surveying India's major landfill sites: Deonar in Mumbai, Dhapa in Kolkata, Jawahar Nagar in Hyderabad, and Ghazipur in Delhi. Each reveals the persistence of open dumping despite regulatory calls for closure Historically, landfills were placed on the outskirts of cities, deemed to be less valuable for development. However, as urban sprawl has engulfed these peripheries, low-income populations, often living in informal settlements or on unoccupied land, find themselves in the shadow of these dumpsites. The lack of political influence, limited access to resources, and low land values in these areas make them vulnerable to environmental burdens like landfills, which are typically far removed from wealthier parts of the city. This spatial inequity exacerbates environmental and social justice issues. Communities living near these landfills suffer from the direct consequences of inadequate waste management, including polluted air from burning trash, contamination of groundwater, and the spread of diseases through unmanaged waste. In contrast, wealthier areas benefit from more efficient waste management systems, including regular collection, recycling programs, and proper landfill sites located at a greater distance. The lack of effective policy enforcement, inadequate infrastructure, and limited public awareness on waste segregation have compounded these challenges.

Between 2001 and 2021, India's urban population grew by over 91 million. Projections estimate over 600 million people will live in cities by 2036 [41]. Alongside this demographic shift, municipal solid waste (MSW) generation has exploded, now estimated to exceed 165 million tonnes annually. Yet, the systems tasked with managing this waste remain underdeveloped, outmoded, and deeply reactive. Over 3,000 legacy dumpsites remain active across India, many operating well beyond capacity[42] covering over 16000 hectares of land. India's policy frameworks, though ambitious on paper, falter in practice.

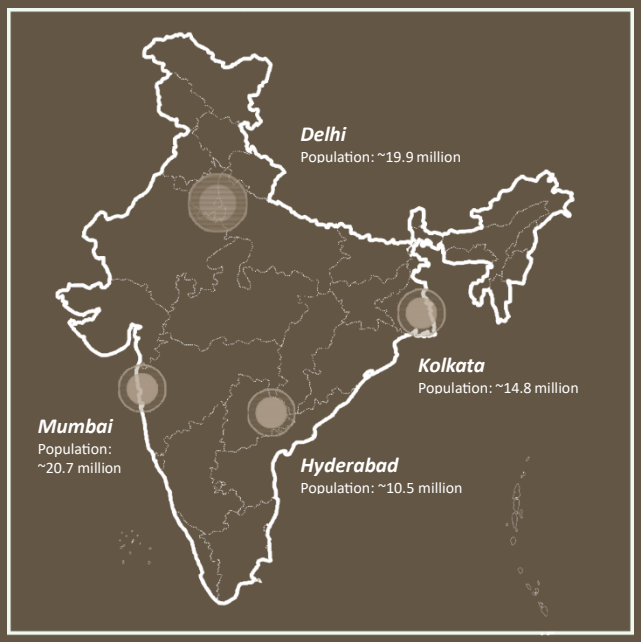
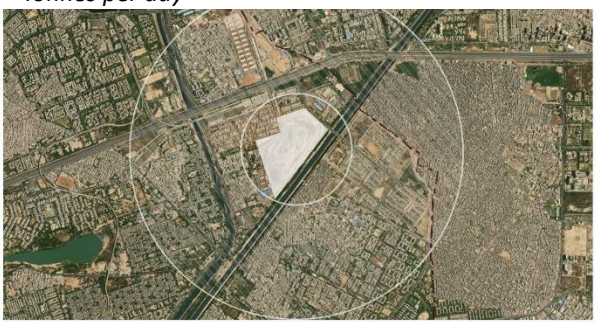


*Figure 17: Some of the Mega Landfill – Dumpsites in India (Source: Author, Google Earth) *Tonnes per day*



Ghazipur Landfill, Delhi – 70 acres | 2,600 TPD* | **72 m**



Deonar Landfill, Mumbai – 770 acres | 5,500 TPD* | **36 m**



Jawahar Nagar, Hyderabad – 350 acres | 4,500 TPD* | **40 m**



Dhapa Landfill, Kolkata – 21 ha | 3,000 TPD* | **20 m**

The Solid Waste Management Rules (2016) mandated source segregation, decentralized treatment, and closure of open dumps. Yet, reports from Chintan and the Centre for Science and Environment (CSE) indicate poor compliance, with over 60% of cities lacking operational composting or MRF (Material Recovery Facility) infrastructure[43]. This systemic failure has left Indian cities oscillating between outdated, overburdened dumpsites and fragmented, poorly implemented reforms. Rather than strengthening decentralized infrastructures such as composting units, segregation systems, and local MRFs, municipal authorities have leaned toward large-scale, centralized solutions that promise quick fixes. It is within this policy vacuum that waste-to-energy (WTE) plants have emerged as the emblem of modernity and efficiency.

Despite mounting evidence of their inefficiency, waste-to-energy (WTE) plants continue to receive disproportionate attention and investment from state and municipal bodies in India. Promoted as high-tech, space-saving solutions capable of reducing landfill volumes while generating power, these incineration-based facilities have become the poster child for modern waste infrastructure. Unlike Western nations, where municipal waste often comprises largely dry, recyclable materials, Indian waste is wet-heavy, consisting of over 50% organic matter[44] due to dietary patterns rich in fresh produce. Packaging remains relatively limited, and household-level segregation is rare. The resulting waste is high in moisture and low in calorific value- qualities that severely undermine the efficiency and safety of incineration[45].

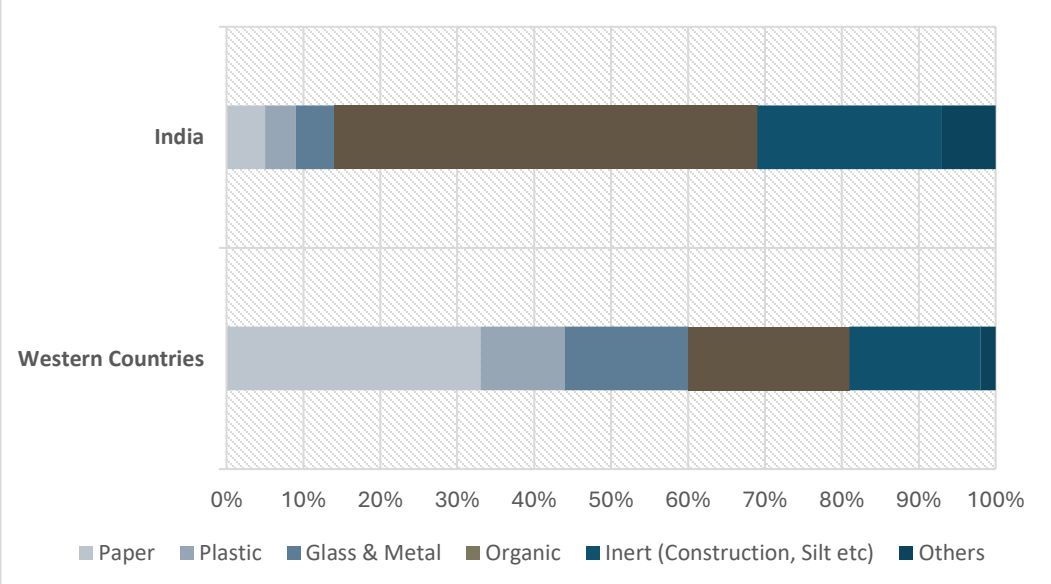


Figure 18: Comparison of municipal solid waste composition in India and Western countries. (Source: Author; Data derived from the article "Sourcing the Science…" (ScienceDirect))



Figure 19: Waste-to-energy plants and overflowing landfills spark public protests across India. (Source: iamrenew / "Why Waste-to-Energy Plants Are Bad News")

In practice, WTE plants across India have underperformed, failed outright, or faced fierce resistance. Technical inefficiencies, high operational costs, and toxic emissions have triggered legal battles, community protests, and even plant closures. The so-called solution has, in many cases, become a new form of environmental hazard. Also, this techno-managerial push often sidelines alternative systems: smaller-scale, decentralized, and socially embedded models that are not only more ecologically sound but also better attuned to India's waste realities. This disconnect is reinforced by a deeper structural issue: the uncritical transplantation of Western waste paradigms into Indian cities. The result is a lopsided system that clings to centralized landfilling and incineration- an "out of sight, out of mind" logic that merely shifts pollution from land to air, rather than addressing it at its source.



3.2 Delhi: The Capital City & its Silent Crisis

With a population surpassing 20 million and generating over 11,400 tonnes of municipal solid waste (MSW) each day[46], Delhi exemplifies the infrastructural contradictions of a rapidly expanding capital. Despite its economic prominence and urban aspirations, the city's waste management system remains deeply fragmented- both institutionally and spatially. Governance is splintered across multiple bodies: the North, South, and East Delhi Municipal Corporations (NDMC, SDMC, EDMC), the Delhi Development Authority (DDA), the Delhi Pollution Control Committee (DPCC), and the New Delhi Municipal Council (NDMC). These overlapping jurisdictions produce a bureaucratic tangle of unclear responsibilities, coordination failures, and systemic underperformance[47]. This institutional fragmentation has created a landscape where infrastructure operates in silos, and waste becomes an afterthought in urban design. Rather than integrated planning, Delhi's waste system follows a model of spatial displacement, rooted in the belief that distancing refuse from daily life can resolve its consequences. This approach has resulted in waste being concentrated in marginalized areas, often far from the city's affluent neighborhoods, where the environmental and health impacts are most acutely felt. The absence of a cohesive, city-wide strategy has exacerbated

the inefficiency of waste collection, segregation, and disposal. As a result, Delhi's urban waste challenges remain a persistent issue, undermining the city's aspirations for sustainable and equitable growth.

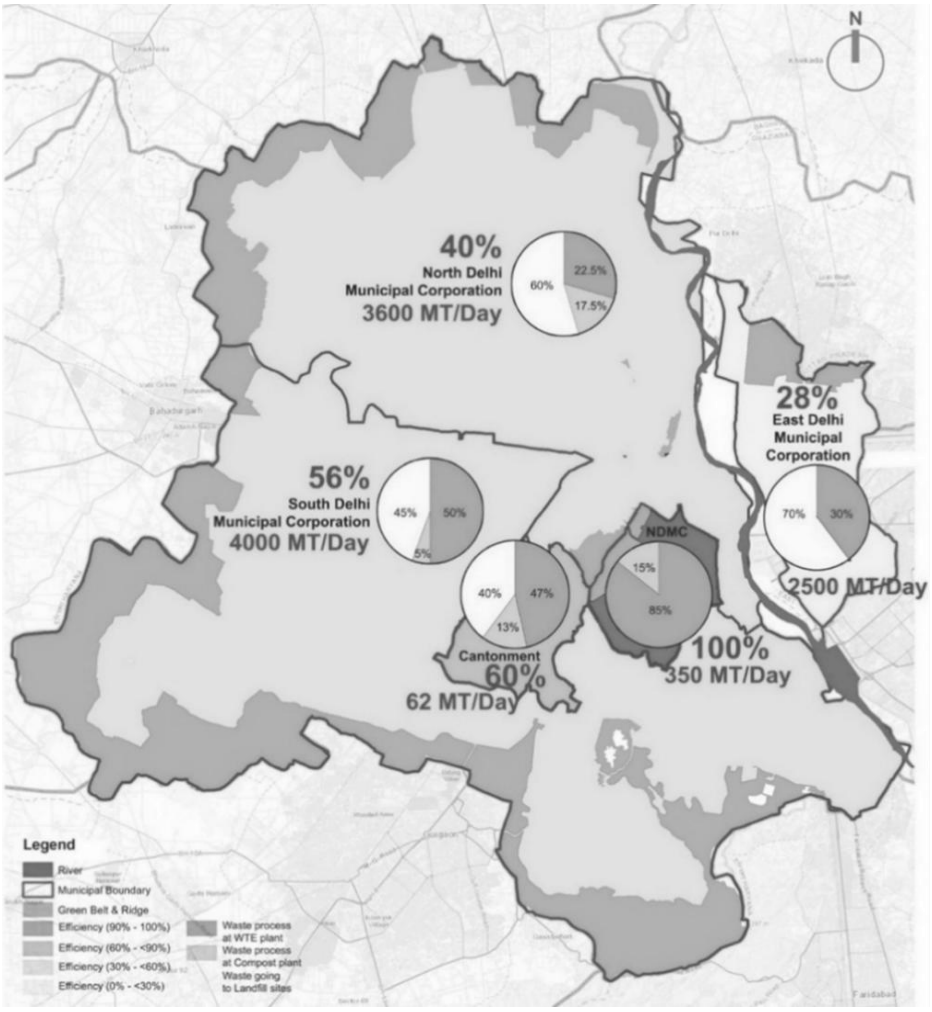


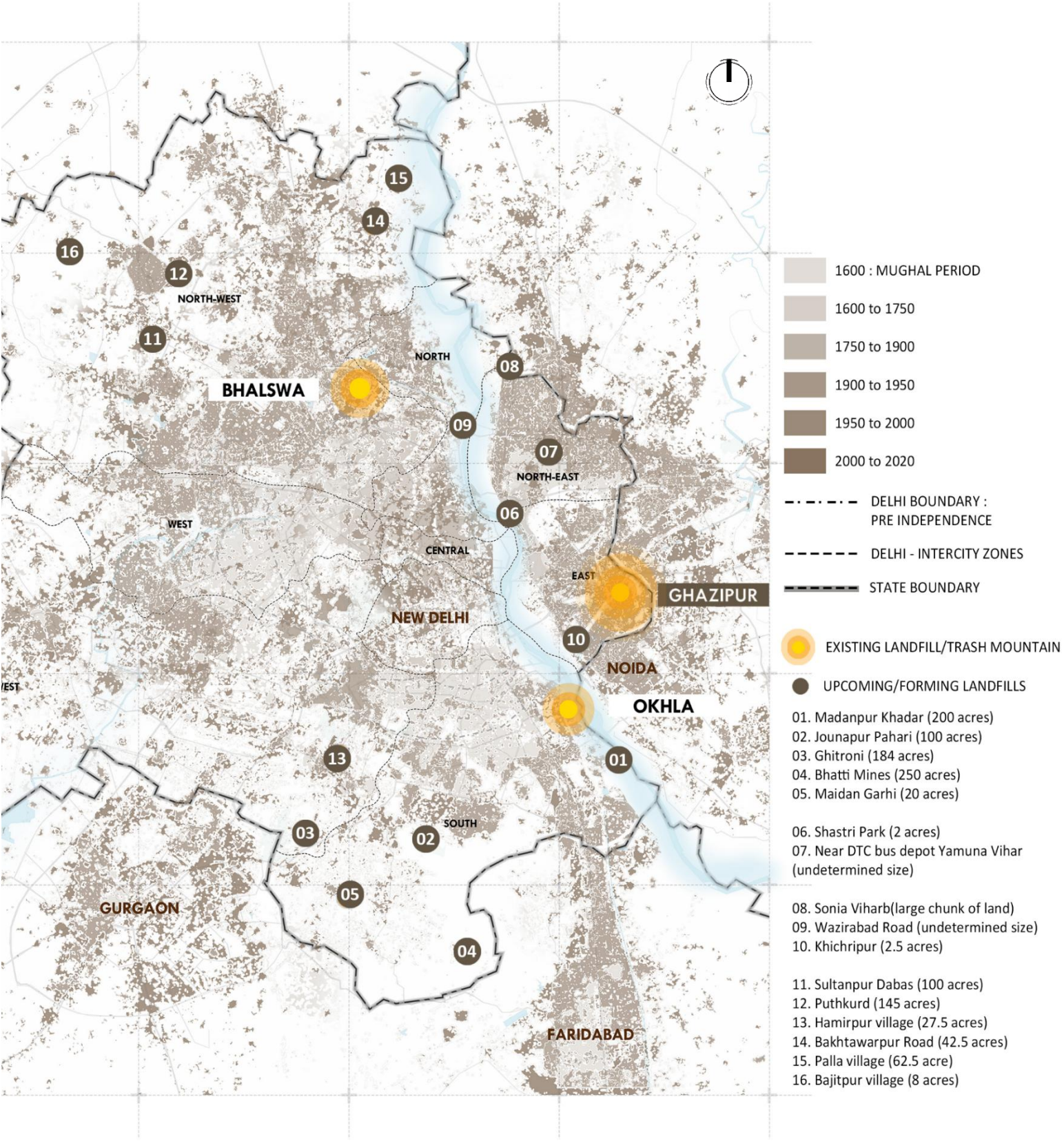
Figure 20: Waste generation and processing efficiency across Delhi's municipal bodies. (Source: "Baseline Physical Infrastructure Report." Centre for Policy Research, New Delhi)

The Fallacy of Distance as Solution

Landfills in Delhi were established with the logic of removal. Ghazipur (1984), Bhalswa (1994), and Okhla (1996) were located at the city's then-edges, chosen precisely for their remoteness. Planners believed that spatial distance would ensure environmental and social detachment. But cities are not static. *Figure 21* illustrates how Delhi has expanded through rapid urban sprawl and informal housing growth, engulfing its own peripheries.

Figure 21: Urban sprawl in Delhi across centuries with existing and upcoming landfill sites.
(Source:Author; Data Derived from GIS; Maps of Delhi)




15
14
16
12
NORTH-WEST
11
NORTH
08
BHALSWA
09
07
NORTH-EAST
06
WEST
CENTRAL
EAST
GHAZIPUR
NEW DELHI
10
NOIDA
OKHLA
13
01
SOUTH
03
02
05
GURGAON
04
FARIDABAD
1600 : MUGHAL PERIOD
1600 to 1750
1750 to 1900
1900 to 1950
1950 to 2000
2000 to 2020
DELHI BOUNDARY : PRE INDEPENDENCE
DELHI - INTERCITY ZONES
STATE BOUNDARY
EXISTING LANDFILL/TRASH MOUNTAIN
UPCOMING/FORMING LANDFILLS
01. Madanpur Khadar (200 acres)
02. Jounapur Pahari (100 acres)
03. Ghitroni (184 acres)
04. Bhatti Mines (250 acres)
05. Maidan Garhi (20 acres)
06. Shastri Park (2 acres)
07. Near DTC bus depot Yamuna Vihar (undetermined size)
08. Sonia Viharb(large chunk of land)
09. Wazirabad Road (undetermined size)
10. Khichripur (2.5 acres)
11. Sultanpur Dabas (100 acres)
12. Puthkurd (145 acres)
13. Hamirpur village (27.5 acres)
14. Bakhtawarpur Road (42.5 acres)
15. Palla village (62.5 acre)
16. Bajitpur village (8 acres)

The maps in *Figure 21* trace the spatial growth of Delhi over four centuries, from a compact Mughal-era settlement in 1600 to its dramatic expansion in 2020. In 1600, the city remained concentrated around the Yamuna River, with dense habitation restricted to its historic core. By 1750, the colonial presence had begun to shape peripheral growth, though the city remained relatively bounded. The late 19th and early 20th centuries (1900) marked a period of significant expansion, followed by the planned development of New Delhi in 1950, which pushed the urban boundary outward. After 2000, liberalization and accelerated migration triggered uncontrolled sprawl, as the city extended into surrounding rural land, consuming agricultural fields, ecological belts, and wetlands. The right-hand map overlays this urban growth with Delhi's waste infrastructure.



Figure 22: Aerial view of landfill in Delhi, visible from 2km away. (Source: All That's Interesting, 2019)

Today, these landfill sites are no longer "outside" the city- they are embedded within its dense urban fabric, adjoining residential colonies, roads, and commercial areas. The illusion of separation has collapsed; the landfills now loom as vertical monuments to systemic failure- visible, odorous, and hazardous[48]. All three sites have exceeded their height and capacity limits, operating in flagrant violation of environmental norms. Despite Supreme Court interventions, they continue to receive thousands of tonnes of unsegregated waste each day. Worse still, Delhi has identified 16 more "upcoming" or "potential" landfill sites- suggesting not a transition away from landfilling, but a doubling down on the same outdated model[49]. This spatial logic turns vast areas into sacrifice zones, designed not to process or reduce waste but to bury it. Instead of investing in decentralized recovery systems or local processing units, Delhi continues to accumulate waste in its body, creating zones of permanent toxicity and exclusion.

Figure 23: Delhi, Waste & Statistics
(Source: Author)

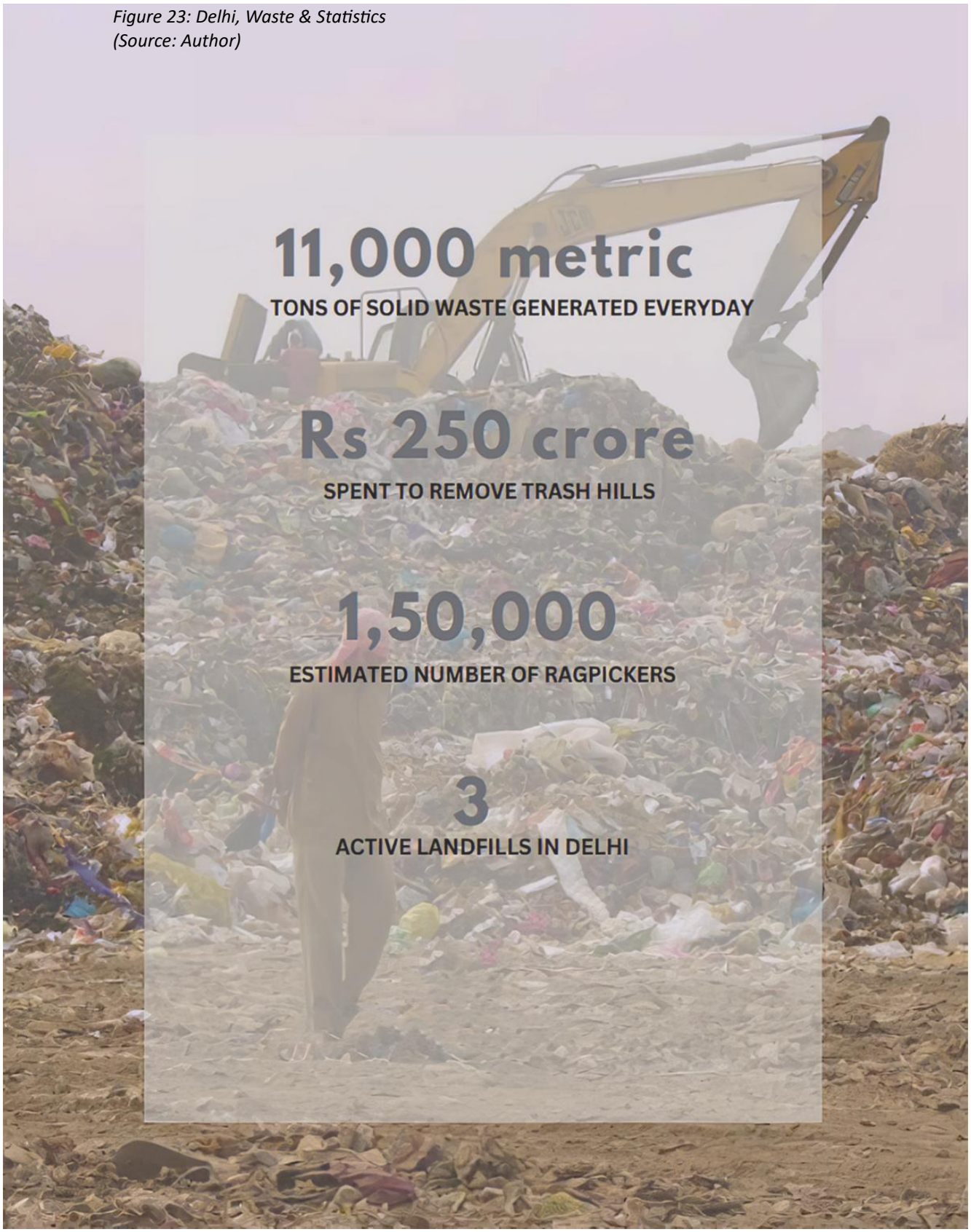
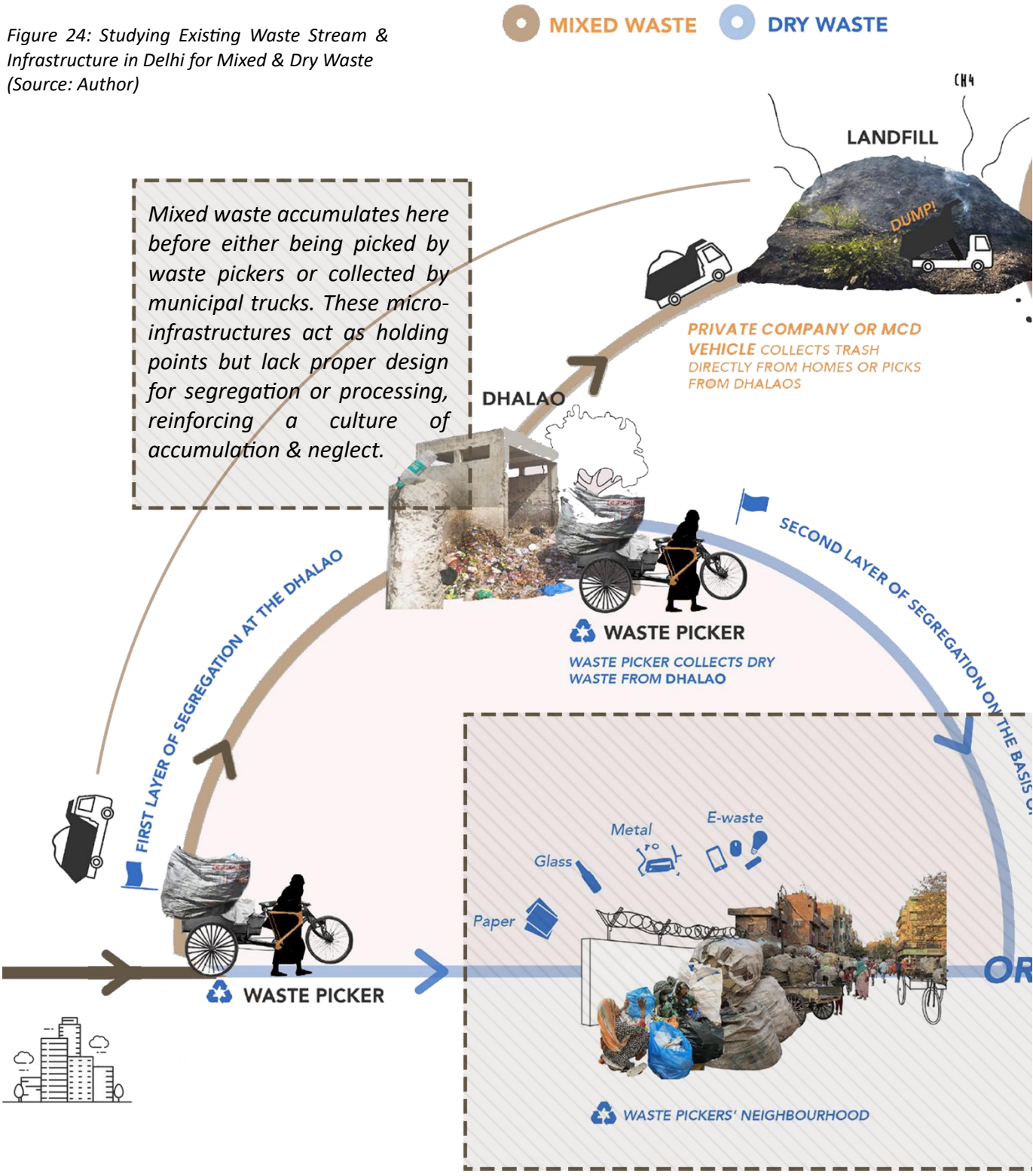
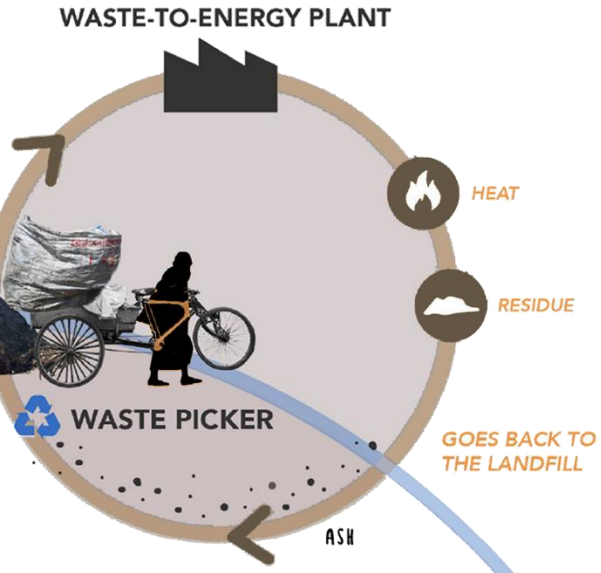


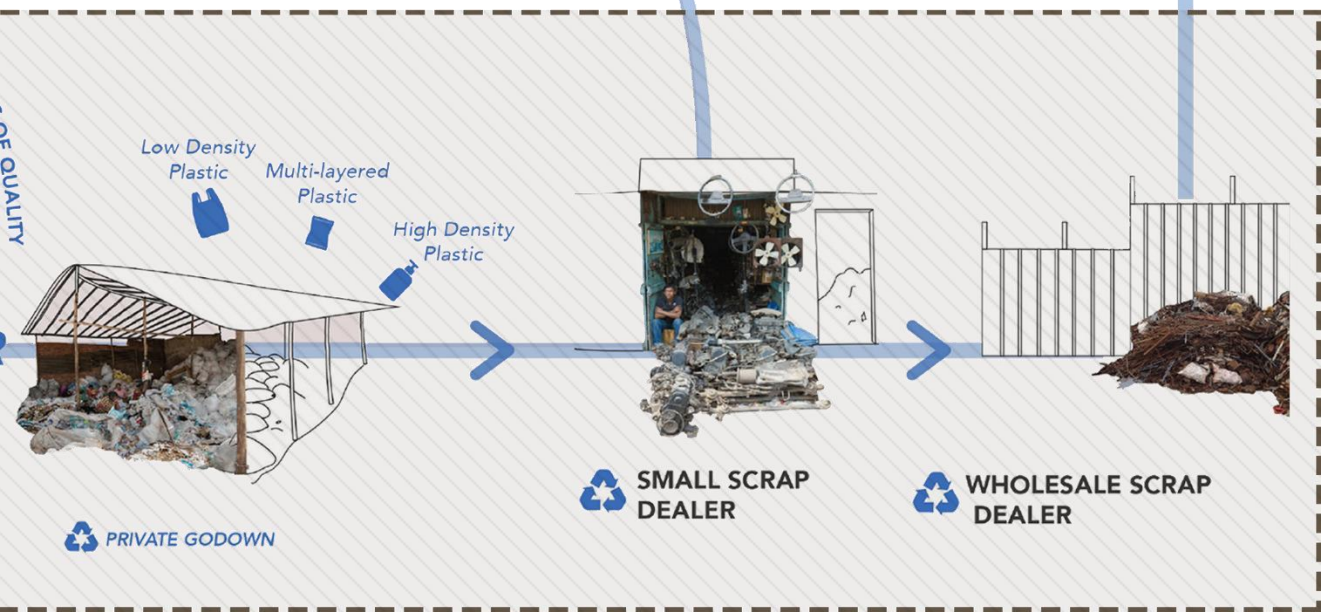
Figure 24: Studying Existing Waste Stream & Infrastructure in Delhi for Mixed & Dry Waste (Source: Author)





Studying this fragmented flow is crucial because it reveals how Delhi's waste infrastructure is designed less to process waste than to remove it.

Materials are sorted by type and resale value, sustaining local economies but often in unsafe, unhygienic conditions outside formal planning frameworks.



Spatializing Neglect: Dhalaos and the Logic of Removal

Figure 24 illustrates the fragmented and multi-tiered waste flow in Delhi, showing how materials move from neighborhood dhalaos to endpoints like landfills, scrap dealers, or waste-to-energy plants. The process begins with informal waste pickers who perform the first level of segregation - retrieving paper, glass, metal, and plastics from largely mixed waste. These materials are then taken to the picker's neighborhood, private godowns, or roadside yards, where a second round of sorting happens by material type and resale value. High-quality recyclables pass through a decentralized economy of small scrap dealers and wholesale buyers, while unsegregated or low-value waste is picked up by municipal or private vehicles and transported to landfills or incineration plants. The city has historically lacked sufficient investment in decentralized segregation, composting, or recycling facilities. Instead, it relies on a patchwork of informal labor and private scrap markets to sustain material recovery, while municipal systems perpetuate displacement into dumpsites. This system exposes a city where recycling is driven more by necessity than planning- where informal labor fills the void left by broken infrastructure. It is a model grounded not in transformation, but disappearance: waste is moved out of sight and thus out of mind. Nowhere is this logic more visible than in the micro-infrastructures scattered across Delhi- chief among them, *the dhalao*. Introduced in the 1970s as neighborhood depots, dhalaos are masonry enclosures meant to hold waste until municipal pickup[50]. Though intended as collection nodes, most operate outside the realm of design. Without ventilation, signage, sanitation, or accessibility, they function more as decaying overflow zones than civic infrastructure. Their public utility has faded; in reality, they are ambiguous, often disused spaces where formal and informal systems intersect.

Dhalaos mark the first and most visible point of contact between people and their waste. Despite their proximity to everyday life, they have become architectural blind spots- unsanitary, overflowing, and neglected. Most lack roofs, gates, lighting, or toilets, and are sited near markets or drains. Many are either overburdened, abandoned, or repurposed. Waste, mixed and unsorted is dumped into dhalaos ranging from 4.5×3 meters to 13.5×9 meters in size, storing between 4 to 16 tonnes of garbage.[51]. Without placement norms, they are unevenly distributed. Residents rarely use them directly due to distance and decay. Instead, informal collectors carry out door-to-door collection and sorting- often without protection or infrastructure- before waste is loaded onto trucks and sent to landfills, reinforcing the cycle of removal. Animals, odor, and unscheduled pickups further exacerbate public frustration and environmental risk, often leading to citizen complaints and proposals to phase out dhalaos entirely in favor of

trolleys and smaller bins[52]. Yet these changes, while operationally efficient, ignore the deeper spatial and social void created by their removal. From a design perspective, the dhalao remains a potent site of inquiry. Its embeddedness in nearly every neighborhood gives it latent potential- not only as a logistical node but as a civic interface.

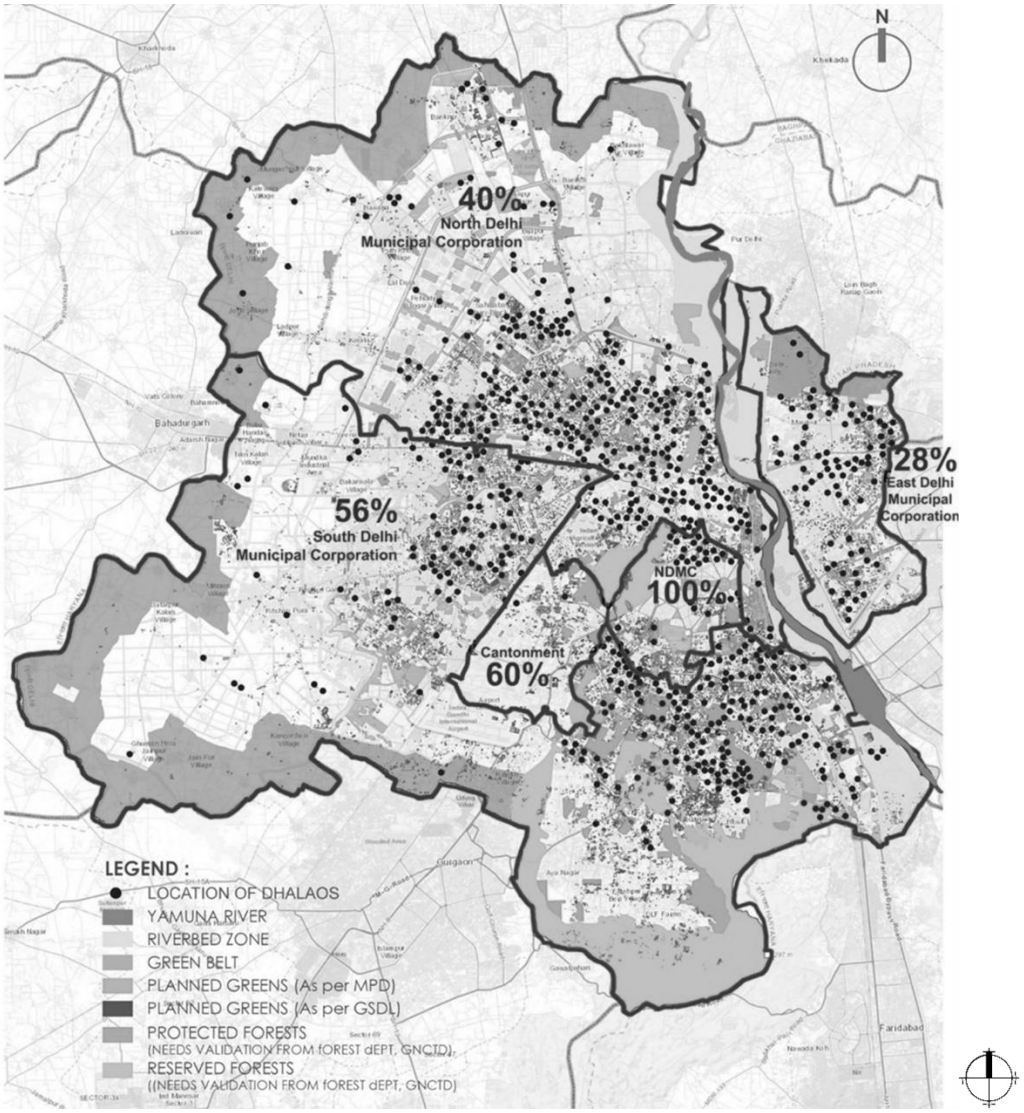


Figure 25: Distribution of Dhalaos Across Delhi's Municipal Jurisdictions
(*(Source: "Baseline Physical Infrastructure Report." Centre for Policy Research, New Delhi)*

This map shows the spatial distribution of dhalaos (neighborhood waste collection points) across Delhi, overlaid on municipal boundaries and ecological zones such as the Yamuna riverbed, green belts, and protected forests.

Figure 26: Dhalaos as Sites of Urban Breakdown (Source: Author)





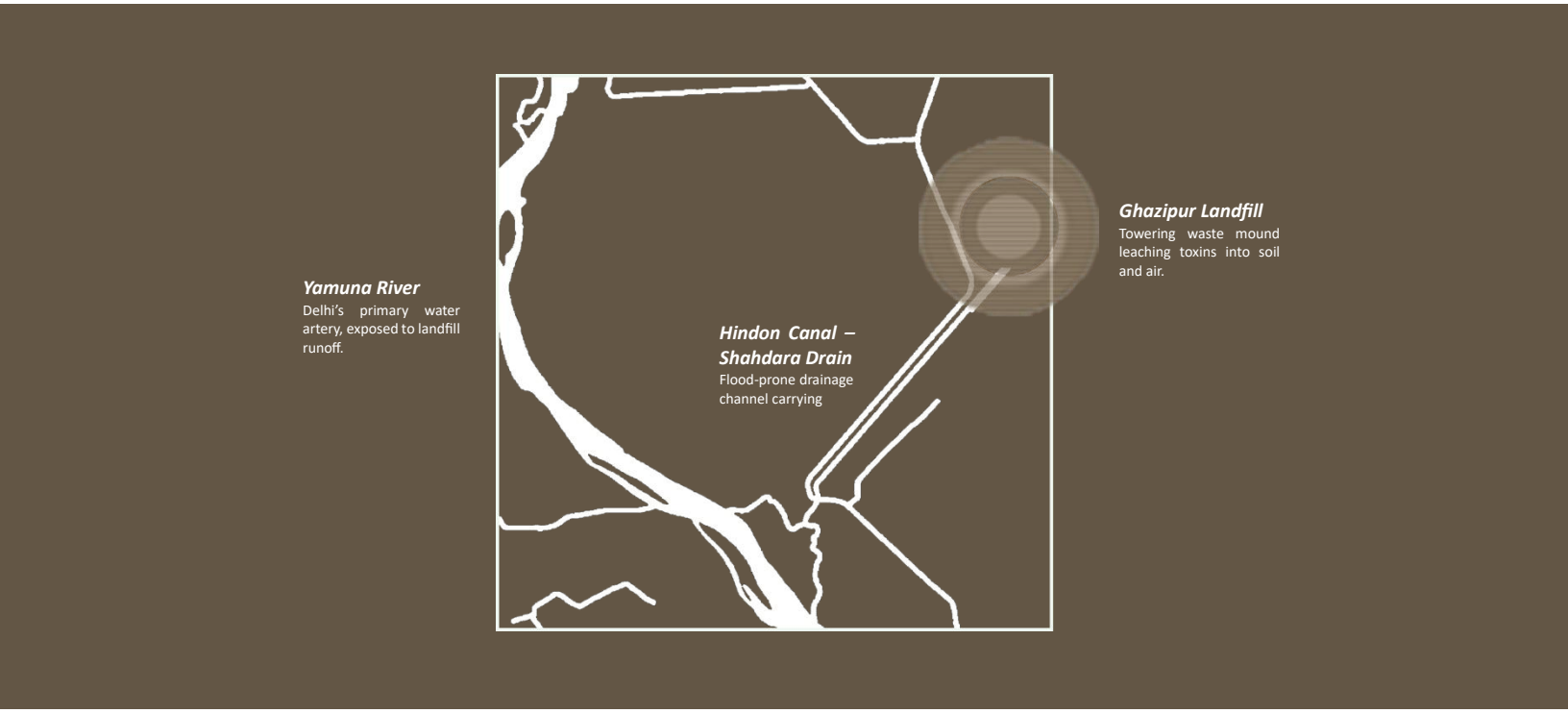
Public Urination
Lack of sanitation facilities, misuse of walls.

Rodents & Pests
Visible health hazard around bins.

Stray Animals
Cows and dogs scavenging waste, blurring human–animal boundaries.

Overflowing Waste Spill
Garbage piles leaking beyond the structure into the street.

No segregation zones
Absence of spaces for organic/recyclable waste. Unsafe workspace for formal workers.



3.3 The Ghazipur Dumpsite: Urban Waste on Display

Among Delhi's many infrastructural breakdowns, the Ghazipur landfill stands as its most catastrophic and enduring symbol. Located in East Delhi near the city's edge, the site receives over 2,600 metric tons of mixed waste daily, making it one of the most overburdened disposal sites in the National Capital Territory. Multiple wards across East and Northeast Delhi - spanning diverse urban typologies including high-density housing, informal settlements, commercial corridors, and transit hubs- funnel their waste through fragmented local collection systems[53]. These materials pass through a network of dhalaos and informal transfer points before being transported by diesel-powered municipal trucks, often traveling 20 to 30 kilometers per round trip. The cumulative effect of hundreds of such trips per day significantly escalates fuel consumption and carbon emissions, reinforcing the unsustainable dependence on long-distance waste transport and centralized disposal.[54].

Originally designated as a temporary dumpsite in 1984, the Ghazipur area was once fertile farmland alongside the Hindon Canal. Its transformation into a landfill emerged from short-term fixes during Delhi's early phases of unregulated urban expansion.

Meant to closed by 2002, Ghazipur instead expanded vertically due to political delays and the absence of functioning material recovery facilities (MRFs), community composting, or decentralized processing hubs. Today, it has swollen into a 70-acre, 65-meter-high mountain of trash- surpassing the height of the Qutub Minar[vi] and visible from the elevated metro rails and major arterial roads[55]. From afar, it mimics a monument; from up close, it is a mountain of toxicity.

Figure 27: Height Comparison of Ghazipur Landfill with major historic monuments in Delhi & nearby (Source: "Landfill to Landform: A Story of Transformation")

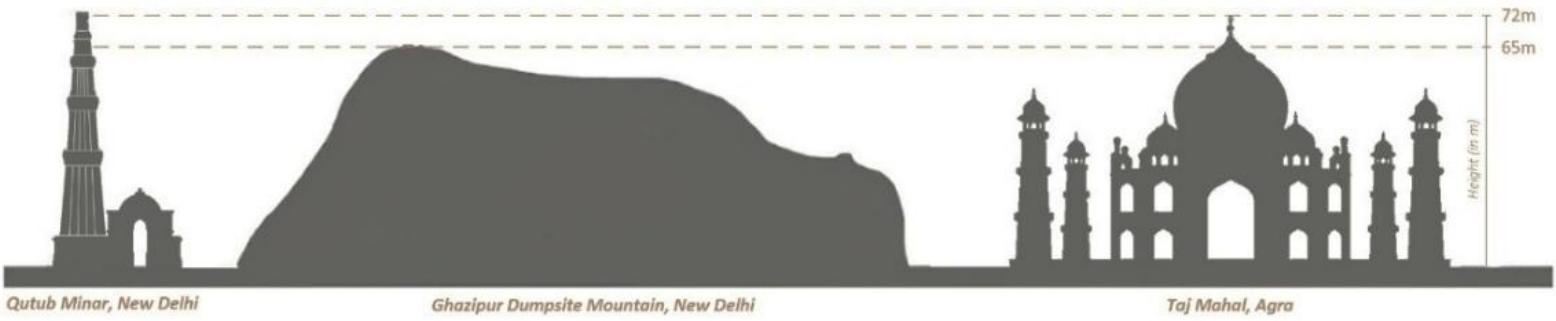




Figure 28: Ghazipur Dumpsite, now a part of city fabric (Source: Daily Mail India)

[vi] Qutub Minar is a UNESCO World Heritage monument and one of Delhi's most iconic historical landmarks. It stands at approximately 72.5 m, making it the world's tallest brick minaret.

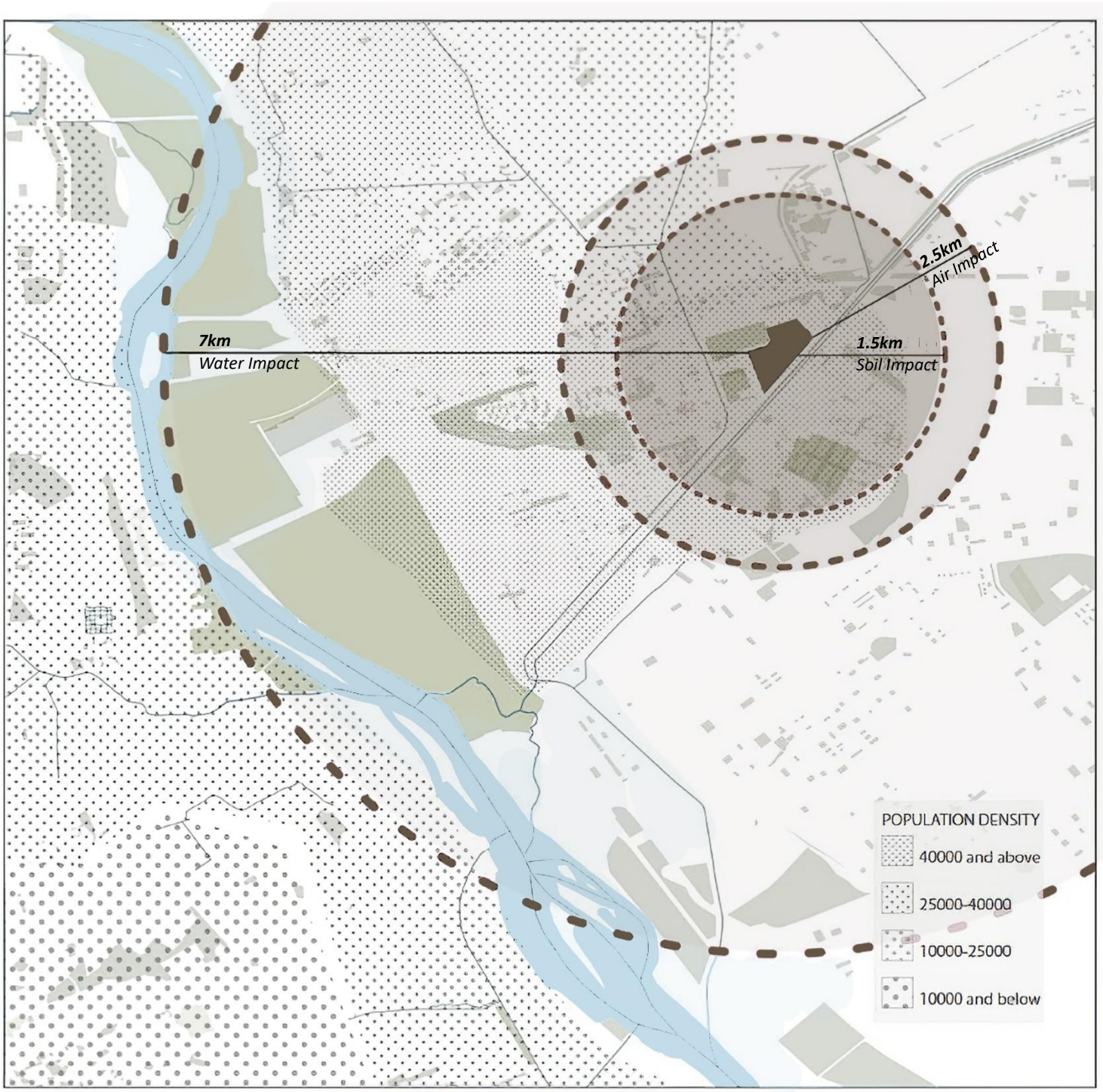


Figure 29: Population density distribution around Ghazipur landfill, highlighting the overlap between high-density residential areas and the landfill's buffer zone.
(Source: "Landfill to Landform: A Story of Transformation")

Unlike engineered landfills, Ghazipur lacks basic safeguards such as leachate liners, slope stabilization, methane capture, or stormwater management. Waste is dumped directly onto compacted ground without containment, allowing toxins to seep into the subsoil and damage Delhi's eastern aquifer systems[56] The map in *Figure 29* demonstrates how the Ghazipur landfill is embedded within a dense urban fabric. Population clusters exceeding 40,000 people per sq. km lie within its immediate influence zone, exposing thousands of residents to risks of air pollution, leachate seepage, and degraded living conditions. The landfill's proximity to the Yamuna floodplain and ecologically sensitive zones further intensifies the vulnerability of these communities. This visualization underscores the critical spatial contradiction in Delhi's planning: the siting of mega-waste infrastructure adjacent to both dense housing and fragile ecological systems.

The landfill functions like a sponge, absorbing monsoon rain and unpredictably displacing it, often flooding adjacent neighborhoods within a *7 km* radius. The lack of functional drainage or slope stabilization makes the mound highly unstable during the rainy season, with landslides posing a persistent danger to surrounding settlements, roads, and infrastructure[57]. Such collapses are not isolated incidents but recurring seasonal events, each underscoring the fragile and hazardous nature of this waste mountain. Decomposing organic matter within the landfill produces methane gas, which accumulates within the waste layers and ignites spontaneously particularly during Delhi's extreme summer heat. These methane explosions, along with surface and deep fires within the waste mass, release toxic emissions, including dioxins, carbon monoxide, sulfur oxides, and fine PM2.5 particulates, severely degrading air quality within a *2.5 km* radius across East Delhi. The resulting chemical smog can persist for days, coating entire neighborhoods in haze and triggering respiratory distress, asthma, and cardiovascular ailments among vulnerable populations. The phenomenon turns waste into an atmospheric hazard, spreading the crisis well beyond the landfill's physical boundaries.

Furthermore, leachate runoff: an untreated toxic liquid created when rainwater percolates through waste carries heavy metals, nitrates, and other harmful substances into surrounding soils and drains. This contamination extends up to a *1.5 km* radius, poisoning agricultural land, degrading groundwater quality, and directly affecting the fertility of peri-urban farming zones that many communities depend on for subsistence. Seasonal flows of leachate also drain into nearby water systems, most critically the Yamuna River and the Shahdara drain, compounding Delhi's water pollution crisis.

The environmental and health impacts of Ghazipur's mismanagement thus spread far beyond the landfill site itself. The site becomes not just a local nuisance but an active, city-wide hazard, destabilizing entire ecologies and communities.

Figure 30: "Mountain of Waste" – Ghazipur Landfill (Source: Author)





Waste-to-Energy Plant
Built beside the landfill, adding emissions to an already toxic landscape.

Low-Income Housing Belt
Dense neighborhoods on the edge, directly exposed to pollution and disease.

Poultry & Fish Market
Directly adjacent to the landfill.

Metro Line View
The landfill looms in everyday commute, a reminder of Delhi's waste crisis.



A Landscape of Entanglement

Despite its overwhelming toxicity, the Ghazipur trash mountain site is deeply embedded in the metabolic life of East Delhi. It is not a remote periphery but a tightly woven node- surrounded by a chaotic mesh of human, ecological, and economic flows. Within a short radius of the mound lie the Ghazipur poultry, fish, and chicken markets; a wholesale fruit and vegetable mandi; a wholesale flower market; a state dairy farm; and the Waste-to-Energy (WTE) plant. Each of these sites generates and receives material daily linking their rhythms to the landfill's own cycle of intake and decomposition. To the south, transport yards, informal recycling depots, and meat-processing units form a semi-industrial corridor, while to the north and east, dense low-income housing colonies edge right up to the landfill boundary. During monsoon, water runoff from the mound spills into markets and residential lanes, carrying leachate and triggering floods. Fires from spontaneous methane ignition fill the area with acrid smoke, settling over produce stalls and housing alike. Despite this, livelihoods persist. Ghazipur has become both a processor and a polluter, a labor zone and a health hazard- an impossible yet essential part of the city's functioning.



Figure 31: Satellite images of Ghazipur landfill (2010–2022) show the uncontrolled vertical and horizontal expansion of the waste mound. (Source: Google Earth)

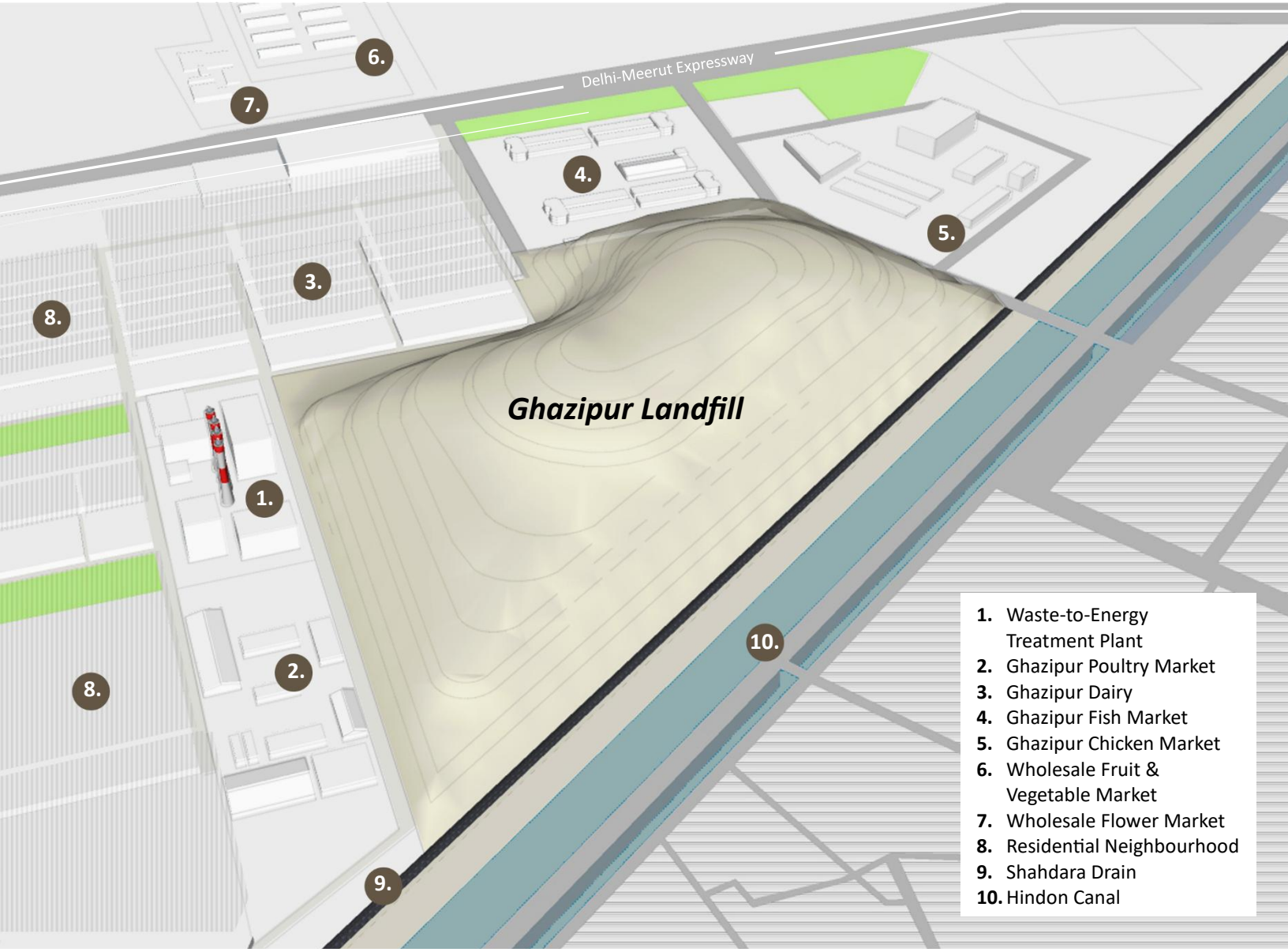
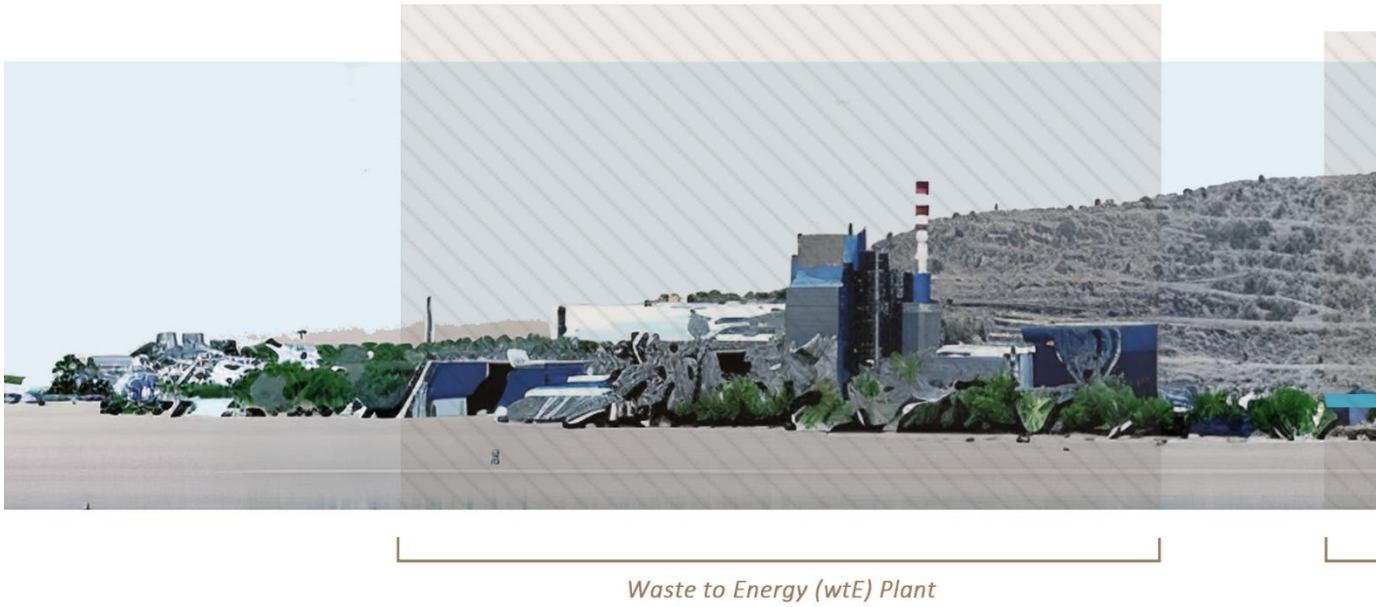
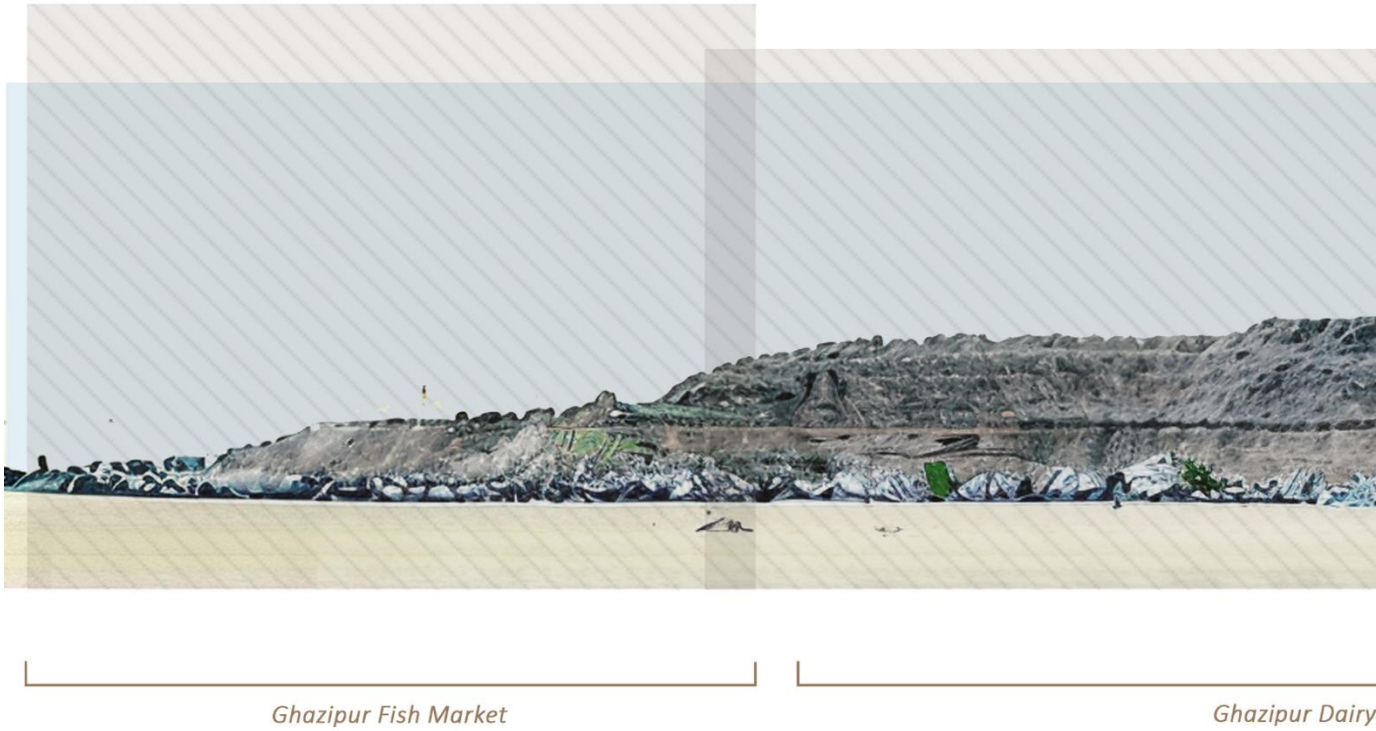


Figure 32: Ghazipur Landfill & Surroundings (Source: Author)

Figure 33: Elevations of the Ghazipur landfill show its entanglement with surrounding urban programs: the Waste-to-Energy plant, Bakra Mandi (poultry market), fish market, and dairy farm; revealing the collision of waste, industry, and everyday life at the city. (Source: Author)







Ghazipur Bakra Mandi (Poultry Market)



Farm

Waste to Energy (wtE) Plant

The Human Cost of Waste & A Distorted Urban Ecology

Ghazipur is not merely a site of accumulation- it is a site of daily bodily risk. Leachate, the black viscous fluid formed from decomposing waste, seeps into the canal and groundwater. A 2022 DPCC report found samples with nitrate, lead, cadmium, and coliform levels far exceeding legal limits[58]. During monsoon, the mound becomes a toxic swamp, with runoff flooding adjacent colonies. The Hindon Canal, once a seasonal lifeline, now serves as a conduit of contamination. The human toll extends far beyond environmental exposure. Waste pickers- some permanent, some seasonal migrants- arrive at dawn, moving across the landfill's unstable terrain before municipal trucks arrive. Their work begins with climbing. Ghazipur's slopes are steep, eroded, and uneven, formed not by design but by the random layering of compacted and loose waste. There are no designated paths, no safety railings, no stabilizing berms. At any moment, a minor landslide can send a worker tumbling, especially during monsoon when the landfill's sides become slick with rain and liquefied garbage. These "slopes of danger" are negotiated barefoot or in worn plastic sandals, with waste pickers carrying sacks, sticks, and metal hooks to salvage material.[59] Women and children are especially vulnerable. Many women sort materials while shielding infants in makeshift cloth slings.

Children as young as eight participate in scavenging, often barefoot, competing for recyclable scraps. There are no shaded areas, no rest shelters, no water stations- just the landfill's open expanse, where every act of labor unfolds under extreme physical duress. They are denied formal employment by the municipal corporations yet rely entirely on waste to survive. In the event of injury or illness, there is no recourse. Waste work, here, is structurally criminalized- necessary for the city but made informal to avoid responsibility[60]. In ethnographic interviews, waste pickers describe the landfill not only as a workplace but as a terrain of fear and exhaustion. *"The slope gives way when it's wet,"* said a 32-year-old male picker from Gonda, UP. A woman in her fifties working near the poultry market, stated: *"The smell never leaves us. Even when we bathe, it stays"*[61]. These narratives reveal more than precarity; they expose a profound absence of spatial care. Ghazipur is not just dangerous- it is indifferent. It offers no dignity, no space to pause, no recognition of the humans it depends on. Scientists have warned that the proximity of humans, animals, and medical waste poses serious risks of zoonotic disease. The landfill does not just pollute- it sustains a warped ecosystem of survival and collapse. It is no longer inert ground; it is a multispecies battleground shaped by hunger, neglect, and the leftovers of a city that looks away.

Ghazipur is also an ecological attractor. Birds such as black kites, pigeons, eagles and crows- hover overhead, feeding on organic and poultry scraps. Wetland birds like Asian openbill storks, displaced by the Yamuna's ecological degradation, have been observed foraging in its pools of leachate[62]. Flocks of feral dogs roam the site, occasionally attacking pickers or marketgoers. Rodents thrive, becoming disease vectors. Cattle and pigs graze on decomposing vegetables and plastics, injuring themselves in unstable terrain.



Figure 34: The Ghazipur landfill illustrates a distorted urban ecology where humans, cattle, and migratory birds coexist amid toxic waste. Survival, labor, and food chains intersect here, exposing the hidden human and environmental costs of Delhi's waste crisis.
(Source: Gregoire Dubois)

Part 3 Endnotes

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Part 4

Waste as Opportunity

Precedents; Strategies & Design Framework



Figure 35: From landfill waste to restored ecological landscape.
(Source: ArchDaily)



Overview:

This part builds the conceptual and spatial foundation for the design proposals that follow. Drawing from both global and Indian contexts, it explores how waste can be reimagined not as residue to be buried but as a dynamic material and urban resource. The selected precedents illuminate critical alternatives to conventional containment models: some operate at the scale of engineered parks, others at the scale of neighborhood loops; some are driven by policy, others by people.

4.1 Reclaiming Waste as Design Opportunity in India

India's historical waste systems were intrinsically circular. Kitchen scraps were composted, greywater irrigated agricultural fields, cow dung was used as both fuel and building material, and leftovers fed animals. These decentralized, caste-mediated systems were grounded in spatial proximity, ecological logic, and daily rhythm. Waste was neither invisible nor undesirable- it was part of the material life of the city. Colonial reforms disrupted these systems by reframing waste as a health hazard. Post-independence planning adopted centralized, Westernized models that prioritized containment over integration. The dhalao emerged as a modern enclosure: a concrete bin replacing vernacular typologies, divorced from both ecological process and community life. What was once managed locally became dislocated, disembodied, and detached from public responsibility[63].

This rift continues today. Delhi's Ghazipur landfill is now slated to be capped- a technique imported from the Global North that layers synthetic membranes, soil, and turf to conceal the mound[64]. But capped landfills in India often leak, smolder, and exclude public access. Nearby, a Waste-to-Energy (WTE) plant incinerates mixed waste with minimal segregation, emitting toxic pollutants and further distancing waste from its origins. Despite well-documented failures- including technical breakdowns, pollution spikes, and opposition from environmental groups- new WTE plants continue to be proposed across Delhi[65]. These projects receive hefty public investment without any significant improvement in waste segregation at source, which remains below 30% across the city[66]. These technical solutions promise transformation but offer only containment - solutions that are expensive, exclusionary, and often ecologically unsound. Plans to cap Ghazipur alone are estimated to cost several hundred crores, yet do not address the root failures of Delhi's waste infrastructure: inadequate decentralization, poor public participation, and the erasure of informal labor. Crucially, these approaches sidestep the structural questions: What systems produce waste? What spatial and economic frameworks perpetuate it? What design interventions can regenerate it?

Architecture and urban design, historically absent from waste discourse, offer tools to reframe waste as a spatial and social opportunity. Beyond containment, the city can be reimagined as a landscape of material flows: streets as micro-collectors, dhalaos as hybrid public-utility spaces, and landfills as layered ecological and civic landscapes. Well-designed waste infrastructure can provide dignified workplaces for informal labor, foster public engagement with circular practices, and restore ecological function within dense urban fabrics. As one waste picker in East Delhi remarked, "If the space is well-planned, we can work safely, and people will respect what we do." Similarly, a local urban planner noted, "Waste is the city's pulse;

when we hide it, we lose touch with how the city lives." This thesis argues that architecture, landscape, and urban planning must lead the next phase of transformation in India: not as reaction, but as proposition[67].



4.2 International Case Studies: Waste as Resource

To understand how waste can be reimagined as a civic and spatial asset, this section examines three international precedents where design disciplines-landscape architecture, infrastructure planning, and vernacular urbanism have engaged directly with waste. Rather than concealing or outsourcing waste management, these projects embed it into the spatial, ecological, and cultural logic of the city. Each offers a distinct design approach: territorial transformation, infrastructural transparency, and embedded informality.

Freshkills Park

Location: Staten Island, New York, USA
Year: Masterplan initiated 2001 – ongoing
Area: 2,200 acres
Architect / Designer: James Corner Field Operations
Key Words: Landfill reclamation, phased remediation, ecological restoration, performative landscape design, public engagement, spatial sequencing, urban integration, topographic transformation



Figure 36: From toxic landfill to ecological public park, Freshkills illustrates the transformation of Staten Island's waste landscape into a restored civic terrain.
(Source: ArcGIS StoryMaps — "Hydrology and Pollution Management at Freshkills")

Freshkills Park, located on Staten Island, New York, exemplifies how post-consumer waste landscapes can be transformed into civic, ecological, and recreational assets. Formerly the world's largest landfill, the site received up to 29,000 tons of municipal waste per day[68] at its peak. After closure, the park's masterplan, adopted a phased approach to remediation[69], ecological restoration, and public

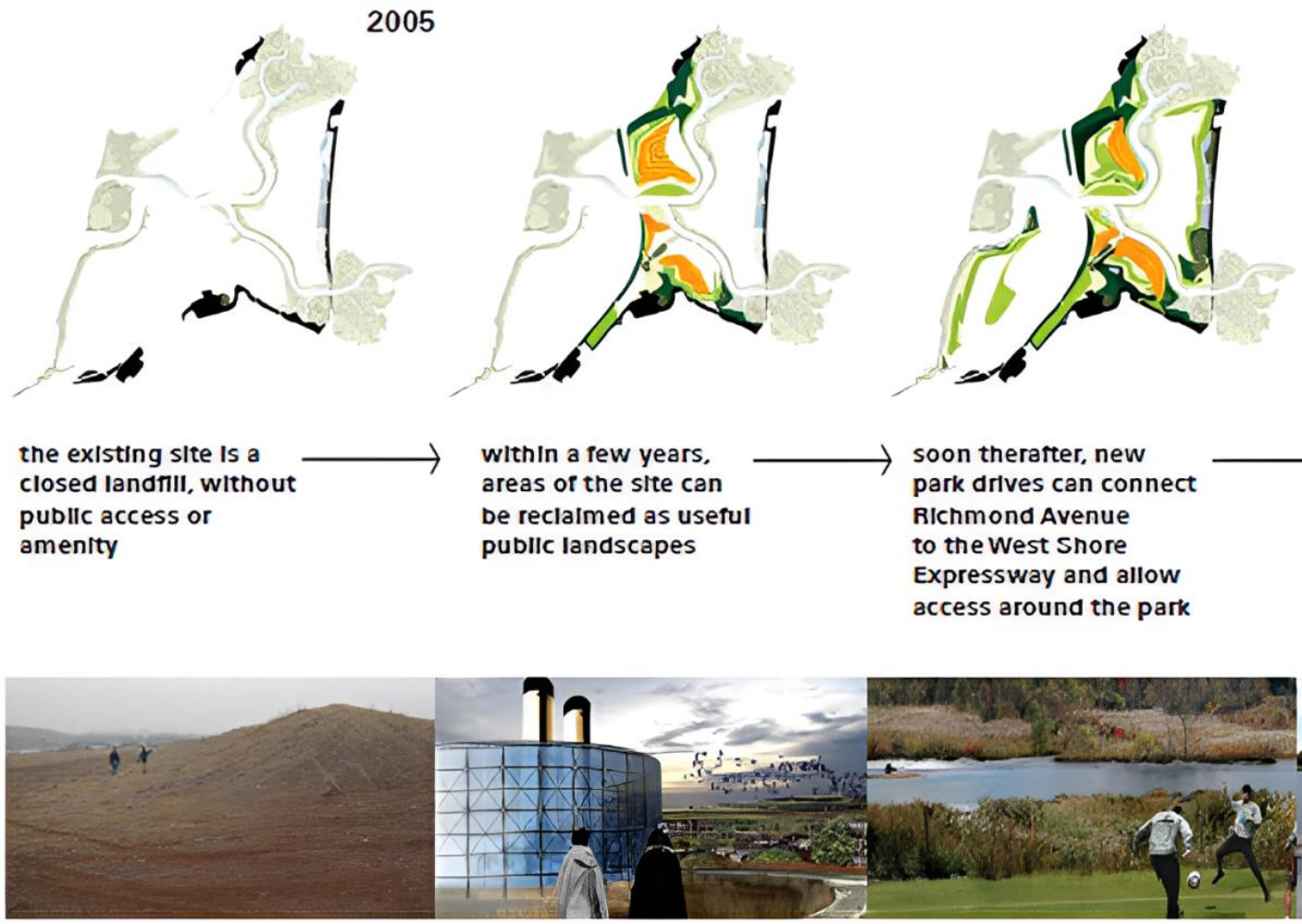
engagement, aiming to convert a heavily polluted site into a functional, multi-layered public landscape. The remediation process begins with engineered containment, capping landfill mounds with multiple synthetic layers, compacted clay, and topsoil to manage leachate and vent methane gas safely. Over this technical substructure, the park introduces ecological design layers: restored wetlands, native grass meadows, habitat zones, trails, and public amenities. Topographic manipulation converts the original waste mounds into legible, walkable landscapes, turning environmental hazard into spatial opportunity.

Freshkills employs careful spatial sequencing. Circulation paths for pedestrians, cyclists, and maintenance vehicles are choreographed across elevations, connecting constructed wetlands, bird habitats, and elevated viewing platforms. Minimal structures- pavilions, docks, event lawns- are embedded in the landscape to preserve the site's ecological narrative[70]. Public programming, including kayaking, birdwatching, and environmental education, activates the space without overwhelming its restored natural systems. The park connects Staten Island to wider blue-green infrastructure, establishing corridors for wildlife, hydrology, and recreation. Transportation planning ensures accessibility via highways and public transit, integrating the park into the urban fabric while maintaining a low-impact civic presence. Rather than erasing its waste history, Freshkills reframes it as an educational and experiential landscape, demonstrating that landfills can be transformed not just technically, but spatially, socially, and environmentally.

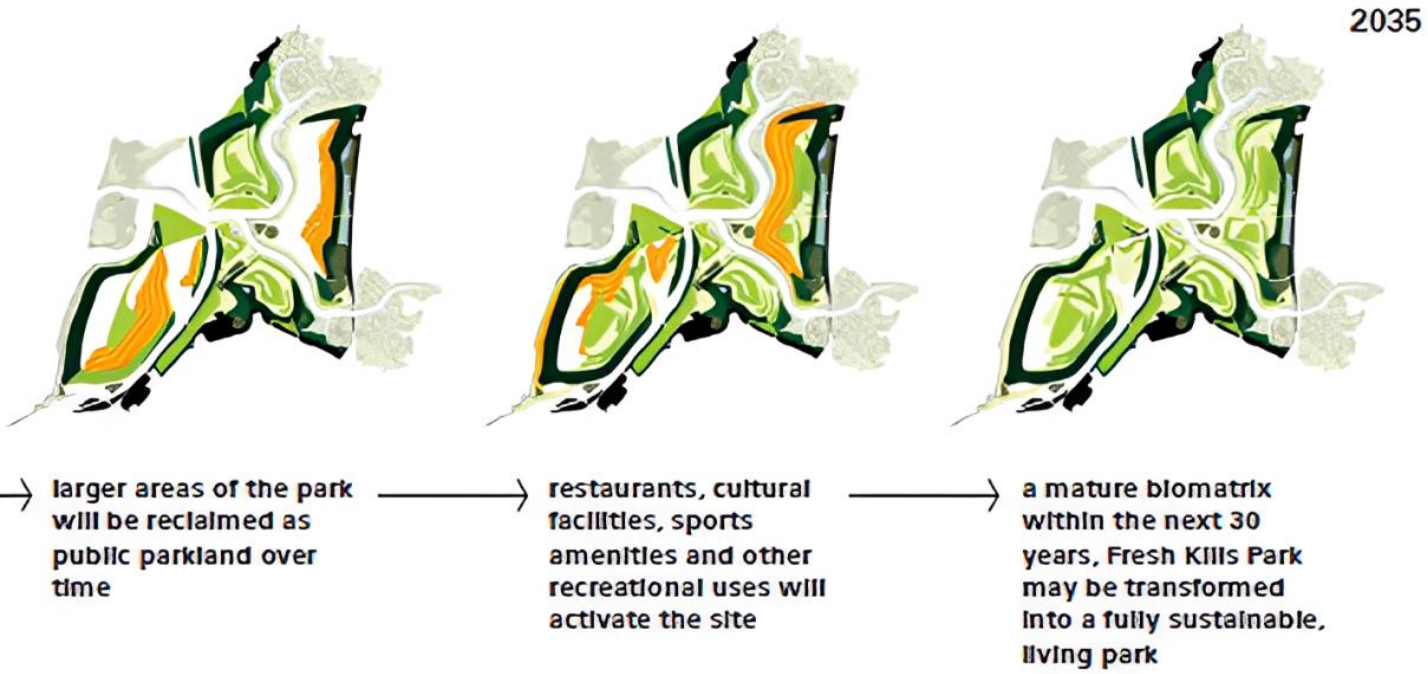


Figure 37: Kite flying, kayaking, and birdwatching animate Freshkills Park as symbols of its transformation from landfill to public landscape.(Source: Freshkills NewYork)

Figure 38: Freshkills Park evolves from a closed landfill in 2005 to a sustainable living landscape by 2035, gradually opening to public access, recreation, and ecological restoration.
(Source: Freshkills NewYork)



Significance: Freshkills demonstrates that landfills are not urban scars to be hidden but latent landscapes of possibility. Its success lies in layering technical remediation with ecological design, spatial sequencing, and civic engagement. It reframes landfill reclamation as a cultural project, turning waste management into public memory, ecological infrastructure, and everyday recreation. As one of the world's largest ecological restoration projects, Freshkills is a precedent for how cities can reintegrate damaged sites into the blue-green urban fabric, addressing both environmental justice and public space deficits.





Freshkills demonstrates that landfills can be transformed through a step-by-step process, beginning with technical remediation and layering ecological and civic functions on top. For Ghazipur, this reinforces the need for a phased approach, before any public reuse. The project also shows the value of integrating technical waste systems with ecological design. Importantly, Freshkills reframes waste history as part of the public narrative, suggesting that Ghazipur, too, can shift from a symbol of failure to a site of education and awareness. Finally, the integration of Freshkills into Staten Island's wider hydrological, mobility, and ecological networks highlights a path for Ghazipur: to move beyond isolation and function as part of Delhi's urban commons.

Sunset Park Material Recovery Facility

Location: Brooklyn, New York, USA
Year: Completed 2014
Area: 11 acres
Architect / Designer: Selldorf Architects
Key Words: Material Recovery Facility, industrial infrastructure, environmental sustainability, operational legibility, public engagement, urban integration

The Sunset Park MRF, designed by Selldorf Architects and operated by Sims Municipal Recycling, redefines the architectural language of waste infrastructure. Situated on a former brownfield along the Brooklyn waterfront, the facility processes over 18,000 tons of recyclables per month. Architecturally, the 11-acre campus is organized around a linear spine, with metal-clad volumes that house high-bay storage and sorting conveyors. The main tipping building, constructed from 99% recycled steel, is designed for sectional clarity, while clerestory glazing introduces natural daylight, reducing energy dependence[71]. Roof-integrated solar panels, bioswales, and stormwater treatment systems create a closed-loop environmental envelope[72].

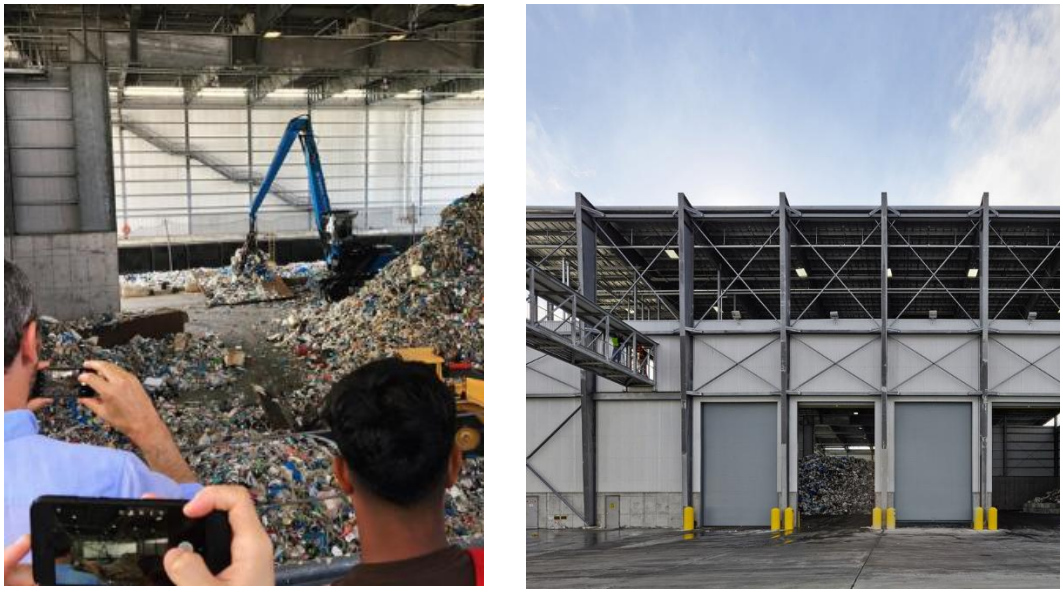


Figure 39: Visitors observe recycling operations at Sunset Park MRF, where New York's waste is sorted and processed. (Source: ArchDaily – Selldorf Architects)

The site plan follows the spatial logic of material flow: trucks offload at dedicated bays, conveyors move recyclables through sequential manual and automated

sorting stations, and elevated walkways and galleries allow visitors to observe operations, reinforced with educational signage. Urbanistically, Sunset Park anchors waterfront industrial revitalization, reactivating disused piers and reducing truck transport by over 250 miles per trip. The site simultaneously accommodates industrial logistics, environmental remediation, and public accessibility, demonstrating how functional infrastructure can be embedded within a broader urban framework. By choreographing circulation for trucks, employees, maintenance vehicles, and visitors, the project balances operational efficiency with spatial experience, while minimal architectural interventions such as pavilions, observation platforms, and green infrastructure - reinforce the facility's civic presence without compromising workflow.

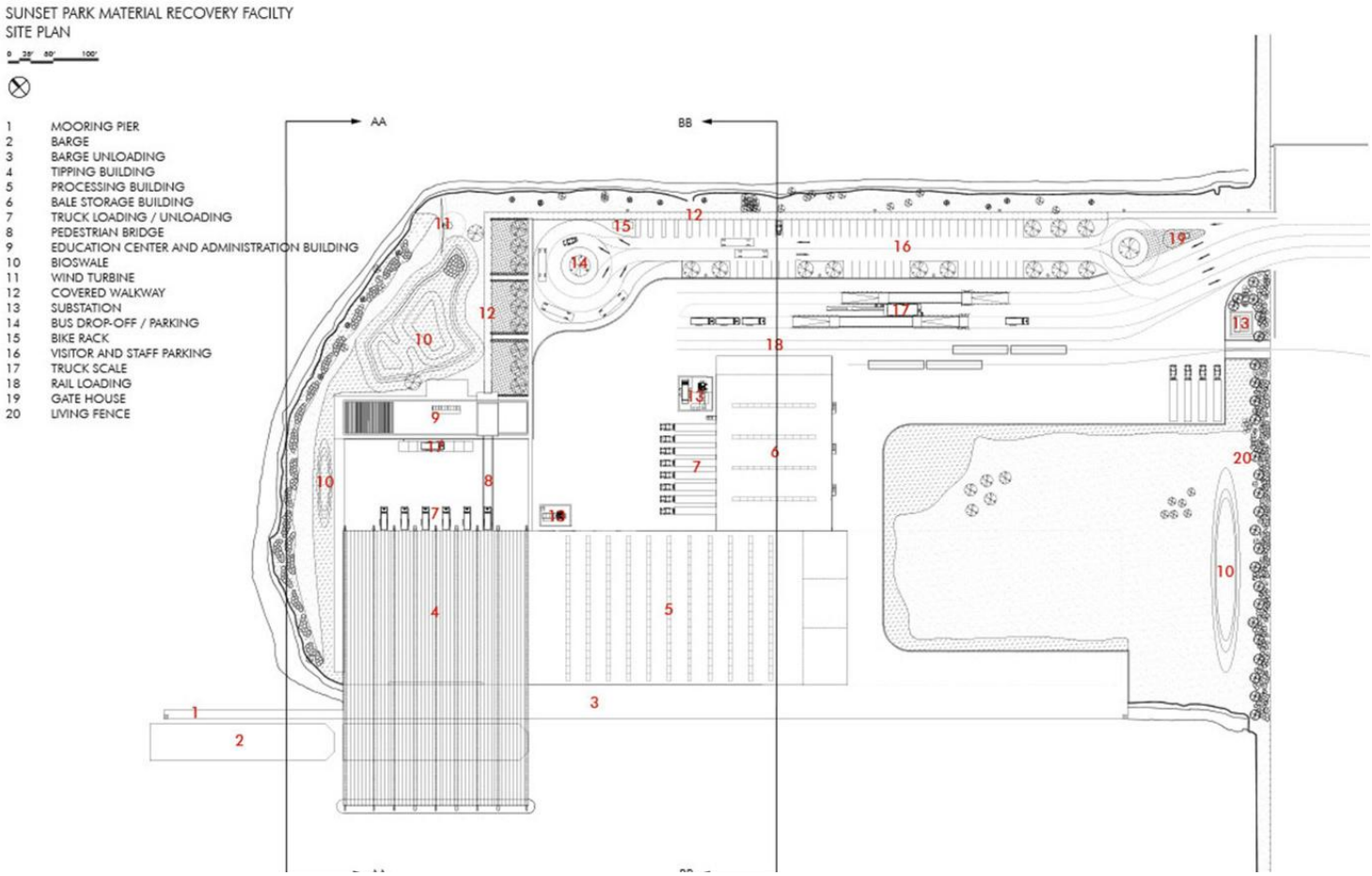
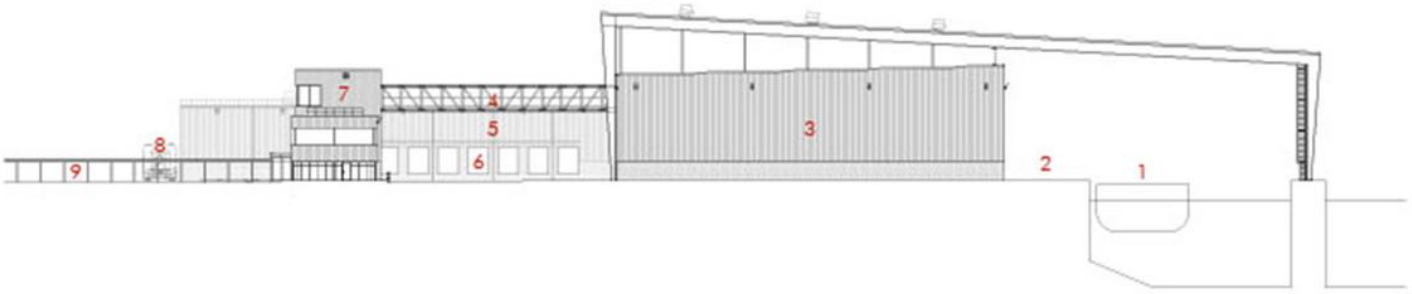


Figure 40: Site plan of Sunset Park MRF showing integrated processing halls, education spaces, and waterfront access. (Source: ArchDaily – Selldorf Architects)



1 BARGE
2 BARGE UNLOADING
3 TIPPING BUILDING
4 PEDESTRIAN BRIDGE
5 BALE STORAGE BUILDIING
6 TRUCK LOADING
7 EDUCATION CENTER AND ADMINISTRATION BUILDING
8 RAIL LOADING
9 COVERED WALKWAY

Figure 41: Section of Sunset Park MRF highlighting barge unloading, tipping halls, storage, and the public education center. (Source: ArchDaily – Selldorf Architects)

Significance: Sunset Park MRF demonstrates that industrial waste infrastructure can transcend its purely functional role to become an architecturally and socially meaningful landscape. By making material flows legible, integrating sustainable design strategies, and offering public observation, the facility redefines how society perceives and interacts with waste. It provides a precedent for designing infrastructure that is efficient, environmentally responsible, and pedagogically valuable, challenging the invisibility of waste while advancing urban industrial revitalization. The project underscores that material recovery facilities can serve as civic and educational assets, proving that transparency, operational clarity, and design sophistication are not mutually exclusive in the context of urban waste management. Interactive education center at Sunset Park MRF engages visitors in learning about recycling and material transformation.

For Delhi, Sunset Park demonstrates how location and logistics can dramatically influence system efficiency suggesting that Ghazipur could be reimagined by leveraging water and rail for waste movement instead of road-heavy truck transport. The project also emphasizes architectural transparency, showing that waste infrastructure need not be hidden but can act as a space of education and public engagement. For Ghazipur, adopting this approach means designing facilities that balance industrial necessity with ecological sensitivity, allowing waste

systems to be seen not as urban scars but as integral, teachable parts of the city's metabolism.



Figure 42: Pedestrian bridge connects the education center with recycling operations at Sunset Park MRF (Source: ArchDaily – Selldorf Architects)



Figure 43: Interactive education center at Sunset Park MRF engages visitors in learning about recycling and material transformation. (Source: ArchDaily – Selldorf Architects)

Zabbaleen Settlements

Location: Manshiyat Naser, Cairo, Egypt
Year: Self-built, established since 1940s
Area: Varies across multiple neighborhoods
Architect / Designer: Self-built, vernacular practice
Key Words: Informal waste recovery, vernacular urbanism, ecological labor, hybrid program, spatial efficiency, incremental design, resilient systems

The Zabbaleen settlements in Cairo represent a self-organized and highly efficient approach to municipal waste management, developed entirely outside formal planning frameworks. Established in the 1940s, these neighborhoods manage nearly two-thirds of Cairo's municipal waste, achieving recovery rates exceeding 80%, a figure unmatched by most formal waste systems.[73] The urban fabric of Manshiyat Naser is dense, vertically layered, and multifunctional. Residences, workshops, waste sorting floors, animal enclosures, and religious spaces coexist in hybrid arrangements that maximize both spatial and labor efficiency. Ground floors function as reception and initial sorting areas, with sacks of plastics, metals, and cardboard stacked in courtyards. Upper floors are residential, while rooftops host pigs and goats that consume organic waste, closing the loop of local material recovery. Circulation paths simultaneously serve as transport corridors and social connectors, integrating work, movement, and community life into a single spatial system[74]. There is no rigid separation between domestic and industrial activity; labor and life coexist within the same architecture. The spatial organization reflects an intimate understanding of waste flows, proximity, and real-time processing, ensuring resilience and operational efficiency without formal planning recognition. Modernization and privatization efforts in the early 2000s, which attempted to replace Zabbaleen labor with foreign contractors, highlighted both the fragility and the ingenuity of these informal systems, as well as the environmental regressions that followed attempts to displace them[75]. However, modernization projects, such as Cairo's privatization of waste contracts in the early 2000s, attempted to displace them with foreign contractors. This led to both environmental regression and the marginalization of indigenous systems.

Significance: The Zabbaleen settlements demonstrate that cities can construct highly functional waste systems from the ground up, relying on vernacular knowledge, ecological labor, and incremental spatial strategies. These settlements provide a model for resilient, integrated, and socially embedded waste infrastructure, highlighting the potential of informal urbanism as a source of architectural and ecological innovation.



Figure 44: In Cairo's Zabaleen settlement, waste is collected, sorted, and recycled directly within dense residential neighborhoods. (Source: Matthew Cassel)

4.3 Indian Case Studies: Embedded Design Logics

India's urban waste crisis is marked by extremes- of scale, informality, innovation, and neglect. While cities like Delhi have relied on centralized landfilling and costly waste-to-energy solutions, several smaller municipalities have piloted alternatives rooted in decentralization, local labor, and low-cost systems. Yet even these celebrated examples remain under-analyzed in waste management discourse.

Devguradia Landfill Remediation

Location: Indore, Madhya Pradesh, India
Year: Bioremediation initiated 2018 - ongoing
Area: 100 acres
Architect / Designer: Indore Municipal Corporation (IMC), technical and engineering team
Key Words: Bio-mining, mechanical remediation, legacy waste management, partial capping, terraced landscaping, limited ecological restoration, infrastructural efficiency, lack of public engagement

Devguradia Landfill in Indore exemplifies a large-scale technical approach to legacy waste management in India. Once spanning nearly 100 acres and containing over 13 lakh metric tonnes of accumulated municipal waste, the site underwent a major bioremediation effort starting in 2018 [76]. The Indore Municipal Corporation (IMC) implemented mechanical bio-mining to excavate, dry, sieve, and segregate waste using trommel machines[77]. Materials were sorted into compostable fines, plastics, Refuse Derived Fuel (RDF), and inert matter. The mound was reshaped, partially capped, and overlaid with terraced landscaping and turf to present a visually "clean" site. Composting sheds were added on the periphery but remained disconnected from ongoing city waste flows[78].

Architecturally and ecologically, the intervention is limited. No layered ecological systems were introduced to restore soil health or hydrology. Public programming, ecological monitoring, or adaptive reuse frameworks were absent. The site remains a visually restored plateau, functional primarily in logistical terms rather than spatial, ecological, or civic dimensions. While nationally lauded for its technical efficiency, the project highlights the gap between mechanical remediation and transformative landscape design. For cities like Delhi with legacy

waste challenges, Devguradia demonstrates that excavation alone does not equal regeneration; design and ecological integration are necessary to reconnect land to life.

Significance: Devguradia serves as both precedent and caution. It illustrates how large-scale waste excavation and capping can achieve visible cleanliness and operational efficiency, yet fail to deliver long-term ecological, social, or architectural value. The case underscores the importance of integrating design thinking, ecological systems, and public engagement into landfill remediation, providing lessons for Delhi's Ghazipur and similar sites.



Figure 45: Indore's Devguradia landfill transformed from a burning dumpsite in 2016 to a restored green public space by 2023. (Source: IndiaSpeaks)

Ambikapur Waste Management

Location: Ambikapur, Chhattisgarh, India
Year: 2016 – ongoing
Area: City-wide; 17 ward-level Resource Recovery Centres (RRCs)
Architect / Designer: Ambikapur Municipal Corporation & Women-led SHGs (informal and formal systems)
Key Words: Decentralized waste management, women-led sanitation, resource recovery, composting, vermiculture, participatory systems, infrastructurally thin, proximity-based spatial logic, informal architecture

Ambikapur offers a national model for decentralized waste management and women-led sanitation. Since 2016, the city has operated without a central landfill, relying instead on a door-to-door segregated collection system feeding into 17 ward-level Resource Recovery Centres (RRCs). Over 450 women from self-help groups (SHGs) are employed as formal sanitation workers[79]. Trained in composting, segregation, and vermiculture, they manage dry and wet waste in parallel streams: organic waste is composted in on-site pits and tanks, while recyclable dry waste is manually sorted and sold through designated channels. Each ward achieves near-zero waste-to-landfill ratios[80].



Figure 46: Women workers in Ambikapur collect segregated waste using e-rickshaws, forming the backbone of the city's zero-waste model. (Source: Princeton University, The Ambikapur Model)

Spatially, the system is effective but infrastructurally minimal. The RRCs often consist of makeshift sheds, open-air enclosures, or partially built facilities with tin roofs and porous perimeters. Worker safety, hygiene, and long-term durability are largely unaddressed: many sites lack water access, toilets, lighting, and formalized leachate management. The design of composting pits and related infrastructure is frequently improvised. Despite these limitations, Ambikapur's waste system thrives on proximity, daily rhythms, and social ownership. Architectural intervention could reinforce this participatory model, transforming RRCs into spaces of civic engagement, education, and neighborhood commons, while maintaining operational efficiency.



Figure 47: Women in Ambikapur sort household waste in decentralized segregation sheds, enabling a zero-landfill system. (Source: Princeton University, The Ambikapur Model)

Significance: Spatially, the system is effective but infrastructurally minimal. The RRCs often consist of makeshift sheds, open-air enclosures, or partially built facilities with tin roofs and porous perimeters. Worker safety, hygiene, and long-term durability are largely unaddressed: many sites lack water access, toilets, lighting, and formalized leachate management. Despite these limitations, Ambikapur's waste system thrives on proximity, daily rhythms, and social ownership. Architectural intervention could reinforce this participatory model, transforming RRCs into spaces of civic engagement, education, and neighborhood commons, while maintaining operational efficiency.

SWaCH Cooperative

Location: Pune, Maharashtra, India
Year: 2007 – ongoing
Area: City-wide, neighborhood-level dhalaos and collection points
Architect / Designer: SWaCH Cooperative & Pune Municipal Corporation (labor-led governance, informal spatial frameworks)
Key Words: Labor integration, informal-to-formal transition, public-private partnership, decentralized waste collection, neighborhood dhalaos, spatial neglect, civic infrastructure, social inclusion

Pune demonstrates how labor integration can drive urban waste governance without relying on major technological intervention. Since 2007, the city has formalized informal waste pickers through SWaCH (Solid Waste Collection and Handling Cooperative), a public-private partnership combining municipal oversight with worker-led operations[81]. Pune demonstrates how labor integration can drive urban waste governance without relying on major technological intervention. Since 2007, the city has formalized informal waste pickers through SWaCH (Solid Waste Collection and Handling Cooperative), a public-private partnership combining municipal oversight with worker-led operations[82]. Informal waste pickers were officially recognized, provided with ID cards, assigned collection routes, and compensated directly by residents. This integration has created a more accountable and efficient labor system, elevating the social status of workers and ensuring steady material recovery across neighborhoods.
Despite progressive policy, spatial infrastructure remains inadequate. Most sorting occurs at neighborhood dhalaos or informal corners, which are often dilapidated, exposed to weather, and poorly maintained. While governance mechanisms are robust, the absence of architectural investment limits operational efficiency, worker safety, and civic visibility. The disconnect between formal labor recognition and spatial provision reveals a critical lesson: without built form that embodies dignity, policy gains remain fragile.

Significance: The Pune SWaCH system underscores the importance of connecting policy, labor, and spatial design. While it exemplifies labor-led governance and decentralized waste management, it also highlights the limits of informal spatial arrangements. For cities like Delhi, where informal labor remains central to waste systems, Pune emphasizes that operational success depends as much on the design of space as on the recognition of labor. Properly designed dhalaos can transform functional infrastructure into sites of civic value, ensuring sustainability, dignity, and neighborhood integration.

Informal ●·····● ***Formal***



Figure 48: A SWaCH worker in Pune conducts door-to-door waste collection, integrating informal labor into the city's formal system. (Source: Laxmi Naraya)

4.4 The Vellore Model: Ecosystems and Urban Waste

Vellore's Solid and Liquid Resource Management (SLRM) model stands as one of India's most ecologically intelligent and socially grounded approaches to urban waste. Spearheaded by S.S. Rajendran, the system challenges both centralized waste infrastructure and the mechanization of waste processing by returning to a logic of proximity, participation, and multi-species labor[83]. In contrast to Delhi's waste system which depends on long-haul transport, remote landfills, and late-stage intervention: Vellore's SLRM model operates on the premise that waste should be handled at its source, immediately and with care. In India, over 50–60% of municipal solid waste is organic in nature, a figure that significantly shapes the country's waste profile. In most Indian cities, biodegradable waste remains unsegregated, hauled long distances, and incinerated or landfilled: causing methane emissions, leachate, and nutrient loss. Vellore counters this with architectural and temporal precision: daily collection, sorting, and processing in small neighborhood-scale units within walking distance. This drastically reduces the need for trucks, central MRFs, or energy-intensive sorting[84]. A defining innovation of the Vellore SLRM model is its use of multi-species integration to close organic loops. Instead of relying solely on mechanized processing, the system assigns functional roles to animals transforming waste into ecological productivity. Each species participates in the waste metabolism of the city, offering a biologically diverse alternative to centralized, energy-intensive systems.

- **Cows** in the dairy units provide milk, but more critically, their dung and urine are routed into biogas digesters and composting pits. This produces clean energy and nutrient-rich soil amendments.
- **Chickens** consume food scraps and convert them into protein, while their manure feeds composting processes or is used as fish feed- creating inter-species linkages between poultry and aquaculture.
- **Ducks** roam fishponds, their droppings fertilizing the water while also helping control pests, a dual function that supports fish farming without chemical input.
- **Fish** are fed a mix of vegetable waste, insects, and poultry droppings, converting low-value biomass into protein. The ponds also act as natural nutrient sinks.
- **Frogs**, though not farmed, are encouraged as biological pest regulators within the aquatic systems, reducing the need for pesticide intervention.
- **Earthworms** in the vermicomposting beds digest organic waste, including cow dung and poultry litter, to create "black gold": a nutrient-rich compost that completes the soil cycle.

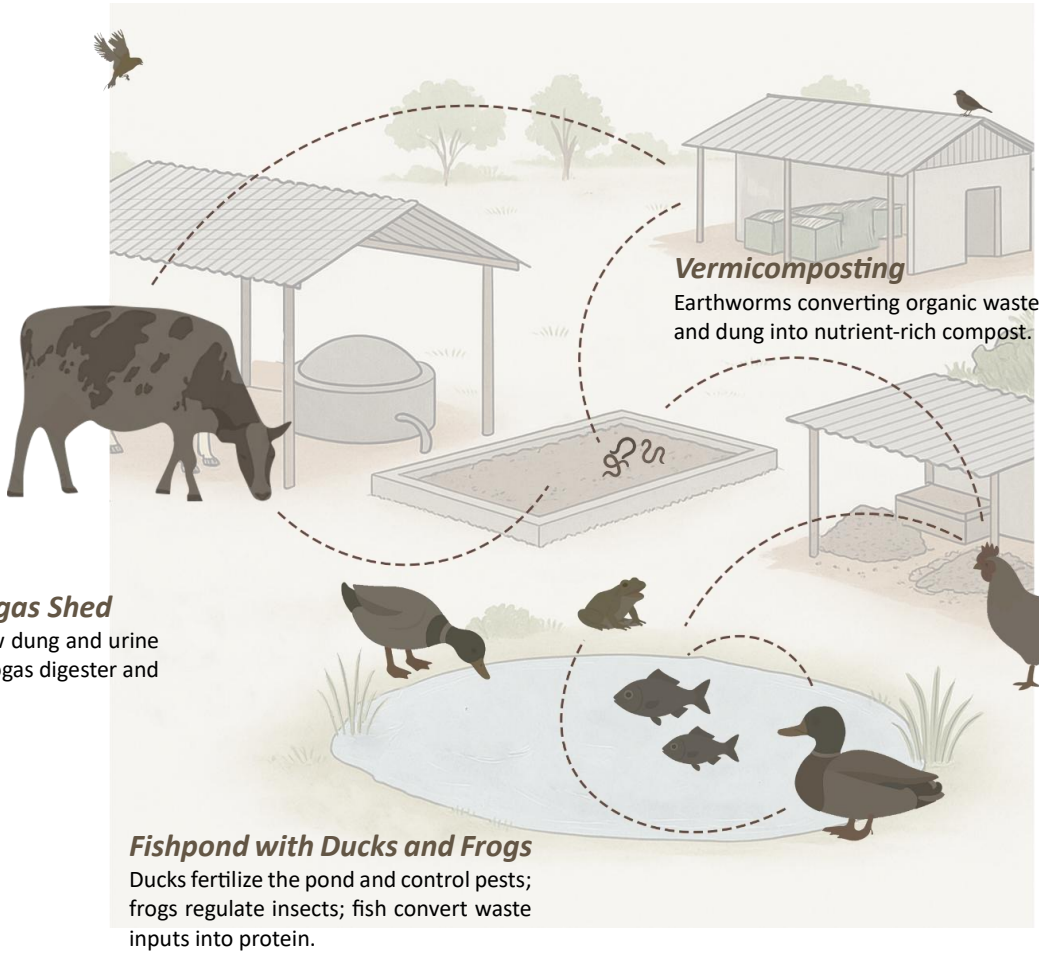


Figure 49: Multi-species integration in Vellore's SLRM model. (Source: Author)

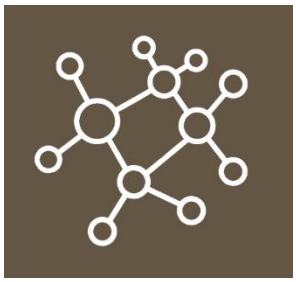
The presence of animals does not romanticize waste labor; it reconfigures the ecological circuitry of organic waste, making digestion visible, audible, and embodied. Rajendran emphasizes that *"wet waste loses 70% of its value within 4 hours of generation,"* highlighting the urgency of spatial-temporal design in waste systems[85]. This is not just a technical insight- it is an architectural imperative. Structures are timed, not just sited: drying floors, composting racks, feeding zones, and sale kiosks all function in rhythm with organic decomposition. The Vellore SLRM model is central to this thesis because it redefines waste architecture as something multi-scalar, ecological, and relational. Rather than treating animals or waste workers as peripheral, it places them at the heart of the system. For Delhi's future, the lesson is clear: rather than relying solely on costly WTE plants or caps, an approach to build infrastructure of relationships- between waste and value, human and animal, space and time must be considered.

4.5 Strategic Design Principles

Drawing from a diverse range of global and Indian precedents, this thesis advances a spatial strategy that shifts the paradigm of waste management from containment and concealment to integration and regeneration. Rather than viewing waste as an externality to be removed, the proposed framework positions it as a material and ecological actor within the city's metabolism. Applied across multiple scales- citywide, neighborhood, and site-specific: the framework enables a phased and context-sensitive transformation of waste infrastructure. In doing so, it reimagines waste not as residue, but as a generative force that can repair landscapes, dignify labor, and reshape the spatial politics of Delhi's urban future.

Strategy 1:

Decentralize to Reduce Distance and Delay



Delhi's current waste system depends on long-distance transport to centralized landfills, resulting in delays, high emissions, and loss of material value. Decentralizing infrastructure brings waste processing closer to the point of generation, enabling real-time segregation, reducing travel-related emissions, and easing the burden on mega landfills. A decentralized system creates local loops of resource recovery and accountability- anchored within the everyday rhythms of the neighborhood.

Strategy 2:

Design for Ecology and Infrastructure Together



Waste infrastructure need not remain sterile or hidden. When ecological systems are embedded into waste processing sites, they enable urban repair: restoring soil health, treating greywater, reducing heat stress, and supporting biodiversity. This layered design approach transforms infrastructure into living systems. At Ghazipur and similar sites, such hybrid landscapes can double as public commons - blurring the line between environmental utility and civic space. Animals can also support this ecological integration, contributing to

organic waste processing and enriching the environmental life of these systems.

Strategy 3:

Create Participatory Waste Spaces



Infrastructure must be made civic. This requires making waste visible, accessible, and shared through co-location with educational elements, community zones, and facilities for informal workers. Sorting sheds can double as training centers; education walls can communicate circularity; composting stations can become gardens. These interventions shift waste from a stigmatized backend to a pedagogical front- dignifying labor, building local ownership, and encouraging behavioral change.

The visual strategy adopted in this thesis favors diagrams, vignettes and conceptual site planning, a deliberate choice to foreground conceptual clarity and design principles. Given the layered complexities of the Ghazipur context and the multiplicity of development pressures, this schematic approach allows for a more flexible and interpretive engagement with waste systems and the site. Rather than prescribing fixed solutions, the representations aim to provoke critical reflection and open-ended dialogue. This method also reflects the iterative nature of the research, which has drawn from multiple sites and precedents to inform a broader spatial strategy.

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Part 5

Beyond Disposal

Spatial Dynamics at the Intersection of Waste and Design



Figure 50: Dignifying Margins (Source: Author)



Overview:

This part proposes a shift. Building on the principles outlined in Part 4, it moves from centralized containment to decentralized care. Rather than routing all waste to distant landfills or incinerators, the strategy embeds localized infrastructure into the everyday fabric of the city designed not only for efficiency, but for public visibility, ecological repair, and labor dignity.

5.1 Multi-Scalar Design Framework

The transformation of Delhi's waste system cannot be imagined as a singular intervention, nor can it be confined to the periphery where its failures are currently staged. Instead, it must unfold as a distributed spatial strategy embedded directly within the everyday neighborhoods that generate the waste in the first place.

1. Dhalao Redesign as Urban Commons

(Neighbourhood Level Implementation)

Dhalaos are reimagined not as inert bins but as neighborhood-scale nodes for active waste engagement. Redesigned dhalaos combine dry and wet waste segregation zones, green buffers, educational signage, and tool storage for worker dignity. A waste zoning map- based on density, land use, and waste typologies guides their strategic placement. This approach shortens the waste circuit, fosters participation, and lays the groundwork for local circular economies.

2. Community-Driven Material Recovery Facility

(Ward Level Implementation)

At the ward scale, Material Recovery Facilities (MRFs) are co-located with public commons, learning centers, and compost units. These are not hidden sheds but open and inclusive civic spaces - where informal workers have structured roles, and the community engages directly with waste flows. Transparent sorting zones, training areas, and compost gardens serve as both infrastructure and education. This spatial strategy bridges the gap between informal expertise and formal systems.

3. Ghazipur Dumpsite Transformation and Ecological Restoration

(City Level Implementation)

Ghazipur's legacy as a toxic monument is addressed through phased biomining, ecological remediation, and programmed reuse. Following material extraction, the land is recontoured with wetlands, meadows, and productive landscapes—including animal-integrated compost farms and trails. Public pathways, educational nodes, and seasonal markets reintroduce civic life. Rather than sealing waste underground, the site

becomes a layered ecology: a living archive of Delhi's waste legacy and its possible futures. Together, they form a distributed, replicable system aimed at transforming Delhi's waste infrastructure from a linear trajectory of extraction and disappearance into a circular, spatially just ecology of return.

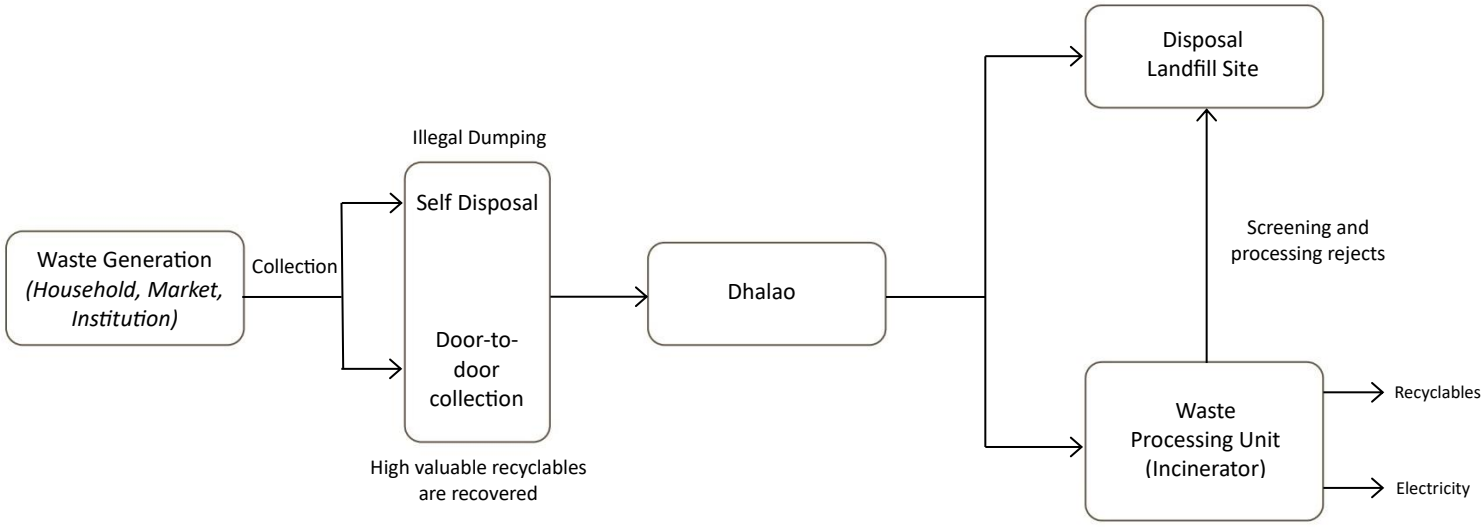


Figure 51: Existing Waste System + Spatial Dynamic

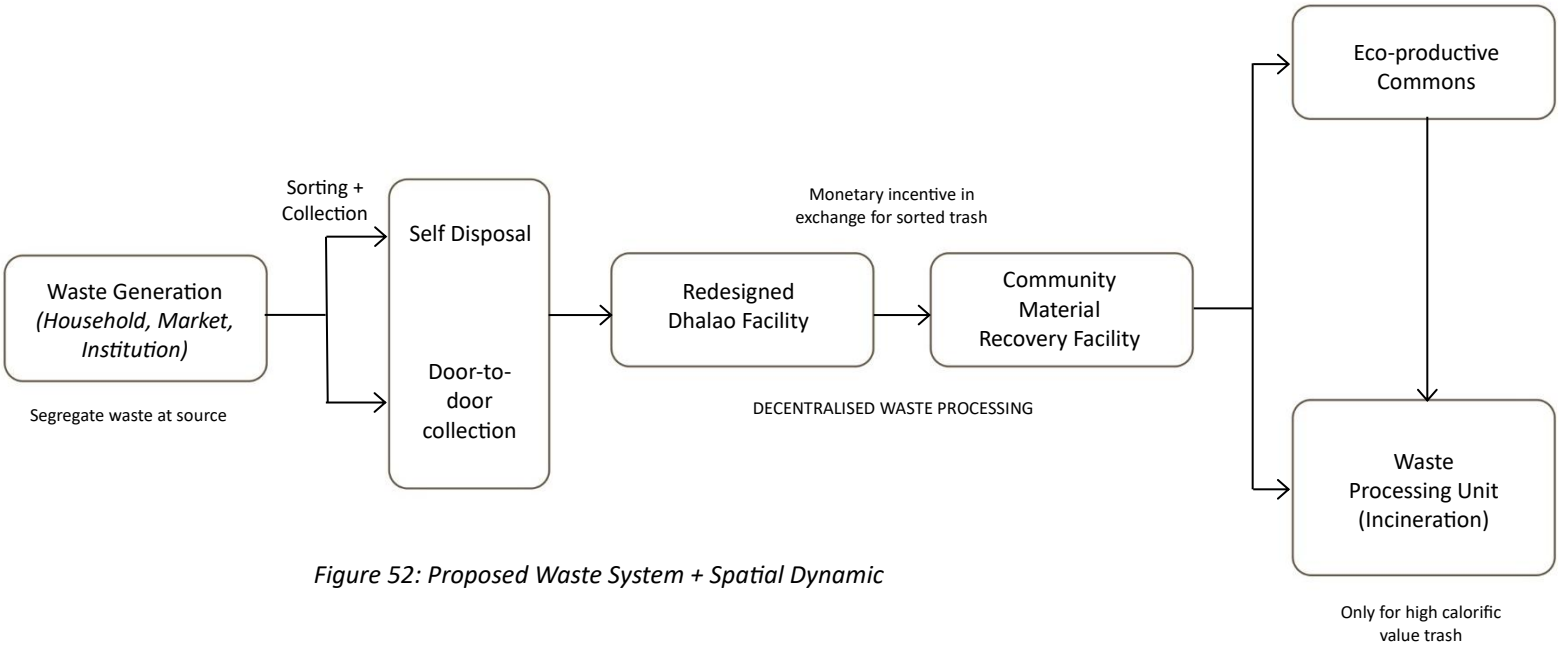


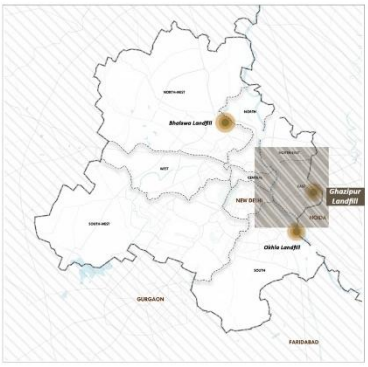
Figure 52: Proposed Waste System + Spatial Dynamic

5.2 Spatial Strategy and Pilot Framework

To demonstrate this approach, the thesis proposes a pilot framework across select sites in East Delhi and Northeast Delhi: two regions whose waste streams contribute heavily to the Ghazipur landfill's daily load. These regions represent the contradictions of Delhi's urbanization: they are dense, vibrant, and socially diverse, yet they suffer from chronic infrastructural mismatch, fragmented governance, and civic neglect. Waste becomes both a symptom and an accelerant of this neglect - piling up in dilapidated dhalaos, clogging drains, and finally being displaced onto the city's growing mountain at Ghazipur. This very dysfunction, however, makes them fertile grounds for experimentation. By intervening where waste pressure is most acute, the pilot strategy demonstrates how new systems of recovery can be prototyped, tested, and scaled outward. The framework is conceived as a network of interlinked neighborhood loops. Each loop is structured around two key components: a distributed system of redesigned dhalaos, and a centrally located Material Recovery Facility (MRF) that aggregates and processes waste at a neighborhood scale. Six to eight dhalaos form the nodes of a loop, each designed to hold and process waste long enough to stabilize and extract value before it is transported. Instead of trucks hauling mixed garbage across long distances, waste is moved by low-emission e-rickshaws and handcarts, minimizing both the time waste spends in transit and the carbon footprint of its movement.

This circulation model is deliberately *decentralized.* It interrupts the current linear system: collection, displacement, dumping; and instead builds a circular ecology within each neighborhood. Waste is held locally, treated locally, and where possible, its by-products: compost, recyclables, RDF are reintegrated back into the neighborhood or nearby markets. Labor, too, is kept local. Informal waste workers who already operate invisibly in these areas are given formalized roles within the loop, reducing their dependence on the distant landfill economy and embedding their labor within a dignified neighborhood infrastructure. The logic of the pilot is *replicability*. Each loop adapts to its own conditions: land availability, residential-commercial mix, street width, traffic patterns- yet follows the same underlying framework. In this way, it becomes a scalable template that can be applied across Delhi's wards. At its core, the framework spatializes three principles: *hold waste locally, treat labor with dignity, and embed recovery within public life.*

By doing so, the pilot strategy reframes waste infrastructure not as a hidden backend but as an everyday civic asset. The neighborhood loop becomes not just a logistical system but a spatial and social reorganization of urban life around waste: visible, participatory, and restorative.

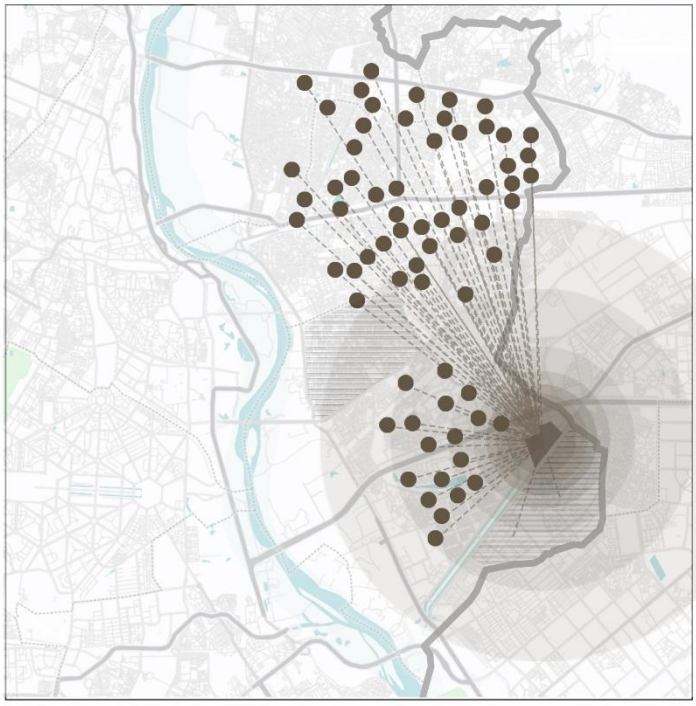


Pilot Spatial Strategy: East & North-East Delhi

Existing Centralized System

Centralized flows move all waste from dhalaos to Ghazipur landfill.

collection → transport → dumping



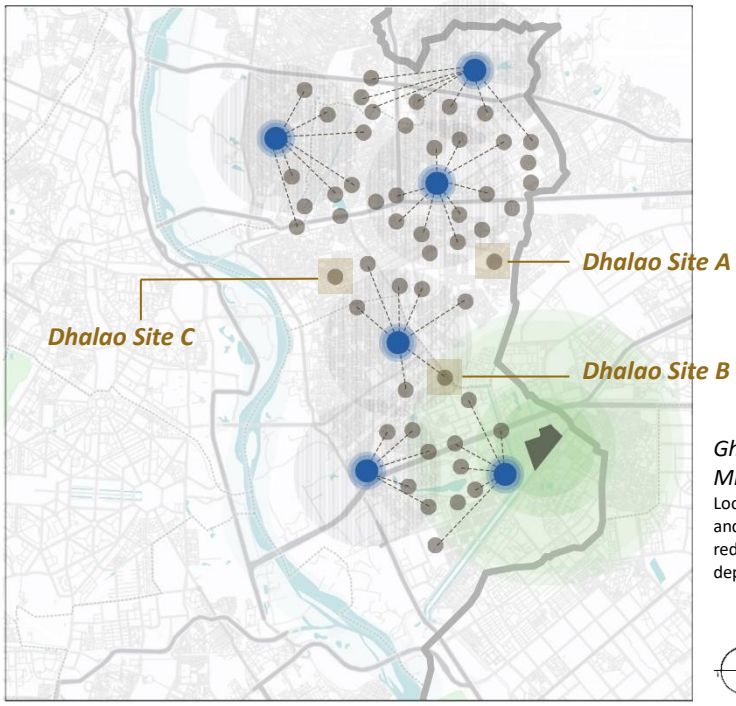
Ghazipur Landfill
singular endpoint of the current system

Existing Dhalaos *Redesigned Dhalaos* *Material Recovery Facilities (MRFs)*

Proposed Pilot Framework

Decentralized loops link dhalaos to local MRFs for neighborhood recovery.

hold waste locally → treat locally → recover value → reintegrate outputs



Ghazipur Landfill & MRFs
Localized processing and recovery loops reducing landfill dependence

Figure 53: Shift from a linear, landfill-dependent system to decentralized neighborhood loops that process and recover waste locally through dhalaos and MRFs. (Source : Author)

5.3 Dhalao Redesign as Urban Commons

At the most local scale of Delhi's waste system lies the dhalao, a modest but overburdened structure. Originally conceived as neighborhood-level enclosures where residents could deposit refuse before municipal collection, dhalaos were meant to bridge household disposal with city-wide transport. Scattered across wards, they are the lowest rung of Delhi's waste infrastructure, quietly embedded into the everyday urban fabric. In principle, they are critical nodes of the system- designed to concentrate waste locally, ease collection, and serve as logistical intermediaries between households, trucks, and transfer stations. In practice, however, the dhalao has become a *symbol of dysfunction.* Typically enclosed in concrete shells or fenced plots, they are poorly maintained, often overflowing and unsanitary. What was once intended as connective infrastructure has, over decades, turned into a space of neglect and decay. *Figure 54* illustrates this collapse vividly. Sections through typical rights-of-way show how dhalaos spill garbage directly onto the street, obstructing circulation and narrowing pedestrian access.

Yet dhalaos also reveal the contradictions of Delhi's waste economy. They are places where formal and informal systems intersect. Municipal trucks deposit unsegregated refuse, while informal workers extract recyclables directly from the heaps. Here caste, labor, and class visibly converge: residents pass by in discomfort, the municipality treats them as backend storage, and waste pickers - work in plain sight yet without recognition. In this sense, dhalaos embody both degradation and resilience: they are dysfunctional, yet also indispensable to the survival of the city's recycling chain.

This thesis proposes a *reversal of their role.* Instead of serving as points of displacement: spaces where waste is temporarily contained before being expelled to Ghazipur - dhalaos can be redesigned to hold waste in place, however briefly, long enough for it to be sorted, composted, and reintegrated into material cycles. Waste is not hidden but spatialized; not discarded but designed for. In this reversal, the most neglected node of Delhi's waste system becomes an opportunity: a civic platform where invisible labor is acknowledged, ecological cycles are activated, and the city's everyday engagement with waste is reshaped. By situating these redesigned dhalaos within the public realm, they can transform from neglected back-end enclosures into visible neighborhood assets. Their reconfiguration offers not only cleaner streets but also dignified working conditions for waste labor. In doing so, dhalaos can become active sites of education, engagement, and community awareness, reframing waste as a shared civic responsibility rather than a problem to be hidden away.

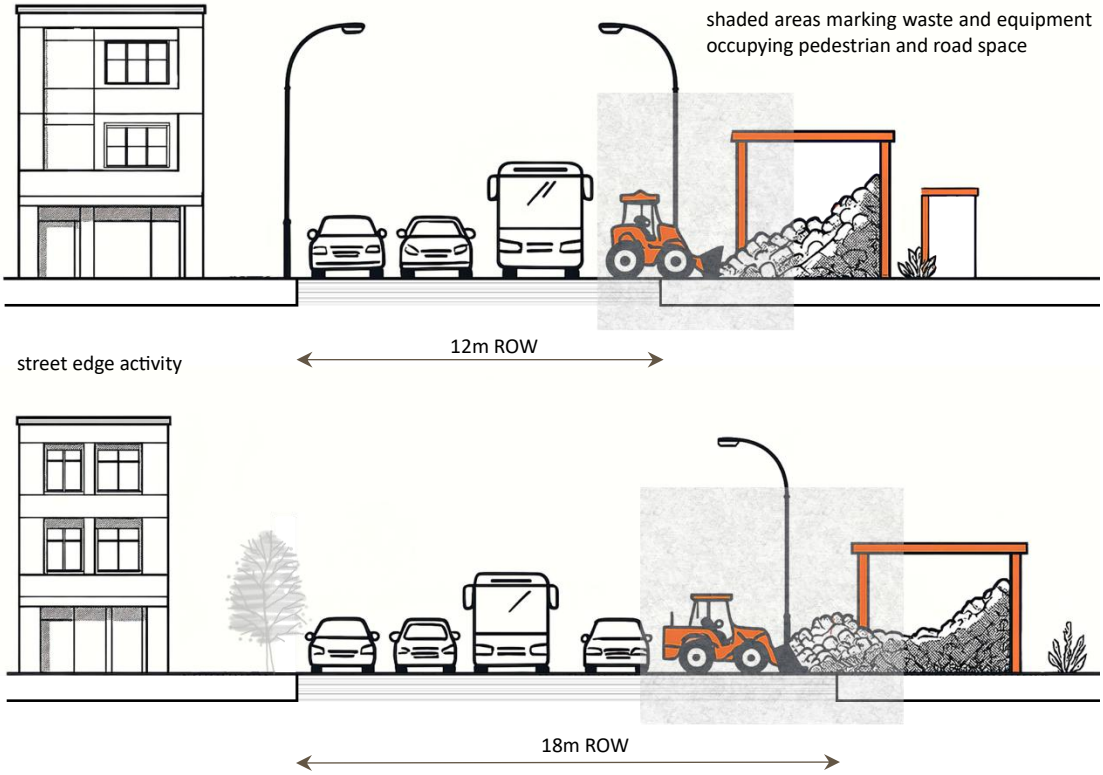


Figure 54: Sections show how overflowing dhalaos and waste-handling vehicles encroach onto the footpath and carriageway, restricting pedestrian movement and reducing road capacity for traffic. (Source: Author)



Figure 55: Overflowing dhalao with unsegregated waste spilling into the street, creating unsanitary conditions and obstructing public space.(Source: TERI)

Dhalao Site A: Existing

Located at neighborhood edge

Figure 56: The dhalao as urban infrastructure reveals its dual life. (Source: Author)

FORMAL

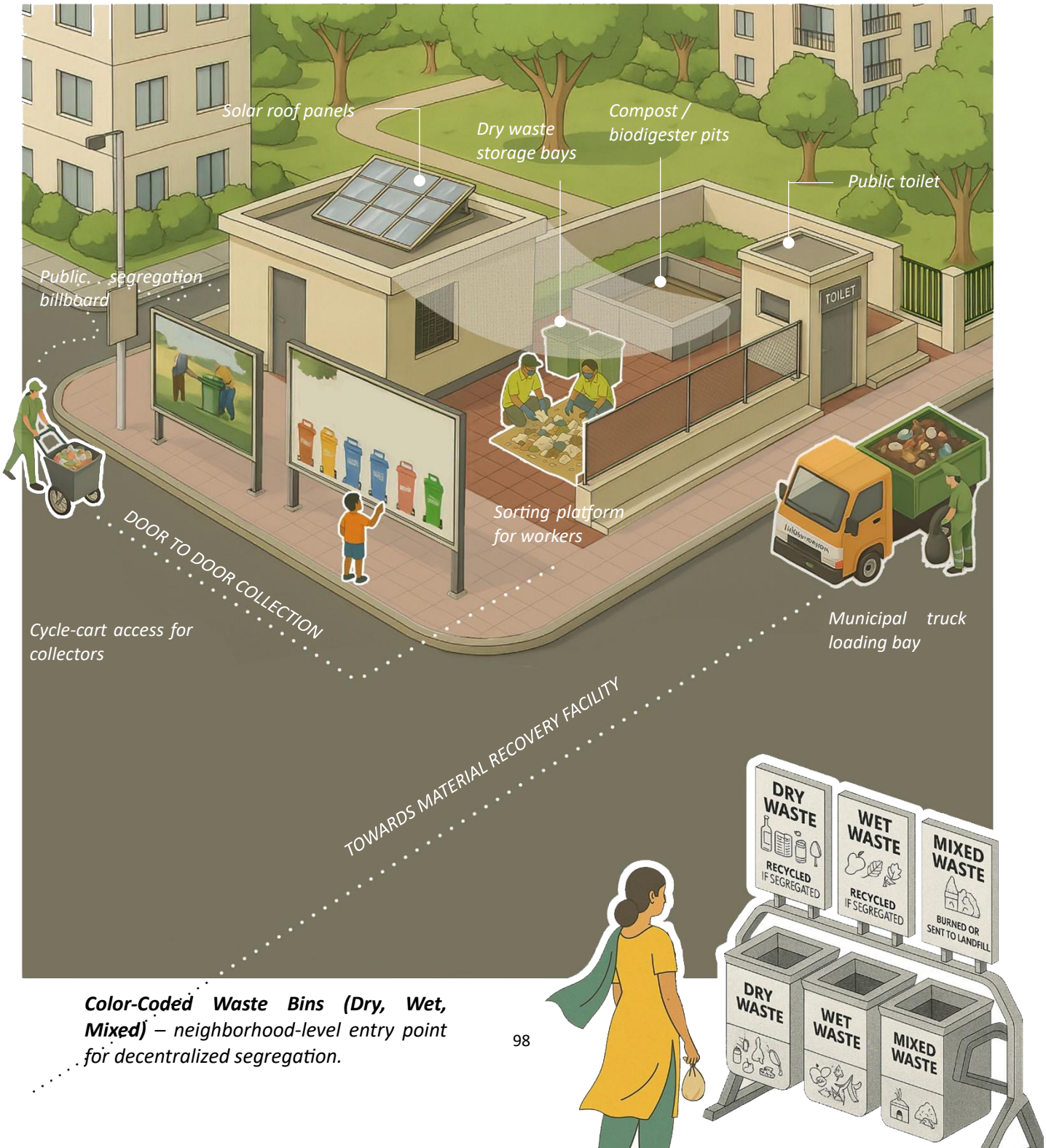
INFORMAL



Dhalao Site A: Redesigned

Large (75 sqm): Neighborhood-edge facility designed for bulk waste and direct truck interface, with space for sorting, composting, and storage.

Figure 57: Redesigned neighborhood dhalao: from backend enclosure to civic waste commons (Source: Author)

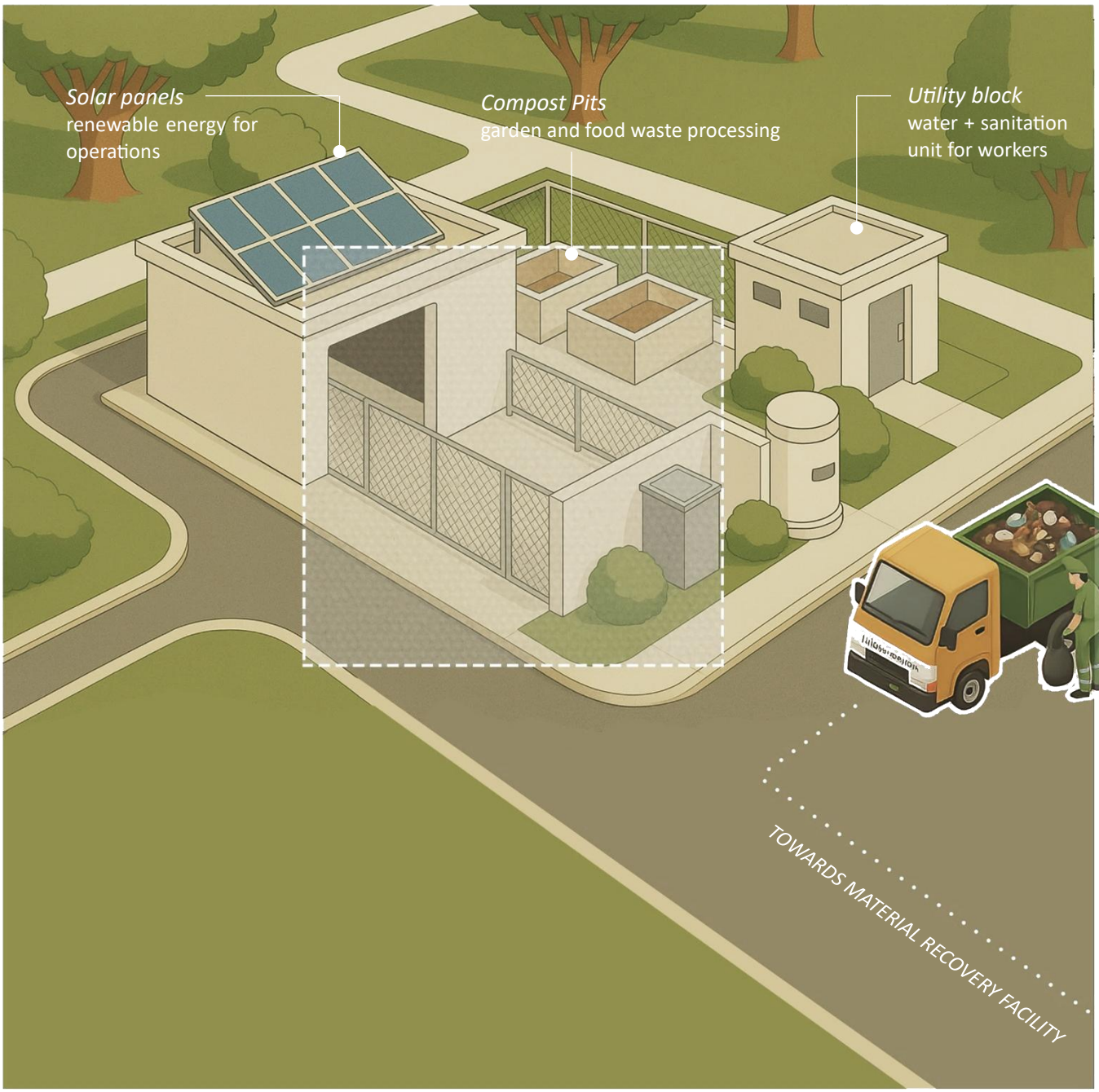


Color-Coded Waste Bins (Dry, Wet, Mixed) *– neighborhood-level entry point for decentralized segregation.*

Dhalao Site B: Redesigned

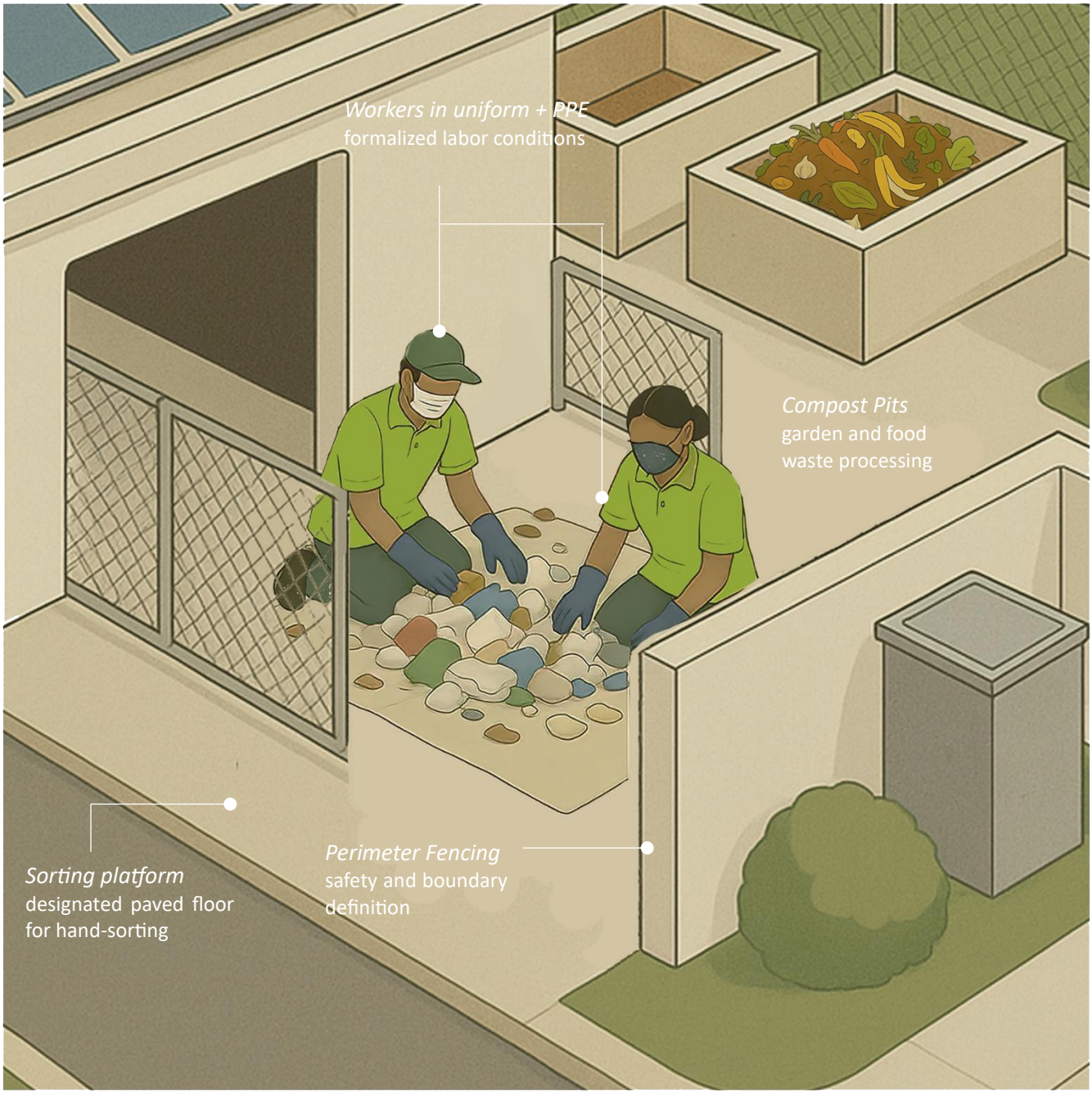
Medium (60 sqm): Public-area facility adjoining gardens and markets, prioritizing composting of household and vendor waste with truck access.

Figure 58: Integrated Park dhalao: from backend enclosure to composting hub within public space. (Source: Author)



Dhalao Site B: Interior Sorting Activity

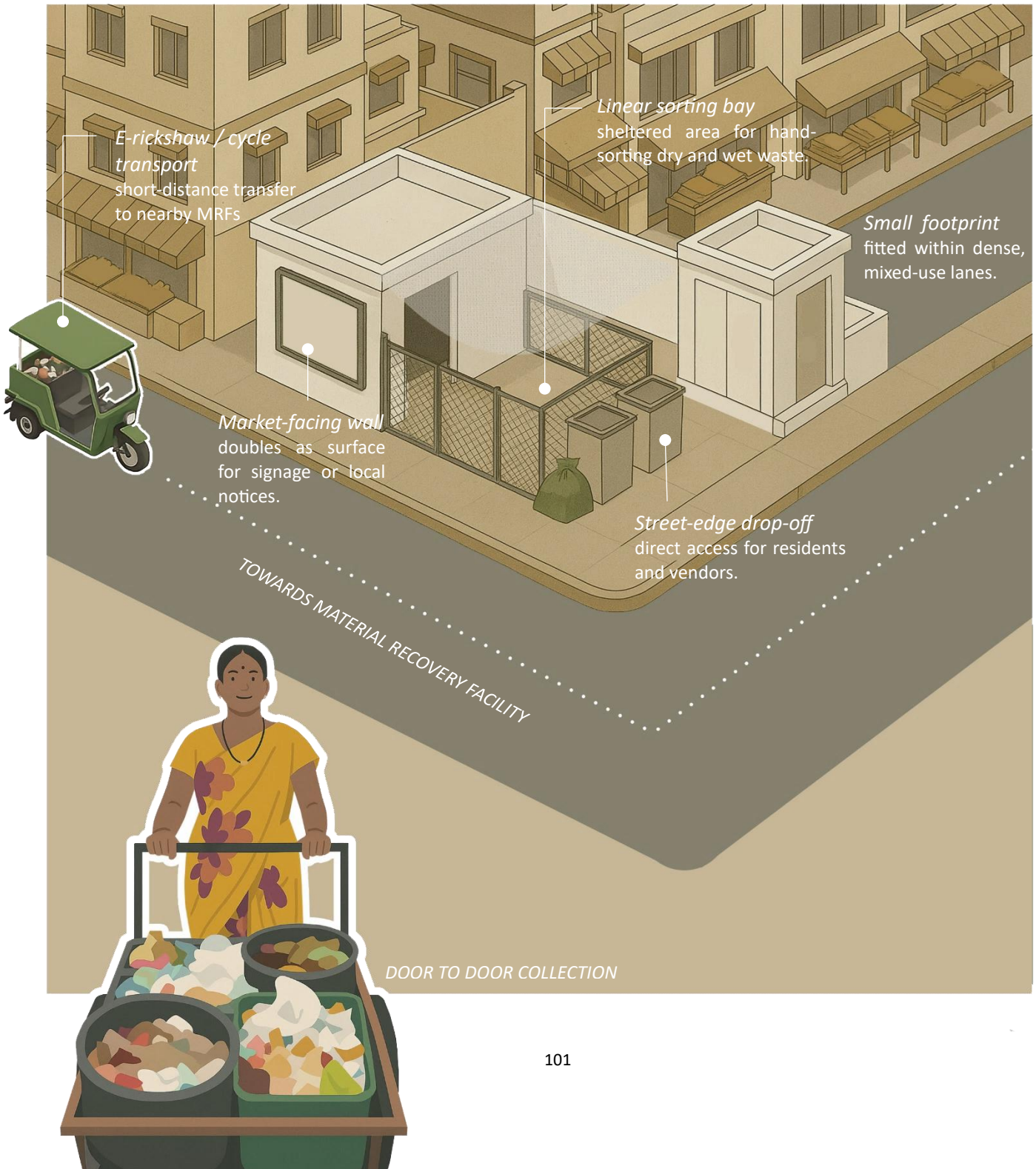
Figure 59: On-site segregation: Waste workers hand-sort collected material into paper, plastic, and glass streams, enabling higher recovery and recycling rates. (Source: Author)



Dhalao Site C: Redesigned

Small (45 sqm): Compact, linear layouts for dense Delhi lanes, prioritizing hand-sorting with minimal vehicle access.

Figure 60: Small dhalao: transforming narrow-lane dumping into organized micro-infrastructure. (Source: Author)



The redesigned dhalao is conceived not as a sealed shed but as an urban common. It integrates functional elements: segregation bays, compost pits or biodigesters, sheltered sorting areas, and storage with amenities that humanize the site: toilets, seating, drinking water, shaded rest zones, solar lighting, and signage for public education. Low fencing and green buffers ensure safety and hygiene while keeping the space open to visibility. Unlike existing typologies that push waste to the margins, these redesigned dhalaos are sited within the pulse of neighborhood life: at market edges, within parks, or along residential streets. They are meant to be seen and used, not hidden and ignored.

Three modular types respond to context and density:

- *Large (75 sqm):* Neighborhood-edge facility designed for bulk waste and direct truck interface, with space for sorting, composting, and storage.
- *Medium (60 sqm):* Public-area facility adjoining gardens and markets, prioritizing composting of household and vendor waste with truck access.
- *Small (45 sqm):* Compact, linear layouts for dense Delhi lanes, prioritizing hand-sorting with minimal vehicle access.

Across all scales, the design logic prioritizes segregation, safety, and civic participation.



Figure 61: Inside the dhalao: safe, ventilated spaces for manual sorting and organized storage of recyclables. (Source: Author)



Figure 62: Handcart and e-rickshaw collection enables door-to-door waste pickup, reducing reliance on trucks for short distances. Households actively segregate waste at source, forming the first step toward a decentralized system. (Source: Author)

"Before it was just garbage, now I see it turning into compost."



Figure 63: Organic waste is transformed into nutrient-rich compost through vermicomposting. Workers handle waste in safe, covered units: turning daily discards into a resource for soil regeneration. (Source: Author)

5.4 Community Driven Material Recovery Facility

To support redesigned dhalaos, the second-tier intervention is the neighborhood-scale Material Recovery Facility (MRF). Unlike the distant transfer stations and landfills that dominate Delhi's waste geography, these facilities are conceived as civic institutions-visible anchors of recovery, education, and neighborhood economy. Each MRF is scaled to serve clusters of six to eight dhalaos, ensuring that waste is stabilized close to its point of origin: dry fractions are segregated and baled for industry, while wet fractions are composted or digested into soil amendments. This proximity reverses Delhi's entrenched logic of displacement, replacing it with one of local circulation.

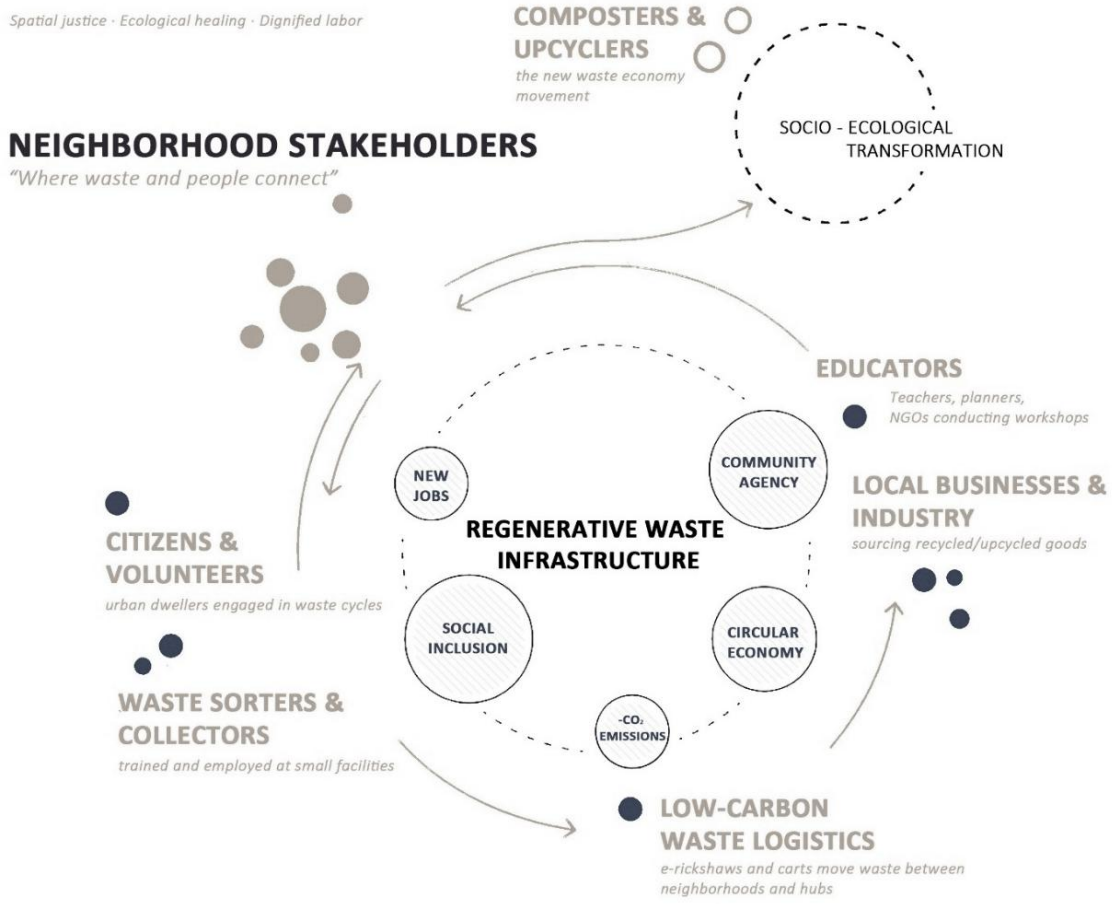


Figure 64: Neighborhood stakeholders: linking waste and people for regenerative infrastructure. (Source: Author)

Figure 64 maps the ecosystem of actors who animate this system. Waste collectors are trained and integrated into formalized facilities; composters and upcyclers generate soil, craft, and products from recovered fractions; educators and NGOs embed knowledge into households and schools; citizens sustain segregation and outreach; and businesses source recycled inputs to strengthen circular markets. These distributed actors are linked by low-emission neighborhood logistics that tie households, dhalaos, and MRFs into one continuous loop of recovery.

Figure 65 illustrates how the program extends outward into spaces of visibility and exchange. Beyond sorting halls, its program includes classrooms where schoolchildren learn ecological practices, training halls where workers gain new skills, and upcycling studios where discarded materials are reimagined as products. Public toilets, shaded rest zones, kitchens, and health kiosks are embedded into the plan, ensuring that the facility acknowledges and supports the people whose labor sustains it. A defining feature is the Materials Marketplace, a public-facing edge where repaired and upcycled goods are displayed and circulated. Here residents encounter the value drawn from their own waste streams, and informal workers find pathways into dignified, self-sustaining livelihoods. Attached workshops reinforce this exchange, enabling neighborhood economies to emerge around reuse and repair. In this sense, the MRF becomes both a processing facility and a civic common.

The architecture reinforces this ethos of openness. Located on civic plots or underused land at the margins of drains, canals, or public facilities, the MRF occupies spaces the city typically treats as infrastructural voids. Instead of closed, opaque sheds, these facilities are designed as porous and breathable structures: ventilated halls, shaded walkways, and internal courtyards that bring light and air into spaces of labor. Their permeable edges invite visibility without stigma, signaling that recovery is a shared civic responsibility rather than a hidden backend operation. In this reconfiguration, the MRF challenges Delhi's prevailing model of invisible labor and remote processing. Workers are no longer hidden at the margins but recognized as stewards of civic space. Their skills are formalized, their presence dignified, and their contribution made legible through architecture. The MRF thus becomes both machine and message: a facility that stabilizes matter and a civic landmark that reshapes how the city perceives its discarded life. By embedding recovery within neighborhoods, waste flows are remapped not as disappearance into Ghazipur but as return into soils, workshops, and markets. Mapping dhalaos, routes, and circulations is no longer a technical exercise but a design act: a way of visualizing circularity, ecological repair, and justice in the everyday city.

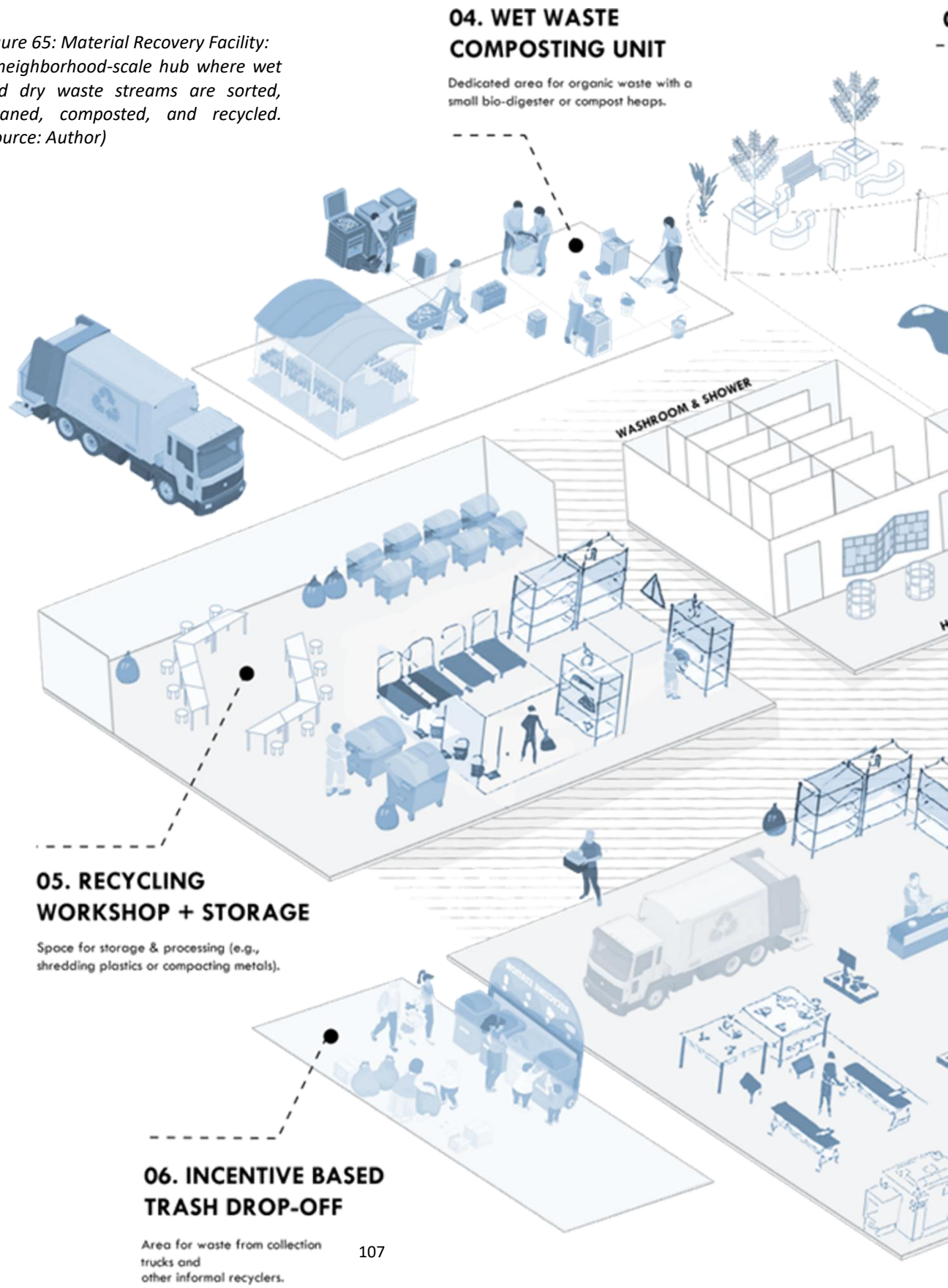


Figure 65: Material Recovery Facility: A neighborhood-scale hub where wet and dry waste streams are sorted, cleaned, composted, and recycled. (Source: Author)

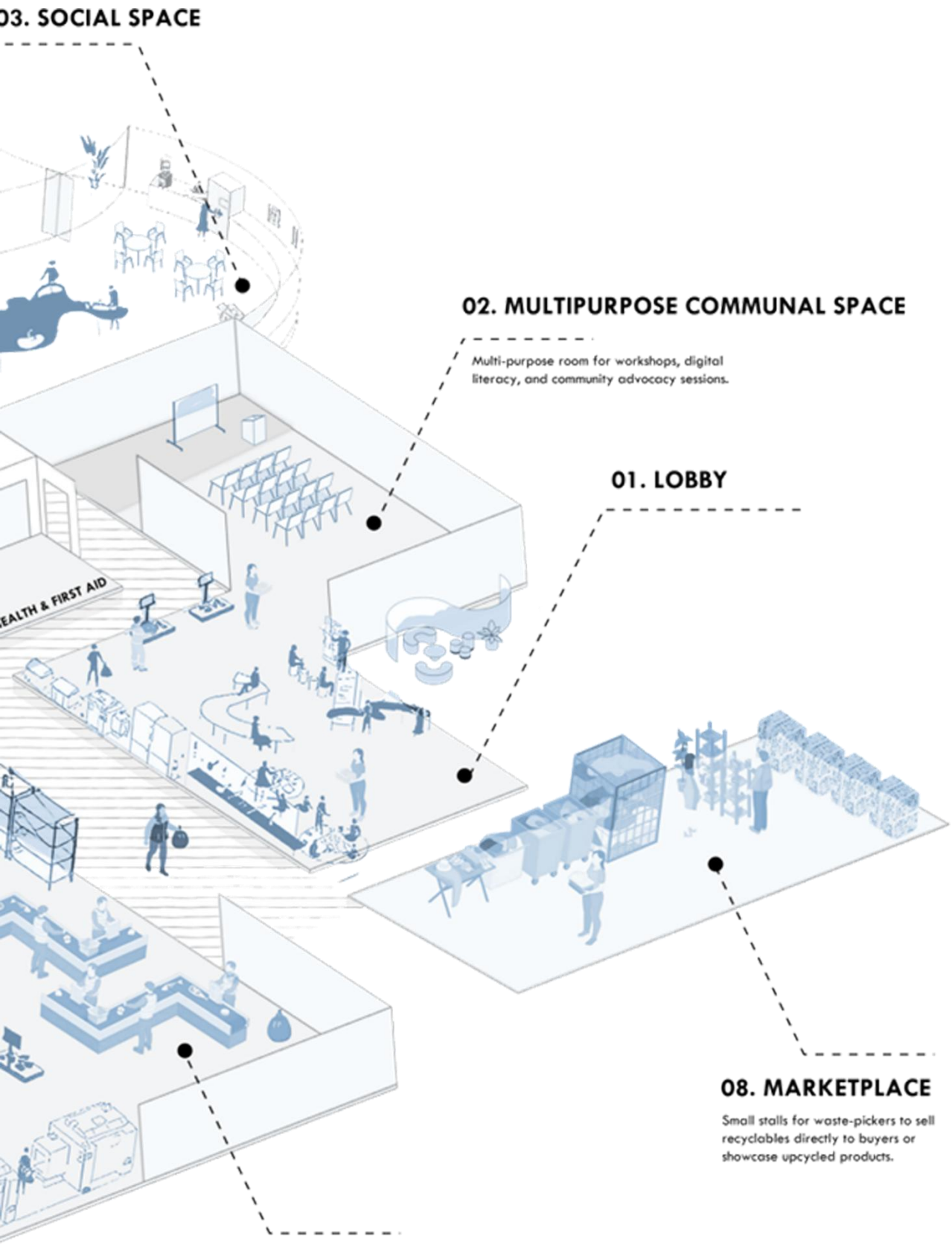

03. SOCIAL SPACE
02. MULTIPURPOSE COMMUNAL SPACE
Multi-purpose room for workshops, digital literacy, and community advocacy sessions.
01. LOBBY
EALTH & FIRST AID
08. MARKETPLACE
Small stalls for waste-pickers to sell recyclables directly to buyers or showcase upcycled products.
07. DRY WASTE SORTING & CLEANING
Open yet sheltered space for segregating & cleaning materials like plastic, glass, and organics.



Figure 66: Inside the MRF, women sort mountains of discarded plastics, paper, and packaging, transforming the chaos of waste into streams of recoverable material. (Source: Author)



Figure 67: On the composting floor, workers tend to organic waste, turning what was once decay into fertile soil for the city's future. (Source: Author)

5.5 Ghazipur Dumpsite Remediation

While decentralization tackles the future, the legacy of the past must also be confronted. Ghazipur, Delhi's largest and most infamous landfill remains a towering toxic archive of urban failure. Even after its official closure, the site continues to leak leachate, release methane, and cast a spatial shadow over East Delhi. Current strategies: capping, fencing, or siting Waste-to-Energy plants do little more than conceal.

This thesis repositions Ghazipur not as a static "dumping ground," but as a dynamic terrain of repair. The proposed transformation unfolds in four distinct phases, each grounded in a different logic of recovery: biomechanical, biological, hydrological, and productive. Each phase is anchored by the evolving morphology and infrastructural systems of the landfill. Together, they seek to dismantle the mountain not only physically, but conceptually, reconfiguring it as a regenerative civic landscape that reconnects Delhi's citizens to the processes and consequences of urban waste. The project acknowledges that such transformation cannot be instantaneous; it is necessarily slow, layered, and iterative. Phases overlap and interlock, with biomining and material recovery paving the way for soil remediation, wetlands, and eventually public programs. What emerges is not a single "finished" park but a living landscape of transition: where each stage of repair is itself productive, legible, and open to civic engagement. Ghazipur becomes a pedagogical ground, a site where waste is not hidden away but metabolized into energy, soil, water, and eventually, public space.

The design framework also insists on coexistence of labor and ecology. Waste pickers who once risked their lives climbing the unstable mountain are re-integrated as operators of biomining plants, as stewards of composting plots, and as guides in educational spaces. Their presence becomes an anchor of continuity, grounding the project in social equity as much as environmental repair. The act of dismantling the landfill is therefore also an act of re-imagining the city's relationship with waste. No longer exiled to the periphery, waste infrastructures are recast as ecological and civic commons. In this shift, Ghazipur transforms from Delhi's most visible failure into its most radical demonstration of recovery: a landscape that makes repair both material and cultural.



Figure 68: View from the peak of Ghazipur landfill: waste spilling into the city it was meant to contain. (Source: ANI Photo)

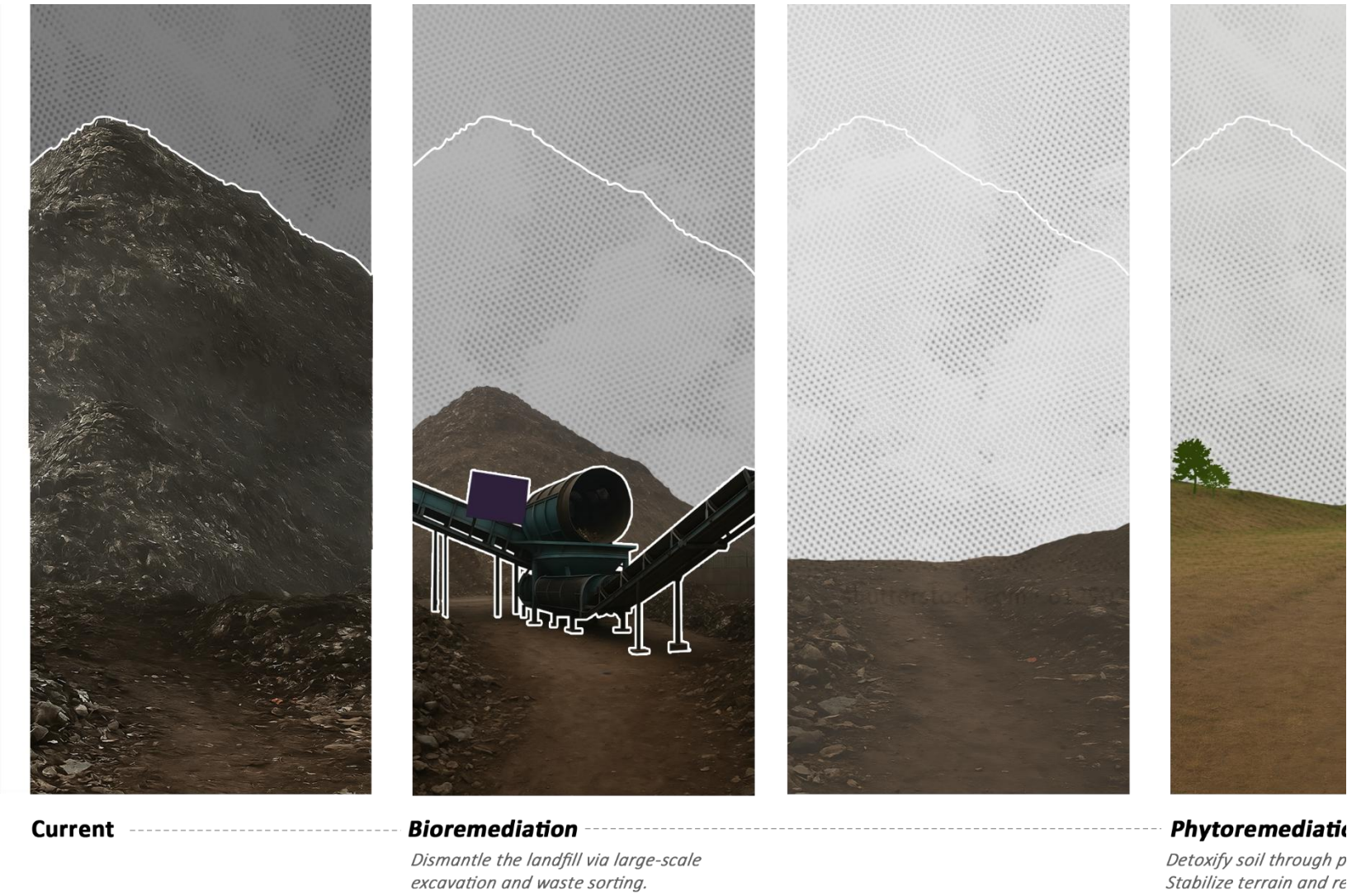
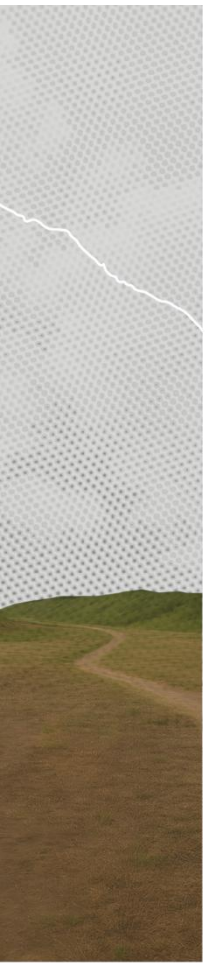


Figure 69: Ghazipur Dumpsite Remediation Vision (Source: Author)









on

lant-based remediation.
educe contamination.

Constructed Wetland

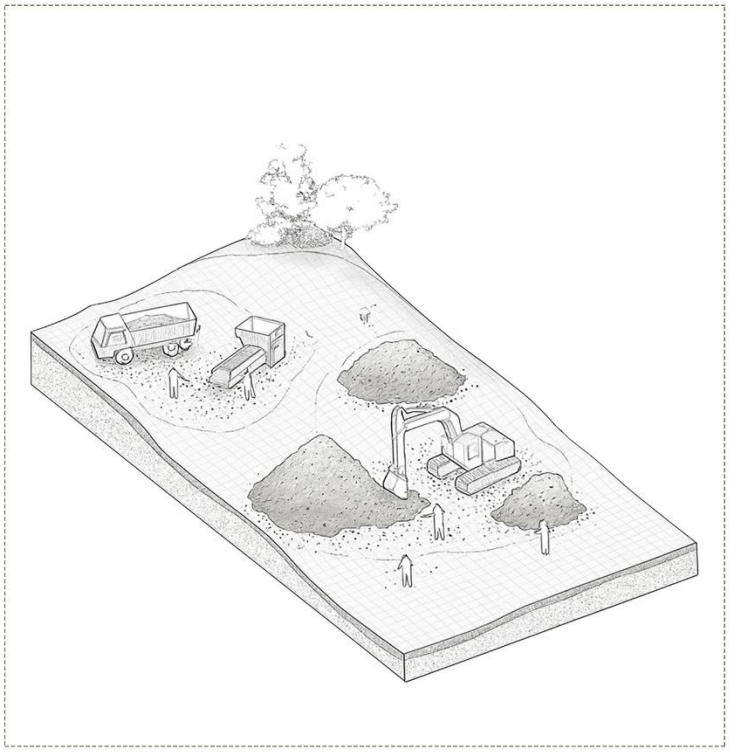
Treat contaminated water and leachate, restore hydrology, and enhance biodiversity.

Post Remediation Use

Convert the restored site into a productive urban landscape and ecological commons.

Phase 02 Phase 03 Phase 04

Bioremediation of Legacy Waste



Excavators and conveyors systematically dismantle the landfill mass. Trommel machines separate the excavated waste into fractions: fines, recyclables, combustibles, and rejects, initiating the transition from dumpsite to material recovery.

Landform Contouring

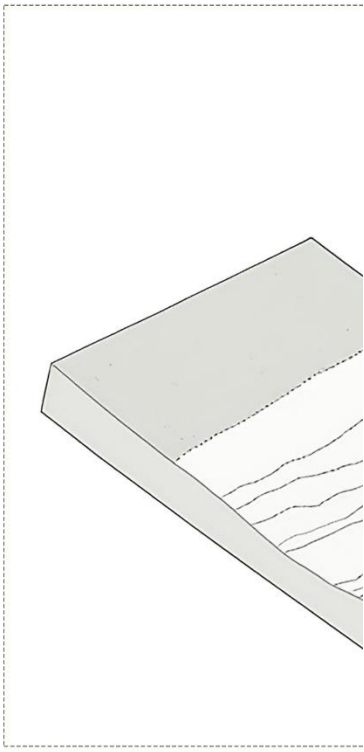
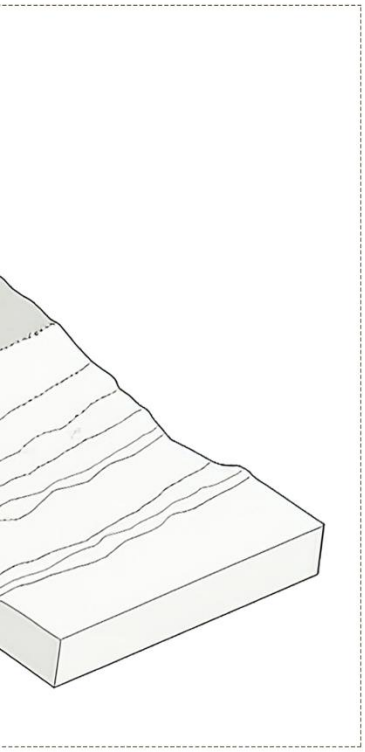
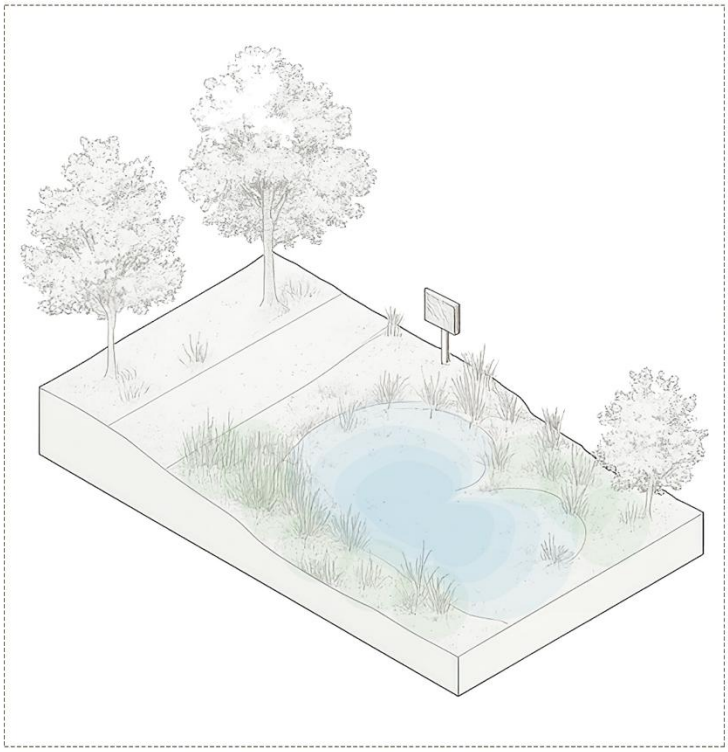


Figure 70: Ghazipur Dumpsite: Land Remediation (Source: Author)

Phytoremediation and Wetland Establishment





Planted trees, grasses, and constructed wetland cells begin soil and water remediation. Vegetation stabilizes slopes, wetlands filter leachate, and early ecological repair signals the site's shift from waste ground to living landscape.

Phase 1: Bioremediation through Excavation



Figure 71: Biomining and Waste Fraction Recovery Process (Source: Linru Wang (Research) + Author)



RDF (Refuse-Derived Fuel: plastics, textiles)	Inert Construction Debris (bricks, concrete, stones)	Organic Biomass (wood, vegetation remnants)	Compostable Fines (soil-like fraction, low-grade organics)	Stabilized Soil Fraction (for berms, road subgrade, bricks

The first phase initiates the mechanical dismantling of the landfill mass through large-scale bioremediation. Legacy waste: comprising decades of mixed municipal refuse is excavated in controlled grids using backhoes, grab cranes, and conveyor-based loading systems. At the heart of this process are trommel machines, which separate materials based on size and density. As the waste is fed into these rotating drums, it is sieved and divided into fractions: inert construction debris, recoverable plastics, metal fragments, low-calorific compostables, and non-recyclable rejects. Refuse-derived fuel (RDF) is extracted and sent to industrial co-processing units or regulated cement kilns, while inert material is earmarked for road subgrade or embankment filling.

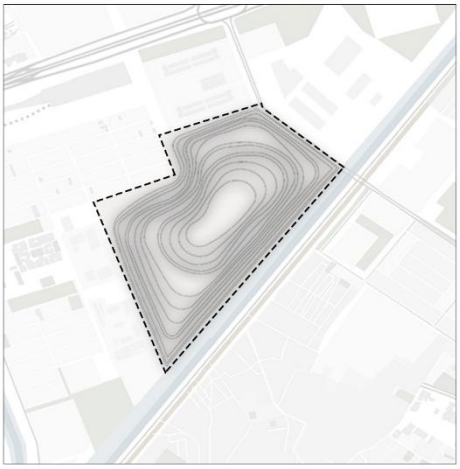
Material recovery during this process typically follows the ratios observed in similar Indian remediation projects. On average, 35–40% of the excavated waste consists of fine soil-like material, produced from long-decomposed organic matter and inert dust[86]. Unsuitable for agriculture due to contamination, this material is often repurposed into fly ash bricks, paver blocks, or filler for road construction[87]. In this thesis, it is proposed that these fines be reused directly in the construction of new decentralized waste infrastructure- such as dhalaos, MRF foundations, and landscaping berms: thereby transforming landfill waste into architectural substrate. An additional 25–30% becomes RDF, a combustible fraction composed largely of plastics and textiles. While this is not ideal, current Indian regulations allow its use in cement kilns and WTE units, where emissions are more tightly monitored[88]. 5–10% of the waste stream yields valuable recyclables: metals, glass, and dense plastics which are redirected into informal recycling economies, sustaining the livelihoods of waste workers integrated into the sorting chain. The remaining 15–20% consists of contaminated or unrecoverable materials, which are either sent to engineered landfills for safe disposal or stored temporarily until suitable treatment is available[89].



Figure 72: Transformation of Legacy Waste Fines into Building Material
(Source: Packing up PFSs; Experiment by Emy Bensdorp)

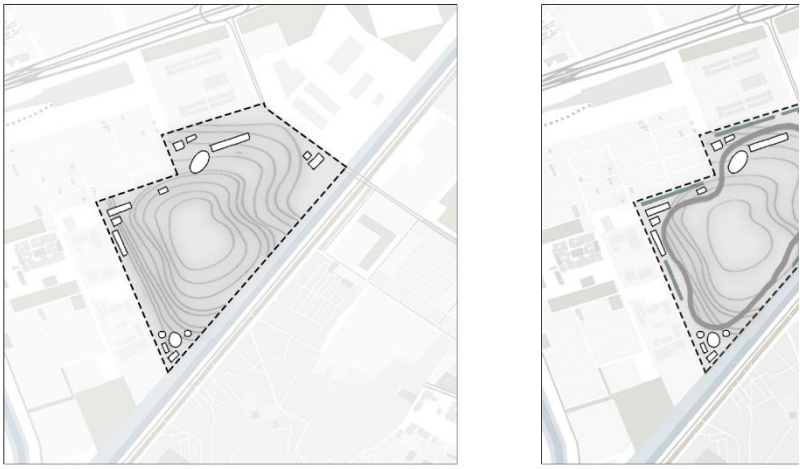
The site plan for this phase marks the zoning of active excavation areas, temporary material sorting pads, vehicle corridors, and buffer edges to control dust and odor. Each excavation zone is bordered by wind-breaking screens and dust suppression sprinklers to mitigate air pollution during dry seasons. As segments of the mound are dismantled, terrain is temporarily leveled and stabilized using compacted soil from sorted inert waste. Topographic contours are redrawn as the verticality of the landfill gradually diminishes.

Existing Landfill Condition



Current profile of the waste mound with steep, unstable slopes.

Temporary Infrastructure Setup



Establishment of access roads on all four sides for fire tender movement and placement of biomining machinery. Site prepared with service infrastructure and controlled access for phased excavation.

Figure 73: Phased Transformation of Ghazipur Landfill through Bioremediation (Source: Author)

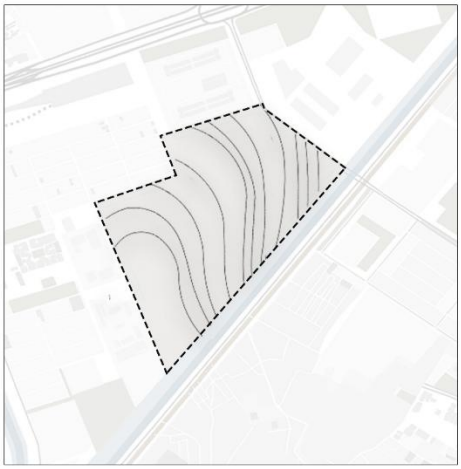
In this phase, the site does not yet appear “restored”- it is in flux, chaotic, and infrastructurally raw. Yet it represents the most fundamental shift: the refusal to cover up failure and the commitment to deal with waste by bringing it back into the field of vision and labor. It sets the foundation for subsequent ecological processes by removing the bulk of the mass that has, for decades, acted as a toxic compress on the local ecosystem. By the end of this phase, the site is no longer a monolithic mound but a fragmented, graded terrain- ready to receive the biological interventions of Phase 2.

Biomining in Progress



Ongoing excavation as the waste mound is systematically dismantled and reduced in height.

Landform Contouring with Excavated Soil



Stabilized fines reused to create new contours and berms, preparing ground for ecological restoration.

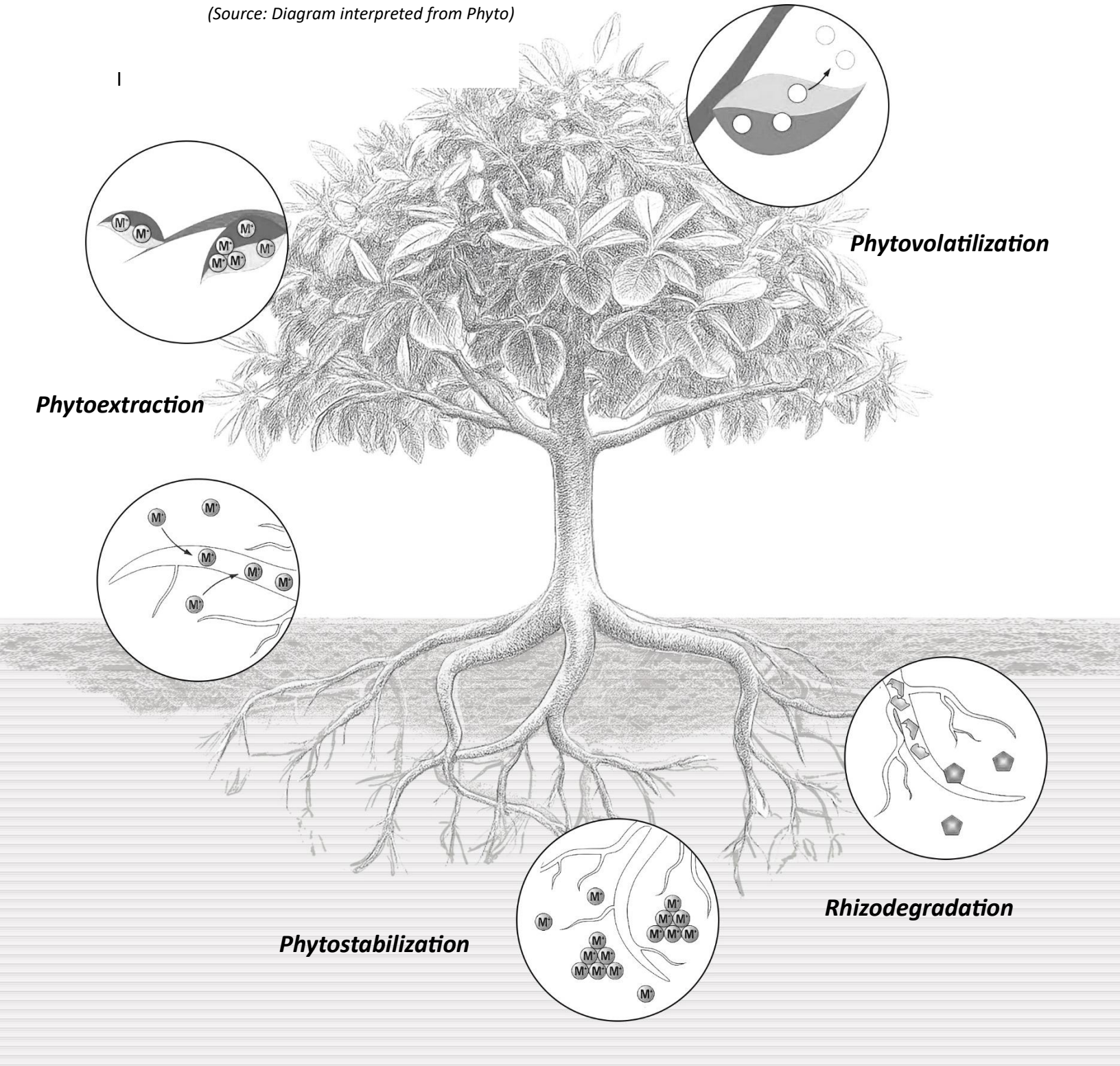
Phase 2: Phytoremediation

Following large-scale excavation and material recovery through bioremediation, the second phase initiates phytoremediation: a nature-based strategy that deploys plants to detoxify, stabilize, and regenerate the disturbed terrain. At Ghazipur, where the subsoil is heavily contaminated with heavy metals, ammonia-rich leachate, and suspended toxins from decades of unregulated dumping, phytoremediation offers an ecologically embedded and low-cost alternative to chemical remediation. Unlike engineered containment or surface sealing, this method heals the land from within, using biological processes to restore soil and groundwater health over time. Phytoremediation at Ghazipur follows four key biological mechanisms: suited to the diverse contaminants and soil profiles present on site:

- Phytoextraction[90]: where hyperaccumulator species such as *Brassica juncea* (Indian mustard) and *Vetiveria zizanioides* (vetiver grass) absorb heavy metals like cadmium, lead, and arsenic into their tissues.[91] These plants are periodically harvested, with the biomass safely incinerated or processed in bio-secure facilities off-site.
- Phytostabilization[92]: through deep-rooted trees and grasses like *Casuarina equisetifolia*, *Saccharum spontaneum*, and *Doob grass*, which immobilize contaminants, reduce erosion on landfill slopes, and prevent the lateral migration of toxins into the Yamuna floodplain or adjacent low-income residential neighborhoods[93].
- Phytovolatilization[94]: where wetland species such as *Typha latifolia* (cattail) and *Phragmites australis* facilitate the uptake and transformation of volatile compounds like mercury, ammonia, and selenium, which are safely released into the atmosphere in diluted, less toxic forms.
- Rhizodegradation[95]: in which fibrous-rooted species like *Colocasia esculenta* (taro), *Cyperus alternifolius*, and *Canna indica* generate microbially rich root zones that support the breakdown of organic pollutants, including hydrocarbons and chemical residues from household and industrial waste streams.

By the end of this phase, Ghazipur's formerly dead terrain begins to show the first signs of ecological recovery. What was once a toxic, compacted mass of refuse gradually softens into a living surface. Green networks take root across the remediated slopes, woven from reeds, vetiver grasses, hardy shrubs, and pioneer species that stabilize the soil and absorb residual contaminants[96]. In this transformation, the site begins its crucial shift from a place of extraction and exhaustion toward one of regeneration.

Figure 74: Phyto mechanisms deployed at Ghazipur Dumpsite to facilitate Phytoremediation (Source: Diagram interpreted from Phyto)



Phase 3: Constructed Wetlands

Following phytoremediation and terrain stabilization, the third phase introduces constructed wetlands as ecological infrastructure for filtering residual leachate and restoring hydrological balance. These wetlands are not ornamental, but performative: designed to filter residual leachate, regulate hydrology, and support the return of biodiversity. At Ghazipur, where decades of unlined dumping have compromised groundwater and adjacent drains, this step is critical to ensure long-term safety and environmental reintegration. Wetlands are placed at the site's lowest contours, where terrain regrading in earlier phases channels leachate naturally. Pre-treatment basins remove sediments and grit before water enters the wetland system. Site plans outline zones for inlet filtration, horizontal and surface flow wetlands, and discharge buffers-all integrated into a gently terraced topography.

Two treatment systems operate in sequence:

- Horizontal Subsurface Flow Wetlands: Wastewater flows laterally through a porous gravel and sand matrix beneath the surface. Planted above are root-dense species like *Typha latifolia* (cattail), *Phragmites australis* (reed), and *Cyperus alternifolius* (umbrella sedge), which together create an anaerobic and aerobic root zone.[97] As water passes through, microbial colonies attached to the root surfaces metabolize organic matter, nitrates, and ammonia. Heavy metals and suspended solids are trapped within the substrate layers, while root exudates enhance biofilm formation for efficient breakdown[98].
- Surface Flow Wetland: Following HSSF treatment, water enters an open wetland where it flows over a planted bed of gravel, silt, and organic media. This system supports additional oxygen exchange, light penetration, and nutrient cycling. Wetland vegetation such as *Colocasia esculenta* (taro), *Canna indica*, *Lotus*, and floating islands of *Water Hyacinth*[99] absorbs residual nutrients while simultaneously providing habitat complexity. Surface wetlands are also aerated through shallow contours and floating baffles that encourage turbulence and contact with plant roots[100].

Together, these systems perform advanced tertiary treatment of wastewater, removing up to 95% of organic pollutants, 80–90% of nitrogen, and significant loads of heavy metals[101]. Outflow is clean enough for irrigation or recharge, exiting via bioswales into Delhi's wider drainage network. The conceptual diagram depicts these interactions: plant-root systems, microbial zones, sedimentation, and evapotranspiration.

Figure 75:Strategy for Constructed Wetlands & Leachate Management at Ghazipur Dumpsite (Source: Author)

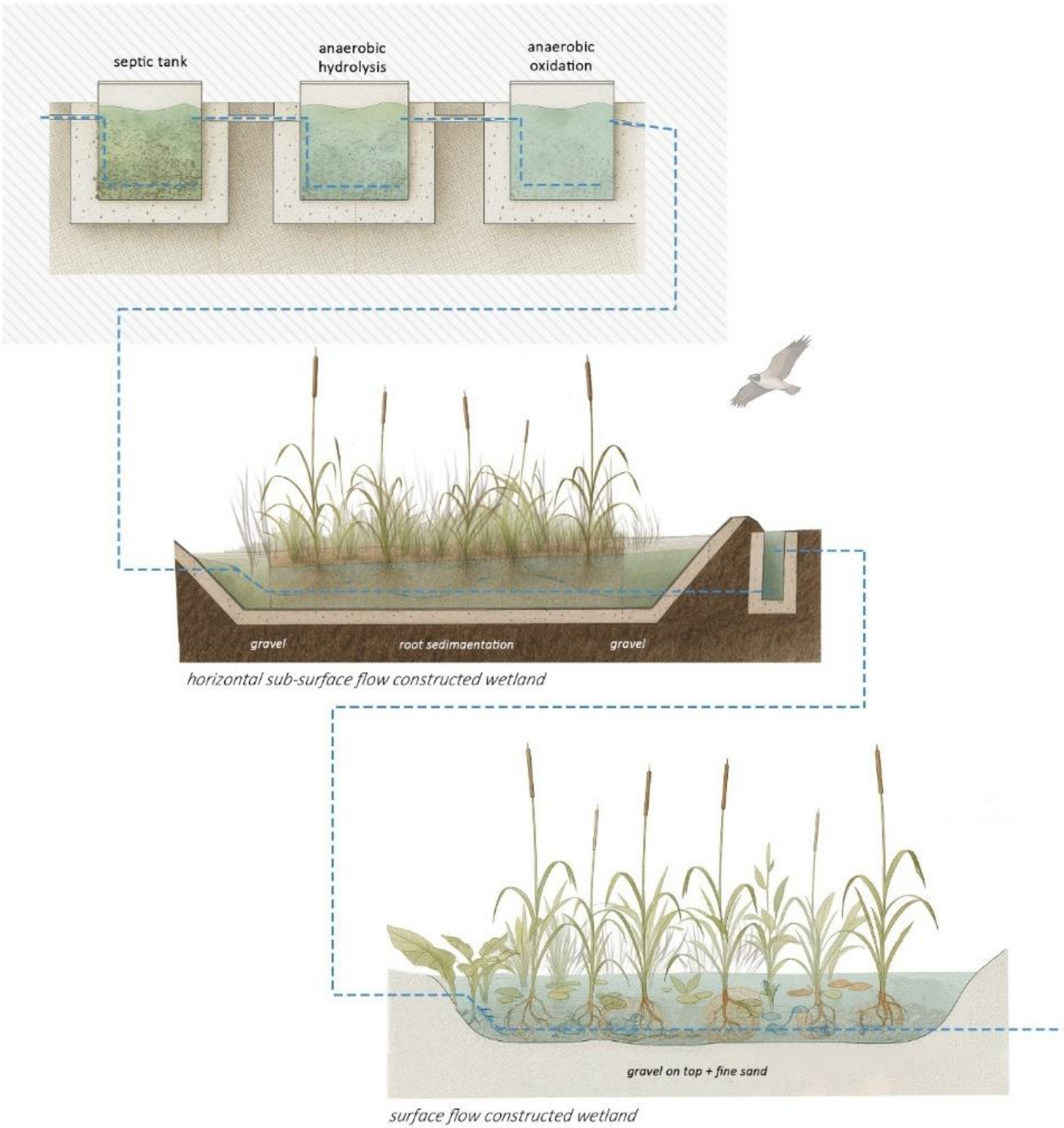
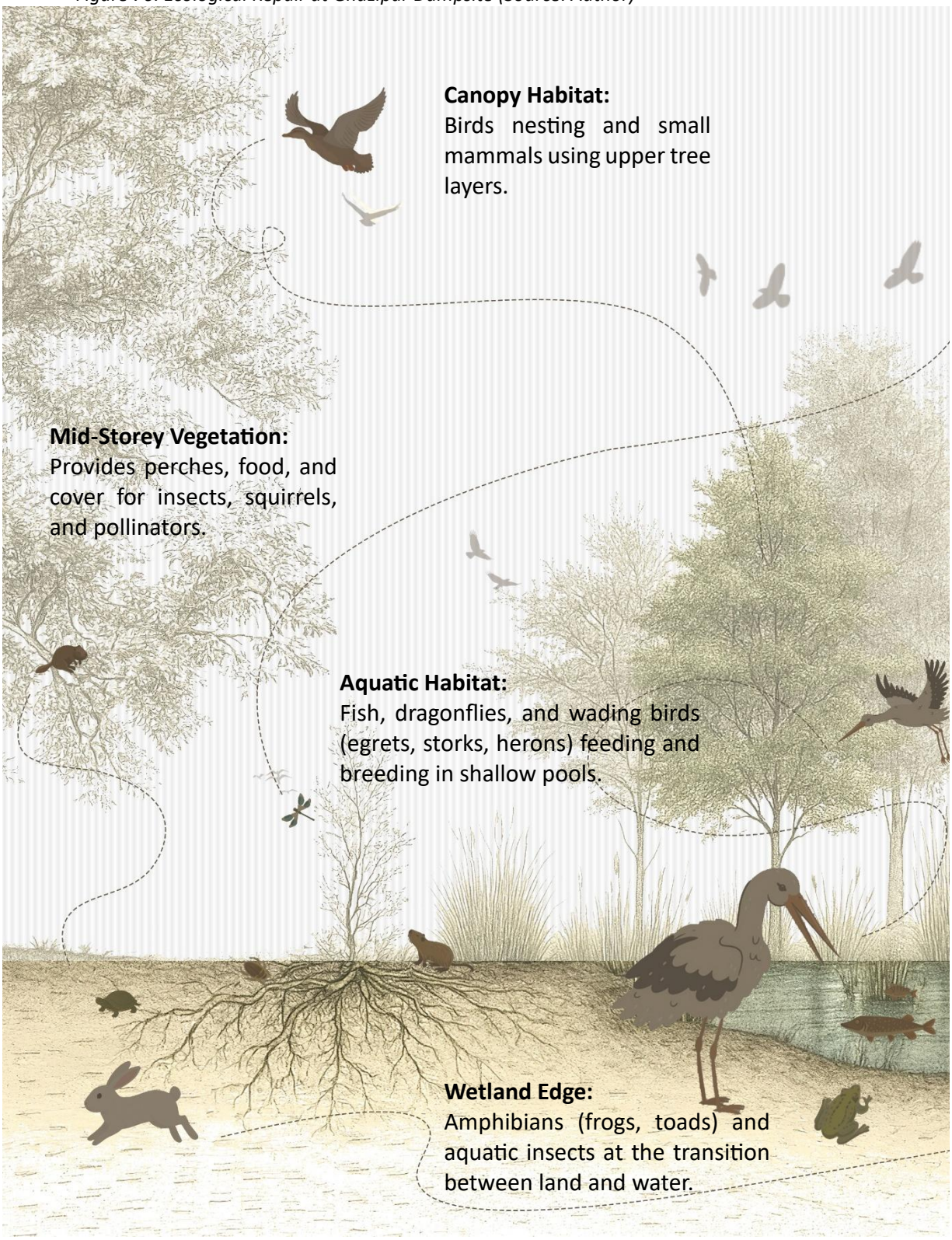


Figure 76: Ecological Repair at Ghazipur Dumpsite (Source: Author)



Beyond the technical task of water purification, the wetland landscape initiates a more profound process of ecological repair. As nutrient loads diminish and water quality stabilizes, the habitat slowly regains the capacity to host life. Emergent vegetation: cattails, reeds, vetiver, and lotus create new niches for nesting and shelter, while submerged plants oxygenate the shallows. Gradually, species long displaced from East Delhi begin to return. Egrets and herons wade in the channels, while painted storks-once common along the Yamuna floodplain trace their migratory paths back across the site. Black-winged stilts and lapwings reappear at the water's edge, and flocks of kites circle above, using the ponds as seasonal feeding grounds. Amphibians, led by frogs and toads, establish breeding pools, and dragonflies hover above the surface: keystone indicators that water health is stabilizing.

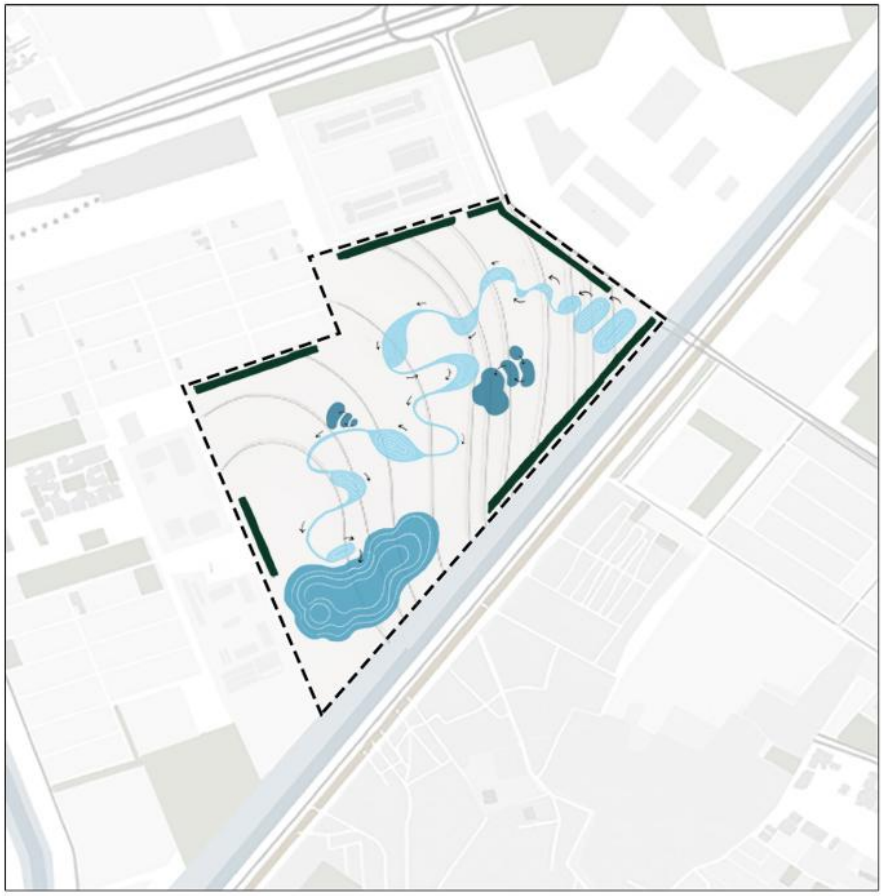
The margins of the site also participate in this recovery. Grasslands and planted berms begin to host butterflies, bees, and small mammals, while soil microbes expand and diversify, improving porosity and accelerating the breakdown of residual contaminants. Earthworms and insects return to the soil, enriching it further and stitching the waste ground back into ecological cycles. Native grasses act as both stabilizers and attractors: vetiver binding steep slopes, while flowering species invite pollinators that had retreated from the urbanized terrain.

These early signs of biodiversity are more than symbolic gestures. The return of painted storks, herons, and frogs to Ghazipur signals that toxicity is being replaced by ecological balance, and that the land is beginning to sustain relationships beyond human engineering. Each species marks the shift from remediation to regeneration: a visible affirmation that the site is no longer inert matter, but an active ecological system.

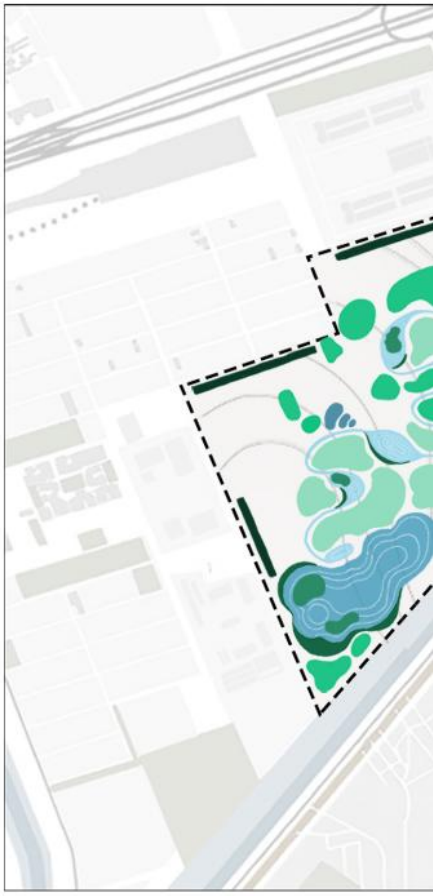
By the conclusion of Phase 3, Ghazipur's terrain is visibly and functionally transformed. What once read as a scar of industrial remediation now unfolds as a mosaic of slow-flowing water, layered vegetation, and the movement of birds, insects, and amphibians across its surface. These constructed wetlands mark a turning point: no longer infrastructure for containment, but ecological landscapes of coexistence. They prepare the site to enter its final phase not as a blank, sanitized canvas, but as a living common-where waste, water, species, and community are entangled in new forms of shared ground.

Figure 77: Typology & Site Planning Strategy (Source: Author)

Constructed Wetlands
Typology + Planning Strategy



Phytoremediation
Typology + Planting Strategy

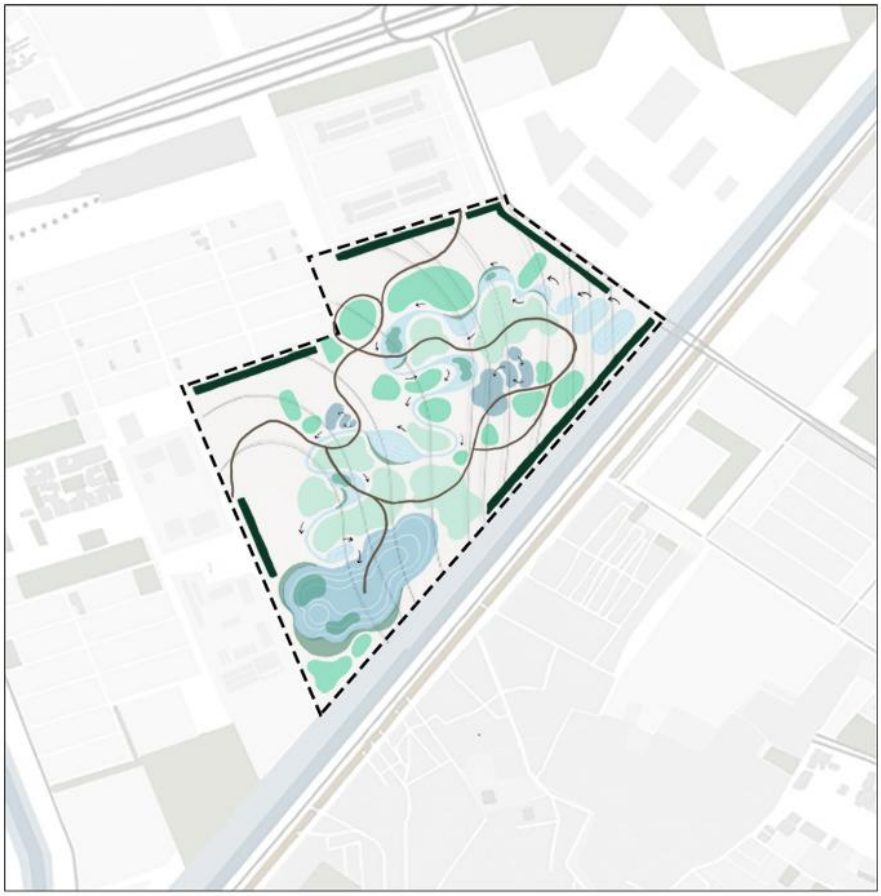


Subsurface Flow Wetland Cells
Surface Flow Wetland
Leachate & Black Water Filtration Chanels

Post Remediation Land Use

Planning Strategy + Routes





Vegetation Plantation Buffer

Wet Planting Mix (frequent submersion)

Steep Bank Mix (soil stabilisation & ease of planting)

Manicured landscaping & grazing grounds

Nature & Educational Park Trail

Phase 4: Post Remediation Land Use

The final phase completes Ghazipur's transformation: from a hazardous dumpsite into a productive, regenerative urban commons. Rather than sealing the land beneath layers of concrete or topsoil, the site is designed to remain dynamic, porous, and useful. Its restoration does not end in surface greening but continues as a working landscape that processes materials, generates livelihoods, and repairs urban metabolism. This vision moves beyond the idea of a closed landfill park. It foregrounds the coexistence of human activity and ecological function, where waste systems remain visible and legible shared through participatory infrastructures rather than hidden behind fences. Yet to understand the post-remediation usage of the site, it is necessary to situate it within Delhi's growing demand for waste processing space. The city generates not only vast amounts of dry waste but also large volumes of wet waste, which comprise the majority of India's waste composition. Addressing both streams together is critical to designing a system that is sustainable and future ready.

In Chapter 4 (Section 4.4), the thesis examined the Vellore Solid and Liquid Waste Management (SLWM) model as a precedent. The study emphasized two key insights: the importance of treating wet waste as a resource and the necessity of timely processing to prevent its degradation into pollutant. The Vellore model demonstrated how livestock, composting, and biogas can be integrated with waste-to-resource practices, creating ecological and economic synergies. Mapping the prominent markets around Ghazipur reveals that the raw material required for such a system already exists within proximity. Within a 1.5 km radius of the landfill, Delhi's wholesale produce markets generate large quantities of vegetable, fruit, poultry, and fish waste, the very feedstock suited for SLWM systems *(Figure 80).* This adjacency offers Ghazipur an opportunity to evolve from being the endpoint of waste into a processing node directly linked with the urban metabolism.

This thesis therefore proposes an interpretation of the Vellore SLWM model tailored to Delhi's context and layered onto the existing Waste-to-Energy plant at Ghazipur. The proposal envisions dry and wet waste processing integrated with new urban greens and wetlands that restore ecological function, while also establishing spaces for learning and civic engagement. Crucially, it calls for the inclusion of informal workers within this system, securing their livelihoods and embedding them within a circular economy framework. In doing so, Ghazipur's post-remediation landscape becomes more than a reclaimed site: it becomes an urban common that demonstrates how waste, ecology, and community can coexist and regenerate together.



Figure 78: Aerial View of Ghazipur Landfill and Surrounding Urban Fabric
The image shows the expansive footprint of the Ghazipur landfill, with its terraced waste mound abutting the canal. (Source: Google Earth)

Figure 79: Connectivity and Market Proximity around Ghazipur Landfill (Source: Author)
The map highlights the landfill's strategic position within a dense network of arterial roads and infrastructure.

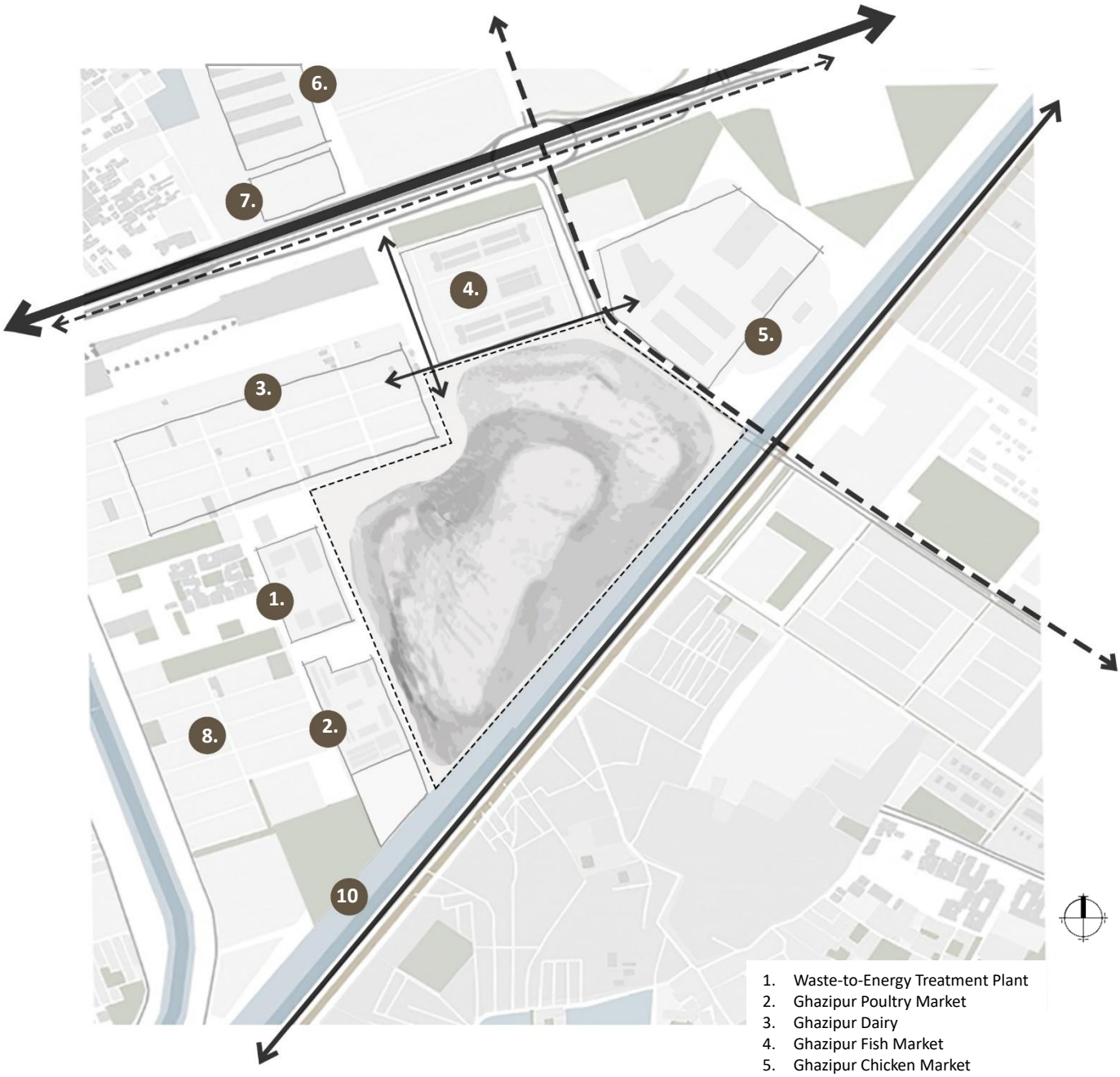
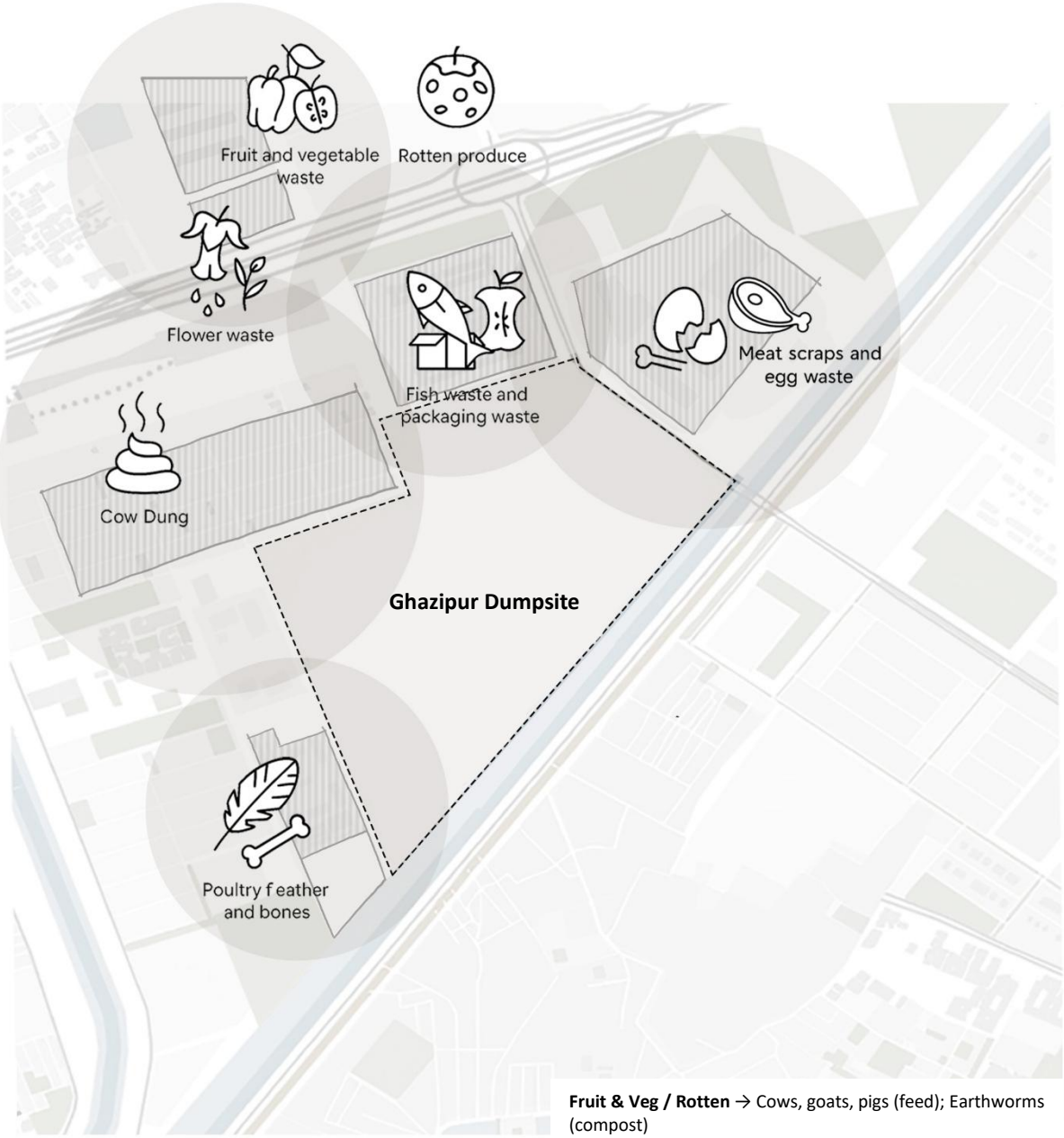


Figure 80: Organic Waste Streams Surrounding Ghazipur Landfill (Source: Author)
The drawings maps waste types generated by bulk generators within 1.5 km of the landfill.



Fruit & Veg / Rotten → Cows, goats, pigs (feed); Earthworms (compost)
Flowers → Cows, goats (fodder); Earthworms (compost)
Cow Dung → Biogas microbes (energy); Fish (fertilizer slurry)
Poultry Feathers & Bones → BSFL (protein feed); Microbes (fertilizer)
Fish Waste → Poultry, pigs (feed); BSFL (compost/feed)
Meat & Egg Waste → Pigs, poultry (feed); BSFL (compost/feed)

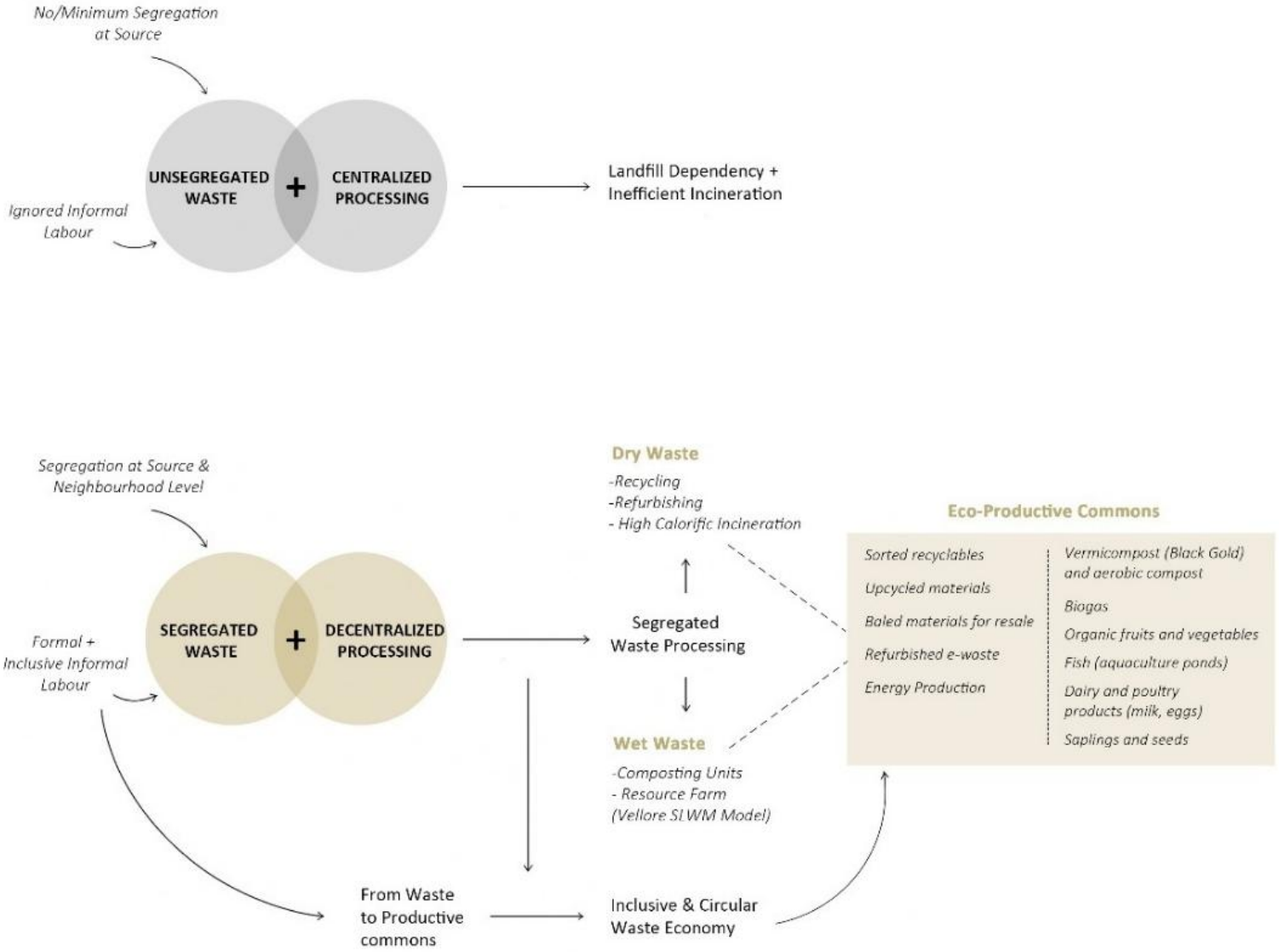


Figure 81: Key Program Components of the Post-Remediation Landscape (Source: Author)

- **Dry Waste Processing & Refuse-Derived Fuel (RDF) Facility**
  High-calorific materials such as multilayer plastics, soiled paper, and low-grade packaging are collected, sorted, and shredded in a dry waste processing shed. Recyclables like metals and glass are diverted into recovery channels, while the remaining combustible fraction is converted into Refuse-Derived Fuel (RDF) for the nearby waste-to-energy plant. As a pre-processing hub, this facility reduces the load on landfills, improves thermal efficiency, and ensures cleaner incineration through controlled emissions.

- **On-Site Composting & Biogas Units**
  Wet organic waste from local markets and vendors is directed into decentralized composting sheds and biogas digesters. These units produce high-quality manure and bioenergy that return value to nearby farms and reduce reliance on synthetic fertilizers. By capturing organics at the source, they prevent methane leakage once common at the landfill and demonstrate the ecological and economic benefits of decentralized systems.

- **Recycling & Upcycling Workshops**
  Former rag pickers are formally employed in workshops equipped for sorting, recycling, and upcycling. Women-led enterprises repurpose discarded materials into reusable bags, building tiles, pulp goods, and art from flowers and recovered dry waste. These hubs generate livelihood opportunities while feeding into a resilient local circular economy where discarded material is consistently revalued.

- **Urban Agriculture, Poultry, Aquaculture & Seed Zones**
  Ponds, coops, and rotational fields integrate fish, poultry, and crop cycles with waste systems, where organic refuse becomes feed and fertilizer. Ducks and fish clean irrigation channels, while poultry consume scraps. At the site's margins, seed banks, nurseries, and fodder plantations supply municipal greening programs and schools, strengthening biodiversity and climate resilience while reconnecting waste flows to food systems.

- **Civic Education & Public Access**
  The remediated landscape doubles as a civic learning ground. Walking trails connect classroom pavilions, compost education stations, and eco-interpretive signage, encouraging residents, students, and workers to engage with the systems that sustain them. By combining education with access, the site evolves into a living classroom- an active public space that ties ecological infrastructure to social inclusion.

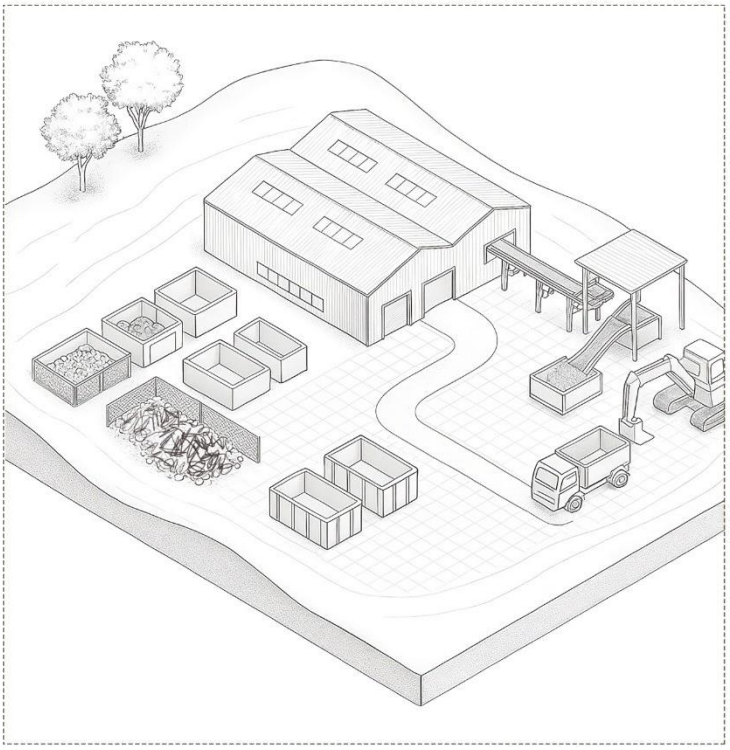
Figure 82: Post-Remediation Site Plan
(Source: Author)



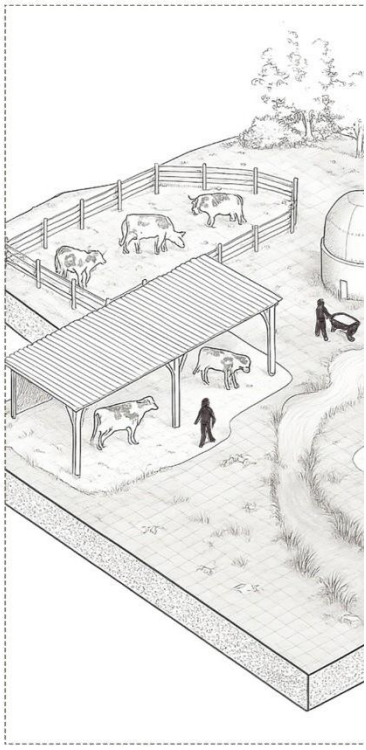
Figure 83: Detailed Site Plan of Post-Remediation Ghazipur
(Source: Author)



Dry Waste Processing & Refuse-Derived Fuel (RDF) Facility



On-site Composting & Biogas Units



Recycling & Upcycling Workshops

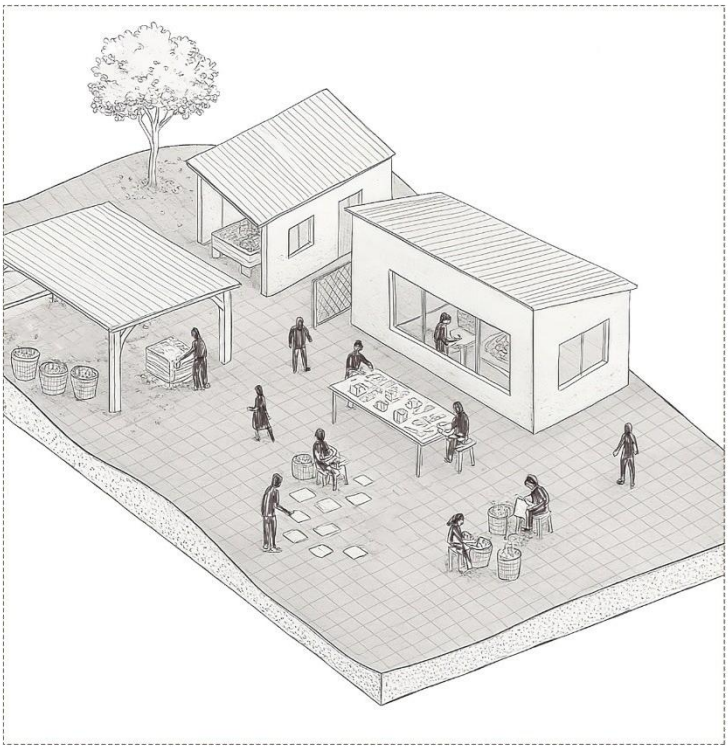
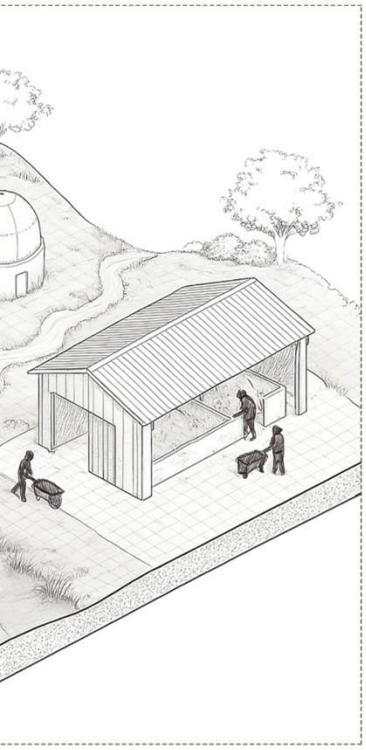
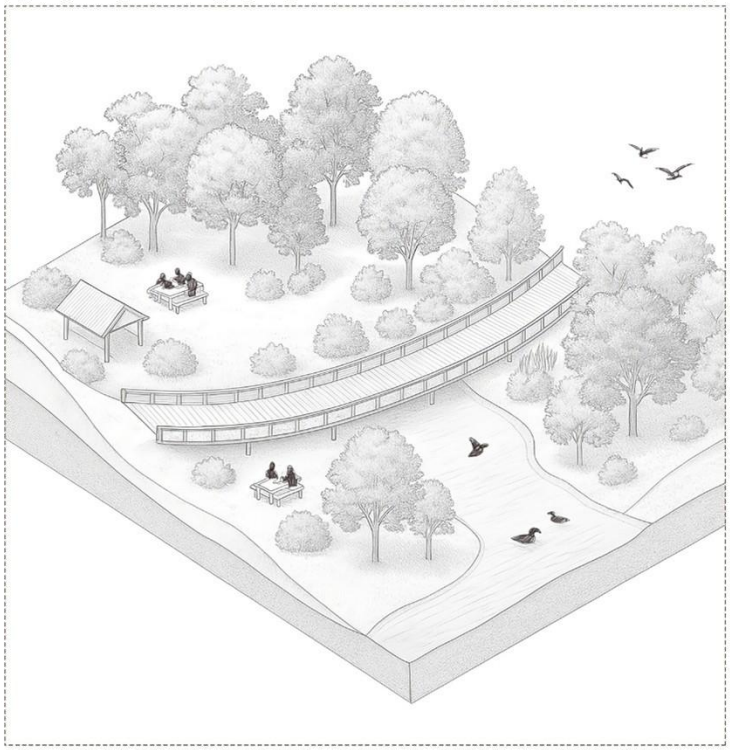


Figure 84: Post Remediation Land Use Scenarios as per proposed functions (Source: Author)

Urban Agriculture, Aquaculture & Nature Zones







Civic Education & Public Access

By fusing waste infrastructure with ecological design, the remediated site no longer functions as a passive green overlay but as a living system: producing clean energy, restoring soil fertility, regenerating biodiversity, and offering civic space back to the city. Ghazipur becomes a productive urban lung for East Delhi, reversing decades of environmental damage and infrastructural abandonment. This transformation marks a shift from extractive urbanism to regenerative urban stewardship' where land is not buried and forgotten but revived, reprogrammed, and returned to the public realm.

Towards a Replicable Framework for Landfill Remediation in India

More than a singular intervention, this multi-scalar approach: anchored in bioremediation, ecological repair, and community participation- offers a replicable design framework for landfill remediation across India. While every dumpsite emerges from distinct geographies, governance failures, and waste cultures, the spatial tools developed at Ghazipur demonstrate how context-specific remediation can be both systemic and sensitive. Through careful analysis of land use patterns, waste flows, ecological risk, and social dynamics, this model adapts to varied urban conditions while retaining core principles of decentralization, circularity, and justice. Ghazipur, in this sense, is not merely a site of recovery- it becomes a blueprint for India's other landfills to transition from zones of exclusion to landscapes of regeneration.

"We were once seen only as part of the garbage. Now, our labor has turned from neglect into dignity."



Figure 85: Informal workers trained in ecological restoration, transforming landfill remediation into a source of livelihood, dignity, and long-term stewardship of the land. (Source: Author)

Part 5 Endnotes

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Conclusion

Waste as Architecture, Land as Legacy

This thesis began with a simple observation: waste, though omnipresent, is systemically designed to disappear. In India's cities, it is displaced to the margins- absent from planning, policy, and public imagination. This erasure is not neutral. It reflects how urban systems value land, labor, and life. Waste is not just a logistical issue of collection and disposal; it is a spatial, ecological, and political question: one that architecture and planning can no longer ignore. Across chapters, this thesis has traced waste not as an endpoint, but as a design problem: one shaped by proximity, visibility, and material flows. From Delhi's neighborhood dhalaos to the towering monument of Ghazipur, it reveals how centralized systems have collapsed under the weight of invisible labor, monofunctional infrastructure, and fragmented governance. The conclusion is clear: In India, design has been absent from waste; and it must return.

Through a multi-scalar framework, this work proposes an alternative future. Dhalaos are reimagined as decentralized nodes of education, sorting, and care. Ward-scale MRFs and compost facilities are embedded within walkable distances, returning waste to the realm of everyday civic life. Ghazipur itself: once a vertical scar of toxic accumulation, is transformed into a living landscape of ecological remediation, social employment, and productive reuse. This thesis argues that planning in India must shed its reliance on technocratic 'solutions' like landfill capping and incineration. These strategies often imported from the Global North do not address the root crisis. They bury problems, displace communities, and mask toxicity with surface-level remediation. The Ghazipur incinerator may promise energy, but at the cost of emissions, health risks, and the continued erasure of informal labor. A capped landfill becomes a park only for those who never worked in its shadow. This is not design- it is denial. Instead, the thesis turns to India's vernacular systems for inspiration. Composting pits, cow dung fuel, greywater reuse, and informal segregation networks offer decentralized, circular, and materially intelligent models, long dismissed as 'backward,' yet more sustainable than modern mega-projects. These are not just ideals, but pragmatic blueprints.

Architecture must learn to interpret and retool them. Five key directions emerge from this work:

- ***Disincentivize landfilling and incineration*** by investing in hyperlocal waste infrastructure rooted in architecture, not just engineering.
- ***Restore visibility and dignity*** to waste work through transparent facilities, civic integration, and worker-centered design.
- ***Co-locate ecological systems*** like wetlands, bioswales, and animal zones with waste infrastructure, blurring the boundary between utility and environment.
- ***Reform zoning*** to support decentralized models, including spatial provisions for composting, reuse, and educational public commons.
- ***Legitimize informal systems*** by embedding them into the spatial, legal, and economic frameworks of urban development.

Yet even as this thesis offers direction, it leaves open the questions that truly matter. What happens after Ghazipur is capped or incinerated as per current government plans? Who inherits that land- those who built the landfill, or those who suffered beneath it? And if waste has become our dominant urban artifact- rising higher than monuments - what legacy are we leaving behind? If architecture, through design, can dignify housing, water, and mobility, then why has it failed to do so for waste in Indian cities? Can we design not for disappearance, but for excess, transforming what we hide into a civic common?

This thesis offers one possible answer: that waste, if confronted through design, can move from being a scar to a source. The land we discard can become the land we reclaim. And that architecture and planning, when they turn to face what has long been ignored, can become the very tools through which the city remembers, repairs, and reclaims what it once chose to forget.

Waste, in any form, is an inevitable aspect of urbanisation. The future of our cities depends not on how we bury our waste, but on how we choose to live with it. Will we keep designing for disappearance; or begin to design for integration?

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