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# The Blue-Green Infrastructure Paradigm in India: Landscape Design Proposal for transforming the Mahalaxmi Racecourse into a Resilient City Park, Mumbai

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## ABSTRACT

Accelerated urbanization in megacities around the world has resulted in an acute shortage of open spaces, the living infrastructure that modulates climate and creates community. Dense coastal cities in India e.g., Mumbai has experienced intentional paving over of the natural greens overtime bringing down already low open space per capita levels while increasing the risk of urban hydrological disasters. Current city stormwater systems that are designed on traditional discharge-based engineering are ill-equipped to handle the sudden surge of monsoon rainfall events. There is an urgent need to reimagine grey infrastructure in urban areas as hybrid green-blue landscapes. The objective of this paper is to provide landscape design strategies to transform Mumbai's 120-acre Mahalaxmi Racecourse land parcel into a high performance, resilient public open space through application of the Sponge City concept. The design workflow consists of an initial bio-physical overlayed site analysis which determines that the Mahalaxmi Racecourse is a low-lying basin that currently collects runoff from surrounding urban catchment. After establishing opportunities for site-scale stormwater management beyond basic park aesthetics the project moves to formulate a design basis rooted in Nature-based Solutions (NbS) that can detain a 5-year peak rainfall event across most of the central part as marshes and ponds thereby lowering site's current runoff coefficient of 0.85 to 0.45. Design guidelines are developed based on desired engineered landscape outcomes such as a Native Arboretum Core planned, and Riparian Bio-Filtration Spine that naturally purifies urban runoff through root-zone Phyto-treatment. Additionally, network-level design strategy such as the incorporation of an underground transit under-pass and an elevated walkway loop was proposed to overcome the sites disconnect from adjacent railway and major road grids respectively. Operational sustainability was designed into the project through implementation of a Closed-loop Stewardship Model that segments larger site into revenue-generating Active Cells that subsidize maintenance operations of less used Ecological Core Cells. The speculative Master Plan effectively unlocks the enormous potential of underutilized urban mega voids and provides a replicable template for transforming them into equitable, productive, self-sustaining infrastructure that enhances urban resilience and increases public access in cities of the Global South.

**Keywords:** landscape stewardship, public space democratization, stormwater management, urban resilience

## INTRODUCTION

The increasingly urbanised world has changed the physical equation between ecology and urbanism. The nature's 'green' hydrologic system has been replaced by the engineered 'grey' surface; denying natural infiltration and causing disruption in water cycle leading to increased runoff, land degradation and loss of urban

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ecosystem services. Now with unstable climate conditions and erratic rainfall patterns, open spaces are needed not just for civic amenities but for urban necessities. Indian cities currently face an open space crisis; lack of accessibility and quality performances. Presently, per capita open space standards in urban coastal cities fall significantly lower than global benchmark. These open spaces hold significance in serving as places for our health, equality as well as environmental safety. They are our net contributors of oxygen, ground absorption of rainwater and help cool down the severe UHI effect. Given the lack of availability of contiguous land in such densely populated cities, it is improbable to look for open land to carve out parks; it is essential we look at the restrictions around gaps or urban voids in the city. Small back alleys, institutional precincts, private clubs, a lot of brownfield sites which are usually restricted from public use are potential sites for landscape interventions.

The primary focus in this project is at Mumbai city, a hyper dense coastal city majority of which is built on reclaimed land. Mumbai is one of the global cities which is susceptible to face major threat from climate change due to its low altitude. Torrential rains during monsoon and the event of cloudbursts coinciding with high tides have led to perpetual severe flooding every year. Runoff from such an increase in rainfall has exceeded the drainage capacity of the city. Sewerage systems which are largely century old follow conventional build-hard-engineer strategies where every storm water drain is designed to push the water away from the source as fast as possible. Not solving but speeding up the water flow, this ageing grey infrastructure causes flash floods in concentrated pockets of the city. This push for higher growth and development without a water resilient strategy has resulted in what we call today as the need to practice Landscape Urbanism. Where landscape is designed to strategically hold water, let it soak and slow instead of just disposing it off.

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**Fig.1 Site Location and History (Source: Author)**

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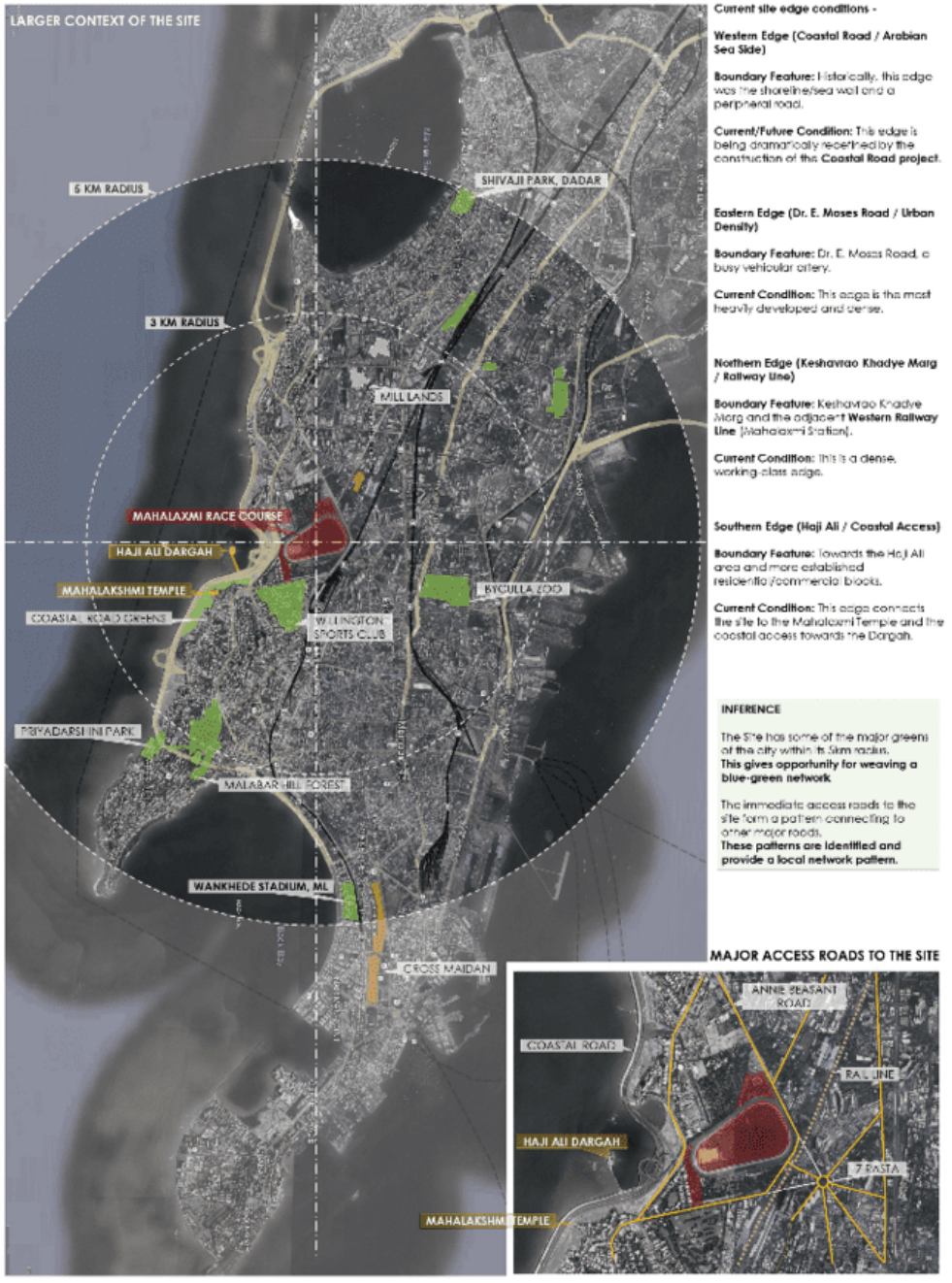


**Fig 2. Context Plan (Source: Author)**

Essentially implementing the ideology of a Sponge City, this research focuses at landscape as a sponge that retains, absorbs, and purifies rainwater where it falls using Nature-based solutions. The prime site being the Mahalaxmi Racecourse precinct, a closed gated 120-acre terrain in South Mumbai provides a large canvas to implement this framework regionally. The site currently has controlled general public access owing to its racecourse heritage. The design does not replace what the site already is, it co-exists. Using advanced architectural zoning, grading, and vector movements the existing oval track is maintained and allows horses to still be trained on-site amidst the high performing democratic park designed around it.

## Impact of Accelerated Urban Modification on Hydrological and Social Ecosystems

Briefly documenting how intense urban interventions have negatively impacted the site & its surrounding ecology this paper argues that it is the time to shift to a new approach for designing open spaces in our cities that can endure pressure of changing weather conditions over the years. By virtue of replacing absorptive ground with impervious surfaces like concrete pavement, skyscrapers and transit lines the hydrology of South Mumbai has been detrimentally transformed. Soil compaction and removal of floodplains have created a pseudo urban

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landscape with very high runoff ratios. During periods of sudden inundation these waters find no respite and millions of litres of storm water runoff travel through outdated storm drain systems. Coupled with backflow from the sea these grey infrastructures begin to experience acute overflow resulting in endemic flash-flooding at edges of racecourse. In addition, decades of public exclusion from the 120-acre precinct have produced vast urban dichotomy depriving millions their right to access one of the largest lungs in the city.

**Hydrological Calculation and Modelling Framework**

To quantify the site's stormwater capacity and runoff dynamics, the hydrological assessment utilizes the Rational Method: $Q = C \times I \times A$

Where:

- $Q$ = Peak runoff rate ($m^3/s$)
- $C$ = Composite runoff coefficient
- $I$ = Rainfall intensity (mm/hr), derived from the India Meteorological Department (IMD) Rainfall Intensity-Duration-Frequency (IDF) curves for Mumbai (5-year return period design storm of 300 mm over 24 hours)
- $A$ = Catchment area ($120$ acres $\approx 485{,}622\ m^2$)

The baseline condition, dominated by compacted turf and paved grey infrastructure, yields a composite runoff coefficient ($C_{base}$) of **0.85**. The proposed landscape interventions apply a spatially distributed Sponge City approach: $C_{proposed} = \frac{\sum(C_i \cdot A_i)}{A_{total}}$

Through targeted land-cover conversions—allocating 35% of the site to bio-retention wetlands ($C = 0.15$), 25% to native arboretum canopy ($C = 0.25$), 25% to porous/gravel paving ($C = 0.40$), and retaining 15% for active track turf ($C = 0.60$)—the composite runoff coefficient is reduced from 0.85 to 0.45.

**Need for the Study**

Mahalaxmi Racecourse presents an opportunity for re-programming given acute environmental crisis, deficit of open spaces, and looming climate vulnerabilities facing South Mumbai today. The Racecourse ground functions as a depression in land for the surrounding urban fabric it is nestled within. More importantly, it serves as unused storm water conveyance infrastructure. With limited storage and a high runoff coefficient, when intense rain events or cloudbursts occur it sends surplus storm water through municipal channels causing flash-flooding in adjacent neighbourhoods. Mumbai also suffers from a severe lack of open space per capita and urgent need to convert underutilized open spaces into public realms. There is an urgent need to transform Mahalaxmi Racecourse into a Resilient Park using Sponge City concept framework, that retains the historic equestrian programming, by integrating biophilic stormwater infrastructure and native forest, while aiding in restoring groundwater, mitigating the heat island effect, and creating an egalitarian self-regulating common in India's only island city.

**Site Introduction**

Located within South Mumbai's low-lying coastal plains, the site covers an area of about 120 acres and is encircled by Western Railway's operational tracks to the west, Lala Lajpat Rai Marg and Arabian Sea's blue edge to the south- west, Haji Ali Urban Node to the south and elevated built-forms of G-South Ward residential neighbourhoods to the north and east. Conditions on-site range from irregular urban topography traversed by a continuous 2400-meter elliptical long-distance horse racing track, elevated level central in-fields and side-cut edge depressions periodically occupied by stables, paved parking lots and private club infrastructure. Towards

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the south-western part within the central field exists a prominent edge depression that serves as an enormous ungoverned catchment basin during rains.

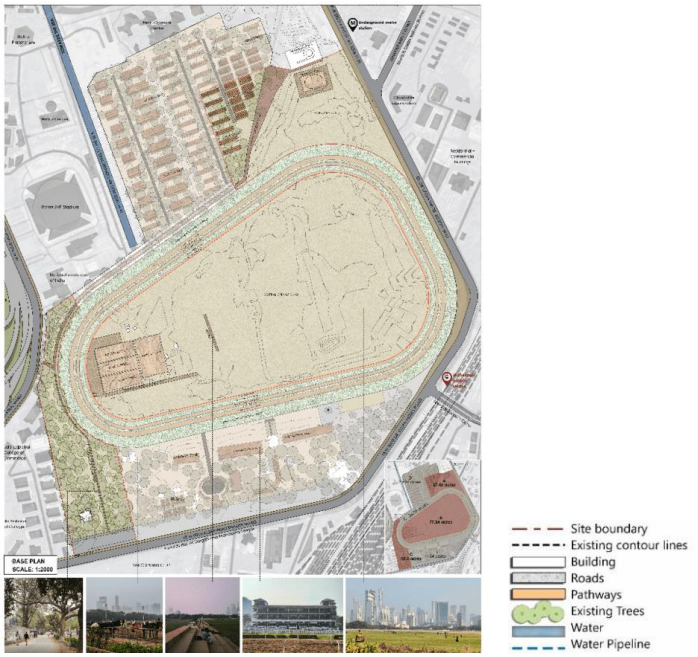


**Fig 3. Existing site plan of study area at Mahalaxmi Racecourse (Source: Author)**

Networks of sub-grade horseshoe rings and stables exist predominantly on the north and west side of site conditions. Site's central infield is majorly non-arboreal pasture grassland and the west or north-western edge contains patchy strips of arbor alongside the railway line. Predominantly because land-reclamation efforts on-site for the establishment of the Racecourse, back in the late 1800's permanently filled in a tidal depression that once existed. With the regional geomorphology of the site and its innate sensitivity to backflow, the site is prone to acute seasonal flooding leaving most of the land-area practically unusable for conventional development. The existing gated entrance off a high-speed arterial road to the west shut out connectivity to dense neighbourhoods towards north and east of the racecourse. Loss of canopy layer vegetation and dominance of open grass allows for no intermediary buffer to filter loud noise-pollution and air pollution caused by heavy railway and road traffic; it also increases the water requirements for maintenance and soil erosion. Trees on-site are only found thickly along the tight west edge that borders the Railway tracks. An existing storm water outfall adjacent to north of the site serves as the outlet for runoff for surrounding neighbourhood to the north. Lines of shallow cement lined grey open channel drains dissect portions of the interior of the site; these were likely implemented during early phases of racecourse development to quickly channelize water out to sea but face extreme backflow during high tide.

**Ecosystem Service Monetization (Cost-Benefit Framework)**

Blue-green infrastructure analysis requires weighing initial capital expenditure against long-term operational savings and values of ecosystem service created.

| Benefit Category | Mechanism & Urban Impact | Valuation Matrix |
|---|---|---|
| **Flood Damage Mitigation** | Captures 300 mm monsoon surge, preventing overflow into surrounding neighbourhoods of G-South Ward residential and commercial zones. | Mitigates BMC flood insurance claims and emergency response costs. |
| **Pumping Energy Savings** | Decreases stormwater runoff entering BMC grey infrastructure drains through bio | Decreased peak energy demand of BMC Stormwater Drain (SWD) pump-stations. |

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| | | |
|---|---|---|
| | infiltration/gravity fed filtration and landscape evapotranspiration. | |
| **Microclimate Mitigation** | 40% tree canopy shade reduces localized ambient temperatures by 2-3°C. | Shifts cooling load of adjacent development/hardscape (cools Urban Heat Island Edge). |
| **Revenue Generation** | Generates BMC maintenance endowments through activation of edge-cell kiosks, programmed plazas, and eco-tourism features. | Self-funding operational loop minimizes municipal tax subsidies. |

# METHODOLOGY

The design is structured around four stages of landscape engineering design process.

- Stage 1 establishes a theoretical framework by analyzing international precedents with Sponge City initiatives and transit-oriented developments, using these ideas to set up a stringent Matrix of KPI's with objectives to capture 300mm of rain from monsoons and achieve a storm-water absorbency goal of 40%.
- Stage 2 surveys the site conditions, specifically focusing on site slopes that contribute runoff separate from the larger 1.5km Watershed while measuring constructed obstacles.
- Stage 3 converges findings from previous stages into a zoning diagram to address water quantity concerns by allocating the site's flood plains for designation as an Ecological Sponge. This is paired with maintaining the existing protected turf landscapes of the racetracks to function as another active layer of the design.
- Stage 4 is the designed masterplan. Through calculating coefficients of runoff values and various pervious surfaces, and illustrating depths of cut and fill, the plan aims to achieve zero-net flooding within 48 hours of a storm or heavy rainfall.

**Natural System Analysis**

The natural system analysis was utilized to deduce existing site conditions mainly with respect to topography, hydrology and vegetation. This analyzed set created the technical parameters for what the design intervention would need to address:

Topographical Catchment Basin: The site functions as bowl shaped depression that collects storm-water runoff from surrounding urban areas (1.5km radius). There is an opportunity to route storm-water runoff into containment areas through strategic grading and plantings to alleviate regional flooding.

Reduce Rain-runoff Potential: Due to its regionally low elevation, site is prone to tidal influx and drainage from adjacent outfalls. The design can utilize the natural depressions on site to create large central retention networking that acts as buffering tool to decrease sites runoff coefficient.

Native Vegetation and Micro-climate Layering: The existing landscape is defined by a mono layer of turf grass. There is an opportunity to implement native arboretum and woodland buffers, aim for 40% canopy coverage and decrease surface temperatures by 2-3° C.

Spatial Zoning for Layered Co-existence: The site is physically compartmentalized creating obvious zones of performance. The design can create safe perimeter program for existing horse-racing to thrive while allowing other areas to perform majority of bio-filtration, noise abatement, and transit interfaces.

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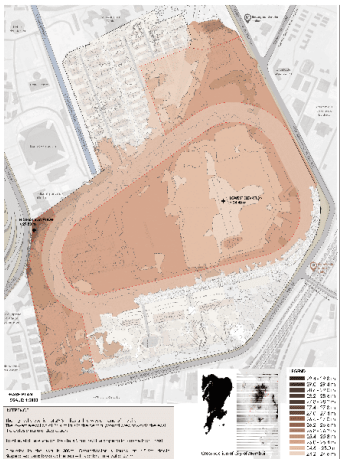
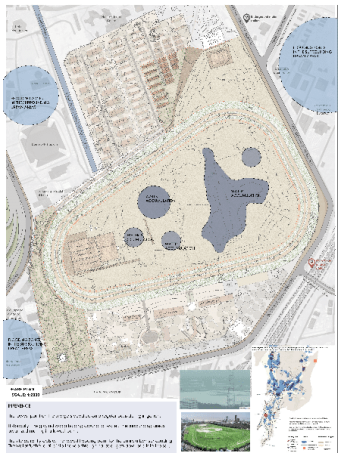
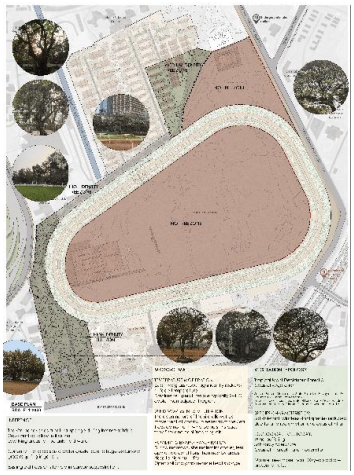


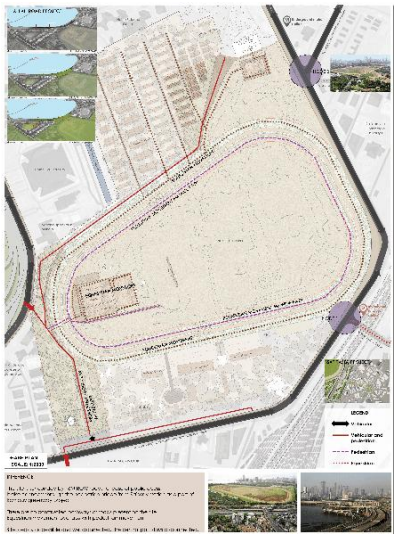
Topography: low and high points



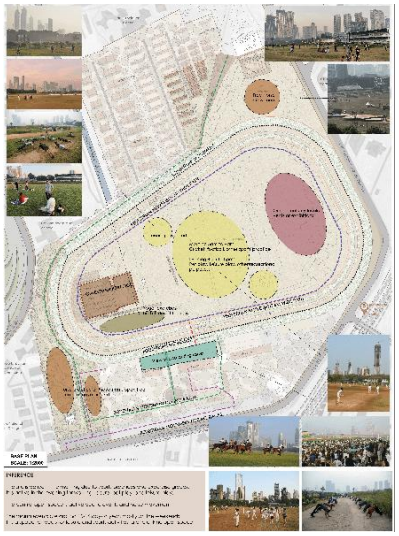
Hydrology: potential water bodies



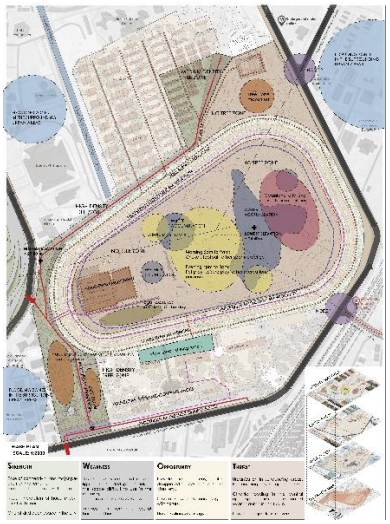
Vegetation: need trees in the field



Circulation: potential access points



Activities: active & passive areas



Site synthesis: SWOT analysis

Fig 4. Site synthesis and Design interventions (Source: Author)

## RESULTS AND DISCUSSION: THE PROPOSED SCHEME

The design proposal for the Mahalaxmi Racecourse re-imagines the grounds from a traditional municipal park-landscape into a performance-based prototype for Sponge City infrastructure.

Strategically located within a hyper dense coastal plain, the masterplan is anchored by stitching together narratives embedded in the site's transformation from an elite exclusionary colonial institutional zone to an inclusive socio-economically productive landscape for the city.

Historically, site formation is bound to the reclamation of "Mahalaxmi Flats" marshlands from the Arabian sea in the late 1800s as grounds for horse racing. Since then, the landlocked island, raised high from surrounding context by layers of enclosing walls and arterial traffic infrastructure has remained disconnected from the city.

The masterplan responds to site context through a regenerative framework of pulse, breathing new life into the site's latent natural and built systems; enhancing socio-spatial connectivity while mitigating Mumbai's annual monsoon flood pulse.

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**Fig 5. Proposed landscape design site plan (Source: Author)**

Positioned across the vast 120-acre site are three unique landscape bands activated by varying levels of performance metrics addressing site history, movement-layering, program continuity, and ecological function responding to specific site needs and opportunities.

**Zone 1: Buffer Plain and Transit Loop (Social Shell)**

The first band borders the northern, eastern, and south-eastern edges of the park where it meets dense residential District of G-South Ward. In this zone, the park begins its programme of public democratization introducing multiple-entries into the landscape. Ground movement is orchestrated around a large arrival plaza focused around the entry-level Metro station connected to city. The loop acts as a shield for park visitors from traffic speeds and offers uninterrupted views of the interior park scape stretching all the way to distant Arabian Sea.

Public infrastructure and programming along this landscape belts includes:

- Landscape Pavilion: Located at main entrance plaza introducing people to history of Mumbai's water topography.
- Civic Lawn: Carved out of existing ground slope along edges allowing space to be used for public programmes.
- Pavilion Cluster with café: Lightweight low-rise high-permeability structures enveloped by soft flexible seating.
- Pitch-and-putt and Family Lawns: Placed strategically across slope of racecourse buffer these lawns are punctuated with play pods, therapeutic gardens, outdoor fitness areas and yoga lawns.

**Zone 2: Active Crop Row and Protected Racing Trace (Operational Matrix)**

The unique agenda driving the landscape masterplan at Mahalaxmi Racecourse site is one of co-existence. Recognizing the inherent culture embedded within site, the design integrates the program of horse racing into the larger landscape canvas allowing for both active uses to co-exist. The Outer race-track trace as well as infield grass-textured training tracks remain active, operable landscape features. Segregated from other landscape movements using simple vertical shifts in grade and vegetative screens, park visitors and horses can safely move through the site independently. While park is open, these landscapes remain visually accessible yet operationally isolated from other civic activities using subtle plant screening and sunken walkways.

Zone 3: The Ecological Core and Sponge Infrastructure (The Blue-Green Sink)

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Spanning centre field and lowest elevations in south-west corner of the city, this precinct acts as the green infrastructure powerhouse of South Mumbai. Designed as a giant absorbent landscape machine, it absorbs and slows down runoff from a 300mm annual monsoon deluge. This precinct's slopes have been recontoured into a series of cascading shallow seasonal bio-swales and bio-retention corridors. Bio-swales reduce flow velocity while simultaneously removing road runoff pollutants through phytoremediation at the root-soil interface.

Channelling into Mumbai's lowest park node, these bio-swales flood into a series of stepped wetlands and retention ponds. Engineered with stepped low weir check-gates, this floating network ponds-in-time millions of litres of storm water that would've otherwise rush into Mumbai's chronically inundated civic drains, creating a buffer against tidal reversal. A series of contiguous floating landscapes therefore emerge on-site seasonally, a lake that attracts birds and migratory waterfowl in the monsoon, while in the dry-season the berms of this levee pond system recede to expose a network of public promenades and footpaths. Technical strategy for development of this 120-acre landscape centres around principles of low-impact development. As part of a strategy to increase water retention within precinct, all pathways and circulation surfaces are porous. Structural components of park infrastructure including pavilions and viewing platforms are crafted from rapidly renewable local bamboo fabrics and lightweight wood constructions.

**Planting Strategies Adopted**

The planting design palette for the high performing park restores a robust coastal habitat to the site. It moves away from mono-culture grasses and towards purposefully designed wet-zone & dry-zone layering:

- Dry Zones - Designed to absorb urban heat island impact and filter contaminants from nearby built edges, mixed-species trees create shaded spaces and airborne pollution sinks within and around the park. Trees selected for dry zones within the park form an under-canopy that delivers 40% homogeneous shade to lower ambient temperatures by 2–3° C. The native
- arboretum utilizes a mix of Mimusops elengi (Bakul), Syzygium cumini (Jamun), Bombax ceiba (Katesavar), and Madhuca longifolia (Mahua). Trees around the high polluting/disturbance edges of the park form rows of dense, evergreen barrier that acts as wind-break and sound-buffer - above of Azadirachta indica (Neem) and Pongamia pinnata (Karanj) mix; and ground-understory of dense native shrubs, lowering ambient noise pollution by 10–15 dB.
- Wet Zones - Designed to absorb monsoon deluge and create natural bio-filtering zones the low-lying retention landscape is planted with moisture tolerant, salt tolerant, native tree, and grasses depending upon the slope. The wettest edge is planted with Typha angustifolia and Phragmites karka to absorb and bio-filter urban suspended solids. Edges and inundation zones are planted with Terminalia arjuna (Arjun), Lagerstroemia speciosa (Jarul), and Ficus racemosa (Umber) which also serve to bind loose soils along these swampy banks. Salt tolerant species such as Coccoloba uvifera and Casuarina equisetifolia were also planted acting as buffers for noise too.


**Fig 6. Part Plan of Planting at the edge of the water bodies, boardwalk bridge, and cricket buffer**

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**Fig 7. View from the water body**

**Fig 8. View of the children's park**

**Fig 9. View of the meadow**

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**The Closed-Loop Stewardship Model and Phased Activation**

The 120-acre public master plan implements a self-sustaining Closed-Loop Stewardship Model to eliminate dependence on taxpayer-money for operations and maintenance, managing the park as a productive, circular infrastructure project divided into three operational cells, where each cell actively sustains the others:

1. Active Cells (Financial Backbone): Strategic, high-footfall peripheral edges and eco-kiosks adjacent to transit plazas produce revenue allocated towards a site-specific maintenance endowment fund.
2. Productive Cells (Resource Capitalization): Bio-digesters onsite, produce compost transforming organic stable waste into rich fertilizer for the native arboretum, neutralizing chemical inputs.
3. Core Cells (Urban Ecological Sink): Commercial surpluses directly finance non-revenue ecological assets, supporting continuous wetland desiltation systems, surrounding wildlife, and bio-filtration maintenance.

Phased implementation strategy creates a monitoring framework and by crowd-sourcing park management, daily visitors become stewards of the space and Mahalaxmi Racecourse can truly become a self-sustaining, equitable and commons governed landscape.


Fig 10. Stewardship structure and Closed Loop self-sustaining model

**Governance, Stakeholder Engagement, and Implementation Framework**

Transforming a heritage asset into public blue-green infrastructure requires multi-tier governance, inter-agency coordination, and public participation.

**Phase 1: Institutional & Public Consensus**

├──> Key Stakeholders: MCGM/BMC (SWD Dept), RWITC, UDD, Heritage Committee

└──> Public Co-Design Workshops & Local Ward Consultations

**Phase 2: Regulatory Approvals & Statutory Clearances**

├──> Environmental Impact Assessment (EIA) & Coastal Regulation Zone (CRZ)

└──> Heritage Preservation Clearance for Equestrian Structures

**Phase 3: Phased Spatial Execution**

├──> Stage A: Peripheral Buffer Plazas & Bio-swales (Zero track interruption)

└──> Stage B: Core Wetland Excavation & Phytoremediation Network

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**Multi-Stakeholder Alignment:**

- Municipal Corporation of Greater Mumbai (MCGM / BMC): Primary municipal oversight for stormwater integration.
- Royal Western India Turf Club (RWITC): Primary leaseholder; protected racing tracks ensure uninterrupted operational continuity.
- Urban Development Department (UDD) & Mumbai Heritage Conservation Committee (MHCC): Ensures preservation of historic grandstands and open-space zoning.

**Public Participation & Co-Design:** Prior to construction, participatory mapping workshops with G-South Ward residents will refine non-racing public amenities (jogging tracks, family zones, and educational wetlands) to ensure equitable spatial access.

## CONCLUSION

This project reclaims the Mahalaxmi Racecourse; a restricted, vacant urban wasteland, as a publicly accessible landscape resilient to climate change. Deploying the landscape's unique bowl-shaped topography, the proposal unlocks an efficient, scalable model for Sponge Cities that mitigates flash-flood conditions caused by heavy precipitation events common to highly urbanised regions across Mumbai. Enhancing rather than detracting from the Racecourse's heritage identity the project enables simultaneous public accessibility and ecological restoration ambitions by demonstrating how racehorse training operations and blue-green infrastructure can peacefully cohabit using spatial planning. Implementing an expansive wetland for storm-water as well as riparian bio-filtering waterways allows for the detention and filtration of rainwater lowering the site's runoff coefficient and eliminating the risk of flooding for surrounding neighbourhoods. This intervention works in conjunction with native species-led planting strategy that produces a tiered canopy layer countering severe micro-climatic UHI effect through evapotranspiration. The parametric approach allowed for modelling of landscape-as-a-business by designing with an emphasis on self-sustaining endowment that continues to generate operational fees for maintenance costs directly at the landscape. Crowd-sourced stewardship turns public users into park custodians, allowing Mahalaxmi Racecourse to evolve into a self-financing, resilient and commons owned landscape. City-wide, Mahalaxmi Racecourse can be perceived as a catalytic, productive template for city officials and designers looking to convert urban open spaces into a carbon-negative landscape, a critical move for climate-positive resiliency in Mumbai and the Global South at-large.

This document presents blue-green concept as a theoretical landscape proposal. Simulation/model validation, Pilot field testing, and water quality sampling will have to be determined by BMC following project construction.

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