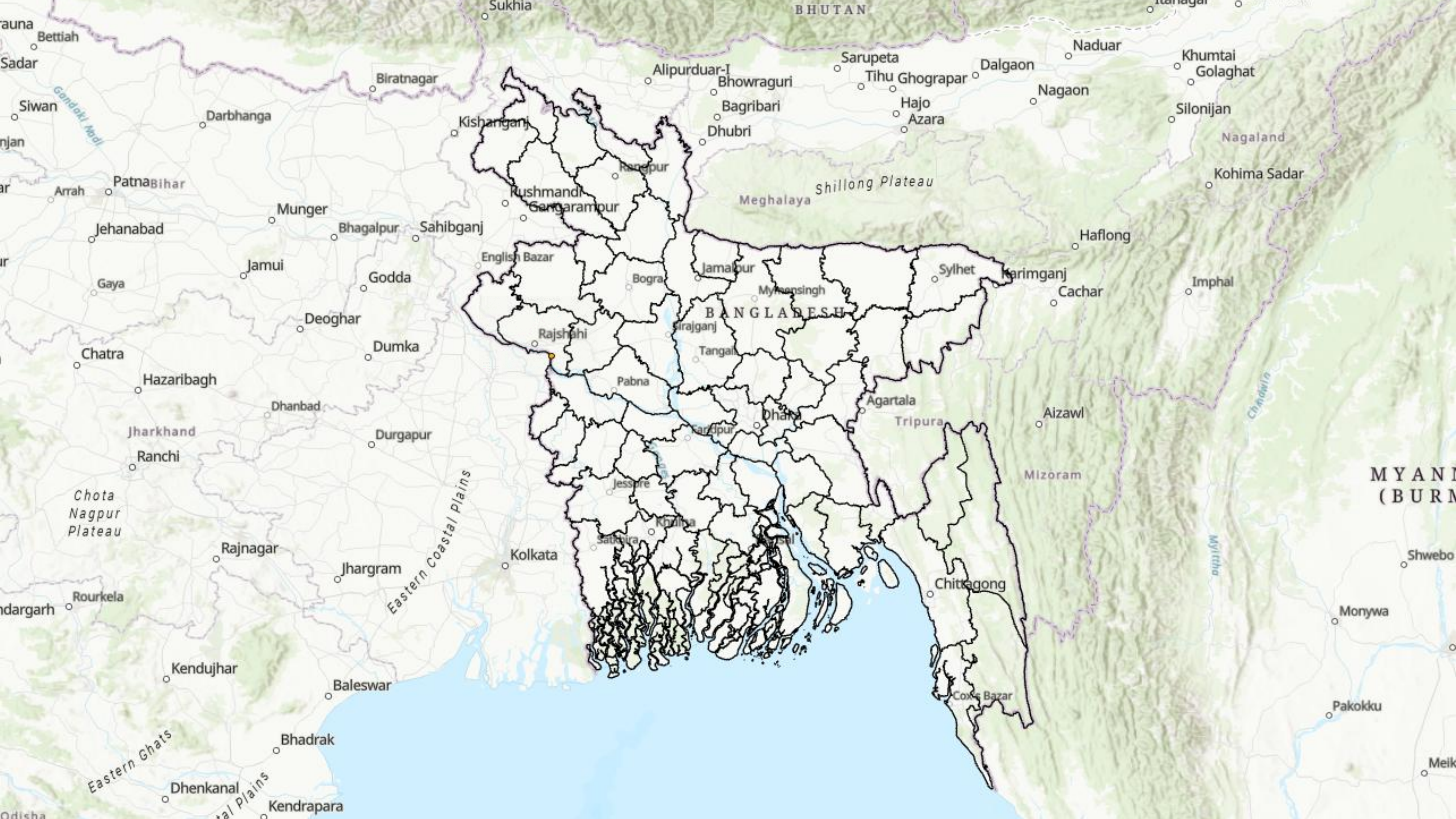
Revitalizing Riverbank Systems through a Sponge City Framework and Nature-Based Solutions toward Sustainable and Resilient Communities in Charghat, Rajshahi

Group 06

2107011, 2007013, 2107015, 2107028, 2107047


BHUTAN
Sukhia
Bettiah
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Biratnagar
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Sarupeta
Tihu
Ghograpar
Hajo
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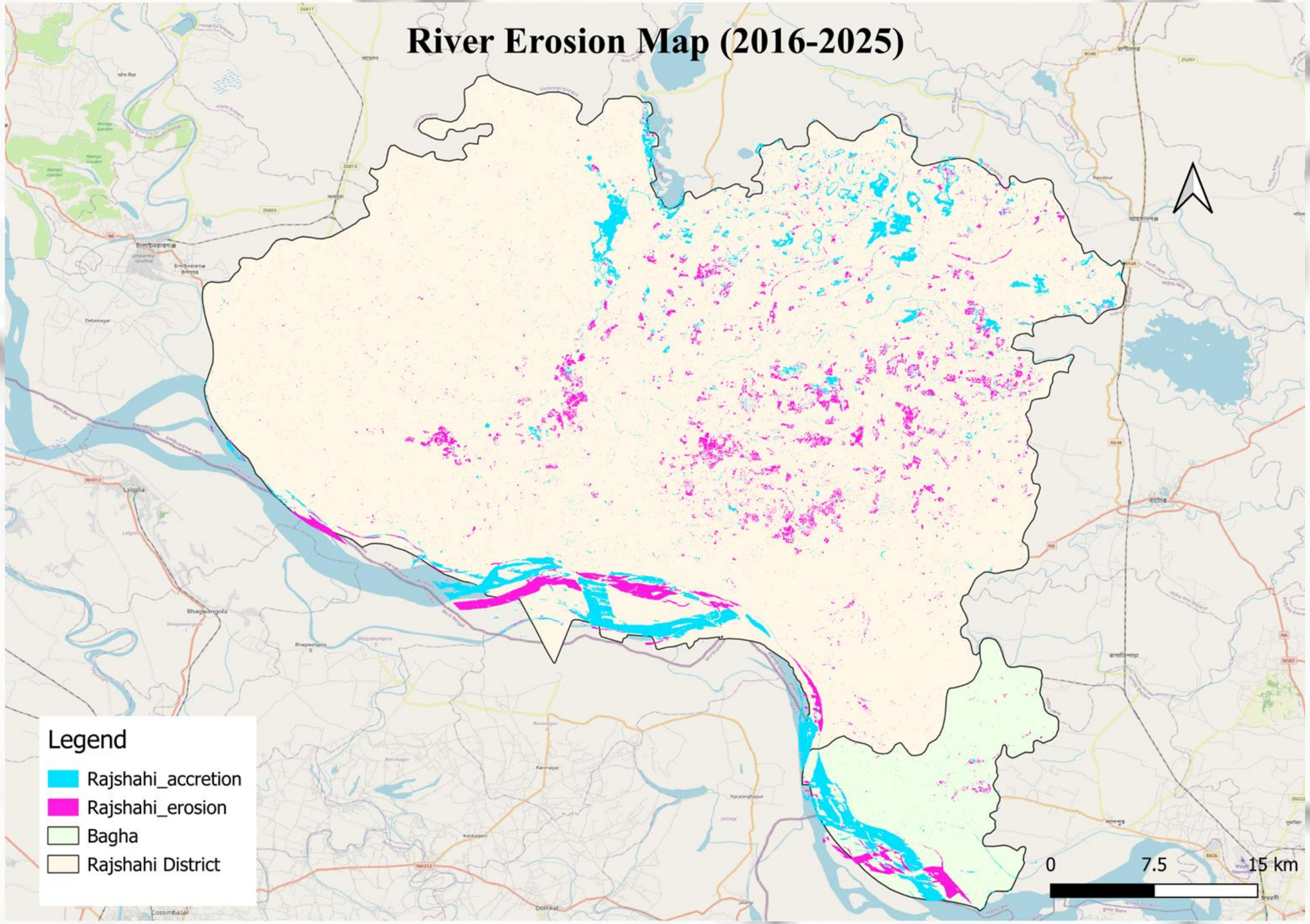
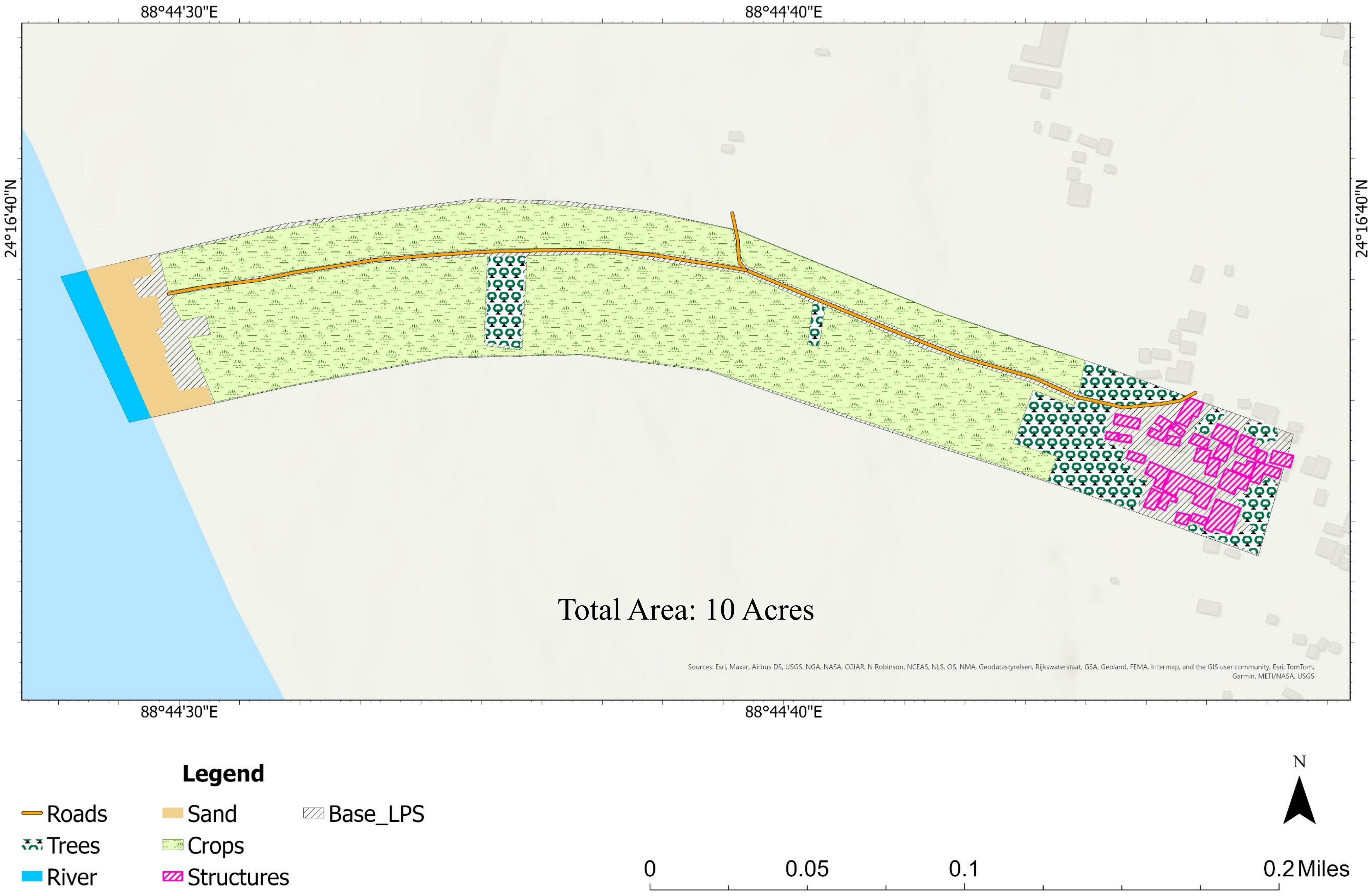
Dalgaon
Naduar
Nagaon
Khumtai
Golaghat
Silonijan
Nagaland
Kohima Sadar
Rangpur
Shillong Plateau
Meghalaya
Patna
Bihar
Arrah
Munger
Kushmandi
Gangarampur
Jehanabad
Bhagalpur
Sahibganj
English Bazar
Jamui
Gaya
Godda
Bogra
Jamalpur
Mymensingh
BANGLADESH
Sylhet
Karimganj
Cachar
Haflong
Imphal
Deoghar
Dumka
Rajshahi
Sirajganj
Tangail
Chatra
Hazaribagh
Pabna
Dhanbad
Jharkhand
Ranchi
Durgapur
Agartala
Tripura
Dhaka
Faridpur
Aizawl
Mizoram
Chota Nagpur Plateau
Jessore
Khulna
Satkhira
Eastern Coastal Plains
Kolkata
Rajnagar
Jhargram
Rourkela
Chittagong
Monywa
Shwebo
MYANMAR (BURMA)
Kendujhar
Baleswar
Cox's Bazar
Pakokku
Bhadrak
Eastern Ghats
Dhenkanal
Kendrapara
Odisha


River Erosion Map (2016-2025)
Legend
Rajshahi_accretion
Rajshahi_erosion
Bagha
Rajshahi District
0
7.5
15 km

Base Map (Charghat)



Site Characteristics:

- Rapid lateral migration and frequent channel shifting
- Highly erosion-prone, causing continuous bank retreat
- Loose, sandy alluvial soil with weak geotechnical strength
- Very low permeability (~3.5×10^{-7} cm/s) causing poor drainage
- High pore-water pressure buildup during floods
- Soil strength highly sensitive to moisture increase
- Cohesion ≈ 153 kN/m²; friction angle ≈ 22° (reduces with saturation)
- Compressive strength drops by ~46% with higher water content
- Typical failures: slab-type, planar sliding, and toppling
- Leads to loss of land, settlements, and infrastructure

Objectives

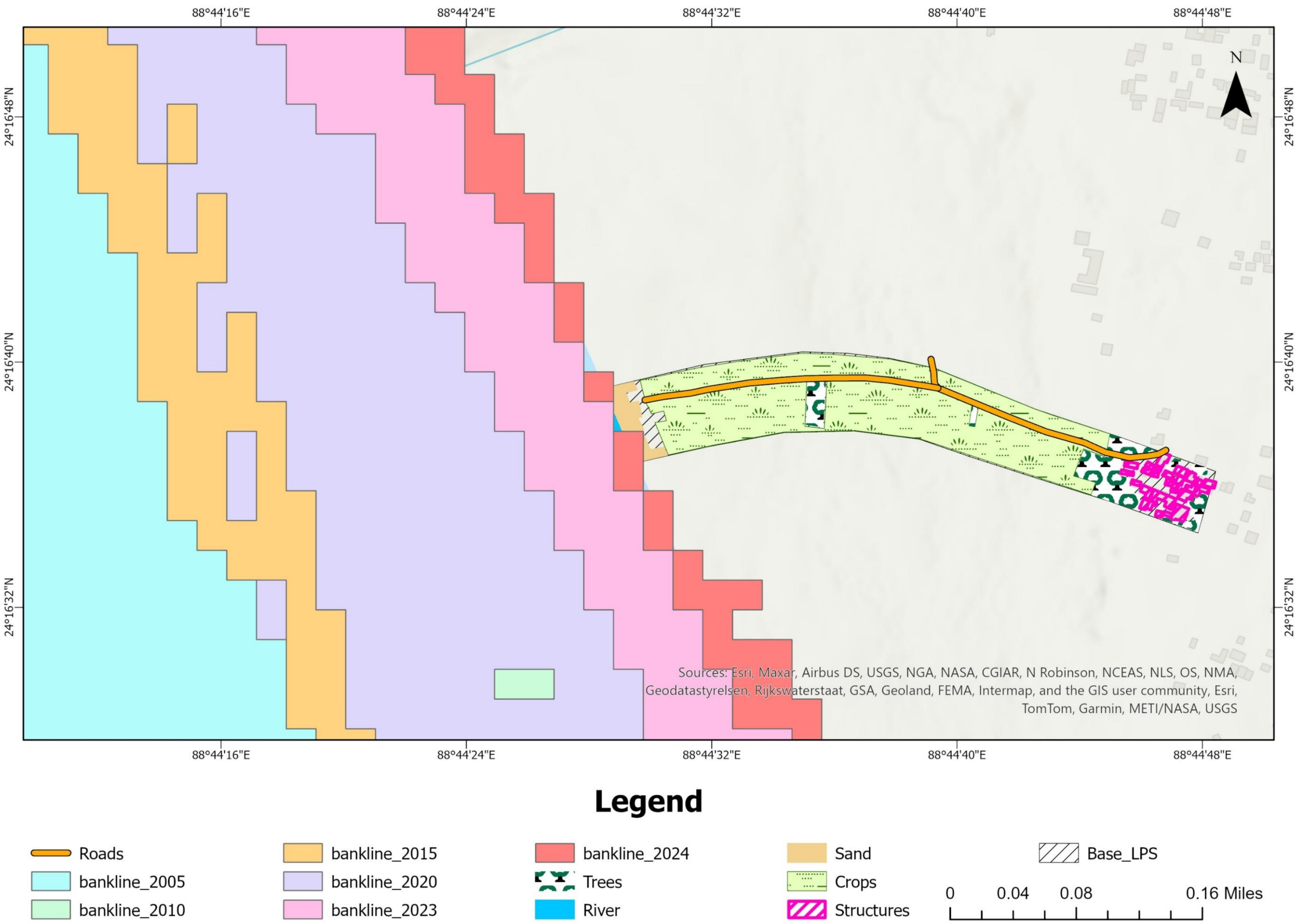
To analyze the spatiotemporal dynamics of riverbank morphology and simulate future channel migration patterns.

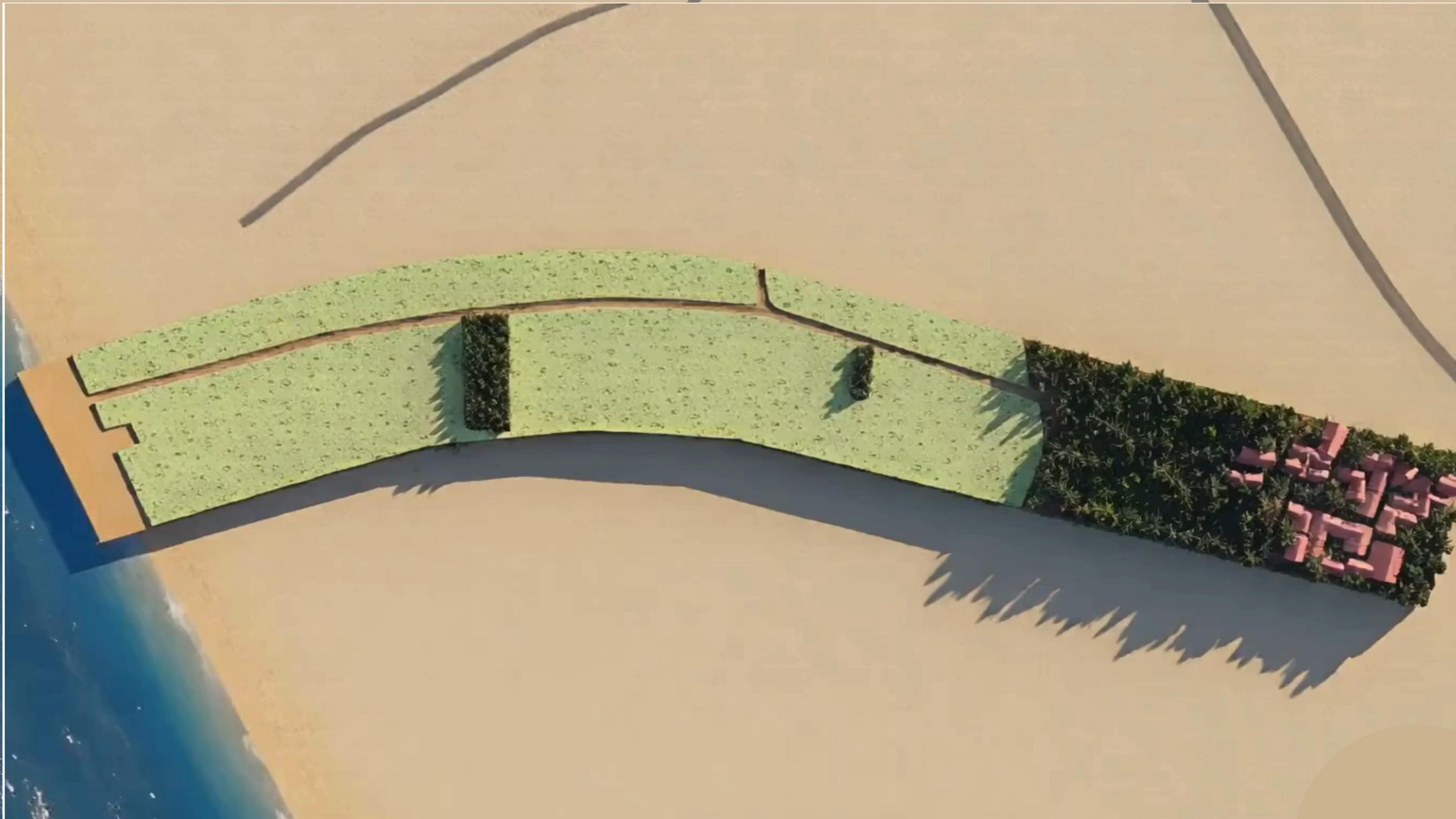
To formulate a strategic landscape redesign framework for sustainable and climate-resilient riverbank erosion management.

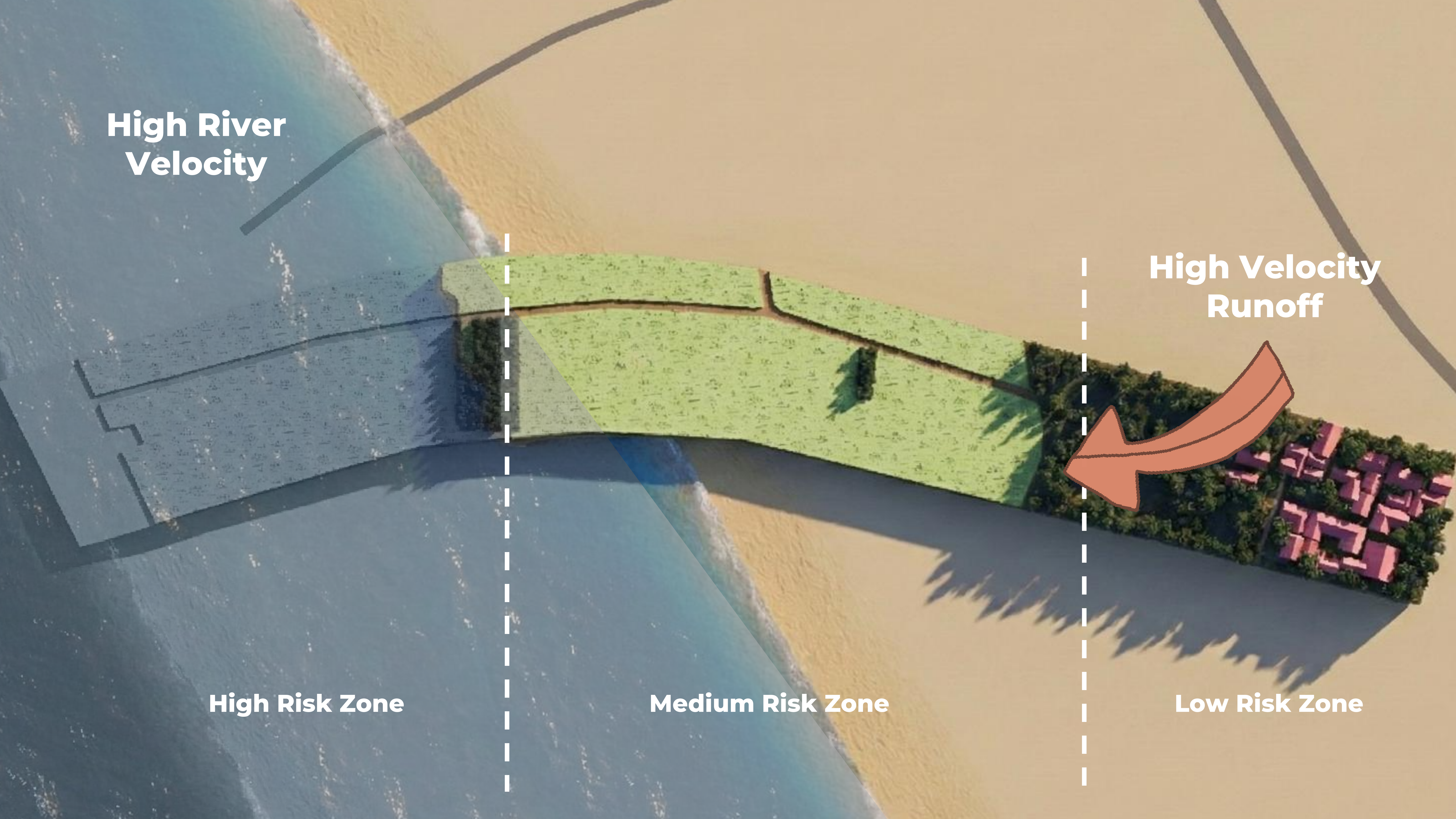
Objective 01

Morphological Dynamics & Simulation Visual

Two Decades of Erosion (Shoreline Changes)






High River Velocity
High Velocity Runoff
High Risk Zone
Medium Risk Zone
Low Risk Zone

The Human Cost (Community Insights)

Economic Loss: The community loses approx. 20 bighas of arable land annually, destroying their primary livelihood.

The Debt Trap: Families are forced to take loans just to survive the erosion season.

Psychological Impact: There is a constant fear of displacement. Schools are at risk, disrupting education.

The community explicitly stated: existing measures are failing. They are desperate for a sustainable solution. These heartbreaking concerns forced us to look beyond traditional engineering. They drew our attention to one specific goal: finding a sustainable solution that can truly protect the smile of that community.






Objective 02

Formulate a strategic landscape redesign framework

SPONGE CITY

A sponge city is an urban development model that mimics natural hydrology by absorbing, storing, filtering, and reusing rainwater. Instead of rushing stormwater away through pipes, it slows water down, lets it infiltrate into soil, and integrates natural and engineered solutions for resilience against flooding, water scarcity, and climate extremes.

CORE OBJECTIVES

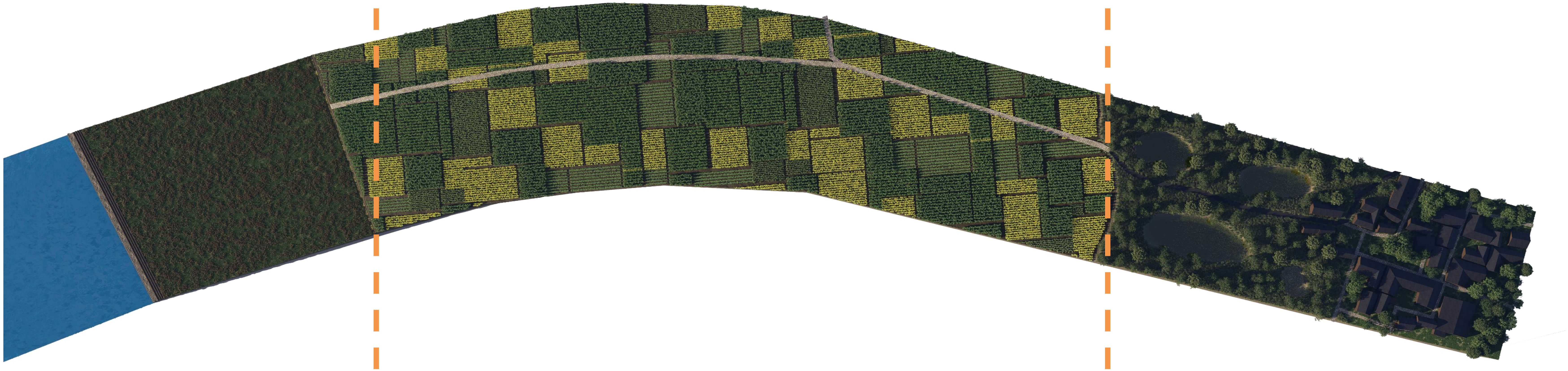
1. Flood Mitigation
2. Water Reuse
3. Groundwater Recharge
4. Water Quality Improvement
5. Climate Adaptation
6. Ecological & Social Benefits
7. Runoff reduction
8. Cooler microclimate
9. Reduces the pore-water pressure

Main Components: Permeable Surfaces, Green Infrastructure, Blue Infrastructure.

Novelty: Applying Urban Flood Models to Riverbank Erosion.

The Proposed Plan:
Zoned Landscape Strategy

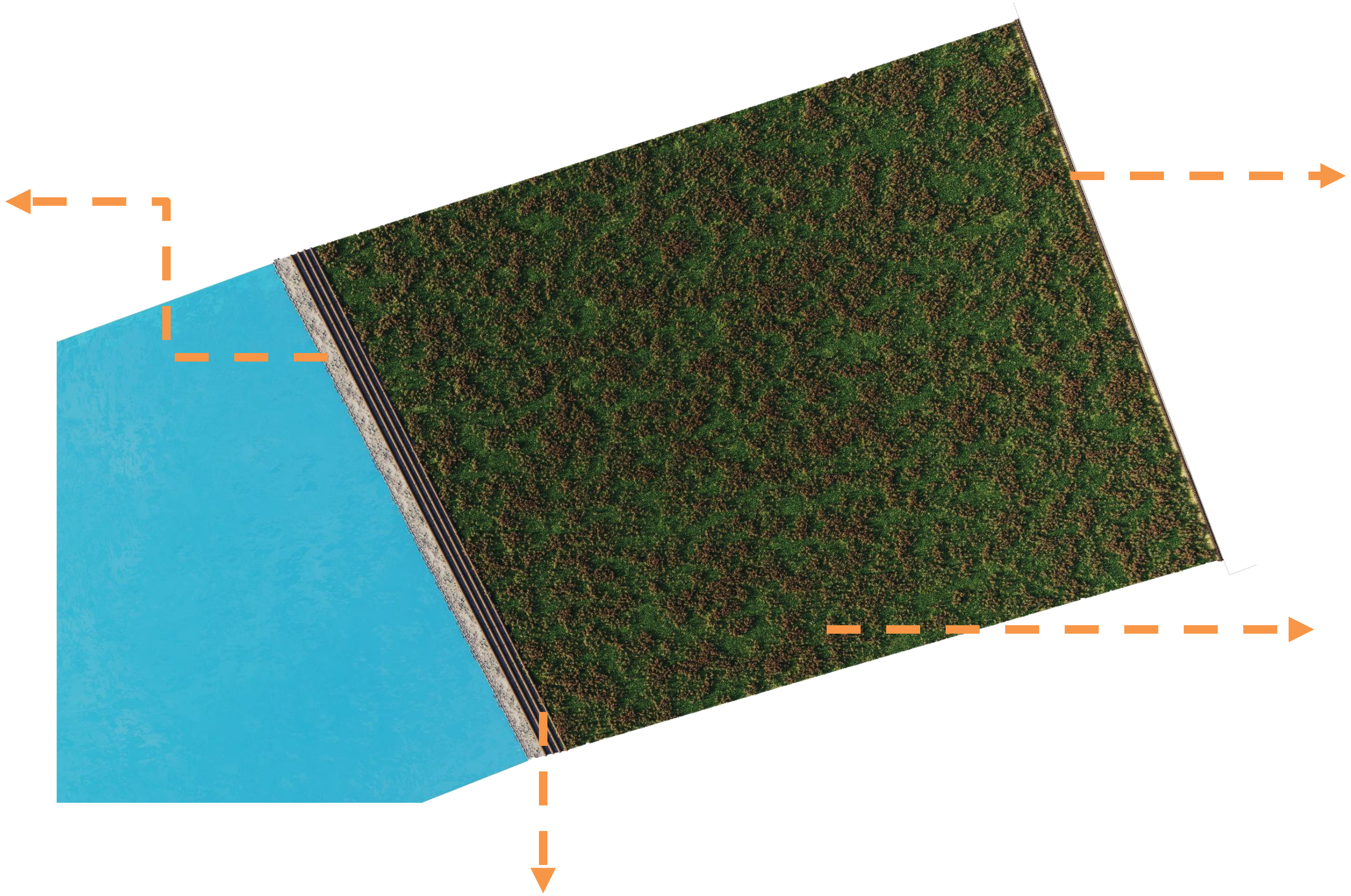
High Risk Zone	Medium Risk Zone	Low Risk Zone
3 Acres (Appx.)	**4 Acres (Appx.)**	**3 Acres (Appx.)**



ZONE 1	**ZONE 2**	**ZONE 3**
TOE PROTECTION (IN-STREAM) ZONE	**MID-SLOPE ZONE (BANK SLOPE STABILIZATION & FILTRATION)**	**TOP BANK / HINTERLAND ZONE (RUNOFF & PORE PRESSURE CONTROL)**

ZONE 1

TOE PROTECTION (IN-STREAM) ZONE



Wire Gabions with Local Rock

Material Composition: Heavy galvanized steel wire mesh (double twisted) filled with locally sourced river stones (granite/limestone).

Dimensions: 1m x 1m x 2m rectangular cages stacked in a stepped formation.

Void Ratio: 35% - 40% porosity.

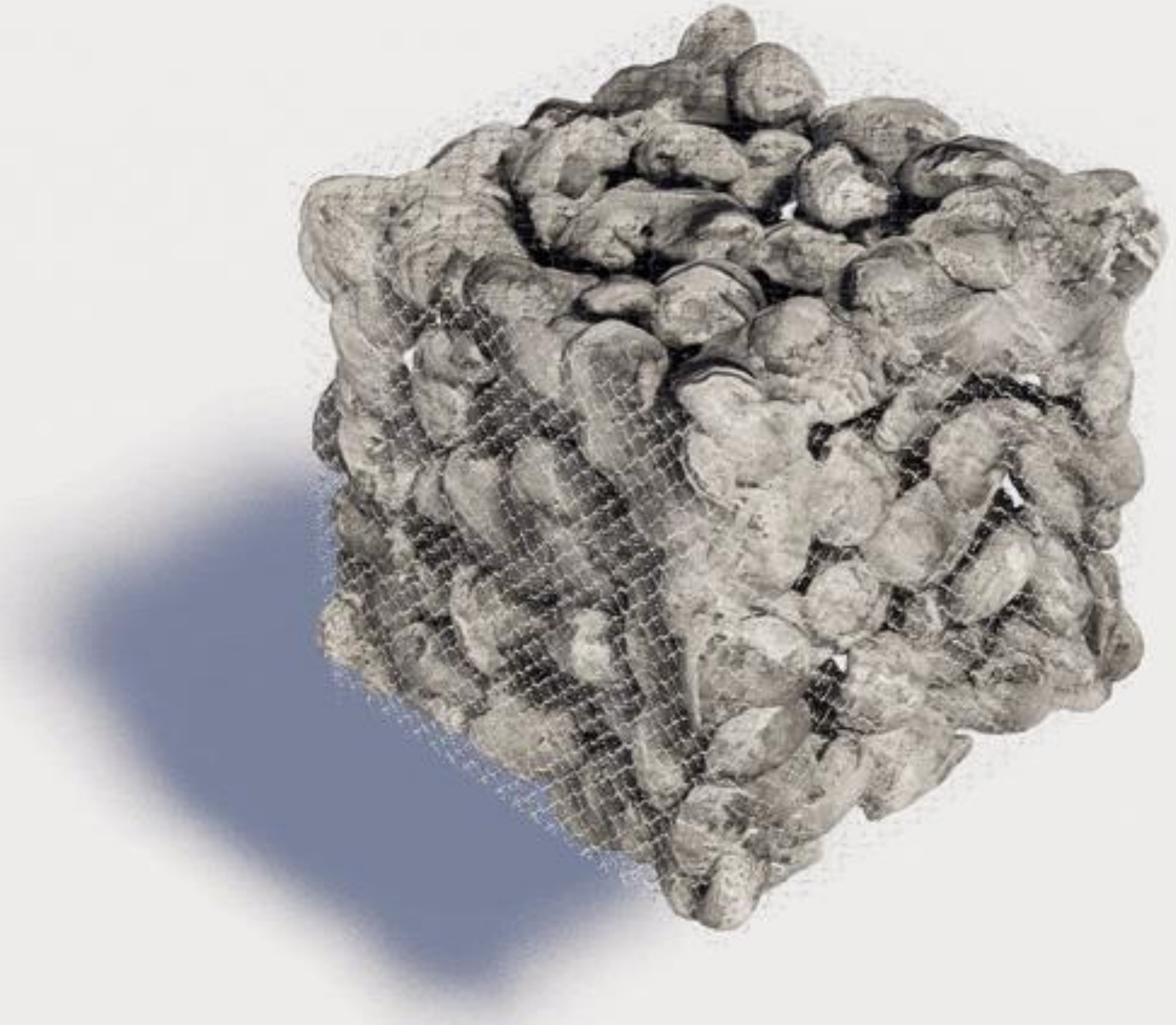
Placement Strategy: Continuous placement along the entire 250m critical scour zone at the water level.

Function & Mechanism:

- **Energy Dissipation:** unlike concrete, which *reflects* waves (causing scour), the porous gaps absorb wave energy and break the hydraulic force.
- **Drainage:** Allows groundwater to seep out freely, preventing hydrostatic pressure buildup behind the wall.

Landscape Aesthetic Contribution:

- **Texture:** Provides a rough, granular texture that mimics a natural riverbed rather than a smooth, artificial concrete scar.
- **Integration:** Over time, sediment gets trapped in the voids, allowing semi-aquatic plants to grow *out of the rocks*, softening the hard engineering line into a "Green Edge".



Coir Logs (Bio-Rolls)

Material: Compressed coconut fibers wrapped in biodegradable natural netting.
Size: 300mm – 400mm diameter cylinders.
Lifespan: 3–5 years (biodegradable).
Placement: Placed at the toe of the slope, just behind the gabions.
Function & Mechanism:

- **Sediment Trap:** They slow down water velocity, causing sediment to settle and build up a natural "bench" or mini-terrace.
- **Vegetation Substrate:** They act as a nursery medium for riparian plants to take root before the log decays.

Landscape Aesthetic Contribution:

- **Line:** Creates a soft, organic curvilinear definition of the water's edge.
- **Transition:** Acts as a visual buffer between the water and the land, eliminating the harsh visual boundary typical of engineered banks.

Vetiver Grass (Chrysopogon zizanioides)

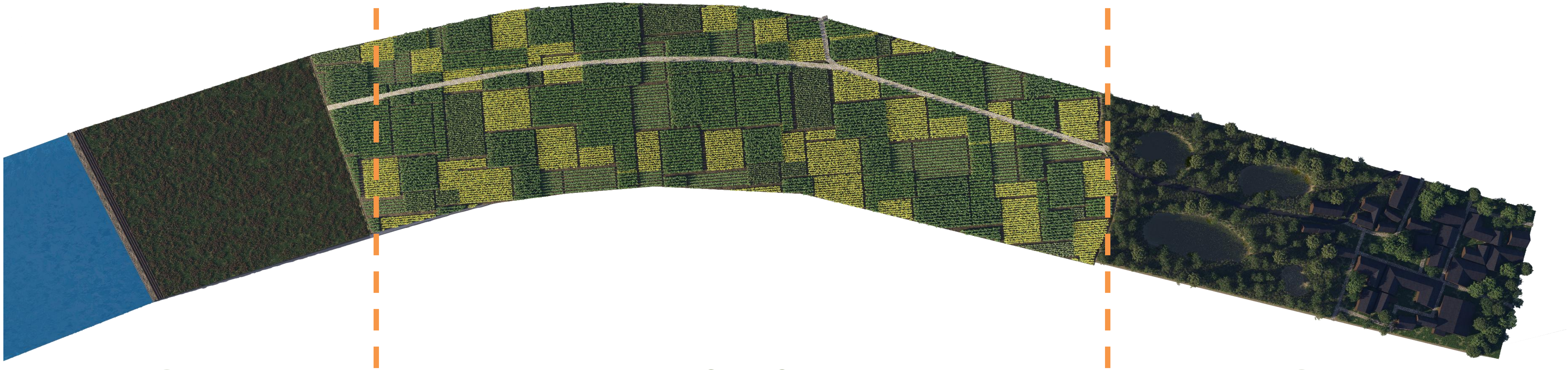
Biological Traits: Sterile (non-invasive), stiff stems, massive root system.
Root Depth: Penetrates 3–4 meters vertically.
Tensile Strength: Average root strength of 75 MPa (equivalent to 1/6th of mild steel).
Planting Density: Rows spaced 1m apart; 10-15 plants per linear meter.
Function & Mechanism:

- **Deep Anchoring:** The roots act as "living soil nails," crossing shear failure planes and increasing soil shear strength by ~40%.
- **Flow Reduction:** The stiff stems above ground reduce runoff velocity, trapping sediment and preventing sheet erosion.

Landscape Aesthetic Contribution:

- **Form & Rhythm:** Creates defined, vertical green lines that emphasize the contour of the land.
- **Seasonal Interest:** Provides lush green cover year-round, replacing the look of scarred, eroding brown earth with a vibrant living texture.

The Proposed Plan:
Zoned Landscape Strategy



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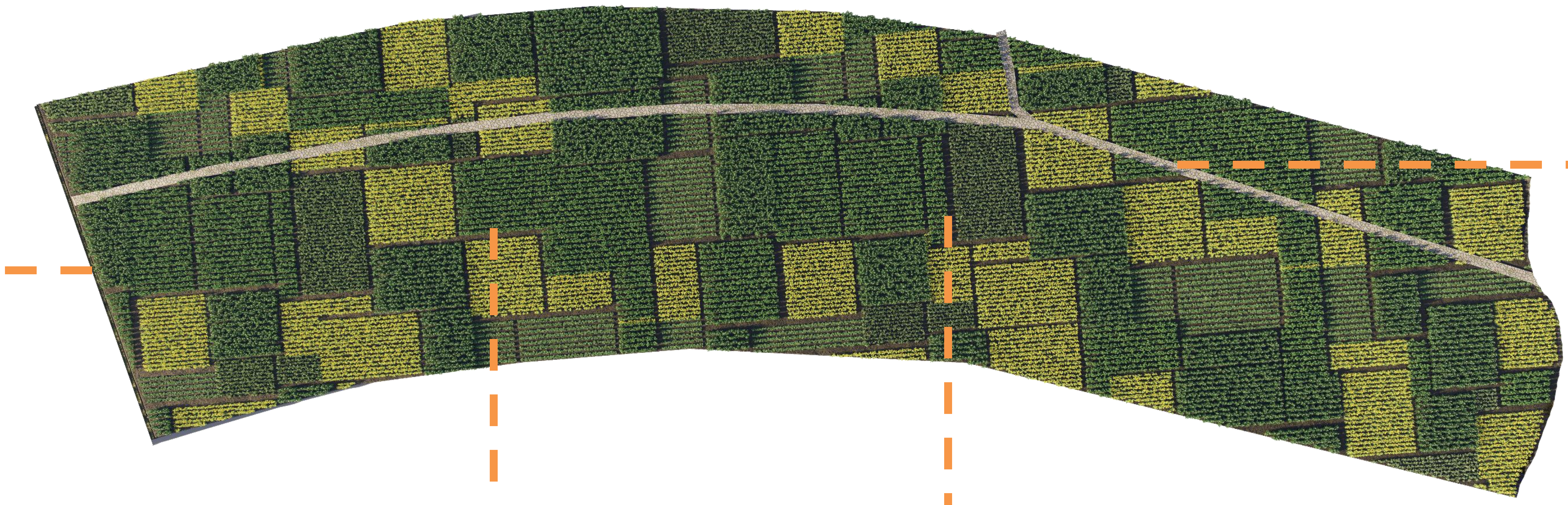
TOE PROTECTION (IN-STREAM) ZONE

ZONE 2
MID-SLOPE ZONE (BANK SLOPE STABILIZATION & FILTRATION)

ZONE 3
TOP BANK / HINTERLAND ZONE (RUNOFF & PORE PRESSURE CONTROL)

ZONE 2

MID-SLOPE ZONE (BANK SLOPE STABILIZATION & FILTRATION)



Permeable Pavement Roads

Live Crib Walls (Logs + Live Branches)

Protected Farming Plots

Check Basin Irrigation System

Live Crib Walls

Construction: Box-like interlocking timber frames (using untreated local hardwood or treated bamboo).

Infill: A mix of local rocks (for weight) and soil (for growth).

Live Material: Live willow or *Dol Kolmi* cuttings layered between the timbers.

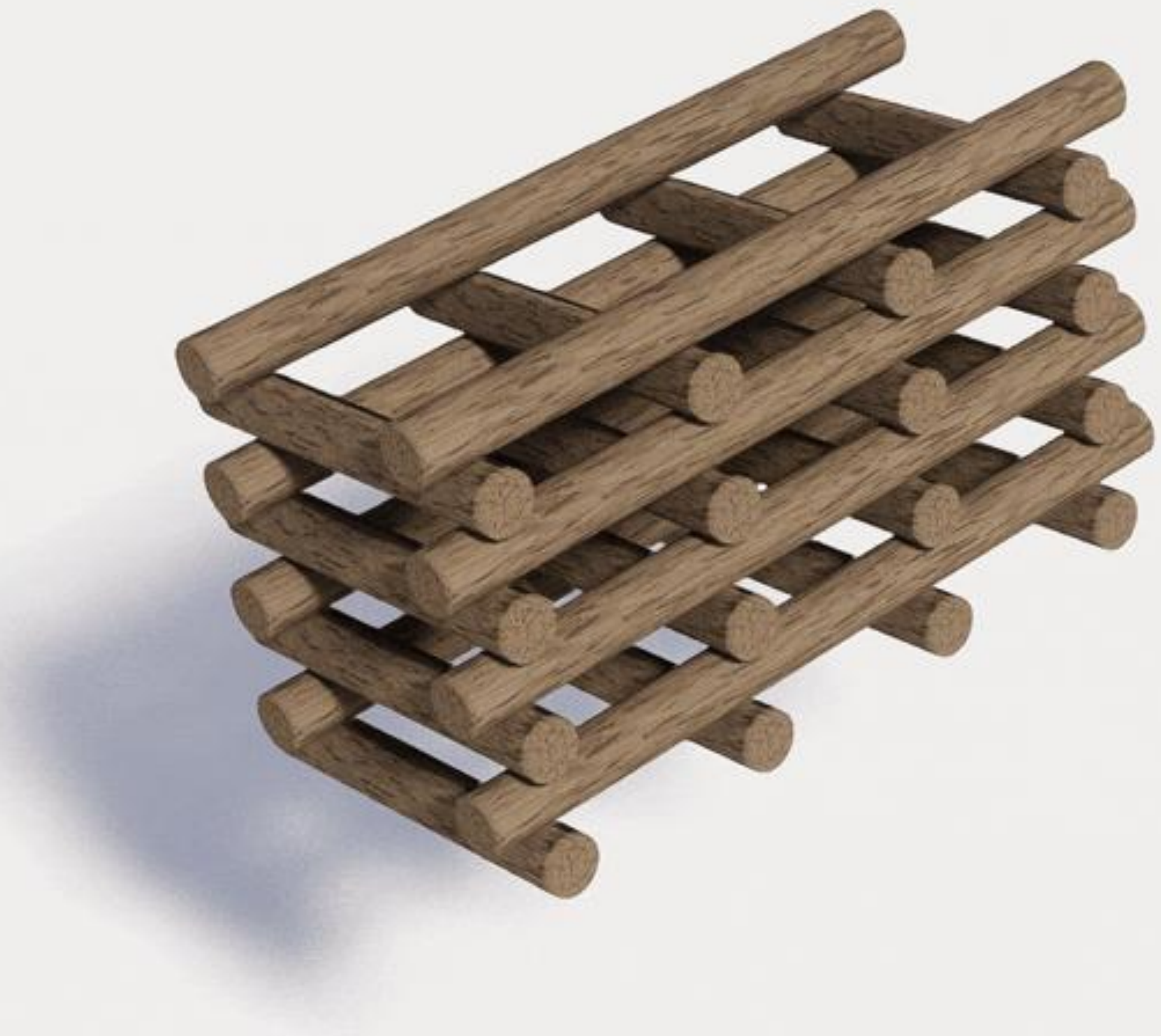
Function: Acts as a gravity retaining wall.

Engineering Mechanism:

- **Mass Stability:** The weight of the rocks provides immediate resistance against sliding.
- **Root Reinforcement:** As the live cuttings grow, their roots bind the fill material to the slope behind it, turning the whole structure into a monolithic block.

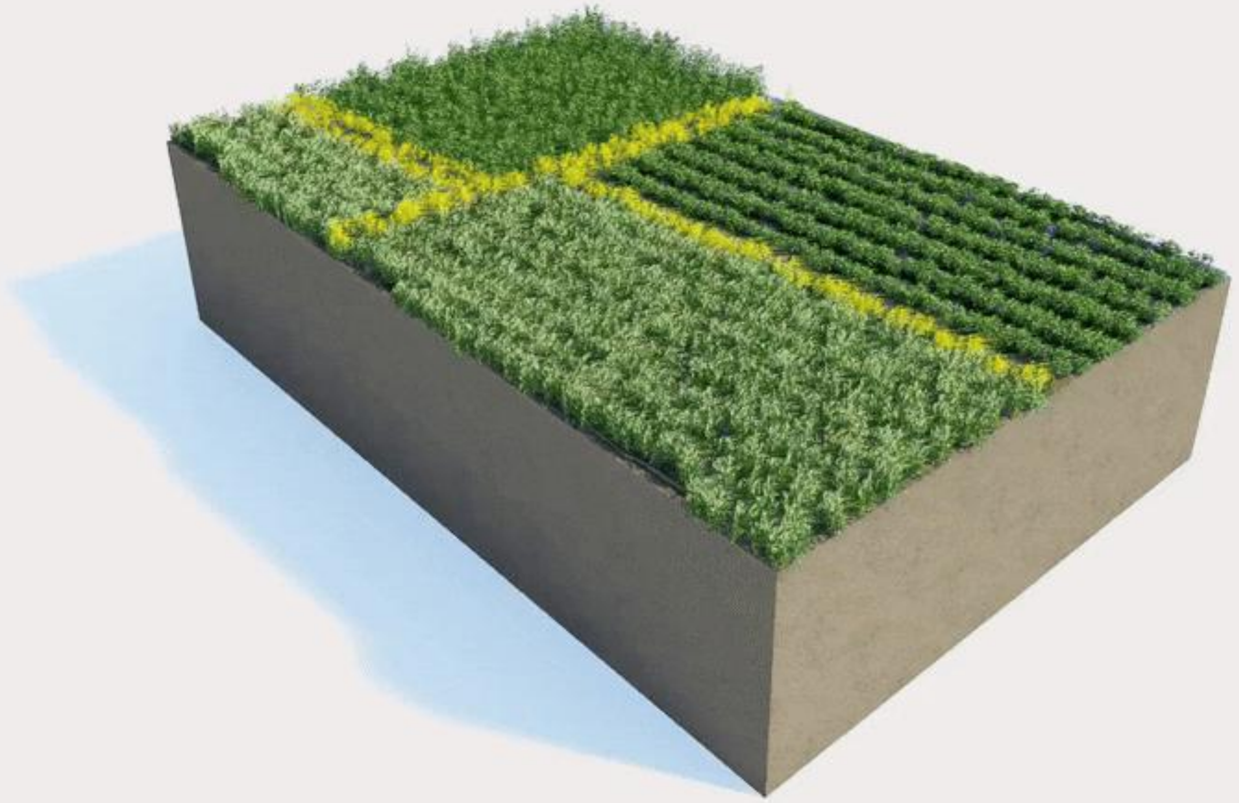
Landscape Aesthetic Contribution:

- **Form:** Provides a rustic, structural definition to the slope, breaking up the verticality.
- **Transformation:** Starts as a "wooden structure" but evolves into a "green living wall" within 1-2 seasons, blending engineering with nature.



Protected Farming & Check Basins

Technique: "Micro-catchment" agriculture.
Design: Small earthen bunds (15-20cm high) built around individual planting pits or rows.
Crops: Low-tillage crops (like lentils or vegetables) rather than deep-ploughing crops that disturb the soil.
Engineering Mechanism:
Runoff Interception: The basins trap rainwater *in situ*, preventing it from gaining velocity and turning into sheet flow.
Soil Moisture: Increases soil moisture retention, reducing the need for irrigation, which can destabilize slopes.
Landscape Aesthetic Contribution:
Texture & Pattern: Creates a quilt-like pattern on the landscape, showcasing the productive capability of the land.
Cultural Harmony: Preserves the agrarian identity of the village while making it safe, showing that "protection" doesn't mean "abandoning agriculture.



Permeable Pavement Roads

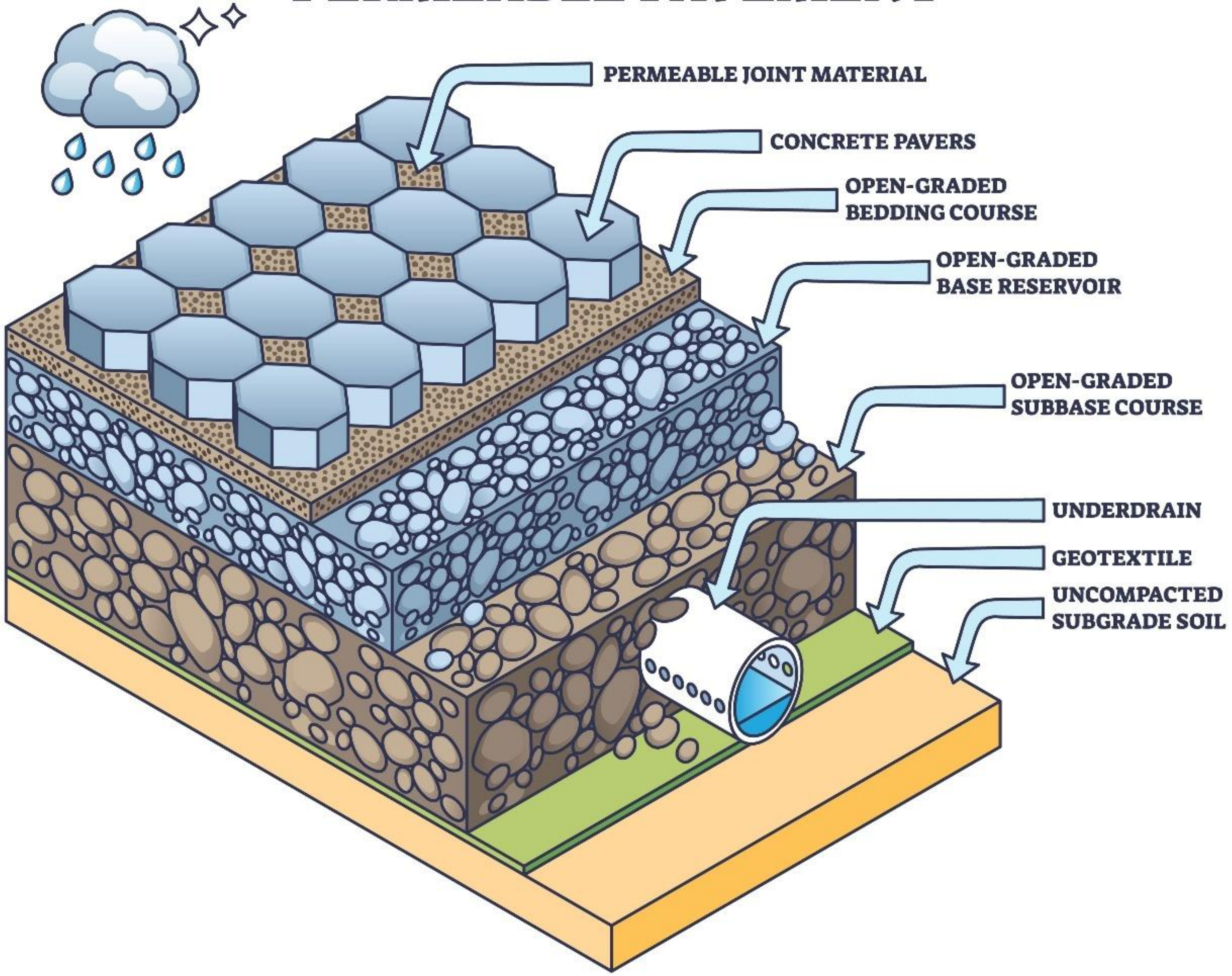
Load Bearing: Capable of supporting light village traffic (vans, rickshaws).
Permeability: 100% surface infiltration capacity.
Base Layer: No fines, concrete, or coarse aggregate to store water underneath.
Engineering Mechanism:

- **Source Control:** Stops runoff *before* it starts.
- **Groundwater Recharge:** Replenishes the local aquifer directly rather than losing water to the river.

Landscape Aesthetic Contribution:

- **Integration:** Blends the road into the green fields. It doesn't look like a "highway" cutting through a village; it looks like a sturdy path within nature.
- **Rhythm:** The grid pattern creates a sense of order and direction.

PERMEABLE PAVEMENT



The Proposed Plan:
Zoned Landscape Strategy

ZONE 1
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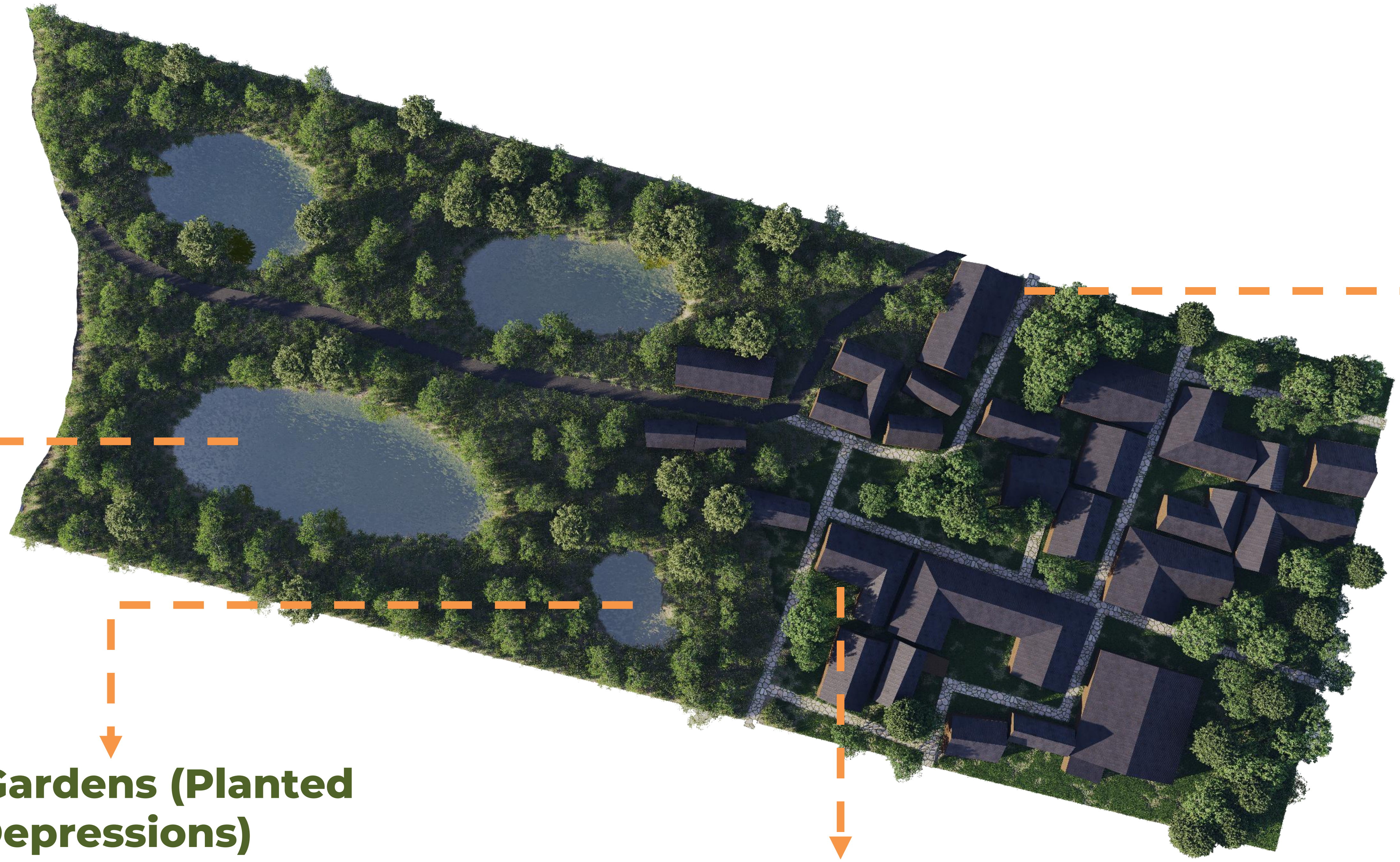


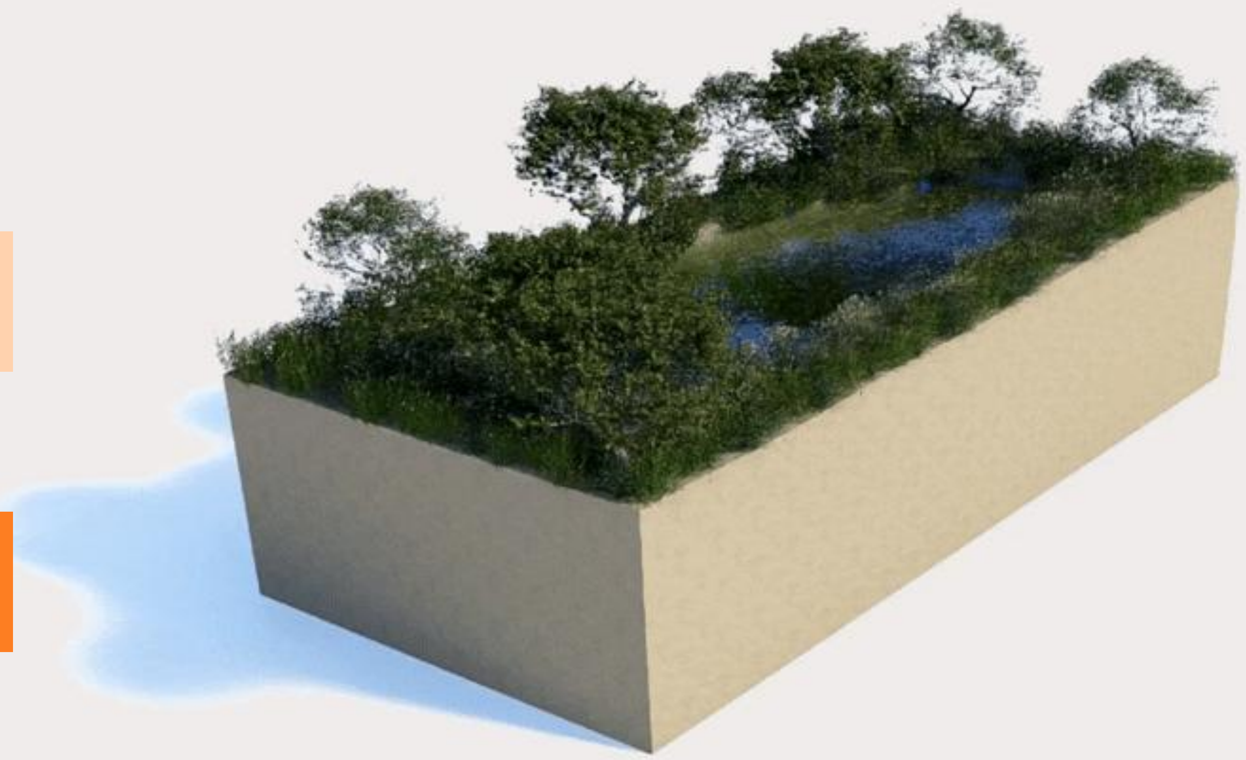
Retention Ponds

Depth: 15m – 20m (permanent pool + temporary flood storage).
Lining: Clay-lined bottom (natural) to allow slow seepage but hold water during dry spells.
Capacity: Designed to hold the "First Flush" of heavy monsoon rains (approx. 20-30% of surface runoff).
Engineering Mechanism:

- **Peak Flow Reduction:** Acts as a buffer tank. It holds the sudden rush of floodwater and releases it slowly, preventing the "hydraulic hammer" effect on the riverbank.
- **Sediment Settling:** Allows silt to settle out before water moves toward the river.

Landscape Aesthetic Contribution:

- **Reflective Surface:** Introduces the element of "Still Water" (serenity) contrasting with the "Moving Water" of the violent river.
- **Focal Point:** Acts as a community gathering space (Ghat) during the dry season.



Rain Gardens with Native Reeds

Plant Selection: Native wetland species that can survive both waterlogging (monsoon) and drought (winter).

Soil: Amended soil (sand/compost) to increase infiltration rate to >50mm/hr.

Engineering Mechanism:

- **Bio-filtration:** The dense root mats of reeds filter out pollutants (nitrates/phosphates) from household wastewater before it infiltrates.
- **Evapotranspiration:** The broad leaves of Canna plants pump excess water into the air, actively drying out the saturated soil.

Landscape Aesthetic Contribution:

- **Color:** *Canna* provides bright red/yellow flowers, adding vibrancy to the green/brown palette.
- **Soft Texture:** The swaying reeds add movement and softness to the landscape, contrasting with the hard paved areas.

Drainage Swales

·**Geometry:** Trapezoidal or parabolic shape (gentle slopes, easy to mow/cut grass).
·**Gradient:** 1-2% longitudinal slope to guide water slowly to the Retention Pond.
·**Vegetation:** Short turf grass or creeping vines.
·**Engineering Mechanism:**
·**Conveyance:** Moves excess water away from house foundations without causing erosion (unlike concrete drains which speed up water).
·**Roughness:** The grass increases friction, slowing down the water velocity.
·**Landscape Aesthetic Contribution:**
·**Line:** Acts as a "Green Ribbon" connecting different houses to the central pond.
·**Soft Engineering:** Replaces open, smelly concrete drains with green, walkable depressions that are visually unobtrusive.

CONCLUSION

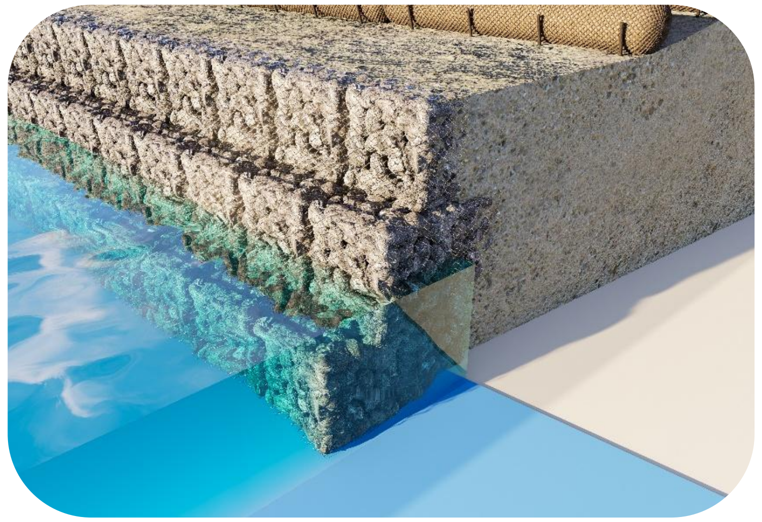
Expected Outcome & Replicability

By implementing this framework, we achieve two things:

- **Ecological:** We reduce erosion velocity and restore riparian habitats.
- **Socio-Economic:** We protect the 20 bighas of annual loss, securing livelihoods and stopping the cycle of debt.

Most importantly, this is a **Replicable Model**. This zoning strategy, protecting the toe, stabilizing the slope, and sponging the hinterland, can be adapted to any riverbank in Bangladesh facing similar threats.





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THANK

YOU!

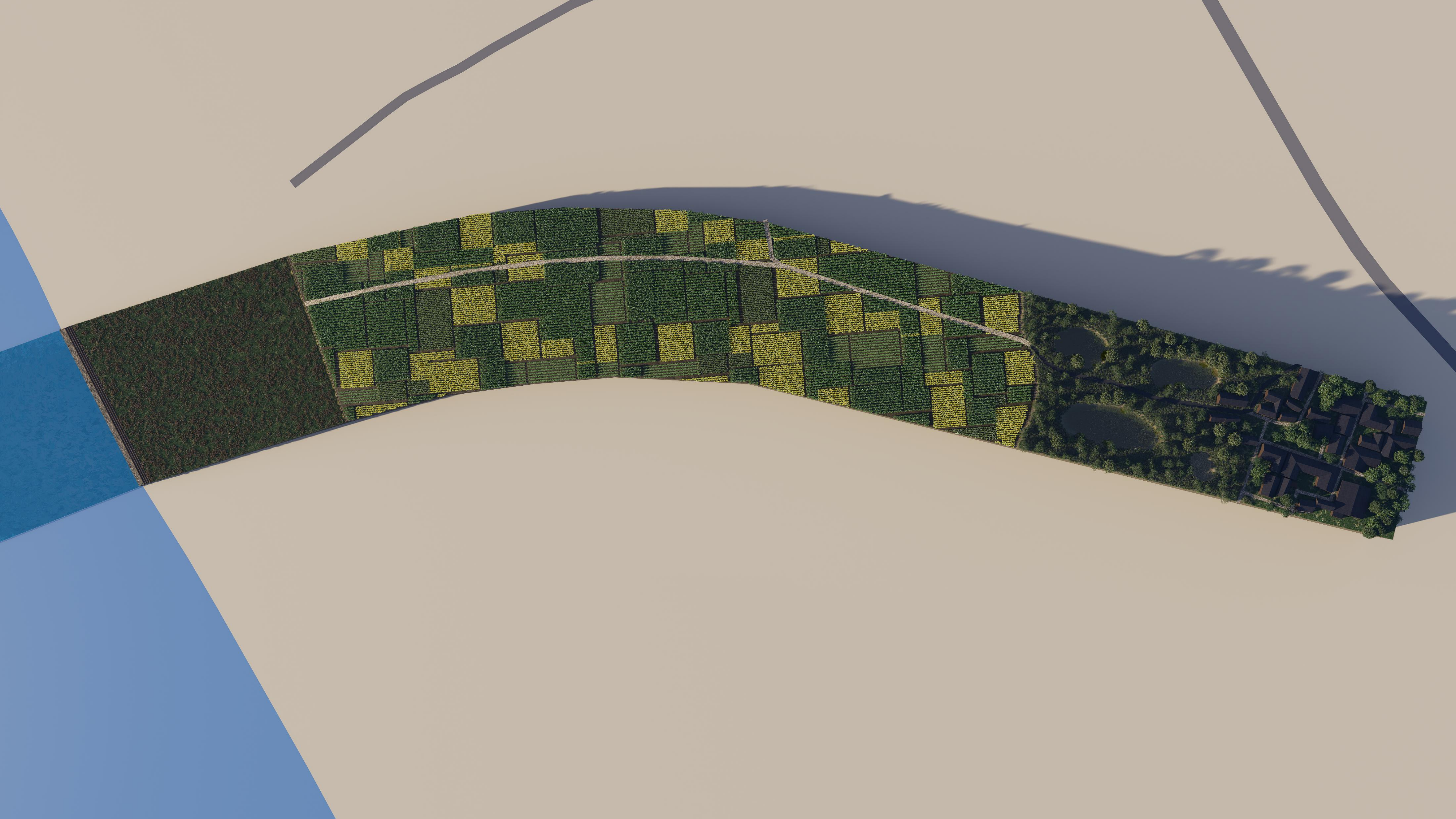
APPENDIX

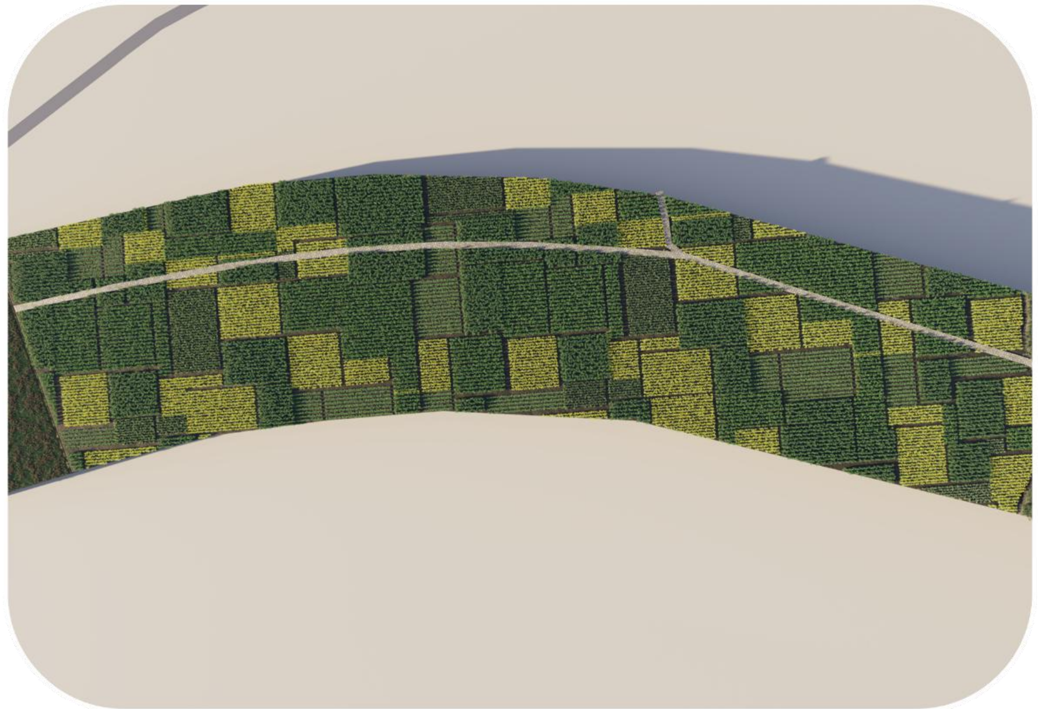
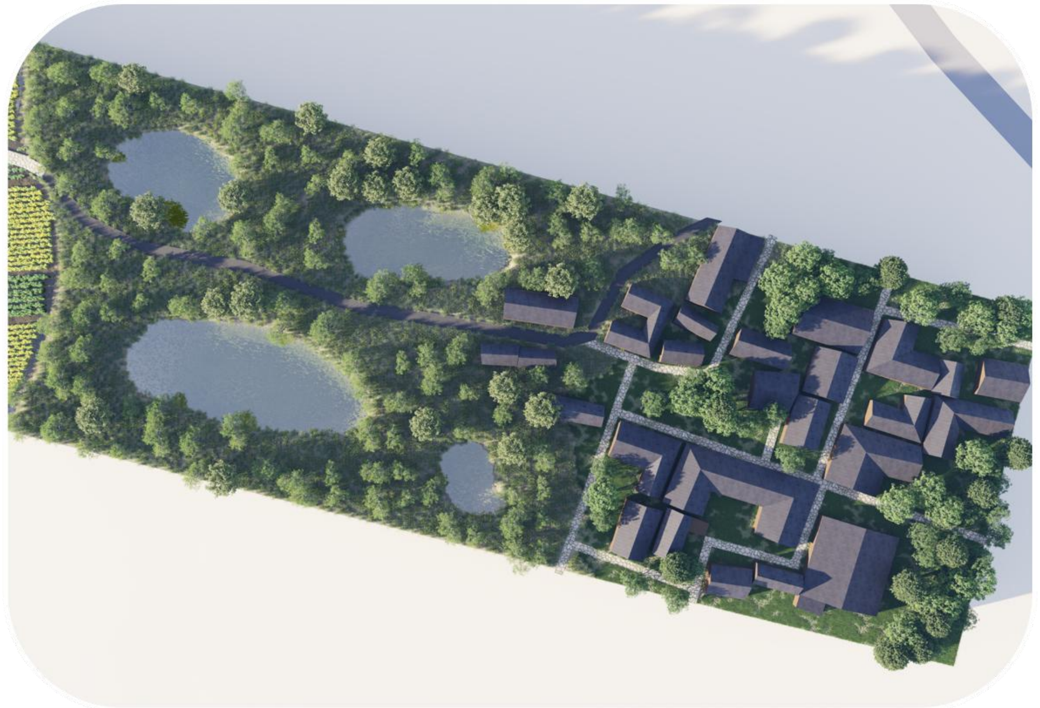
ELEVATION

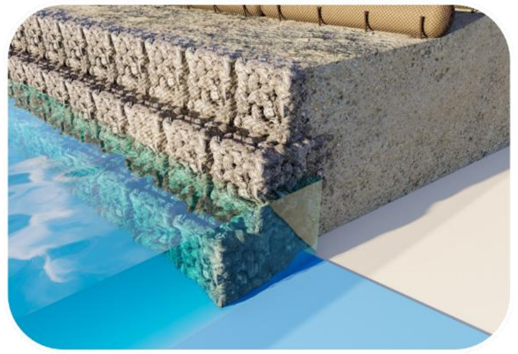
Cost Difference

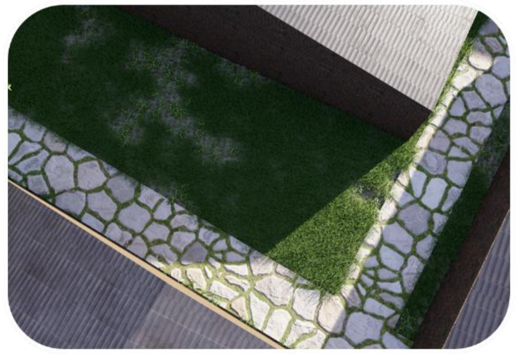
Function / Zone	Concrete (Hard Engineering) Element	Cost (BDT)	Nature-Based / Sponge City Element	Cost (BDT)
Toe protection (in-stream)	RCC concrete toe wall	18,000 – 25,000 / m	Wire gabions with local rock	14,000 – 18,000 / m
	Concrete apron / slab	45,000 – 65,000 / m	Coir logs (coconut fiber rolls)	1,200 – 1,800 / m
	Sheet pile / rigid toe (optional)	80,000 – 120,000 / m	Live crib walls (logs + live stakes)	6,000 – 9,000 / m
Slope protection (mid-slope)	Concrete block revetment	30,000 – 45,000 / m	Vetiver grass plantation	400 – 600 / m
	Cement mortar jointing	3,000 – 5,000 / m	Bamboo fascines & stakes	1,200 – 2,000 / m
	Sand + geotextile filter layer	6,000 – 9,000 / m	Terraced earthen bio-swales	2,500 – 4,000 / m
Top bank / runoff control	Impervious concrete pavement	2,500 – 3,500 / m^2	Rain gardens	600 – 1,000 / m^2
	Concrete drain / chute	4,000 – 6,000 / m	Permeable pavement (brick lattice)	1,200 – 1,800 / m^2
	RCC storage structure	1,200 – 1,800 / m^3	Retention ponds / check basins	300 – 500 / m^3
Maintenance (5–10 yrs)	Crack repair, toe failure	8,000 – 15,000 / m	Vegetation upkeep & replanting	1,000 – 2,000 / m

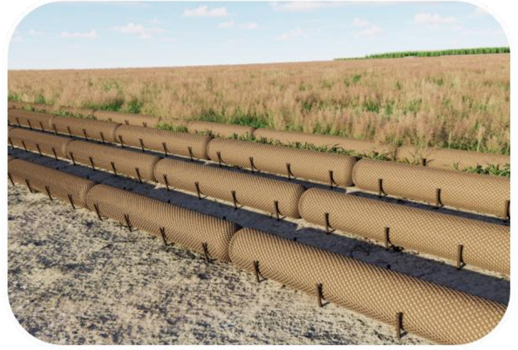
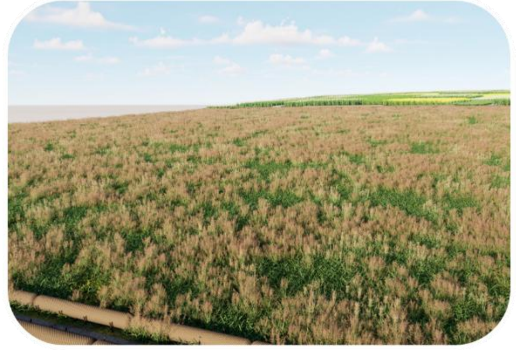
Concrete structures cost 2–5 times more than Nature-Based Solutions, yet **fail faster in dynamic rivers like the Padma**







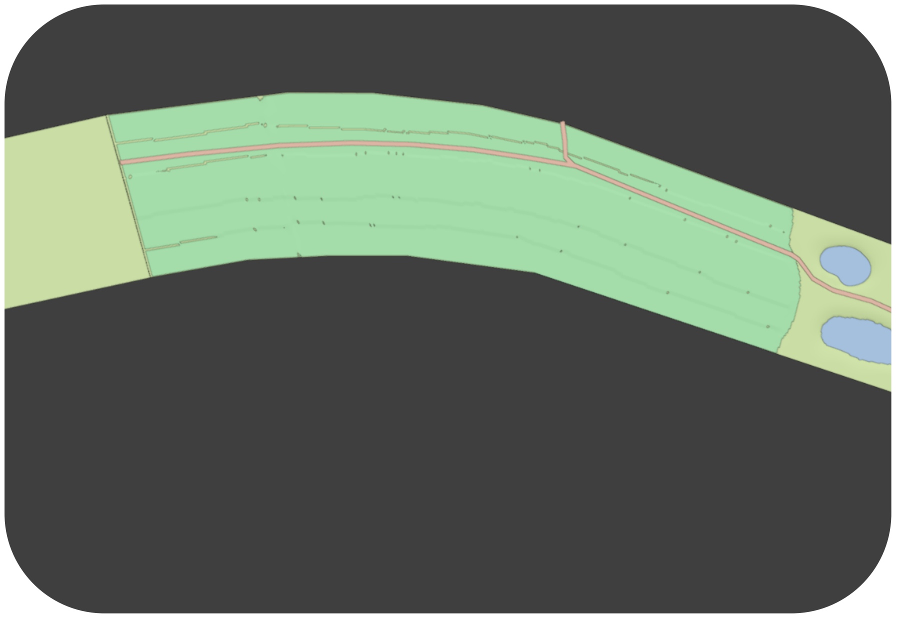



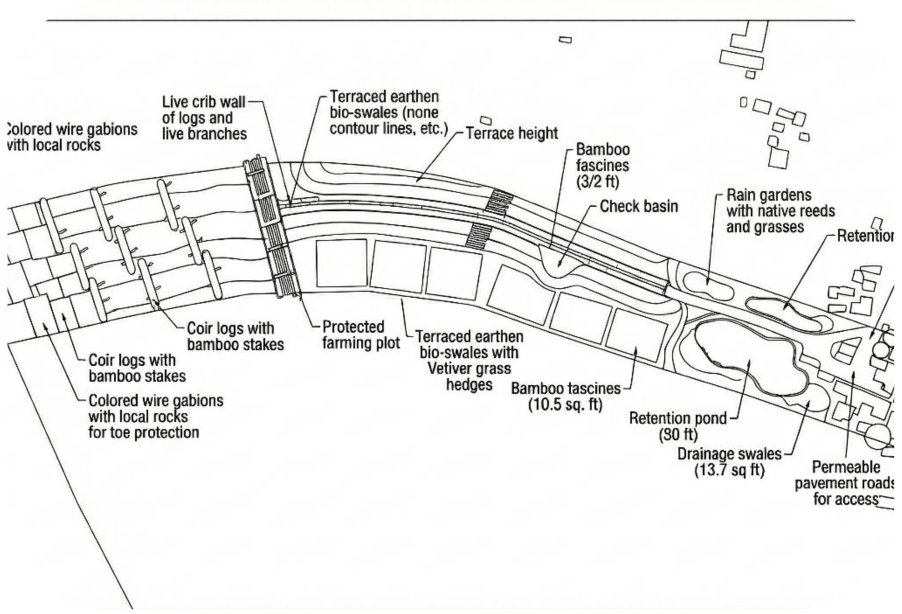


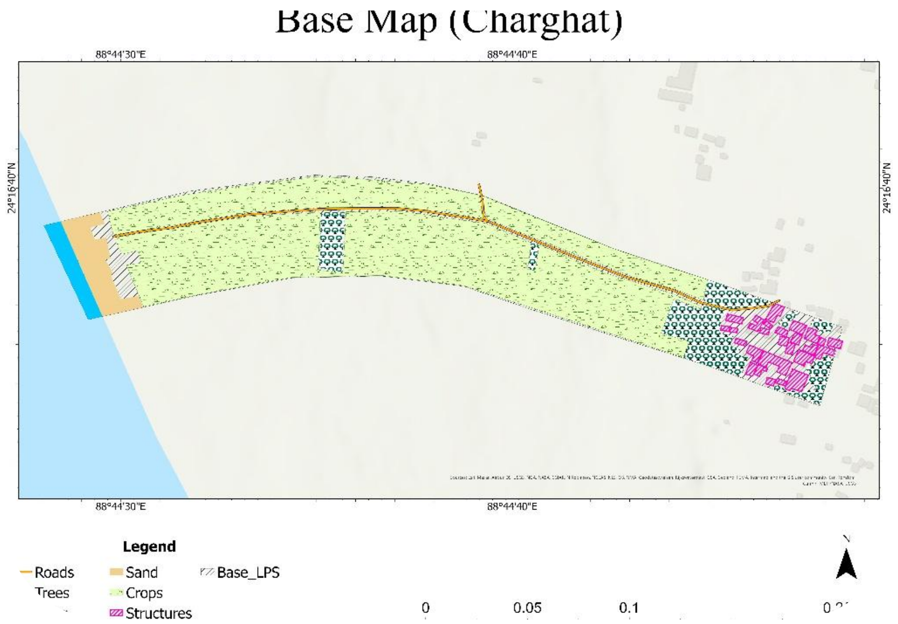







Colored wire gabions with local rocks
Live crib wall of logs and live branches
Terraced earthen bio-swales (none contour lines, etc.)
Terrace height
Bamboo fascines (3/2 ft)
Check basin
Rain gardens with native reeds and grasses
Retention
Coir logs with bamboo stakes
Protected farming plot
Coir logs with bamboo stakes
Colored wire gabions with local rocks for toe protection
Terraced earthen bio-swales with Vetiver grass hedges
Bamboo tascines (10.5 sq. ft)
Retention pond (50 ft)
Drainage swales (13.7 sq ft)
Permeable pavement roads for access


Base Map (Charghat)
Legend
Roads
Trees
Sand
Crops
Structures
Base_LPS
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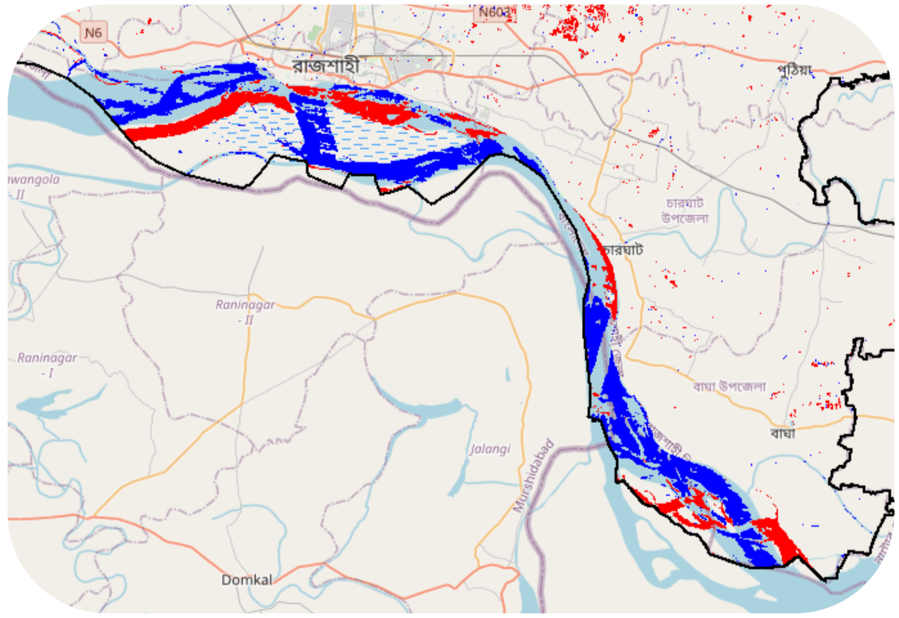
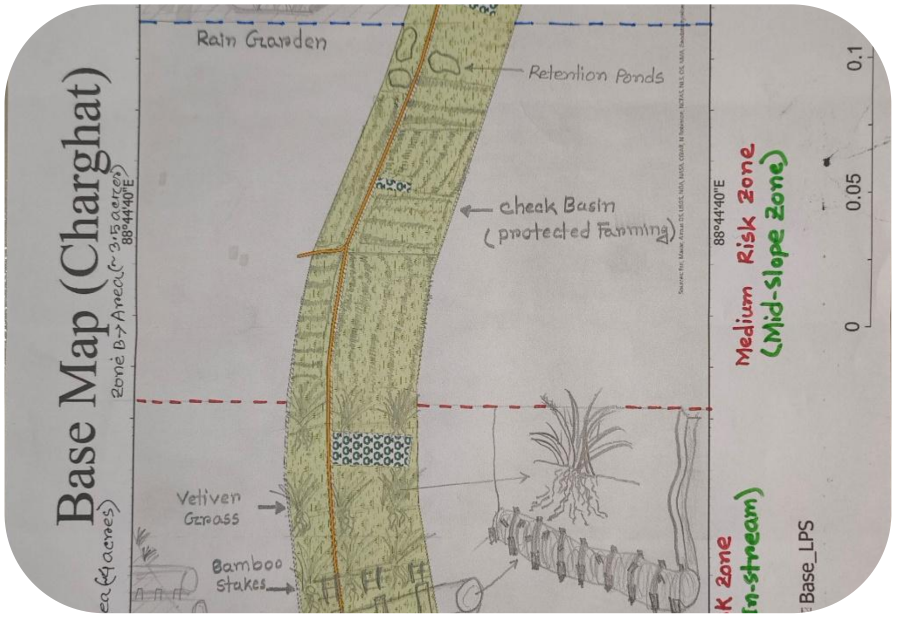
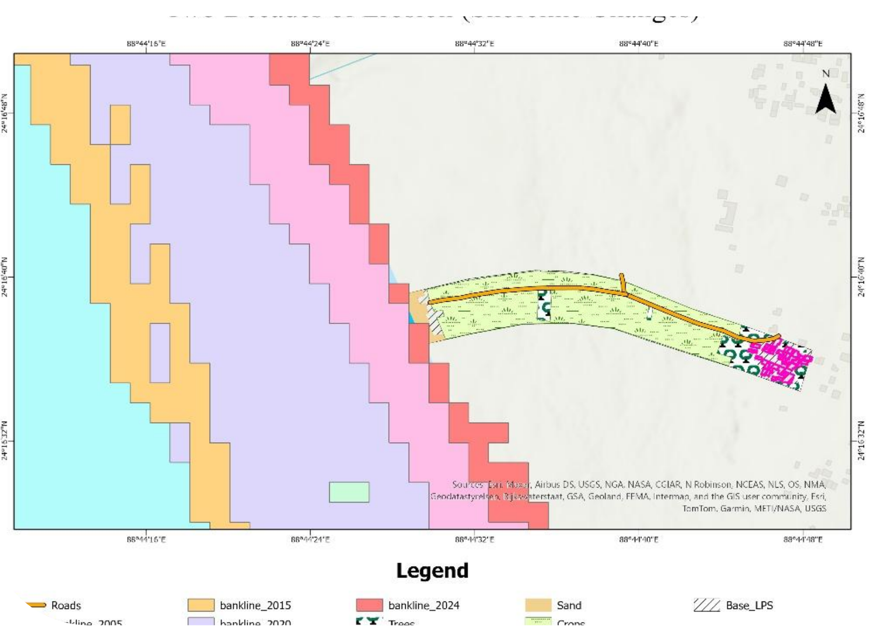

Raninagar
Jalangi
Domkal


Base Map (Charghat)
Rain Garden
Retention Ponds
check Basin
(protected Farming)
Vetiver Grass
Bamboo Stakes
Medium Risk Zone
(Mid-slope Zone)
Base_LPS


Legend
Roads
bankline_2015
bankline_2020
bankline_2024
Trees
Sand
Crops
Base_LPS