Green Strategic Partnership
India-Denmark

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A Report on

Eco-restoration of the Aravalli Landscape

(Executive Summary)

Sankala Foundation

January, 2026

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Voice for a Sustainable Planet

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About the Report

This report presents a summarised version of 'A Report on Eco-restoration of Aravalli Landscape', based on the research conducted by Sankala Foundation in 2025. The research presented a scalable, evidence-based eco-restoration model for the Aravalli Landscape, developed through integrated ecological, geospatial, hydrological and socio-economic assessments. It outlined key degradation drivers and introduced a structured restoration framework featuring strategic units, micro-plans, terrain-specific interventions, native species strategies and blue–green infrastructure. Aligned with the Aravalli Green Wall Project (AGWP), Sankala Foundation's research report offers actionable pathways to strengthen ecological resilience, restore hydrology and enable community-led stewardship across the Aravalli region.

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Front cover: Glimpses of the Aravalli landscape.
Back cover: The natural forest of Mangar Bani, Faridabad.

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Chapter 1

Introduction to Sankala Foundation's eco-restoration initiative

Land degradation and climate stress in a global context

Land degradation has emerged as one of the most pressing environmental challenges of the twenty-first century. Globally, nearly one quarter of the planet's land area is degraded, threatening biodiversity, food security, and the livelihoods of more than three billion people (Fig. 1). Climate change amplifies these pressures through erratic rainfall, prolonged droughts, increased temperatures, and extreme weather events, accelerating soil erosion, habitat loss, and desertification.

Global assessments by the Intergovernmental Panel on Climate Change (IPCC) and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) highlight a systemic decline in terrestrial ecosystems. Forests, drylands, grasslands, wetlands, and mountains—many of which are already fragile—are experiencing degradation at unprecedented rates. As ecological integrity erodes, so too does the capacity of these landscapes to regulate climate, stabilise soils, store carbon, and sustain communities. Against this backdrop, landscape-level ecological restoration has gained prominence as a scientifically robust and climate-resilient response. Eco-restoration not only rebuilds ecosystems, but also strengthens community resilience, water security, and climate adaptation pathways.

Land Degradation and Desertification: India's context

India faces significant land degradation and desertification challenges, with nearly 30 per cent of its geographical area affected. The National Action Plan to Combat Desertification (NAPCD) identifies unsustainable land use, invasive species, mining, deforestation, and water stress as the principal drivers of ecological decline.

Figure 1: Global burden of land degradation and restoration targets showing populations affected, migration risks, and restoration goals based on IPBES (2019) and UNCCD estimates

Dryland regions, in particular, are highly vulnerable. Erratic monsoons, groundwater depletion, shifting cultivation patterns, and rising temperature extremes weaken India's environmental stability. Forest loss, fragmentation, and habitat degradation have contributed to regional biodiversity collapse and hydrological imbalance.

Over the past decade, the Government of India has strengthened its commitment to land restoration through the Bonn Challenge, United Nations Convention to Combat Desertification (UNCCD) Land Degradation Neutrality (LDN) targets, and the Green India Mission. Yet the pace of ecological decline—combined with pressures of urbanisation, industrial expansion, and resource extraction—demands more ambitious, data-driven, and community-anchored approaches.

Aravalli landscape, the ecological backbone of north-western India

Stretching across Gujarat, Rajasthan, Haryana, and the National Capital Territory of Delhi, the Aravalli range represents one of the world's oldest mountain systems—estimated to be over 2.5 billion years old. This ancient ridge forms the ecological spine of north-western India, moderating climate, regulating water flows, and acting as a natural barrier against the eastward expansion of the Thar Desert (Fig. 3).

The Aravalli range supports a mosaic of ecological habitats, including dry deciduous forests, scrublands, grasslands, wetlands, and rocky outcrops, sustaining hundreds of plant and animal species. It hosts more than 400 plant species, 200 bird species, and numerous mammals, including several species protected under the Wildlife (Protection) Act, 1972 (Gaury and Devi, 2017). Hydrologically, the Aravalli range maintains several river systems and contribute significantly to groundwater recharge. Forested ridges reduce surface run-off, enhance percolation, and stabilise catchments. These functions are particularly critical in the National Capital Region (NCR), where the range mitigates heat island effects and improves air quality by reducing dust loads (Fig. 2).

Socio-economic and cultural significance of the Aravalli range

The Aravalli range has shaped human civilisation for millennia. Evidence from archaeological sites demonstrates the presence of early Harappan settlements, supported by mineral-rich geology and perennial water sources. Over centuries, communities have depended on the mountain range for fodder, fuelwood, traditional medicines, and pasture.

The range today sustains one of India's largest livestock populations, supporting rural livelihoods through dairy

Water recharge system – 17 rivers/rivulets, 4 Ramsar sites

Habitat for endangered species– 22 Wildlife sanctuaries and 4 Tiger Reserves (Great Indian Bustard, Tigers, Leopards, Wolves, Vultures)

Foster biodiversity and regulates micro-climate, rainfall and control droughts

Provide vital resource– fuelwood, fodder, medicinal plants, commercial products

Supports 56.5 million livestock, largest in India

Mines and mineral (70 different mineral, 67 commercially exploited)

Major Industrial hub

Tangible and intangible cultural resources– UNESCO World heritage sites

Figure 2: Ecological Importance of the Aravalli range

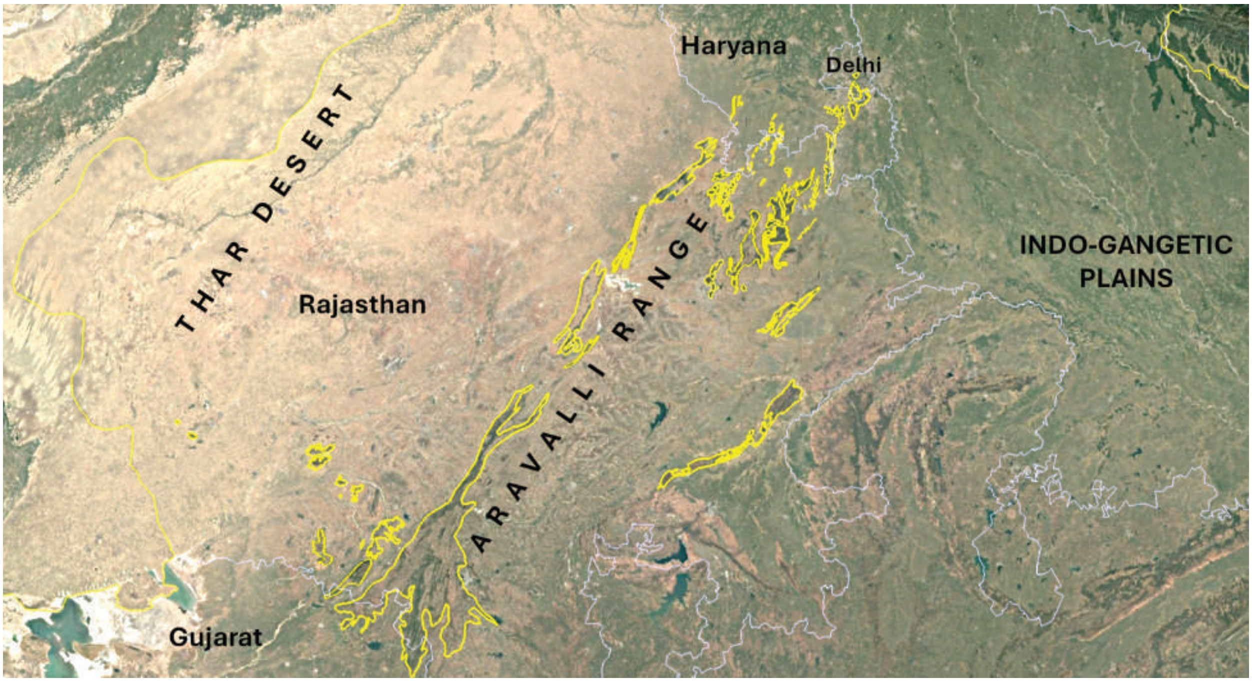


Figure 3: Google earth image showcasing the Aravalli range in northwestern India, stretching across Gujarat, Rajasthan, Haryana, and Delhi

and mixed farming systems. Rainfed agriculture across the range relies heavily on the microclimatic stability and soil productivity maintained by these forests.

Culturally, the Aravalli's are home to numerous spiritual and pilgrimage sites such as, the holy pond of Pushkar, Ajmer Sharif, Ranakpur, Mount Abu—reflecting centuries of sacred associations. These cultural landscapes enhance local stewardship and provide a foundation for community-led conservation.

Degradation and emerging threats in the Aravalli range

Despite their significance, the Aravalli's have faced decades of ecological degradation driven by anthropogenic and climatic pressures. Despite their immense ecological significance, the Aravalli hills have undergone extensive degradation over several decades, as highlighted in the MoEFCC Detailed Action Plan (2025).

Widespread deforestation, unregulated mining, encroachment, overgrazing, and rapid urbanisation have fragmented habitats and eroded the natural barrier function of the range.

The weakening of this barrier has allowed desert sands to drift eastwards through identified gaps, accelerating desertification across Rajasthan and Haryana. The 'Detailed Action Plan (DAP) for the Aravalli Landscape Restoration (Aravalli Green Wall)', published by MoEFCC further notes that declining canopy cover, invasive plant proliferation, disrupted hydrology, and soil erosion have collectively impaired the Aravalli's role in groundwater recharge, climate regulation, and biodiversity connectivity (Fig. 4).

Urban pressures along the Delhi–Gurugram–Faridabad belt, coupled with the misclassification of ecologically sensitive ridges as 'wastelands', have intensified environmental stress. These compounded threats underscore the urgent need for a coordinated, multi-state, science-led restoration strategy across Gujarat, Rajasthan, Haryana, and the National Capital Territory of Delhi, as envisioned in the Aravalli Green Wall framework.

Legal and policy framework governing the Aravalli range

The Supreme Court of India has played a pivotal role in safeguarding the ecologically vital Aravalli range through decades of landmark judgments. Beginning with 'M.C. Mehta v. Union of India' (1987–2004) and reinforced in the ongoing 'T.N. Godavarman' case (1996 onwards), the Court invoked the precautionary principle, expanded the definition of 'forest', and imposed sweeping mining bans across Haryana, Rajasthan, Delhi, and Gujarat. Key orders halted mining in 2002, extended bans in Haryana (2009), mandated native-species restoration, and established continuous oversight by the Central

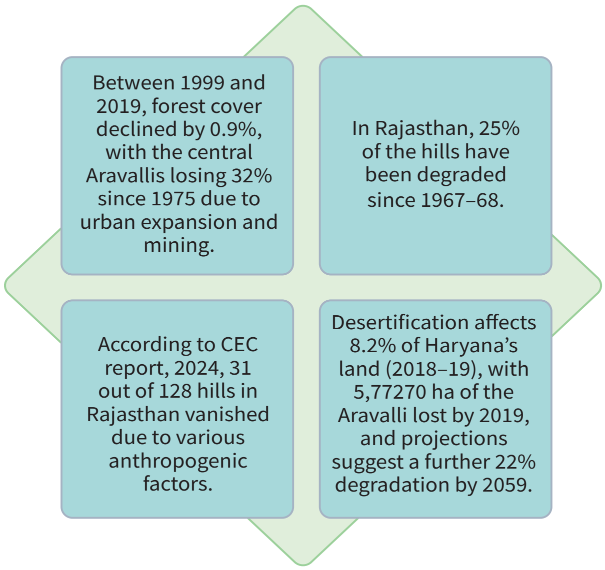


Figure 4: Desertification and degradation in the Aravalli landscape

Empowered Committee. Despite state-level watershed programs, tiger reserve protections, and community-led efforts showing recovery potential, dense forest cover has significantly declined in districts like Udaipur, Banaskantha, and Sabarkantha (1999–2021). Recent 2024–2025 rulings continue to deny mining relaxations, demand uniform Aravalli demarcation, and direct immediate demolition of illegal encroachments (6,793 structures identified in Haryana alone).

On 20 November 2025, the Supreme Court accepted the MoEFCC committee's recommendation defining, as part of an interim, uniform framework to guide regulation and management.The Court also directed MoEFCC, through ICFRE, to prepare a Management Plan for Sustainable Mining (MPSM) for the entire Aravalli system across Gujarat, Rajasthan, Haryana, and Delhi-NCR. Aravalli hills as landforms with more than 100 m elevation above local relief, with clusters within 500 m recognised as an Aravalli range. Until this plan ensures sustainable resource use and safeguards ecosystem integrity, the Supreme Court has stopped the issuance of all new mining leases in the Aravalli hills. This direction marks a significant step towards protecting the ecological stability of the region and strengthening long-term restoration efforts such as the Aravalli Green Wall.

These directives underscore that ecological integrity remains non-negotiable, highlighting the urgent need for coordinated, science-based restoration and long-term stewardship.

Subsequently, by order dated 29 December 2025, the Supreme Court kept the operative portions of its 20 November 2025 directions in abeyance and directed a fresh high powered review of the definition and demarcation of the Aravalli hills and ranges.

Across nearly four decades, more than 15 Supreme Court directives have reinforced core environmental principles: the precautionary, polluter-pays, and inter-generational equity principles. The establishment of the Central Empowered Committee (CEC) and subsequent involvement of the National Green Tribunal (NGT) have institutionalised judicial monitoring of reclamation and compliance. Orders mandating satellite-based demarcation and submission of progress reports ensure transparency and accountability.

While violations persist, judicial vigilance has prevented irreversible ecological loss and compelled executive action. The Court's jurisprudence positions ecological protection as integral to the constitutional right to life under Article 21, thereby embedding environmental stewardship within India's legal framework. In synergy with policy initiatives like the Aravalli Green Wall, these rulings collectively constitute a powerful foundation for long-term restoration and governance of the Aravalli landscape.

The need for a landscape-level eco-restoration approach

Despite its vital importance, the Aravalli landscape has been severely degraded by decades of deforestation, illegal mining, uncontrolled grazing, and rapid urbanisation. This degradation stems from unsustainable practices driven by short-term gains. At the same time, global assessments show that restoration offers strong economic value: inaction can cost more than three times the cost of restoration, while well-planned measures can yield benefits up to ten times the investment (IPBES, 2018).

Consequently, eco-restoration is not only ecologically imperative but also economically prudent, while supporting the preservation of indigenous knowledge and cultural practices. The concept of land ethics, deep ecology and ecological civilization also provides intensive needs to ecologically restore the Aravalli's. Given the scale of degradation, fragmented governance, and rising ecological pressures, isolated or piecemeal interventions are no longer adequate. Restoration must be:

- **At landscape-scale**, integrating forests, scrublands, wetlands, agriculture, and habitation areas;
- **Data-driven**, grounded in baseline analysis and spatial diagnostics;
- **Community-anchored**, ensuring local ownership and livelihood linkages;
- **Multi-disciplinary**, combining ecological science, traditional knowledge, and innovative practices;
- **Institutionally integrated**, aligning state and national frameworks.

Aravalli Green Wall Project: Need of the hour

A coherent, scientifically robust model is essential to regenerate the Aravallis, enhance climate resilience, and secure long-term ecological stability. To combat this, the Aravalli Green Wall Project (AGWP) was inaugurated by the Union Minister for Environment, Forest and Climate Change on the International Day of Forests, as part of the National Action Plan to Combat Desertification and Land Degradation through Forestry Interventions. The initiative forms a crucial component of India's broader effort to combat land degradation and desertification under global conventions.

Objectives of AGWP

The Aravalli Green Wall envisions a 1,400 km-long and 5 km-wide green belt, a buffer around the Aravalli range, extending from Porbandar (Gujarat) to Panipat (Haryana). The initiative aims to:

- Arrest land degradation and curb the eastward expansion of the Thar desert.
- Restore degraded land through afforestation and natural regeneration.
- Act as a dust and pollution barrier for north-western India.
- Enhance biodiversity, water quality, and carbon sequestration capacity.
- Generate green livelihoods, promote community participation, and contribute to SDG 15: Life on Land.

The first phase targets 8.1 lakh ha of degraded forest and scrubland restoration within a 2.7 million-ha buffer, with a projected investment of ₹16,053 crore. The Haryana Forest Department has committed to restoring 24,990 ha over three years, including 6,063 ha in Gurugram.

Sankala Foundation's Initiatives on Eco-restoration

Against the backdrop of widespread degradation and national restoration commitments, Sankala Foundation conceptualised and initiated the development of a eco-restoration plan for for the Aravalli landscape. The aim of this pilot project is to inspire state and national policy action to restore this critical landscape.

Sankala Foundation's eco-restoration plan

The Sankala Foundation has positioned itself as a dedicated knowledge partner and catalyst for ecological restoration in the Aravalli states. Its initiatives are built on scientific evidence, participatory planning, and multi-stakeholder collaboration.

- **Institutional partnerships and mandate**

  In 2024–2025, Sankala formalised two landmark partnerships:
  - An MOU with the **Embassy of Denmark** in India, enabling technical cooperation; and
  - An MOU with the **Haryana Forest Department**, recognising the Foundation as a knowledge partner for the AGWP.

These collaborations have strengthened institutional coordination and grounded the initiative within the larger national framework for landscape restoration.

Pilot Studies

The pilot targets 839.80 hectares of degraded forest land across four villages—Gairatpur Bas, Shikohpur, Sakatpur, and Naurangpur over 3408 hectares of land. The overarching goal is to create a scalable model for restoring ecological balance, enhancing biodiversity, and promoting sustainable livelihoods.

The Sankala Foundation's Eco-restoration (SER) Plan provides a science-led, community-driven, and scalable framework that strengthens the AGWP. Using rigorous baselines, spatial analysis, and participatory planning, it enables precise identification of degraded areas and context-specific restoration

- **Project approach and scope**

  Sankala's approach for the project integrates:
  - comprehensive baseline assessments;
  - landscape-level ecological planning;
  - community engagement and capacity building;
  - microplanning for four pilot villages (Gairatpur Bas, Naurangpur, Sakatpur, and Shikohpur);
  - development of restoration techniques tailored to terrain and degradation types;
  - alignment with AGWP, state action plans, and India's national commitments.

Chapter 2

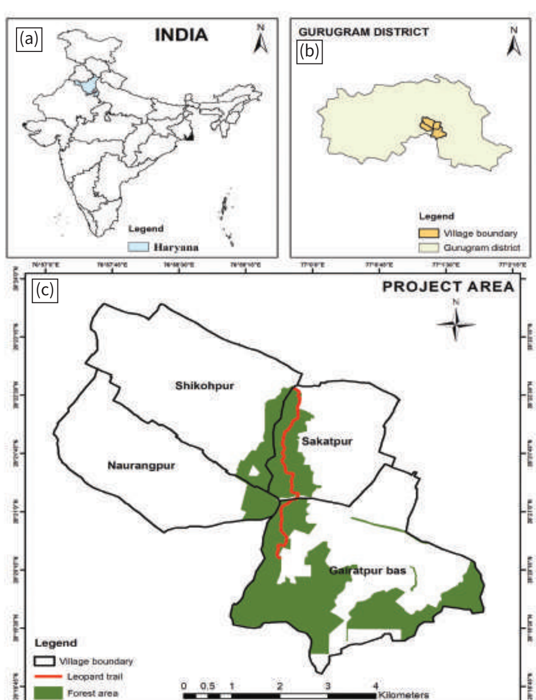
Methodology and key findings

Overview of baseline study approach

A comprehensive baseline assessment was undertaken to understand the ecological, socio-economic and biophysical conditions of the Aravalli landscape across the four project villages—Gairatpur Bas, Naurangpur, Sakatpur and Shikohpur—and their surrounding forest areas (Map 1). The baseline served as the evidence foundation for the eco-restoration plan and was designed to capture the multidimensional nature of degradation, resource dependence, and environmental pressures.

The study followed a **four-pillar approach**, covering:

1. **Ecological and biophysical assessments** – vegetation structure, successional stage, alien-invasive species, habitat quality;
2. **Geospatial analysis** – LULC, NDVI, terrain, drainage, and degradation mapping;
3. **Socio-economic assessments** – household surveys, Focus Group Discussion (FGD)s, key informant interviews;
4. **Hydrological and ecosystem services mapping** – water bodies, recharge zones, catchment areas.



Map 1: (a) Political map of India highlighting the state of Haryana 1(b) A physical map of Haryana with highlighted Gurugram district 1(c) Project area showcasing the leopard trail, in Gurugram District, Haryana

Multiple tools were used, including participatory rural appraisal, transect walks, field measurements, and analysis of satellite imagery. This ensured a holistic understanding of the landscape's current condition and the pressures shaping its ecological health.

Together, these methods provided a comprehensive evidence base against which the current condition of the Aravalli landscape could be assessed, forming the basis for the key findings presented in the following section.

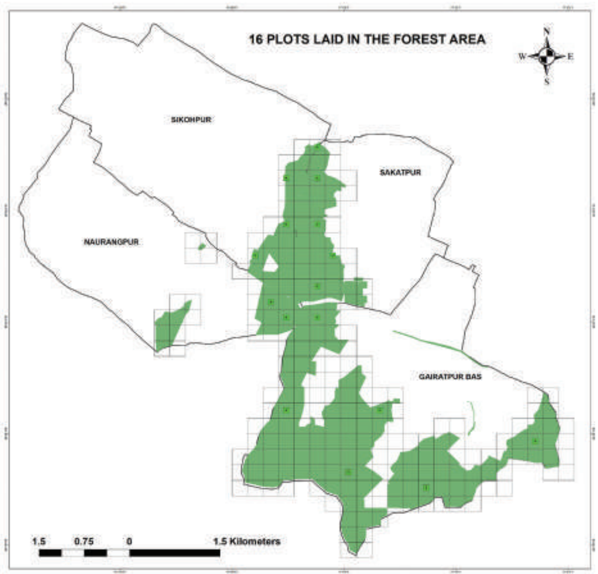
Key findings

Drawing upon the four-pillar methodology outlined above, the baseline assessment generated a clear set of findings that collectively illustrate the ecological, spatial and socio-economic dynamics shaping the project landscape. The findings, presented in alignment with the methodological pillars outlined above, provide an evidence-based understanding of the environmental stressors that the restoration plan must address.

Ecological and biophysical findings

The ecological surveys done on designated plots (Map 2) indicate that the project landscape largely represents an intermediate successional stage, characterised by scattered trees, dense stands of hardy shrubs and widespread colonisation by invasive species. Native late-successional species are sparsely distributed, reflecting both past disturbances and ongoing pressures. Species such as *Prosopis juliflora* and *Lantana camara* dominate large patches, outcompeting native shrubs and young saplings, thereby suppressing natural regeneration processes.

Soil assessments revealed shallow profiles in rocky terrain and low moisture retention in sandy areas, both of which constrain vegetation growth. Habitat fragmentation—arising from a combination of anthropogenic pressures and ecological decline—has further reduced structural complexity, diminishing the quality of fauna habitat (Table 1). Together, these patterns confirm that the landscape requires targeted ecological interventions



Map 2: Study area with designated field markers of the biophysical assessment

rather than generic plantation-based approaches.

Geospatial findings

The geospatial analysis presents a clear and data-driven picture of the landscape's physical form, vegetation patterns, land use dynamics, and hydrological stress. High-resolution satellite imagery, Digital Elevation Models, Normalized Difference Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI) indices, and long-term Land Use and Land Cover (LULC) datasets were used to understand the extent and nature of degradation across the project area.

The combined evidence indicates rapid land-use transitions, declining vegetation cover, depletion in soil moisture, and expanding urban heat-island effects. These findings directly inform the spatial prioritisation of eco-restoration interventions.

Table 1: Key findings of the biophysical and ecological data

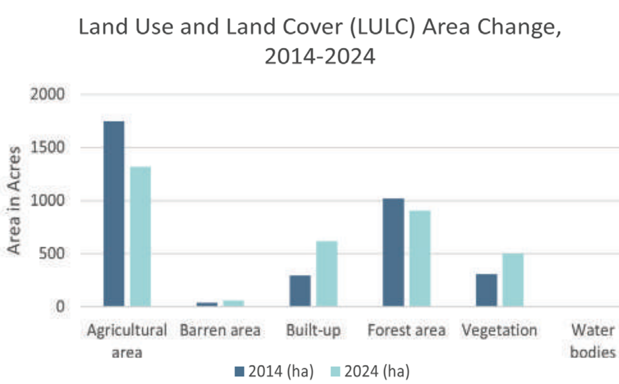
Forest type	**Northern Tropical Thorn Forest**
Flora	• Most Dominant botanical family- Fabaceae • Prominent species of this family - *Indigofera linnaei, Acacia nilotica* etc. • 77% of species are native, followed by 20% invasive-alien and 3% introduced. Total no. of Plant species: 31-42 **Shannon's Index: 1.3 -2.4** **Simpson's Index: 0.7-0.89** Both indices indicate low to moderate Biodiversity
Fauna a) Avifauna	• Avifaunal Diversity (secondary) - 7 (Sakatpur) - 148 (Bhondsi) • Avifaunal Diversity (primary survey) - 36 species, with 4 migratory species. • Avifaunal Diversity (secondary) - 7 (Sakatpur) - 148 (Bhondsi) **Shannon's Diversity Index - 1.73** **Simpson's Diversity Index - 0.74** Both indices indicate low to moderate Biodiversity
b) Mammals	• 15 species (secondary data)
c) Reptiles and amphibians	• 20 - 29 species (secondary data)
d) Butterfly and moths	• 57 - 90 species (secondary data) (Note: Secondary data compiled from various surveys and reports by the Wildlife Institute of India (WII), Bombay Natural History Society (BNHS), research on the Aravalli Biodiversity Park (ABP) data.)
Soil Quality	The region is prone to soil erosion and degradation due to poor soil health. Soil Organic Carbon (SOC) levels are relatively poor, ranging between 0.7% and 2.74%, which limits soil structure stability and reduces moisture retention capacity. Nutrient availability is also suboptimal.
Water Quality	The Gurgaon block has been categorised as overexploited, reflecting unsustainable extraction levels. Groundwater depth fluctuates significantly, with pre-monsoon levels ranging between 2.35 metres below ground level (mbgl) and 116.85 mbgl, and post-monsoon levels between 1.65 mbgl and 115.3 mbgl. The quality of both groundwater and surface water in the region varies between C1S1 (good quality, suitable for irrigation) and C2S2 (moderately good quality, requiring some management

- **Landform and slope characteristics**

Slope analysis shows that the terrain ranges from 0° to 36°, with 80–90 per cent of the area comprising gentle slopes, while the remaining proportion includes rocky ridges and steeper escarpments. The Digital Elevation Model places the landscape between 254m and 364m, revealing two distinct physiographic units: floodplains and hilly rock ridges. These variations strongly influence run-off, soil erosion patterns and vegetation distribution.

- **Land Use and Land Cover (LULC) change**

LULC mapping reveals substantial land-use conversion over the past decade. Agricultural land has decreased by approximately 429 ha, while forest area has shrunk by 114 ha, indicating sustained pressure on natural vegetation. Barren land shows a modest increase of 22 ha, whereas built-up area has expanded significantly by 323 ha, reflecting rapid urbanisation in peri-urban Gurugram (Graph 1).



Graph 1: Change in LULC between 2014 and 2024

At the same time, patches of vegetation have increased by 196 ha, much of which corresponds to scrub, early-successional species and invasive-dominated patches rather than mature forest cover (Map 3).

- **Vegetation health**

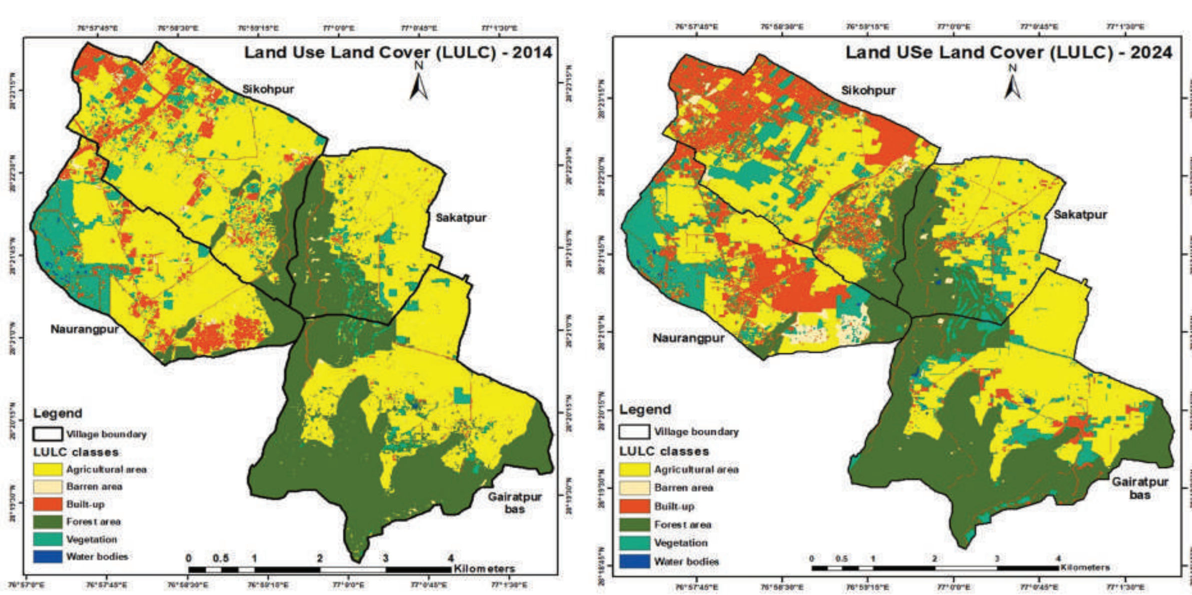
NDVI analysis demonstrates that the project area remains largely devoid of dense vegetation. NDVI values ranged from –0.067 to 0.507 in 2014 and –0.027 to 0.521 in 2024, indicating only marginal improvement in vegetation cover. These values are consistent with a shrub-dominated, intermediate successional landscape. Low NDVI areas overlap strongly with rocky terrain, steep slopes and heavily grazed patches, mirroring field observations of sparse canopy cover and invasive species dominance (Map 4).

- **Heat stress and urban heat island patterns**

Land Surface Temperature (LST) analysis shows pronounced heating, with temperatures reaching 47.8°C (March 2024) and peaking at 56.6°C (April 2020). Urban Heat Islands (UHI) are concentrated around densely developed zones with minimal green cover, illustrating the thermal impact of rapid expansion of impervious surfaces. This reinforces the need for vegetative buffers, soil moisture retention, and native canopy enhancement (Map 5).

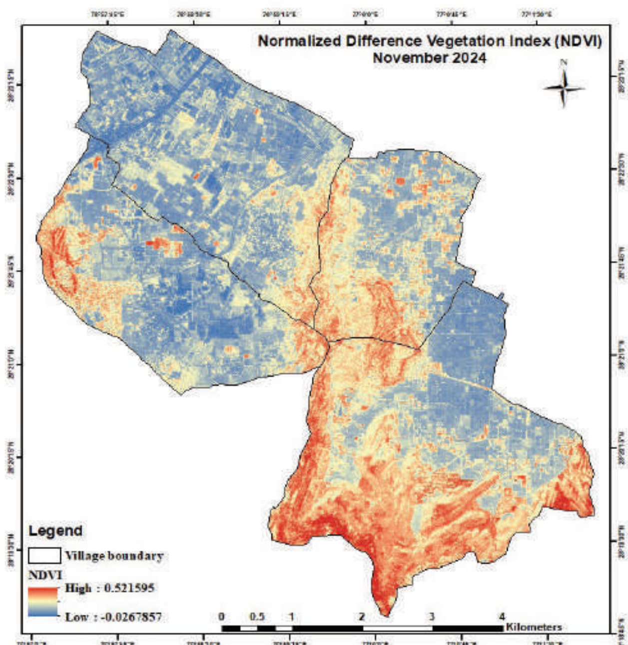
- **Soil moisture (NDMI)**

NDMI analysis categorises the area into dry, moderate and moist zones. Dry zones align with barren and built-up areas, reflecting poor water retention, compacted

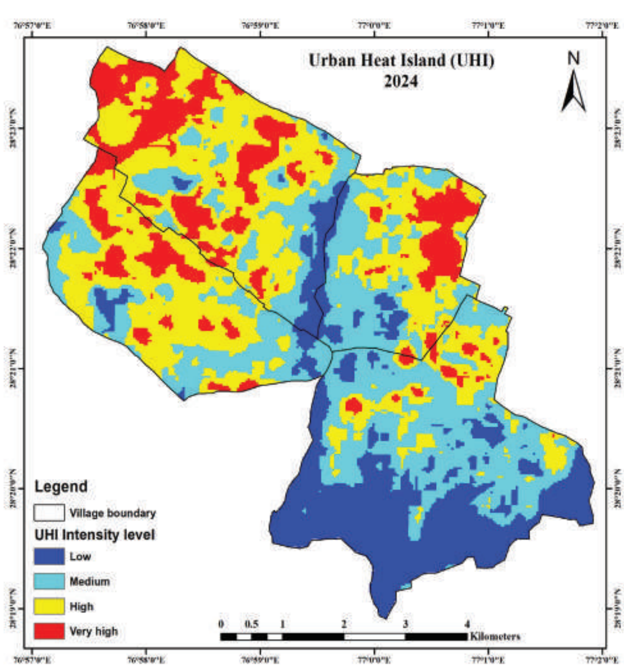


Map 3: LULC map of the study area from 2012 and 2024

soil and high run-off. Moist zones are clustered around existing forest patches and agricultural fields, indicating areas where soil-water interaction remains functional. These patterns correspond directly with observed vegetation distribution and the deterioration of surface water bodies (Map 6).



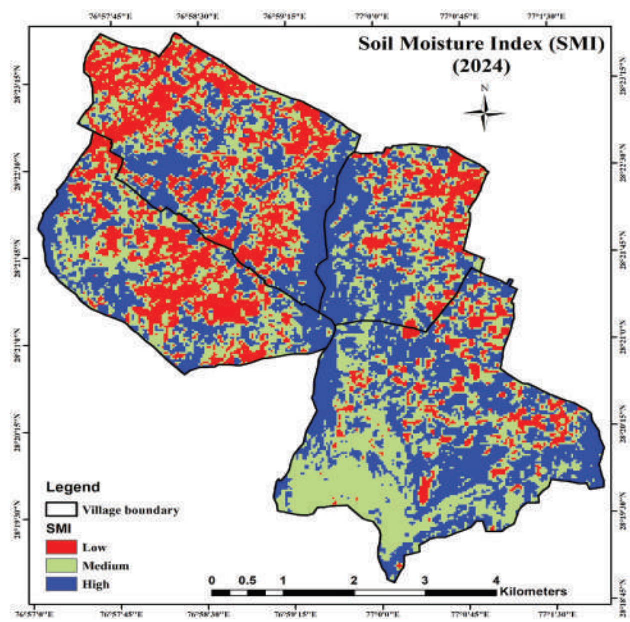
Map 4: NDVI analysis of the study area



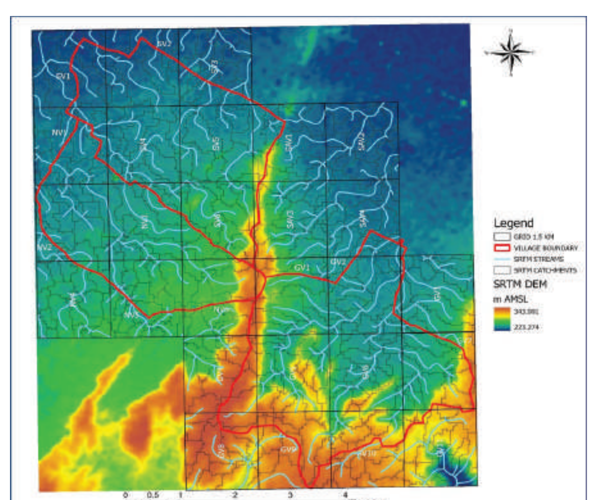
Map 5: Urban Heat Island (UHI) analysis of the study area

- **Drainage and hydrological assessment**

Hydrological mapping highlights multiple signs of distress. The area has suffered a 20 per cent loss of water bodies over the past decade, with 7 out of 41 ponds having disappeared. The remaining water bodies are largely eutrophic, silted, or seasonally functional, greatly limiting groundwater recharge potential (Map 7). Natural drainage lines are drying or rerouted due to encroachment, construction and landscape modification, leading to altered run-off patterns and increased erosion. These findings are consistent with community reports of declining groundwater levels and growing water scarcity.



Map 6: Soil moisture analysis in the study area



Map 7: Drainage network, watershed and hydrological assessment

Socio-economic findings

Across all villages, communities remain heavily dependent on forests and common lands for fodder, fuelwood, grazing and other biomass needs. Livestock-based livelihoods are central to household economies, resulting in sustained grazing pressure on already degraded slopes and scrublands. Women, in particular, shoulder a disproportionate share of biomass collection and water management tasks, travelling longer distances due to declining vegetation and water availability.

The socio-economic surveys also highlighted limited livelihood diversification, which increases the reliance on forest resources in times of stress. Community perceptions across focal group discussions consistently pointed to water scarcity, heat stress and reduced tree cover as the most immediate environmental challenges. Although willingness to participate in restoration activities is high, households expressed the need for technical guidance, institutional support and mechanisms to ensure sustained community involvement. Discussions with local governance bodies and frontline agencies revealed fragmented roles across departments, underscoring the need for coordinated restoration efforts.

Ecosystem services

The assessment shows that the Aravalli landscape continues to provide essential ecosystem services, but almost all of them are under increasing stress. Provisioning services such as fuelwood, fodder, groundwater and locally valued medicinal plants remain central to rural livelihoods, yet their availability is declining as vegetation cover decreases and water bodies deteriorate.

- Regulating services have weakened considerably: reduced vegetative cover and widespread invasive species have increased soil erosion, diminished natural water filtration and contributed to rising local temperatures and heat-island effects.
- Supporting services—such as nutrient cycling, soil formation and habitat continuity—are similarly affected, with erosion, siltation and habitat fragmentation disrupting long-term ecological processes.
- Cultural services, particularly those linked to sacred groves and traditional ecological knowledge, remain important to communities but are threatened by rapid urban expansion and the loss of native species.

Overall, the landscape's ability to provide dependable ecosystem services is diminishing, reinforcing the need for integrated restoration to rebuild ecological function and community resilience.

Table 2: Socio-economic findings in the study area

Assessing Points	Key Findings
Water Resource Availability	Water sources are mostly seasonal, with heavy dependence on groundwater. Some villages report water scarcity impacting agriculture.
Livelihood Dependency on Ecosystem	Agriculture and livestock are primary income sources, but increasing climate stress is forcing diversification into non-farm labor. Alternative livelihood options (agroforestry, agritourism, apiculture, etc.) could be beneficial.
Traditional Knowledge and Practices	Indigenous soil and water conservation practices exist but are declining due to modernisation and external influences.
Socio-economic Constraints	Limited financial resources and lack of market access hinder sustainable livelihood transitions, especially for women.
Gender Roles in Ecological Stewardship	Women play a significant role in resource management but lack decision-making power in restoration initiatives.
Educational Awareness on Ecosystem	Environmental awareness is low; younger generations are more receptive, indicating potential for educational interventions.
Institutional Gaps	Weak coordination between government agencies, lack of policy implementation, and inadequate financial and technical support slow down restoration efforts. Strengthening institutional frameworks can enhance project success.

Table 3: Ecological services analysis and key findings

Service Type	Gap Identified	Implications
Provisioning	Exploitation of forests and groundwater	Risk of depletion without management; needs regulation and sustainable harvesting plans.
Regulating	Surface water depletion, soil degradation	Highlights urgent need for landscape-level water and soil conservation planning.
Supporting	Poor forest regeneration, invasive species spread	Restoration strategies must include native species planting and invasive control.
Cultural	Lack of formal recognition/ integration of sacred sites	These areas could be leveraged as community-led biodiversity hubs under eco-restoration plans.

Taken collectively, these findings reveal a landscape under considerable ecological and socio-economic strain, underscoring the urgent need for a structured, scientifically informed and community-responsive eco-restoration strategy, which is detailed in the subsequent chapters.

Learnings from Analysis of Curated Case Studies for Aravalli Restoration

A critical analysis of nine curated national and international eco-restoration case studies provided key learning points.

This process identified six essential Intervening Components (IC) suitable for the Aravalli landscape. The core insights confirmed that:

- Restoration Techniques are critical for biodiversity and desertification control.
- Community participation, Capacity Building, and Traditional Knowledge are fundamental to achieving long-term success.
- Innovation (e.g., eco-tourism and smart technologies) offers robust, scalable solutions.

These findings advocate for a balanced, context-specific, and tailored approach, blending ecological science, community engagement, and innovative practices to ensure effective and sustainable restoration. These insights directly shape the restoration plan's framework, guiding scalable and impactful interventions across the Aravalli region.

A waterbody taken over by Algal Bloom at the project site

Chapter 3

Strategic Eco-restoration plan

Rationale and landscape approach of the plan

The strategic ecological restoration plan for the Aravalli project landscape has been developed to respond to the complex and interlinked degradation patterns identified through the baseline assessment. The findings demonstrate that ecological pressures, hydrological decline in soil moisture, invasive species spread, and socio-economic dependence on biomass are collectively eroding the landscape's resilience. In this context, eco-restoration cannot be conceived as a set of isolated activities; instead, it must function as a landscape-level strategy grounded in ecological science, terrain logic, hydrological processes and community stewardship.

To respond effectively to these pressures, it is essential to first understand how the Aravalli landscape functions as a connected ecological system. The Aravalli's form a mosaic of forests, scrublands, agricultural patches, village commons, rocky ridges and seasonal drainage systems. Their ecological functioning depends on the connectivity of these units.

Based on this understanding, the landscape approach adopted in this plan focuses on the following core priorities:

- Restoring native ecological structure and function;
- Enhancing water security through integrated blue–green infrastructure;
- Strengthening native biodiversity and ecological succession;
- Improving microclimatic conditions; and
- Embedding community institutions as long-term custodians.

This approach aligns with national priorities under the Detailed Action Plan from MOEFCC, the Aravalli Green Wall Project, and India's commitments towards Land Degradation Neutrality. By grounding the plan in the realities of terrain, vegetation structure, hydrology and community dynamics, it ensures that restoration outcomes are both ecologically viable and socially sustainable.

The six strategic components of the framework

The eco-restoration strategy is built on six interlinked components that together form the foundation for designing eco-restoration pathways across the project landscape. These components draw upon the strategic framework and respond directly to the drivers of degradation identified in the baseline survey and through literature review.

These six components act as the building blocks of the restoration strategy and guide how interventions are structured across the landscape. The strategic components are as under (Fig. 5).

1. **Restoration techniques:** This includes scientific and site-appropriate actions such as assisted natural regeneration, selective invasive species management, densification through native shrub–tree layering, soil and moisture conservation structures, slope stabilisation and habitat enhancement through ecosystem-specific interventions.

2. **Community participation:** Local communities and village institutions are central to long-term ecological recovery. This component emphasises roles for women's groups, village committees, grazing groups, and youth volunteers in restoration planning, oversight, monitoring and resource stewardship.

3. **Capacity building:** This includes structured training programmes for frontline forest staff, community groups, PRI members and youth, focusing on native

Figure 5: Intervening components of the eco-restoration plan

species identification, ecological monitoring, nursery management, sustainable grazing practices and water conservation techniques.

4. **Conservation tools:** Tools include GIS-based monitoring systems, ecological health cards, seasonal ground-truthing protocols, biodiversity registers and field-based checklists that ensure scientific tracking and transparency throughout restoration.

5. **Innovative practices:** This consists of integrating climate-resilient agricultural practices, bio-engineered soil stabilisation methods, regenerative land-use models, nature-based solutions and water-saving technologies that complement native vegetation restoration.

6. **Traditional ecological knowledge (TEK):** This component integrates indigenous knowledge on plant selection, soil-binding shrubs, water pathways, seasonal cycles and culturally significant species woven into restoration logic.

This holistic approach treats the entire ecosystem and its human inhabitants as a cohesive unit, encompassing five key Landscape Components (LC): forests,

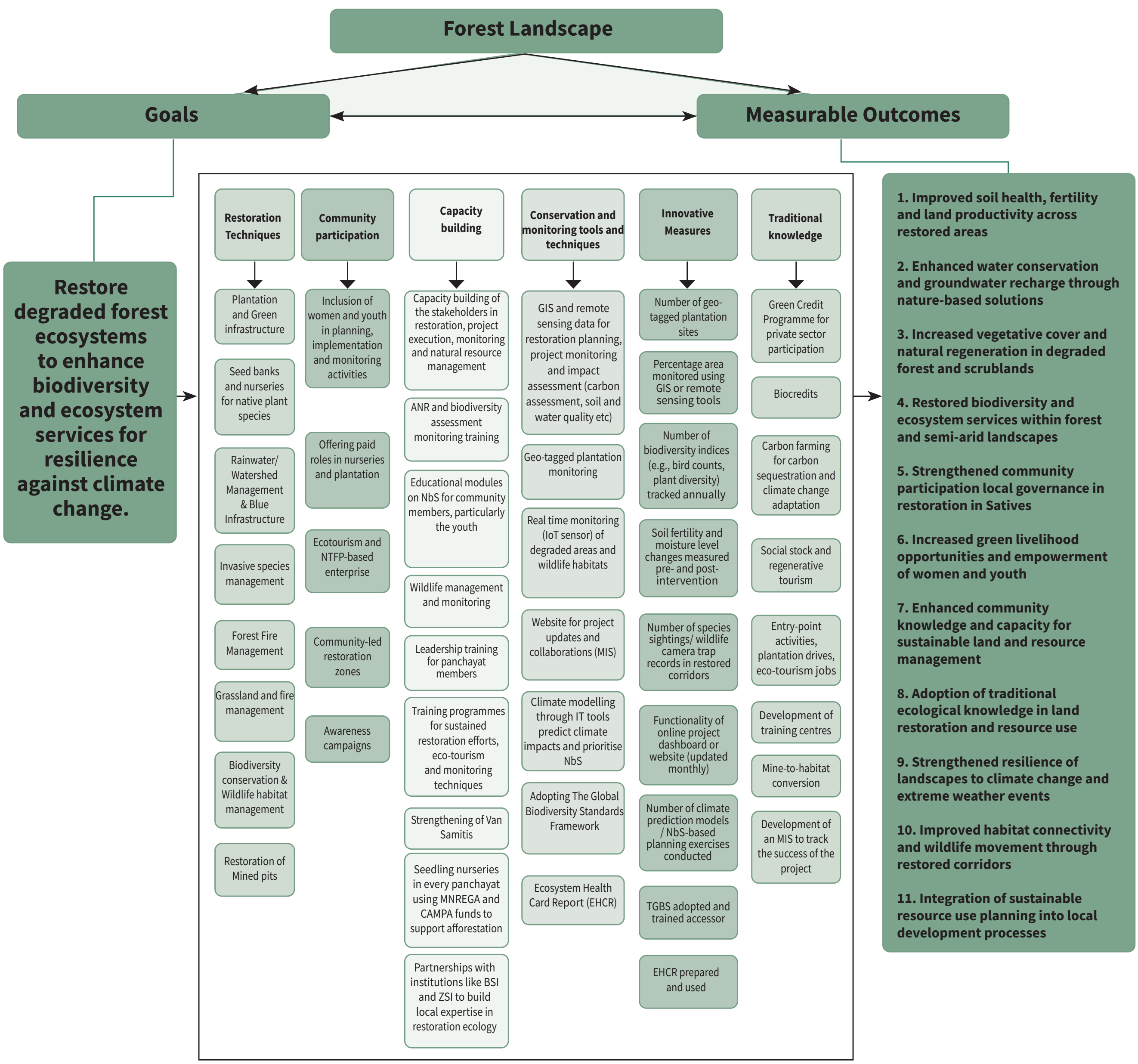


Figure 6 : Recommended framework for eco-restoration of the forest landscape (FL), detailing goals, strategic units, dynamic units, and indicative measurable outcomes

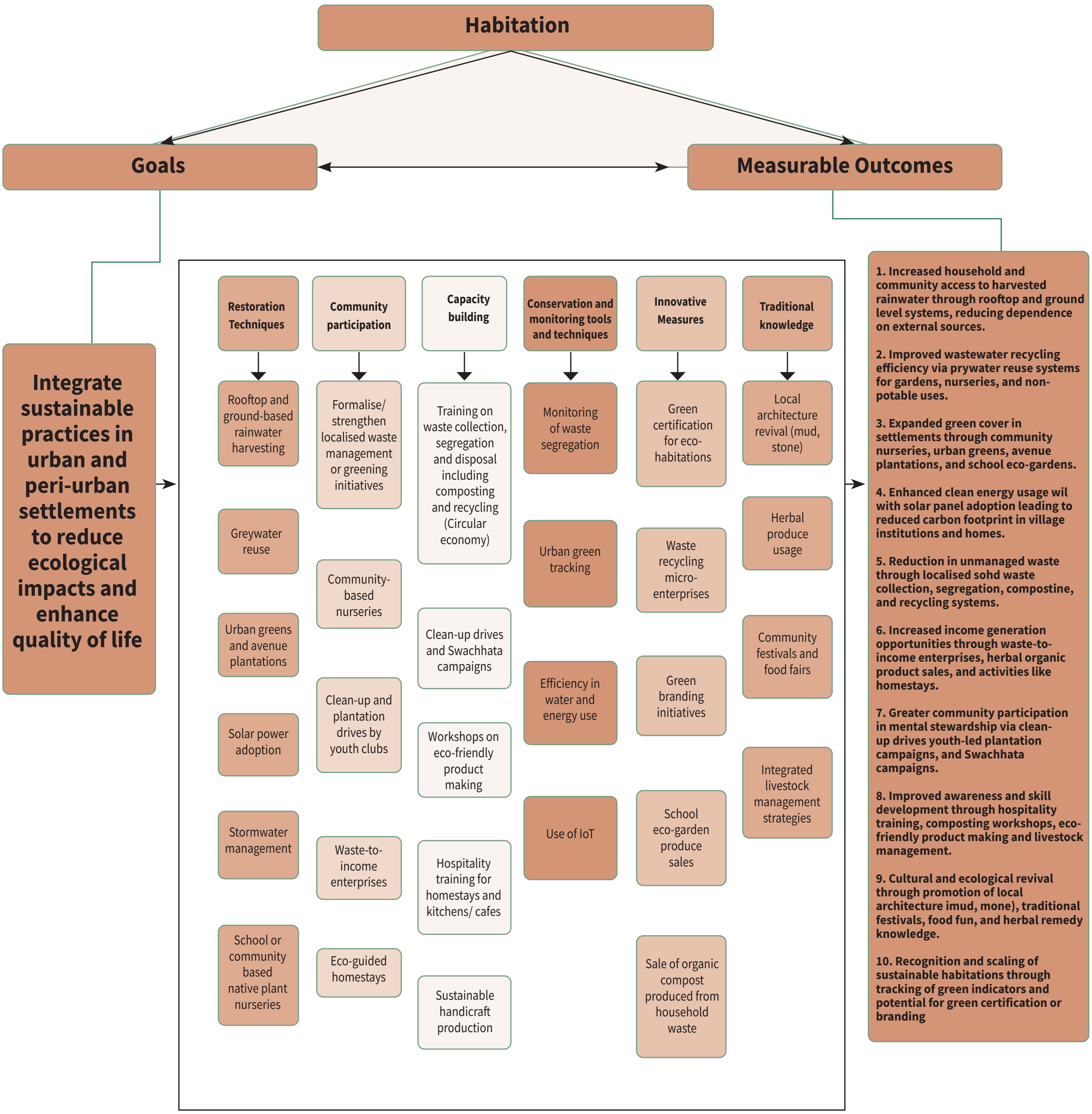


Figure 7: Recommended framework for eco-restoration of the forest landscape (FL), detailing goals, strategic units, dynamic units, and indicative measurable outcomes

agricultural lands, scrub and common land, water bodies, and habitation areas. The strategy promotes collaboration, fosters integrated problem-solving, and delivers cost-effective, sustainable land-use practices for large-scale restoration. The plan focuses and is centred around habitation landscape addressing the cause-and-effect relation of the degradation with that of the anthropogenic induced degradation.

Together, these components create a coherent framework that links ecological restoration with community processes and long-term resilience.

The recommended approach for restoration of forest landscape (FL) and habitation landscape (HL) in Aravalli region, (two of the five landscapes) that can be implemented is indicated in Fig. 6 and 7.

Restoration Micro-plan architecture

Micro plans for project villages

To translate the strategic framework into village-level action, the micro-plan follows a clear and sequential set of stages (Fig. 8). Development of micro-plan framework involves following major steps:

Steps A: Scoping

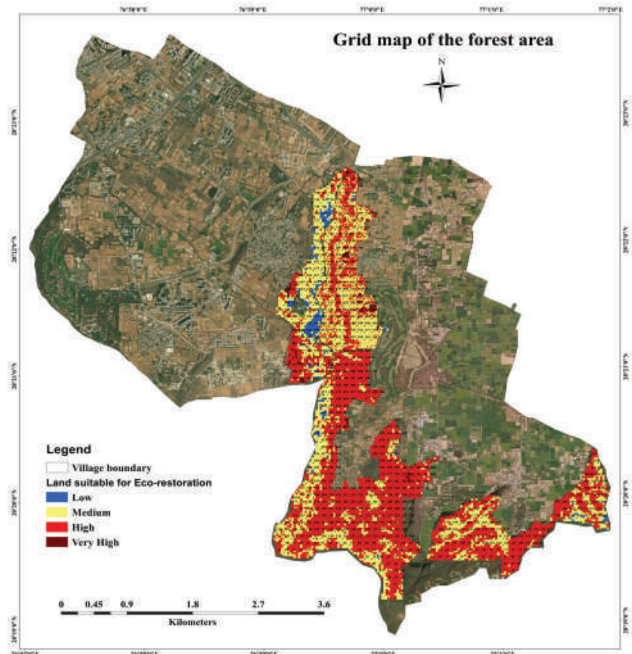
Scoping visits are done to determine the area which needs restoration based on qualitative and quantitative data acquired from ecological surveys, socio-economic studies and literature review.

Step B (B1 to B4) Planning and designing

B1: Project area grid map

Complementing the landscape-level strategy, detailed micro plans have been tailored for four villages in the project area, Gairatpur Bas, Shikohpur, Sakatpur, and Naurangpur, based on their unique ecological profiles and socio-economic contexts.

In the forest landscape of the project villages, a grid based GIS approach was used for the identification of the degraded areas suitable for the eco-restoration (Map 8).



Map 8: Degree of land degradation in the forest area of project villages- Gairatpur Bas, Shikohpur, Sakatpur, and Naurangpur in Gurugram, Haryana

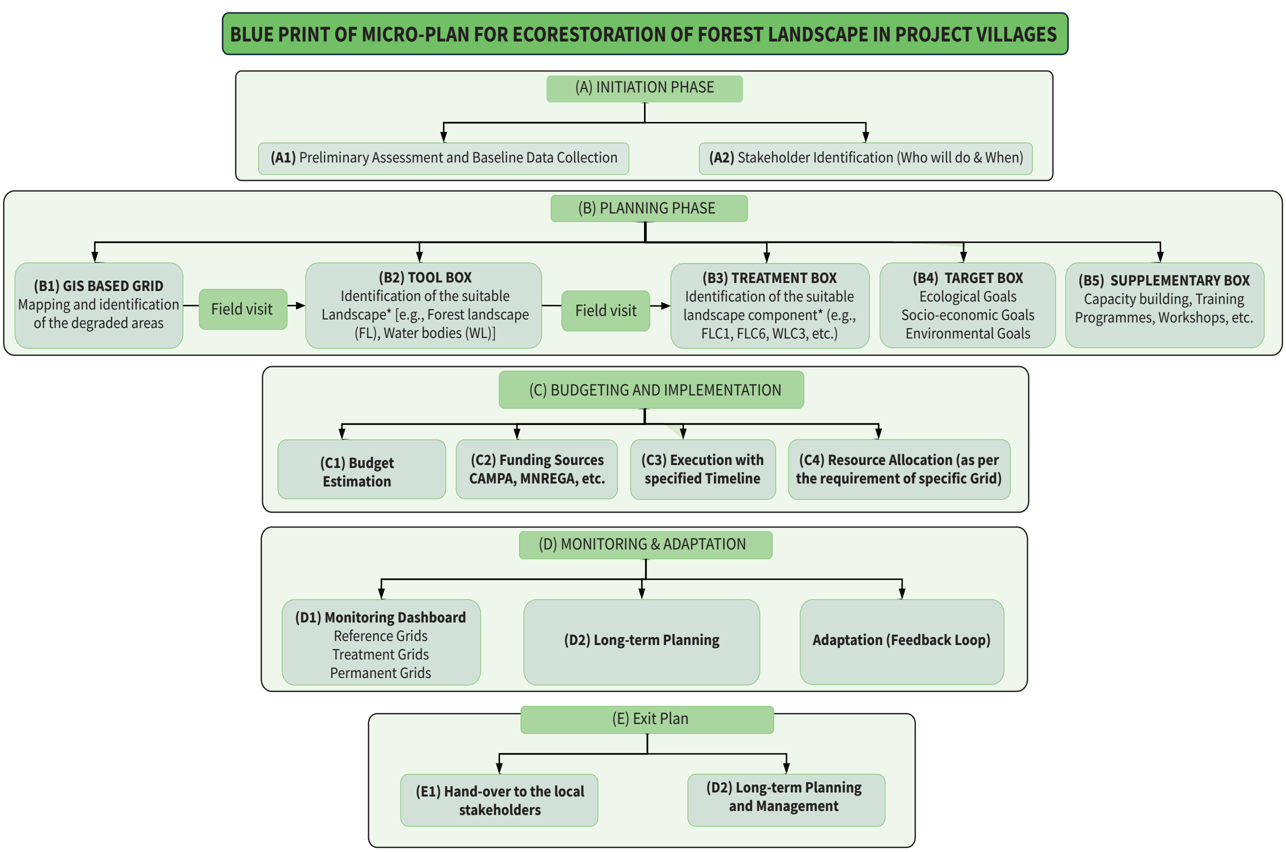


Figure 8: Flow of activities for preparation of a micro-level restoration planning

The weighted overlay analysis model was incorporated using four thematic maps viz., Land Use Land Cover (LULC), Normalised Difference Vegetation Index (NDVI), Soil Moisture Content (SMC), and slope of the area for the demarcation of four categories (Low, Medium, High, and Very High) of degraded areas.

After the grids are developed a core innovation of this plan is the tool box–treatment box architecture, developed to ensure that restoration pathways are systematic, evidence-based and responsive to local conditions. Moreover, during the implementation grid level planning can be achieved.

B2: The Tool Box (30 Strategic Units)
The Tool Box combines the six strategic components with the five landscape types (forest, scrub, grassland, wetland, and rural/agricultural mosaic) to generate **30 strategic units**. These units represent thematic areas such as habitat structuring, water conservation, invasive removal, nurse-species establishment, blue–green infrastructure and community governance models.

Fig. 9 as under, illustrates a comparative radial prioritisation of landscape components and capacity needs across different land-use categories—forest, agricultural land, scrub, water bodies, and habitation. By visualising all components simultaneously, the diagram highlights how intervention needs vary across landscapes—for instance, forests may demand stronger restoration measures, while habitation areas may require greater focus on community participation or knowledge systems.

B3: The Treatment Box (163 Dynamic Units)
While the Tool Box helps classify strategic needs, the Treatment Box converts these into concrete on-ground actions. The Treatment Box further pin-points the strategic units into **163 site-specific dynamic units**, representing actionable interventions such as:

- FLC1a Plantation and Green infrastructure
- FLC1d Invasive species management
- FLC2 d Ecotourism and NTFP-based enterprise
- FLC2 e Awareness campaigns
- FLC3 b Capacity building of the stakeholders
- FLC3 e Training programmes for sustained eco-restoration
- FLC4 b Geo-tagged plantation monitoring
- FLC5 b GIS based monitored and Evaluation per grid
- FLC6 a Green Credit Programme for private sector participation
- FLC6 c Carbon farming for carbon sequestration and climate change adaptation

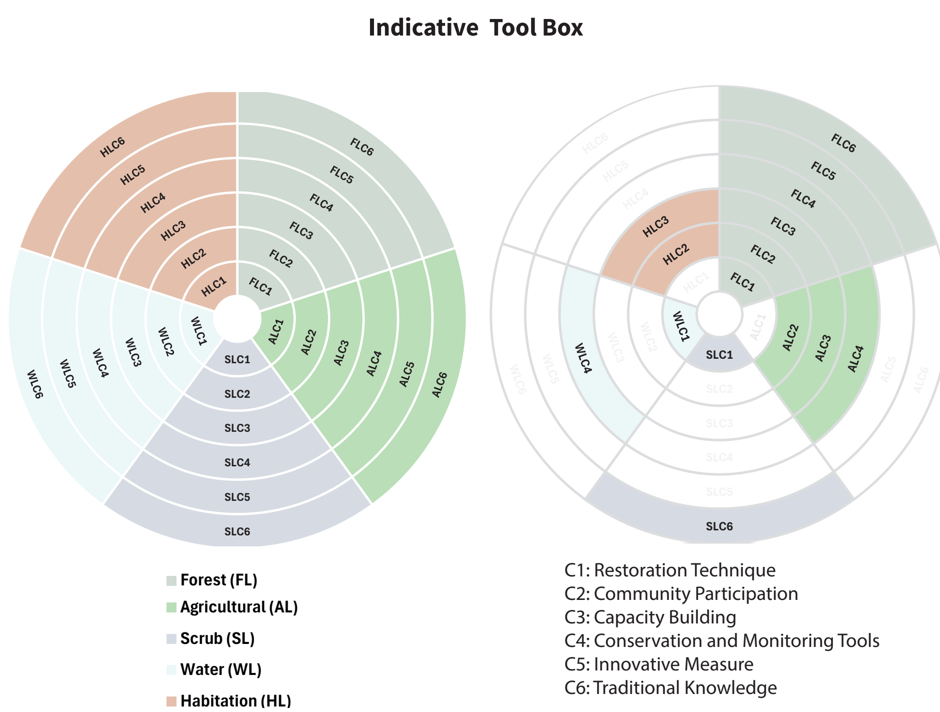


Figure 9: Generation of tool box from strategic units in the pilot area

B4: SMART targets

To ensure that these interventions are implementable and measurable, the Treatment Box is further refined into Specific, Measurable, Achievable, Relevant, Time bound (SMART) targets, so that the plan can be implemented using specific goals converting the Treatment box into actionable plans. Table 4 below showcases the SMART box created for the study area.

Indicative Treatment Box

Forest Landscape:

FLC1a Plantation and Green infrastructure
FLC1d Invasive species management
FLC2 d Ecotourism and NTFP-based enterprise
FLC2 e Awareness campaigns
FLC3 b Capacity building of the stakeholders
FLC3 e Training programmes for sustained eco-restoration
FLC4 b Geo-tagged plantation monitoring
FLC5 b GIS based monitored and Evaluation per grid
FLC6 a Green Credit Programme for private sector participation
FLC6 c Carbon farming for carbon sequestration and climate change adaptation

Agricultural Landscape:

ALC1a Contour bunding, vegetative barriers, and field bund stabilisation

Water Bodies:

WLC4 b Ecological monitoring of water bodies

Open Scrublands

SLC4 b Community clean-up drives and Waste Segregation Centres

Habitation Landscape:

HLC2a Formalise/ strengthen localised waste management or greening initiatives
HLC3 b Clean-up drives and Swachhata campaigns

Figure 10: Dynamic unit selection and forming the treatment box for one of the pilot villages -Sakatpur, Gurgram, Haryana

Table 4: Indicative SMART targets for study area

Grid ID	Condition and Need	Assigned Intervention	Target Quantification
DA26-G101	Rocky barren land, no vegetation	Drilling, grass seeding with native mix	5 ha seeded (Part of the 15 ha total seeding target)
DA26-G102	High Prosopis invasion	Invasive species management	1 ha cleared (Part of the 5 ha total clearance target)
DA27-G201	Soil erosion and low water retention	Contour trenching, fodder seeding	2 km trenches + 3 ha seeded (Part of the 15 ha total seeding target)
DA27-G202	Proximity to Leopard Trail, grazing pressure	Controlled grazing, natural fencing	Grazing exclusion on 4 ha
DA28-G301	Rocky patches with scattered natives	Assisted natural regeneration	3 ha supported
SV5 (Pond S1)	Eutrophic pond, algae cover	Algae removal, bund strengthening	Pond cleaned + bund repaired (Pond 1 of 4)
SV6 (Pond S2)	Dry, filled with garbage	Waste removal, excavation	Pond re-excavated (~0.5 ha) (Pond 2 of 4)
SV7 (Pond S3)	Dry, no bunding	Stream channelisation, bund construction	Bund built, pond revived (~1 ha) (Pond 3 of 4)
SV8 (Pond S4)	Bunded but eutrophic	Desilting, nutrient load reduction	Pond capacity improved by 30% (Pond 4 of 4)

C. Budgeting and implementation

With interventions defined and targets set, the next requirement is to estimate resources and plan implementation. The planning phase adheres to a principle of integrated financial management. As outputs are defined and quantitative targets are established, a simultaneous process of budgeting is undertaken for cost estimation.

This ensures that the feasibility of the proposed interventions is immediately assessed against required resources.
Budget = Treatment box + support activities cost

D: Monitoring and adaptive management

MIS and a dashboard will indicate progress in percentage for each grid. The target here means the work allocated, man-days and work created (Table 5).

Scaling up by automation

The true potential of this restoration plan lies in its digital nature. Codifying the strategic plan into a backend algorithm and a front-end dashboard simplifies and automates monitoring and implementation for on-the-ground teams. (Fig. 11)

E: Exit and Long-term sustainability plan

Once monitoring mechanisms are in place, attention must shift towards ensuring the long-term sustainability of the restored landscapes. Criteria for successful exit plan and community handover should be based on pre-determined criteria. For example, more than 80% survival rate, functional governance, financial mechanism in place, community capacity sustained. Institutional handover here means formal transfer to community.

Institutional handover here means formal transfer to community groups and local governing bodies, for circular sustainability of the restored landscape. The successful long-term sustainability of the eco-restoration will ensure the active engagement and eventual transfer of stewardship to the local community.

Scalability and applicability

The strategic and micro plans form a scalable blueprint for eco-restoration. This adaptable eco-restoration plan is replicable across the Aravalli's semi-arid, peri-urban settings, offering a practical framework balancing ecology and community needs.

Table 5: Indicative Monitoring and Evaluation for the targets integrated with the dashboard

Strategic Component	Output Indicator (Planned Goal)	Planned Target	Achieved Progress	% Completion	Status
			(Reported progress from the ground)	(completion marked by the nodal)	(can be updated) (CERTIFIED GOALS APPEAR HERE)
FLC1 (Restoration Techniques)	Hectares of rocky terrain restored (seeding)	15 ha	6.5 ha	43%	In Progress
WLC4 (Blue Infrastructure)	Number of ponds restored (S1,S4)	4 ponds	2 ponds	50%	In Progress
FLC2 (Community Engagement)	Jobs created in restoration/ nurseries	35 jobs (youth/ women)	33 jobs	94%	Near Target
ALC2 (Community Engagement)	Farmers adopting agroforestry buffers	40 farmers	15 farmers	38%	Requires Push
FLC4 (Monitoring Tools)	% area monitored using GIS/ Geo-tagging	100% (of restored area)	90%	90%	On Track
FLC6 (TEK)	Elders engaged for TEK documentation	10 elders	10 elders	100%	Complete

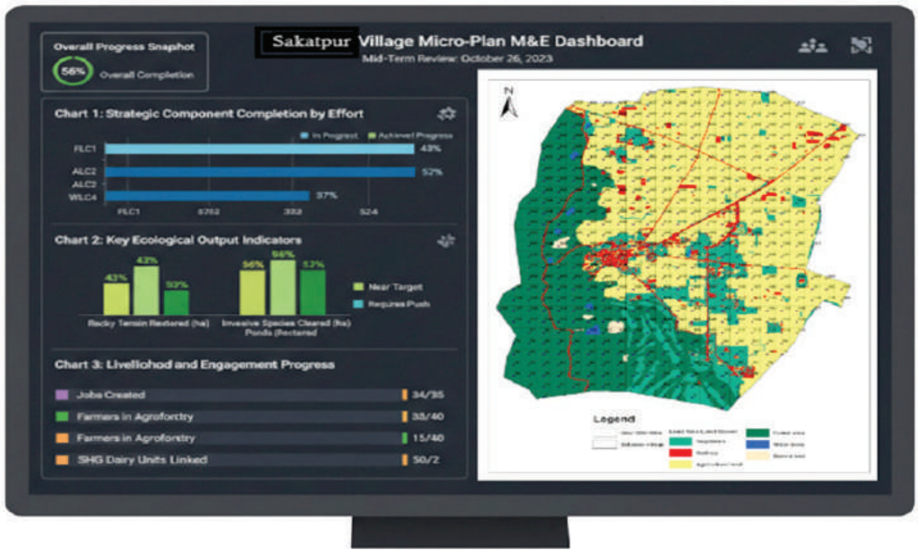


Figure 11: An Indicative image of monitoring and evaluation dashboard for study area, Sakatpur village, Gurugram, Haryana

Figure 12: Indicative Blue-Green infrastructure for the habitation landscape of the pilot study area. Proposed rainwater management interventions in lower catchment (habitation) that may be applied

Terrain-specific restoration strategies - Blue and Green infrastructure

Since terrain strongly influences ecological processes, restoration strategies must be customised to local soil, moisture and microclimatic conditions. Terrain is one of the most critical determinants of restoration outcomes. The project landscape comprises three broad terrain categories: **rocky**, **sandy** and **mixed**. Each requires a tailored strategy based on soil depth, moisture retention, erosion potential, microclimate and species survivability.

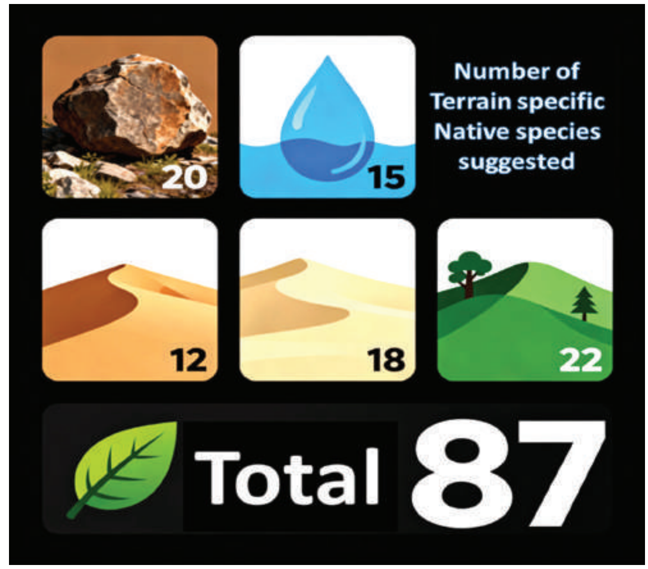
Rocky terrain strategy

Rocky areas have shallow soils, high run-off and low moisture retention. Restoration here focuses on:

- soil and moisture conservation (staggered trenches, micro-catchments);

a)

Terrain Type	Native Species Count
Rocky Terrain	20
Wetland	15
Rocky & Sandy Terrain	12
Sandy Terrain	18
Foothills/Valley	22
Grand Total	87



b)

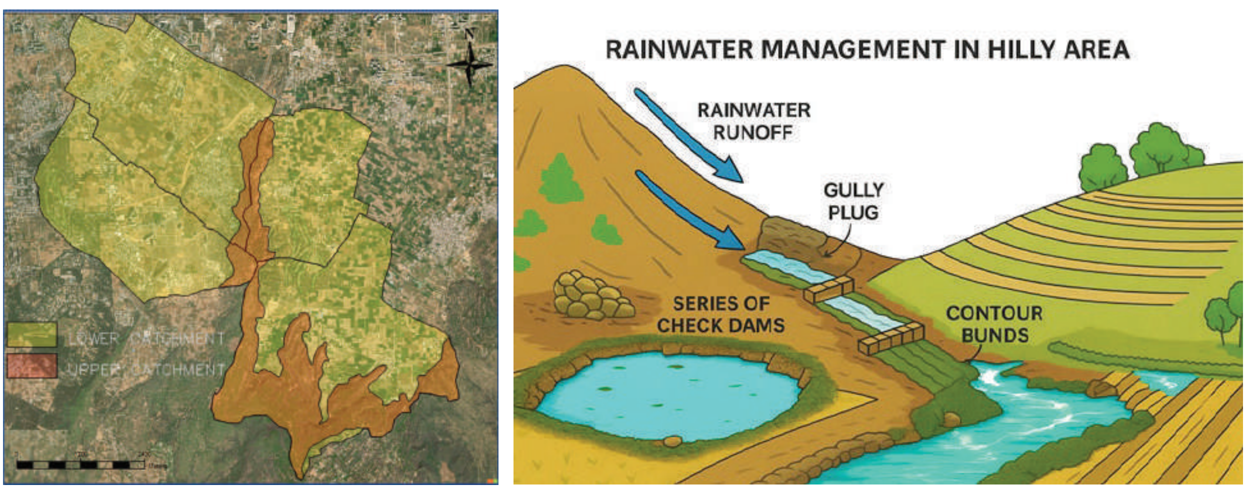


Figure 13: a) Number of Native Species Suggested for eco-restoration, categorised by site-specific terrain and habitat within the project Area. b) Schematic drawing of rainwater management in upper catchment (forest area) of study area

- slope stabilisation with native shrubs and pioneer tree species;
- establishing native nurse species clusters tolerant tothin soil layers;
- preventing further fragmentation through ecological fencing and vegetation strengthening.

Sandy terrain strategy
Sandy patches exhibit high erodibility, low organic content and weak water retention. Restoration interventions include:
- grass–shrub–tree tri-layered planting;
- vegetative bunds and windbreak structures;
- water harvesting depressions;
- soil-binding species combinations to reduce erosion.

Mixed rocky–sandy terrain strategy
These transitional areas require a phased and adaptive approach:
- combining stabilising shrubs with drought-tolerant trees;
- deploying targeted SMC structures;
- using species that tolerate variable soil conditions;

creating micro-watersheds for restoring ground water levels.

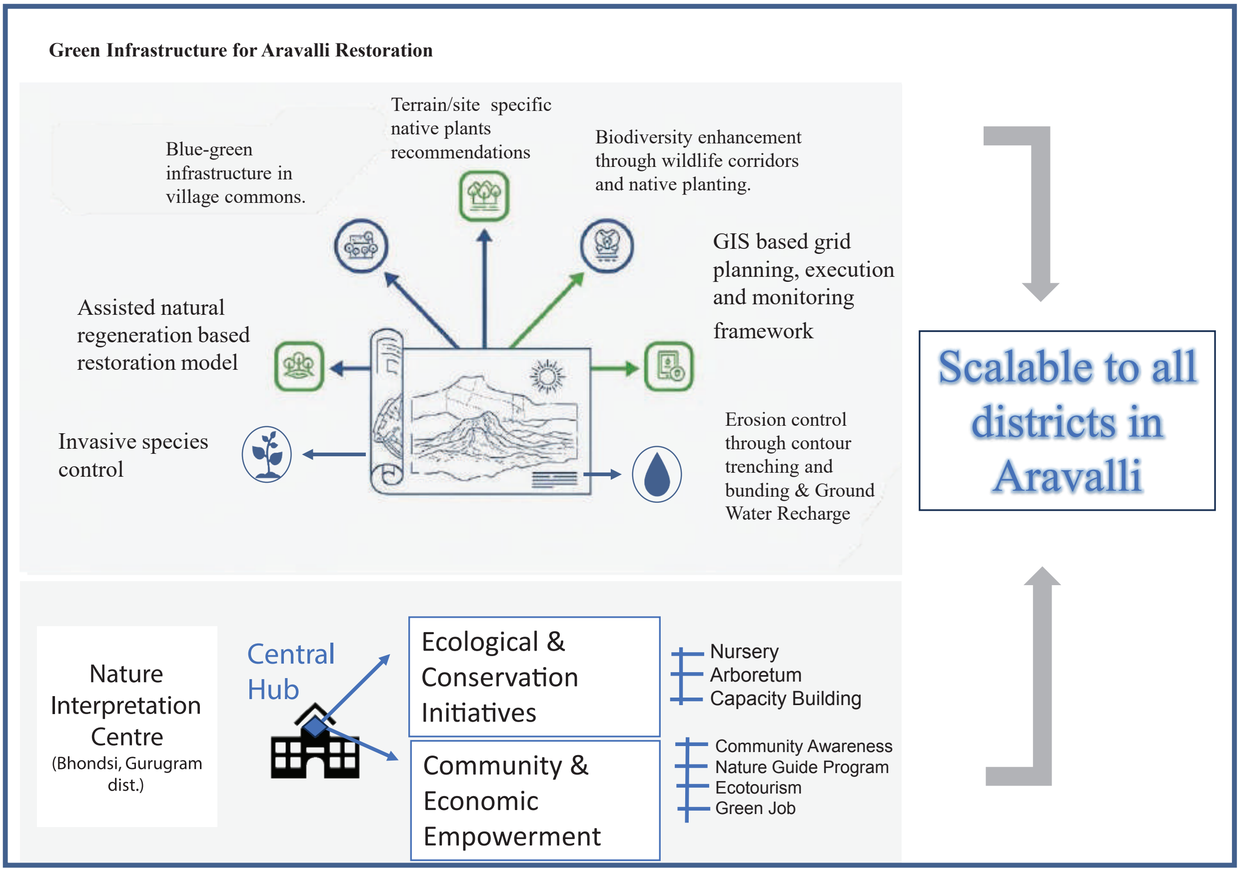


Figure 14: Blue print for the eco-restoration structure that can be scalable to the entire Aravalli range

Native species reintroduction

To complement terrain-based interventions, species selection must follow ecological logic and natural succession patterns. The species strategy draws upon the ecological succession patterns, ensuring that restoration accelerates to climatic climax of the succession and enhances biodiversity without resorting to monoculture plantation approaches. (Fig. 13)

Key elements include:

- **Native nurse species** such as *Grewia flavescens*, *Helicteres isora*, *Clerodendrum phlomidis* and *Adhatoda vasica*, which create microhabitats and enable early successional recovery.
- **Associate species** that provide canopy, shrub, climber and ground layers, improving ecological structure.
- **Terrain-wise species clusters** that match physiological tolerances:
  - Rocky: *Boswellia serrata*, *Sterculia urens*, *Ficus spp.*
  - Sandy: *Salvadora persica*, *Capparis decidua*, *Acacia senegal*
  - Moist to wet: *Syzygium cumini*, *Dalbergia sissoo*
- **Reference site benchmarking**, particularly using Mangar Bani as a model of mature Aravalli forest structure.
- **Functional species roles**, including soil-binding shrubs, nitrogen fixers, shade providers, pollinator species and ground stabilisers.

This strategy ensures ecological coherence, climate resilience and long-term survivability across different terrains.

Water and soil management

Blue–Green infrastructure forms the hydrological foundation of landscape restoration and supports the survival of vegetation interventions. Hydrology and soil stability form the backbone of landscape resilience. The restoration plan integrates blue–green infrastructure to improve infiltration, reduce run-off, restore water bodies and revive natural hydrological pathways. (Fig. 14)

Key interventions include:

- **Check dams, gully plugs and contour trenches** to slow run-off and enhance infiltration;
- **Earthen and vegetative bunds** to stabilise slopes and retain moisture;

- **Recharge pits and percolation wells** in moderate slopes and alluvial zones;
- **Wetland and pond revival**, including desiltation, edge planting and protection from grazing;
- **Bio-engineered interventions** using native species for slope stabilisation.

These interventions support hydrological balance while complementing vegetation restoration.

Implementation Strategy

Implementation is a 7-year, 3-phase activity spread across all landscape components based on identified priorities. Given the long-term funding need, the strategy requires multi-sourced funding over the entire period, utilizing innovative mechanisms like green funds, carbon credits, bio-credits, and CSR. An effective implementation agency must provide multi-landscape leadership, carefully leveraging the proposed Special Purpose Vehicle (SPV), with an integral risk and mitigation plan.

Monitoring, Evaluation and Adaptive Management (MEAM)

Long-term success depends on continuous tracking of ecological changes and adapting interventions accordingly. Long-term ecological restoration requires robust monitoring and adaptive decision-making. The MEAM framework provides a structured, transparent and scientifically grounded system for tracking progress and improving interventions.

MEAM dashboard

A GIS-linked monitoring dashboard enables spatial tracking of restoration sites, vegetation recovery, species establishment, SMC improvements and water structure performance.

Ecological health cards (EHCs)

Simple field-based scoring tools for seasonal assessments, evaluating vegetation health, soil conditions, water retention and community participation.

Feedback loops

Adaptive mechanisms integrate field observations, community feedback and seasonal performance to refine restoration actions. This ensures that interventions remain responsive to ecological realities.

Together, the landscape approach, strategic components, terrain-based logic and species strategies create a coherent ecological restoration framework capable of addressing long-term degradation in the Aravalli range.

A view of leopard trail in project area

Chapter 4

Results

Following the baseline assessments (as detailed in Chapter 2), a set of planning and implementation-preparatory outputs were produced. These include grid-level treatment identification, validation of terrain filters, development of intervention units, and preparation of micro-planning inputs for each village as discussed in chapter 3.

Planning outputs generated after the studies

The analytical and field assessments were translated into practical planning outputs that support implementation at the grid and village levels (Table 6). These outputs do not repeat the restoration plan, but represent the operational steps required to begin execution.

Table 6: Overview of the analytical outputs derived from ecological and geospatial assessments, shaping subsequent planning and intervention pathways

Assessment Theme	Observations
Degradation Pattern	The forest area across the project landscape shows a predominance of High to Very High degradation classes, as identified through grid-based analysis.
Key Drivers Identified	Invasive species dominance (*Prosopis, Lantana*), shallow rocky soils, continuous grazing pressure and loss of native vegetation were confirmed as primary drivers of degradation.
Hydrological Stress Zones	Several grids displayed low soil moisture and altered drainage pathways, consistent with NDMI and slope-based assessments.
Priority Grid Types	Rocky ridges and scrub-dominated slopes emerged as the most ecologically stressed areas requiring immediate restoration attention.

Field validation and feasibility assessments

During the preparatory phase, the project team undertook a series of field-based feasibility assessments to validate the restoration approaches proposed in Chapter 3. These exercises focused on understanding on-ground conditions, community use patterns and terrain behaviour, rather than implementing physical pilot interventions.

Key activities included:

- Field investigation of representative rocky, sandy and mixed-terrain patches to assess their suitability for proposed SMC measures.
- On-site evaluation of grazing pressure, vegetation structure and invasive species presence, used to refine the applicability of specific restoration units.
- Visual assessment of water bodies and drainage pathways, including the condition of bunds, extent of siltation and seasonal flow patterns, to inform the design of pond revival measures.
- Discussions with community members to understand current land-use practices, local constraints and feasibility of interventions such as controlled grazing or natural vegetation barriers.
- Ground verification of terrain conditions and species-suitability logic through observation of existing native species clusters and micro-habitats.
- Identification of practical considerations (e.g., access routes, labour availability, slope gradients) that may influence implementation sequencing.

These field assessments provided essential insights into ecological and community conditions and helped refine the restoration logic for grid-level and village-level micro-plans. No structural interventions were carried out at this stage, as the objective was to ensure technical feasibility and community acceptance before commencing implementation.

Capacity building and community awareness

To ensure that the restoration plan can be effectively operationalised, the preparatory phase prioritised capacity strengthening and awareness-building across local institutions, frontline staff and community groups. These actions were aligned with the project's emphasis on community stewardship and long-term sustainability, as outlined in the brief report.

Key activities included:

- Technical capacity building of frontline staff of the Haryana Forest Department, focusing on ecological restoration principles, native species identification, terrain-based interventions ecological literacy, Assisted Natural Regeneration (ANR), nursery and arboretum management, wildlife corridor management, and biodiversity management,, invasive species management and the application of restoration units.

- Awareness sessions in all four villages, using maps, field photographs and simple ecological illustrations to explain degradation patterns, the importance of native vegetation, soil–moisture conservation and the role of community participation.
- Engagement with women's groups and SHGs, recognising their central role in biomass collection, water management and local ecological stewardship. Discussions highlighted opportunities for women's leadership in nursery management, species monitoring and water-body protection.
- Consultations with grazing groups and livestock owners to discuss controlled grazing, fodder alternatives and the ecological need for recovery zones.
- Institutional familiarisation for Panchayats and local committees on how monitoring, protection and reporting systems would function during implementation.

These activities have strengthened ecological understanding, improved acceptance of restoration actions and built early ownership within the community—a critical requirement for successful implementation (Fig. 15). Based on a Training Needs Analysis and stakeholder mapping, the project defined actionable steps for expansion:

Recommended targeted interventions
Recommendations included developing additional tailored IEC materials and designing specific programs to further engage stakeholders and strengthen their role.

Entry point activities (EPAs)
To immediately engage stakeholders and foster community involvement, four high-impact initiatives with detailed Standard Operating Procedures (SOPs) were proposed (Table 7).

Table 7: Suggested entry-point activities in the study area

Activity	Focus
Model Nursery of Aravalli Native Plants (Bhondsi)	Sustainable sourcing and propagation
Arboretum of Aravalli Plants	Education and Research
Eco-Trails (Bhondsi Forest)	Education and Conservation awareness
Eco-Restoration and Grassland Creation (Naurangpur Panchayat Land)	Sustainable land use and practical restoration

Salient features of Sankala's eco-restoration plan

The Sankala Foundation's pilot project establishes a scalable, site-specific micro-planning based eco-restoration plan, designed to supplement broad

Figure 15: Photos of training session and capacity building sessions conducted by Sankala Foundation in the study area

policy frameworks like the MoEFCC's DAP by offering actionable, localised strategies for the Aravalli landscape.

Main features of the project

The plan's success is rooted in its integrated, multi-faceted approach:

1. Scientific foundation and strategic planning

- **Scientific baseline surveys:** Rigorous data collection identified restoration needs, set goals, and selected appropriate techniques based on ecological succession stages.
- **Strategic framework:** Policy goals were translated into 30 Strategic Units (SU) and 163 Dynamic Units, developing output indicators for all SU to guide monitoring.
- **Case study insights:** Restoration components were selected based on curated analysis of similar successful projects.

2. Comprehensive ecological design

- **Five landscape- six component-based planning structure:** The plan applies a five-landscape framework integrated with six intervening components, enabling a unified ecological design that remains flexible and tailorable across the wider Aravalli range.
- **Unique macro to micro architectural plan:** Its architecture—expressed through the Tool Box (30 strategic units) and the Treatment Box (163 dynamic units)—provides a structured, evidence-based method to select interventions according to landscape type, degradation driver and grid condition.
- **Ecological succession stage-based inputs:** Restoration prescriptions are grounded in the site's current ecological succession stage, ensuring actions support natural recovery trajectories rather than impose generic plantations.
- **Habitation landscape at the focus:** With a deliberate focus on the habitation landscape, the design addresses the cause–effect pathways of anthropogenic pressures, enabling green transitions through improved biomass management, drainage rehabilitation and native vegetation recovery.
- **Modular structure:** The modular structure, supported by scope for automation, dashboard-based monitoring, and algorithmic scaling, makes the approach suitable for replication across multiple Aravalli districts.

3. Actionable site-specific micro-plans

- **GIS grid-based planning:** This localised planning used GIS grids to design the Treatment Box, containing specific restoration techniques chosen based on site conditions.
- **Native species and prioritisation:** Restoration zones were prioritised using ecological and social criteria, utilising native species selected for terrain-specific needs.
- **Automation and exit plan:** The system features and ideates an automated dashboard for monitoring and a clear exit plan for successful handover.

4. Capacity building and implementation tools

- **Capacity building:** A program anchored in pilot activities was designed to build local institutional capacity for stewardship among staff and community members.
- **Standard operating procedures (SOPs):** Clear SOPs streamline implementation across crucial areas, including native species selection, invasive species management, water harvesting (Blue-Green Infrastructure), and establishing nurseries and eco-trails.

5. Innovative measures and sustainability

- **Innovative components:** The plan integrates innovation and Traditional Ecological Knowledge (TEK) into its core design.
- **Forward-thinking strategies:** It incorporates concepts like regenerative tourism, biodiversity credits, the Aravalli Green Fund, social stock exchange platforms, and citizen science platforms.
- **Implementation strategy:** It uses a Landscape-based approach supported by diverse and innovative funding mechanisms for long-term sustainability.

6. Monitoring and scalability

- **Risk mitigation and MEAM:** A robust Monitoring, Evaluation, and Adaptive Management (MEAM) system is integrated, featuring proactive risk mitigation, technology-driven monitoring (MIS, GIS, IoT), and the Ecosystem Health Card (EHC) for evaluation.
- **Scalability framework:** Grounded in an evidence-based, inclusive methodology, the plan is explicitly designed to be a replicable, adaptive model for restoring ecological integrity and climate resilience across all 29 Aravalli districts.

Collectively, these outputs position Sankala's initiative as implementation-ready and grounded in scientific, community-centred planning. The convergence of analytical rigour, terrain-specific design, stakeholder engagement and implementation strategy sets the stage for structured micro-planning and scalable restoration across the Aravalli landscape.

Chapter 5

Strengthening the Aravalli Green Wall Project: Way forward

The Aravalli Green Wall Project (AGWP), launched by the Ministry of Environment, Forest and Climate Change (MoEFCC), seeks to restore ecological connectivity, reverse land degradation and enhance climate resilience across the Aravalli range. The eco-restoration plan developed for the four project villages directly supports this national mandate by providing a replicable, scientifically grounded, community-centred model for landscape restoration in semi-arid, peri-urban contexts. This chapter outlines how the project strengthens the AGWP, expands its on-ground applicability and contributes to long-term regional resilience.

How this project strengthens the AGWP

1. Operationalising AGWP at the micro-scale
While AGWP provides a broad national framework, this project demonstrates how its goals can be translated into **actionable micro-plans**, aligned with terrain, hydrology, and socio-ecological realities.
Key contributions include:

- Grid-based degradation diagnostics;
- Terrain-filtered treatment pathways;
- Village-level community stewardship systems; and
- Integrated blue–green infrastructure design.

These components bridge the gap between policy intent and field execution, providing a practical 'AGWP-in-action' model.

2. Demonstrating localised solutions for a regional problem
The Aravalli landscape varies widely in terrain, settlement pressure and vegetation structure. The project's modular restoration architecture offers AGWP a flexible toolkit that can be scaled and adapted across other districts.

3. Strengthening water security within AGWP
By integrating hydrological restoration (pond revival, drainage strengthening, infiltration enhancement), the project aligns strongly with AGWP's focus on climate resilience and drought mitigation in the region.

4. Advancing native biodiversity goals
The species strategy demonstrates how native Aravalli flora can be restored systematically, accelerating ecological succession and creating continuous habitat patches, which is one of the core objectives of the AGWP.

5. Embedding community driven change
Through capacity building, awareness programmes and proposed monitoring committees, the project strengthens the AGWP's emphasis on community-led ecological recovery, ensuring longevity beyond the implementation period.
6. habitation, additional components, site specific yet comprehensive plan

Impact pathways

The project lays the groundwork for measurable ecological and socio-economic impacts that align with AGWP priorities:

Ecological Impact

- Improved vegetation cover and native species recovery based on the ecological successional stage
- Enhanced soil stability and reduced erosion
- Increased groundwater recharge through SMC and pond restoration
- Strengthened wildlife corridors and microhabitats

Hydrological Impact

- Reconnected drainage lines
- Revived ponds and improved water retention
- Blue–green infrastructure buffering against extreme weather events

Socio-economic Impact

- Reduced time burden on women for biomass and water collection
- Enhanced local climate resilience
- Opportunities for green livelihoods (nurseries, eco-trails, monitoring roles)
- Strengthened local governance on ecological issues

5.4 Policy advocacy and national relevance
This rigorous, scalable plan provides actionable, customisable strategies directly aligned with India's commitments under:

- UN Convention to Combat Desertification (UNCCD) – Land Degradation Neutrality (LDN)

Table 8: Actionable Recommendations for Ecosystem Restoration Integrating Habitat Rehabilitation, Water Management, Policy Reform, Community Stewardship and Digital Monitoring

Category	Recommendations
Forest/ Habitat Restoration	Establish native species nurseries and implement community-based fire management.
Biodiversity Management	Create wildlife corridors, reintroduce native fauna, and adopt global standards (TGBS).
Invasive Species Management	Develop multi-year strategies for invasive removal, engaging youth and women.
Water Management	Revive johads, construct check dams, and integrate blue-green infrastructure.
Livelihood Diversification	Promote eco-tourism, regenerative tourism, and Non-Timber Forest Product (NTFP) value chains, supported by training.
Institutional Strengthening	Form Village Restoration Committees (VRCs) and foster collaboration among forest officials, Urban Local Bodies (ULBs), and NGOs.
Policy Integration	Mainstream eco-restoration into urban Master Plans and zoning regulations.
Monitoring	Operationalize a Management Information System (MIS) with IoT for adaptive management.
Awareness	Integrate restoration into school curricula and public campaigns.

- National Mission for a Green India (GIM)
- National Action Plan on Climate Change (NAPCC)
- Aravalli Green Wall Project (AGWP)

Key policy contributions

- Demonstrates a **proof-of-concept model** for AGWP implementation at the village scale
- Introduces a replicable monitoring framework (GIS dashboard + EHC)
- Offers a structured approach to integrate **traditional knowledge**, **gender perspectives**, and **community institutions** in restoration
- Provides a financing logic involving CSR, green credits and blended funds—relevant for AGWP's long-term financing needs

Impact and policy advocacy

This rigorous, scalable plan provides actionable, customisable strategies aligned with global commitments. It proves the feasibility of achieving ecological integrity and climate resilience, underscoring the urgent need for wider implementation following the Aravalli Green Wall Project launch. The key impacts are listed in table 8.

The plan illustrates the feasibility of achieving large-scale Aravalli restoration by combining scientific rigour with participatory governance. It also provides an evidence base to advocate for:

- Institutional strengthening at district level
- Integration of micro-plans within regional Master Plans
- Cross-state collaboration across Haryana, Delhi, Rajasthan and Gujarat under AGWP

Policy and programme developments

The AGWP scaled up significantly on World Environment Day (5 June, 2025), when the Hon'ble Prime Minister Shri Narendra Modi launched its next phase, expanding the 'Ek Ped Maa Ke Naam' campaign. This ambitious plan targets establishing a 1,400 km-long, 5 km-wide green-belts across the Aravalli range in Delhi, Haryana, Rajasthan, and Gujarat. The first phase prioritises restoring 8.1 lakh ha of degraded forests/scrubland within a larger 2.7 million ha buffer zone, at an estimated cost of INR 16,053 Cr.

The project is explicitly focused on mitigating environmental challenges like improving water systems, curbing dust storms, and stopping the eastward expansion of the Thar Desert. As a key commitment, the Haryana Forest Department pledged to restore 24,990 ha of degraded forest over three years, including 6,063 ha in Gurugram.

The Foundation's efforts in establishing a contextualised eco-restoration for the Aravalli eco-restoration is timely and appropriate for ground level implementation (Fig. 16).

Way Forward: Strengthening AGWP implementation

To build on the scientific, operational and community-centred framework presented in this report, the next phase of AGWP implementation must focus on structured scaling, institutional alignment and long-term stewardship. The following priority directions will strengthen the uptake and replication of the model developed through this project:

1. Baseline study: To identify drivers of restoration, restoration opportunity, stakeholder mapping and priortising restoration sites.

2. Comprehensive landscape based restoration plan; the one suggested by Sankala Foundation with 30 strategic units and 163 dynamic units for comprehensive planning and implementation.

3. Site- specific micro planning: as suggested here in the model plan for successful monitoring and evaluation and long-term sustainability.

4. Institutional integration: Integrate the micro-plan templates, grid-based diagnostics and dashboard framework into district-level Aravalli Master Plans, Forest Working Plans and AGWP state action plans to ensure uniform adoption across departments.

5. Scaling through district-level units: Establish dedicated AGWP implementation cells at the district level that coordinate multi-departmental action—forest, panchayat, water, rural development and urban bodies—to ensure simultaneous progress on hydrology, vegetation and community stewardship.

6. Financing the next phase: Operationalise a blended financing approach that combines state budgets, corporate social responsibility(CSR) funds, green credits and bio-credit mechanisms under a dedicated Aravalli restoration fund. This will provide the long-term financial continuity needed for landscape-scale restoration. CAMPA should focus on eco-restoration rather than plantation targets.

7. Community institutions and local participation: Strengthen joint forest management committees (JFMCs), biodiversity management committees (BMCs), women's groups and self-help groups (SHGs) as custodians of restored sites. The capacity building and SOPs developed through this project should now be formalised into state training modules to build sustained local stewardship.

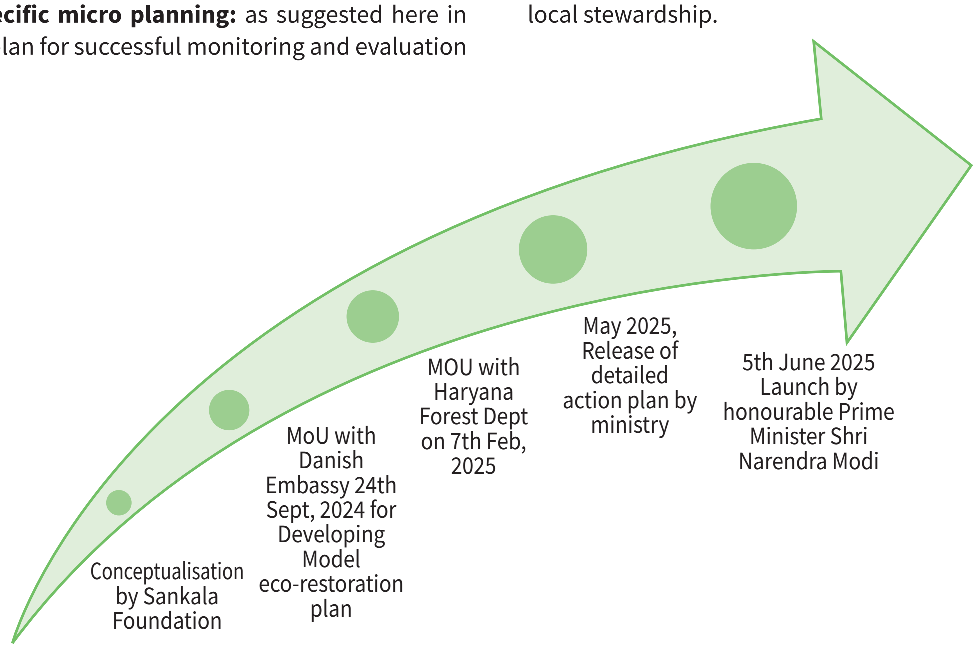


Figure 16: Timeline of key policy milestones, from Sankala's 2024 proposal to the AGWP launch in 2025

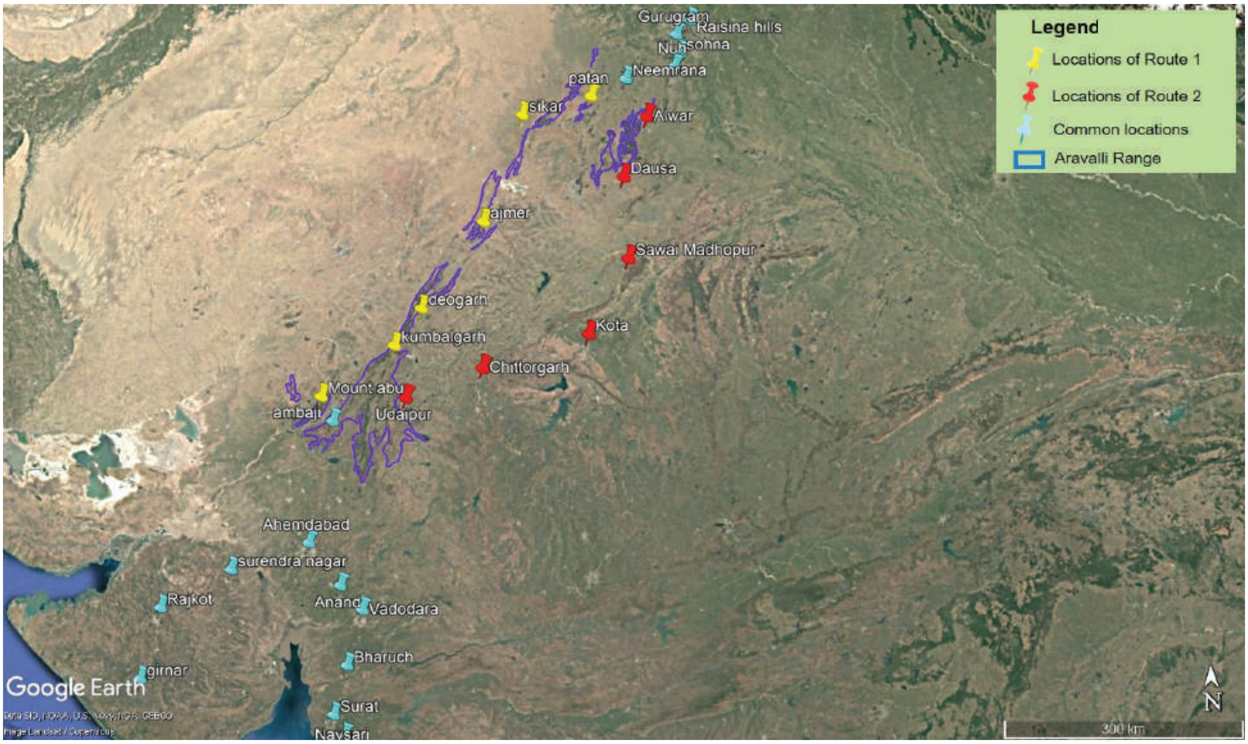


Figure 17: Google Earth image with pinned locations for yatra route

8. Technology and monitoring roll-out: Scale the digital MEAM system and restoration dashboard developed in the pilot villages to all AGWP districts to enable real-time monitoring of treatment units, species survival, water structure performance and labour inputs.

9. Phased expansion roadmap: Adopt a three-tier operational roadmap:
Year 1: District adoption of templates, initiate dashboard roll-out, select two districts for scaling.
Years 2–3: Expand grid-based restoration across priority corridors, activate district AGWP Units.
Years 4–7: Achieve contiguous restoration across the AGWP belt and integrate outcomes into climate resilience plans.

10. Developing Risk and Mitigation Strategy.

Creating ground-level momentum through the 'Aravalli Green Yatra'

These strategic steps position AGWP for systematic, evidence-driven expansion while ensuring ecological integrity and community ownership remain central.
The Sankala Foundation's Aravalli Green Yatra is an innovative 12-week grassroots movement conceptualised to mobilise stakeholders across the 29 Aravalli districts for mass engagement and implementation of the Aravalli Green Wall Project (AGWP), aligning with the UN Decade on Ecosystem Restoration.

The Yatra will traverse Gujarat, Rajasthan, Haryana, and Delhi, focusing on four key objectives:
Ecological Action: Promoting mass afforestation and sanitation.

1. Water Security: Enhancing water availability through watershed management.
2. Pollution Control: Mitigating pollution via clean-up drives and advocacy.
3. Sustainable Development: Fostering eco-friendly livelihoods and preserving cultural heritage.

The project reinforces the AGWP's objective of creating a continuous, climate-resilient green corridor along the Aravalli range. By offering a scientifically robust, socially anchored and operationally viable model, it demonstrates how restoration can be scaled across all the districts of the Aravalli range.

Taken together, these strategic, institutional and citizen-led pathways provide AGWP with a robust and scalable model for restoring the ecological resilience of the Aravalli range. The project demonstrates that landscape restoration, when rooted in science and community participation, can be both achievable and transformative.

Kair *(Capparis decidua)*, a native species of the Aravalli range and is a common sight along the leopard trail in Gurugram, Haryana.

Red-vented bulbul *(Pycnonotus cafer)* bird native to Aravalli range.

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About Sankala Foundation

The Sankala Foundation is a non-profit organisation established in 2022 under Section (8) of the Companies Act, 2013 of India. Our primary focus is to strengthen the knowledge base and promote dialogue among various stakeholders to foster initiatives that contribute to the sustainability of our planet. We are particularly committed to mitigating the effects of climate change and environmental disasters, with a strong focus on protecting and fostering vulnerable communities.

The Foundation actively engages in research and promotes knowledge–based advocacy. We strive to contribute to the development of sustainable policies and practices, and to foster partnerships at all levels with governments, NGOs, the scientific community, and domain experts who share similar objectives.

The Sankala Centre for Climate and Sustainability (SCCS) aims to advance knowledge and action to combat climate change and promote sustainability. The Centre focuses on building alliances with the government and non-governmental organisations, UN agencies, international organisations, scientific communities, and domain experts with shared objectives to create synergy and drive collective action.

The Sankala Centre for Cultural and Natural Heritage (SCCNH) aims to preserve, promote, and study India’s rich cultural and natural heritage. The Centre is dedicated to advancing knowledge and awareness of cultural traditions, historical sites, ecosystems, and biodiversity through interdisciplinary research, conservation efforts, and community engagement. It serves as a bridge between academic research, policy development, and community-driven heritage initiatives.

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Sankala Foundation

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