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An initiative of Abhipsa Foundation

Haryana Forest Department
Government of Haryana

EY Foundation

The Green Wall of Aravalli:

A Roadmap for Ecological Restoration

Report| June 2025

Contributors to the Study:

Reviewers:

- Ernst & Young Foundation
- Dr. Fawzia Tarannum, co-Founder & Strategic Advisor, GuruJal
- Mr. Avinash Mishra (Former Advisor, NITI Ayog)
- Mr. Ashish Dev Kapur, Vice Chairman & Trustee, GuruJal

Project Lead: Ms. Shubhi Kesarwani, co-Founder & CEO, GuruJal

Research Team:

Environment Section:

- Mr. Sachin Kumar, former CTO, GuruJal
- Dr. Syed Maqbool Geelani, Projects Lead, GuruJal
- Dr. Ranjana Ray Chaudhari, HoD Water Resources Department, TERI SAS
- Mr. Chetan Agarwal, Forest & Independent Analyst, CEDAR
- Mr. Pulkit Sharma, Program Manager – Forestry, GuruJal
- Mr. Sunil Harsana, Forest Researcher & Conservationist
- Mr. Shivansh Ghildiyal, GIS Associate, GuruJal
- Mr. Jasin S., Assistant Manager of Research, GuruJal
- Mr. Aakash, Drone Associate, GuruJal
- Mr. Jitender Kumar, Water Project Associate, GuruJal
- Mr. Ismail Ahmad, Forestry Associate, GuruJal
- Ms. Pratha Mishra, Intern, GuruJal
- Mr. Bharat Ramachandran, Intern, GuruJal
- Ms. Sonia Garg, Vice President, Saahas
- Ms. Hetal Jalad, Waste Researcher, Saahas

Society Section:

- Ms. Ashita Mall, Communications Lead, GuruJal
- Dr. Rupamanjari Sinha Ray, Associate Professor Economics, MDI
- Ms. Anjali Singh, Community Mobilization Associate, GuruJal
- Mr. Faraz Ahmad, Assistant Manager of Communications, GuruJal

Governance Section:

- Ms. Anjali Sharma, former Program Manager, GuruJal
- Ms. Nishita Bannerjee, Social & Cultural Insight Strategist

Contents

Foreward

Shri Rao Narbir Singh

Hon'ble Forest Minister, Government of Haryana

The Aravalli Range is one of India's oldest and most ecologically vital mountain systems. It has long played a central role in preserving Haryana's environmental balance—acting as a barrier to desertification, recharging groundwater, and supporting unique biodiversity and local livelihoods.

In today's age, the environment is a critical issue that demands our urgent attention. As the challenges of climate change, deforestation, and ecological degradation grow more severe, it becomes increasingly important to research and understand the issues our environment is facing. Only then can we design appropriate, effective, and sustainable solutions.

Humans and the environment are not separate—they complete each other. When we protect our forests, lakes, and natural ecosystems, they, in turn, protect and sustain us. This interdependence lies at the heart of this report, which offers a comprehensive roadmap for the conservation and restoration of the Aravalli ecosystem, with particular attention to the Damdama region.

I commend all stakeholders, researchers, and government departments who have come together to create this important document. The report reflects a deep commitment to science-based policy, community involvement, and long-term environmental stewardship.

I congratulate everyone involved for taking this crucial step. May this report inspire further action and collaboration in our collective mission to restore and protect Haryana's natural heritage.

Rao Narbir Singh
Hon'ble Forest Minister,
Haryana Forest Department,
Government of Haryana

Preface

विनीत कुमार गर्ग
भा.व.से.
Vineet Kumar Garg,
I.F.S.

प्रधान मुख्य वन संरक्षक एवं
वन बल प्रमुख, हरियाणा
Principal Chief Conservator of Forests
& Head of Forests Force (HoFF), Haryana

D.O. No. PS/PCCF/340
Dated 30/05/2025

Preface

The Aravalli Range, one of the world's oldest fold mountains, holds immense ecological, hydrological, and socio-cultural significance for the Indian subcontinent—particularly for the state of Haryana. As a natural shield against desertification, a vital groundwater recharge zone, and a haven for biodiversity, it is central to the region's environmental stability. However, over the decades, relentless urban expansion, infrastructure development, deforestation, and neglect have eroded the ecological fabric of this ancient landscape.

This study emerges from a shared concern and growing urgency to restore and conserve the Aravallis—specifically around Damdama Lake in the Gurugram district. It is both a response and a roadmap: a response to the environmental degradation we witness today, and a roadmap to revive one of Haryana's most critical natural ecosystems.

Drawing from field research, data analysis, and community consultations, the report delves into the region's climate patterns, land use, soil quality, water systems, biodiversity, socio-economic dynamics, and governance structures. Each chapter seeks to inform policy, mobilize community action, and drive sustainable development.

The project area, encompassing the villages of Abheypur, Damdama, and Kherla have demographic and socio-economic profiles of communities which reflect both the challenges and the possibilities. With over 80% of the population engaged in agriculture and heavily dependent on forest resources, conservation efforts must be inclusive, participatory, and livelihood-linked to be sustainable.

This book outlines practical recommendations: from eco-restoration measures and water conservation strategies to community-driven waste management and invasive species control. The vision is to create a Biodiversity Park that not only preserves the natural heritage of the Aravallis but also fosters environmental awareness, cultural engagement, and sustainable livelihoods.

Ultimately, this is a call to action—for government agencies, conservationists, researchers, and local communities. The health of the Aravallis is deeply entwined with the well-being of the people it sustains. It is our hope that this study serves as both a foundation and a catalyst for long-term ecological resilience and community stewardship in the region.

30/05/2025
Vineet Kumar Garg, IFS

C-18,Van Bhawan, Sector-6, Panchkula-134109
Tel.No. 0172-2563988, 94164 12800 E-mail: pccf-hry@nic.in, papccf@gmail.com

Acknowledgement

This study is a pursuit to scientifically restore the north-western bio wall of Aravalli. It is a compilation of research and enquiry around eighteen parameters of Environment, Society and Governance (ESG) to understand the depth and evidence based causes of environmental degradation in the Forest Areas of Kherla, Damdama, Abheypur and Damdama Lake. The Baseline study has the roadmap as the guidance manual to develop the effective conservation and implementation plan for the region's eco-restoration, which is often missing in most projects. It has been a result of primary and secondary research from July 2023 - July 2024 done with the support of Ernst & Young Foundation. I want to acknowledge the contribution of our Trustees Mr. Ashish Dev Kapur and Strategic Advisor, Dr. Fawzia Tarannum for their unwavering support, my colleagues from GuruJal and expert researchers from TERI SAS, CEDAR and MDI.

We extend our deepest gratitude to Ernst and Young Foundation and all those who have believed and contributed to the successful completion of Baseline Report on the Aravalli Range and Damdama Lake. We are especially thankful to Mr. Amit Khatri, IAS, former DC Gurugram, Mr. Narinder Sarwan, former DDPO Gurugram, Mr. Shubhash Yadav, former DFO Gurugram for their visionary leadership and guidance, to preserve Aravalli and desertification expansion. We are grateful to Dr. Yash Garg, IAS and Mr. Nishant Yadav, IAS, Mr. Prashant Panwar, IAS and Dr. Satbir Kadian for leading the way for the project and constant support.

We gratefully acknowledge the collaboration and support of the officers and field staff of District Administration Gurugram, Haryana Forest Department, Haryana Tourism Department, Irrigation and Water Resources Department Gurugram, PHED Department Gurugram, and the District Development and Panchayat Department Gurugram. Their commitment was vital to this baseline assessment and in developing effective strategies for ecological restoration.

Our sincere thanks also go to the former and present Sarpanches and people of Abheypur, Damdama, and Kherla Villages of Gurugram District for their crucial local knowledge, active cooperation, and engagement. Their contributions have greatly informed our approach and strengthened the impact of our recommendations. Their combined efforts have been instrumental in advancing our mission, and for that, we are profoundly grateful.

Warm Regards,

Shubhi Kesarwani,
co-Founder & CEO,

List of Figures

List of Tables

Abbreviations

BDP	Bio-diversity Park
BOD	Biological Oxygen Demand
C&T	Collection & Transportation
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
ha	Hectare
HSPCB	Haryana State Pollution Control Board
IMD	Indian Meteorological Department
IUCN	International Union for Conservation of Nature
Kg	Kilograms
lpcd	Litre Per Capita Per Day
LPG	Liquified Petroleum Gas
LST	Land Surface Temperature
LULC	Land Use Land Cover
MDF	Moderate Dense Forest
Mg	Milligrams
MNDWI	Modified Normalized Difference Water Index
MoEFCC	Ministry of Environment, Forest and Climate Change
MPN	Most Probable Number
MRF	Material Recovery Facility
NABL	National Accreditation Board for Testing and Calibration Laboratories
NCR	National Capital Region
NE	North East
OF	Open Forest
pH	Potential of Hydrogen
PLPA	Punjab Land Preservation Act
S	South

SE	South East
SOIB	State of India's Board
SPP	Species
SWM	Solid Waste Management
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
USGS	United States Geological Survey
VDF	Very Dense Forest
WHO	World Health Organization

About GuruJal

Haryana has been identified as one of the most water stressed States of the Nation. Currently in Haryana, 19 out of 22 districts are declared to be in the 'Dark Zone' of the country; over-exploitation of ground water resources takes place in these Districts. This is primarily due to the fact that Haryana historically has been an agricultural state, currently with 78.8% of the land being used for farming, and thus generating most of its revenue from agricultural produce. The main agricultural products that have been cultivated have been of rice, wheat and cotton, which are all water intensive crops. As mentioned earlier; to meet the growing demands of high agricultural produce, freshwater canals were built for irrigation purposes during the Green Revolution. These canals however were not able to meet the consequent freshwater demand. Therefore, groundwater has continuously been pumped out to meet the demands for irrigation.

GuruJal, an initiative of Abhipsa foundation formerly the Special Purpose Vehicle (SPV) of District Administration Gurugram, started in May 2019 as public private partnership to oversee water mismanagement and make Gurugram a water secure district through effective water governance. Now working as an independent organization working in the field of water security and natural resource conservation through Nature Based Solutions.

SUPPORT A POND — Rejuvenate and restore water bodies by cleaning, remediating, and landscaping the water, soil and subsurface material

eco restoration — Increase the forest cover by intensive afforestation and to restore the degraded patches of Aravalli hills in the form of Biodiversity Park

We for Water — The WeforWater fellowship is designed to train, educate, and empower youth to become skilled water experts. This initiative focuses on cultivating the next generation of leaders in water conservation and management.

WATER PROOFING — Install rainwater harvesting systems and onsite training of fixing water leakages

ESG ADVISORY — Enabling the corporates to meet their sustainability goals through a developed road map for meeting ESG targets, transition plans and implementation, national and international framework aligned sustainability reporting.

CONNECT THE DROPS "GURUJAL" — Awareness campaign to mobilize community to improve state of water, conserve, and utilize judiciously.

Executive Summary

Introduction

The Aravalli Range is one of the oldest mountain ranges on Earth, extending approximately 670 kilometers through northern and western India. It plays a critical role in the ecological and climatic systems of regions like Haryana, where it acts as a natural barrier against desertification, a key groundwater recharge zone, and a biodiversity hotspot. However, due to rapid urbanization, deforestation, and developmental activities, the ecological integrity of the Aravalli hills has been severely compromised.

Significance of the Aravalli Range

The Aravalli Range holds immense ecological importance as it acts as a natural barrier that prevents the spread of the Thar Desert into eastern Rajasthan, the Indo-Gangetic plains, Haryana, and Western Uttar Pradesh. The range also serves as a crucial groundwater recharge zone, essential for towns like Gurugram and Faridabad, ensuring the future groundwater security of southern Haryana. Moreover, the Aravalli hills support a unique biodiversity, including various endangered flora and fauna, making them a vital ecological asset.

Despite their significance, the Aravalli Range faces severe environmental challenges due to rapid urbanization and infrastructure development. These activities have led to water scarcity, loss of biodiversity, high pollution levels, and land degradation. Haryana, which has one of the lowest forest cover percentages in India at just 3.59%, relies heavily on the Aravalli Range for its green cover and ecological balance. The degradation of this landscape has resulted in a pressing need for immediate conservation efforts to restore and protect this vital ecosystem.

Project Objectives

The proposed project in the Gurugram district focuses on the conservation and restoration of the Aravalli Range to address these environmental challenges. The key objectives include:

- To protect and conserve the existing flora and fauna of the region,
- To rejuvenate one of the biggest lakes of the district i.e., Damdama Lake,
- To create awareness about the significance of Aravalli and its Vegetation and to create ownership and self-belongingness among the local community,
- To Serve as a hub for education, cultural and conservation activities,
- To develop eco-tourism and self-sustaining model for the locals.

Strategic Components of the Study

To achieve the project objectives, the report outlines a comprehensive study composed of the following components:

- **Climate**: Understanding the climatic conditions and their impact on the region.
- **Land**: Assessing land use patterns and degradation.
- **Hydrology and Hydrogeology**: Studying water resources and groundwater recharge mechanisms.
- **Biodiversity**: Documenting existing species and habitats, identifying key conservation areas.
- **Archaeology**: Preserving the cultural heritage of the region.
- **Waste Management**: Addressing waste disposal and pollution control.
- **Social Assessment**: Evaluating the social impact of the project on local communities.
- **Governance**: Analyzing the governance structures that will support the project's implementation and sustainability.

Demography Profile

The project area includes three villages adjacent to Damdama Lake and the proposed Biodiversity Park: Abheypur, Damdama, and Kherla. These villages, situated in Sohna block of Gurugram district, collectively cover an area of approximately 4,055 acres and have a combined population of around 17,553, with a significant proportion of youth (about 60%).

- **Population Growth:** Over the past four decades, the villages have seen substantial population growth: 164% in Abheypur, 148% in Damdama, and 181% in Kherla, with Kherla experiencing a particularly steep increase due to workforce migration.
- **Gender Distribution:** According to the 2011 Census of India, the male-to-female ratio was 53:47 in Abheypur and 52:48 in both Damdama and Kherla. However, recent surveys show a drop in the overall female population from 48% in 2011 to 43% in 2023.

Socio-Economic Profile

Understanding the socio-economic dynamics of the villages is crucial for designing effective interventions and ensuring the project's success.

- **Occupational Distribution:** Approximately 80% of the population is engaged in agriculture, with a significant dependency on forest resources for daily needs. Fuelwood from Keekar and LPG cylinders are the primary cooking fuel sources.
- **Scheduled Castes:** The proportion of Scheduled Castes in the villages as per the 2011 Census was 16% in Abheypur, 22% in Damdama, and 24% in Kherla.
- **Literacy Levels:** Literacy is a key factor in ensuring community participation in project activities. As per the 2011 Census, the average literacy rate in the three villages was 66%. A recent survey indicates a significant improvement, with the current literacy rate standing at 80%.

- **Workers Classification:** The majority of the workforce comprises main workers, particularly in Damdama, where 87% of the population is engaged in main work. Marginal workers are more prevalent in Abheypur, where they constitute 30% of the workforce.

Findings

Climate Conditions

- PM10 and PM2.5 account for 84-85% of total pollution, with levels 3-6 times above permissible limits.
- In January, temperatures in the park ranged from 18-21°C.
- June saw temperatures exceeding 45°C in the north-eastern and eastern boundaries.
- September temperatures exceeded 35°C in the north-eastern and south-western parts during the monsoon.

Soil Characteristics

- Organic matter is less than 0.5%, indicating poor soil quality.
- Moisture content is below 3% in most areas, except around the lake. Immediate improvements are needed.

Land Assessment

- In June, vegetation was mainly around the lake with NDVI values up to 0.32. Other areas had low NDVI values (0.1-0.2), indicating bare soil.
- By September, NDVI values increased to 0.4, with some areas showing negative values (-0.03), indicating water presence.

Hydrology

- Check dams and gully plugs are recommended at critical locations to improve water retention and restore channels.
- These interventions could increase lake depth by one meter, ensuring more consistent water availability.
- Gully plugs will help with erosion and sedimentation, while check dams will control water flow and facilitate groundwater recharge.

Biodiversity

- **Forest Types**: The area features Tropical Dry Deciduous Forests and Tropical Thorn Forests, with common types including 6B/E2 *Acacia senegal* forest, 5B/E1-DS1 *Anogeissus pendula* scrubs, and 6 E4/DS1/1S1 Desert Dune Scrub near the lake.
- **Dominant Vegetation**: *Acacia senegal* forms extensive patches, while degraded *Anogeissus pendula* scrubs indicate past dominance of 5B/E1-*Anogeissus pendula* forest. *Prosopis juliflora* an invasive tree species dominates the majority of area.

- **Understory Plants**: *Grewia tenax* and *G. flavescens* are common in hilly areas, with presence of young *Holoptelea integrifolia* and *Vallaris solanacea* .
- **Other Vegetation**: Ziziphus scrubs are found, and Desert Dune Scrub is noted in sand deposition areas.
- **Plant Species Checklist**: The survey identified 262 plant species, including 40 tree species (23 within plots, 17 outside), 20 shrub species (8 within plots, 12 outside), 167 herbs, and 35 climbers, reflecting diverse habitats and vegetation types.

Recommendations

Climate-linked Suggestions

- Utilize the lake's water surface for temperature control and balance evapotranspiration. Monitor temperature and oxygen levels to assess microclimate variations and the biodiversity park's impact on air quality.
- Implement rooftop rainwater harvesting to meet the water needs of 200-1200 persons, reduce groundwater pressure, and enhance water security.
- Adopt eco-restoration measures to increase groundwater levels by at least 0.3 meters within a year.
- Protect the lake through soil conservation and check dams to maintain its 15-hectare spread and support eco-tourism with a water level of 1.5-2 meters.

Rooftop Rainwater Harvesting

- Capture rainwater to reduce groundwater stress. Damdama, Abheypur, and Kherla can harvest up to 13.42, 19.42, and 31.45 million liters annually, respectively, meeting the water needs of 525, 760, and 1231 persons.

Biodiversity Park Interventions

- Implement soil conservation techniques such as jute or coir geo-textiles on slopes to prevent erosion.
- Install micro-check dams and trenches to conserve soil moisture and support seedling growth.
- Use abandoned borewells for rainwater harvesting to help maintain lake water levels.

Fuelwood and Grazing

- Allocate areas for fuelwood collection and grazing while focusing on regeneration. Engage fuelwood collectors in site restoration and invasive species management.

Alternate Energy Sources

- Assess and promote alternative energy sources to reduce reliance on forest resources, making conservation efforts more acceptable.

Invasive Weeds

- Gradually replace invasive exotic weeds to enhance native biodiversity and prevent their dominance.

Lake-side Zone

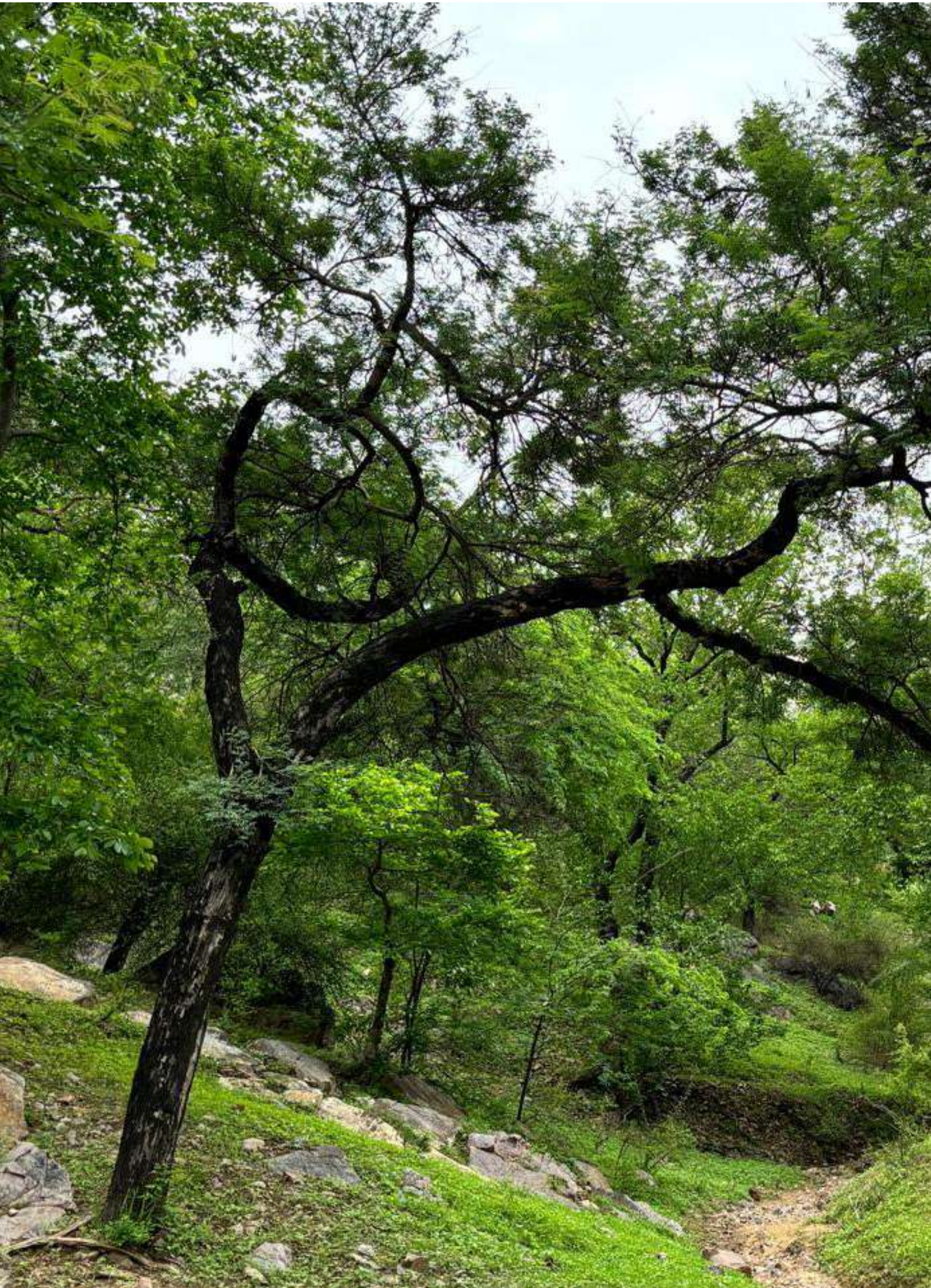
- Remove invasive species and prevent waste dumping around the lake. Treat wastewater before it enters the lake.

Waste Management

- Conduct an IEC/BCC campaign to shift community behaviour, enhance waste management infrastructure, and align with national and global sustainability goals. Reduce waste burning, promote source segregation, and compost wet waste.

Social Recommendations

- Focus on enhancing rural livelihoods and income through agroforestry connections and community-based initiatives. Support cultural practices, social cohesion, and environmental aesthetics to foster community engagement and pride. Address socio-economic inequalities and promote educational and cultural activities within ecological spaces.



Chapter 1: Background

India is one of the oldest civilizations in the world with a rich, varied, and unique culture. It is a vast country with great diversity in physical features that include amongst others, dry, evergreen forests, snow-clad mountains, a long coast, and fertile plains. India is one of the 10 most forest-rich countries and one of the 17 mega biodiverse regions of the world.[1] In term of freshwater resources it also begs 10th position across the world.[2] We depend on forests for our survival, from the air we breathe to the wood we use. Besides providing habitats for animals and livelihoods for humans, forests also offer watershed protection, prevent soil erosion, and mitigate climate change. But in the past few centuries, with the exponential increase in the population, the demand for resources derived from forests has also increased in a likewise fashion.

Aravalli hills are one of the oldest mountain ranges on earth and are the prominent landforms shaping the West-Indian climate and biodiversity. Aravalli with its lush green forests used to act as a green barrier and acted as an effective shield against desertification. It checked the spread of the Indian Desert (Thar) towards eastern Rajasthan, Indo Gangetic plains, Haryana, and Western Uttar Pradesh.

The forests of the Aravalli range in Haryana are now the most degraded in India, and most of the indigenous plant species have disappeared. The rapid urbanisation, deforestation, mining, and developmental activities are destroying the unique landscape that requires immediate conservation attention. These vulnerable areas used to be biologically rich and supported several unique elements of flora and fauna.

The Aravalli Range is an ecologically significant region with semi-arid features, unique biodiversity, and tracts of forested areas. Since it is a semi-arid zone with annual monsoon rainfall varying between 500mm to 600mm, the hydrology of this region is critical for supporting biodiversity, maintaining ecological balance, and providing critical water resources. The National Capital Delhi as well as the Faridabad, Gurugram, and Nuh districts of Haryana are significantly influenced by the local climate that the Aravalli hills regulate.

According to India State of Forest Report (ISFR) 2019, published by the Forest Survey of India (FSI) the total forest and tree cover of the country is 80.73 million hectares which are 24.56 percent of the geographical area of the country. The total forest cover of the country, as per the current assessment is 7,12,249 sq. km which is 21.67% of the total geographic area of the country.

Haryana is primarily an agricultural state of India and 80% of the total geographical area is under agriculture. As per the Champion & Seth Classification of Forest Types (1968), the forests in Haryana

[1] https://pib.gov.in/newsite/PrintRelease.aspx?relid=176496
[2] https://www.worldatlas.com/articles/countries-with-the-most-freshwater-resources.html

belong to three Forest Type Groups i.e., Tropical Dry Deciduous Forest, Tropical Thorn Forest, and Subtropical Pine Forests.

The Forest Cover in the State is 1,602.44 sq. km which is 3.62% of the State's geographical area. In terms of forest canopy density classes, the State has 28.00 sq. km under Very Dense Forest (VDF), 450.90 sq. km under Moderately Dense Forest (MDF), and 1,123.54 sq. km under Open Forest (OF).

Ecological significance for the country has helped in checking the extension of the Thar Desert towards the east and National Capital in the north. Rich in biodiversity and mineral resources, Aravalli Ranges has a great ecological, social, and economic significance of the regions in which it exists.

Once rich in natural resources, the region has continuously faced degradation of its natural resources. Due to tremendous pressure from the vicinity of the area and lack of awareness about natural resource preservation. This calls for the need to preservation of natural resources in the world's oldest mountain chain by conservation of flora, fauna, and water resources through the development of biodiversity park and revival of lake. Both biodiversity park and lake will help in enriching ecology of the region.

District At a Glance

Gurugram district is situated on south-eastern part in Indian Haryana state has an area of 1258 sq.km. In the north, it is bordered by the Union Territory of Delhi, in the east by Faridabad, in the north-west by Jhajjar and Rewari districts of Haryana and in the west by the Alwar district of Rajasthan state and south by the Nuh district of Haryana state.

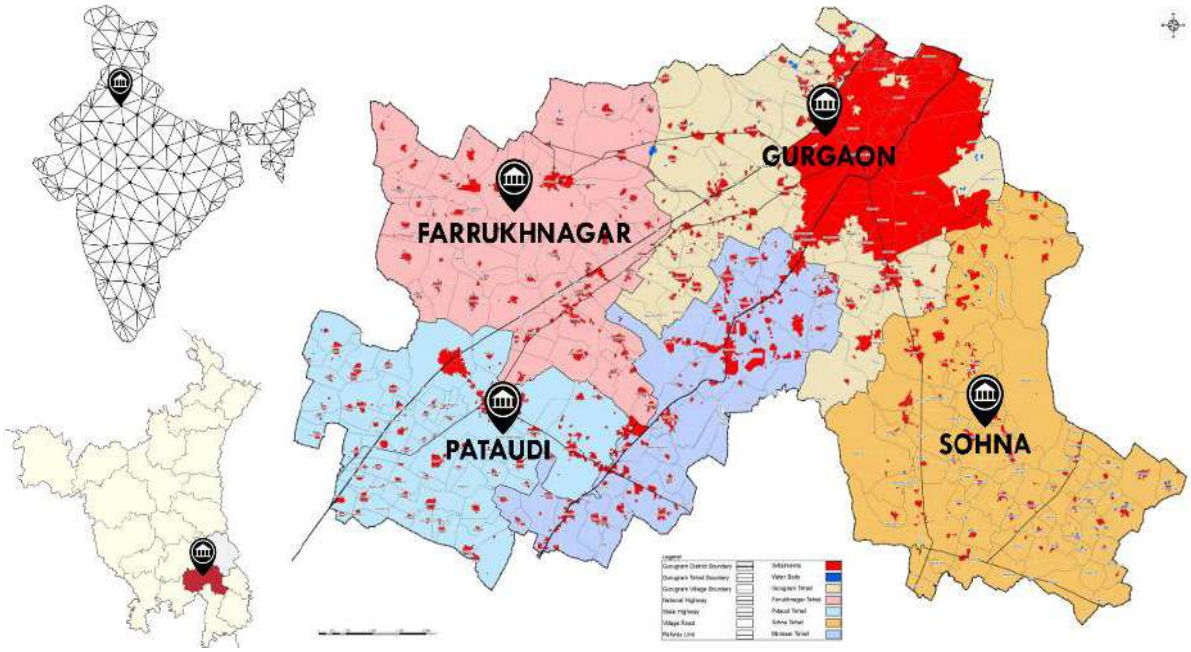


Figure 1: Gurugram District Map

Gurugram district is largely occupied by alluvial plains, traversed by elongated ridges of Delhi quartzites. The area is well connected by roads and railways. National Highway 48, 248 connecting Delhi with Jaipur and Gurugram with Alwar respectively passes through the district. Major state highways are – No. 13, No 28, No 26 and No. 15A connecting Palwal – Sohna, Gurugram – Rewari – Narnaul – Singhana road and Jhajjar – Farrukh Nagar – Gurugram respectively. Almost all the villages are connected by metalled roads. Northern Railway Broad gauge main line Delhi – Gurugram – Rewari and branch line Garhi – Harsaru – Farrukh Nagar meter gauge branch line was constructed as far back as in 1883 for the salt traffic of that area. Administratively, the district is divided in four Blocks, namely, Gurugram, Pataudi, Farrukh Nagar, Sohna, and one sub – divisions, Gurugram. Gurugram town is the headquarter of the district.

Gurugram is home of many Multi-National Companies, home of India largest auto makers namely: Maruti Suzuki and Hero Moto Corporation. Due to these reasons, population of the area is increasing rapidly and migratory population. In context of the above, infrastructure development is necessary to cater necessities of the population.

Project Area

Biodiversity Parks are unique landscapes/ riverscapes of wilderness where ecological assemblages of native species are recreated over marginal/ degraded landscapes/ riverscapes. Biodiversity Parks are based on the ecological restoration principle and the underlying principle is to establish self-sustaining ecosystems that have biodiversity and function that generate ecological services that contribute to well-being of humans.

Lakes can be natural or man-made water bodies, which are constructed to store rainwater during the rainy season. Lakes are man-made or natural depression area in the region according to the slopes/gradient where water naturally flows into these, the main reason for the construction of the lake is to collect all the rainwater which falls in the watershed of the region and use rainwater in the summer season for various purposes like bathing, washing of cloths, drinking water for animals and also for recreational and spiritual rituals of the region.

Biodiversity is critical for the existence of life on the planet Earth. The different gross landforms that include mountains, plains, rivers and oceans together with their rich ecological diversity support a myriad of life forms. The life forms and their environments together with interactions among life forms and between life forms and their environments constitute Biodiversity. Biodiversity is also often referred to as Biological Diversity (Diversity at all levels of biological organization).

The Aravalli Range is a mountain range in Northern-Western India, running approximately 670 km in south-west direction, starting near Delhi, passing through southern Haryana and Rajasthan, and ending in Gujarat. The discontinuous patches of Aravalli hillocks in Southern Haryana are exposed in

Faridabad, Palwal, Gurugram, Nuh, Bhiwani, Rewari and Mahendragarh districts. Sand, bajri and quartzites are mined from various localities from the hills of Manger-Harchandpur, Bhondsi-Sohna.

Figure 2: Aerial View of Project Area

Along the foothills of Aravalli's in Damdama and Abhyepur region, Damdama lake which is a part of Biodiversity region was commissioned by the British in the year 1947 for rainwater harvesting. In its current form, however, what makes Damdama Lake enticing is that it is home to over 190 species of native and migratory birds. In monsoons, water levels reach as high as 3 to 4 meter, creating habitat for winter migratory birds.

The Aravalli's act as a barrier between the fertile plains in the east and the sandy desert in the west. Historically, it is said that the Aravalli range checked the spread of the Thar desert towards the Indo-Gangetic plains, serving as a catchment of rivers and plains. This Aravalli is rich in biodiversity and provides habitat to 300 native plant species, 120 bird species and many exclusive animals like the jackal and mongoose. Aravalli's have an impact upon the climate of northwest India and beyond. During monsoons, it provides barrier and monsoon clouds move eastwards towards Shimla and Nainital, thus helping nurture the sub-Himalayan rivers and feeding the north Indian plains. In the winter months, it protects the fertile alluvial river valleys from the cold westerly winds from Central Asia.

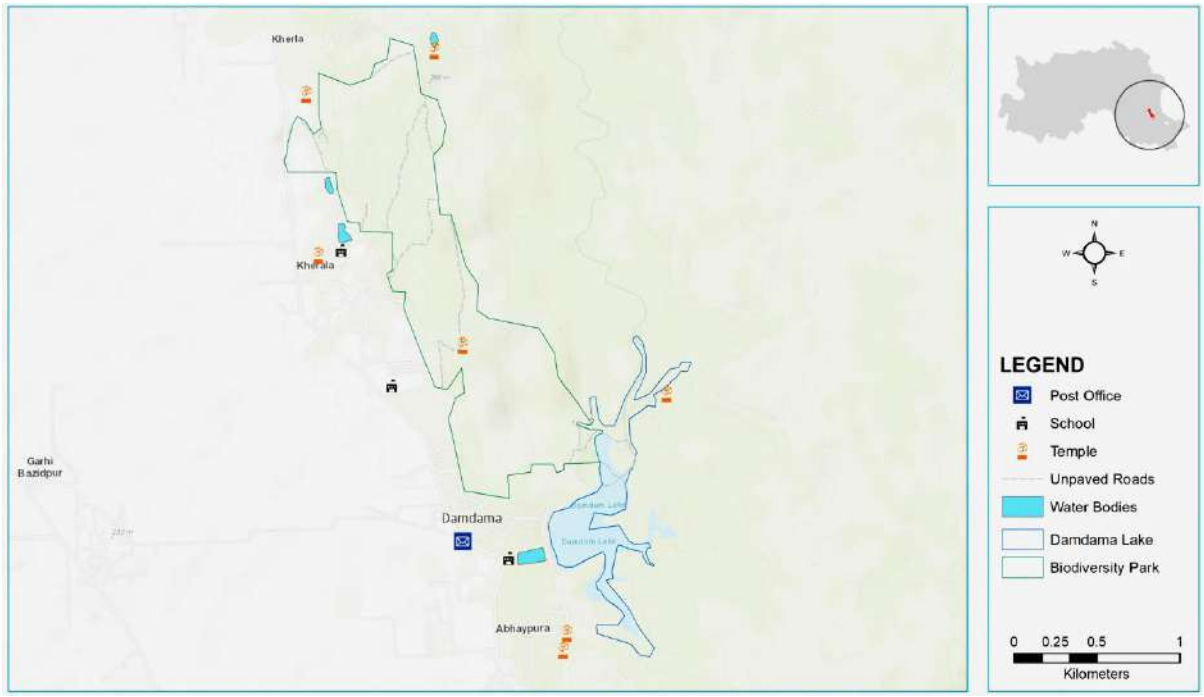


Figure 3: Project Area Map

Project area i.e., rejuvenation of lake in foothills of Aravalli (biggest freshwater survival lake in Delhi NCR) and development of biodiversity park which is degraded forest land. Total project area is 500 acres out of which lake area is 80 acres and biodiversity park area is 420 acres. This region was once very rich in flora and fauna species and a home of several biodiversity, along with rich biodiversity there are also 10 ponds in and around the project area. It was believed that to increase the green cover of the area seeds of Prosopis Juliflora had been planted manually and airborne leading a way for the spread of foreign species taking over indigenous species.

Need of the Project

Gurugram is one of the fastest growing urban agglomerations across the nation. Aravalli's the oldest mountain range criss-cross the district is of great ecological significance as the region is facing great environmental challenges due to increasing population which leads to urbanisation and infrastructure development. Gurugram which continuously facing water scarcity, loss of flora & fauna, high pollution level and land degradation due to urbanisation. One of the most prominent and ecologically significant regions which act as green lungs and source & storage of fresh water for the district is Aravalli's ranges. Therefore, protection, management, and conservation of Aravalli's in the region are vital for the ecological and environmental sustainability of the region.

It has also been identified as an important groundwater recharge zone and are very important to the future groundwater security of south Haryana towns like Gurugram and Faridabad and provide fresh water to millions of people and one of the major roles of Aravalli is it acted as affective shield against desertification.

The rapid deforestation and developmental activities are destroying the unique landscape that requires immediate conservation attention. These vulnerable areas are biologically rich and support several unique elements of flora and fauna. Hence proper assessment and monitoring is necessary for restoration of the biological diversity because lack of ecological information leads to mismanagement.

Figure 4: Biodiversity Degradation in Project Area

For Haryana, having the lowest forest cover at around 3.59% of the total forest cover in India, the Aravalli range is the only saving grace, providing the major portion of its forest cover. They also function as a groundwater recharge zone for the regions around that absorb rainwater and revive the groundwater level. This range is considered the “lungs” for the world’s most polluted air of Delhi–National Capital Region (NCR).

The Aravalli’s provide the only major forest cover in the state of Haryana which has a total forest cover of just 3.59% lowest among all Indian states. They also function as a groundwater recharge zone for the regions around that absorb rainwater and revive the groundwater level. There is a need to recognize the importance of the region and take active steps to protect it. Also, it is necessary to preserve such natural resources in the world’s oldest mountain chain by conservation of flora, fauna, and water resources by developing pockets of biodiversity in the form of Biodiversity Park which may act as examples of Resource Conservation in Aravalli’s.

Project Objective

The broad objectives of the projects are:

- To protect and conserve the existing flora and fauna of the region,
- To rejuvenate one of the biggest lakes of the district i.e., Damdama Lake,
- To create awareness about the significance of Aravalli and its Vegetation and to create ownership and self-belongingness among the local community,
- To Serve as a hub for education, cultural and conservation activities,
- To develop eco-tourism and self-sustaining model for the locals.

To achieve the objectives of the project it is necessary to develop a baseline on the present state of water, biodiversity, archaeology, waste, community, political ecology & governance and suggest ways to augment, preserve and protect the Ecosystem of the region. The study comprises of seven components which are distinct yet cross-cutting.

a) Climate
b) Land
c) Hydrology and Hydrogeology
d) Biodiversity
e) Archaeology
f) Waste
g) Social Assessment
h) Governance

Village: **Damdama, Kherla & Abheypur**
Ownership of the Land: **Gram Panchayat**
Type of Forest: **Tropical Thorn, Dry Deciduous and Sandy Dune**
Type of Lake: **Freshwater**
Flora & Fauna: **More than 185+ species of plants, birds, mammals and insects.**
Biodiversity Park

- Area: **~ 420 acres**
- Perimeter: **~ 8.99 km**

Damdama Lake

- Area :**~ 80 Acres**
- Perimeter: **~ 7.7 km**

Total Area of the project: **~ 500 acres**
Total Perimeter of the project: **~16.69km**

Chapter 2: Brief Profile of Project Area

Introduction

Gurugram district has a rolling plain interspersed by extensions of Aravalli's. Aravalli ranges offshoot along the western part of the district and further up to the National Capital, Delhi in the north-east. These rocks are one of the oldest mountain systems in the Country and the hillocks are dissected by rain fed torrents. Physiographically we can subdivide the district into two sub-parts: Gurugram Plain and Sohna Undulating Plain with Aravalli Offshoots. Gurugram Plain spreads over northern and north-western parts of Gurugram tehsil and whole of Pataudi tehsil. The region as a whole is a plain area and is quite homogeneous to Sahibi Plain of Rewari district. Sohna Undulating Plain with Aravalli offshoots extends over parts of Sohna and Gurugram tehsils. The entire region is covered with rocky surfaces of Aravalli Offshoots. These landforms make a series of flat-topped ridges. Only some patches of land are under cultivation. Due to offshoots of Aravalli ranges, the region is undulating. There is little cultivation owing to rocky areas, poor soil cover and roughness of surface.

Figure 5 Physiography of Aravalli's

Along the foothills of Aravalli's in Abheypur and Damdama villages, Damdama lake is located which was commissioned by the British in 1947 for rainwater harvesting and ownership of land is with Tourism Department and biodiversity park is situated in Damdama and Kherla villages of Sohna block in Gurugram district. Biodiversity Park is under control of Forest Department and falls under Section

4 and 5 of PLP Act, 1900 however ownership of land is still with gram panchayats. Brief profile of villages where project area is located is discussed in below section.

Demography Profile

There are 3 villages adjacent to the Damdama lake and a proposed Bio-diversity Park for which the gram panchayats have stated to cooperate with us. These 3 villages are: Abheypur, Damdama and Kherla. These villages are in Sohna block of Gurugram district having an area of 2028.74, 689.4 and 1336.8 acres respectively. Total current population of these 3 villages combined is approximately 17,553 of which around 60% of the population is youth. Population of Abhyepur, Damdama and Kherla village approximately is 5000, 4500, 8053 respectively as per Sarpanch of respective villages.

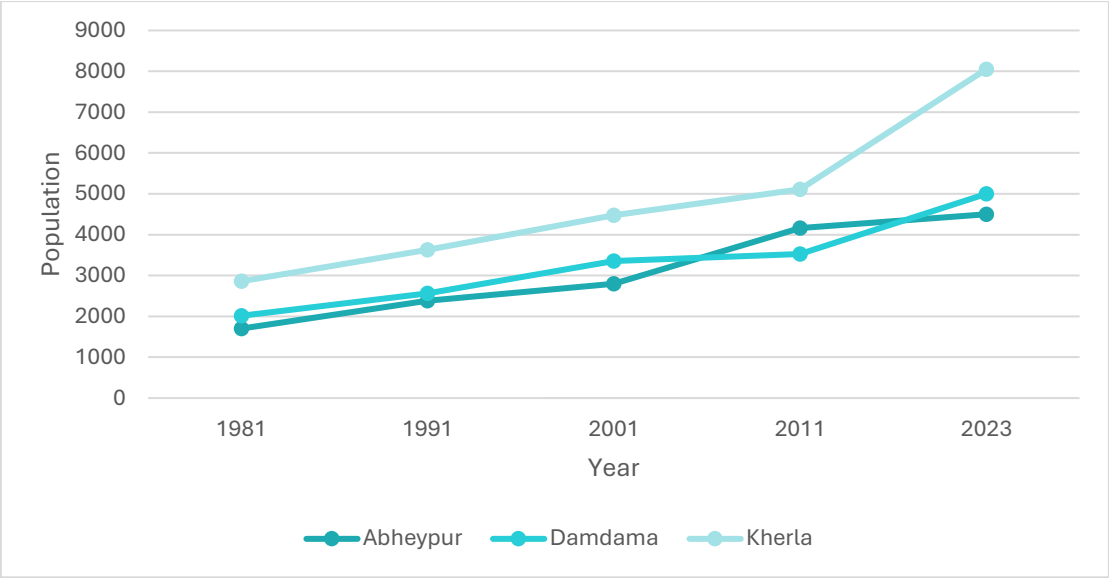


Figure 6: Population Data of Villages

In the above figure, population changes from 1981 to 2023 is shown. An increase of 164%, 148% and 181% was seen in the last 4 decades for the villages of Abheypur, Damdama and Kherla. Though the 3 villages show a linear growth rate in its population, there is a sudden and very steep increase in the population of Kherla village which can be attributed to migration of workforce.

According to the Census of India, 2011 the population of males and females in Abheypur is 53% and 47% respectively. Whereas, in both the villages of Damdama and Kherla the population of males and females is 52% and 48%. As per our recently conducted survey, a drop has been registered in the overall female population in 3 villages from 48% in 2011 to 43% in 2023.

Socio-Economic Profile

Socio-economic profiling is crucial for any project as it provides insights into the factors such as income, social groups, types of workers, literacy levels, etc., among other factors which are very crucial for tailoring interventions effectively, allocating resources efficiently, and assessing risks and

vulnerabilities. Socio-economic profiling also facilitates measuring impact, informing policy development, and ensuring equity and inclusivity by targeting marginalized groups. Overall, it enables more targeted, efficient, and impactful projects across various sectors.

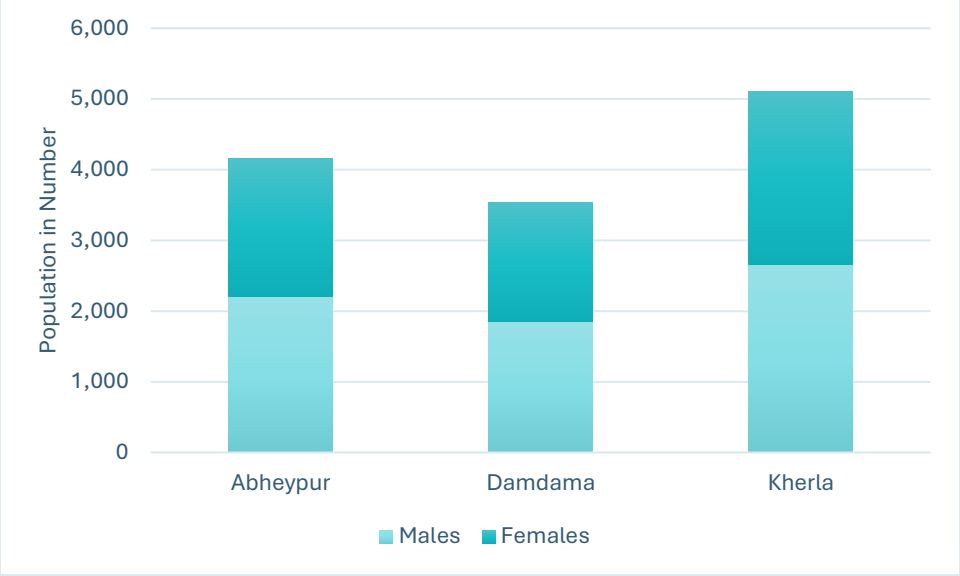


Figure 7: Male Female Population in Villages

Around 80% of the people are engaged in agriculture. People are majorly dependent upon the forest resources for their day-to-day activities and consumption. Majority of the people use fuel wood of Vilayati Keekar and LPG cylinder as the main source of cooking. They are dependent on Aravalli for fuel wood, as approximately 30 Kg of wood is bought once in a year collectively. Irregular cutting of Vilayati Keekar results in its ununiform spread leading towards more invasion there by emerging as dominant species.

As per the Census of India, 2011 Scheduled Castes in Abheypur, Damdama and Kherla village was 16%, 22% and 24% respectively.

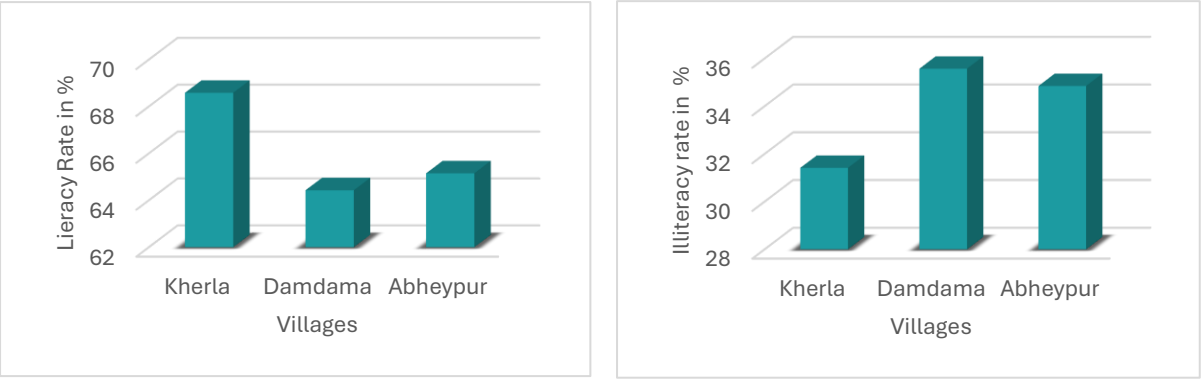


Figure 8: Literacy and Illiteracy Rate in Villages

When carrying out any restoration and rejuvenation activity, it becomes imperative to look into the literacy level as the people would be the ultimate beneficiary of the project. If people are not literate

enough to understand the importance and relevance of the project/activity, then things might get complicated during implementation of the interventions and ultimately while handing over the project to the community.

In India, a person aged seven and above, who can both read and write with understanding in any language, is treated as literate. According to the 2011 census, the average literacy rate of the 3 villages was 66%. Kherla had the highest literacy rate of 69% followed by Abheypur and Damdama which had 65% and 64% of literacy levels respectively. During our recently conducted household survey it was found out that the literacy level of the 3 villages has improved significantly where the literacy level now stands at 80% registering an increase of 14%.

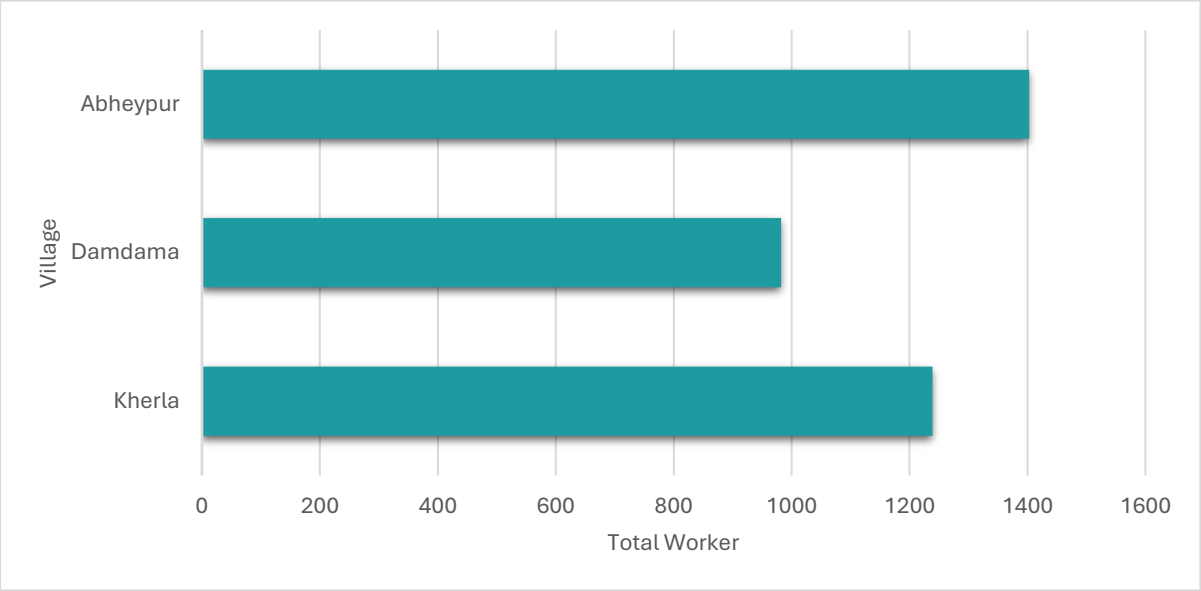


Figure 9: Total Workers in the Villages

There are main and marginal workers working as cultivators, labourers, household industries, non-household industries, working in plantation, livestock, fishing, forestry, hunting and allied activities. According to the Census of India, 2011, a person who works for atleast 183 days in a year for economic productivity is considered as main worker. Whereas a person who has worked less than 183 days in a year is considered a marginal worker. Village Damdama consists of the highest percentage of main workers at 87% followed by Kherla and Abheypur. Marginal workers population stood highest at Abheypur with 30% of the workforce engaged in it which is followed by Kherla and Damdama.

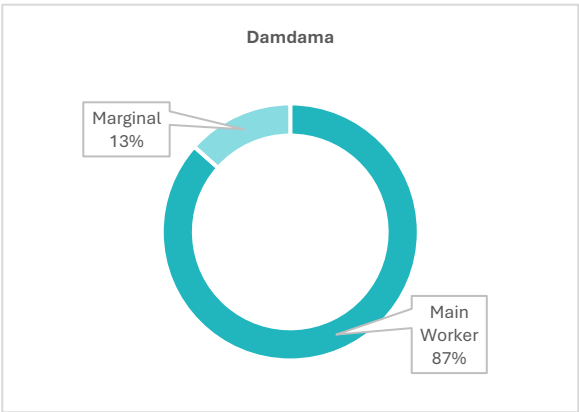


Figure 10: Main and Marginal Woker Distribution in Villages

Physical Infrastructure

The importance of infrastructure for economic growth and development in rural area can hardly be overemphasised in a developing economy like India. Improving basic infrastructure such as roads, transport, electricity, telecommunications, housing, health, water, and sanitation is essential for development and wellbeing of the rural population. Despite the crucial importance of infrastructure, significant deficiencies have persisted in rural infrastructure. Similarly, in Abheypur, Damdama and Kherla villages details of physical and social infrastructure acquired from sample household and transportation survey can be seen below.

Water Supply

Of all municipal services, provision of potable water is perhaps the most vital. People depend on water for drinking, cooking, washing, carrying away wastes, and other domestic needs. Water supply systems must also meet requirements for public, commercial, and industrial activities. In Damdama and Kherla village, there is almost 90% coverage of pipeline connection. Availability of Water through pipeline depends on available of electric connection. On an Average water supply is available for 6 hours a day. As per CPHEEO standards average per capita per person water supply in the village is 90 LCPD. Moreover, almost over 70 % of the households have an overhead tank of capacity 1000 Litres. Nevertheless, quality of the water is good unless it is mixed with sand and settleable solids. In 10% of area where there is no availability of pipeline connection, they depend on either borewell or surrounding houses for water. There are 2 community wells in both the villages and 30% of the population depends on ground water for usage. Near Damdama village a freshwater lake, Damdama lake is formed due to accumulation of water coming from Aravallis. This lake was commissioned by British in 1947 for

Figure 11: Water Supply Line

Rainwater harvesting. Over some decades ago this lake was served as drinking water source for the Damdama village, at present it is used for household purposes and animal bathing.

Figure 12: Team Conducting HH Survey

The Household (HH) Survey was conducted across all three villages of the project, selecting a representative 10% of households from each village. The primary objective of this survey was to gain insights into the social dynamics of the community, understand their livelihood resources, assess water amenities and usage patterns, and identify methods of waste disposal. The survey covered various parameters and made an effort to encompass all the ward areas within each village, providing a comprehensive understanding of the community's living conditions.

Water Source and Quality

The primary water sources in the surveyed villages include community resources and private borewells (Figure 11). Community resources involve gram panchayat borewells, contributing significantly to the water supply in these areas. Damdama exhibits a higher reliance on community resources, with 95% of households utilizing them. Kherla and Abheypur also depend on these sources prominently, with 85% and 60% of households, respectively, benefiting from community resources. This underscores the vital role of gram panchayat borewells in providing accessible and essential water supply to the communities.

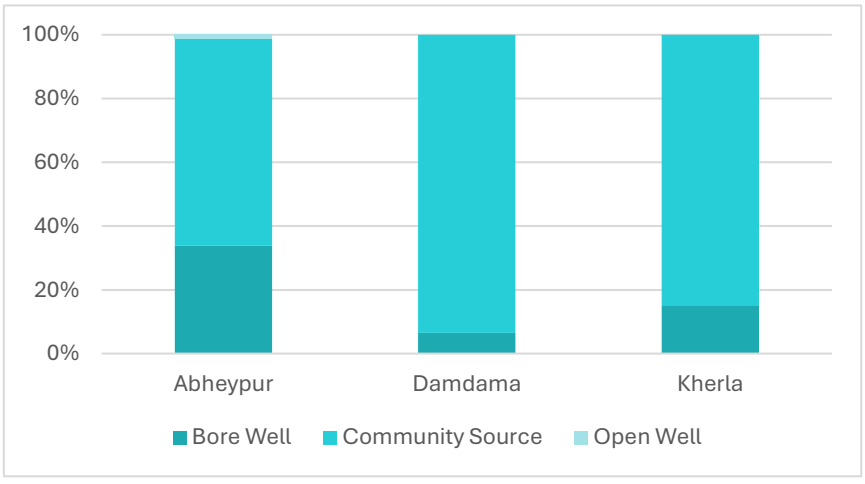


Figure 13: Sources of Water Supply in the Village

The majority of households receive good-quality water from community sources as shown in figure 11. However, approximately 5% of areas across the villages face challenges with water quality, indicating a need for targeted interventions as depicted in figure 14 below.

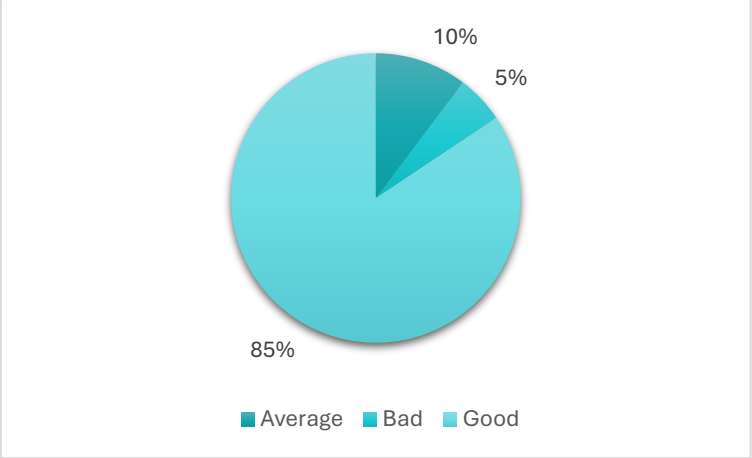


Figure 14: Water Quality Perception Among Villagers

Borewell Ownership

The control of public borewells lies with the gram panchayat, while some households have private borewells. Across Damdama, Kherla, and Abheypur, gram panchayat borewells are the dominant water source for households. In Kherla, 76% rely on gram panchayat borewells, 10% on private borewells, and 2-3% have both connections. Damdama shows 53% utilizing gram panchayat borewells, 6% from private borewells, and 3-4% with both connections. In Abheypur, 52% are connected to gram panchayat borewells, and 23% rely on private borewells. This emphasizes the crucial role of gram panchayat borewells in supplying water to the majority of households.

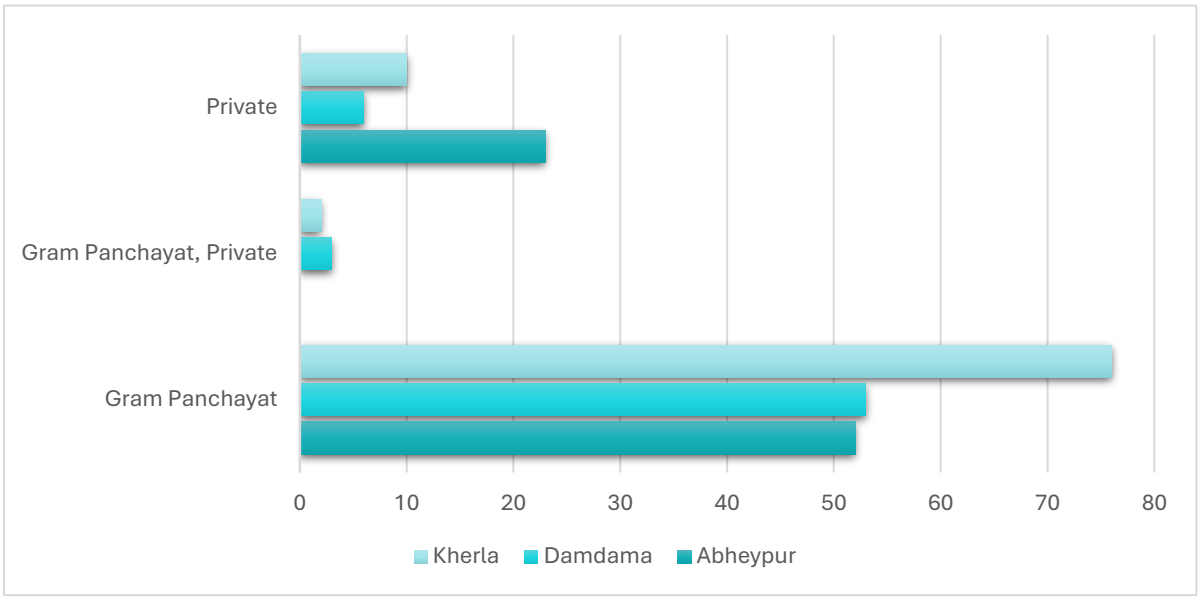


Figure 15: Ownership of Borewells

Duration of Water Supply

The average water supply hours are approximately 2.5-3 hours, with variations observed in summer, winter, and monsoon seasons (Figure 14). During summer, increased water consumption leads to

extended supply hours, while in winter and monsoon, decreased demand results in shorter supply periods.

In Abheypur, gram panchayat water supply hours extend to 3.8 hours in summer, 3.4 hours in winter, and 3.2 hours in monsoon. Damdama experiences shorter water supply hours, with 1.25 hours in summer and a consistent 1 hour in winter and monsoon. Kherla witnesses 2.56 hours of water supply in summer, 2.1 hours in winter, and 1.4 hours in monsoon. These variations highlight the dynamic relationship between water supply hours and seasonal water demands across the surveyed villages.

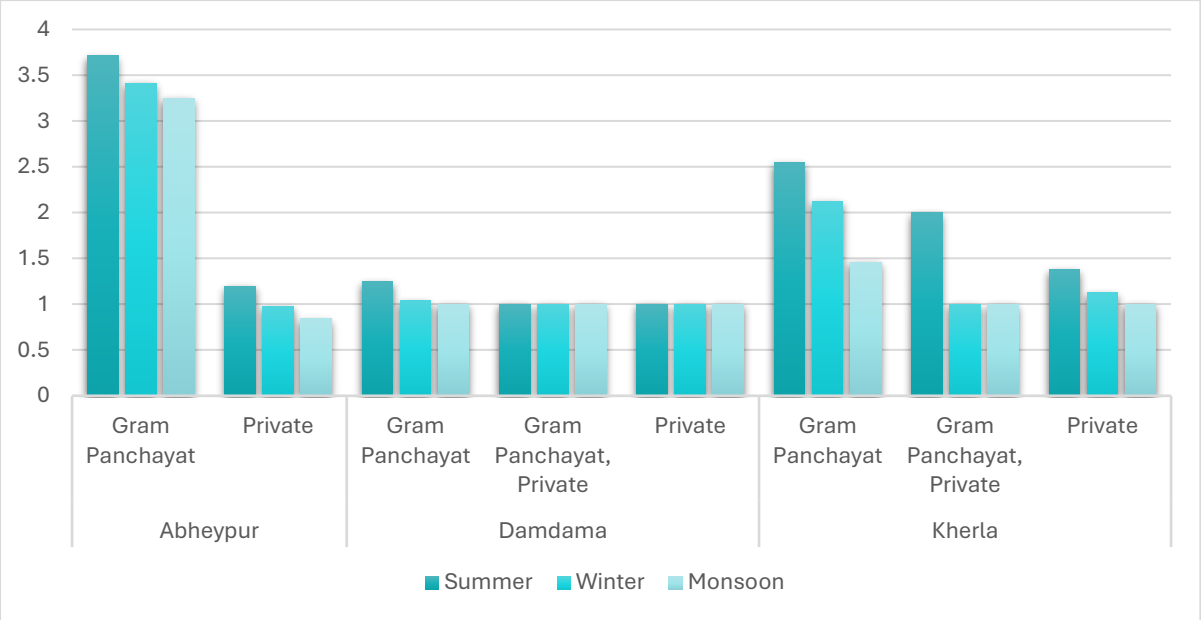


Figure 16: Average hours of water supply

Figure 17: Water Supply Infrastructure

Sanitation and Drainage

There is no proper sewerage network in both the villages, all the wastewater from households is disposed into open drains running along the side of the road and they are further being disposed into larger water source for disposal. These open drains are the only single disposal point for both storm water and wastewater, sometimes they get clogged with dumping of solid waste thereby creating unhealthy environment in the surroundings of the village. Almost 96% of the households are having individual toilets in their houses, where the human waste is further being dumped into septic tank and soak pits. Open defecation is slightly observed in Kherla village and people of this village use Aravallis for open defecation. There is no wastewater treatment plan nearby the villages within the vicinity of 5 Km.

Figure 18: Drainage Network in Villages

Transportation

Project area (lake and biodiversity park) is located around 24 km from Gurugram district headquarter. As project area of 500 acres is near to a prominent tourist attraction Damdama lake. It is easily accessible by any means of travel. By Road it is Just a few kilometres off the Gurugram-Alwar highway, the area is well connected via road to Delhi and other major cities of the country.

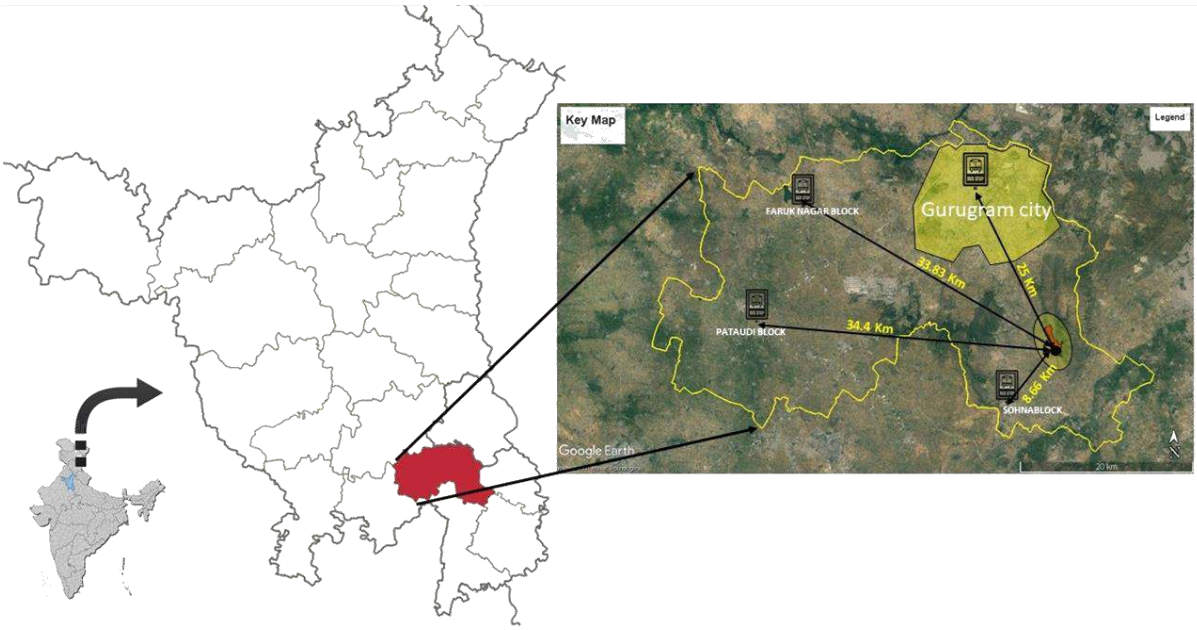


Figure 19: Distance of Project Area from Nearby Towns

By Rail it is Merely 40 km away from the Faridabad Train Station. It's easy to reach the biodiversity area if you choose to travel by train and it is a very affordable option, and by air, this area is situated 39 km away from the Indira Gandhi International Airport. It's fairly accessible and catching a flight won't be an issue. Major traffic is attracted from nearby tier I tier II cities and towns like Delhi, Gurugram, Faridabad, Sohna and Bhondsi. Community linkages map of project area is shown in figure 18.

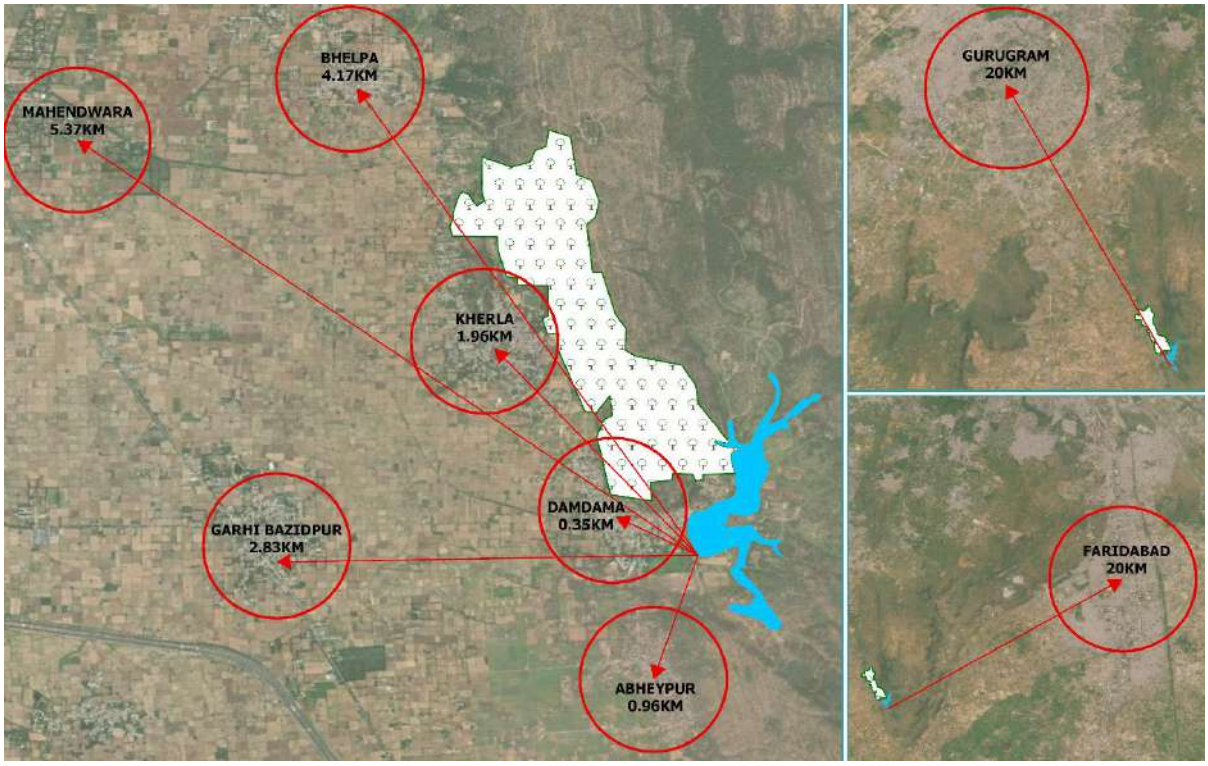


Figure 20: Aerial Distance of Project Area from Nearby Towns

Electricity

In these two villages major source of lightening is electricity, unlike solar or biogas availability and more than 97% of the households are having electrified. Duration of the electricity on an average in Damdama and Kherla villages are 18 hours to 12 hours respectively. Duration of water supply is majorly dependent on availability of electricity. 85 % of connections are legal connections. Transmission lines run through the middle of the biodiversity park region in Aravallis.

Figure 21: Transmission Line Passing through Project Area

Solid waste

Solid waste management is the crucial element in developing a Biodiversity Park, if Solid waste is properly and efficiently managed in Abheypur, Damdama and Kherla villages then the impact of land degradation on biodiversity park decreases. Solid waste is the major problem in Kherla village when compared to Damdama and Abheypur village. In Damdama and Abheypur village, Solid waste management workers collects solid waste from all the households and then disposed - off further to a dumping site. Sarpanch along with residents has set up a dumping site nearby the village to dispose municipal solid waste, in case collection workers are not available. Every household pays on an average of Rs. 30/- to Rs. 40/- for collection of solid waste. Those people who are not able to pay the fare, either they dump near the dumping site or in the drains. In Kherla village there is no specific dumping site for solid waste disposal, in 40% of the area Solid waste workers comes and collects the waste and in majority of the area there is no provision for solid waste collection resulting in dumping of waste in Aravallis, on roads and storm water drains. Detailed Solid waste management in discussed in Chapter 3G.

Figure 22: Dumping of Solid waste in the Village

Social Infrastructure

Social infrastructure plays an important role in both the economic development of a nation and the development of society's quality of life. Social infrastructure likes hospitals, educational institutions, cultural spaces etc. enhances social wellbeing and furthers economic growth by providing basic services and facilities which allow businesses to develop and flourish. In Abheypur, Damdama and Kherla villages details of social infrastructure are as discussed below.

Health care centres

High-quality health care helps prevent diseases and improve quality of life. Helping health care providers communicate more effectively can help improve health and well-being. Strategies to make sure health care providers are aware of treatment guidelines and recommended services are also key to improving health. In Damdama, Abheypur and Kherla villages there is only one health care clinic and there is no proper health care within the vicinity of 5 km radius, nevertheless there are some ayurvedic doctors who are using indigenous medicinal plant species from Aravallis for small diseases treatment.

Educational Institutions

Education has a direct impact on reducing poverty, improving health, longevity and quality of living. In Rural India there are still some gaps in educational infrastructure, some villages don't have minimal educational facilities, but fortunately in these villages people and students are accessible to primary, middle and senior secondary schools. In Damdama village there are 1 primary school and 1 secondary school which includes both government and private schools within a distance of 500 meters radius from Damdama lake. In Kherla village there are 3 primary schools and 3 Senior secondary schools within a vicinity of 500 m radius of Kherla main bus stop. School children can become potential ambassadors for safeguarding biodiversity park and educating other villagers, the importance of biodiversity richness and its safeguard. In Abheypur village there is 1 government senior secondary and primary school.

Religious spaces

Religious spaces play a vital role in any village, where it binds the aesthetic, ethical, peaceful and cultural sense of the place. In both the villages aesthetic sense of Mandir is increased with the presence of Johad; a traditional water body. In Damdama village Johad Wala mandir is present at an altitude of 272 m above the ground level, adding rich cultural value to the village especially during festivals. In Kherla village Shiv mandir is present at the foothill of Aravallis near Johad serving as an aesthetic place. Devdas and Mahapurush temple is prominent temple in Abheypur village.

Figure 23: Johad Wala Temple of Kherla Village

Chapter 3: Need for Baseline Assessment

Undertaking a comprehensive baseline study, for rejuvenation of Damdama Lake and developing a biodiversity park, serves several crucial purposes:

Understanding Current Conditions: Baseline studies provide a detailed understanding of the current state of the area in question, encompassing various parameters such as water quality, climate patterns, soil health, biodiversity, cultural heritage, waste management practices, and societal dynamics. This understanding is essential for identifying existing challenges, opportunities, and potential constraints that may influence the restoration and biodiversity park creation efforts.

Identifying Environmental Baselines: Baseline studies establish environmental baselines by documenting key environmental parameters such as water quality, habitat types, species diversity, and ecological processes. These baselines serve as reference points against which future changes can be measured, allowing project stakeholders to assess the effectiveness of restoration efforts and monitor ecosystem health over time.

Informing Restoration Strategies: Baseline studies help inform the development of effective restoration strategies by identifying priority areas for intervention, sensitive habitats or species that require protection, and potential restoration techniques or approaches suited to the local context. Understanding the ecological, hydrological, and socio-economic dynamics of the area enables project planners to tailor restoration efforts to address specific needs and maximize ecological and societal benefits.

Supporting Decision-Making and Stakeholder Engagement: Baseline studies provide a scientific basis for decision-making and stakeholder engagement by presenting comprehensive data and analysis on environmental, social, and governance aspects relevant to the project. This information enables informed decision-making, fosters collaboration among stakeholders, and facilitates transparent communication about project goals, strategies, and potential impacts.

Facilitating Monitoring and Evaluation: Baseline studies establish a baseline against which project outcomes and impacts can be monitored and evaluated. By collecting data on various parameters before project implementation, project stakeholders can track changes over time, assess the effectiveness of interventions, and adapt management strategies as needed to achieve project objectives and ensure long-term sustainability.

Overall, baseline studies are essential for laying the foundation for successful restoration and biodiversity conservation initiatives by providing a comprehensive understanding of the current conditions, informing strategic planning and decision-making, and facilitating monitoring and adaptive management throughout the project lifecycle.

Baseline Assessment Study List

Baseline study of the project is majorly divided into three categories i.e. Environment, Social and Governance. Under each category studies which necessary for to study the project area are listed in table 1 below.

Table 1: List of Baseline Studies

Category	Head	Studies
Environment	Water	➔ Hydrology ➔ Hydrogeology
	Climate	➔ Air Quality Monitoring ➔ Rainfall Patterns ➔ Noise Monitoring
	Land	➔ Soil Characteristics ➔ Archaeology ➔ Lithology ➔ Geomorphology ➔ Geological ➔ Geospatial
	Waste	➔ Solid Waste ➔ Liquid Waste
	Biodiversity	➔ Flora Survey ➔ Fauna Survey
Social	Individual	➔ Dependency on the forest and lake
	Community	➔ Ecological Interaction & Collective Responsibility Mapping ➔ Income Generation & Benefits ➔ Social Movements
	Commercial	➔ Employment Generation Potential
Governance	Government Institutions	➔ Village Governance ➔ Government Programs & Policies ➔ International, National, State and Village ➔ Institutions/Programs affecting the project
	Private Institutions	➔ Schools, Colleges and other similar institutional groups and their dependency and influence on the project
	Civil Societies/Volunteer Groups	➔ Economy, Activities, Benefits and Dependency

Chapter 3A : Climate

The Gurugram district has a sub-tropical continental monsoon climate marked by extreme hot and cold temperatures during the summer and winter months, dry air baring humid monsoon months, and scanty rainfall.

Temperature

The district records the highest temperatures in May and June, with an average daily maximum temperature of about 41°C. On the hottest days, the temperatures soar up to 45°C and more. From April, hot and dusty westerly winds locally known as “loo” began to blow, making the weather harsh. During winters, the coldest days are witnessed in January when the average daily minimum temperature goes down to 5.4°C, and the average daily maximum is about 21.4°C. A report on climatic trends and variability published by Saci WATERs, India, in 2013 reveals that in the long-term trend of the past five decades (1957-2010), both average minimum and maximum temperatures are increasing in the district. The annual average minimum temperature is increasing at a statistically significant rate of 0.046°C per year. The annual average maximum temperature also shows an increasing trend at 0.007°C per year, although it is statistically insignificant (Shah et al., 2013).

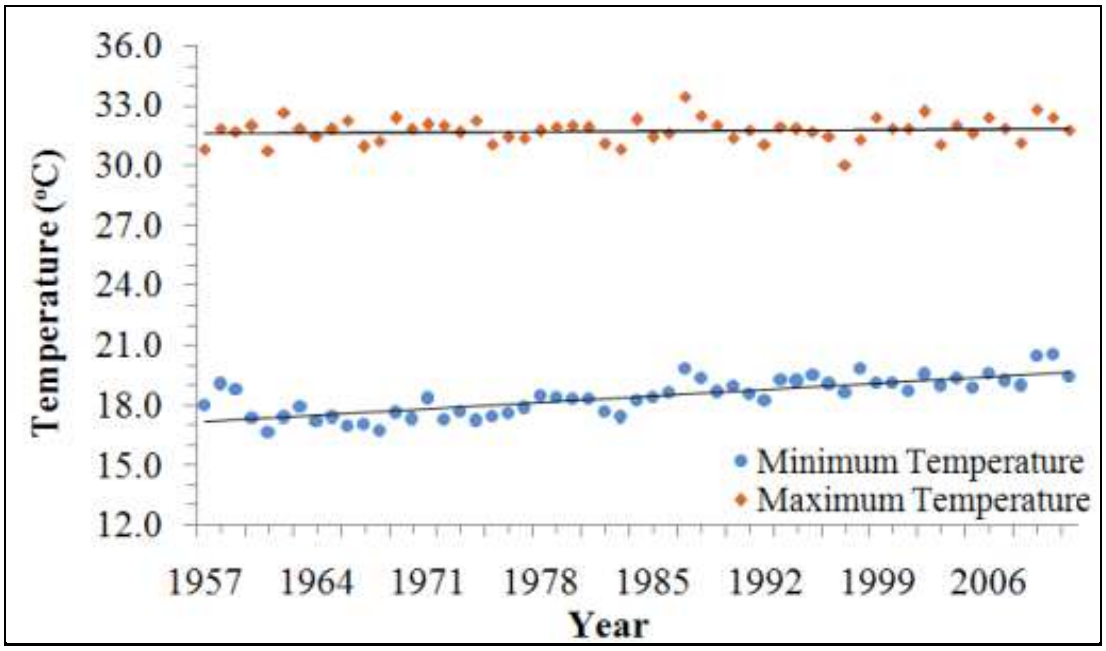


Figure 24: Trends in Mean Minimum and Maximum Temperature at Gurugram for the Period 1957-2010

Due to deficiency of large canopy tree species in the project area, land temperature in biodiversity park region is high as 50°C during the month of June, another reason for higher temperature is lack of topsoil in the area and rocks are exposed on the surface.

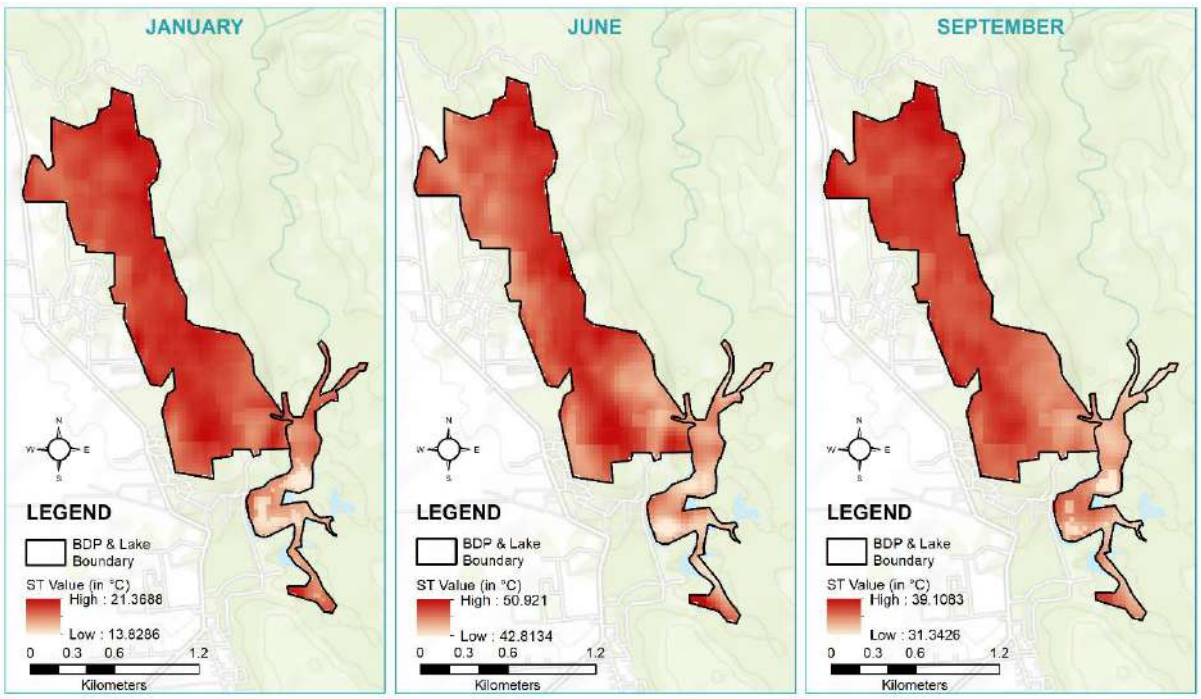


Figure 25: Land Surface Temperature Map of Project Area

Figure 26: Exposed Rocks in Project Area

Rainfall

The monsoon season in Gurugram spans from July to mid-September during which there is high humidity in atmosphere. The annual average rainfall in the Gurugram district is 500-600 mm, spread across 28 rainy days on an average in a year. According to IMD data for a period of the recent past 30 years (1989-2018), the mean annual rainfall in the Gurugram district was 529.2mm, which is higher than the overall state average of 499.7mm (Guhathakurta et al., 2020).

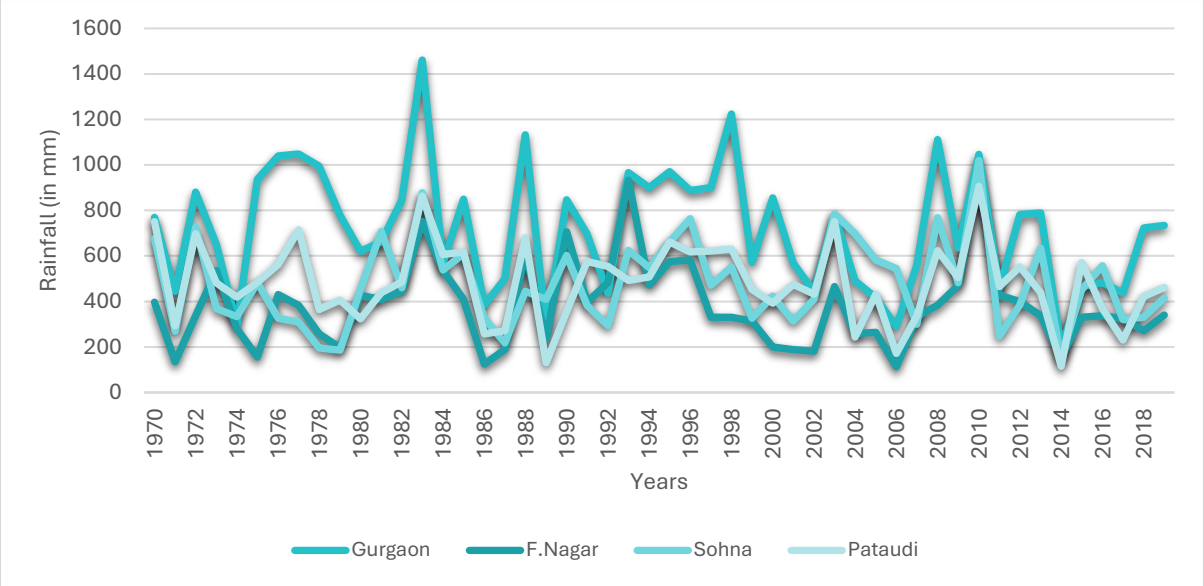


Figure 27: Block Wise Rainfall of Gurugram District for the Year 1970-2019

Project area which falls under the Sohna block of Gurugram district, for computing rainfall in the region 30-year average rainfall in Sohna block is 501 mm which lower than the district average. Year wise annual rainfall trend of Sohna block is shown in figure 26.[3]

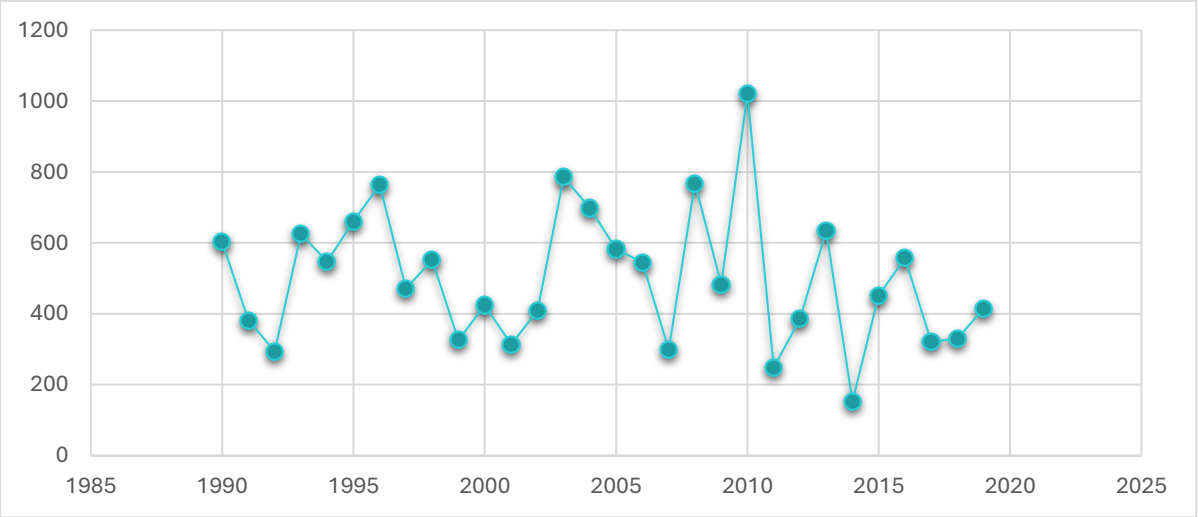


Figure 28: Sohna Block Rainfall Data (1990-2019)

Wind Direction

It is observed that wind in our project area is dominantly flowing towards north-west and west direction for the majority of days each month throughout the year.

- During the **winter season** (January and February), the majority of days either had **calm** winds or winds flowing in a **northwest direction** for 8 days each month.

[3] *(Source: Hydrology Department, Gurugram)*

- During the **pre-monsoon season** (March to May), the winds flowed predominantly in the west and northwest directions for 6 to 10 days each month.
- In the **monsoon season** (June to September), the **winds** flowed quite calmly in all directions.
- August and September were the months when the wind was calm for the majority of days.
- During the winter season (October to December), again the winds were **calm for 12 to 15 days of each month**.

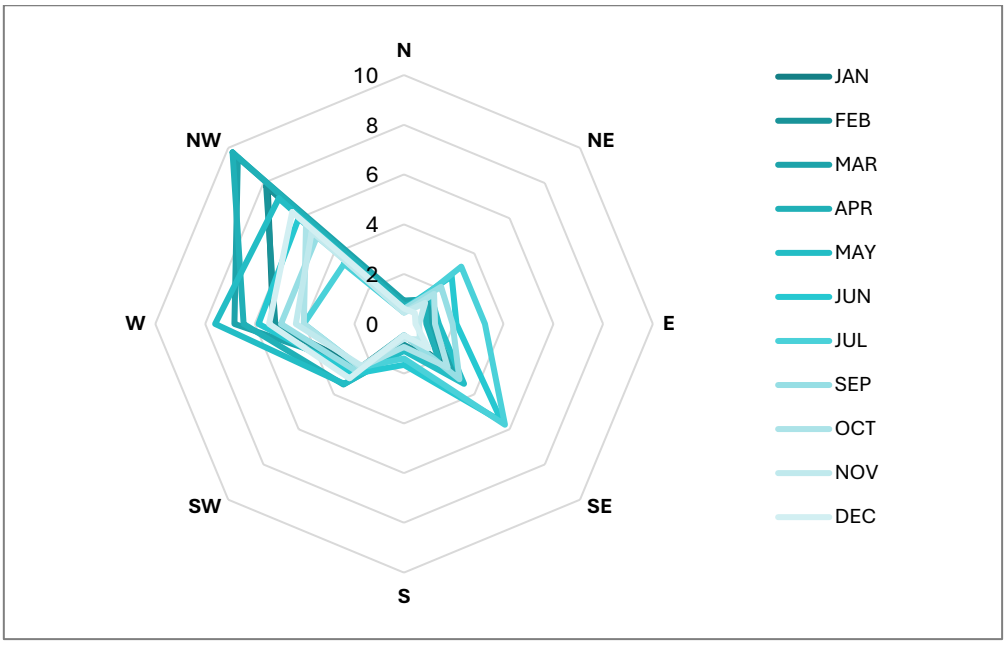
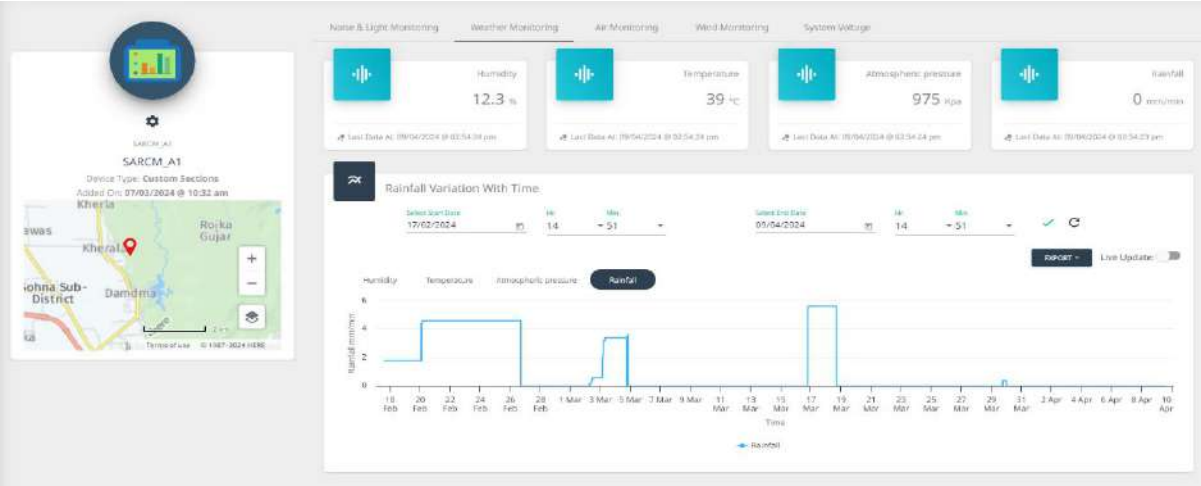
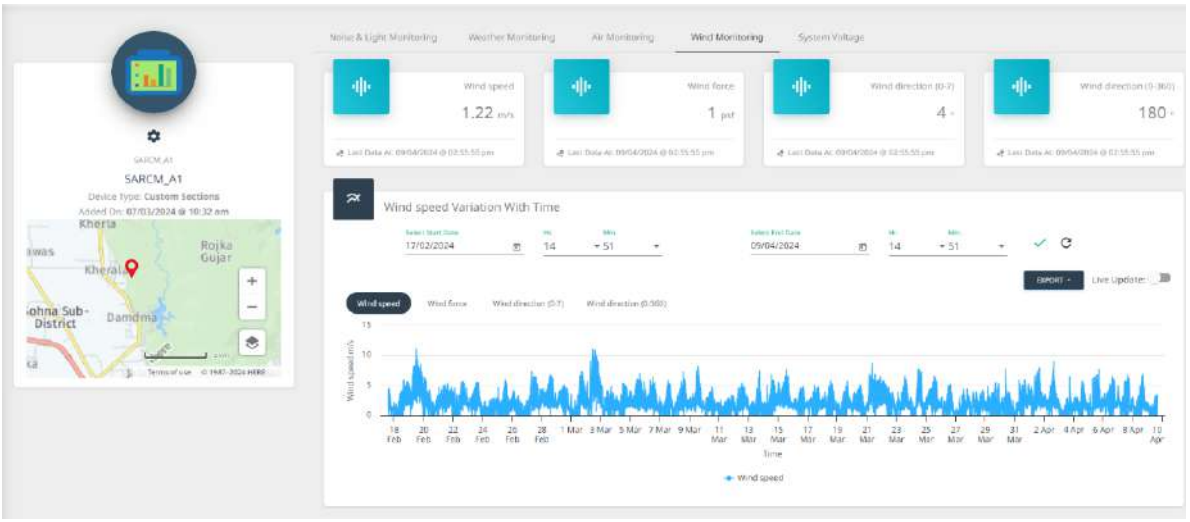


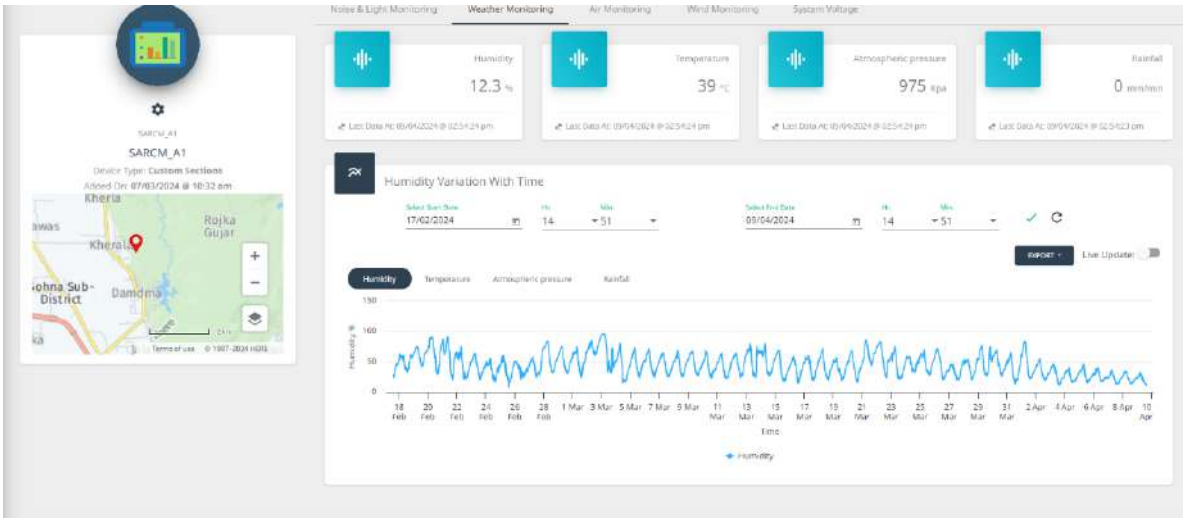
Figure 29: Windrose Diagram of Project Area

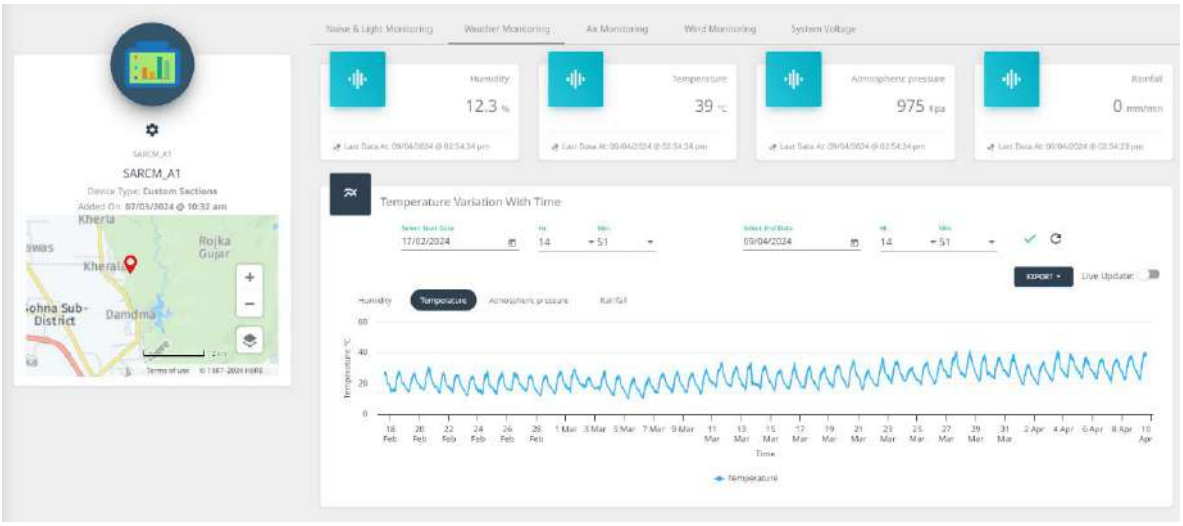
Weather Station

For continuous monitoring of climate data (rainfall, temperature, wind direction, pressure) weather station has been setup in project area. This will help us to monitor and understand the real time monitoring of climatology of the area, to plan the intervention based on the climate characteristics and also help in understand the impact of climate after project completion. Snapshots from real time monitoring weather station portal are attached below.









It is evident from the temperature snapshot that ambient temperature near the project area is already reached around 40°C during the initial months of the summer season.

Chapter 3B: Land

Geomorphology

The geomorphological origins were studied, and it was found out that the project area and its surroundings are composed of aeolian, denudational and minor structural origins. The project area which is covered with Aravalli hills are composed of structural origin, which are landforms formed by the differential weathering of rocks and the deposition of the resulting debris under the influence of exogenetic geomorphic forces. Whereas the nearby villages: Kherla, Abheypur and Damdama are composed of aeolian origin which are landforms composed by involving erosion, transportation, and deposition of sediment by the winds.

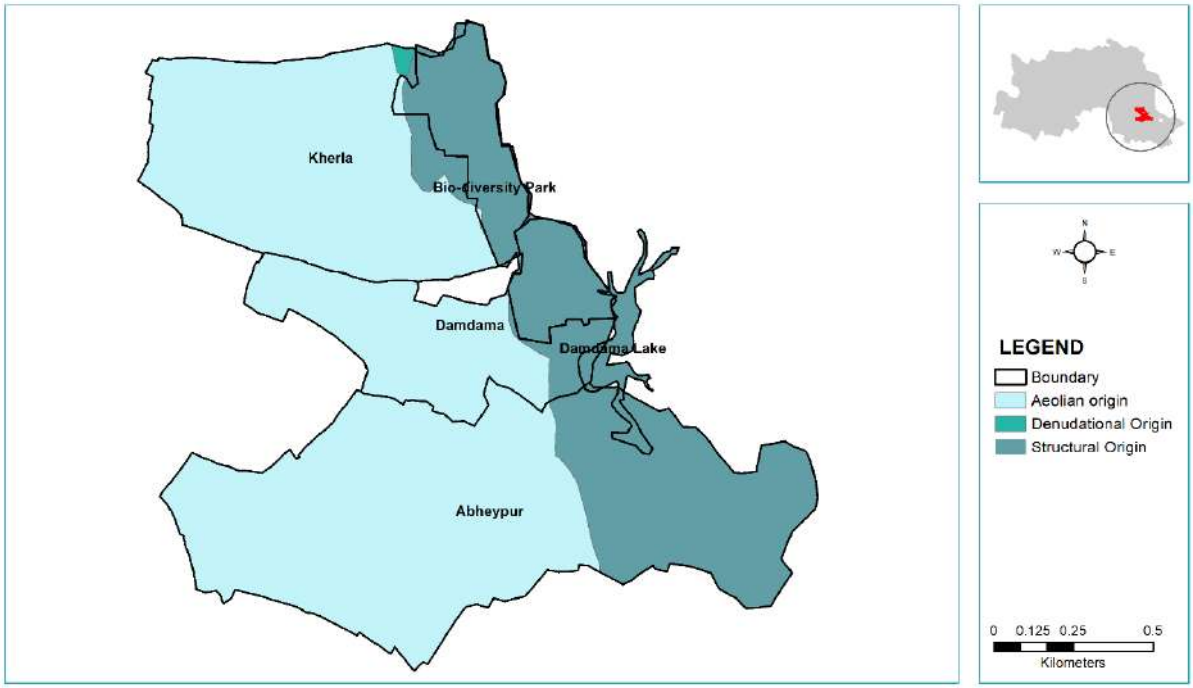


Figure 30: Geomorphology Map of Project Area & Villages

Figure 31: Type of Rocks in Project Area

Soil Chemical Properties

The present study was conducted to study the variability in soil properties in relation to landform, in the present investigation, 40 sample points were selected for sampling shown in figure 33.

Figure 32: Soil Collection

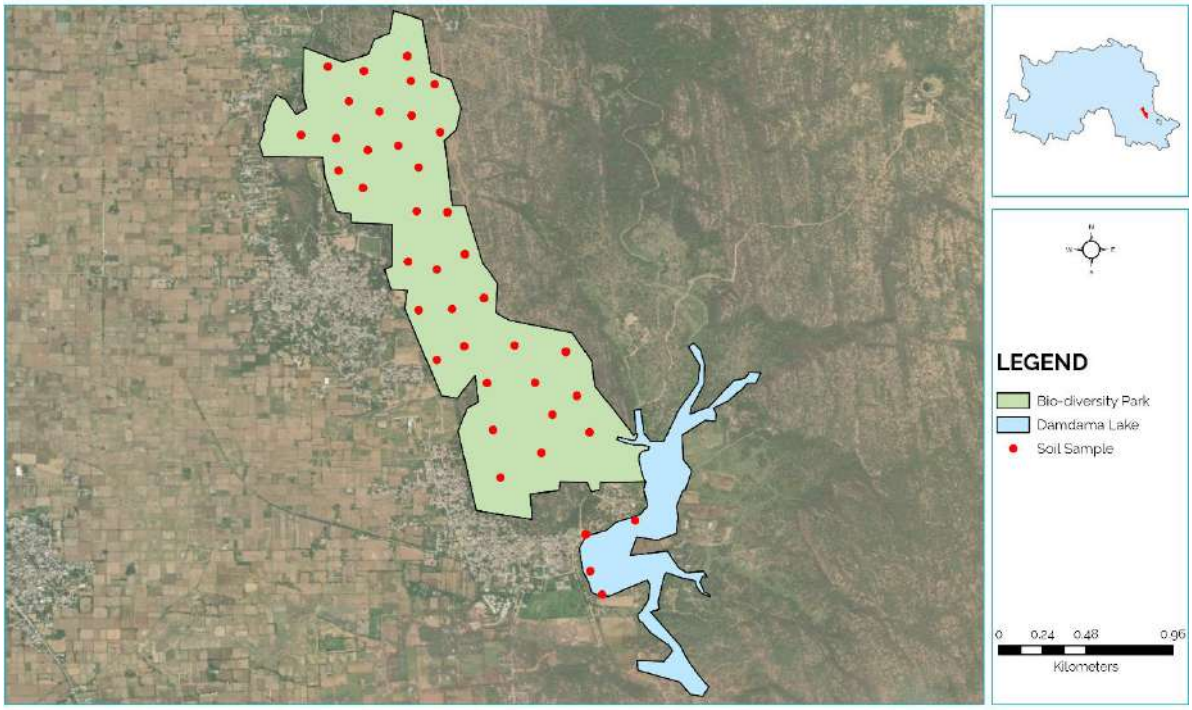


Figure 33: Soil Sample Collection Location

Magnesium - Magnesium protects plants through improved root growth and therefore enables access to water in deeper layers of soil. Magnesium is the central core of the chlorophyll molecule in plant tissue. Thus, if Mg is deficient, the shortage of chlorophyll results in poor and stunted plant growth. High magnesium content can be seen in the south-west part of the biodiversity park. Whereas the soil around lake has lowest magnesium content ranging between 12-31 mg/kg.

Phosphorus - Phosphorus is a most important element present in every living cell. It is one of the most important micronutrients essential for plant growth. Phosphorus most often limits nutrients remains present in plant nuclei and act as energy storage. High and very high phosphorus content ranging from 176 to 478 mg/kg can be seen in the northern part of the project area.

Total Nitrogen - Nitrogen is very important for plant growth, plant food processing and chlorophyll production. Sometimes nitrogen is also dangerous, it can cause the plant to burn, causing the leaves to wither and the plant to be unable to produce flowers. Nitrogen may also cause many environmental damages to groundwater and the ocean. Majority of the project area is nitrogen rich in nature. Western and south-western part of the project area contains nitrogen between 231-343 mg/kg.

Figure 34: Soil near Damdama Lake

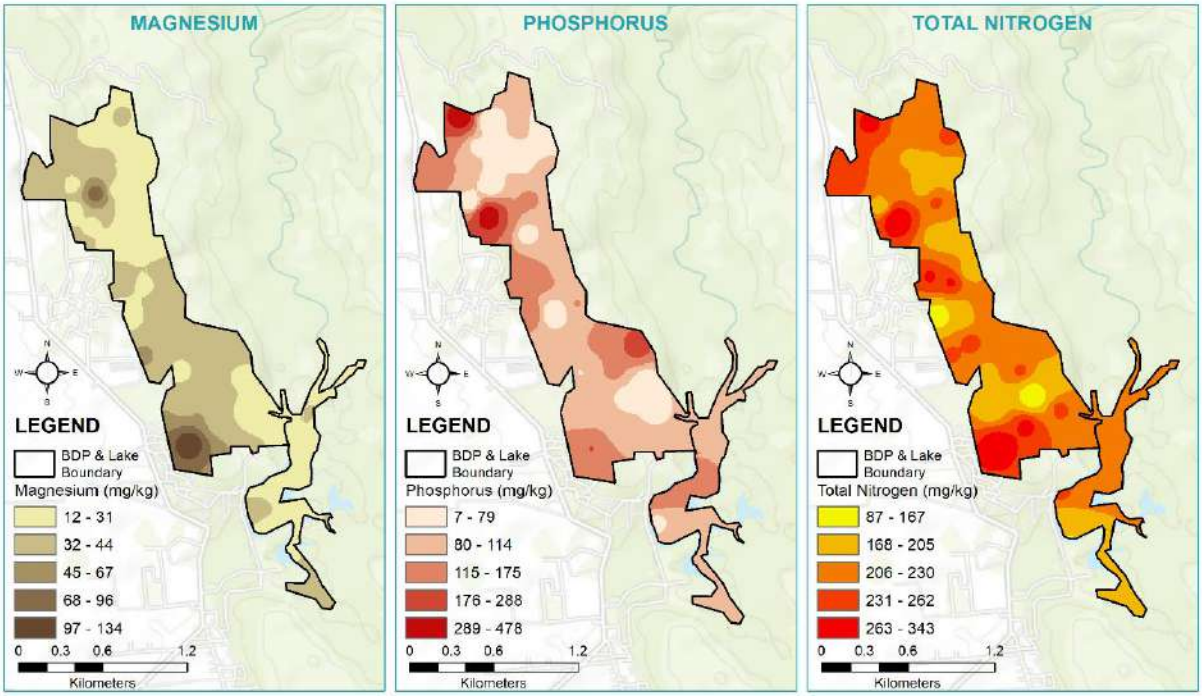


Figure 35: Level of Magnesium, Phosphorous and Total Nitrogen across Project Area

pH - The most significant property of soil is its pH level, its effects on all other parameters of soil. Therefore, pH is considered while analysing any kind of soil. If the pH is less than 6 then it is said to be an acidic soil, the pH ranges from 6-8.5 it's a normal soil and greater than 8.5 then it is said to be

alkaline soil. In the present investigation the pH of the soil ranges between 6.1 to 8.31 with a mean value of 7.2 indicating that the soils are near neutral to slightly alkaline.

Potassium - Potassium helps regulate the opening and closing of the stomata, which regulates the exchange of water vapor, oxygen and carbon dioxide. If potassium is deficient or not supplied in adequate amounts, it stunts plant growth and reduces yield. Very high and high potassium content ranging between 236 to 613 mg/kg can be seen in the north-western part of park and southern part of the lake. Whereas the majority of the area of the biodiversity park have very low potassium content between 29-72 mg/kg.

Organic Matter - Organic matter includes any plant or animal material that returns to the soil and goes through the decomposition process. In addition to providing nutrients and habitat to organisms living in the soil, organic matter also binds soil particles into aggregates and improves the water holding capacity of soil. Most soils contain 2–10 percent organic matter. However, even in small amounts, organic matter is very important. Except for the north-western part of the biodiversity park where the organic matter is more than 1%, rest of the soil in park and lake have organic matter less than 0.5%.

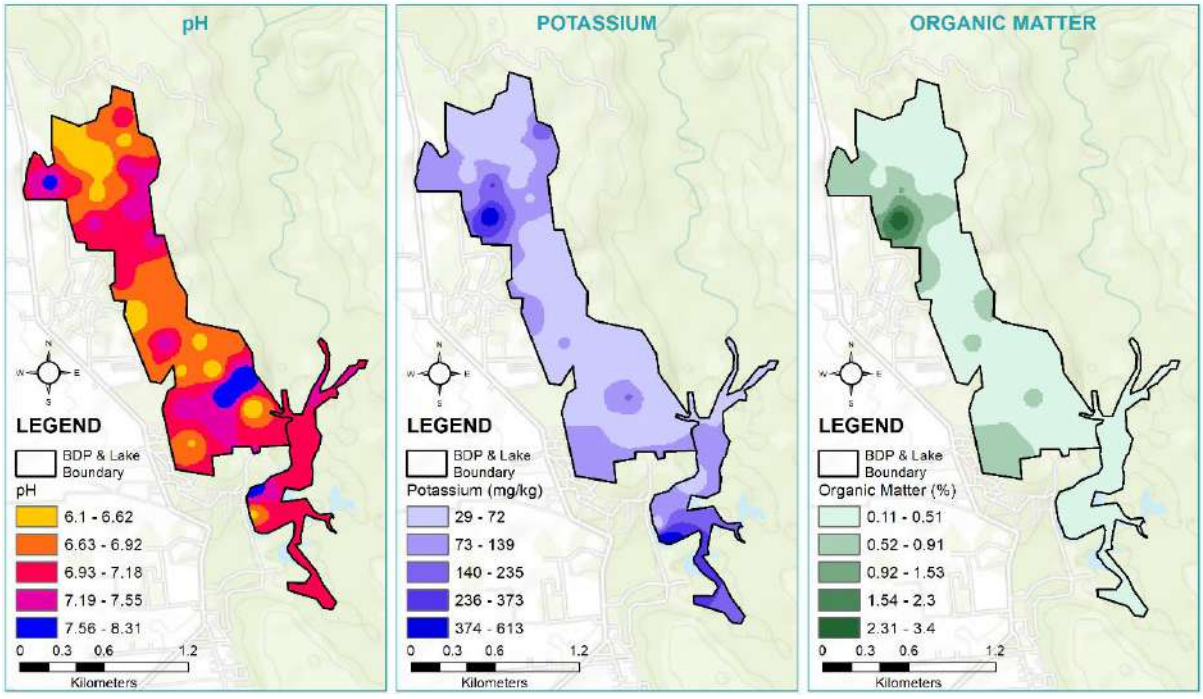


Figure 36: Distribution of pH, Potassium and Organic Matter

Iron - Iron is an essential micronutrient for almost all living organisms because iron plays a vital role in metabolic processes such as DNA synthesis, respiration, and photosynthesis. In addition, many metabolic pathways are activated by iron, and it is a prosthetic group for many enzymes. The imbalance between the solubility of iron in the soil and the demand for iron by plants is the main cause

of iron poisoning. The soil of both the biodiversity park and lake is iron rich where the iron content in the soil is above 16866 mg/kg, where some areas also have iron content as high as 24979 mg/kg.

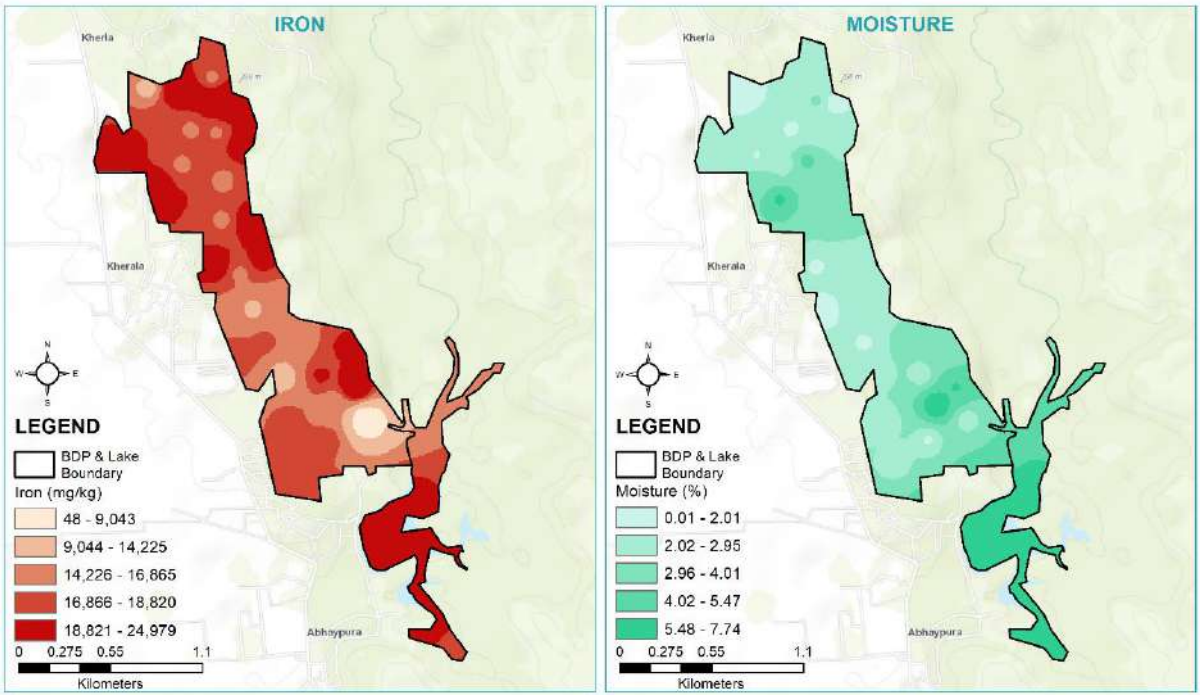


Figure 37: Distribution of Iron and Moisture Content in Project Area

Moisture - Soil moisture is the amount of water in the active layer of the soil. The water content of the soil is a vital element in the hydrological cycle and vegetation growth. High moisture content is seen in the soil around lake where it is more than 4%. In the biodiversity park, majority of the area has moisture content which is less than 2.95%.

In addition to this, low values of soil organic carbon around 0.5% is the BDP area is a cause of concern. This reaffirms the decision to conserve the area as BDP which will help in preserving soil and natural vegetation in the region. Thus, proper measures need to be taken for soil conservation on the hills to prevent further erosion.

Land Use and Land Cover

Land Use and Land Cover (LULC) for the 3 villages of Damdama, Kherla and Abheypur was mapped for the year 2023 by digitization of polygons. USGS Level I classification was adopted in which 6 classes namely – Built-up Areas, Vegetation, Water Bodies, Aravalli Range (Mountain), Open Space and Agricultural Land were mapped.

LULC maps play prime role in planning, management, and monitoring programmes at local, regional, and national levels. This type of information, on one hand, provides a better understanding of land utilization aspects and on the other hand, it plays an important role in the formation of policies and programme required for development planning.

The total area of Abheypur, Damdama and Kherla village is 8.06, 2.79 and 5.48 sq.km. respectively.

- Agricultural land is the dominant class in all the three villages where it occupies 61-66% of the total land cover which is followed by Aravalli range.
- Abheypur has the largest area under Aravalli ranges where it occupies 26% of the land cover which is around 2.11 sq.km. Though area under Aravalli mountains in Damdama village is just 0.63 sq.km but it covers 23% of its total land area.

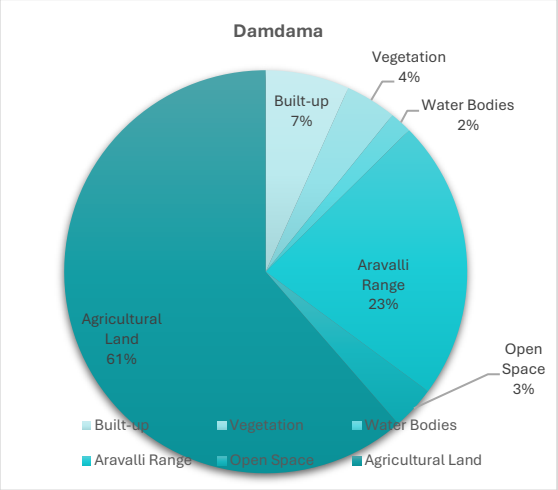


Figure 38: LULC Distribution of Damdama Village

- The percentage of land under built-up areas is almost similar in Kherla and Abheypur village which is about 6-7% of the total land cover. Damdama village has the least amount of area under built-up category where it covers only 0.18 sq.km.
- The area under water bodies is majorly present in the Damdama village because of the presence of Damdama lake where it covers around 2% of the total land area. Whereas, the other two villages have small water bodies present under them.

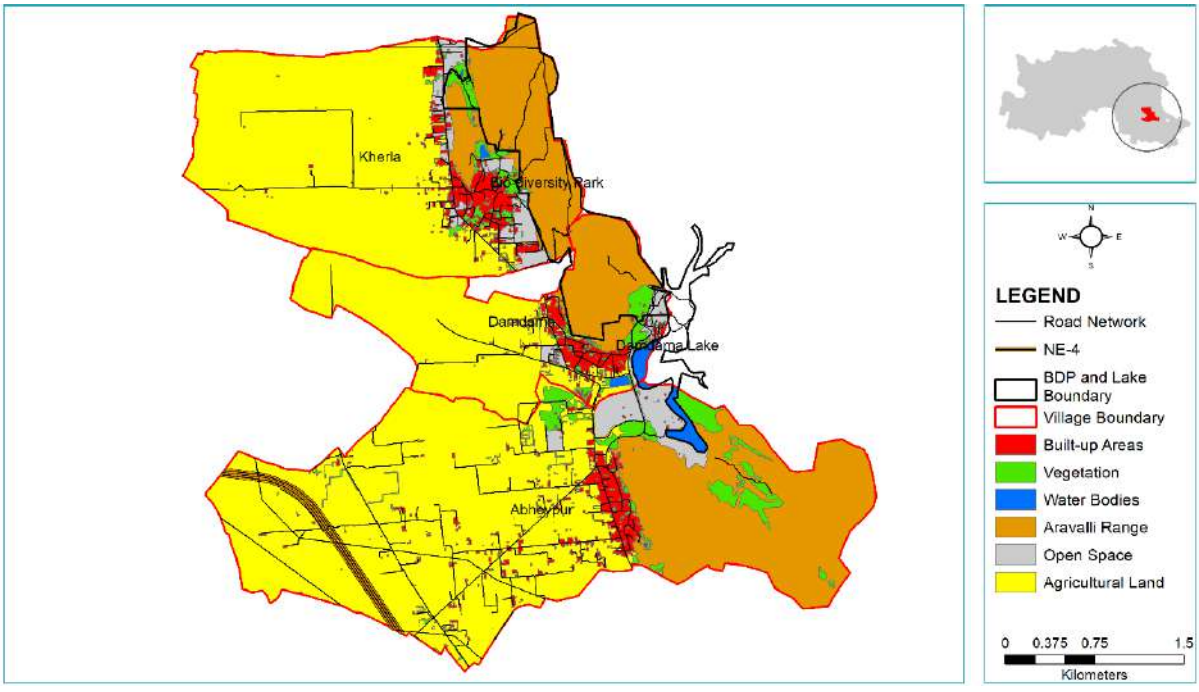


Figure 39: LULC of Villages, Year 2023

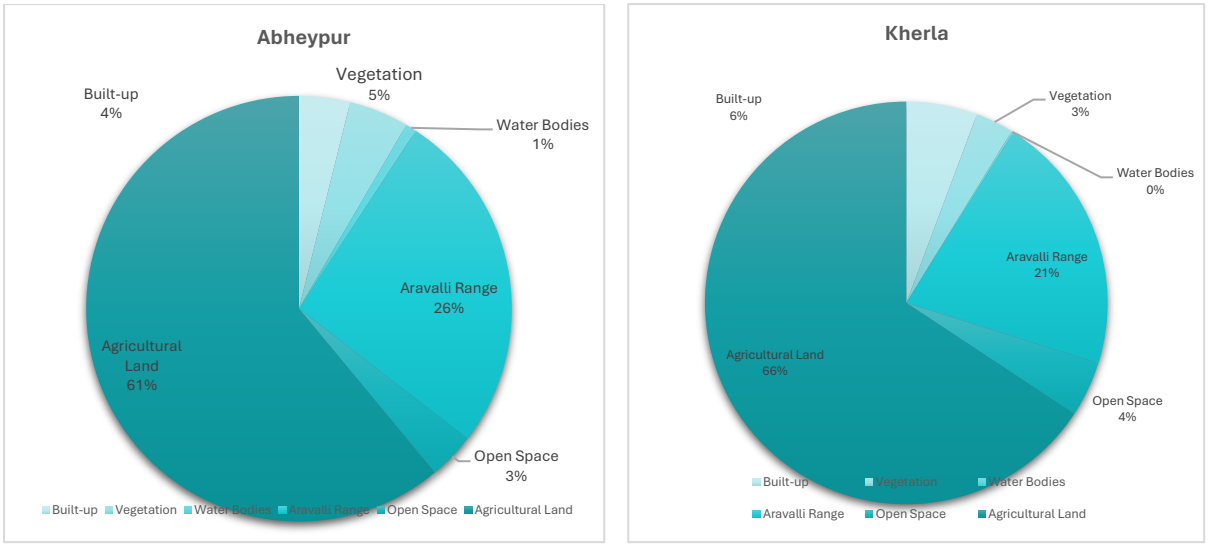


Figure 40: LULC Distribution of Abheypur and Kherla Village

Lithology

The soil profile and lithology were determined by studying the bore log data obtained from District Hydrology Department, Gurugram. The bore log data were analysed to get the overall soil profile of project area.

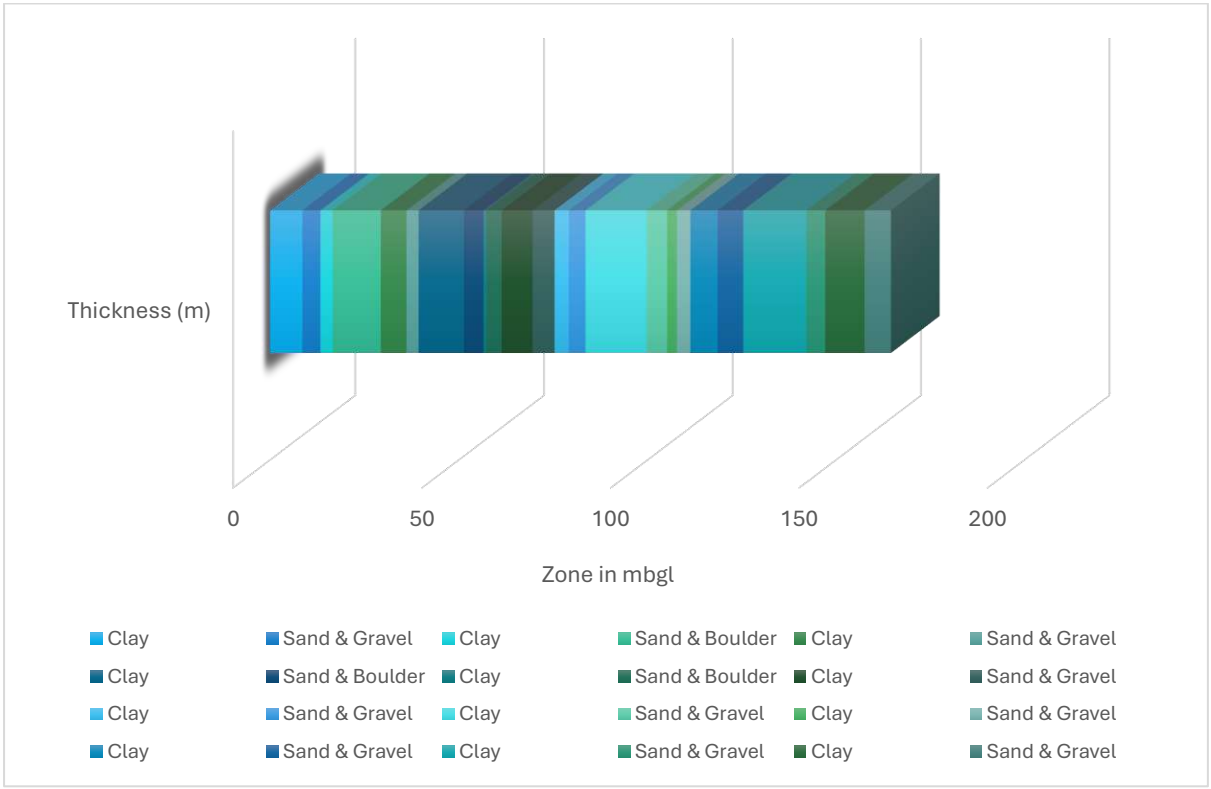


Figure 41: Bore log of Damdama Village

Chapter 3C: Hydrology and Hydrogeology

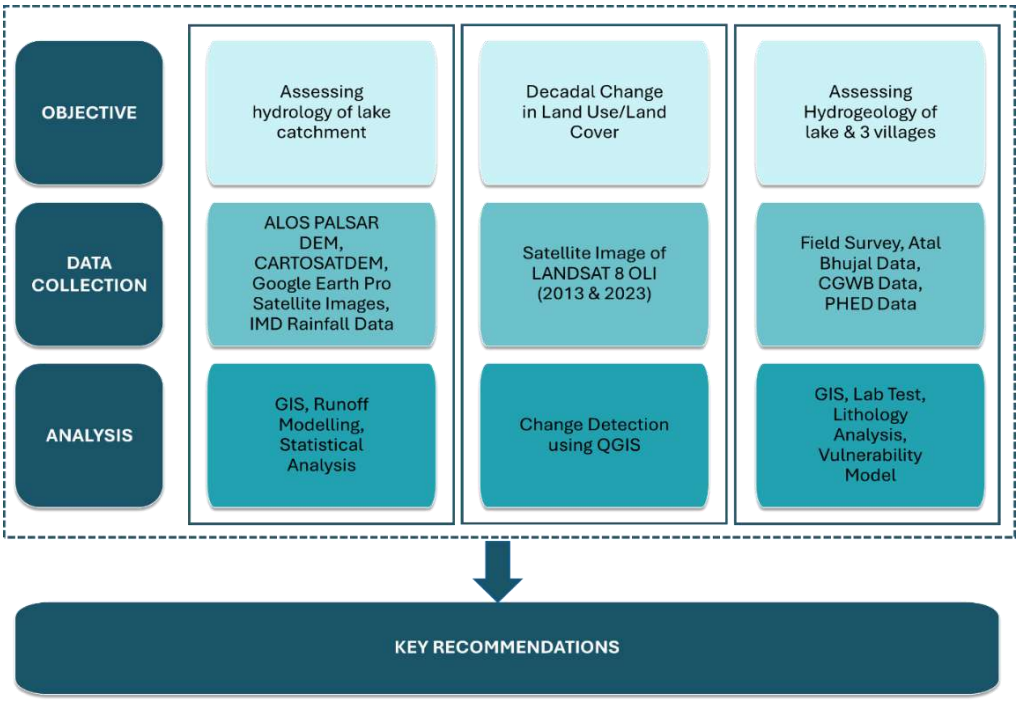
Objectives

Given the challenges in the proposed biodiversity park area the following objectives were identified for the hydrological and hydrogeological study.

- To conduct hydrological assessment to establish a baseline for eco-restoration of Damdama lake and its catchment.
    - Delineate micro and major watersheds to determine drainage pattern.
    - Map waterbodies within the catchment.
    - Analysis of rainfall pattern to estimate trends.
- To assess the hydrogeology of the lake and determine aquifer vulnerability in the proposed park area and the surrounding villages – Damdama, Abheypur and Kherla.
    - To map well locations in the villages.
    - Assess the hydrogeology of the proposed biodiversity park area and neighbouring villages.
    - To assess the water quality and its impact on aquifer vulnerability.
- To estimate the water harvesting potential and identify feasible locations for groundwater recharge.

Methodology

The methodology used for hydrological and hydrogeological assessment is shown below.



Findings

Watershed Delineation

Damdama Lake has catchment of approx. 24.5 sq.km. or 5000 acres. Detailed watershed map and stream order delineation was made considering the major watershed of the Damdama Lake. There are five major sub basins which form the major lake catchment area of 24.5 sq.km as shown in Figure 42. The lake lies in sub basin 5. The biodiversity park (BDP) lies partially in the lake catchment and partially outside the lake catchment. A very small portion of Abheypur village forms part of the lake catchment (sub basin 5). Likewise There are 11 micro watersheds in the proposed Biodiversity park as can be seen in Figure 46.

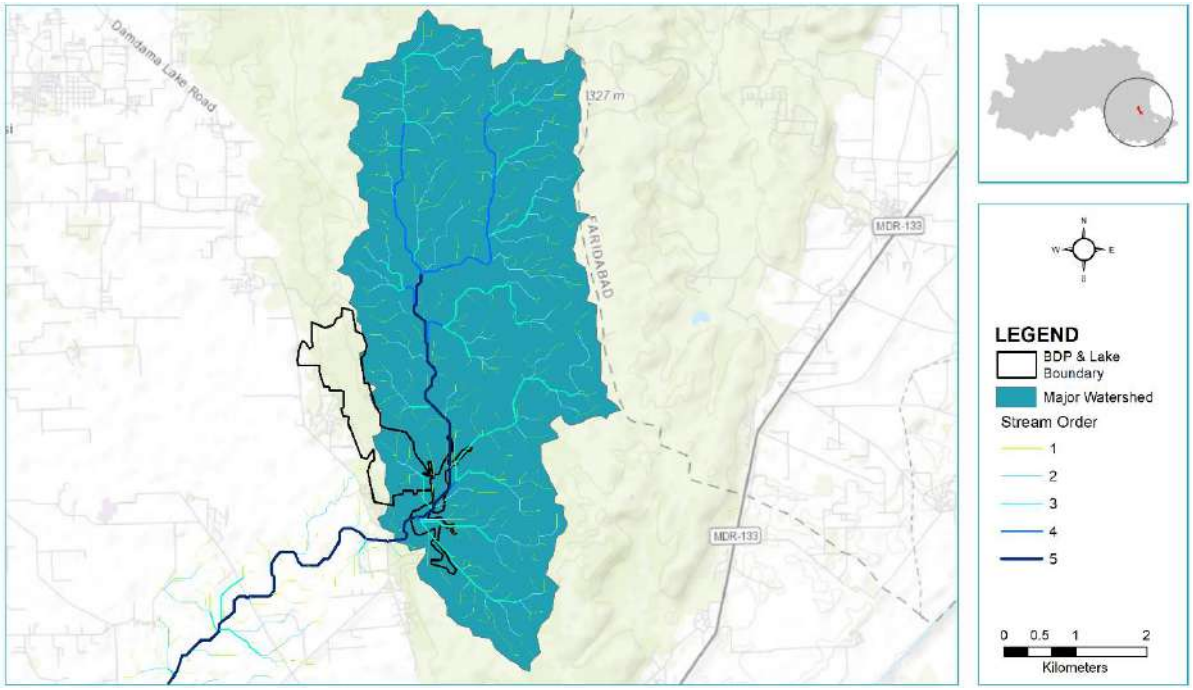


Figure 42: Watershed of Damdama Lake

Figure 43: Damdama Lake Catchment

Figure 44: Aerial View of Damdama Lake in the Month of September 2023

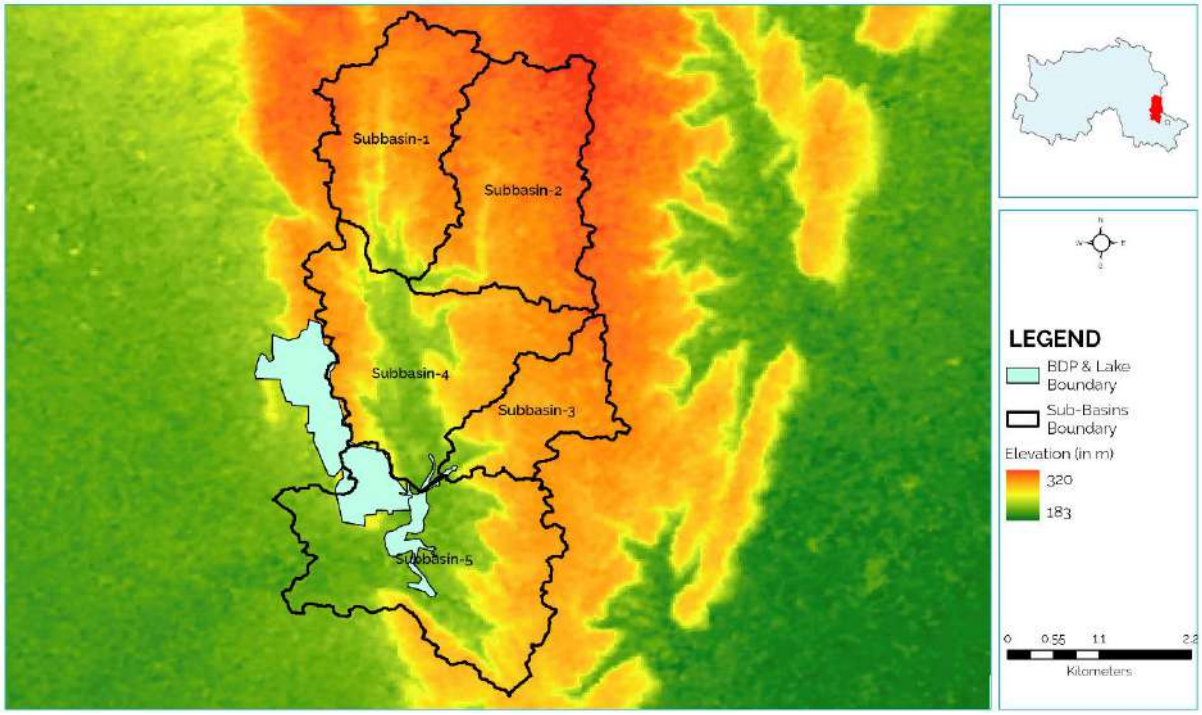


Figure 45: Subbasin of Project Area

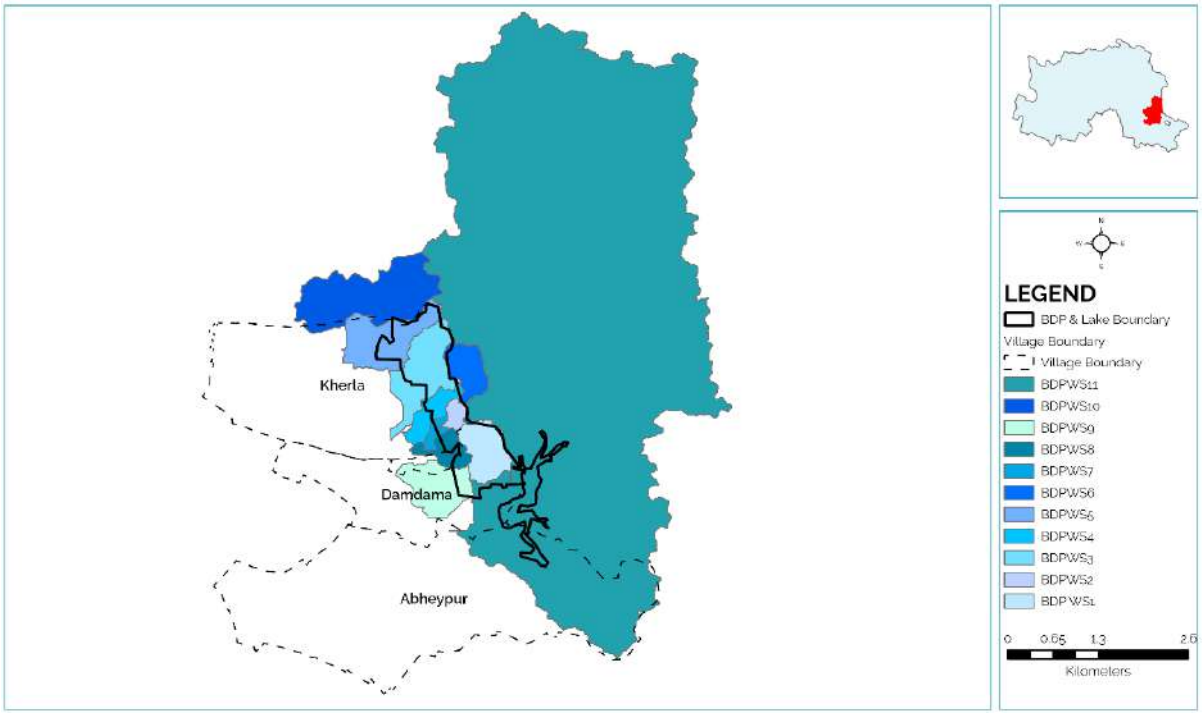


Figure 46: Micro-watershed in Proposed Biodiversity Park and Lake

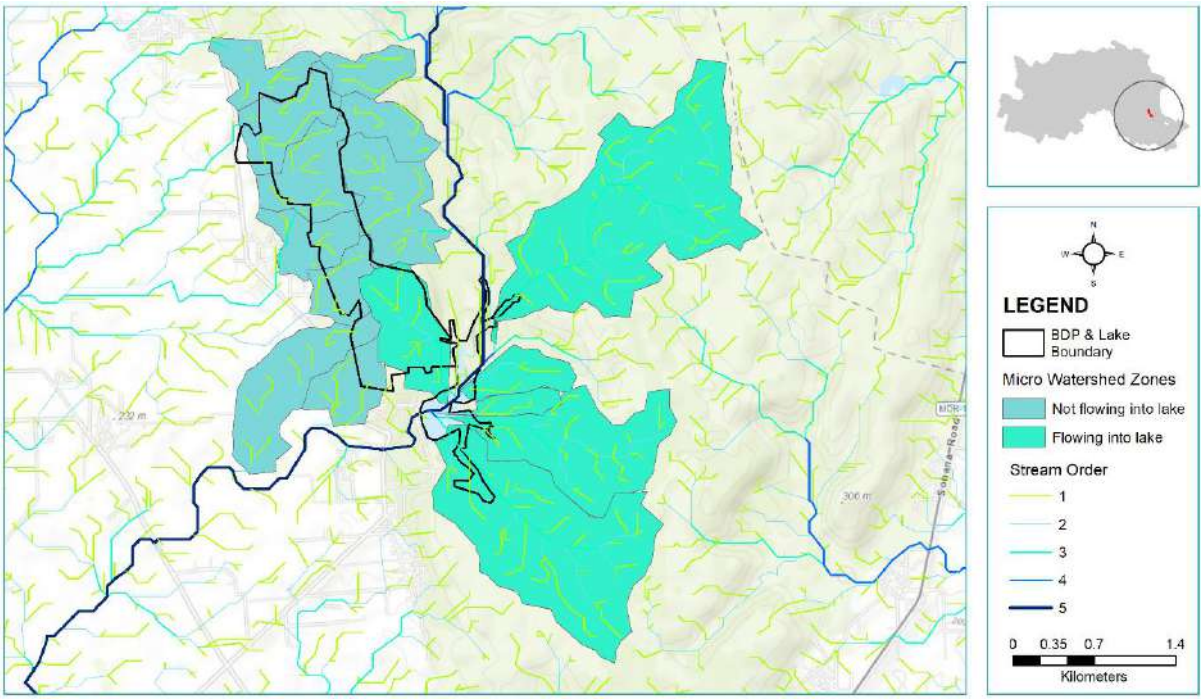


Figure 47: Micro-watershed Flowing and Not Flowing into the Lake

Waterbody Mapping

The waterbody map can be seen in figure 49. A total of 26 depressions were identified within the lake's catchment of 24.556 sq.km. There are four depressions that appear to have water throughout the year, with areas of 2607, 6729, 1550, and 1938 m^2 as shown in the map. These depressions are detected as natural sinks by the model (HEC HMS software). The remaining 22 that were identified do not appear to be natural and are thus assumed to be depressions created by mining. The 22

depressions have the potential to act as local sinks for water storage and recharge. There is one depression in the study region behind Saras Complex, whose area is 21730 m^2, shows runoff accumulation which eventually joins the channel connecting to the lake. Redesigning of this to retain water for a longer period can help in increasing water level in the lake.

Figure 48: Depressions along the Catchment

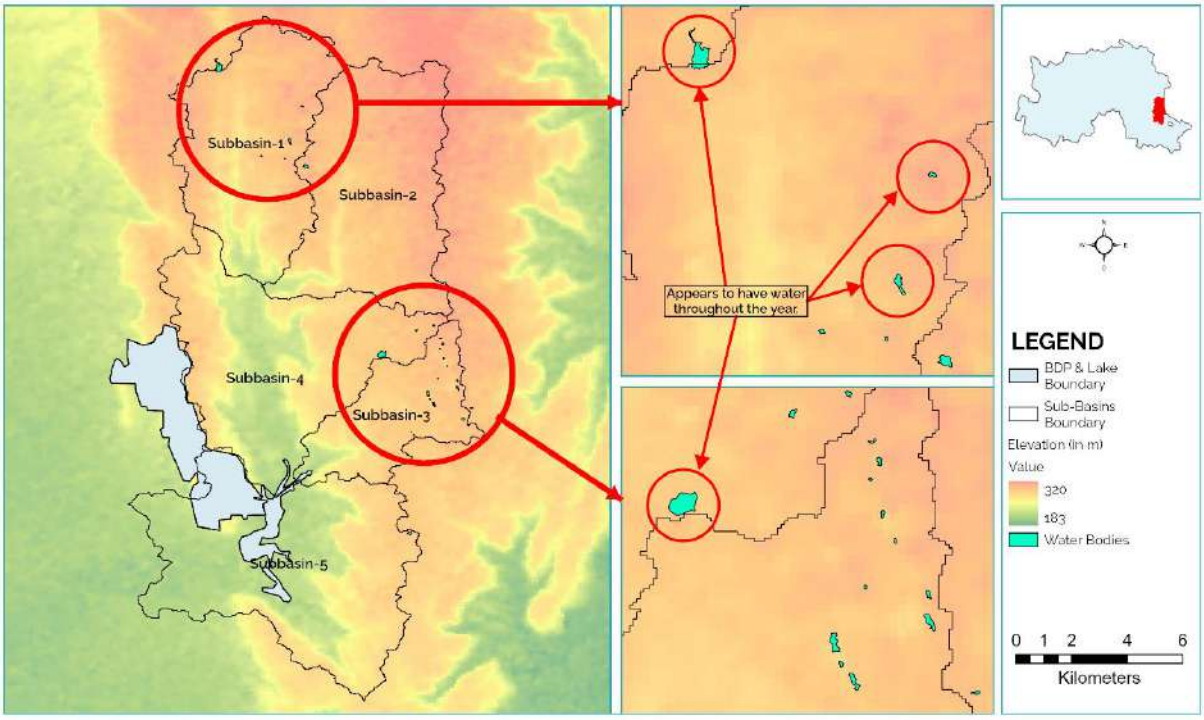


Figure 49: Water bodies in the Damdama Lake Catchment

Flow and Drainage Pattern

In sub-basin 1 and sub-basin 2, two significant streams classified as Order 5 and Order 6 have been identified. These two streams converge at sub-basin 4, combining to create a larger stream categorized as Order 7. This unified stream serves as the conduit carrying water to the lake. However, sub-basin 3 plays a minor role in contributing to the lake, primarily due to extensive mining activities

that have disrupted the natural flow of the stream. Furthermore, the formation of new depressions is observed in sub-basin 3, further impacting its contribution to the lake.

Figure 50: Upstream of Damdama Lake

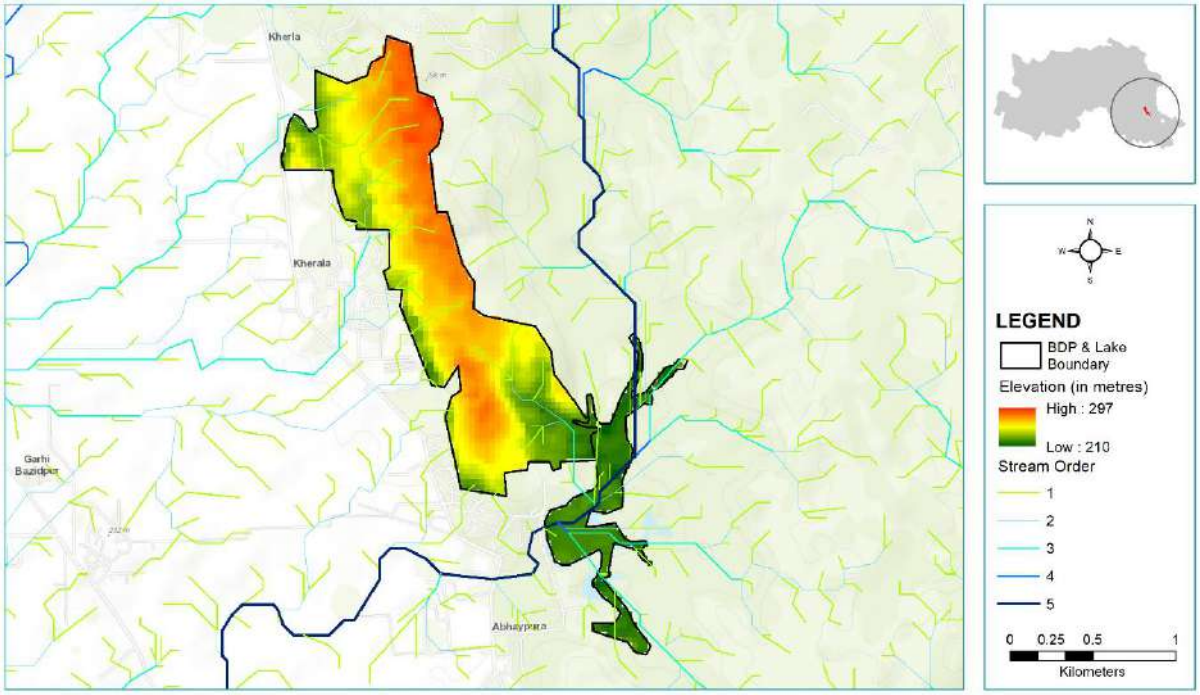


Figure 51: Drainage Network of Project Area

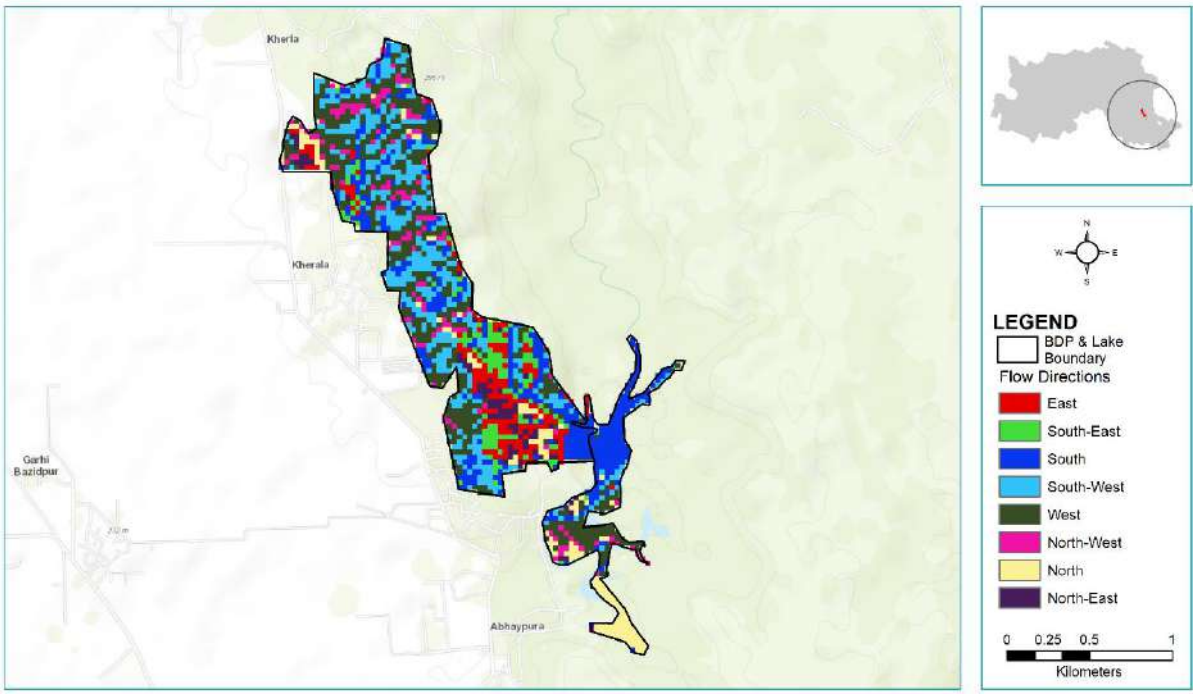


Figure 52: Flow Direction Map of Project Area

Change Detection

In Sub-Basin 1, the flow path has undergone a substantial reduction of almost 2/3, primarily affecting stream order 5, which serves as the primary carrier from the upper ridge to the valley (Figure 54). Over time, the initial length of 607.7m observed in earlier maps (2007) has diminished to 219 m by 2011. Similarly, the stream from Sub-Basin 2, classified as stream order 6, has experienced a notable 1/3 reduction from 1562m to 572 m by 2011.

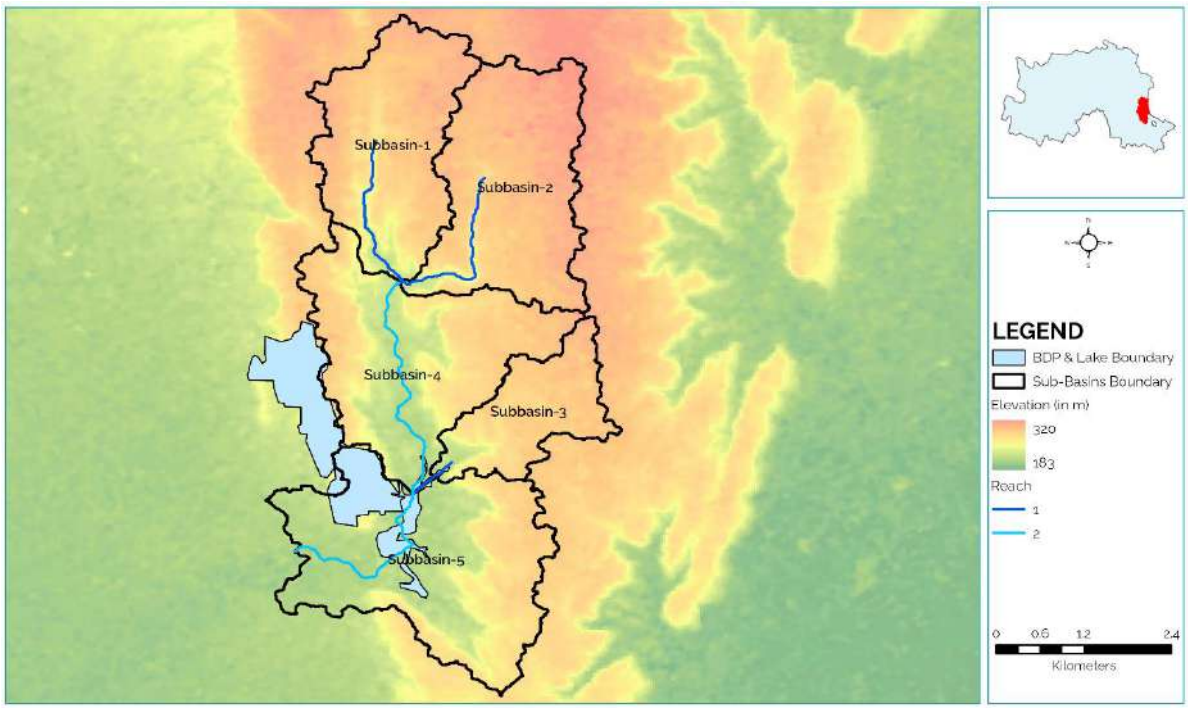


Figure 53: Flow and Sub-basin Map

The mining activities in the ridge area are likely responsible for these hydrological shifts. The impact of mining extends beyond disrupting hydrological regimes; it has also resulted in significant siltation, blocking smaller hydrological channels. This, in turn, has led to changes in flow direction, particularly noticeable in Sub-Basins 3 and 4. Consequently, there has been a decrease in channel flow, accompanied by extreme siltation, obstructing the natural course of streamflow.

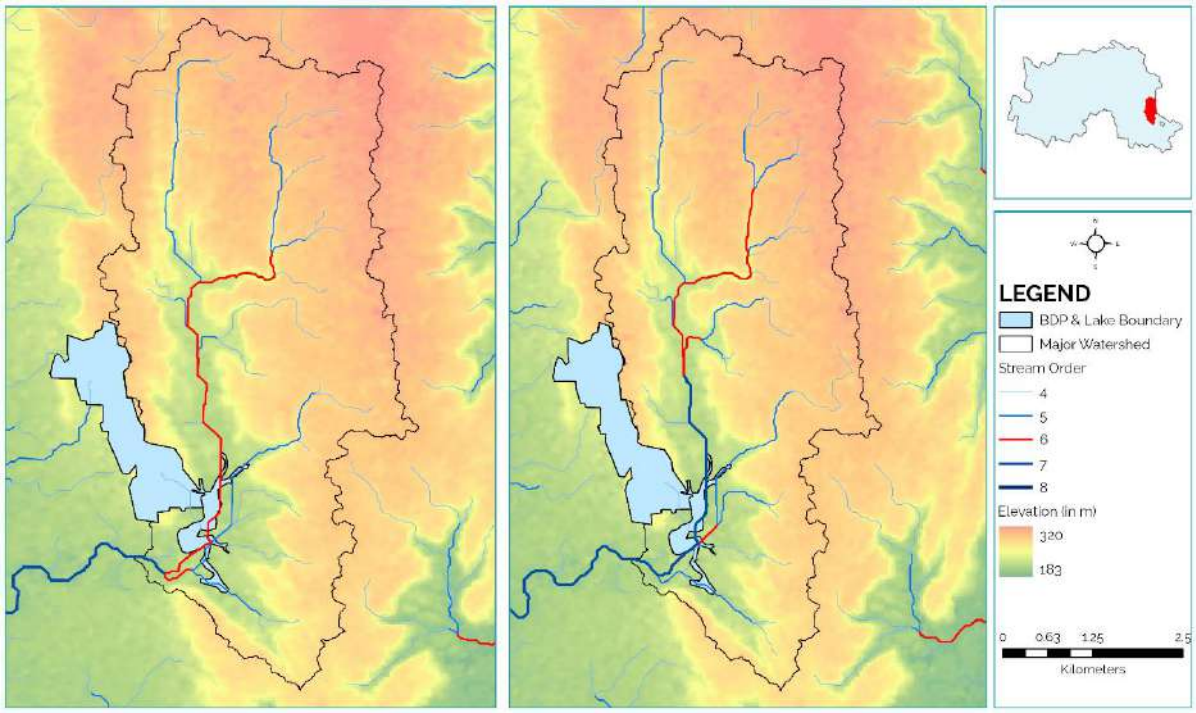


Figure 54: Change Detection Flow Map from Year 2007 to 2011

Assessment of lake volume and surface area

The lake's area is reported to be of 80 acres (3,23,744 m^2 based on Demarcation Report) and the same may be verified by the drone survey. The maximum water depth recorded in October,2023 was 1.8 m, during the depth measurement exercise carried out with the help of boat and measuring staff.

The temporal analysis of Damdama Lake's hydrological parameters, encompassing rainfall, surface area, assumed average depth, and volume, provides insights into the fluctuating dynamics of this water body. Examining the data spanning from October 2011 to November 2023, the observed variations in rainfall and impact on the lake's volume reveals contribution from climatic and anthropogenic factors. In October 2011, the recorded total monsoon rainfall for that year was 535.79mm, the lake surface area was 44 hectares. Subsequent fluctuations in rainfall, particularly low annual rainfall 2016, reflect a decrease in lake spread to 10.2 acres in March 2017. However, in September 2017, the monthly rainfall of 115 mm contributed to lake spread increase to 63.8 acres.

The lake's surface area, which measured 44 hectares at the conclusion of the monsoon season in October 2011, has experienced a significant decline, and now it is less than half of its size during the post-monsoon period. The most alarming reduction was recorded in June 2019, marking the lowest

lake area spread in recent times at a mere 1.49 acres. As of December 2023, the current lake spread area has increased, albeit modestly, to 46 acres.

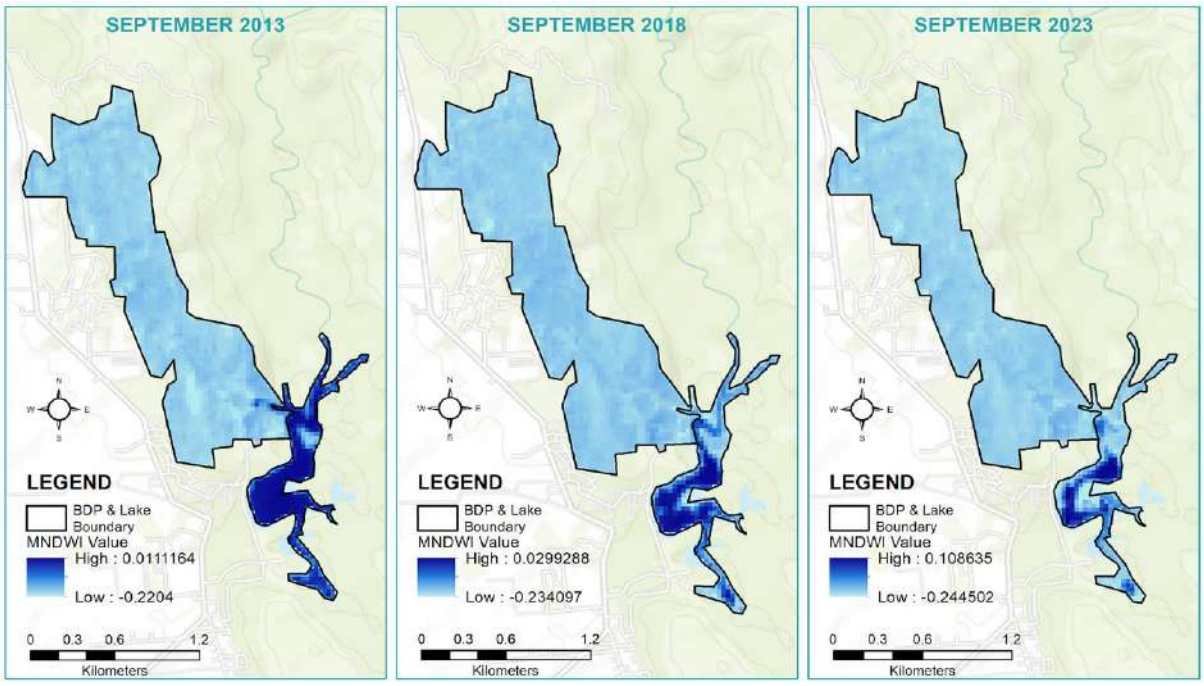


Figure 55: Modified Normalized Difference Water Index Map of Project Area

Figure 56: Damdama Lake in June 2023

Figure 57: Damdama Lake as of April 2024

Figure 58: Damdama Lake During Monsoon

The fluctuations observed in different months and years highlight the relationship between meteorological conditions, disruption in the upstream sub basins, changes in hydrological channels, groundwater abstractions and the lake's response. The highest volume recorded in December 2011 is indicative of the lake's capacity to capture and retain water during favourable conditions at 108 acre

and completely recharging the aquifer in the foothills. The variations impact the lake catchment's biodiversity, influencing the availability of habitats for organisms and migratory bird species. Additionally, the lake's role in groundwater recharge and sustaining local ecosystems is intricately linked to its volume, necessitating a holistic understanding for effective conservation strategies.

The changes in the water surface area of a lake were also observed using Google Earth. The time slider feature to access historical satellite images, allowing for the selection of specific years of interest. Zooming in on each corresponding satellite image enabled the location of the lake, and the Google Earth polygon drawing tool was employed to delineate the water surface area by creating vertices and closing the polygon for each selected year.

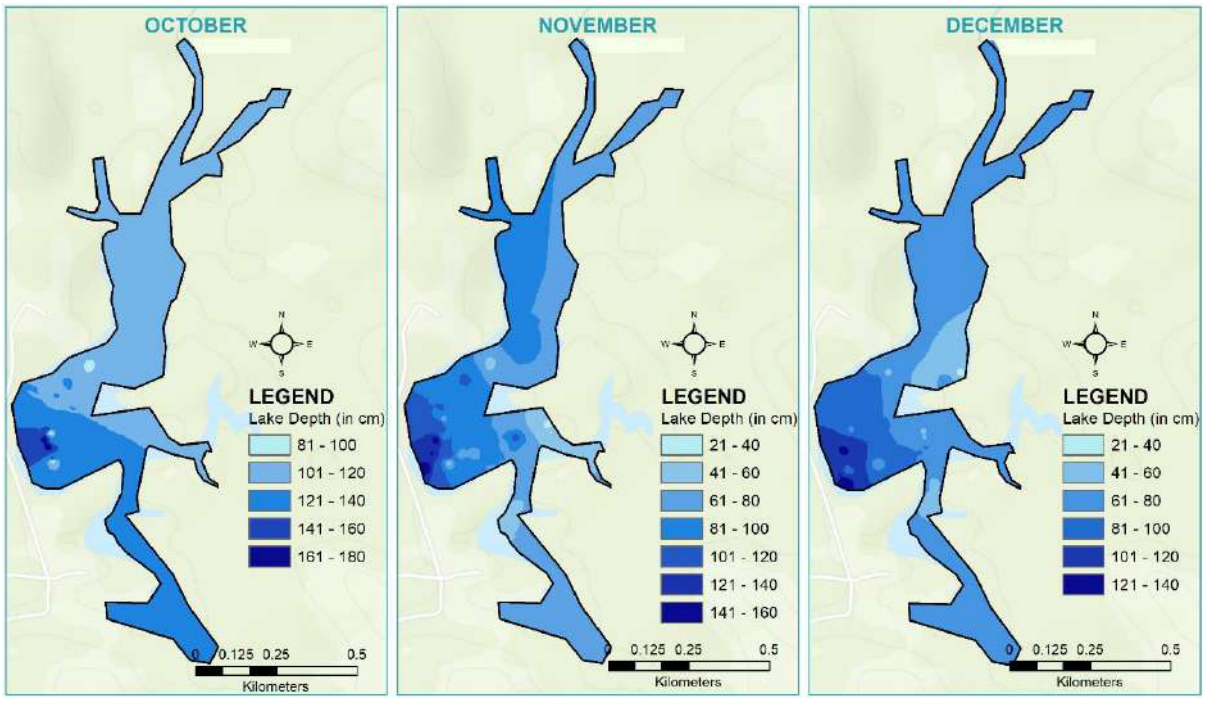


Figure 59: Lake Depth Map as per Primary Survey During October to December 2023

To assess the flooding situation daily rainfall data of recent 30 years (1990-2020) was undertaken to assess the intensity of single-day extreme events within the catchment. These events significantly contribute to the generation of runoff from the catchment, providing insights into the conditions under which the lake levels rise and may lead to overflow during extreme rainfall events. The extreme rainfall days were analysed, and it is found that there are 19 events of one-day rainfall of intensity between 50 mm and 100 mm, there are 36 occurrences of five-day event where rainfall varies from 50 mm-150 mm (Figure 60 and 61).

The normal average rainfall is 583 mm, with the 50% dependable rainfall recorded at 569 mm. An annual rainfall ranging between 900-1000 mm is anticipated once every 10-12 years. However, in the past decade, two instances of annual rainfall exceeding 900 mm occurred, specifically in the years 2021 and 2022. Despite this, the lake's spread reached 59 acres post-monsoon, considerably lower

than the 108 acres recorded in 2011. This reduction is a clear indication of heavy groundwater extraction and disruptions in the upper catchments.

A declining trend in the rainfall pattern within the Gurugram catchment has been observed. The lake experienced flooding when an additional runoff of 3,113,500 cubic meters (3.1 million cubic meters) resulted from a 212 mm rainfall between July 7 and July 12, 1993. This caused the lake to reach a depth of 5 meters. The probability of a 5-day rainfall of 212 mm occurring is once in 125 years. The chances of such an event are minimal, given the lake's water depth of 1.5 meters or less. Additionally, an extra 3 meters depth over the lake spread would require a much larger rainfall.

Flooding in the lake can happen with a 200 mm rainfall in 5 days only if there are preceding incidents of 2-3 occurrences of 100 mm rainfall in the 10 days prior to the 200 mm rainfall event. Despite heavy extraction, the lake's potential volume storage capacity, with an average depth of 1.1 meters, currently stands at 16.48-hectare meters of volume or 181,280 cubic meters.

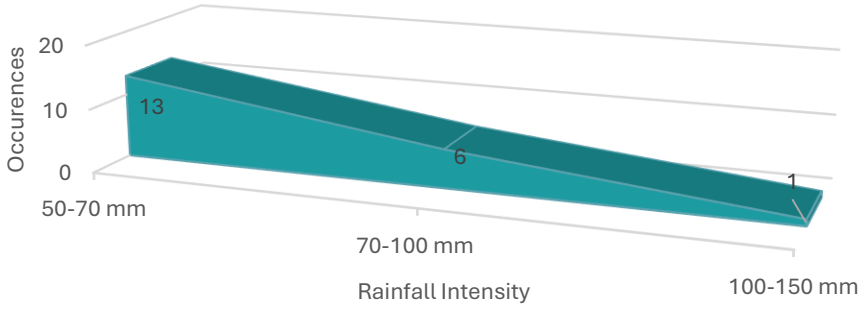


Figure 60: Rainfall Intensity v/s Number of Occurrences -1 Day

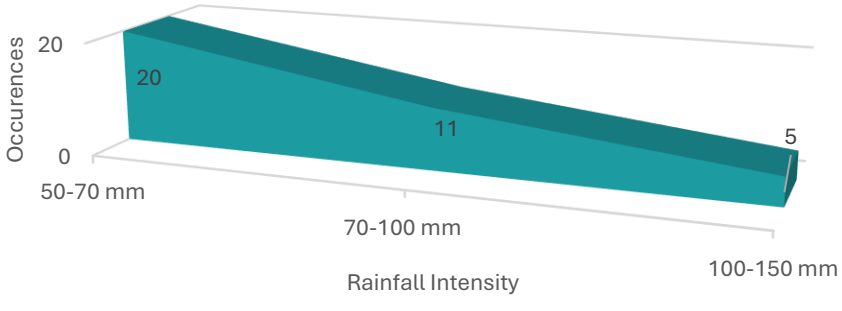


Figure 61: Rainfall Intensity v/s Number of Occurrences -5 Day

Hydrogeology

Groundwater level variation pre and post monsoon

After studying the geological profile, it was found out that the project area and the surround region is of Paleopreterozoic-Mesopreterozoic and Quaternary Age. The rock exposures in Damdama region of Aravalli's are the Delhi supergroup of rocks which consists of Quartzite interbedded with mica-schist. The quartzite ridge has ground water which occurs in fractures, joints and crevices. Sandy layers at various depth form major water bearing horizons above the crystalline basement. This is also verified by presence of ground water at very low level of around 31-35m. The Damdama lake region consists of loose brown aeolian deposits. These are wind-blown deposits from Thar desert that are blocked by Aravalli's which are deposited at foothills. They have excellent infiltration properties and allow water to percolate towards the aquifer. We can see that from the map as well that the ground water in and around the Damdama lake region can easily be found within 5-15 m of depth.

The aquifer was detected by borewell mapping in the villages of Damdama, Abheypur and Kherla. The location of borewells mapped in Damdama, Kherla and Abheypur gave a spatial understanding of the groundwater present in the region. The number of borewells in Abheypur, Damdama and kherla are 7, 10 and 13 respectively. There were also 10 abandoned borewells also detected in the three villages. The mapping exercise gives an understanding of the approximate number of wells present in the region which in turn gives an idea on extraction of groundwater.

Figure 56 to 58 shows the fluctuation in groundwater level for the 3 villages pre and post monsoon period as monitored under Atal Bhujal yojana since 2015. During the years 2020 and 2021 there has been rise in water table at the village, there could be other reasons but the year 2021 was a good rainfall year (recorded 988mm rainfall). The years 2016-2019 had below normal rainfalls as seen in figure 46, this can be observed by increase in depth of water table in all three villages.

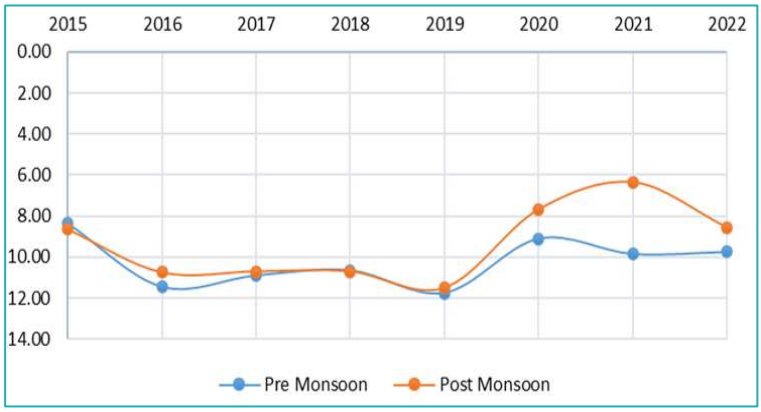


Figure 62: Damdama Village Groundwater Table

It can be observed that the water table has little variation over the years. The influence of borewells on the lake and the flow of groundwater from the lake to the aquifers have helped in maintaining the groundwater levels in the region. The deeper water levels in Kherla can be attributed to the absence of fine sand layer and lower hydraulic conductivity of 0.44 m/day, Damdama village lithology can be approximated to Kherla village as they fall in the same groundwater table line and are outside the watershed of the lake.

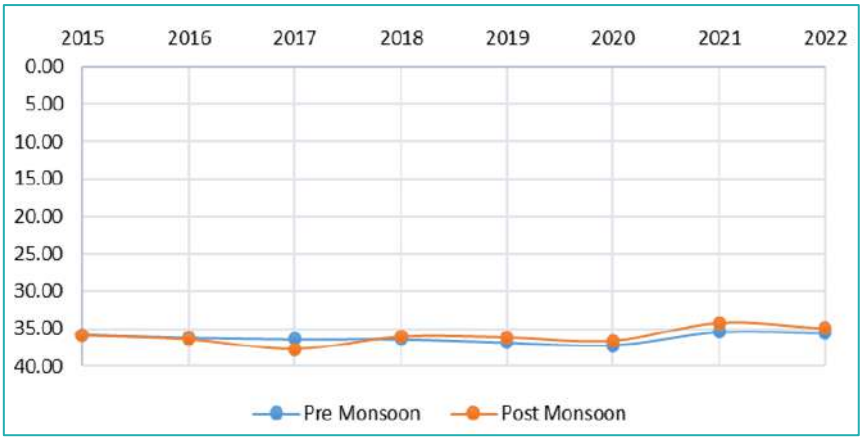


Figure 63: Kherla Village Groundwater Table

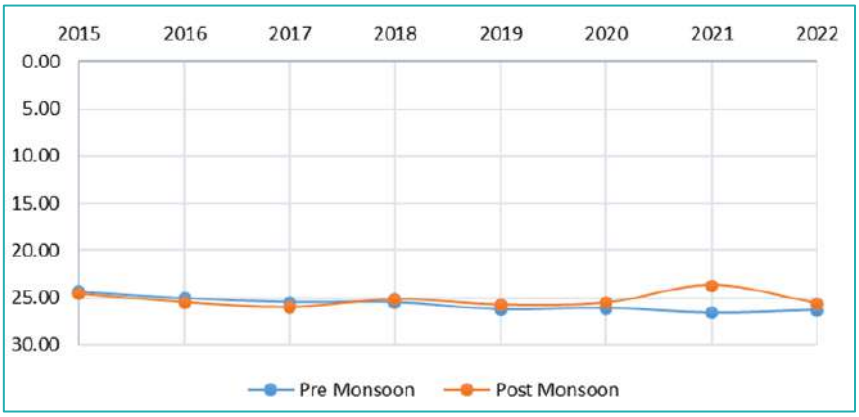


Figure 64: Abhyepur Village Groundwater Table

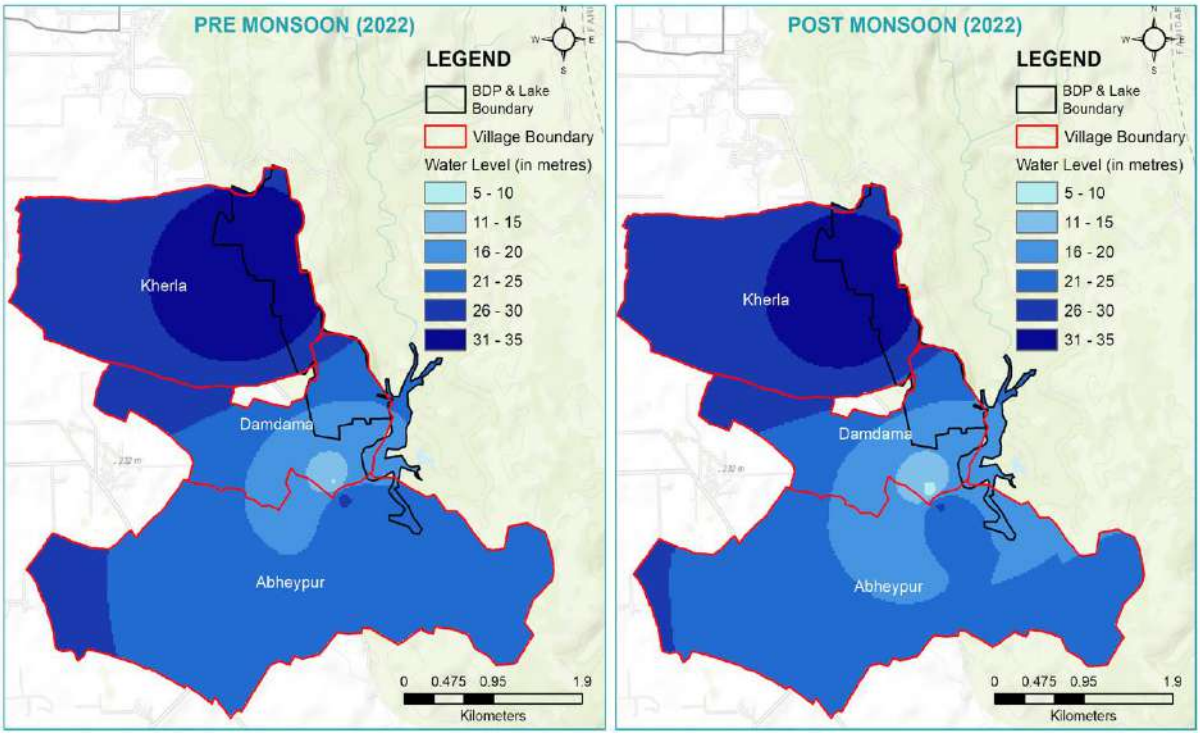


Figure 65: Pre and Post Monsoon Groundwater Table

Detection of Aquifers and Hydraulic Conductivity

From the geological profile and rock structure of the area, the groundwater aquifer is present only in the sandy layers at the foothills and surrounding regions as the runoff flows from the hills to the foothills. This makes it important to trace the aquifer in the 3 villages of Damdama, Abheypur and Kherla.

The aquifer was detected by borewell mapping in the villages of Damdama, Abheypur and Kherla. The lithological data of surrounding villages were analyzed to get the soil type and thickness of aquifers. The soil hydraulic conductivity for the aquifer was calculated by matching the standard values of hydraulic conductivity for each soil type. The data from Atal Bhujal yojana reports and data from Hydrology department and PHED department were used to determine the groundwater level depth and study its fluctuation pre and post monsoon.

Mapping well locations

The location of borewells mapped in Damdama, Kherla and Abheypur gave a spatial understanding of the groundwater present in the region. The Borewells (BW) used for public water supply by PHED in the 3 villages (Abheypur, Damdama and Kherla) surrounding the lake were mapped from primary survey and secondary data from PHED department (Figure 67).

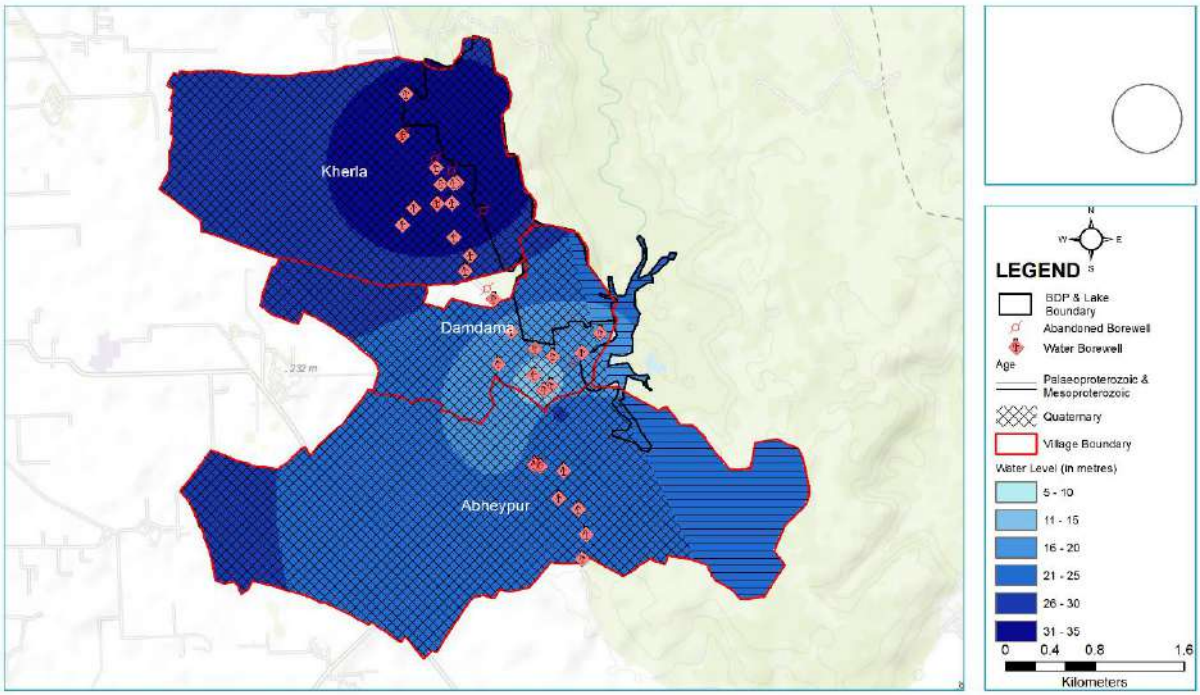


Figure 66: Borewell Locations and Groundwater Table in Each Villages

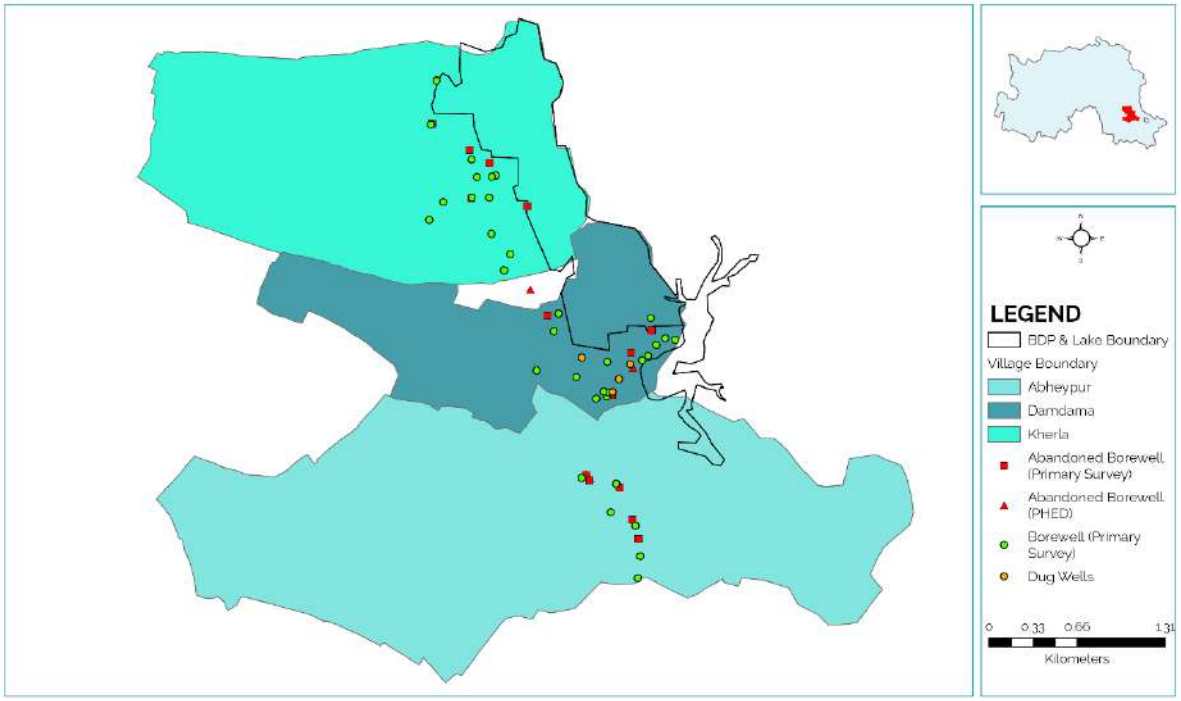


Figure 67: Borewell Location in Villages

Figure 67 shows the location of Borewells in the Damdama, Kherla and Abheypur villages used for drinking water supply installed by PHED which are mapped through field survey. Among the wells installed by PHED, 29 are functional and 13 are abandoned borewells.

Figure 64 shows the detailed map of borewell locations in Abheypur village only. The village has a total 6 borewells used for public water supply and 1 borewell in the temple present in south of the village. During the field survey 5 abandoned borewells were found but the PHED records show 2 of them. Only a part of Abheypur lies in the catchment of Damdama. Abheypur receives runoff from nearby hills also and groundwater within the village is found to be saline and is not fit for drinking, the reason for the saline water present only in a small patch may be due to the localised run-off from the surrounding hills outside the catchment of the Damdama lake.

Damdama village is present to the west of the Damdama lake. Figure 64 shows the detailed map of borewell locations of PHED and other locations like resort, fisheries, and Indira Gandhi (IG) holiday home in the village. The village has 10 PHED borewells for water supply, 1 borewell of the fisheries department which extracts water to grow fish seedlings for export, 2 borewells in SARAS tourist resort of government, 1 borewell in cremation ground and 1 in Indira Gandhi holiday home for Children. The village has 4 abandoned borewells out of which 2 were used for public water supply, 1 is of fisheries department and 1 is of IG home. There are also 4 dug wells within the village out of which only the one in the centre has some water in it.

Influence of borewells on the lake

The borewells present in the villages exert an influence on the water in the lake. The flow of water is from the lake to the groundwater aquifer present in the region which is quantified by the radius of influence. The radius of influence of a borewell gives a fair idea on the area from which it draws water, this varies depending on type of soil, hydraulic conductivity, drawdown during pumping and aquifer type. The radius of influence of the borewells used for public water supply in three villages of Damdama, Abheypur and Kherla was calculated using the formula given below:

Radius of Influence of unconfined aquifer

$R= 3000 * S * (K_{sat})^{0.5}$ (Kirieleis-Sichardt, 1930)

Where, R – Radius of influence in m

S- Drawdown in m

K_{sat}- Saturated hydraulic conductivity in m/sec

The details of borewell in the three villages was obtained from PHED department which have details on drawdown, discharge, head. The drawdown values and discharge were used to calculate radius of influence and plotted on a map at Figure 68.

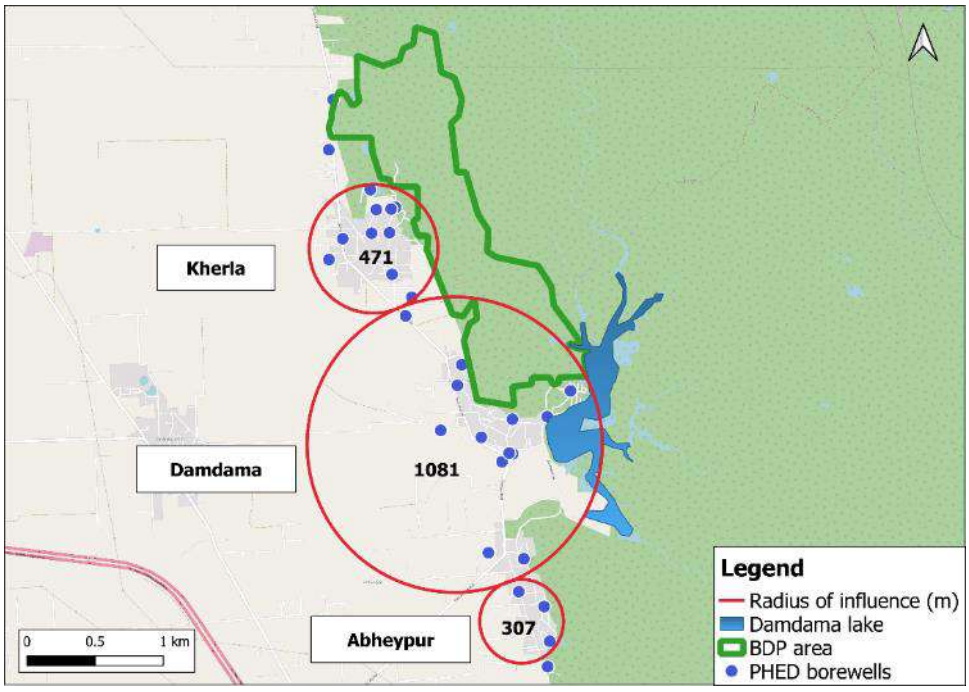


Figure 68: Influence of Groundwater Extraction

As seen from the map, Abheypur and Kherla fall outside the catchment of Damdama lake thus most of the borewells in those villages have a localized radius of influence as depicted by the red circles in figure 68. Most of the extraction in Damdama occur within a radius of 1 KM from the lake, borewells

in Kherla and Abheypur extract water from localized aquifers within a smaller radius than Damdama (471 m and 307 m respectively).

Aquifer vulnerability

The vulnerability of groundwater aquifers is given by an index developed by US EPA called DRASTIC index. The index considers various aquifer and surface characteristics to calculate the vulnerability of the aquifer. The acronym DRASTIC stands for depth of water table (D), Recharge (R), Aquifer media (A), soil media (S), topography of the region (T), impact of Vadose zone (I) and hydraulic conductivity of the aquifer (C). Weights are given for each parameter and ratings are given based on the site condition for each parameter. The higher the rating and weight more is the vulnerability of the aquifer.

DRASTIC = DrDw + RrRw + ArAw + SrSw + TrTw + IrIw + CrCw (Aller et al.,1987)

Where, *r- rating and w-weight*

The DRASTIC index shows high vulnerability in Damdama, Abheypur, Garhi Bazidpur and Daula villages. The presence of fine sand aquifer with a hydraulic conductivity of 3.45 m/day and a shallow water level of 10-12 mbgl are the main reasons for high vulnerability. This makes it important to identify the septic tanks present in these villages and conduct solid and liquid waste surveys to identify hotspots of pollution.

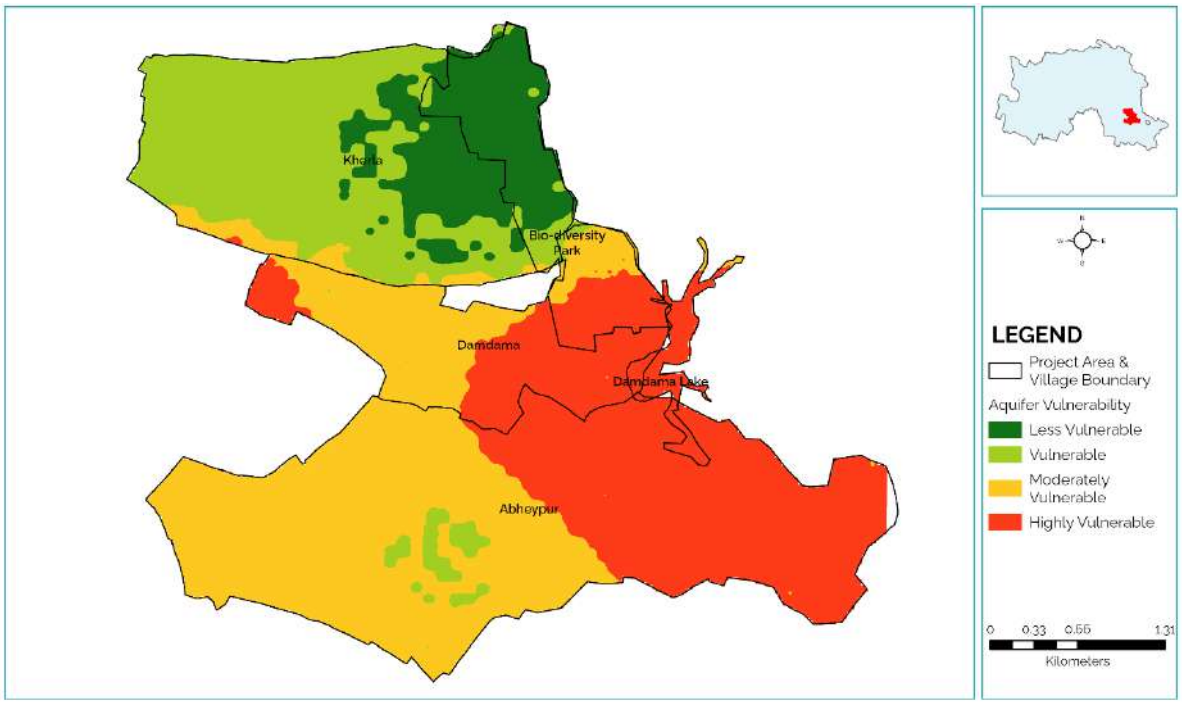


Figure 69: Aquifer Vulnerability Map

The added fact that the groundwater is heavily dependent on the lake makes the aquifer in Damdama more susceptible to vulnerability. Measures must be taken to prevent the aquifers from being damaged by conserving the quantity & quality of water in the lake. Kherla has a low vulnerability

despite its water turning saline because it has deeper water levels and a clayey sand aquifer with low hydraulic conductivity of 0.44 m/day does not allow pollutants to penetrate easily.

Installation of Automatic Water Level Recorders

To further understand the aquifer system and estimate the influence of lake levels and abstraction on groundwater level continuous monitoring is required. For this purpose, three Automatic Water Level Recorders (AWLR) are installed near Damdama lake at the locations shown in Figure 70.

The water level recorded by the AWLR was matched with Atal Bhujal reports, they were found to be matching the current values given in the report. Three more AWLR's will be installed one each in the three villages of Damdama, Abheypur and Kherla to monitor the groundwater at each village.

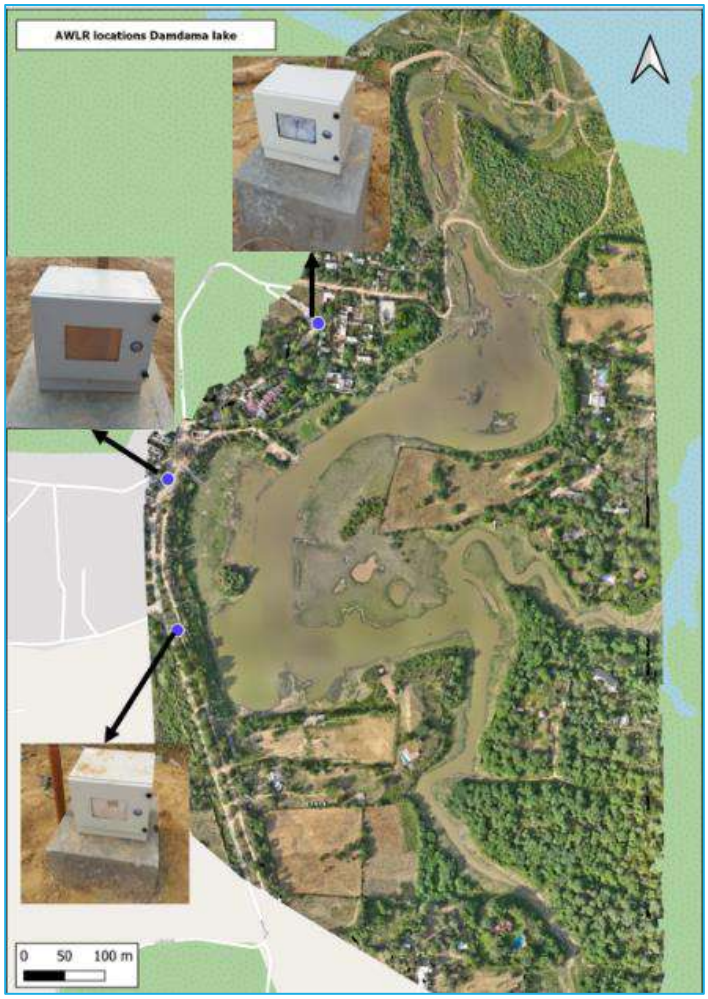


Figure 70: AWLR Locations

These AWLR are installed near the lake to monitor the groundwater table fluctuation around the lake across the year. This will be helpful to analyse the relationship between the groundwater table and lake level fluctuations.

Chapter 3D: Biodiversity

Objective

The objectives of the baseline assessment is to benchmark the current ecological state of the area and provide a baseline for comparison in the future.

An **ecological assessment** will provide an overview of the ecosystem services of the area, and asses the forest vegetation and avi-fauna (including birds, mammals, reptiles, amphibians, etc.). The benchmarking will provide an overview of the current forest condition, and its uses, and also record the presence of avi-fauna in the area.

Regular monitoring over time will provide feedback on the ecological changes and impacts and provide inputs for planning the restoration at this site and possibly learnings for restoration in the broader landscape.

The study has been conducted in the early winter season of October – December. For a full inventory of avi-faunal species it is important to do a yearlong baseline with assessments in each season – as the species vary by season particularly for of insects, reptiles, and birds and herbs.

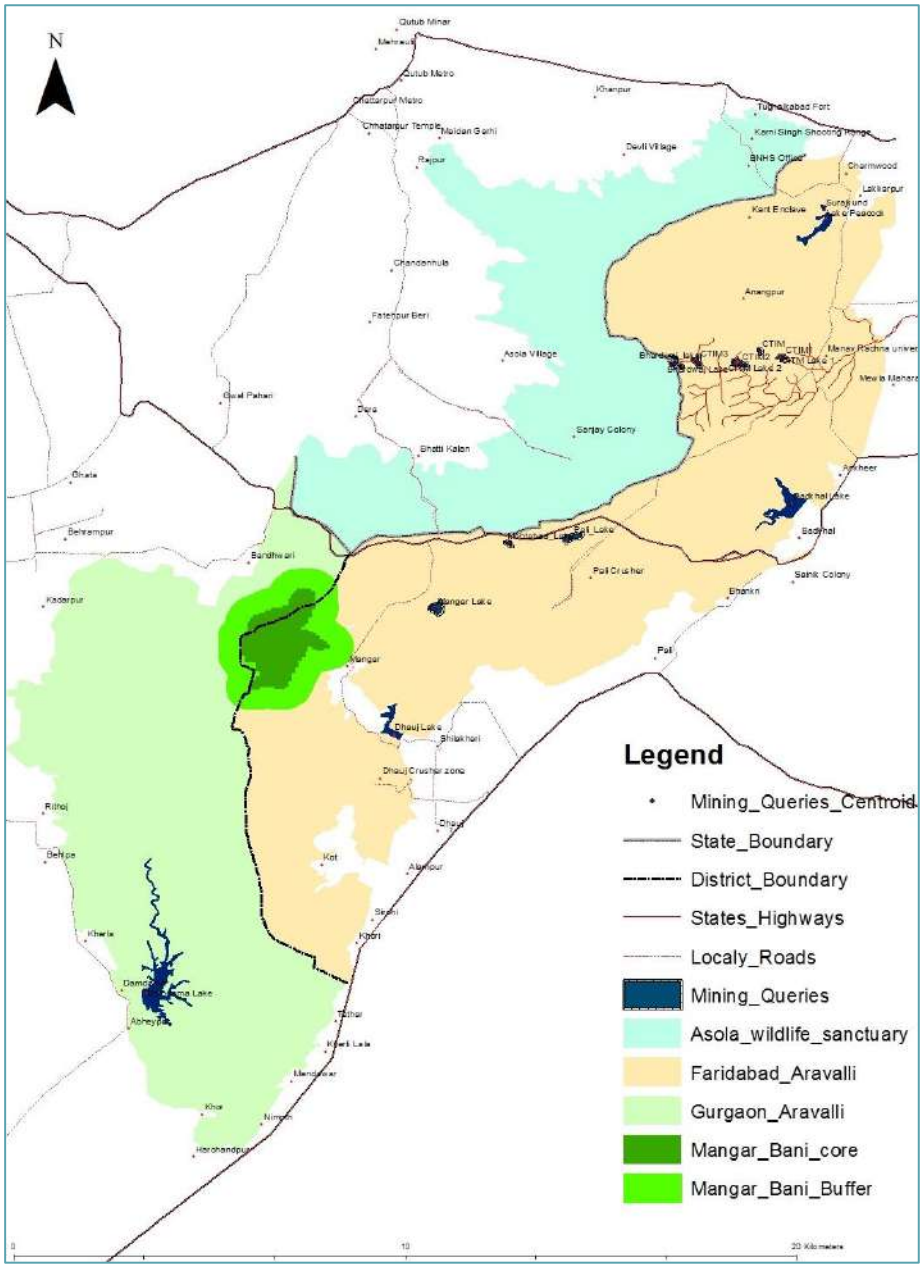


Figure 71: Nearby Aravalli's in the Region

Vegetation Assessment

Topographical exploration and rapid reconnaissance. The first step was to explore the area and understand the topography of the area. The area was broadly classified into the hilltop, the hill slopes, and the sandy dune area closer to the lake. In addition, there was the lake itself and the lake shores areas – which was gently sloping. At the same time a preliminary exploration of the vegetation and the avi-fauna was also undertaken, and some record photographs were taken of signs of reptiles and mammals as well as insects. Maps were generated of the location and the habitat zones.

The broad methodology followed was to do informal walks as well as transects and note the presence of species for mammals, birds, insects, mammals. For amphibians – the waterbodies were visited in the evening time. For reptiles, this being the lean season signs were observed during the transects and overall fieldwork. Finally for birds point counts were also made. For vegetation – a species list was generated via transects, while the forest types were identified in different habitats and a quantitative assessment of the trees and shrubs was also made.

The specific methodology for each of the topical baselines is provided with the results and discussion below.

Methodology

Approach and methodology. A three-stage process was followed to assess the forest vegetation of the site. First, a checklist of vegetation species including herbs and climbers, in addition to shrubs and trees was generated by criss-crossing the site.

Second, the forest types as identified by Champion and Seth (1968) prevailing in different habitats were identified. In all the forest types were identified in around 19 locations across the site to identify the current prevailing forest types, the dominant species, the level of degradation, and the likely succession pathway for the same.

The third step was a quantitative assessment of the trees and shrubs by laying forest plots across the site. The survey included the following:

- 54 circular plots of 0.1 ha (1000 m^2) each, with a radius of 17.84 metres were laid.
- The trees were classified as seedlings (ht 0-50 cm), saplings (ht 50-130 cm), and trees (height >130 cm).
- For all tree stems with girth > 5 cm (i.e., diameter > 1.6 cm), the girth/diameter was recorded.
- The tree stems with girth <5 cm was counted.
- Height was measured for all tree species individuals.
- The data was analysed to generate the density (trees/ha), frequency, and abundance. The Importance Value Index (IVI) and other diversity indices were also calculated.

- Circular plots were laid as it is easier to lay circular plots by directly measuring distances to plot centre (Cox, 1990) and more efficient (Paudal et al 2019).
- Each tree was identified at species level and its girth was measured at breast height 1.30m above the ground. If any tree was found to be divided into multiple stems before reaching 1.30 m above the ground, girth of each stem with more than 5 cm of thickness was recorded.
- The tree girth data was classified in the following distribution ranges.

Table 2: Distribution range for different girth classes

Girth Class	Range
A	< 5cm
B	5 - 15 cm
C	15 - 30 cm
D	30 – 60 cm
E	60 – 90 cm
F	90 - 150 cm
G	150 - 300

The study area map showing the broad topographic zones and the location of the plots is provided below.

Density, Frequency and Basal Area: Density, frequency and basal area are the quantitative parameters that are used to define the distribution of species. Density is a measure of number of rooted individuals of a species per unit area while frequency is derived from the number of the quadrats in which the species occurs and is expressed in %. Basal area is the amount of land covered by the stem/tree trunk in m^2.

Density=Number of rooted individuals of a species recorded in all the plots

Total number of plots laid

Frequency (rooted) = Number of plots in which species is present x 100

Total number of plots laid

Basal Area=3.14x r^2

Abundance = Number of rooted individuals of a species recorded in all the plots

Number of plots in which species is present

Findings

Aravallis and their Forest Types

Aravallis are divided into three sub-regions':

a) Northern Aravallis

b) Central Aravallis, and

c) Southern Aravallis

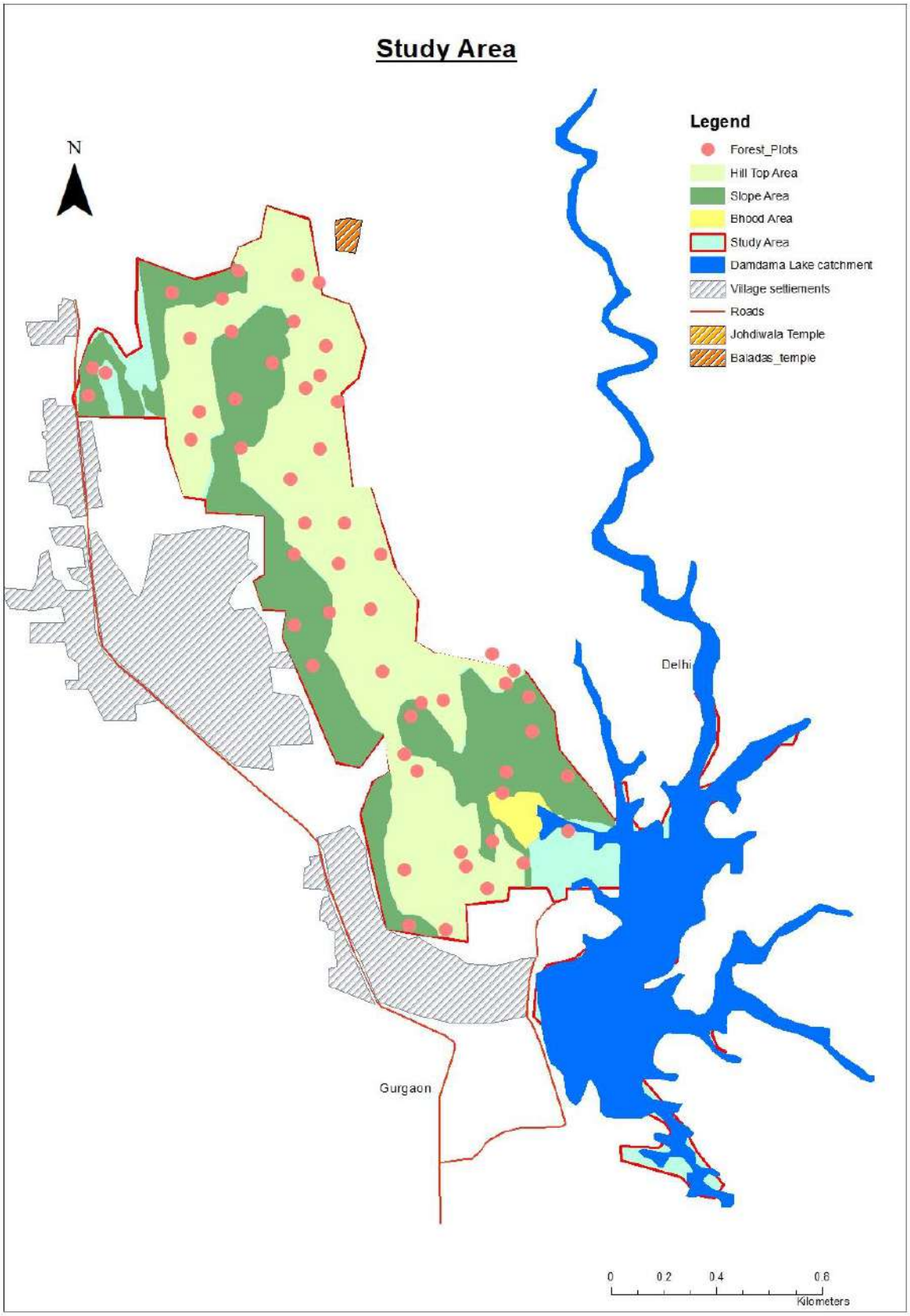


Figure 72: Study Area Map with the Plot Distribution and Broad Topographical Zones

Northern Aravallis start from Delhi and end in Jaipur-Ajmer zone of Rajasthan. The Aravallis confined to Haryana are part of Northern Aravallis, hence hilly area of Kherla-Damdama village is a part of Northern Aravallis. The terrain of the panchayat land is hilly, criss-crossed by nallahs. During heavy rains, sometimes flow is reported for a short time in monsoon season. Blown sandy soil is deposited here and there in the foothills and hill slopes. The dunal area is under succession of vegetation and in fully stablished form. Soil layer is very thin or absent on hill slopes. Being a typical Aravalli ecosystem, climax Kumtha (*Acacia senegal*) is the main forest type, interspersed with Dhok (*Anogeissus pendula*) in the degraded state. *Prosopis juliflora* is conspicuously present in the foothills, valleys, and slopes.

Figure 73: Northern Aravalli of Project Area

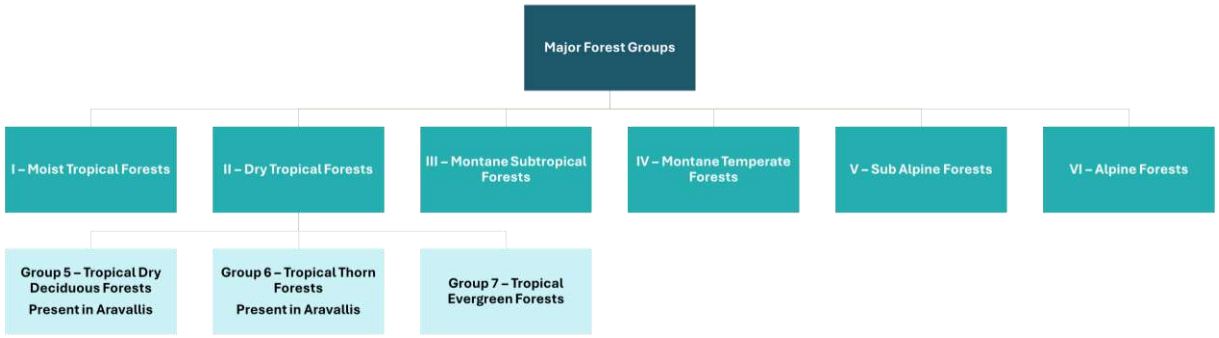


Figure 74: Classification of Aravallis forest by Champion and Seth, 1968

Champion and Seth, 1968 have classified forests of India into six major groups and 16 sub-groups. Aravallis forest fall under the Major group II- Dry Tropical Forest which is further classified into multiple sub-groups. Sub-group 5 – Tropical dry deciduous forests and 6 – Tropical thorn forest are the main broad forest types in the Aravalli region. Tropical Dry deciduous forest (Sub-group 5) forms the major forest type of India (38.2%).

Forest is dense in valleys and on slopes. Outskirts are facing degradation owing to many anthropogenic activities. In opener areas, perennial and annual grasses are growing. Some grass patches are in very good condition. Hilly areas with more cracks and crevices are supporting luxuriant growth of *Chrysopogon fulvus* grass which is a perennial grass. Good patches of this grass can be seen on the western aspect of a small hill near Kherla village.

The major forest types found in the area are as follows:

- Group 5. Tropical Dry Deciduous Forests
    - Sub-group 5B. Northern Tropical Dry Deciduous Forests
        - 5B/E_1-*Anogeissus pendula* forest
        - 5B/E_1-DS_1- *Anogeissus pendula* scrubs
        - 5B/DS_1 - Dry deciduous scrub
        - 5B/DS_4 - Dry grassland
- Group 6. Tropical Thorn Forests
    - Sub-group 6B. Northern Tropical Thorn Forests
        - 6B/C_1-Desert thorn forest
        - 6B/E_2- *Acacia senegal* forest
        - 6B/DS_1 - Ziziphus scrubs
        - 6 E4/DS_1/1S_1- Desert Dune Scrub

The most common forest type found in the site is 6B/E_2- *Acacia senegal* forest. *Acacia Senegal* is making pure patches at many localities. We also have the presence of 5B/E_1-DS_1- *Anogeissus pendula* scrubs in the degraded state, in patches – suggesting that the area earlier had a good extent of 5B/E_1-*Anogeissus pendula* forest in the past that has got degraded over time.

Grewia tenax and *G. flavescens* are growing as under storey in *Anogeissus* and *Acacia senegal* forests and are common species in hilly area. *Holoptelea integrifolia* is also seen here and there. *Vallaris solanacea* is commonly seen in foothills in ground flora.

Other forest types seen are 6B/DS_1 - Ziziphus scrubs. The sandy forest type category - 6 E4/DS_1/1S_1- Desert Dune Scrub is seen in the blown sand deposition areas closer to the lake.

Vegetation Checklist Survey

A detailed checklist of plants encountered during the extensive transects was prepared. The plants were classified by Family, genus and species and also by the vegetation type (Tree, shrub, herb (including grasses) and climbers). A total of **262 plant species** were encountered in the area of the hills, the foothills, slopes, and the lakeside area.

A total of **40 tree species** were recorded of which **23** were found in the sampling plots and **17 tree species** were found in-between the plots. Similarly for shrubs a total of **20 shrub species** were found – 8 in the plots, and 12 only outside. In addition, **167 herbs** and **35 climbers** were also identified. The number is high as it includes the hilly species, the sandy dune area species, the lake side habitat species as well as certain agricultural species that have 'escaped' into the foothills. A complete checklist of the 262 plant species is provided at annexure 1.

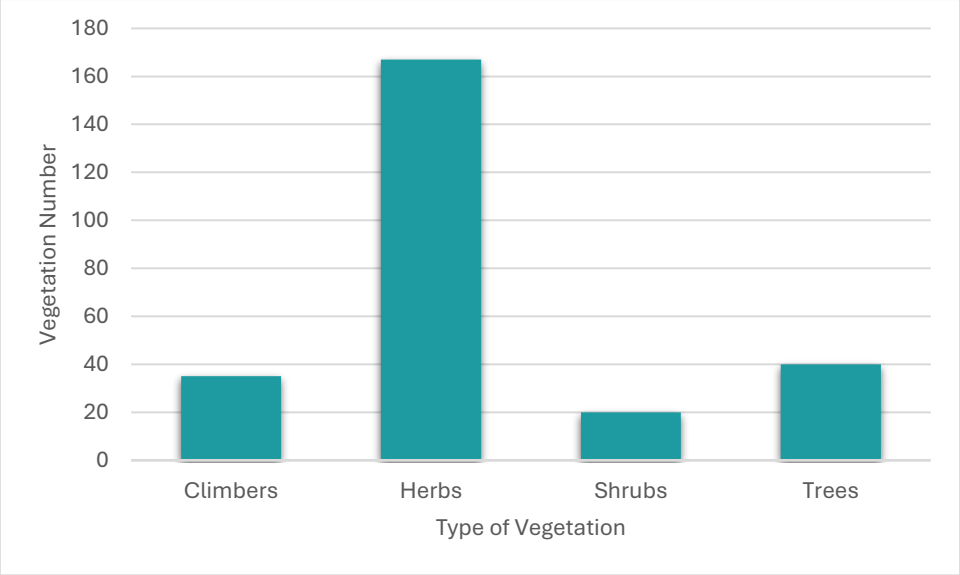


Figure 75: Type of Vegetation Species in Project Area

Forest Plot Survey results

Number of trees (all sizes).

- The highest number of total tree species individuals (seedlings + saplings + trees) were recorded for Hingot (**1420**/ha), due to the high number of seedlings (1090/ha).
- Vilyati Keekar is the second most abundant species in terms of number of individuals (**359.4**/ha) and most abundant in the tree category (313.5/ha).
- Kumuth is the third dominant species (**116.7**/ha) and is the most widespread native forest species.
- Jungli Karondha (**83**/ha) and Dhau (**80.6**/ha) are neck to neck.
- The total number of tree species individuals was **2224 /ha** (with a total count of 12011 across 54 plots)

Table 3: Number of Trees per hectare

S.No.	Species	No. of tree individuals (in 54 plots)	Tree individuals per ha
1	Hingot	7672	1420.7
2	Vilayti Keekar	1941	359.4
3	Kumuth	630	116.7
4	Jungli Karondha	448	83
5	Dhau	435	80.6
6	Neem	163	30.2
7	Israel Babool	157	29.1
8	Raunjh	128	23.7
9	Kair	121	22.4

10	Papdi	121	22.4
11	Kankeda	87	16.1
12	Pasendu	42	7.8
13	Khejdi	19	3.5
14	Dhak	15	2.8
15	Goyakhair	15	2.8
16	Khinjaal	4	0.7
17	Subabul	3	0.6
18	Khatai	2	0.4
19	Khirna	2	0.4
20	Shisham	2	0.4
21	Siris	2	0.4
22	Khajoor	1	0.2
23	Ullu	1	0.2

Number of trees – across size categories.

The breakup of the total number of tree species individuals (**2224 /ha**) is provided in the figure below. The largest number of tree species is in the seedling stage (1179/ha), followed by the sapling stage (376). There are around 66/ha of bushy stems. The total number of coppice trees are 277/ha, and general trees are 277/ha - these add up to 603 trees/ha (coppice and general trees combined).

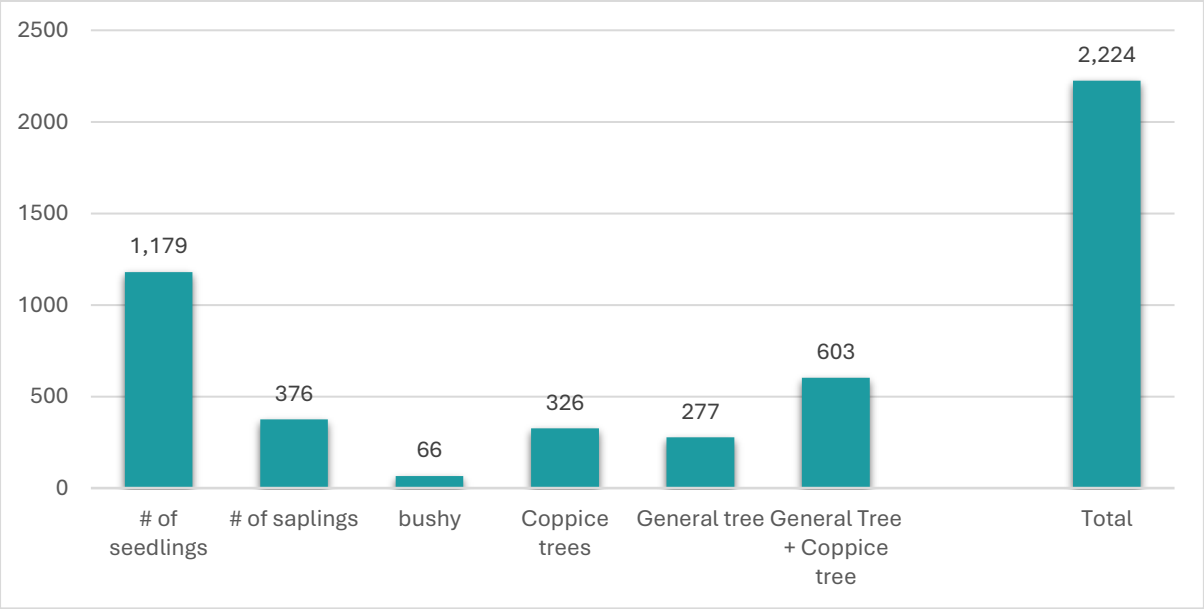


Figure 76: Forest Tree Species Per Hectare - All Species

Hingot dominates the lower size classes – seedlings (1090 of 1179 /ha) and saplings (256 of 376 /ha). The bushy stems category is dominated by Dhau because it is extensively degraded and partly because of the nature of data collection. The coppice tree category is dominated by *Prosopis juliflora* (Vilayati Keekar) (227 of 326/ha). In the remaining tree category – Kumuth comes is third at 47.6/ha, after Vilayati Keekar (86) and Hingot (49).

Table 4: Forest Tree Species per hectare

S.No.	Species	# of seedlings	# of saplings	bushy	Coppice trees	General tree	General Tree + Coppice tree	% of Tree (including coppice)	Total	Tall saplings with girth <5cm
1	Hingot	1090	256.1	0	25.6	49.1	74.6	0	1420.7	53.9
2	Vilayti Keekar	12.2	33.7	0	227.4	86.1	313.5	0.1	359.4	118.1
3	Kumuth	29.3	24.4	0	15.4	47.6	63	0	116.7	13
4	Jungli Karondha	23	23.1	0	20.4	16.5	36.9	0	83	19.3
5	Dhau	0	0.4	66.1	5.6	8.5	14.1	0	80.6	6.9
6	Neem	8	4.8	0	2.6	14.8	17.4	0	30.2	3.9
7	Israel Babool	4.3	5.4	0	4.4	15	19.4	0	29.1	5.6
8	Raunjh	1.7	1.9	0	2.8	17.4	20.2	0	23.7	1.3
9	Kair	1.1	5.7	0	11.3	4.3	15.6	0	22.4	9.4
10	Papdi	4.1	11.1	0	1.9	5.4	7.2	0	22.4	3.5
11	Kankeda	3.1	4.6	0	4.4	3.9	8.3	0	16.1	4.1
12	Pasendu	0.7	1.9	0	1.9	3.3	5.2	0	7.8	1.1
13	Khejdi	0.9	0.6	0	0.4	1.7	2	0	3.5	0.2
14	Dhak	0	0	0	1.5	1.3	2.8	0	2.8	0.4
15	Goyakhair	0.7	1.5	0	0.4	0.2	0.6	0	2.8	0
16	Khinjaal	0	0.2	0	0	0.6	0.6	0	0.7	0.4
17	Subabul	0.4	0	0	0	0.2	0.2	0	0.6	0
18	Khatai	0	0	0	0.2	0.2	0.4	0	0.4	0
19	Khirna	0	0	0	0.2	0.2	0.4	0	0.4	0
20	Shisham	0	0.2	0	0	0.2	0.2	0	0.4	0
21	Siris	0	0	0	0	0.4	0.4	0	0.4	0
22	Khajoor	0	0.2	0	0	0	0	0	0.2	0
23	Ullu	0	0	0	0	0.2	0.2	0	0.2	0
	Total	**1179.4**	**375.7**	**66.1**	**326.1**	**276.9**	**603**	**0.2**	**2224.3**	**240.9**

Number of trees – across girth-class categories.

Forestry surveys often set a girth class floor for ease of data collection and depending on the purpose, e.g. timber oriented surveys classify trees below 30 cm girth as under-sized. As our purpose was to

understand the biodiversity – we undertook a 100% recording of all tree species individuals irrespective of the girth class. The resulting distribution of trees across size classes is displayed in the figure 67. There are 240 trees/ha (with ht > 130 cm), and below 5 cm girth. The 5-15 cm girth class has 277 trees/ha. Thereafter there is a drop in the 15-30 cm girth class category (62 trees/ha). The 30-60 cm tree category has just 19.6 trees/ha, while the higher girth class categories have negligible presence (1.7/ha in 60-90 cm, and 2.2/ha in 90-150 cm).

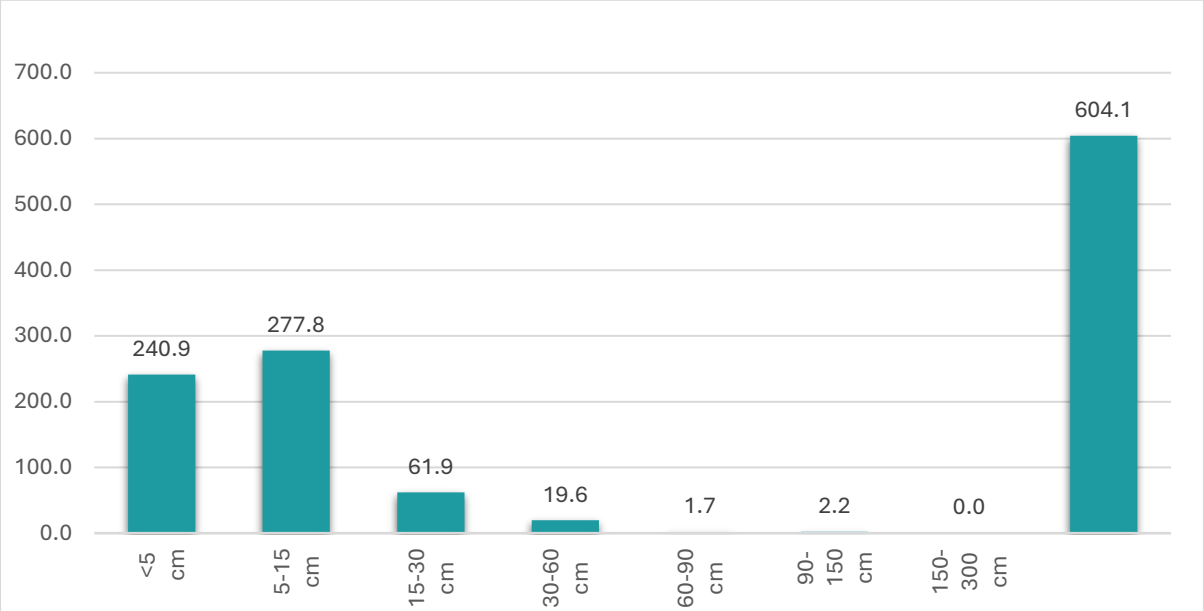


Figure 77: Forest Trees per Hectare (by Girth class, & >130cm ht)

The smaller girth classes (<5 cm, and 5-15 cm) are dominated by the usual suspects - Hingot and Vilayati Keekar. Kumuth has the highest number (21.7/ha) in the 15-30 cm girth class, while in the 30-60 cm girth class – we have Raunjh (5.9/ha) and Kumuth (5.6trees/ha) at first and 2nd place. There are negligible trees in the 60-90 girth class category - Israel Babool (*Acacia tortilis*) – at an average of 1 tree/ha. Similarly in the 90-150 cm class – we have Israel Babool (1 tree/ha), and Raunjh (0.4/ha). The species wise data is displayed in the table below.

Table 5: Forest Trees Per Hectare (by Girth Class)

Species	Total # of trees with girth <5cm stems	Total # of 5 to <15 cm girth Stems	Total # of 15 to 30 cm girth stems	Total # of 30 to 60 cm girth stems	Total # of 60 to 90 cm girth stems	Total # of 90 to 150 cm girth stems	Total # of 150 to 300 cm girth stems	Total
Hingot	53.9	16.9	2.4	1.1	0	0	0	74.3
Vilayti Keekar	118.1	180.0	15.6	2.2	0	0.6	0	316.7
Kumuth	13.0	21.9	21.7	5.6	0	0	0	62.4
Jungli Karondha	19.3	15.7	1.1	0	0	0	0	36.1
Dhau	6.9	6.5	0.4	0	0	0	0	13.7

Neem	3.9	7.0	5.2	1.7	0	0	0	18.0
Israel Babool	5.6	5.6	4.6	2.2	1	1	0	19.6
Raunjh	1.3	4.6	7.0	5.9	0	0.4	0	19.4
Kair	9.4	5.2	0.6	0.0	0	0	0	15.2
Papdi	3.5	2.8	0.6	0	0	0	0	7.2
Kankeda	4.1	3.9	0.4	0	0	0	0	8.3
Pasendu	1.1	3.3	0.6	0	0	0	0	5.4
Khejdi	0.2	1.1	0.7	0	0	0	0	2.0
Dhak	0	1.7	0.7	0	0	0	0	3.0
Goyakhair	0.0	0.4	0.2	0	0	0	0	0.6
Khinjaal	0.4	0.2	0	0	0	0	0	0.6
Subabul	0	0.2	0	0	0	0	0	0.2
Khatai	0	0.2	0	0	0	0	0	0.4
Khirna	0	0.4	0	0	0	0	0	0.4
Shisham	0	0	0.2	0	0	0	0	0.2
Siris	0	0.4	0	0	0	0	0	0.4
Khajoor	0	0	0	0	0	0	0	0.0
Ullu	0	0	0	0	0	0	0	0.2
Total	**240.9**	**277.8**	**61.9**	**19.6**	**1.7**	**2.2**	**0.0**	**604.1**

Basic Statistics: Frequency, Density, And Abundance

Vilayati Keekar is the most frequently occurring species with a presence in all 54 plots and therefore a **frequency** of 100. It is followed by Kumuth at 76 (41 plots) and Kair – 70 ((38 plots). At the other end of the spectrum, we have 4 species that occurred in 1 plot, and another 4 that occurred in 2 plots.

Hingot has the highest **density** by far, of 142, as it has high numbers concentrated in just 16 plots. It is followed by Vilayati Keekar – density of 35.94, and Kumuth – 11.67. In terms of abundance – the top three species are – Hingot (479.5), Vilayati Keekar (35.9), and Dhau (21.8). Kumuth (15.4) comes in at fourth place.

Table 6: Density, Frequency & Abundance of Species

S.No.	Species	Count (# of plots in which spp occurs)	Density	Frequency	Abundance
1	Hingot	16	142.07	30	479.5
2	Vilayti Keekar	54	35.94	100	35.9
3	Kumuth	41	11.67	76	15.4
4	Jungli Karondha	35	8.30	65	12.8
5	Dhau	20	8.06	37	21.8
6	Neem	32	3.02	59	5.1
7	Israel Babool	33	2.91	61	4.8

8	Raunjh	32	2.37	59	4.0
9	Kair	38	2.24	70	3.2
10	Papdi	27	2.24	50	4.5
11	Kankeda	10	1.61	19	8.7
12	Pasendu	15	0.78	28	2.8
13	Khejdi	8	0.35	15	2.4
14	Dhak	6	0.28	11	2.5
15	Goyakhair	7	0.28	13	2.1
16	Khinjaal	1	0.07	2	4.0
17	Subabul	2	0.06	4	1.5
18	Khatai	1	0.04	2	2.0
19	Khirna	2	0.04	4	1.0
20	Shisham	2	0.04	4	1.0
21	Siris	2	0.04	4	1.0
22	Khajoor	1	0.02	2	1.0
23	Ullu	1	0.02	2	1.0

Basal Area

The basal area represents the cross-section area covered by each tree at breast height (1.30 cm). If a tree has multiple stems, then the basal area of each stem is calculated separately and then added as the total basal area of the tree.

The total basal area across all 54 plots and all species was 8.9 m^2. This works out to an average basal area of 1.65 m^2/ha. This is a fairly low number and is due to the low presence of higher girth trees, and the profusion of trees in the smaller girth size classes. Vilayati Keekar has the highest basal area – 0.70 m^2/ha, followed by Kumuth (0.29 m^2/ha), and Raunjh (0.19 m^2/ha), and Israel Babool (0.17 m^2/ha). Dhau (0.009 m^2/ha) comes in at number 13.

Table 7: Species Basal Area m^2/hectare

S.No.	Species	Basal area (m^2)	Basal area (m^2) /ha
1	Vilayti Keekar	3.7986	0.70345
2	Kumuth	1.5763	0.29191
3	Raunjh	1.0313	0.19097
4	Israel Babool	0.9402	0.17411
5	Neem	0.5481	0.1015
6	Hingot	0.1912	0.03541
7	Jungli Karondha	0.1668	0.03089
8	Ullu	0.1471	0.02725
9	Pasendu	0.12	0.02222

10	Papdi	0.0953	0.01765
11	Kair	0.0681	0.01261
12	Dhak	0.066	0.01222
13	Dhau	0.0497	0.0092
14	Kankeda	0.0445	0.00824
15	Goyakhair	0.022	0.00407
16	Khatai	0.0176	0.00326
17	Khejdi	0.0172	0.00319
18	Khirna	0.0089	0.00166
19	Shisham	0.0061	0.00113
20	Khinjaal	0.001	0.00019
21	Siris	0.0009	0.00017
22	Subabul	0.0005	0.0001
23	Khajoor	0.0005	0.0001
	Total Basal Area	**8.91807**	**1.65149**

Spatial Distribution and Concentration of Species

The spatial distribution of the major (and less major) tree species has been assessed by depicting the number of tree individuals of a species occurring at each forest plot on a species distribution map along with the plot number. The maps for the Kumuth, Dhau, Hingot, and Vilayati Keekar are shown below. An additional 8 maps for 8 tree species, and a shrub distribution map for two shrub species are placed in the annexure for reference.

- Kumuth is concentrated in the upper slopes in three patches in the north-east, the centre-east, and the southeast. The highest presence is in plot 28 (76 trees in the plot) – so at an average of 760 trees/ha.
- Dhau has a presence primarily on the slopes. It is present in around 10-12 plots in the north, ranging from 1 to 93 trees per plot. It is absent in the central flat hilltop area, and then occurs again in the slopes towards the south of the site. It is in a degraded state.
- Hingot is present in a concentrated patch in the south-central plain hilltop area, and again dominates in isolated pockets (plots 43,19 and 28).
- Vilayati Keekar is present in all 54 plots – varying from 1 to 82 /plot. In 7 plots, it is less than 10 trees/plot, while it is 40 trees/plot or more (or 400/ha) in 24 plots. It is also widespread in the degraded dhau zone in the north side of the site.

Figure 78: *Acacia Senegal* (Kumuth), is the Dominant Species on the hilltop and also Present in the Slopes

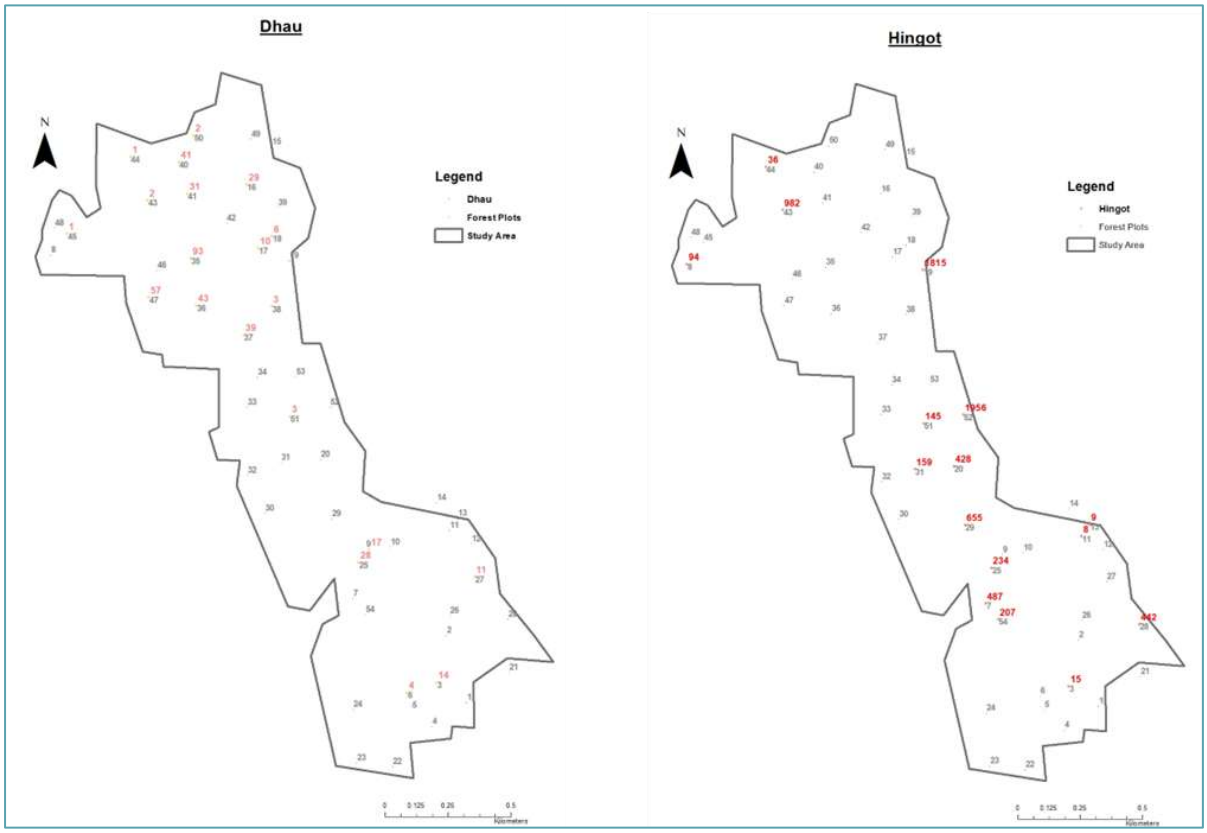


Figure 79: Dhau and Hingot Forest Plot

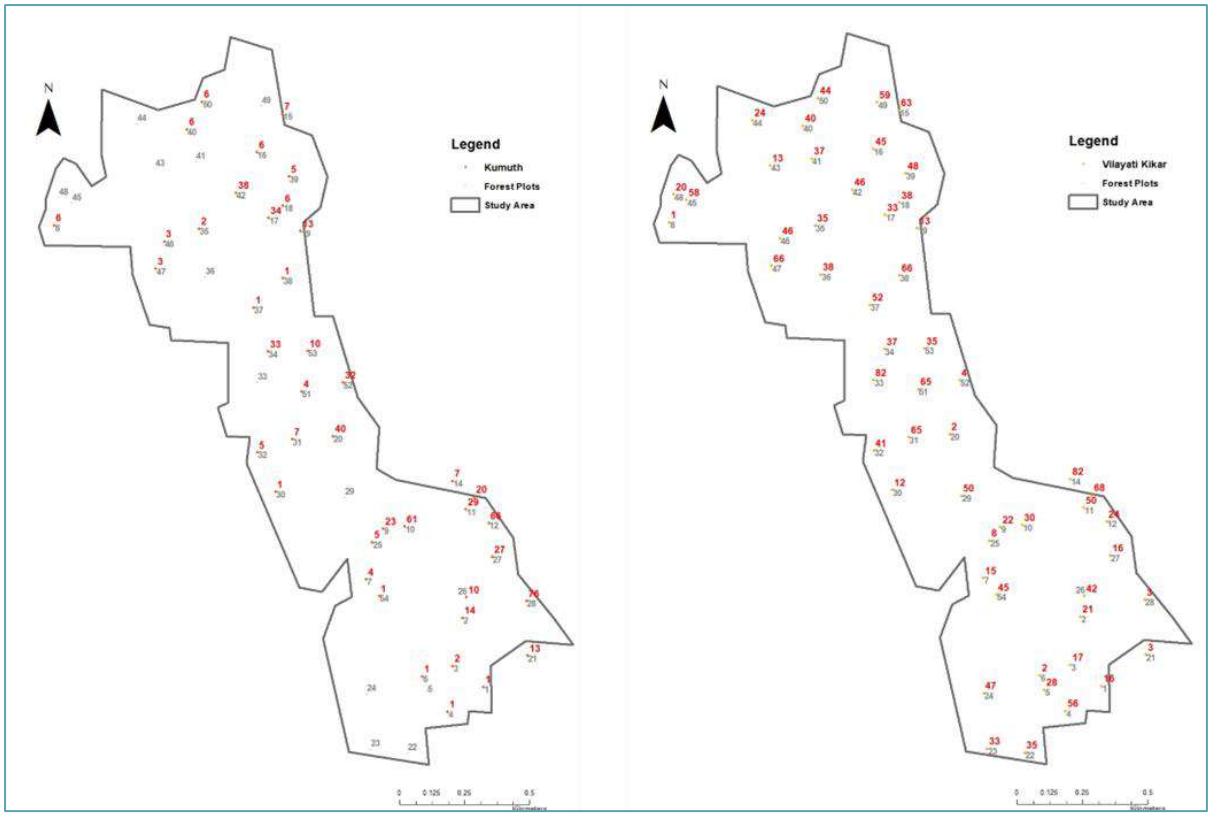


Figure 80: Kumuth (Left Side) and Vilayati Keekar (Right Side) Forest Plot

Proposed Forest Types Spread

The areas of concentration from the Kumuth, Dhau and Hingot maps were identified and mapped on a google earth map of the site, as shown below. Dhau (green line – 3 patches), Kumuth (yellow - 2 patches), and Hingot (blue – 4 patches).

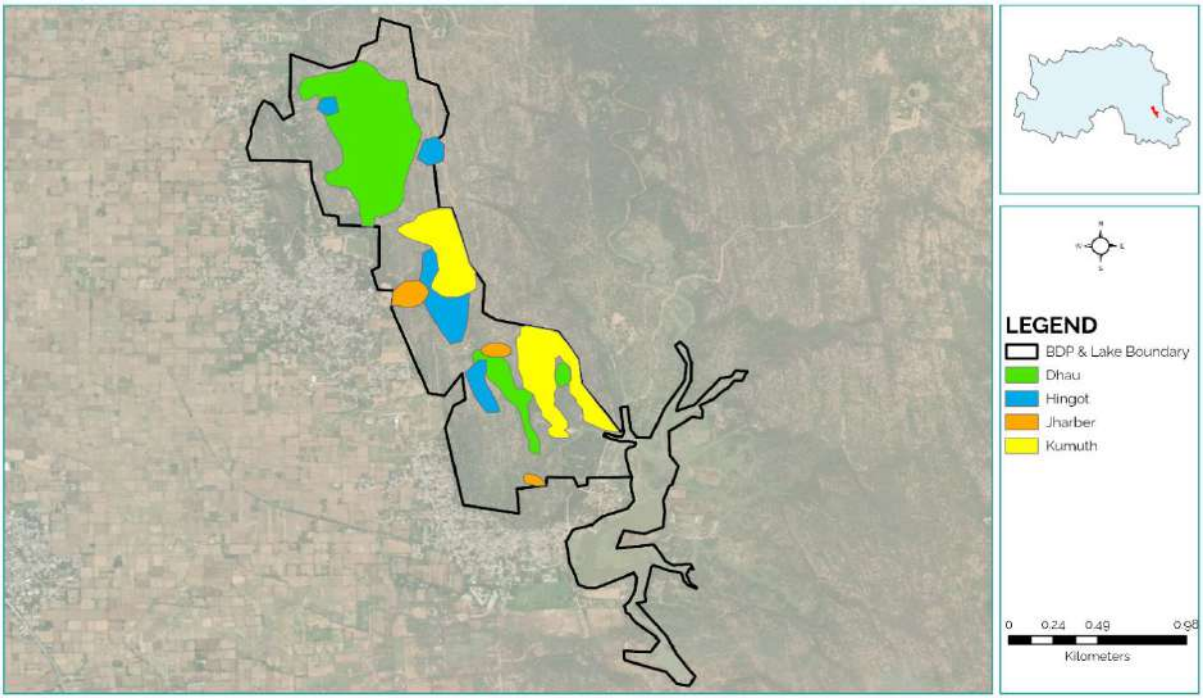


Figure 81: Forest Type Spread Map

Areas with good presence of Jhadber (*Ziziphus nummularia*) were also shown (white line). The Hingot areas were often overlapping with other species. Based on the mapping and the field assessments it may be concluded that the Kumuth areas represent the *Acacia senegal* forest type (6B/E2) and the Dhau areas represent the *Anogeissus pendula* scrub forest type, albeit in its degraded stage (5B/E1-DS1). The Jhadber areas are Ziziphus scrubs (6B/DS1). The remaining areas high a high presence of Vilayati Keekar (*Prosopis juliflora*) and are a mix of 5B/6B (dry deciduous and tropical thorn forest).

Shrubs

A total of 8 shrubs (and two climbers) were encountered in the plots. The average was **1574** shrubs per ha. The dominant shrub was Bansa – at 923/ha, comprising around 58 % of all the shrubs. Dholia (234), Hees (193), and Jhadber(144) also had significant presence.

Table 8: Shrubs Species Per Hectare

S. No.	Local Name	Scientific Name	Number Per ha	Total Count	%
1	Bansa	*Justicia adhatoda*	923.3	4986	58.6%
2	Dholiya	*Securinega leucopyrus*	**234.6**	1267	14.9%
3	Hees	*Capparis sepiaria*	**193.9**	1047	12.3%
4	Jhadber	*Ziziphus nummularia*	**144.8**	782	9.2%
5	Gunger	*Grewia tenax*	57.8	312	3.7%
6	Nagfani	*Opuntia dillenii*	14.8	80	0.9%
7	Hemkand climber	*Maerua oblongifolia*	2.4	13	0.2%
8	Hibiscus micranthus	*Hibiscus micranthus*	1.7	9	0.1%
9	Satawari climber	*Asparagus racemosus*	1.3	7	0.1%
10	Aakh	*Asclepias variegata*	0.2	1	0.0%
	Total		**1574.8**	**8504**	**100%**

The extensive vegetation survey turned up 20 shrub species and around 35 climbers – thus it can be safely said that over half the shrubs and the vast majority of climbers have a very minimal presence on the site and their patches would need to be identified and protected.

The spatial distribution of Bansa (red) and Jhadber (green) is shown in the plot map below. The numbers represent the number of shrubs of that species found in the forest plot in question. Bansa has an extensive presence all across the site, with less numbers in the NE, SE, and S area, and the highest in the western and central regions of the site. Jhadber has a few pockets of significant presence in the central and mid-south region of the site.

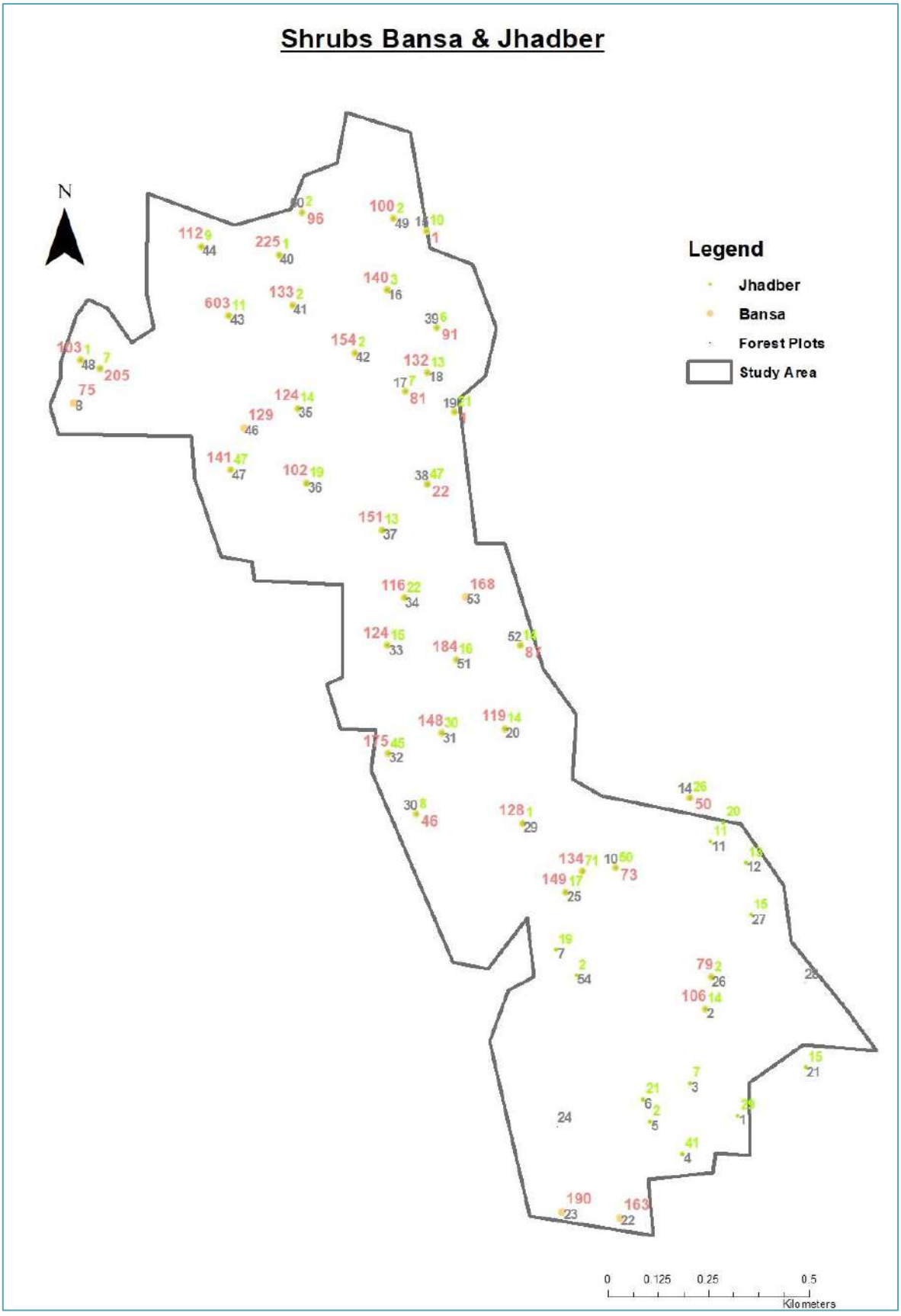


Figure 82: Shrubs Distribution Map

Field Observations

Based on the extensive field survey several observations can be made about the nature of vegetation etc. Detailed field observations from two surveys between 19-22 Oct and 7 – 9 December, are provided below.

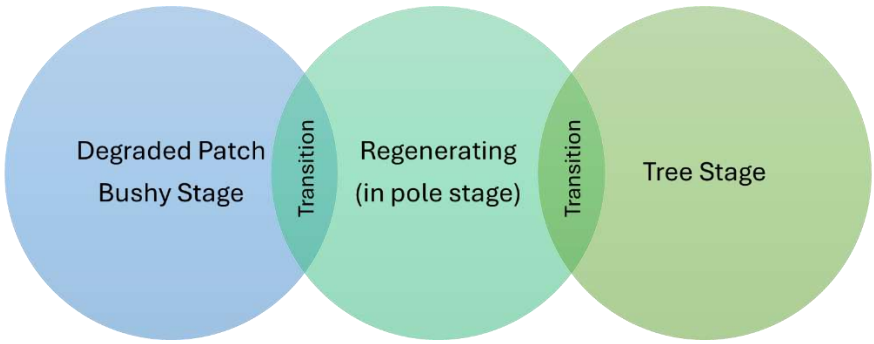
Observations on Kumuth *(Acacia Senegal)*.

The key species of the area is Kumuth/Kumutha (*Acacia Senegal*). It is a highly thorny species of low height. It occurs in pure patches and also makes an edaphic climax and a well-known dry thorny type of forest, namely 6/E2 *Acacia Senegal* Forest. Sometimes this species also occupies oelian (blown sand) sediments. Its dispersal is mainly done by Nilgai and goat. The Kumuth tree is knowns for its '*ulta kanta'* thorns which have 3 barbs – facing 3 different directions. Condition of Kumuth vegetation is better than the Dhau forests but the Kumuth area are under pressure due to over-browsing and allelopathic effect of *Prosopis juliflora*.

Observations on Dhau *(Anogeissus Pendula)*

In theory Dhau can occupy three broad patterns of vegetation. It is found primarily on hill slopes, with accumulation of stony-gritty soil. Three stages of *Anogeissus pendula* are as follows.

- Well protected patches of tree stage
- Regenerating patches, representing pole stage. They are more bushy in nature having multi stressed condition.
- Degraded patches, with highly over-browsed crop, spreading on substratum, with erect leader shoots mostly absent.



During summers, the Dhau forest seems bone dry but after just one or two monsoon or pre-monsoon rains, re-leafing starts at a fast pace and within a few days, the dry forest becomes lush green. During winters, a red tinge appears in the leaves and a reddish glow is seen in the forest. In practice most of the locations seen with Dhau were quite degraded.

Highly degraded *Anogeissus pendula* bushes are dotted here and there indicating that once the primary forest of Dhau was present in an extensive area. Now, due to earlier pressure of lopping and on-going over-browsing by goats, the Dhau is in bad shape. Tree form is not visible in most of the area,

and the species has become a bushy, very twiggy, without apical buds. Dhau is spreading close to the ground int the form of stunted woven and semi-woven branch-mats. This root stock is visible but is in bad shape, with few saplings. Data of Dhau plants from some indicative locations is given below.

Table 9: Number of Dhau Plants in a Plot

Location	Sample plot size (sq. m)	Bushy, degraded & flat on the ground	Bushy with a few intact leader shoot	Tree form	Total
Near plot 17	20 x 20	7	0	0	7
Near plot 18	20 x 20	6	1	1	7
Near plot 3	20 x 20	2	0	10	12
Total	1200	15	1	10	26

The present growing stock of Dhau from this small sample is 216 plants / ha. The ratio of 'good shaped' and 'bad shaped' Dhau is 1:1.6. This ratio is only in patches. In the field, the ratio of degraded Dhau is much higher. Now Dhau has been replaced by Kumuth, Raunjh, and Vilayati Keekar in most of the area. Opportunistic sampling was also done near the Bal das temple in the Kherla hills. The findings are as follows:

S. No.	Size of sample plot	Area of sample plot (sq. m)	No. of plants					
			Hees (Kanther)	Dhak	Dhau (tree)	Dhau (degraded)	Kumuth	Total
1	20 x 20	400	3	1	1	22	0	27
2	20 x 20	400	0	1	0	16	0	17
3	20 x 20	400	0	0	0	15	4	19
	Total	**1200**	**3**	**2**	**1**	**53**	**4**	**63**
	Average rate per ha (extrapolated)		**25**	**16**	**8**	**441**	**33**	**525**

The total root stock (trees and degraded trees) works out to 525/ha in this area. In this patch there was extensive presence of degraded Dhau bushes, which suggests that this area was once an extensive Dhau forest and has now been degraded due to grazing and lopping. In this area the good-shaped and browsed Dhau tree ration is 1:55 It means Dhau is under degradation and 5B/E1 forest has gradually converted to 5B/E1/DS1 due to on-going degradation. If the area is protected and restored, it may still be able to bounce back. If not, the number of Dhau bushes will slowly reduce and the forest will shift to Kumuth and shrub growth and *Prosopis juliflora*. To convert the *Anogeissus pendula* scrub 5B/E1/DS1 forest again into the climax *Anogeissus pendula* 5B/E1 forest over time, the following inputs would be needed:

Steps for Restoring Dhau (*Anogeissus pendula*) Forest

- Browsing should be checked. If not possible to stop in the whole area, it should be done in a phase-wise manner.

- Lopping should be checked, or if not possible to stop completely, then scientific lopping adopting 1 cut method for thin branches and 3-cut method for thick branches can be done in winters.
- Lopping should be avoided in summer and rainy season.
- Cut back and stump dressing may be done under supervision.
- Effective fire control is need if the area is fire prone.
- Seed broadcasting may be done for dhau and associated species before onset of monsoon to facilitate low-cost regeneration.

Observations on Hingot *(Balanites aegyptiaca)*

In some localities, pure patches of Hingot (*Balanites aegyptiaca*) are seen. (Hingot occurred in around 16 plots). Such patches are a product of intensive root suckering of the species. New growth of young plants of different heights, thickness and age are seen around adult mother plants, which are the produced by root suckers. A Hingot, patch was studied near 'Johad wala Mandir'. The findings are presented below.

Table 10: Size of Coppice Plants per Plot

S. No.	Size of plot	Area (sq.m)	Number of coppice plants
1	5 x 5 m	25	22
2	5 x 5 m	25	75
3	3 x 3 m	9	34
4	3 x 3 m	9	7
5	3 x 3 m	9	11
6	3 x 3	9	31
7	3 x 3	9	32
8	3 x 3	9	27
9	3 x 3	9	31
10	3 x 3	9	22
	Total	**112**	**292**

The density of Hingot regeneration works as per the above rapid sampling works out to be 26,071 plants / ha. Hingot is a dry evergreen species, drought hardy and a strong light demander, grazing hardy – it can be grown on compact soil zone to green them rapidly. This is a fire sensitive species and would need to be protected accordingly from fire.

Pulp of fruits of Hingot are eaten by Nilgai. Whole fallen fruit are swallowed by Nilgai which is a ruminant antelope. After rumination, the 'stones' of the fruit are regurgitated. These stones are gnawed by porcupine to get to the kernel. Some half gnawed 'stones' are left as such by the porcupine which imbibe moisture and start germination.

Observations on Vilayati Keekar *(Prosopis juliflora)*

Vilayati Keekar (*Prosopis juliflora*) is a widespread presence in the forest area. From top to bottom, this species is present, particularly in the western slopes and hill top and is regenerating well. Vilayati Keekar was introduced in this area by plantation by the forest department during the 1990s Aravalli Project as a means of foresting the hill common lands and providing a fast-growing source of fuelwood. In this, it has eminently succeeded – perhaps too well – as it is slowly spreading and taking over the degraded patches. During the present surveys, the seeds were seen in most of the samples of Nilgai droppings and porcupine scats. The pods of the plant are pulpy and sweet, which are much liked by Nilgai, hare, porcupine, as well as goat, cows etc. The seeds end up being treated by the peptic juices of the cattle and wild animal and are dispersed widely in the hills.

Status of grasses in the site

Western India possesses two types of grasslands, namely the D-C-L (Dicanthium – Cenchrus - Lasiurus grassland) and D-S grassland (Dicanthium – Sehima). Examples of both grasslands are found in the northern Aravallis, but this Kherla-Damdama zone falls in the D-S Grassland zone.

Where degradation is more, openness is relatively also more, and grasses are coming up relatively well. Since relatively dense and moist patches are very less, hence shade loving grasses are very few. Most of the grasses of the area are strong light demanders.

- *Chrysopogon fulvus* is a chasmophatic grass which prefers crevices of rocky habitat. This grass is very common in the rock-crevices of the 'Devi-wali pahdi' near Kherla village. The western aspect of this hill is having a high-density grass patch of this perennial species. Where soil deposition if present over the rocky sub-stratum, *C. fulvus* has been replaced by *Heteropogon contortus*. Small patches of this grass can be seen in the 'Devi-wali pahadi' towards the lower slope.
- *Oplismenus burmanii,* a shade loving grass, seen in small patches in valleys where canopy density is more than 0.8% and moisture is good.
- *Bothriochloa pertusa, Chloris dolichostachya, and Dicanthium annulatum*, are seen among bushes, where grazing is not easy. *Apluda mutica* is a forest grass which can be seen as an underplant below the top canopy.
- *Melanocenchris jacquemontii and Aristida odscensionis* are an indicator of degradation, overgrazing and poor soil quality. Both these annual grasses play the role of pioneer grasses. Like them, *Oropetium thomaeum* is also a pioneer grass which starts succession on a deposition of thin layer of soil on rocks. This is a small grass, which effectively binds soil on dry rocks.

- *Saccharum bengalense* is a rhizomatus clump making perennial tall grass. It prefers eolian sediments on either slope of hills. Sometimes it makes extensive patches. When it flowers in winter, it becomes notable.
- *Ehinochloa colona* is a hydrophilic grass and grows at the rim of rainy season pools along with many sedges like *Cyperus niveus and C. kyllingia*.
- Dry and degraded grasslands and Euphorbia scrubs are also present in the area. Euphorbia scrub contains *Euphorbia caducifolia* - a dendroid species which prefers dry rocky upper reaches.

Escapes

Some species are neither forest nor grassland species. Species which are grown in houses and gardens, or cultivated in fields sometimes escape and are seen in the wild and grow there on their own – they are called escape species. A few escapes are seen in Kherla-Damdama area like *Catharanthus roseus* (Sadabahar), *Tecoma stans (a hedge plant),* and *Morus indica* (shahtoot) which is grown as a shade tree near tubewells in agricultural fields, cattle sheds and other community areas. Since its fruit are much liked by many frugivorus brids, especially the red-vented bulbul (*Pycnonotus cafer),* which carry its seed to forest areas. *Ratan jot (Jatropha curcas*) is also seen in forest areas, which is an introduced species. Its natural regeneration is not seen in the area. An eye is needed to be kept on escapes in the future, and on their impact on wild habitat, and a check imposed if required.

Phenology of the area

Two peaks of flowering and seeding are visible in the area, as given below:

- Post monsoon peak. After departure of monsoon rains, upto mid-winters, all the grasses and ephemerals produce flowers and fruits.
- Summer peak: Most of trees and bushes of the Aravalli hills flower and fruit from march to June.

The vegetation of Kherla area is mainly of deciduous nature. Leaf fall is seen earlier on slopes and top of the hills and peidmonts, and slightly later in the valleys. A few dry evergreen species are also seen in the area, namely Hees (*Capparis sepiaria*), Hingot (*Balanites aegyptiaca*), Khejri (*Prosopis cineraria*) Pasendu (*Diospyros cordifolia*), Jungli Karondha (*Carissa spinarum*), Roheda (*Tecomella undulata*), Arni (*Clerodendrum phlomides),* Banyan *(Ficus benghalensis).* These trees and bushes are very useful for wild animals to take shelter under their shade or in their crown during the hot summer.

Invasive Plants

The area is prone to several invasive plants. These plants are commonly growing on hill slopes, foothills, roadside and outskirts of villages. The most important invasive plants of the area are as follows:

Table 11: List of Invasive Plants

S. No.	Local name	Latin name
1.	Vilayati Babool / Vilayati Keekar	*Prosopis juliflora*
2.	Besharam /Lantana	*Lantana camara*
3.	Puwad	*Cassia tora*
4.	Puwad	*C. obtusifolia*
5.	Gajar Ghass	*Parthenium hysterophorus*

Degraded outer hills have a strong presence of Prosopis *juliflora*. Local cattle and Nilgai are helping in further spread of this species. This species is gradually entering is deeper zones of the Forest. Nilgai and Porcupine (*Hystrix indica*) are playing a vital role in seed dispersal of *Prosopis juliflora* species as indicated below:

S.No.	Period	Species	No. of Scat/ dropping sites observed	Presence of *Prosopis juliflora* seeds detected
1.	19.10.2023 to 22.10.2023	Nilgai	17 dropping sites	17
2.	19.10.2023 to 22.10.2023	Porcupine	25 scat samples	25

Lantana camara, was not encountered in the hilltop areas, but a few individuals were seen in the valleys having better moisture regime. Fruit eating birds are helping in further spread of this species. *Parthenium hysterophorus* is also spreading fast in the area. This species is quite common in foothills, road sides and outskirts of villages.

Since *Prosopis juliflora* and *Lantana camara* both are strong light demander hence they are suppressing native grasses and other strong light demander species of under storey and ground flora.

Table 12: List of Lower Plants (non-flowering plants)

S. No.	Major Taxa	Latin name
1.	Bryaphyta	*Riccia sp.*
2.	Bryaphyta	Moss
3.	Pteridophyta	*Actinopterus radiatum*
4.	Pteridophyta	*Adiantam caudatum*

Lower plants are less in number. Two sun ferns viz., *Actinopterus radiatum* and *Adiantam caudatum* are seen in cervices of rocks, from top to bottom of the hills. Their density is more towards foothills and in cool, shaded valleys having more than 0.7 crown density. Many mosses and *Riccia* sp. are also seen in cool and shaded areas.

Lake side vegetation

Damdama lake is a small water body adjacent to Abheypur and Damdama village. It is situated in the valley area of the Aravalli hills ecosystem. The Sarus tourism complex is situated on the shore area of the lake. We can divide the lake area into three zones.

- **Zone I:** The water zone – that remains under water for several months.
- **Zone II:** The Grass zone that remains under water for a few weeks during peak rainfall and has some herbaceous vegetation.
- **Zone III:** Is the Embankment zone.

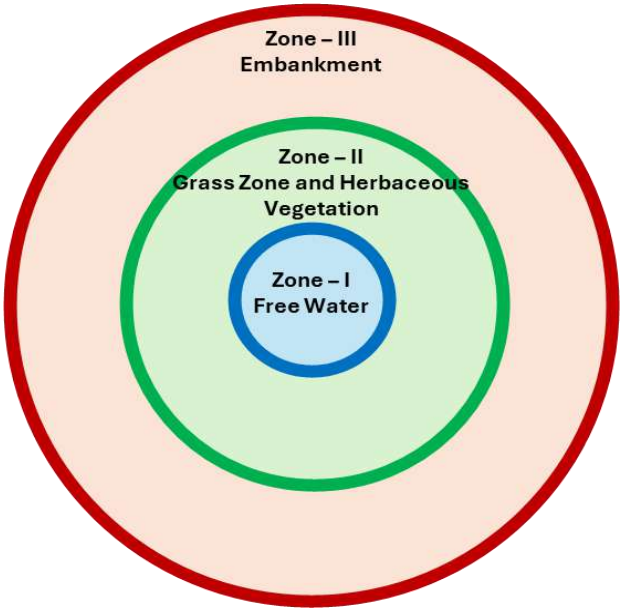


Figure 83: Zone of Damdama Lake

The Damdama lake is a convave depression with a massive embankment. The embankment (zone III) has old to medium aged tree plants of following species.

- *Ficus religiosa*
- *Acacia nilotica*
- *Ailanthus excelsa*
- *Dalbergia sissoo*
- *Morus indica*
- *Moringa oleifera*

Zone II – which faces short term seasonal water submergence has extensive grasses in the initial drawdown period. Later however, there is extensive growth of Gajar Ghas (*Parthenium hysterophorus).* This invasive herb needs to be controlled and removed, so that other native herb species can flourish in the lake side environment.

Mammals

The Aravallis in south Haryana have a rich faunal diversity including leopard (*Panthera pardus*) and Hyena (*Hyena hyena*). Despite this richness there is no sanctuary or protected areas in the south Haryana in the context of wild animals. The wildlife in south Haryana survives only in open landscapes and coexists with the humans since last many centuries. In this context, The Aravallis in Haryana plays vital role in the protection of wild animals by providing them habitats. However, the situation of Aravallis is critical, because a large chunks of forest in Aravallis, have important biodiversity but have limited regulatory protection. That has added several threats to preservation of Aravallis such as real estate, mining, land use change etc. Today the Aravalli Hills is struggling in the face of growing cities, which are replacing the rich forest with unfriendly, concrete jungles. The big challenges to wildlife and forests comes from development operations. Non-PA areas are also home to several important species that are included in the list of species of global importance. Therefore, conservation strategies should focus on preserving and increasing the physical connectivity of these areas. These forest areas with rich biodiversity should be managed in a more scientific manner to maintain and sustain long-term viable mammal populations. Therefore, a landscape strategy should be adopted for the conservation of wildlife and management of land resources in such areas **(*Thapa, A. et al 2021*)**.

The area is degraded so much due to overgrazing and fuel wood collection, mostly covered by Vilayti Keekar (*Prosopis juliflora)*. However, some native species such as Kumuth (*Acacia Senegal)* also have good presence in many pockets, also there is presence of shrub species such as *Ziziphus nummularia* (Jhadber), *Capparis sepiaria* (Hees) etc. which helps wild animals by providing fodder and inhabitation in the area.

The ecological history of an area plays a major role in ecological restoration, particularly as a tool for identifying and characterizing suitable targets for restoration efforts. Ecological restoration efforts should aim to preserve and restore historic ecosystems where feasible **(*Elliott S; 2007*).** Historically, the hills have been used as pasture by local villages for cattle. Now, due to increasing urban livelihoods, the pastoral tradition is decreasing, and future generations of local communities are shifting away from direct use of the forest. In this fluid mosaic of development, the future of wildlife of the area seems to be hanging in the balance. The traditional pastoralists were largely coexisting with the wild animals, but with recent habitat fragmentation, and warming impacts on the local forests, have changed the attitudes of local residents towards wild animals. There are also few reports of incidents where animals, notably leopards, were either killed in lynched by the general people show that, tolerance tends to decrease as people's engagements has reduced **(*Habib, B. et al., 2017*).** In short, presence of wild species is a key indicator of ecological condition of an area.

Inclusion of their presence, distribution and movement in restoration plans may be helpful in the preservation of them by improving their habitats in the future.

Aim and Objectives

The aim of this study is to undertake a preliminary baseline assessment of mammal species in the area, which can help with developing restoration strategies and their outcomes vis-à-vis mammals. The objective is to systematically study and document the presence of mammalian species and understand the occupancy and movement pattern of large carnivores such as hyena and leopard in the human dominated and degraded forest area.

Method

The primary objective of the study was to provide a preliminary baseline for the area as well as understanding occupancy and movement pattern of mammalian species in the area.

"Monitoring wildlife populations is critical to understand species responses to environmental change, and to inform conservation planning and management (Nichols and Williams 2006; Lindenmayer and Likens 2010)." **(Peralta et al; 2022)**

Opportunities to see mammals in the field are often limited because most are small, nocturnal, and secretive. Even many large diurnal mammals are secretive and cannot be observed directly. However, many animals build structures for protection and rearing that are easily visible. Examples such as burrowing nests of rodents, signs produced by the feeding activities of many herbivorous mammals (e.g., knawed roots of saplings by porcupines, knawed seeds, seeds in scat), are equally distinctive. Some rodents and antelope such as the Indian rabbit and nilgai leave droppings in their paths. Large mammal tracks can often be found in wet or muddy areas near lakes, ponds, and streams, where animals come to feed or drink, and also on trails used to move between different habitats are found. Learning to recognize, interpret, and preserve marks and other signs left by mammals can provide information about their habits that cannot be obtained in any other way **(Wemmer et al; 1996)**.

Therefore, we used **the sign survey method** to estimate the presence of mammal species in the area. Major trails of the area were identified by using google earth and on the basis of a physical survey of the area (See Fig. 76). In addition, a few camera traps were installed to obtain photographic sightings of mammals.

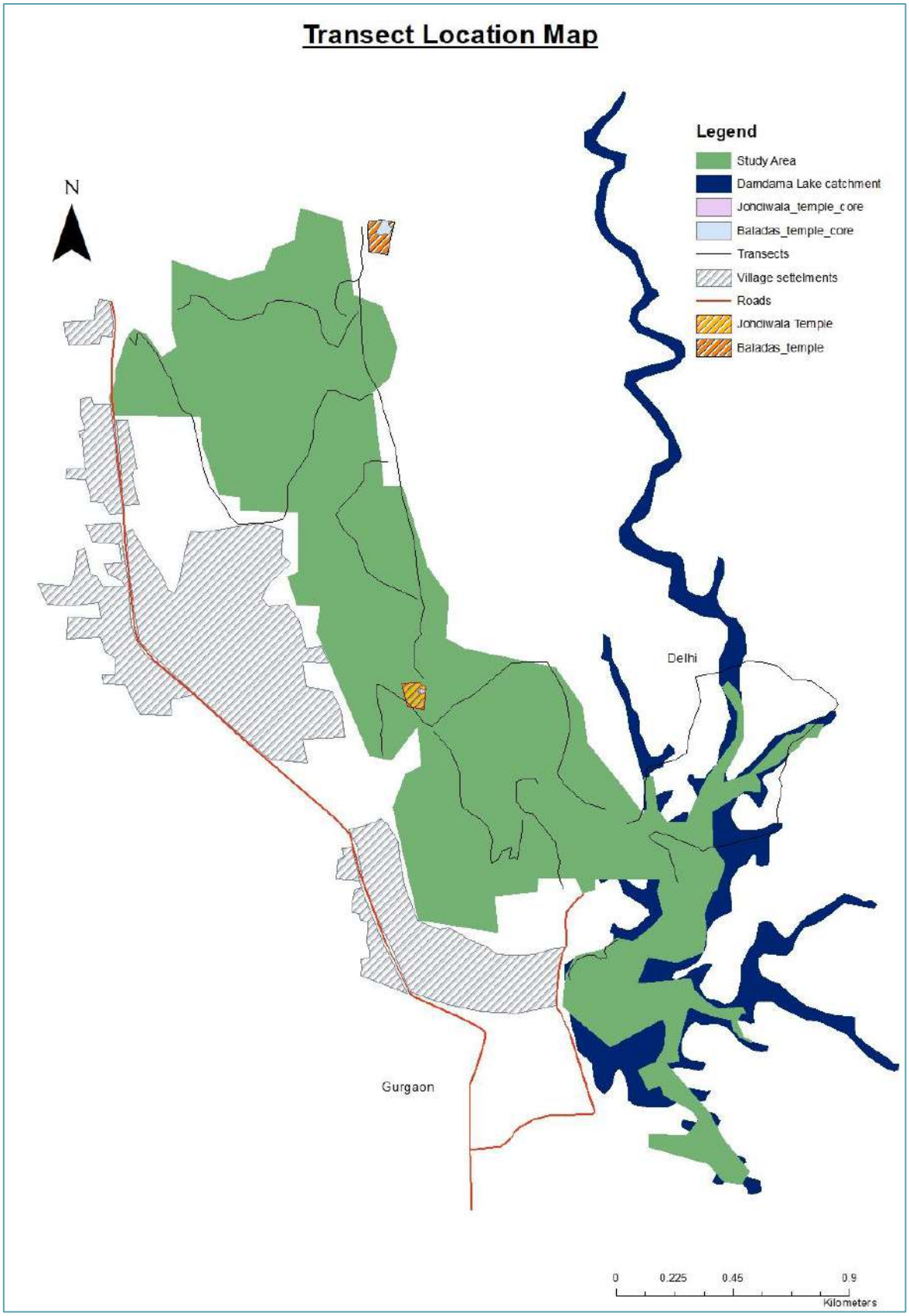


Figure 84: Transect Map for Mammals Survey

During the survey, signs of the presence mammals (scat, pug marks, scratch marks, tracks, quills and direct sightings of animals) were recorded in overall study area. The data will be mapped by using GIS

to show distribution, and occupancy. Sign surveys may be more effective in low-cost alternative for monitoring occupancy and inferring local population abundance ***(Peralta et al; 2022)***. A total of 7 transects were marked along the existing trails in the study area, covering a 12.2 km area, time spent 23 hours 27 minutes in 10 working days, with an average speed of 0.52km/hrs. All possible habitat types as well as forests of different degradation level are included, that were identified during the study. During the survey signs of the presence of mammals (scat, pug marks, scratch marks, tracks and quills etc..) were recorded upto two meters distance on both sides of the transect. Further, any direct sightings of mammals up to a distance of 50 meters on both sides of the transect were also recorded.

Findings

A total 174 signs (sightings and sign) with an encounter rate of 14.3/km were recorded of 12 species of mammals such as Nilgai, Golden jackal, Rhesus macaque, Common leopard, Jungle cat, Ruddy mongoose, Striped hyena, Indian crested porcupine, Indian hare, Indian bush rat, Indian wild pig, Common palm civet, list attached in table 13. Signs of an additional species the Indian Gerbil, were also found.

Table 13: Recorded species in the area

S. No.	Family	Common Name	Scientific Name
1	Bovidae	**Nilgai**	*Boselaphus tragocamelus* (Menon; 2014) 174
2	Canidae	**Golden jackal**	*Canis aureus* (Menon; 2014) 278
3	Cercopithecidae	**Rhesus macaque**	*Macaca mulata* (Menon; 2014) 70
4	Felidae	**Common leopard**	*Panthera pardus* (Menon; 2014) 238
5	Felidae	**Jungle cat**	*Felis chaus* (Menon; 2014) 252
6	Herpestidae	**Ruddy mongoose**	*Herpestes smithi* (Menon; 2014) 268
7	Hyaenidae	**Striped hyena**	*Hyaena hyaena* (Menon; 2014) 274
8	Hystricidae	**Indian porcupine**	*Hystrix indica* (Menon; 2014) 368
9	Leporidae	**Indian hare**	*Lepus nigricollis* (Menon; 2014) 320
10	Muridae	**Indian bush rat**	*Golunda ellioti* (Menon; 2014) 398
11	Suidae	**Indian wild pig**	*Sus scrofa* (Menon; 2014) 204
12	Viverridae	**Common palm civet**	*Paradoxurus hemaphroditus* (Menon; 2014) 260
13	Muridae	**Indian gerbil**	*Tatera indica*

In carnivore species we have found presence of Striped hyena and Common leopard. The most frequent signs were recorded of Striped hyena – 65 observations, with an encounter rate of 5.3/km, but in a limited range of the study area. With 59 observations and an encounter rate of 4.8/km second high frequency were recorded of Common leopard.

Figure 85: Common Leopard Pug Mark

In lesser carnivore we have found single sign (scat) of Jungle cat in the study area. In the omnivore species with the 4 observations and an encounter rate of 0.3/km, presence of Indian wild pig and Golden jackal were recorded equally. Rhesus macaque was recorded two time by direct sightings and encounter rate of it were 0.2/km. With the single sightings and encounter rate of 0.1/km Common palm civet and Ruddy mongoose were rare observations of the study. Common palm civet however was recorded by indirect sighting (scat) and Ruddy mongoose were recorded by direct sighting. In the herbivore species we have recorded high presence of Indian hare with 13 observations (1 direct sighting and 12 signs) and an encounter rate of 1.1/km, Indian crested porcupine 10 sightings (10 signs) and encounter rate of 0.8/km, Nilgai were recorded 9 sightings (3 direct and 6 signs) with an encounter rate of 0.7/km and Indian bush rat 5 observations (1 direct sighting and 4 signs) encounter rate of 0.4/km shown in figure 79. The camera traps generated photos of several animals: leopard (2), hyena (1), wild pig (3), golden jackal (1), Nilgai (4), porcupine (3), hare (1).

Figure 86: Pug mark of Striped hyena & Scat of Striped Hyena in Study Area

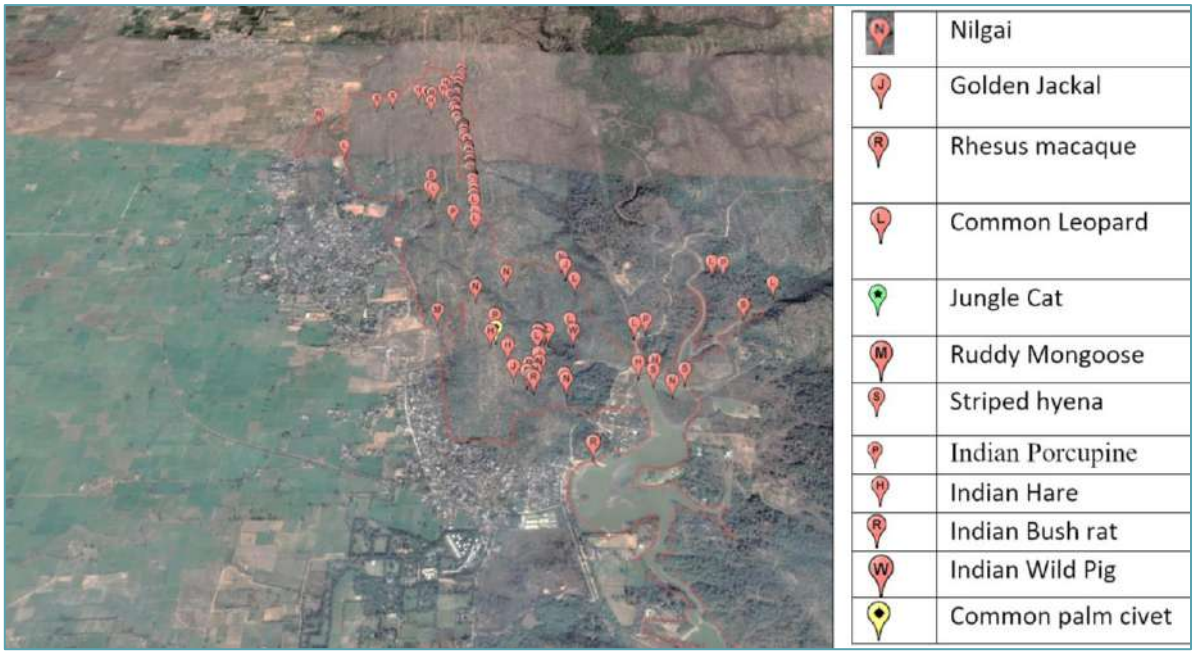


Figure 87: Species Distribution in the Study Area

Figure 88: Indian Hare (Left Side) and Ruddy Mongoose (Right Side)

Figure 89: Nilgai- Male (Left Side) & Nilgai- Female (Right Side)

Figure 90: Indian Bush Rat in the Field Area

Figure 91: Common Leopard Footage through Trap Camera

Figure 92: Golden Jackal (Left Side) and Striped Hyena (Right Side) of the Image

Figure 93: Indian Crested Porcupine (Left Side) & Wild Pig (Right Side) of the Image

Discussion

The project area is outer part of a contiguous and high diverse forest from Rojka Gurjar to Mangar Bani and it act as buffer for the surrounding forest. The area is adjacent to the village settlements in the adjoining plains and is highly degraded and pressurized by over grazing and fuel wood collection. The movement pattern of wild animals shows that the large animal such as Nilgai, Striped Hyena and Common Leopard etc. use this area as their extended range and come into the area from the western Rojka valley area and the Damdama lake surroundings. Small animal such as Indian hare, Indian bush rat and Indian crested porcupine have good population and they live permanent in the study area. During the study we have found dens of Indian crested porcupine, burrows and beating paths of Indian bush rat and droppings of Indian hare in all over the study area. We have encountered Striped hyena and Common leopard signs in high number and Nilgai signs (primarily in form of their droppings) recorded in moderate numbers in the area. The high presence of domestic animals in the study area may be a factor of this, due to which, where is large herbivore such as Nilgai found less opportunity to fed, while predators such as Striped hyena and Common leopard find a high opportunity of prey. The large predator such as Leopard may be attracted towards human dominated areas, where they find additional opportunity to gain food resources because presence of domestic animals (Bista A. et

al; 2021). Large predators such striped hyena and Leopards can live in all types of habitats where dogs and livestock are sufficient as habitat and prey (Athreya V. et al; 2013). However striped hyena have limited occupancy in study area, its sign we have found only on a few trails towards Rojka side. In comparison, the common leopard shows higher occupancy in the area and its signs have been found all over the area. The single sightings of Jungle cat (sign), Common palm civet (sign) and Ruddy mongoose (direct) in such area were by luck only and were rare observations of the study.

Insects

This study covered the checklist of insect's survey, study of habitat types and species mapping of the designated areas. Protecting our environment is of fundamental importance to all of us living in Haryana. We recognize the positive impact we can make by protecting and adding to the environmental richness, including the natural indicators and biodiversity of the ecosystem we operate in. We believe this not only makes the world ecologically viable, but it is also a matter of delivering towards future generations for sustainability.

Further, global climate change is likely to increase pressure on these ecosystems. Besides, existing conservation measures, and particularly implementation, are posing a challenge in addressing rapidly evolving problems at the heart of the city. The nature of the area was that it was mostly built-up human accommodation, which is interspersed with green areas. Also, the area includes plain area, hilly area and lake area.

In this context, the present study was undertaken to consolidate information on the site area. The research specifically centres on insects, with a predominant focus on butterflies. Though there have been no significant studies of the area and at present the scientific literature available on the study area is limited; we had referred to the studies of nearby and similar ecological areas. Some of the reference studies are Butterflies of Delhi with new additions and Butterflies of India region etc.

Objective

The objective of this specific study was to conduct a rapid ecological baseline survey for the area as well as generation of maps, with geo tagged location data for specific species to be provided.

Methodology

The study focused on the project area of Abheypur, Damdama and Kherla villages. A quick literature review was conducted to appreciate the already existing knowledge base on the area. This was followed by a rapid survey yielding primary data on various ecosystems and associated butterflies. Transect walks were done to understand the physical features of the study area.

Area mapping was undertaken before finalizing the strategy for the fieldwork. Exporting aerial images from Google Earth into the Aute Cad application, habitat mapping of the entire study area was carried

out. The image was superimposed on survey plan to understand all the easily identifiable features of the map.

Taxa Surveys: The study area was divided into three habitat types namely *(1) Plain Area (2) Hilly Area (3) Lake Area* keeping in mind the different vegetation found at these locations. With use of line transect insects survey was carried out. With help of point method actual species location was recorded for mapping purposes. The checklist prepared is of the species encountered between October 2023 to December 2023. Only identities of species were recorded through photographs, no collection of insects was undertaken. Data analysis and representation is based on collected data.

Systematic Sampling

Systematic sampling is when samples are taken at fixed intervals, usually along a line. This normally involves doing transects, where a sampling line is set up across areas where there are clear environmental gradients. For example, you might use a transect to show the changes of plant species as you moved from grassland into woodland, or to investigate the effect on species composition of a pollutant radiating out from a particular source.

Line Transect Method

A transect line can be made using a nylon rope marked and at 0.5m, or 1m intervals, all the way along its length. This is laid across the area you wish to study. The position of the transect line is very important and it depends on the direction of the you wish to study. It should be thought about before it is placed. You may end up without clear results because the line has been wrongly placed

A line transect is carried out by unrolling the transect line along the gradient identified. The species touching the line may be recorded along the whole length of the line (continuous sampling). Alternatively, the presence, or absence of species at each marked point is recorded (systematic sampling). If the slope along the transect line is measured as well, the results can then be inserted onto this profile.

Point Count Method

The point count method is a widely used technique for conducting butterfly surveys, providing a systematic and efficient approach to monitor butterfly populations. In this method, observers select specific points within a habitat and record all butterfly species seen within a defined radius or time. This standardized approach allows for the collection of quantitative data on species richness and abundance, aiding in the assessment of ecological health and changes in butterfly populations over time. By focusing on specific points, researchers can ensure consistent sampling, making it easier to detect trends and patterns in butterfly diversity. The point count method is valuable for conservation efforts and contributes to our understanding of the ecological dynamics of butterfly communities.

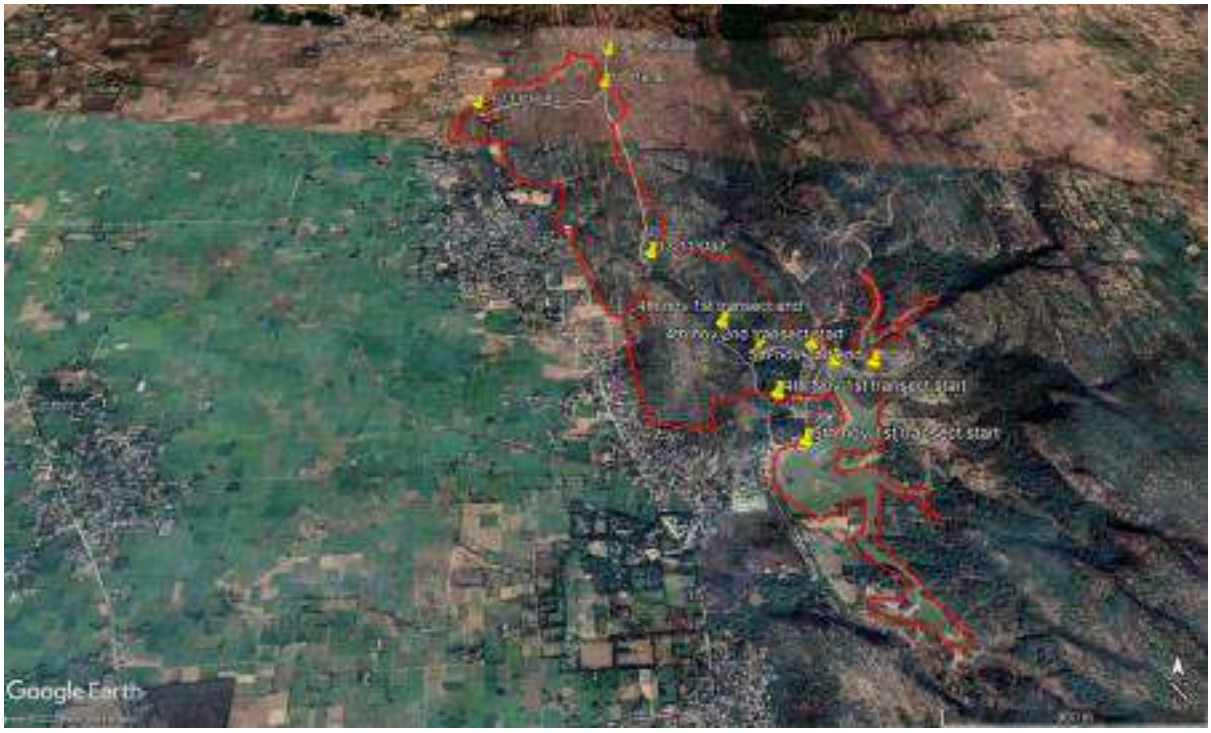


Figure 94: Insects Line Transect Area

Findings

The results of the research done by 2 methods are presented below.

The results of the butterfly survey conducted using the Line Transect method revealed a notable abundance of **Yellow Orange Tip** (*Ixias pyrene*) and **Zebra Blue** (*Leptotes plinius*) in the study area (Table 1). The high numbers of these butterfly species can be attributed to the presence of specific larval host plants, namely ***Capparis* sp. and the blue-flowering plumbago**. The availability of suitable host plants is crucial for the successful development and sustenance of butterfly populations. The observed correlation between the presence of these host plants and the abundance of corresponding butterfly species highlights the importance of habitat specificity in butterfly ecology.

In addition to the Yellow Orange Tip and Zebra Blue, the survey also documented the Scheduled**-1 species of Danaid Eggfly** (*Hyplimnas misippus*). Both male and female Danaid Egg flies were sighted during the survey, indicating the presence of a stable and potentially breeding population in the study area. This observation is particularly significant as Scheduled-1 species are often considered conservation priorities, and their presence can be indicative of the health and biodiversity value of the surveyed ecosystem.

Furthermore, the survey documented the dry season form of the **Blue Pansy** (*Junonia orithya*) and **Plains Cupid** (*Chilades pandava*). The identification of these seasonal forms adds valuable information to our understanding of the phenology and life cycle patterns of these butterfly species.

Seasonal variations in the appearance and behaviour of butterflies are essential factors to consider in comprehensive biodiversity assessments.

The Point Count method employed in the Damdama and Kherla biodiversity park areas yielded a total of **41 butterfly species** belonging to **five different families (Table 3)**. This method provides a snapshot of the butterfly diversity in the designated areas and serves as a valuable baseline for monitoring changes in population dynamics over time. The diversity of species across multiple families further underscores the ecological richness of these biodiversity parks.

Additionally, various other insects such as **ants, beetles, bugs, cockroach, bees & bumblebees, dragonflies & damselflies, flies, grasshoppers, hobbles, hornets, moths, praying mantis, and spiders** were observed.

The comprehensive results of the survey contribute significantly to our understanding of the butterfly fauna in the study area. The data obtained through both Line Transect and Point Count methods offer complementary insights into the abundance, distribution, and diversity of butterfly species. This information can be instrumental in formulating conservation strategies, especially considering the observed associations between butterfly populations and specific host plants. Additionally, the documentation of Scheduled-1 species emphasizes the ecological importance and potential conservation significance of the surveyed areas. Ongoing monitoring and research efforts are essential to further elucidate the dynamics of butterfly communities and to inform effective conservation practices in these biodiversity parks.

Table 14 : Line Transect and Point Count

	Time 7.15 am to 9.40 am	Temp. 18°C	Foggy 4th November
S. No.	Name	Scientific Name	Number
1	Common Emigrant	*Catopsilia pomona*	1+
2	Yellow Orange Tip	*Ixias pyrene*	2+1+1+1+1+1+1+1+2
3	Pea Blue	*Lampides boeticus*	1+1+1
4	Zebra Blue	*Leptotes plinius*	1+1+1+1+1+1+1+1+1+1+1+1
5	Dark Grass Blue	*Zizeeria karsandra*	1+1+1
6	Small Cupid	*Chilades parrhassius*	1+1+1
7	Plain Cupid	*Chilades pandava*	1+1
8	Grass Jewel	*Freyeria trochylus*	1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1
9	Plain Tiger	*Danaus chrysippus*	1+1
	Time 9.40 am to10.28 am	Temp. 18°C	Foggy 5th November
S. No.	Name	Scientific Name	Number
1	Zebra Blue	*Leptotes plinius*	1+1+1+1+1+1+1+1+1+1+1+1
2	Pale Grass Blues	Pseudozizeeria maha	1+1+1+1+1+1+1+1+1+1+1+1+1

3	Grass Jewel	*Freyeria trochylus*	1+1+1+1+1+1+1
4	White Orange Tip	Ixias marianne	1+1+1++1+1+1+1+1+1
5	Yellow Orange Tip	Ixias pyrene	1+1+1+1+1+1+1+1+1+1+1+1+1
6	Common Emigrant	*Catopsilia pomona*	1+1+1+1+1+1+1
7	Danaid Eggfly	Hypolimnas misippus	1+1+1+1+1
8	Blue Pansy	Junonia Orithiya	1+1+1+1
9	Lemon Pansy	Junonia lemonias	1+1+1+1+1+1+1+1+1
10	Plain Tiger	*Danaus chrysippus*	1+1+1+1+1+1+1+1+1+1+1+1
11	Common Grass Yellow	Eurema hecabe	1+1+1+1+1+1+1+1+1+1+1
12	Conjoined Swift	Pelopidas conjuncta	1+
	Time 7.40 am to 9 .28 am	Temp. 18°C	Foggy 13th November
S. No.	Name	Scientific Name	Number
1	Yellow Orange Tip	*Ixias pyrene*	1+1+1
2	White Orange Tip	*Ixias marianne*	1+1
3	Pale Grass Blues	*Pseudozizeeria maha*	1+1+1
4	Zebra Blue	*Leptotes plinius*	1+1
	Time 9.40 am to 10 .28 am	Temp. 18°C	Foggy 13th November
S. No.	Name	Scientific Name	Number
1	Common Gull	*Cepora nerissa*	1+1+1+1+1+1+1+1+1+1+1+1+1+1
2	Plain Cupid	*Chilades pandava*	1+1+1
3	White Orange Tip	*Ixias marianne*	1+1+1+1+1+1+1+1+1+1+1
4	Yellow Orange Tip	*Ixias pyrene*	1+1+1+1+1
5	Common Grass Yellow	*Eurema hecabe*	1+1
6	Grass Jewel	*Freyeria trochylus*	1+1+1+1
7	Plain Tiger	*Danaus chrysippus*	1+1+1+1+1+1+1+1+1+1+1
8	Zebra Blue	*Leptotes plinius*	1+1+1+1
9	Pioneer	*Belenois aurata*	1+1+1+1+1
10	Yellow Pansy	*Junonia hierta*	1+1+1+1
11	Small Orange Tip	*Colotis etrida*	1+1
12	Common Emigrant	*Cattopsilia pomona*	1+1+1+1
	Time 7.40 am to 9 .58 am	Temp. 18°C	Foggy 14th November
S. No.	Name	Scientific Name	Number
1	White Orange Tip	*Ixias marianne*	1+1
2	Yellow Orange Tip	*Ixias pyrene*	1+1+1+1+1+1

3	Pale Grass Blues	*Pseudozizeeria maha*	1+1
4	Common Gull	*Cepora nerissa*	1+1+1+1+1

Table 15: Line Transect Result

Date	Transect	KM
04-11-2023	1	0.51
04-11-2023	2	0.33
05-11-2023	1	0.57
05-11-2023	2	0.26
13-11-2023	1	1.8
14-11-2023	1	0.87

Table 16: Line Transect Details

S. No.	Common Name	Scientific Name	Day -1	Day -2	Day -3	Day -4	Day -5	Day -6	Day -7	Day -8	Day -9	Day -10
Hesperiid ae (Skippers)												
1	Common Banded Awl	*Hasora chromus*		X			X					
2	Indian Palm Bob	*Suastus gremius*			X							
3	Conjoined Swift	*Pelopidas conjuncta*	X									
Papilionid ae (Swallowt ail)												
4	Common Jay	*Graphium doson*		X								
5	Common Mormon	*Papilio polytes*	X									
6	Lime Butterfly	*Papilio demoleus*	X									
Pieridae (White & Yellow)												
7	Small Grass Yellow	*Eurema brigitta*	X									
8	Common Grass Yellow	*Eurema hecabe*	X									
9	Common Emigrant	*Catopsilia pomona*	X									
10	Mottled Emigrant	*Catopsilia pyranthe*	X									
11	Small Orange Tip	*Colotis etrida*	X									
12	White Orange Tip	*Ixias marianne*	X									
13	Yellow Orange Tip	*Ixias pyrene*	X									
14	Small Salmon Arab	*Colotis amata*			X			X				
15	Large Salmon Arab	*Colotis fausta*										
16	Common Gull	*Cepora nerissa*	X									

17	Pioneer	*Belenois aurota*			X							
18	Psyche	*Leptosia nina*								X		
Lycaenidae (Blues)												
19	Common Silverline	*Spindasis vulcanus*					X					
20	Zebra Blue	*Leptotes plinius*	X									
21	Rounded Pierrot	*Tarucus nara*							X			
22	Dark Grass Blue	*Zizeeria karsandra*				X						
23	Forget- me-not	*Catochrysops strabo*			X							
24	Pea Blue	*Lampides boeticus*	X									
25	Common Pierrot	*Castalius rosimon*	X									
26	Bright Babul Blue	*Azanus ubaldus*	X					X				
27	Pale Grass Blue	*Pseudozizeeria maha*	X									
28	Red Pierrot	*Talicada nyseus*			X							
29	Plain Cupid	*Chilades pandava*	X									
30	Small Cupid	*Chilades parrhasius*	X	X								
31	Lime Blue	*Chiladeslajus*				X						
Nymphali dae (Brush Footed)												
32	Plain Tiger	*Danaus chrysippus*	X									
33	Striped Tiger	*Danaus genutia*	X									
34	Common Lepoard	*Phalanta phalantha*							X			
35	Common Castor	*Ariadne merione*	X									
36	Blue Pansy	*Junonia orithiya*	X									
37	Yellow Pansy	*Junonia hierta*	X									
38	Peacock Pansy	*Junonia almana*	X									
39	Lemon Pansy	*Junnonia lemonias*	X									
40	Great Egg fly	*Hypolimnas bolina*	X									
41	Danaid Egg fly	*Hypolimnas misippus*	X									


Figure 95: Blue Pansy (Left Side) and Bright Babul Blue (Right Side)


Figure 96: Common Emigrant (Left Side) & Common Grass Yellow (Right Side)

Herpetofauna Diversity

At the heart of this natural oasis lies the picturesque Damdama Lake, a sprawling water body. The lake not only serves as a visual spectacle but also plays a vital role in the ecological balance of the region, supporting a myriad of aquatic as well as terrestrial life. The lake is surrounded by hillocks with seasonal water channels, small ponds and vibrant open forest. These areas surrounding Damdama Lake provide a refuge for diverse variety of Herpetofauna.

The Damdama region, with its diverse ecosystem comprising forests and a water body like Damdama Lake, provides an ideal habitat for various amphibians and reptiles. Both groups of animals have specific habitat requirements that contribute to their survival and well-being. Here are some key aspects of the habitat requirements for amphibians and reptiles in the Damdama region:

Moisture and Water Sources

Amphibians, such as frogs and toads, have semi-permeable skin that requires a moist environment to facilitate respiration. Presence of water bodies like Damdama Lake and surrounding wetlands is crucial for amphibians. Reptiles also benefit from water sources for drinking, and some species may use aquatic environments for breeding and laying eggs.

Hiding Places

Amphibians often require hiding places during the day to escape predators and maintain moisture levels. Fallen logs, dense vegetation, and undergrowth in the forested areas of Damdama offer suitable hiding spots.

Reptiles, including snakes and lizards, also seek refuge in natural cover such as rock crevices, burrows, or vegetation to regulate their body temperature and avoid predators.

Temperature Regulation

Both amphibians and reptiles are ectothermic, meaning they rely on external sources to regulate their body temperature. The Damdama region, with its varied topography and vegetation, provides a range of microclimates for these animals to thermoregulate effectively.

Vegetative Cover

Amphibians and reptiles benefit from a diverse array of vegetation for various purposes. Plants along the water's edge provide shelter and breeding sites for amphibians, while reptiles may use vegetation for basking and hunting.

Food Availability

The Damdama region's ecosystem supports a variety of insects, small invertebrates, and other prey items that constitute the diet of many amphibians and reptiles. The availability of food resources is vital for sustaining these populations.

Breeding Sites

Amphibians typically require water bodies for breeding, as their eggs hatch into aquatic larvae. The presence of Damdama Lake and associated wetlands, especially the long pools that are formed upstream in the main channel feeding the lake, serves as suitable breeding grounds for amphibians.

Some reptiles may also use specific habitats for nesting and laying eggs, and the availability of appropriate substrates is crucial for successful reproduction.

Biotic Interactions

Amphibians and reptiles are integral parts of the ecosystem, contributing to the balance of the food web. The Damdama region's biodiversity, including the presence of various prey and predator species, supports these important interactions. Frogs eat insects which is beneficial for agriculture. Frogs themselves are food for snakes, aquatic birds, turtles.

Preserving the natural habitats and maintaining the ecological balance in the Damdama region is essential for the conservation of amphibians and reptiles, ensuring the continued health and diversity of the local herpetofauna.

Seasonal Variation (Gurugram: Delhi-NCR):

(a) Autumn (October to November)

- **Amphibians:** As temperatures begin to cool in autumn, amphibian activity may decrease. Some species may start preparing for hibernation. Our current study period falls in this category. Juveniles and subadults of species that have bred during the monsoon can be spotted.
- **Reptiles:** Diurnal reptiles may continue to be active during the relatively milder autumn months. Basking behaviour may still be observed (especially snakes and turtles), and some species may engage in courtship activities.

(b) Winter (December to February)

- **Amphibians:** Many amphibians are less active during the winter months. Majority of species may hibernate conserve energy. Fully aquatic species like skipper frogs may be seen active during this period.
- **Reptiles:** Winter is a period of reduced activity for reptiles. Cold-blooded species may enter hibernation or brumation, seeking shelter in burrows or other insulated locations to survive the cooler temperatures.

(c) Summer (March to June)

- **Amphibians:** Certain amphibians are more active during the summer, taking advantage of warmer temperatures for feeding, breeding (depending on rainfall pattern), and growth. Some early breeding species may be more visible during this period, engaging in courtship rituals (becoming vocally active) and laying eggs in suitable habitats.
- **Reptiles:** Diurnal reptiles, such as snakes and lizards, are often more active during the warmer summer months. Basking becomes crucial for thermoregulation, and these reptiles may be commonly seen in open areas absorbing sunlight.

(d) Monsoon (July to September)

- **Amphibians:** Monsoon brings increased rainfall, creating favourable conditions for amphibians. Breeding activities intensify during this period (large number of vocally active species can be seen), and many amphibians migrate to suitable breeding habitats. Puddles and temporary water bodies become important for tadpole development.
- **Reptiles:** While some reptiles may remain active during the monsoon, heavy rains can influence their behaviour. Some species may seek shelter, while others, especially aquatic turtles, may benefit from the increased availability of water bodies.

It's important to note that variations in activity patterns can occur based on local environmental factors, the specific habitats available, and the adaptations of individual species. Additionally,

urbanization and habitat alteration in Damdama, Gurugram may impact the behaviour and distribution of amphibians and reptiles. Conservation efforts should consider the unique ecological needs of these animals in the context of the local environment.

Findings

Transects were made in the following habitats - the lake shore, upstream on the primary channel, and around waterbodies in the hills and foothills. Targeted visits during the late evening hours to water habitats. In addition, reptiles were observed during the day. Observations in each of these habitats were as follows.

a) Around the lake shore. Several transects was made along the lake shore over three months. No frog was seen as they keep coming to the shore, while frogs become easy food for the aquatic birds, including storks, egrets and ibis. Fish can escape into the centre of the lake. Three turtle species were observed, once each. There was considerable amount of waste material left in the form of offerings of devout people, that was scattered densely along the lake shore, particularly near the bund side which is easily accessible by road.
b) Up-stream in the channel feeding the lake. As the water level had declined - there were many isolated stretches of water that were still to be seen in October. The largest number of frogs were seen there including skipper and cricket frogs. A checkered keelback snake was also seen adjacent to the water on the shore of the channel. A sawing kind of hissing sound was also heard persistently - which was likely a saw-scaled viper.
c) Hill pond. The small pond behind the Johdi wala mandir – was fairly dirty, and no frogs were seen there. However, an Aravalli hill gecko was seen nearby in the evening.
d) Foot hill pond. Around 20 skipper and 15-20 cricket frogs were seen at the Johad in Kherla.
e) Hills. A few Indus valley toads were seen in the foot hill and hill slope in the evening adjacent to the path leading up to the johdi wala temple.

The preliminary herpetofauna survey was conducted in Damdama region during the October and November 2023. The species are listed below.

Table 17: Reptiles: Non- venomous Snakes

S. No.	Common name	Latin name	Local name	Status
1	Pakistan Ribbon Snake	*Psammophis leithii*	NA	Seen. On a Jhojhuru bush. Around 10-11 am. Glided away rapidly.
2	Checkered Keelback	*Fowlea flavipunctatus*	Paani ka saap	Seen. Around 8 pm. Coiled along the bank of stream feeding Damdama.
3	John's Earth Boa / Red sand boa	*Eryx Johnii*	Doh muhi	Reported by locals
4	Indian python	*Python molurus*	Ajgar (locally called Cheeti)	Reported by locals
5	Rat Snake	*Ptyas mucosus*	Dhaman	Reported by locals

Table 18: Reptiles: Venomous Snakes

S.No.	Common name	Latin name	Local name	Status
1	Cobra	*Naja naja*	Naag	Reported by locals
2	Saw-scaled viper	*Echis carinatus*	Jalebiya	Seen once. Basking on baasa shrub in hills around 10 am
3	Common Krait	*Bungarus fasciatus*	Gandaliya saap	Reported by locals

Table 19: Reptiles: Turtle

S.No.	Common name	Latin name	Local Name	Remark
1.	Ganges Softshell Turtle	*Aspideretes gangeticus*	Kachua	Seen in Damdama Lake
2.	Indian Flap Shell turtle/ Indian Mud Turtle	*Lissemys puncpata*		Seen in Damdama Lake
3.	Red eared slider	*Trachemys scripta elegans*		Seen in Damdama Lake. Exotic species. Slider – Released by humans who keep them as pets when they become big – a new concern

Table 20: Reptiles: Lizards

S. No.	Common name	Latin name	Local Name	Remark
1.	Northern House Gecko	*Hemidactylus flavivirids*	Chipakli	Seen
2.	Snake Skink	*Lygosoma punctata*	Saap ki mausi	-
3.	Oriental Garden Lizard	*Colotes versicolor*	Karkaita	*Seen*
4.	Common Indian Monitor	*Varanus bengalensis*	Goh	Not seen in winter season.
5.	Aravalli Hill Gecko	*Cyrtopodion aravallensis*	Karkaita	

Table 21: Reptiles: Frogs

S. No.	Common name	Latin name	Local Name	Remark
1	Indian Skipper Frog	*Euphlyctis cyanophlyctis*	Maindak	Seen in upstream channels and foot hill pond
2	Pierre Wart Frog / Cricket frog	*Minervarya pierrei*		Seen in upstream channels and foot hill pond
3	Indus Valley Toad	*Duttaphrynus stomaticus*		Seen in foot hill and slope on way to temple
4	Indian Bull Frog	*Hoplobatrachus tigerinus*		Seen in upstream channels

Other freshwater species: Fresh water sponges and snails. Several snails sand sponges were seen in the lake near the shore. These indicate that overall, the water is relatively clean, with low levels of pollution.

Herpetofauna in urban areas are currently facing a major crisis of habitat loss and fragmentation along with road kills. Damdama region, Gurugram is currently an important habitat, critical for survival for these city-dwelling herps. Conservation efforts for these amphibians and reptiles with complex life cycles must protect the full range of habitats required by all life history stages. The amphibians are an important food element for snakes and some birds. In turn they also eat insects and thus control their populations. Thus, the water bodies and the adjoining terrestrial habitat in the Damdama region, Gurugram needs to be protected to prevent them from becoming locally extinct.

Figure 97: Pakistan Ribbon Snake (seen on the hilltop – moved away rapidly)

Figure 98: Saw-scaled viper (basking in the sun) {Left Side} Checkered Keelback (Right Side)

Figure 99: Juvenile Ganges Softshell Turtle (Left Side) and Common Garden Lizard (Right Side)

Figure 100: Juvenile Common Garden Lizard (Left Side) & Indian Skipper frog Indian Skipper frog (Right Side)

Avifauna

Rationale for monitoring birds. Knowledge about the population and community ecology of animals and the study of their habitats are necessary for successful conservation strategies (Hanski and Gilpin 1997). Birds make extensive use of vegetation-based sources for food, shelter and breeding. They are diversified over various trophic levels and are sufficiently abundant and detectable to provide quantitative data (Gould and Mackey, 2015). Birds also play an important role in the propagation of some plants. Avifaunal communities are highly sensitive to changes in habitat caused by human use and modification (Raman et al., 1998; Thiollay, 1999; Lohr et al., 2002). This makes them an ideal subject to monitor and consequently, trace changes in a landscape.

Less assessments. Few systematic surveys of avifauna have been done in the Haryana Aravallis. The documentation is in the Atlas of Birds of Delhi and Haryana by Harvey et al. (2006) which is now dated. Some forest tracts in Gurgaon and Faridabad have also been covered on eBird by birders. However, sightings from eBird represent the few tracts regularly accessed by birdwatchers. While there are no

formal avifaunal studies from Damdama, however there are around 40 checklists of the Damdama lake area uploaded on ebird. The hill area is relatively under studied.

Objective

- The specific objective of this study was to compile a baseline data for birds recorded in Damdama encompassing all its habitats, which can help understand its conservation values, and inform conservation action in the area.
- A winter survey was carried out in the months of October to December 2023. We suggest regular, year-round surveys for an all-season assessment of the avifaunal diversity of this region.

Methodology

- Bird surveys were undertaken between 0630 to 1100 hrs in winter. All birds seen or heard along the trails were recorded. Both flying and stationary birds were recorded. In the case of flying species, only those that were likely to be originating in the Damdama area were recorded. Additional notes were taken on bird behaviour, breeding activities and any observed bird-plant interactions. Several experienced birdwatchers from the Delhi NCR region led the field survey on three days and contributed significantly to the checklist.
- Observed birds were identified using the field guide Birds of the Indian Subcontinent (Grimmett, Inskipp & Inskipp 2011), Merlin app and expert inputs. Unidentifiable species were photo-documented and later identified upon discussion with experienced birdwatchers. The bird names used are according to Praveen et al. (2023).
- Apart from field surveys, all bird checklists available for the Damdama landscape (total of 41 lists) were downloaded from eBird dating from 1900 to 2023. Inputs from these checklists have been taken to predict sightings for summer residents and visitors.
- Seasonal status of each species was surmised from field observations, eBird and Vyas (2019). Each species was assigned one of these 5 seasonal statuses:
    - **Resident (R),**
    - **Winter Migrant (W),**
    - **Summer Migrant (S),**
    - **Passage Migrant (P) or**
    - **Vagrant (V).**
- Rare species with low sightings do not have a confirmed seasonal status.
- A habitat preference category was given to each species based primarily on field observations, supplemented by information in Ali and Ripley (1987). The categories were:
    - **Forest specialist (FS),**
    - **Forest generalist (FG),**

  - **Wetland (WL) and**
  - **Open country (OP).**
- The category of forest specialist included species with restricted distribution to relatively better protected forest areas (either dry deciduous or open scrub) within the Delhi NCR Aravalli hills Landscape. These were corroborated using data from eBird and Vyas (2019). The assignment of forest specialist category was confirmed using long-term observations from similar habitats such as Sariska Tiger Reserve and surveys in Mangar village in 2019.
- The forest generalist category included primarily forest species that are more adaptable and found in degraded areas, forest edge, village groves and gardens, in addition to intact forest. Wetland species were those found in and around lakes. Open country bird species were those that were largely found in cultivation, village environs, open degraded scrub, grasslands, and fallow land.
- Birds' species were also categorised into 5 feeding guilds based on Wilman et al (2014). These categories are:
  - **Fruit & Nect.**
  - **Plant & Seed.**
  - **Invertebrate.**
  - **Vertebrate & Carrion and**
  - **Omnivore.**
- 'Fruit and Nect' category birds feed primarily on nectar and fruit (e.g. Sunbirds and Bulbuls), 'Plant & Seed' category birds feed on plant material including aquatic vegetation, vegetative parts of grasses, and seeds (e.g. Ducks, Francolins and Doves); 'Invertebrate' category birds feed on mainly insects and small crustaceans (e.g. Ibises, Flycatchers and Prinias); 'Vertebrate & Carrion' category includes carnivorous birds that hunt for prey (e.g. Eagles and Shrikes) and 'Omnivore' category birds feed on plant material as well as vertebrates and invertebrates (e.g. Babblers and Mynas).
- Additionally, conservation priority category as per State of India's Birds report (2023) was listed for each species. Using abundance trends (Long-term and Current Annual), range size and IUCN global Red List of Threatened Species 2022 (hereinafter 'IUCN Red List'), species in this report have been classified into categories of Conservation Priority for India: High, Moderate and Low. Species of High Priority include those whose abundance indices have declined considerably in the long term and continue to decline today.

Findings

We recorded 117 species in all during the baseline survey Annexure 7. There were 2-3 additional records whose identity was not certain, and these were dropped from the final list. The seasonal status of the birds is given in Annexure 8, in addition to the habitat preference and diet guilds. Conservation status (IUCN Red List and State of Indian Bords (SoIB)) is given in Annexure 9 and 10.

Among the 117 species discussed in this report, 84 were resident, 27 species were winter migrants, 3 species were summer migrants, and 2 species were passage migrants. 1 is conjectured to be vagrant.

In terms of the feeding guilds, 7 species belonged to the 'Fruit & Nect' guild, 60 to 'Invertebrate' 20 to 'Omnivore', 16 to 'Plant & Seed' and 14 species belonged to the 'Vertebrate & Carrion' category.

Species like the Bay-backed Shrike *(Lanius vittatus),* Rufous-fronted Prinia *(Prinia buchanani)*, Plain Prinia *(Prinia inornata),* Yellow-eyed Babbler *(Chrysomma sinense),* White-eared Bulbul *(Pycnonotus leucotis)* and Common Babbler *(Argya caudata)* were easily spotted in the scrub areas, rocky outcrops and fallow land. These areas, winter migrants like White-capped bunting *(Emberiza stewarti)*, Black Redstart *(Phoenicurus ochruros)* and Red-breasted Flycatcher *(Ficedula parva)* were also reported.

In the more protected and less disturbed areas, dry forest specialists were observed. These are likely to occur as residents in Damdama, owing to the large tract of native forest. 5 species from the survey belong to this category (Table 1; Shahabuddin et al 2006). These include Sirkeer Malkoha (*Taccocua leschenaultii*), White-bellied Drongo (*Dicrurus caerulescens),* and White-browed Fantail *(Rhipidura aureola)*.

Wetland species that were reported frequently from the Damdama Lake during the survey were River Tern (*Sterna aurantia)*, Pied Kingfisher *(Ceryle rudis)*, Little Cormorant *(Microcarbo niger)*, Little Egret *(Egretta garzetta)* and Red-wattled Lapwing *(Vanellus indicus)*. The Common Sandpiper (*Actitis hypoleucos)*, Grey Wagtail (Motacilla cinerea), White Wagtail *(Motacilla alba)* and Citrine Wagtail *(Motacilla citreola)* were some winter migrants reported from Damdama Lake in the winter survey.

As many as 7 birds of prey have been reported from the survey. Resident species include Shikra *(Accipiter badius)* and Black-winged Kite *(Elanus caeruleus)*. Steppe Eagles *(Aquila nipalensis)* were reported during the winter survey, soaring low above the forest, looking for prey. Eurasian Hobby *(Falco subbuteo),* that breeds across temperate Eurasia, including the Himalayas, was reported as a passage migrant.

Resident species of open country and forest habitats

Regular summer surveys will shed light on the breeding status of the resident species observed during the winter survey. It is safe to say that a significant proportion of the residents that breed in the surrounding dense forests of Bhondsi and Mangar will be breeding in Damdama as well. These include species like Yellow-footed Green Pigeon (*Treron phoenicopterus*), Plum-headed Parakeet (*Psittacula cyanocephala*), Chestnut-shouldered Petronia (*Gymnoris xanthocollis)*, Baya Weaver *(Ploceus philippinus)* and Common Woodshrike *(Tephrodornis pondicerianus)*.

Forest Specialists

In the open, scrub forests, a notable species reported is the **Marshall's Iora** *(Aegithina nigrolutea),* an endemic to the Indian subcontinent, and having a strong proclivity for sparsely wooded habitat. It is a habitat specialist, believed to be declining in some areas in India because of habitat loss (Vyas 2019). It has been almost completely wiped out from other sections of the Delhi ridge but is being reported from the Southern ridge. Damdama harbours some of the few habitats in the ridge where it is still found.

White-bellied Minivet

(Pericrocotus erythropygius), another endemic to India, is an uncommon bird of grass-and-Acacia-scrub habitats in western and central India (Vyas, 2019). Their typical habitat, very different from their co-generics, is available aplenty on the Southern Ridge (Vyas, 2019). Damdama, in addition to Mangar, is one of the very few habitats in NCR where it has been sighted and is likely to regularly occur. A year-long avifaunal study in Mangar in 2019 reported 27 dry forest specialists. Considering that Damdama harbours similar forests as Mangar, the status of more such species can likely be established in this habitat. Possibilities include Short-toed Snake-eagle (*Circaetus gallicus*), Cinereous Tit (*Parus cinereus*), Yellow-crowned Woodpecker (Leiopicus mahrattensis) and Brown-capped Pygmy Woodpecker (*Yungipicus nanus*).

Wetland species

According to Vyas (2019), the River Tern was known to breed about Delhi, either historically or even until a couple of decades ago, however there is no evidence of their continued nesting. Regular summer surveys can shed light on the breeding status of the River Tern in Damdama lake, adding valuable addition to the knowledge of the landscape.

Expected breeding Residents and Summer Visitors

10 summer visitors like Indian Golden Oriole (*Oriolus kundoo)* and Indian Paradise Flycatcher *(Terpsiphone paradisi)* have been reported from Damdama on the Damdama checklists in eBird. As is conjectured for the residents, these summer visitors that breed in surrounding similar habitats in the Southern ridge (in Delhi), are also likely to breed in Damdama. Other summer visitors that may be expected to breed include Indian Pitta *(Pitta brachyura),* Crested Bunting *(Emberiza lathami)* and Black-headed Cuckooshrike *(Lalage melanoptera)*. The latter has not been reported from Damdama yet. Regular year-round surveys will be able to confirm the breeding status of these species in the landscape, most of which are uncommon in the Delhi NCR.

Other than the rare visitors, more common ones like Green Bee-eater *(Merops orientalis)*, Asian Koel, (*Eudynamys scolopaceus)* and Greater Painted-Snipe *(Rostratula benghalensis)* can be expected in the summer surveys.

During the winter survey, Grey-throated Martins *(Riparia chinensis)* were observed moving in and out of nests in muddy streambanks along Damdama Lake. There is a high possibility of their breeding in this tract. This habitat along the Damdama lake is likely to invite Blue-cheeked Bee-eaters *(Merops persicus)* and Blue-tailed Bee-eaters *(Merops philippinus)* that have been reported on eBird, and whose breeding records have been confirmed in Mangar.

Conservation And Management Landscape

Insights from the survey

The conservation value of the Damdama landscape is shown by the high species diversity of birds (117, from only one winter survey), the occurrence of 5 dry forest specialists of the Delhi NCR, and 3 threatened species (IUCN Red List). 6 species are classified under the 'High' conservation priority category according to SOIB 2023 (Annexure 9). Damdama is also a good habitat for the Indian Peafowl (*Pavo cristatus*), listed as Schedule l species under the Wildlife Protection Act (1972).

Insights from State of India's Birds Report (SoIB 2023)

According to the report, birds that live in a wide variety of open habitats in addition to grasslands, fallow land and open agricultural fields, have faced a steep decline. Our survey reported 17 species that fall into this habitat category and are marked under 'moderate' conservation priority (see Table 1 and 2). Additionally, birds that are woodland specialists (forests or plantations) have also declined more than generalists. The survey reported 5 such species.

5 species from the list of species of highest conservation priority that were determined for Haryana in the State of India's Birds report have been reported in Damdama during the survey. These are Spotted Redshank *(Tringa erythropus),* Common Redshank *(Tringa totanus),* Egyptian Vulture *(Neophron percnopterus),* Great Grey Shrike *(Lanius excubitor)* and Bank Myna *(Acridotheres ginginianus)*.

According to the report, birds that breed in the Arctic face the most pronounced consequences of climate change. Abundance trends of migratory species show that long-distance migrants have declined the most, by over 50%. 16 such long-distance migrants were reported in the survey.

However, long distance migrant species such as Northern Shoveler (*Spatula clypeata)*, Gadwall *(Mareca strepera)*, Eurasian Wigeon *(Mareca penelope)*, Northern Pintail *(Anas acuta)*, Common Pochard *(Aythya ferina)* were last reported from Damdama Lake in 2001 (eBird), despite checklists being submitted thereafter. This indicates a drastic change in the lake habitat, calling for urgent action to preserve and revive the Damdama Lake.

Insights from eBird

Tickell's Blue Flycatcher (*Cyornis tickelliae)* may be resident in localised habitat patches in Delhi NCR (Vyas, 2019). It has been reported frequently from the Mangar region of the Southern Aravallis, along with patchy records from Damdama and other regions of Gurgaon. It is a breeding resident in Sariska

whose forests harbour native northern Aravalli vegetation similar to southern ridge. More records and surveys will shed light on its status in the NCR (Vyas 2019).

Indian Eagle Owl *(Bubo bengalensis)* is endemic to the Indian Subcontinent and local breeding resident about Delhi: in thorn scrubland as are characteristic of the Aravalli landscape and the Southern Ridge (Vyas 2019). It is a species with specialist needs facing rapid decline, and detailed surveys can gather information on its status in Damdama. One sighting was made after the bird survey was completed.

2 Indian Vultures *(Gyps indicus)* were reported in Damdama 2001 (ebird), indicating that it could once have been home to this critically endangered species. These are endemic to peninsular India with a breeding range that extends northwards along the Aravallis as far as Sariska and Alwar.

Conclusion

Our survey shows the presence of forest specialists and locally restricted species in the Damdama landscape. Damdama also supports forest as well as wetland species that are showing rapid decline according to the SOIB 2023. This strongly indicates that Damdama Lake along with its surrounding forests contributes immensely to NCR's avifaunal biodiversity. We believe our study of the rich bird fauna of the Haryana Aravallis, can provide a strong basis for future conservation and ecologically sensitive land-use planning in the Delhi NCR.

Figure 101: White-bellied Minivet (Left Side) & Black-winged Cuckooshrike (Right Side)


Figure 102: Figure 103: Painted Stork (Left Side) & River Tern (Right Side)


Figure 103: Shikra (Right Side) & Black-winged Stilt (Left Side)


Figure 104: Asian Openbill (Left Side) & Pied Kingfisher (Right Side)

Chapter 3E: Archaeology

Introduction

The Damdama-Kherla hills and the Damdama Lake area have been proposed for a biodiversity park in Gurgaon district of Haryana. As part of the baseline assessment, a biodiversity and archaeological baseline is being undertaken prior to preparation of a restoration plan for the same.

A reconnaissance survey was conducted to examine the archaeological potential of the Damdama forest region of the Aravalli ridges during the period of Oct – Dec 2023. This involved a preliminary field scanning by the Gurgaon team during Oct-Dec, followed by a field visit by the Academy for Archaeological Heritage Research and Training (AAHRT) during 20-24th December 2023. During this trip the field survey of the area was undertaken on 21-22nd Dec, we made a few traverses in the Aravalli ridges to revisit some of the previously located/reported archaeological findings as well as look at new areas and understand the cultural matrix of these sites.

Besides, during this exploration of the area, some new evidence has also been brought to light that undoubtedly establishes the archaeological significance of the area.

Methodology

It was purely an archaeological investigation, and the objective was to find out the archaeological potential of the area. Accordingly, the following methodology was adopted during the investigation:

a) In the first phase, the area was traversed by the Gurugram team from October – mid-December 2023. During this phase all the sites found were noted and photographed and their locations recorded.
b) In the second phase, the objective was to revisit the archaeological remains that had already been located by the Gurugram team of the study during preliminary fieldwork to examine them from an archaeological point of view.
c) During the revisit of the earlier known remains, an attempt was to examine the traverses in detail so that any other archaeological remains alongside should also be documented.
d) During the exploration, all the previously known sites and new remains found have been documented with their geo-coordinates, context, present physical condition, type of archaeological remains, and detailed archaeological documentation of each location, including photo documentation.
e) For a better understanding of archaeological remains and their cultural chronology, each archaeological site and remains have been examined in isolation as well as in the context of other archaeological remains, scattered in the surrounding area.

Archaeological Remains

The various archaeological relics belonging to different cultural periods have been recorded systematically during the investigations, are listed here:

Prehistoric Cultural Remains:

The Anangpur site in the Aravalli has already yielded excellent evidence of Lower Palaeolithic cultural remains (Sharma and Ota 1992), and the present area falls in the same geographical and landscape unit. Therefore, logically one should expect such evidence in this area. The Lower Palaeolithic cultural material found at Anangpur is in the form of stone artefacts comprising handaxes, cleavers, choppers, various types of scrapers, debitages, etc. This Stone Age cultural phase is recognized to be the earliest human cultural remains in the country and, its antiquity in India ranges between half a million to 1.5 million years.

Interestingly, during this short exploration in the Damdama area, several Lower Palaeolithic artefacts like handaxes, cleavers, stiff-edged scrapers, etc. were discovered and picked up after proper documentation.

These prehistoric stone artefacts are prepared mostly on quarzitic sandstone. Based on typo-technological features as noticed on these lithic artefacts, the evidence undoubtedly pushes back the human cultural remains in this area to at least 600,000 to 800,000 yrs. Unfortunately, during exploration, it has been noticed that certain archaeologically significant areas are being substantially modified, and imperative archaeological remains are under destruction. For example, much of the Anangpur site and excavations have been overtaken by mining and real estate. However, it may be mentioned here systematic detailed survey in the future is required that may yield more such evidence in the area. The list of such stone artefact findings is appended herewith.

Prehistoric Stone Artefacts

Figure 105: Prehistoric Stone Artefacts

Rock Art (Cupules, Cup Marks, Engravings)

Besides the prehistoric artefact remains, the most promising archaeological evidence brought to light is rock art in the form of cupules, cup marks, and other engravings. From this evidence, it is clear that such evidence that are very common archaeological remains and widely distributed across the landscape characterizes the archaeological potential of the area.

The cupules occur on the surface of coarse grains of sandstone boulders as well as on bedrock. These are depicted on the upper surface of the boulders and bedrock subjected to the vagaries of nature. As a result, it has been noticed that at most of the locations, the physical condition of these cupules is bad and getting destroyed due to the weathering of the rock surface. The main reason for this weathering that is envisaged is the rapid deforestation that has resulted in accelerating the weathering processes and chipping out of rock from its bedding plane due to the thermal effect on such rocks.

It was also noticed that the rubbles protection walls, constructed presumably by the Forest Department, tend to use the same coarse-grained sandstones which are also the rock type on which most of the rock art in the region has been engraved. During exploration it was seen that a boulder with cupules have been broken and used in the construction of rubble walls. A handaxe was also used as a filler to stabilize the wall.

These cupules are in the form of small circular depressions on the rock surface and mostly occur in the form of two lines in a linear pattern. Besides, there are cup marks that are larger than the cupules. Along with this evidence, some foot engraving has also been noticed on a flat boulder. It may be mentioned that these cupules' meaning is not understood to date. However, the occurrence of these cupules is one of the characteristic features of the Aravalli ridges. Detailed systematic investigations in this area may help in understanding the meaning of some of these symbols in the future. It is important to mention that such cupules have already been reported from Aravalli in the Delhi area. As far as the chronology of these features is concerned these can be assigned to a historical period based on the taphonomical features of these cupules and the contemporary evidence from the area as well as adjoining areas to anywhere between circa 2000 to 500 years B.P. In this context, mention may be made of the rich archaeological sites (Lahiri et. al. 1996) located around the ridge area. Besides, during the present exploration small historical settlements have been noticed on the Aravalli ridge itself in the form of rubble wall structures, potsherds, hopscotches, and polished sandstone flat boulders. This clearly shows that Aravallis attracted people in the historical times as well as a part of forest dependence.

Figure 106: Rock Art (Cupules, Cup Marks, Engravings)

Historical Settlements and Associated Cultural Remains:

During the present investigations, at least two locations with definite evidence of historical settlements have been located in the form of several rubble walls of dry masonry. Many of these structures are badly destroyed probably by removing the rubble for the construction of modern walls presumably by the forest department. In the future one has to be careful not to destroy such rare evidence. Besides, these structures are associated with potsherds that confirm the settlement to be of the historical period. Besides, different types of ancient pot-sherds, there are terracotta hopscotches have also been collected.

The interesting part of these historical settlements is that they are located on the Aravalli ridge tops on flat land. Based on the associated findings like potsherd, it may be presumed that these sites could belong to the historical period. Future detailed investigations with some trial archaeological digging will certainly throw more light on these settlements and also can be precisely dated. All this evidence needs to be understood in the context of surrounding evidence (Lahiri et. al. 1996). It may be mentioned here that the study of these historical settlements on the ridges in the future may help in understanding the ancient forest economy during historical times.

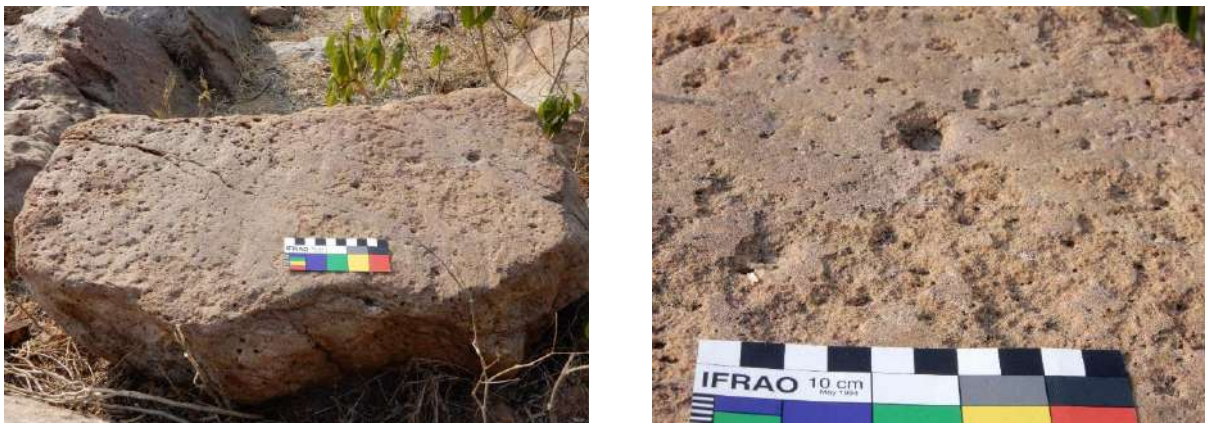


Figure 107: Rubbed Surface

General Observation

From the present reconnaissance survey, it may be concluded that the Aravalli ridges around the Damdama area have undoubtedly been an area of human activity right from prehistoric times onwards through historical periods. This area is very significant to understanding the human cultural transformation from the earliest cultural remains in the form of Stone Age cultures to the present day in this part of the Country. Therefore, the preservation of these rare archaeological remains should be the priority to save them from further destruction. In addition, such rare archaeological heritage in the Damdama area can be promoted for tourism in the future.

Table 22: Prehistoric Stone Artefacts Collected from Project Area

S.No.	Artefact type	Raw material	Physical condition	Remarks
1	Stiff edge scraper	Quartzite (Medium-grain)	Fresh	1. Ventral Surface has (20 % bedding plane surface) 2. It is prepared on grey colour quartzite viz locally available 3. It is double sided scraper prepared on a side flake
2	Handaxe	Quartzite (Medium-grain)	Fresh	1. This handaxe is prepared on flake indeterminate 2. The tip of this handaxe is broken 3. Bifacially retouched handaxe
3	End flake	Quartzite (Medium-grain)	Slightly abraded	
4	Cleaver	Quartzite (Medium-grain)	Fresh	1. Cleaver on End flake 2. Left side of the dorsal surface is broken and some modern damage at the butt end. 3. Bifacially retouched cleaver
5	Hammerstone	Quartzite (Medium-grain)		1. River worn surface 2. Broken to almost half
6	Chopper	Quartzite (Medium-grain)	Slightly abraded	1. It is on core 2. Butt portion has cortex kept intentionally for a good palm grip. 3. It has modern damage.
7	Stiff edge Scraper	Quarzitic sandstone (Coarse grain)	Fresh	1. It is straight edge scraper on a side flake.
8	Flake core	Quarzitic sandstone (Coarse grain)	Fresh	1. Few modern damage
9	Cleaver	Quartzite (Fine grain)	Fresh	1. It is on kombewa flake 2. Convex edge cleaver 3. Working edge damage (modern)

				4. Bifacially retouched
10	Discoid	Quarzitic sandstone (Medium)	Slightly abraded	1. It is on Core
11	Handaxe	Quarzitic sandstone (Medium-grain)	Moderately abraded	1. This art+A1:E13efact was collected by Suneel 2. It is a bifacially retouched handaxe.

Table 23: Archaeological remains from Aravalli ridges in Project Area

S.No.	Nature of Archaeological remains	Geo-coordinates	Remarks
1	Cupules	28° 19' 29.6'' 77° 07'11.0" ± 3m	Depicted on a weathered rock surface of a coarse-grained boulder of Sandstone
2	Cupules	28° 19' 44.1'' 77° 07' 05.8" ± 3m	Depicted on the weathered surface of two different coarse-grained sandstone boulders lying adjoining to each other
3	Cupules	28° 19' 33.4'' 77° 06' 51.0" ± 3m	Depicted on a weathered rock surface of coarse coarse-grained boulder of Sandstone Besides cupules, this boulder contains some human foot carving and an oval-shaped engraving.
4	Cupules	28° 19' 26.5'' 77° 06' 54.3" ± 3m	Depicted on a weathered rock surface of a coarse-grained boulder of Sandstone
5	Cupules	28° 19' 26.6'' 77° 06' 54.3" ± 3m	A sandstone boulder with a rubbed polished surface. Since it is associated with hopscotch and potsherds of the historical period found nearby this boulder may belong to the historical period.
6	Cupules	28° 19' 34.2'' 77° 06' 57.0" ± 3m	Depicted on a huge weathered bedrock surface of sandstone material
7	Cupules	28° 19' 34.3'' 77° 06' 57.0" ± 3m	Depicted on a weathered bedrock surface of Sandstone material.
8	Cupules	28° 19' 36.6'' 77° 06' 56.9" ± 3m	Depicted on a weathered bedrock surface of Sandstone material.
9	Cupules	28° 19' 37.1'' 77° 06' 56.9" ± 3m	Depicted on a weathered bedrock surface of Sandstone material.
10	Cupules	28° 19' 54.3'' 77° 07' 18.5" ± 3m	Depicted on the weathered rock surfaces of sandstone boulders. This stone also contains a rubbed polished surface
11	Cupules	28° 19' 09.0'' 77° 07' 11.1" ± 3m	Depicted on the three distinct weathered surfaces of sandstone bedrock
12	Cupules	28° 19' 06.7'' 77° 07' 09.4" ± 3m	Depicted on a weathered bedrock surface of sandstone material.
13	Cupules	28° 19' 06.3'' 77° 07' 09.2" ± 3m	Depicted on a weathered bedrock surface of Sandstone material.

14	Cupules	28° 19' 07.7" 77° 07' 09.5" ± 3m	A cluster of cupules depicted on two distinct weathered sandstone bedrock surfaces and a boulder
15	Cupules	28° 19' 11.2" 77° 07' 09.2" ± 3m	Depicted on the surface of a weathered sandstone boulder which is dislodged from the nearby area and used in the modern dry rubble wall erected by the forest department. Disturbed context
16	Cupules	28° 19' 13.2" 77° 07' 08.9" ± 3m	There are two sandstone boulders located side by side the weathered surfaces of which have the depictions of cupules.
17	Hopscotch and Potsherds	28° 19' 26.7" 77° 06' 54.2" ± 3m	These remains may belong to the historical period
18	Ancient dry rubble wall structure	28° 18' 54.3" 77° 07' 18.5" ± 3m	Located close to the cupule's depiction on a sandstone boulder (Sl. No. 10). Potsherds noticed these are on the surface, possibly belonging to the medieval period.
19	Ancient dry rubble wall structure	28° 19' 08.4" 77° 07' 09.7" ± 3m	These ancient rubble structures were found with potsherds. Based on potsherds this structure could belong to the historical period
20	Hopscotch and Potsherds	28° 19' 11.2" 77° 07' 09.2" ± 3m	These remains may belong to historical period
21	Potsherds	28° 19' 11.5" 77° 07' 09.2" ± 3m	A large number of pot-sherds noticed on the surface in disturbed context due to recent rubble wall construction by the forest department. Based on pottery type these could belong to the historical period

Chapter 3F: Pollution

Water Pollution

Water quality of the lake was assessed at 15 different locations mentioned as spots, by utilizing the services of NABL Accredited laboratory (Vardan Envirolab, Gurugram). The sampling and Analysis of the tests were carried as per the guidelines of IS:3025 and APHA. The different chemical and biological test parameters for the assessment are provided in Table: 24.

Table 24: Physiochemical parameters for surface water quality of Damdama Lake

S.No.	Test Parameters	Test Method	Units	Standards
1	pH (at 25^{O}C)	IS 3025 (P-11)	.....	6-9
2	Total Hardness (as $CaCO_3$)	IS 3025 (P-21)	mg/l	200
3	Dissolved Oxygen (at 20^{o} C)	IS 3025 (P-38)	mg/l	5 or above
4	Total Dissolved Solids	IS 3025 (P-16)	mg/l	500
5	COD	IS 3025 (P-58)	mg/l	250
6	BOD (3 days at 27 ^{O}C)	IS 3025 (P-44)	mg/l	30
7	Turbidity	IS 3025 (P-10)	NTU	10
8	Alkalinity (as $CaCO_3$)	IS 3025 (P-23)	mg/l	600
9	Total Suspended Solids	IS 3025 (P-17)	mg/l	100

Standards as per discharge of effluent in Inland waters as per Ministry of Environment, Forest and Climate Change Notification, New Delhi, the 1st January 2016.[4]

Table 25: Designated Best Use Classification of Surface water

Designated Best Use	Quality Class	Primary Water Quality Criteria
Drinking water source without conventional treatment but with chlorination	A	➔ Total coliform organisms (MPN*/100 ml) shall be 50 or less. ➔ pH between 6.5 and 8.5 ➔ Dissolved Oxygen 6 mg/l or more, and Biochemical Oxygen Demand 2 mg/l or less
Outdoor bathing (organized)	B	➔ Total coliform organisms (MPN/100 ml) shall be 500 or less. ➔ pH between 6.5 and 8.5 ➔ Dissolved Oxygen 5 mg/l or more, and Biochemical Oxygen Demand 3 mg/l or less
Drinking water source with conventional treatment	C	➔ Total coliform organisms (MPN/100 ml) shall be 5000 or less ➔ pH between 6 and 9 ➔ Dissolved Oxygen 4 mg/l or more, and ➔ Biochemical Oxygen Demand 3 mg/l or less
Propagation of wildlife and fisheries	D	➔ pH between 6.5 and 8.5 ➔ Dissolved Oxygen 4 mg/l or more, and ➔ Free ammonia (as N) 1.2 mg/l or less

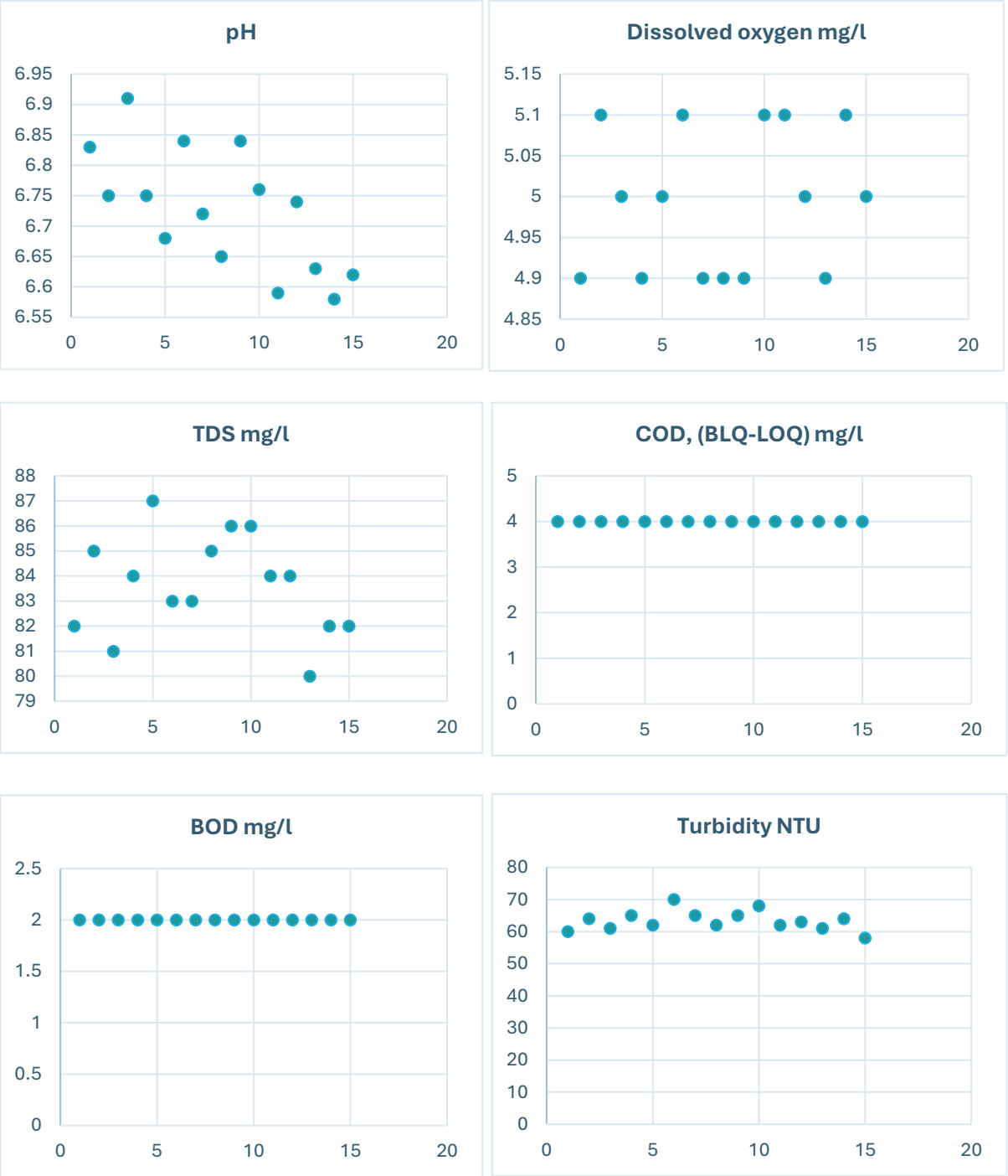
[4] Source: *General Notice No.44.of 2003,* Sections 39 and 96 of the Environment Protection Act 2002; The Environment (Protection) Rules, 1986; CPCB.

Irrigation, industrial cooling, and controlled disposal	E	➔ pH between 6.0 and 8.5 ➔ Electrical conductivity less than 2250 micro mhos/cm, ➔ Sodium Absorption Ratio less than 26, and Boron less than 2 mg/l.

Source: CPCB, Updated on 23rd October 2019

Findings: Surface Water Quality of Different Parameters

The aggregated results of surface water quality of each parameter at different spots of Damdama lake is depicted in Figure 101.



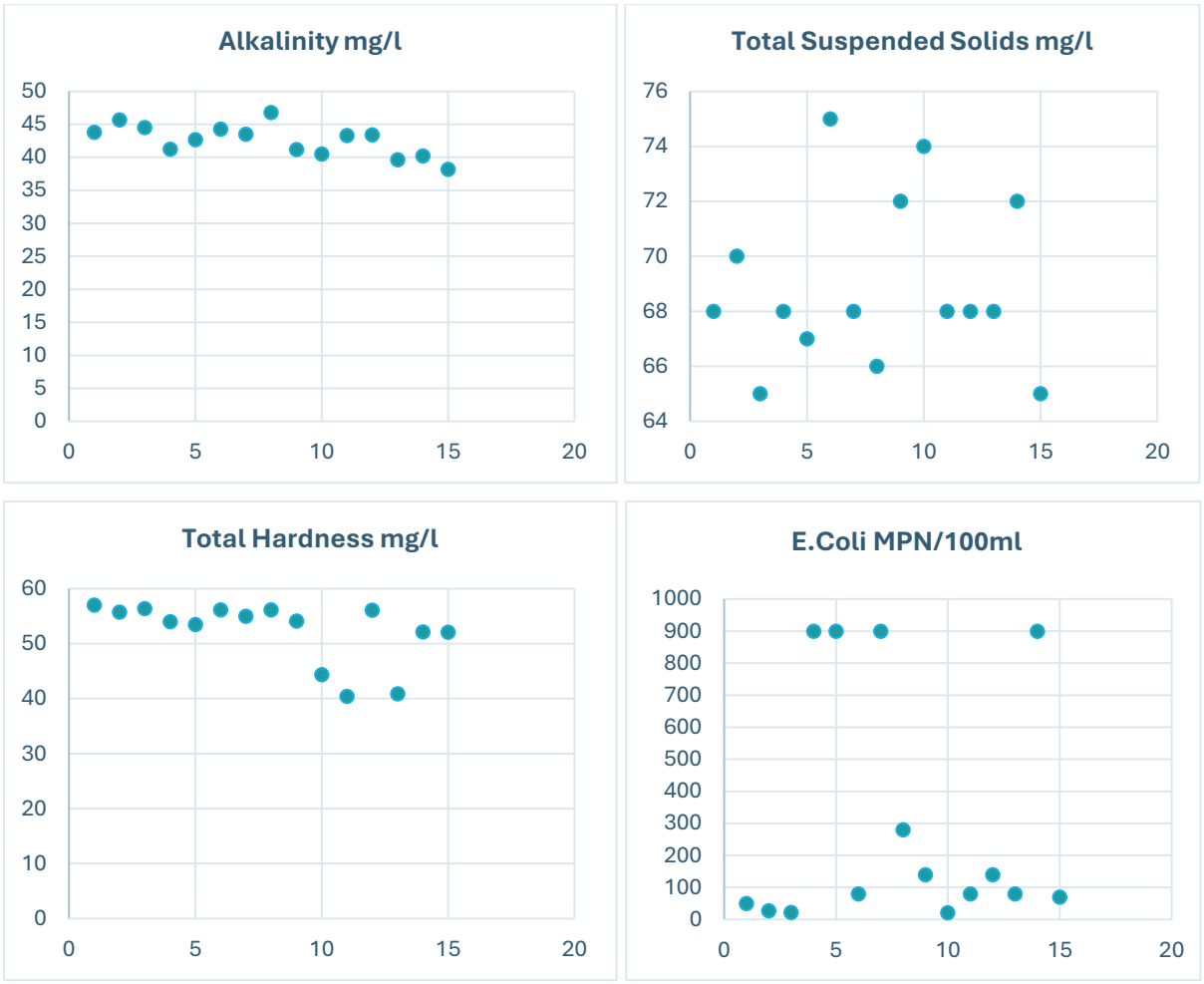


Figure 108: Water Quality Test Result of Damdama Lake

The surface water quality with respect to pH, hardness, TDS, BOD, COD, alkalinity and TSS are within the desirable limits (Figure 108). However, surface water quality with respect to Turbidity and MPN (Figure 108) are very high at most of the spots with respect to the desirable limits set by HSPCB, MOEF and Environmental protection rules.

Figure 109: Wastewater Entering into the Lake

The wastewater and solid wastes generated from the villages of Kherla, Damdama and Abheypur which ultimately finds its way into the lake shall have a detrimental effect on the serenity and water quality of the lake which needs to be addressed by proper solid waste management practices and Wastewater Water Treatment System followed by pre and post sewage wastewater testing, which is proposed to be carried out before and after the execution and management of the lake.

Air Pollution

Air quality monitoring sensors were placed at 2 locations in the biodiversity park during December 15th to December 21st, 2023, to monitor PM2.5, PM 10, SO, CO and O3 in the project area. To understand the air quality of the area.

Findings

- **PM10 and PM2.5** were the **major pollutants** in the study area and constituted nearly **84-85% of the total pollution level**.
- PM10 levels were 12-24 times higher, PM2.5 was 11-19 times higher, and NO2 was 1.5-2 times higher than the permissible limit (WHO, 2021).
- SO_2, CO and O3 were within the permissible limit.

The increase in the Particulate Matter is mainly because of **mining**, **deforestation** and **rampant construction** activities happening in the area.

Figure 110: Air Quality Monitoring Results at 2 Locations

Noise Pollution

Trees and shrubs are one of the best barriers to prevent air and noise pollution in a region. As our project area is divided into two components i.e. biodiversity park and lake revival, so noise pollution was varied from place to place.

Findings

- Noise pollution is mainly dependent upon human interference within the region. Damdama lake doesn't have an ample number of plantations and most of the time villagers gather around the lake shore which makes it noisy most of the time.
- During the **daytime the average noise level** near the lake is **more than 80 dB** because of the gathering of villagers, sellers, visitors, and vehicular movement.
- Whereas in the biodiversity park the noise level drastically reduces because of the presence of more trees and due to less human interference.

The **average noise level** in and **around the park ranges from 30-50 dB**.

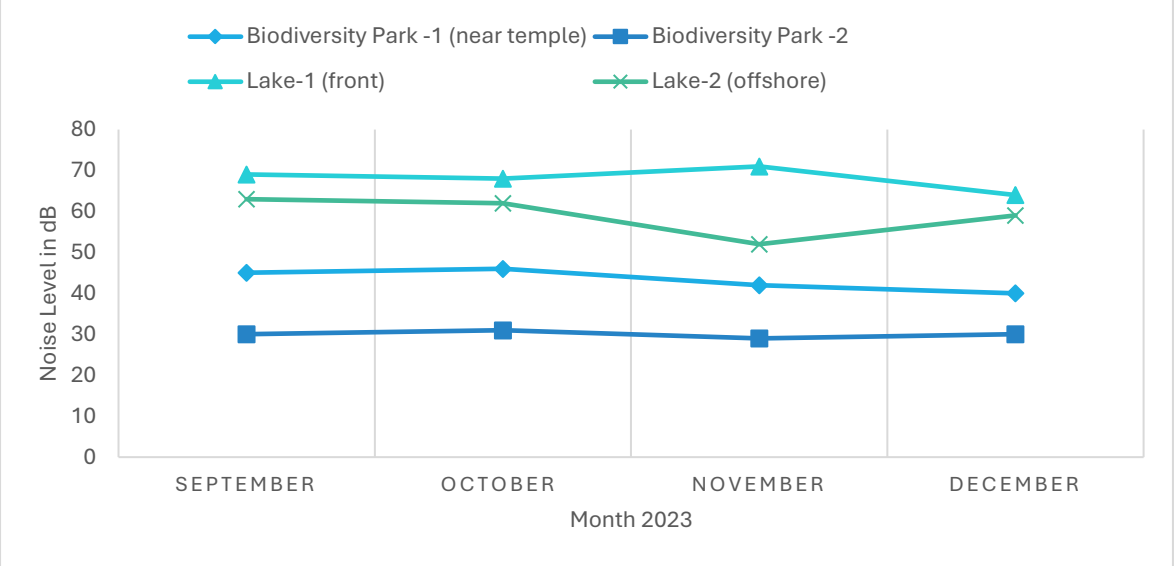


Figure 111: Noise Monitoring Results

Figure 112: Noise Monitoring in BDP and Near Damdama Lake

Chapter 3G: Solid Waste

The irresponsible disposal of solid waste has significant negative impacts on water and ecosystems. Improper disposal, such as littering and dumping waste in water bodies, leads to pollution that can harm aquatic environments and the organisms within them. Plastics and other non-biodegradable materials can persist in water, causing physical harm to aquatic life and disrupting ecosystems. Leachate from landfills, containing harmful chemicals and pollutants, can contaminate groundwater and surface water, posing a threat to both human and ecosystem health. The release of toxins from improperly disposed solid waste can lead to bioaccumulation in aquatic organisms, affecting the entire food chain and potentially reaching humans.

Moreover, the alteration of natural habitats due to the accumulation of waste can disrupt the balance of ecosystems, leading to the decline of biodiversity. The overall impact of irresponsible solid waste disposal on water and ecosystems underscores the importance of adopting responsible waste management practices to safeguard the environment and promote sustainable living.

Figure 113: Solid Waste Dumping along the Damdama Lake

Objectives

The objectives of waste management assessment are as follows:

- To assess the waste management practice in the three villages.
- To understand the awareness level among people regarding sustainable solid waste management practices.
- To identify gaps in the existing waste management system.

Methodological Framework

Primary data was collected from the residents and other stakeholders like ASHA workers and sanitation staff through Focussed Group Discussion (FGD), Questionnaire survey and observation. The framework is shown in Figures 104 and 105. Figure 106 shows the surveys that are being conducted in the villages to understand the waste management practices.

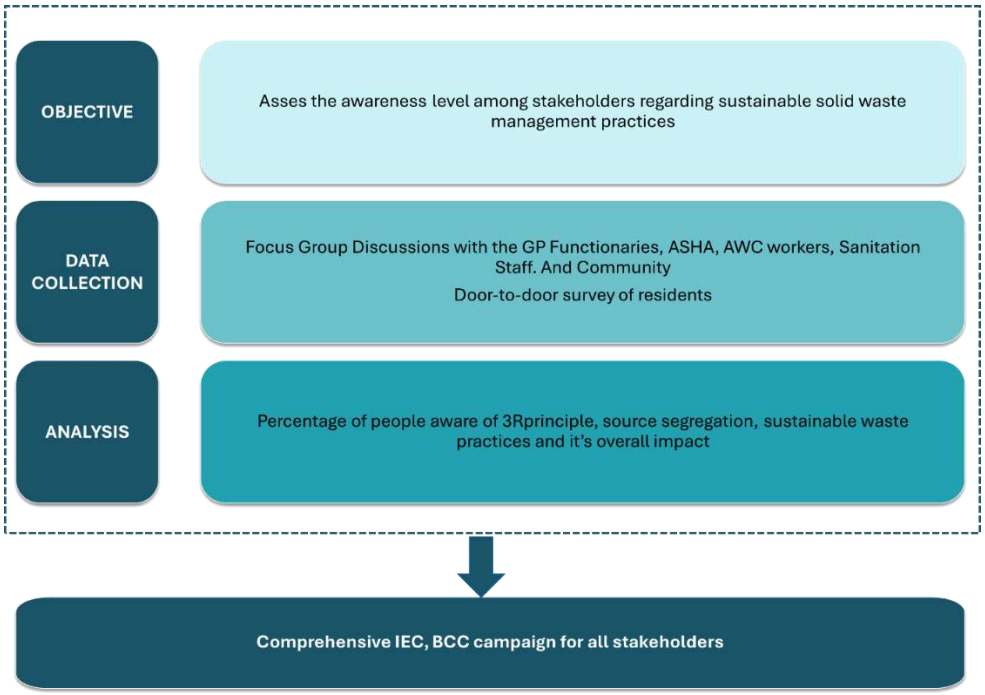


Figure 114: Methodological Framework for Assessment of Public Awareness

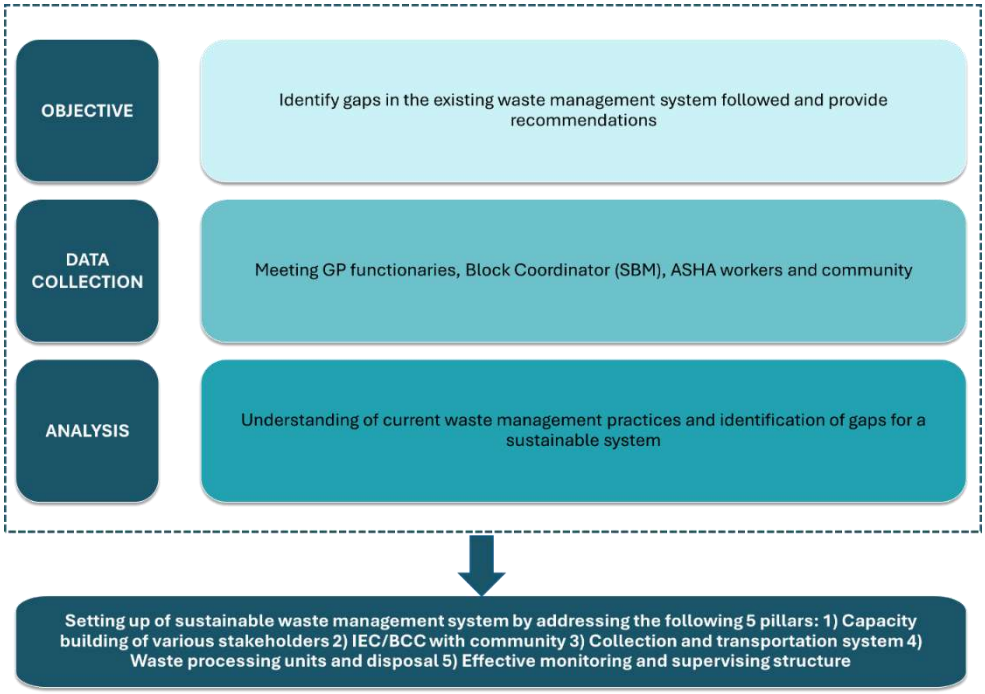


Figure 115: Framework for Gap Identification

Figure 116: Solid Waste Survey in the Villages

Findings

Waste Disposal and Collection Practices

Waste disposal practices across the three villages reveal that the community primarily uses public dustbins for waste disposal, with some opting for open areas or ponds. Additionally, households in all the three villages dispose of waste through door-to-door collection vehicles provided by the gram panchayats. The findings of the questionnaire survey are shown in the figures below.

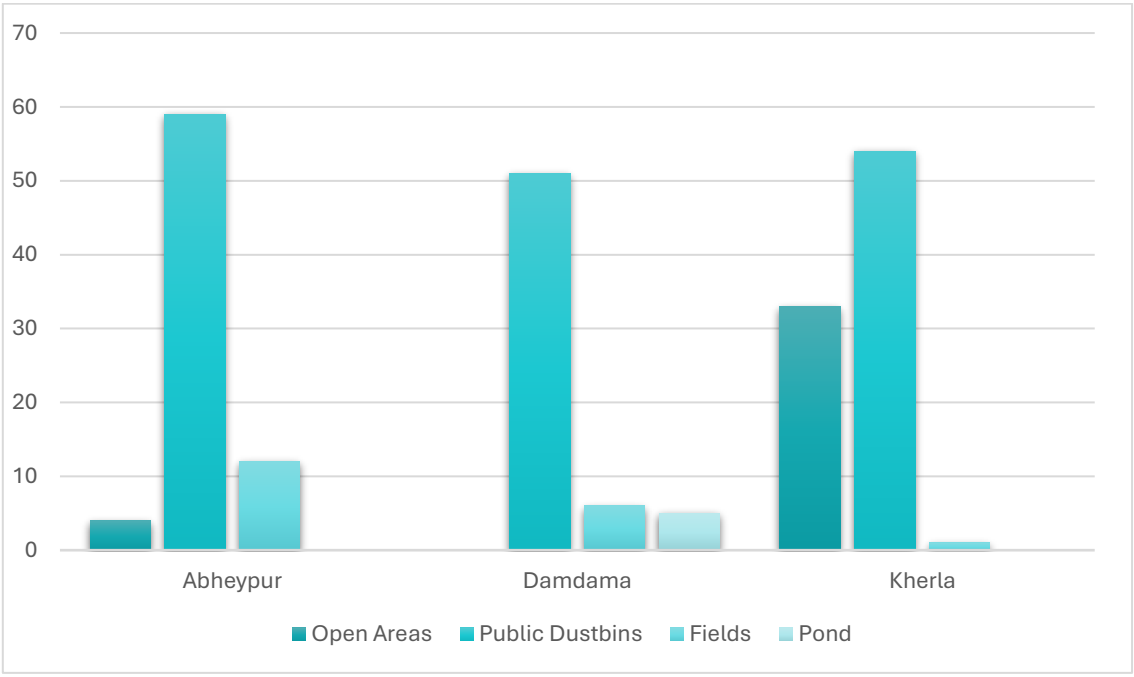


Figure 117: Waste Disposal Site by the Households

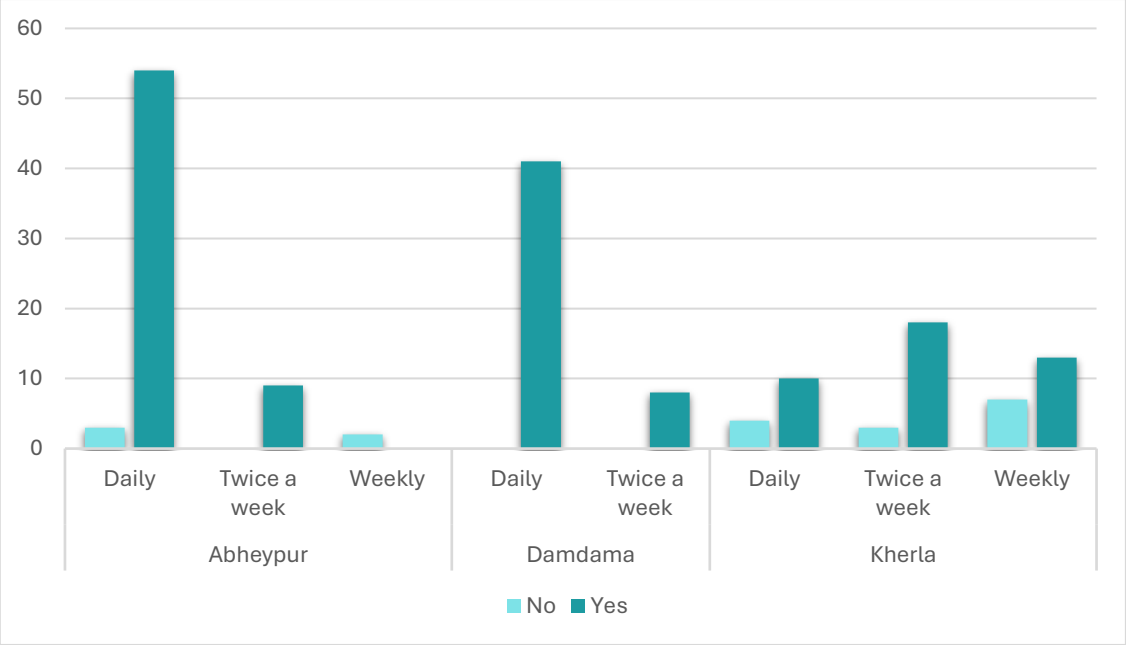


Figure 118: Frequency of Waste Collection

Each gram panchayat has a door-to-door waste collection vehicle, demonstrating a proactive approach toward waste management. The frequency of waste collection (Figure 118) varies, with daily collection in Abheypur and Damdama, and twice a week in Kherla. These findings highlight the diverse waste disposal practices and the effectiveness of door-to-door waste collection systems implemented by the gram panchayats.

Figure 119: Method of Waste Collection

Collection, Transportation (C&T) and Processing

All three villages have outsourced the C&T and processing to a private vendor. There is a common vendor for Damdama and Kherla and different one for Abheypur.

- The vendors have one tractor for C&T services.
- Damdama and Kherla have a Material Recovery Facility (MRF) for waste processing which is not used. Collected waste is dumped outside it.
- There is no MRF in Abheypur, the collected waste is dumped in empty plots outside the village.

Figure 120: Waste Disposal Site

- Collection is not regular in Damdama and Kherla - hence there is lot of dumping and burning all around.
- In Abheypur, collection is regular, but the collected waste is dumped in a central location.

Awareness Among Stakeholders

The residents of all three villages had no awareness on the 3R (Reduce, Reuse, Recycle) principles or segregation. However, in households having livestock (approx. 70%), wet waste was segregated for feeding to their livestock. Certain food waste e.g. onion peels were also mixed in the dry waste. The Gram Panchayat functionaries were aware of Swachh Bharat Mission and 'geela-sukha' (wet/dry) waste. However, they were not very clear on segregation guidelines.

Community was mostly aware of Swachh Bharat Mission for Toilets only and believes 'burning of waste' as a good practice of waste disposal. The community had no understanding on the impact of dumping and burning of waste.

Monitoring and Sustainability

Presently, there is no data collection or waste management monitoring or surveillance system for any components of waste management. Likewise, there is no village committee for monitoring of SWM. The absence of such committees highlights a significant gap in monitoring and supervision across all three Gram Panchayats.

The Village Development Committees (VDCs) are not functional and ineffective in handling the waste disposal issues. There is no byelaw in place in any of the 3 villages, hence there is no provision of user fees. Currently, the payments to the vendors are made through the provisions made under the 15th Finance Commission.

Chapter 3H: Social Assessment

Community Engagement Objectives

- Engaging with the local community to bring awareness towards the impending water crisis.
- Enabling individuals to become community leaders driving changes through small actions.
- Developing strong sense of ownership by contributing in GuruJal's work through various projects and initiatives.

Methodology

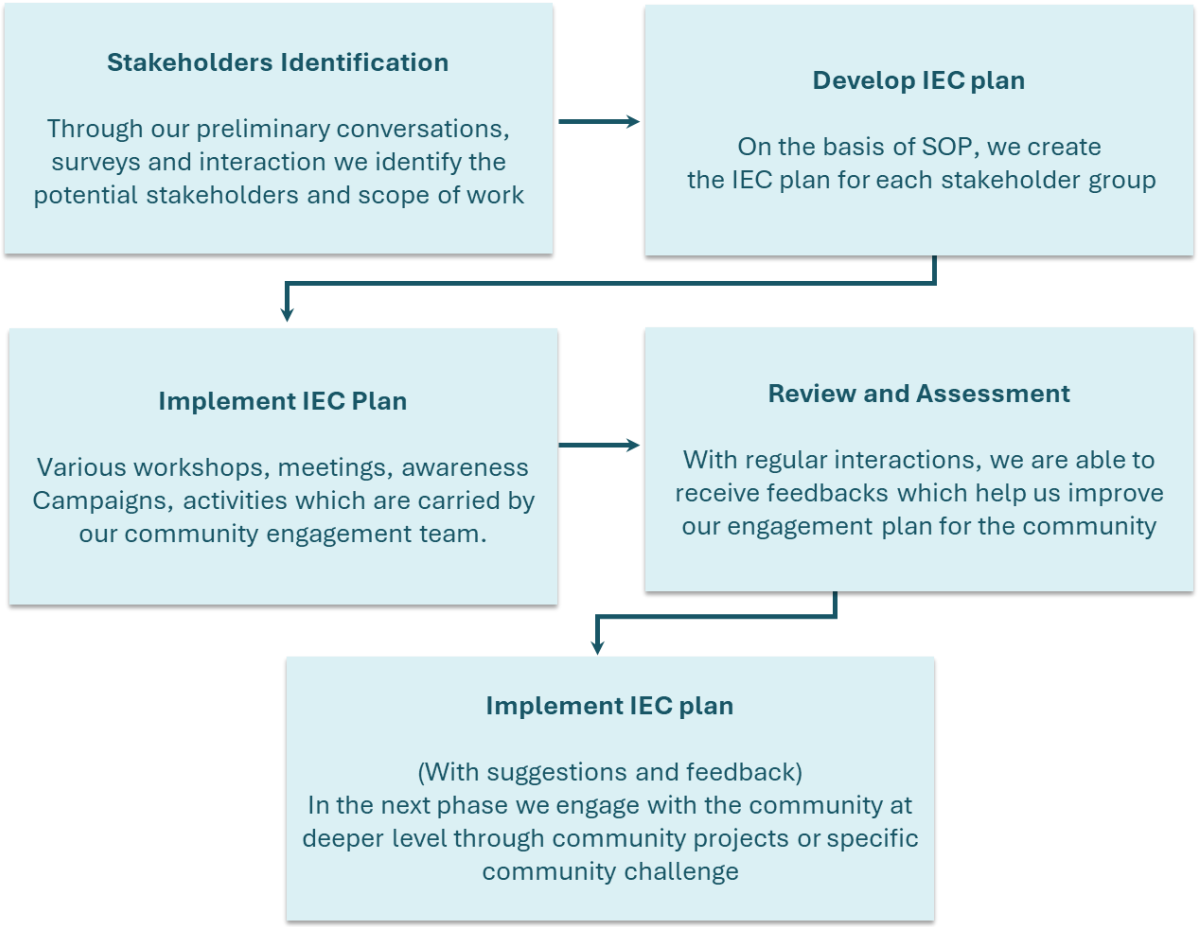


Figure 121: Methodology Adopted for Community Engagement

Stakeholders Identification

Identifying stakeholders is crucial for effective community engagement. We conducted social profiling of the area to understand community dynamics, demographics, religious beliefs, and influential figures. Household surveys helped identify local resources and their utilisation.

Table 26: Stakeholder Identification Methodology

Stakeholder	Engagement medium
Local governing bodies	➔ Initial meeting to establish context ➔ Authorization processes

	➔ Subsequent monitoring and support
Women	➔ Introduction meeting to comprehend stakeholders and project briefing. ➔ Workshops to initiate livelihood support ➔ Meetings to foster behavioral changes
Youth	➔ Preliminary meeting to establish context ➔ Engagement in project through volunteer initiatives
Children	➔ Interaction to raise awareness about water conservation ➔ Involvement in nature-based activities to emphasizes natural resource significance ➔ Activation of an Eco Club for environmental education and engagement

Findings from the Community Engagement

- **Dependency on Aravali for Basic Needs:** The community relies heavily on the Aravali for essential resources, including fuelwood and areas for recreational walks.
- **Waste Disposal in Aravali Ranges:** In various villages, the designated waste disposal areas are within the Aravali range. This points to a critical environmental concern, where waste management practices are impacting the natural habitat of the Aravali.
- **Decline in Native Plant Species and Dominance of Prosopis Juliflora (Kekar):** There is a noticeable decline in the presence of native plant species, with the invasive Prosopis Juliflora (Keekar) dominating.
- **Decreased Water Levels:** The water levels in the area have witnessed a significant decrease. This finding raises alarms about the sustainability of water resources in the region.
- **Role of Women in Wood Collection:** Women emerge as the primary stakeholders engaged in wood collection activities from the Aravali. Recognizing the pivotal role of women in resource gathering highlights the importance of empowering and involving them in sustainable environmental practices.

Challenges

- **Gender relations:** It is difficult to bring men and women together. The community is comfortable with specific gender only during interactions. This affects the value of conversation, seriousness and involvement in the tasks. GuruJal is trying to have a gender balanced team in order to cater different audience. Also, we are making our team more gender sensitive to understand the social differences.
- **Lack of collective thinking**: Community is highly motivated when it comes to their own individual work but when it comes to contributing and getting involved as a collective, they are usually apathetic. GuruJal has been undertaking various activities using art, culture, sport and skill-based workshops as a medium to bring the community together for a common cause.

- **Return on Investment:** People are in favour of work that has quicker return on investment and the transformation is tangible and visible in a short period of time. Environmental projects usually have a long gestation period, and hence associated developments need to be undertaken to keep the community interested.
- **Developing a sense of ownership:** GuruJal is involving the community from the project conceptualisation stage to develop a sense of belongingness among the people. We are parallelly developing grassroot level leadership to ensure community-level governance and management of the interventions.

Figure 122: Fuel Wood Collection by Villagers

Impact

The community mobilisation plan for the project is anticipated to yield numerous positive impacts on the local community across various levels:

- **Environmental Impact:** The plan will significantly enhance biodiversity in the area surrounding the pond. Restoration efforts often lead to improved habitats, fostering a richer and more diverse ecosystem.
- **Employment Opportunities:** Through the utilisation of local resources, the pond restoration project will create employment opportunities, particularly in water-related, biodiversity. Furthermore, the introduction of livelihood projects will contribute to the community's economic sustainability.
- **Behavioural Impact:** Children and the wider community will undergo a transformation in their understanding and actions related to conservation. Targeted interventions, especially those involving conversations about the importance of preserving the pond, will raise general awareness. This could lead to a significant shift in behaviour towards more responsible environmental actions.
- **Sociological Impact:** The mobilisation plan aims to establish a sense of community self-sustainability, encouraging the community to take ownership of the pond's care and upkeep.

This approach instils a communal sense of responsibility and nurtures a more self-reliant community capable of looking after its resources for the long term.

Engagement with Community

Engagement with community will be done by identifying the various stakeholders including children, women, senior citizens, youth etc.

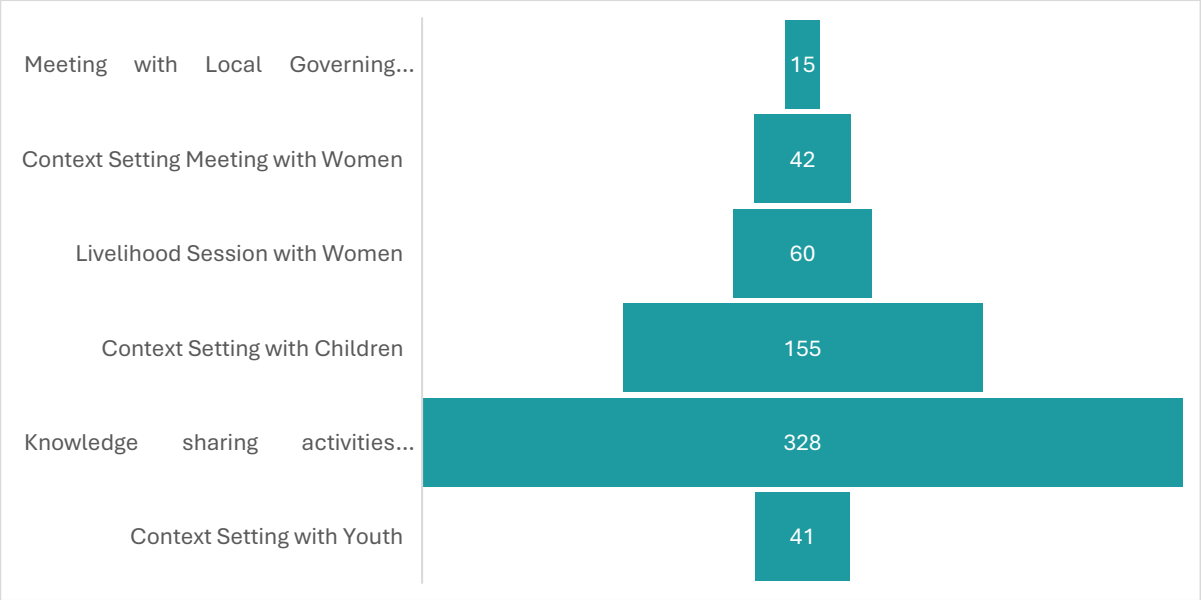


Figure 123: Count of Community Engagement in Various Activities

Figure 124: Engagement with Community Stakeholder

Figure 125: Awareness Session with Children

Figure 126: Awareness Session with Women and Youth

Figure 127: Livelihood Session with Women

WeForWater Fellowship

WeForWater Fellowship is GuruJal's unique apprenticeship program to cultivate knowledge, skills, and attitude in the youth to become leaders, managers, and enablers in the field of environment.

The aim of the programme is to augment the capacity of local governance institutes and communities through well-trained and motivated human resources to bridge implementation gaps and realise the national vision of Ministry of Jal Shakti (mission to make India water secure through Atmanirbhar villages).

The objective is to nurture youth into *water experts* by instilling the appropriate mindset, imparting knowledge, and honing essential skills to enable them to independently tackle environmental crises and become self-reliant in addressing water-related challenges.

Methodology of the Programme

The fellowship module works on H3 Module. The H3 model is the holistic nature of transformative experience and relates the cognitive domain (head) to critical reflection, the affective domain (heart) to relational knowing and the psychomotor domain (hands) to engagement. This model represents the multi-dimensional nature of transformative processes, it also includes the importance of learning context. The H3 stage is defined as follows:

- H1 emphasises personal growth and its extension to the community.

- H2 concentrates on creation, planning, idea generation, community mobilisation, and development.
- H3 centres around on-the-ground action related to individual ideas, solutions, and the execution of existing processes.

Figure 128: H3 Module for Fellowship

Theory of Change

Figure 129: Theory of Change for the Fellowship Programme

Fellows of the Study Area

Deepak, Ajay, and Vinod, hailing from Damdama, Abheypur and Kherla village respectively, have been chosen to participate in this fellowship. They possess an unwavering commitment to bring about meaningful change in his village and demonstrate remarkable dedication to their endeavours. In their role, they actively coordinate on-site initiatives and play a pivotal role in helping the team gain a deep understanding of the local community's needs and challenges.

Figure 130: In-house training Session with Fellows

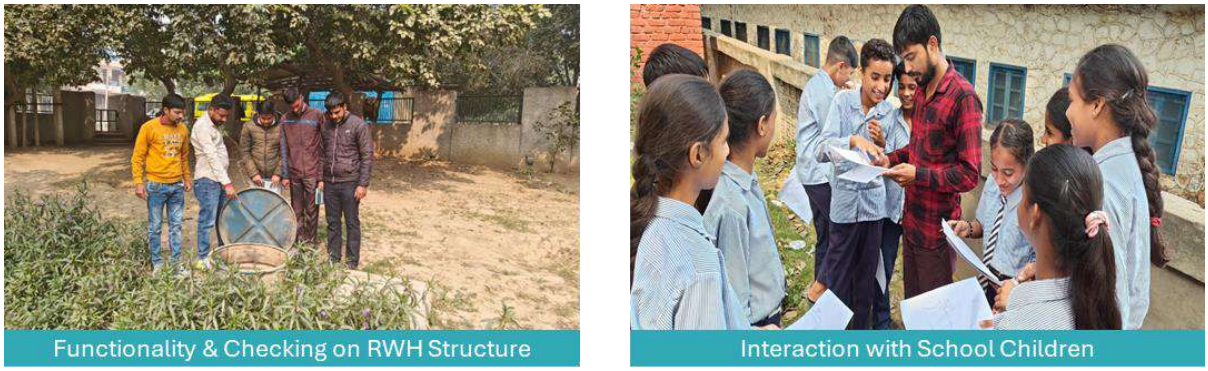
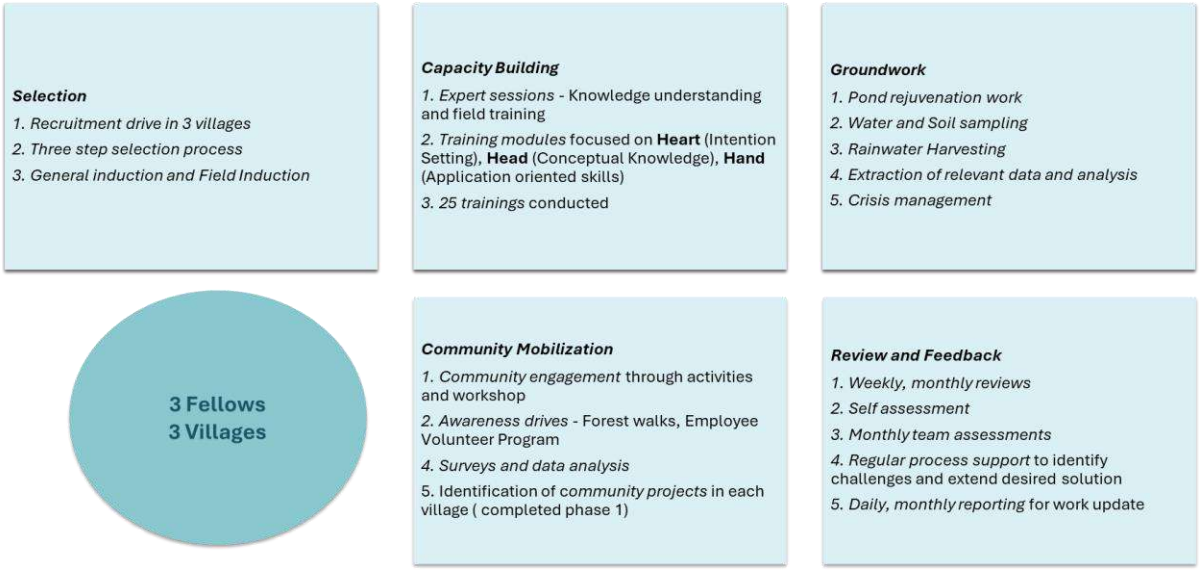


Figure 131: Experiential Learning in the Field

Fellowship Progress



Finding of the Fellowship

Individual to Collective Transformation

- Engaging the community with GuruJal's vision, fostering a collective sense of purpose and responsibility towards environmental stewardship.
- Collaborating with stakeholders to address community needs, promoting inclusive decision-making and partnership-building for sustainable development.
- Promoting knowledge sharing, involvement, and co-creation, empowering individuals to actively contribute to community initiatives and collective action.

Community-Specific Projects

- **Abheypur:** Successful implementation of a community composting initiative, promoting waste management and environmental sustainability at the local level.
- **Kherla:** Development of a permaculture forest involving youth and women, enhancing biodiversity, and providing sustainable livelihood opportunities.

- **Damdama:** Creation of an educational map/tour highlighting biodiversity, raising awareness and appreciation for local ecosystems among residents and visitors.

Challenges and Customized Solutions

- Understanding deep and exclusive village dynamics, employing tools like surveys, interactions, and discussions to tailor solutions to specific community needs.
- Utilizing insights to create effective processes and action plans, ensuring that interventions are relevant, feasible, and impactful.

Employment and Community Development

- Encouraging green jobs and reducing migration by providing opportunities for local employment in sustainable sectors.
- Providing local role models for community service, inspiring youth and community members to actively engage in environmental conservation and community development efforts.
- Impacting youth and community positively through fellowship participation, fostering leadership skills, environmental awareness, and a sense of ownership over local resources and initiatives.

Feedback on Fellowship

Employee Volunteer Program

The Employee Volunteer Program conducted by GuruJal for the EY Foundation plays a pivotal role in aligning corporate objectives with societal needs. It demonstrates the power of businesses to create a positive impact on the community while enhancing employee satisfaction and corporate reputation. Such programs contribute to a stronger, more socially conscious, and engaged workforce.

Table 27: Summary details of the EVP Events

Month	Theme of the Event	Location	No. of Participants	Community Participated
February	Seed Collection Drive	Chandra Shekar Farm	45+	EY Employees
April	Cleaning Drive	Jharsa Bund	70+	EY Employees, Youth Alliance, GMDA, MLA
June	Water Footprint Survey	Kherla	50+	EY Employees, Local Community
July	Plantation Drive	Kherla	65+	EY Employees, Local Community, School Students
September	Cleaning Drive	Damdama	70+	EY Employees, Local Community
December	Forest Walk	Damdama	30+	EY Employees
February	Plantation Drive	Abheypur	50+	EY Employees and Local Community


Seed Collection Drive


Waste Collection Drive


Plantation Drive


Plantation Drive

Figure 132: Glimpses from EVP

Future Plan of Community Outreach in Collaboration with Fellowship

Our water fellows will move towards engaging and interacting with our stakeholders in a much deeper way. Through various in-depth activities, small and long-term projects; we are looking forward to working with the community in a much meaningful manner. Below are some areas in which we have already started our research and working on the planning. Very soon we shall be ready with the

implementation plan and with the help of fellows, we are looking forward to achieving some of the below in the coming quarter.

Community interventions

Jal Pe Charcha - Quarterly gathering with the community leaders to discuss the water crisis and possible solutions. With community leaders like Sarpanch's and other leaders, we wish to make this a regular intervention where all the stakeholders come together and develop a better understanding of the water, its crisis, support needed and possible solutions.

Forest Walks/Heritage Walks/Village Walks - Through this, we wish to bridge the gap between the urban crowd and village context. We are in the process of designing various walks such as **forest walk** (to deepen our understanding about the local flora and fauna, to bring exposure to our urban population about the biodiversity they are surrounded with), **heritage walk** (the villages are a part of some interesting heritage and culture which we wish to exhibit to our urban crowd, helping them to learn about the village culture and heritage), **village walk** (through this we want to bring the village context and experience to our urban population and let them enjoy and experience the perks of a village life making them connect more with the villages)

Jal Mela - Once a year celebration in the local community, where using nature based solutions we wish to connect with community people and help them understand the importance of water. Just like another Mela, this gathering will have various modes of entertainment through games, food, stalls, forums and panels, local experiments around water, collaboration with local NGOS and much more.

Summer Camps For Children Through An Environmental Lens - Yearly space for our community children to enjoy and learn, themed around water.

Events like photography, sports competitions - Quarterly events giving exposure and learning using different mediums like photography etc.

EVP - With EVP, our constant focus is to empower our extended Gurujal community to learn, experience and develop a better understanding wrt water and environment and help them become change agents, who drive change at small or big level.

Workshops/sessions/Information Camps with Different Stakeholders - Knowledge sharing in different capacity with different stakeholders

Community Nature Projects

Community Forest in Kherla - We have identified the scope of work featuring community forest in the village Kherla. A green space using permaculture concepts, our fellow along with the mentors and experts will develop an end-to-end implementation plan for this long-term project.

Community Composting in Abheypur - In Abheypur, we have finished our household surveys which do indicate that community composting is a promising project that can be taken up in the next quarter. Our fellow with the help of his guide, will help in designing a composting system for the community.

Forest walks/Heritage walks/Village walks (for internal and external communities) in Damdama - We are working on creating some regular experience for the external community to come, learn and experience Damdama and its huge biodiversity. Our fellow will help in designing and implementing the plan of action for the same.

Saras Resort Revenue

Saras resort, which is present at the shore of the lake provides a recreational space which is open to public. Even after being operational from the past several years, the net profit of the resort has been continuously decreasing. As of the year 2023-24, the resort has already faced a loss of approximately 56 lakhs. The major reason behind this decrease in the profit is because of the reduction of water area of the Damdama lake, where the surface water area of the lake has decreased about 50%. Thus, serious measures have to be taken up to revive the lake so as to support the nearby economy of the area as well.

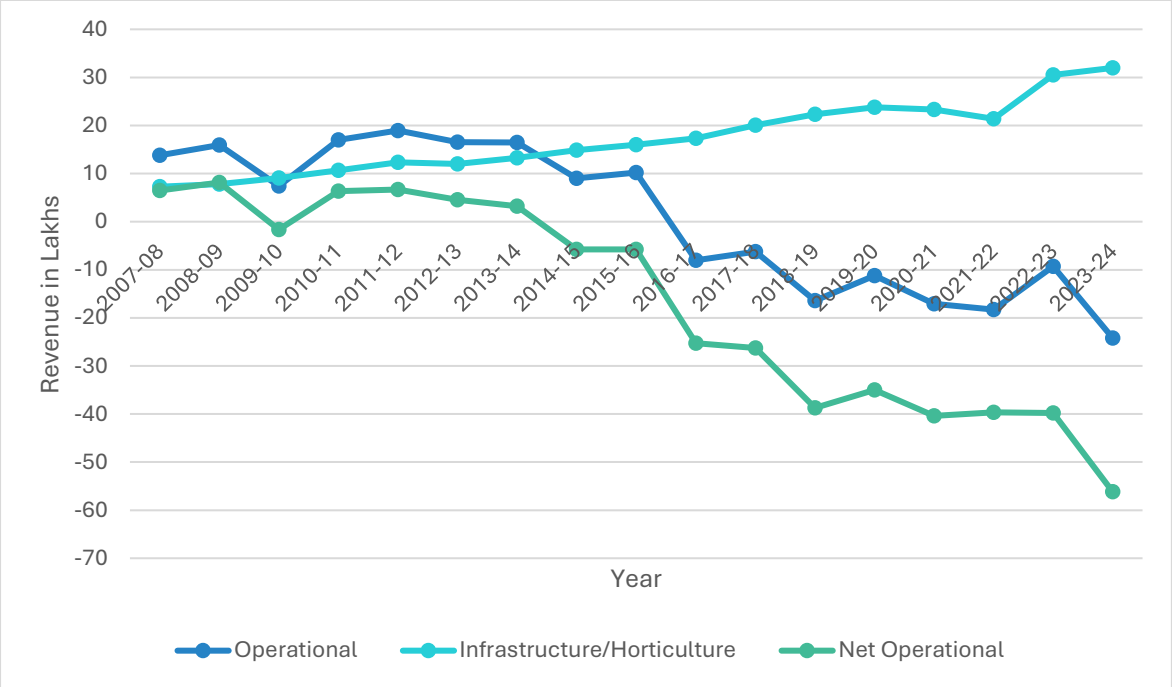


Figure 133: Revenue Generation of Saras Resort, Damdama

Political Ecology

Gurugram's Ecological Infrastructures Through Historical Perspectives

The topographical variations of Gurugram are detailed in primary records, specifically the Haryana District Gazetteers from 1983 (Haryana District Gazetteers, 1983). The gazette provides insights into three distinct regions within Gurugram: The Eastern Alluvial Plain, Western Hilly Region, and North Western Sand Dune Area. Colloquial terms, such as 'Abrez,' signify areas usually underwater, originating from Aravali hills' rivulets, with water levels sustaining large sheets even weeks after the rainy season concludes.

Historical records, including those from 1910, reference significant water bodies like Khalilpur Jheel, which relied on rainwater, transforming the land into a swamp. In response, infrastructural measures were taken, such as constructing a dyke in 1890 across Chandaini Jheel to control water overflow and facilitate surplus water transfer to Chandaini Canal.

The gazette documents the challenges posed by jheels, leading to land damage, hindering cultivation, and causing permanent flooding in low-lying areas ideal for cultivation. Recognizing these issues, historical attempts were made to drain swamps and control floods through embankments. In 1947, infrastructural developments occurred in the state, including the construction of Badkhal Bund and a canal for irrigation purposes, as well as Dhauj Bund upstream of the old bund. Due to topographic differences, the drainage system exhibits complexity, influenced by inland depressions and basins beneath the hills.

Highlighting colonial practices, the Damdama Lake, commissioned in 1947, aligns with broader colonial infrastructure development strategies, marking a significant historical event in the region's water management practices (Haryana District Gazetteers, 1983).

Furthermore, anthropological records of Gurugram evidences the above by showcasing that forest ecology have poses to be useful for landless labourers in the region where forest and its related livelihoods – bidi making, selling of wood, foraging, sale of forest produce, baskets, mats etc. have supported livelihoods (Anthropological Survey of India, 1992).

The above primary accounts drawn from historical and ethnographical sources highlights:

Table 28: Historical and Anthropological Factors for Enabling BPD Project

Topographical	➔ Gurgaon's diverse topography supports various spatial configurations, contributing to its richness in biodiversity (Haryana District Gazetteers, 1983; pg 45)
Social	➔ A distinct relationship exists between ecosystems and livelihoods, especially for landless and nomadic communities in the region.

Cultural	➔ Association of ritualistic, religious, and folk practices to flora (Pipal, barh and ber) and fauna (grey shrikes, owls and crows) of the region. Organization of fairs and festivals around ecological bodies (Suraj Kund Mela) (Haryana District Gazetteers, 1983; pg 99)
Political	➔ Pre-existing infrastructural projects, both pre-colonial and colonial, were designed to manage irrigation systems and tackle topographical challenges in the region, particularly those susceptible to flooding.
Psychological	➔ A sense of pride associated with the region's agricultural, land and infrastructural prosperity. People's close association to topographical variations and cultural practices associated with it.

Objectives of Political Ecology

Following the review of various best practices and secondary literature, the research aims to address the following questions:

- **Socio-economic Dimensions:** Examining the intricate interplay between socio-economic factors and environmental practices, with a focus on how economic structures influence ecological outcomes.
- **Temporal Analysis:** Investigating the historical evolution of political ecology dynamics to discern patterns and trends that have shaped current environmental conditions and resource management.
- **Cross-Cultural Perspectives:** Exploring how political ecology manifests across different cultures, societies, and regions, with an emphasis on understanding the varied approaches to environmental governance.

Methodology

A comprehensive methodological approach has been incorporated to understand the ecological systems' diverse perspectives, temporal dimensions, and cultural contexts. Following process was adopted for the research:

- *Sampling and Interview Types:*
  - Conducted interviews with a diverse sample of 40 individuals, including local residents, officials, and volunteers.
  - Employed both structured and unstructured interview formats.
- *Data Collection Phases and Interview Duration:*
  - Open-ended interviews lasted from ten minutes to an hour, allowing for in-depth exploration.
  - Initiated discussions with an open question about people's relationship to the lake.

- *Language and Cultural Sensitivity:*
    - Interacted with respondents in the local language, fostering a comfortable and open dialogue.
    - Encouraged respondents to share their stories in their preferred manner, asking questions only for clarification.
- *Temporal Contextualization:*
    - Employed occasional interjections to ensure a temporal context in the narratives, framing the stories around the past, present, and future.
    - Explored how various changes in the landscape were experienced by the people.

Findings

The research aimed to unravel the interplay between nature, society, and culture within the communities across three sites—Kherla, Abheypur, and Damdama—as part of the eco-restoration Project. The subsequent findings, coupled with case insights gathered from the field, vividly depict diverse relationships with ecological systems in these three sites. Figure 66 represents the relationship of people with the ecosystem highlighting what the value most. Water, ecology and culture are valued most among the people.

Figure 134: Socio Ecological Value of the Region

A SWOT analysis was carried out from the responses received from the questionnaire survey to understand the public perception about the proposed eco-restoration project.

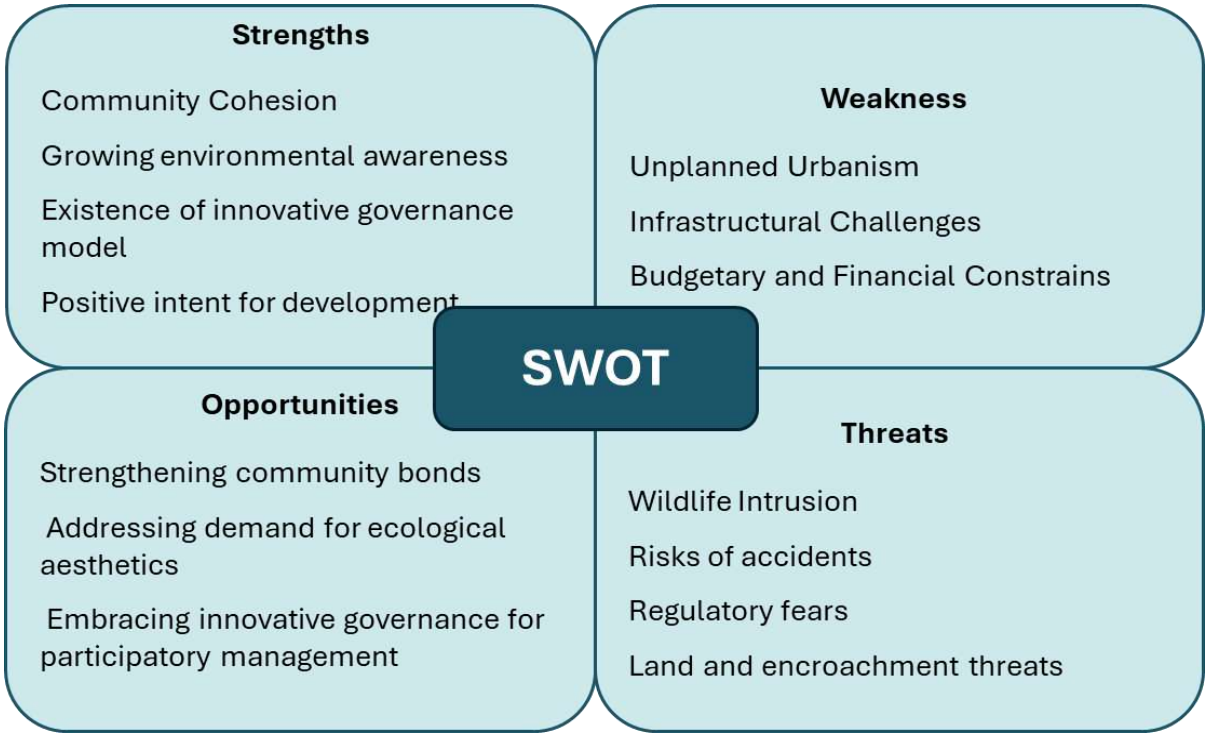


Figure 135: SWOT Analysis of Public Perception of the Eco-restoration Project

Chapter 3I: Governance

Introduction

Governance refers to the process of decision-making and the implementation of those decisions in a society, organization, or other entity. It involves the structures, processes, and mechanisms through which authority is exercised, and decisions are made and implemented.

Need for the Governance

Environmental Protection: The project aims to conserve and protect natural habitats and ecosystems. Governance ensures that decisions regarding land use, resource management, and conservation strategies are made with careful consideration of environmental impacts and sustainability principles.

Stakeholder involvement: At every phase of the project multiple stakeholders will be involved, including government agencies, local communities, environmental NGOs, activists and domain experts, and private entities. Effective governance mechanisms facilitate collaboration, participation, and consultation among these stakeholders, ensuring that diverse perspectives are considered and integrated into project planning and implementation.

Legal compliance: The project must comply with various environmental laws, regulations, and international conventions. Governance frameworks help ensure that the project adheres to legal requirements and permits, avoiding potential legal issues and conflicts.

Resource management: Overall project require effective management of natural resources, including water, soil, vegetation, and wildlife. Governance mechanisms help establish sustainable management practices, such as habitat restoration, invasive species control, and wildlife monitoring, to maintain biodiversity and ecological balance within the park.

Monitoring and evaluation: Governance structures enable the monitoring and evaluation of the project to assess progress, identify challenges, and measure outcomes. This allows for adaptive management approaches, where adjustments can be made based on scientific data and feedback from stakeholders to improve project effectiveness.

Community engagement and empowerment: Local communities plays a crucial role in this project, as the local community is relying on natural resources for their livelihoods. Governance frameworks promote community engagement, empowerment, and capacity building, ensuring that local knowledge and traditional practices are respected and integrated into project activities.

Long-term sustainability: The project aims to achieve long-term conservation goals and benefits. Effective governance ensures that the project's objectives are aligned with broader conservation

strategies and that mechanisms are in place for ongoing management, funding, and stakeholder engagement beyond the project's lifespan.

Governance Objective

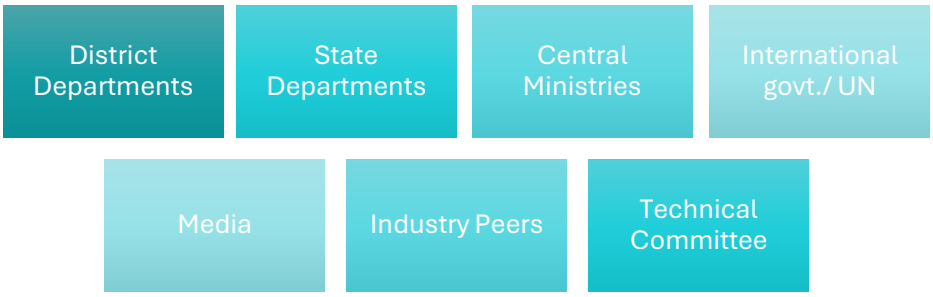
Strengthen relationship of the influential stakeholders (government & non-government, local and global) with the project and its outcomes. Aligning the project with the legislative, executionary, judiciary and media.

Expected Outcome

Smooth delivery of project on ground, spreading knowledge and getting support from all the stakeholders

Stakeholder Mapping

Stakeholder mapping for the governance of the project involves identifying and analysing the various stakeholders who have an interest or influence on the project's governance. Here is a breakdown of potential stakeholders for your project:



Village Governance

Village governance refers to the mechanisms, structures, and processes through which local communities in rural areas manage their affairs and make collective decisions. It typically involves a combination of formal and informal institutions, including elected or appointed leaders, traditional authorities, community assemblies, and local organizations. Village governance plays a crucial role in addressing the needs and priorities of rural populations, promoting local development, and ensuring effective service delivery.

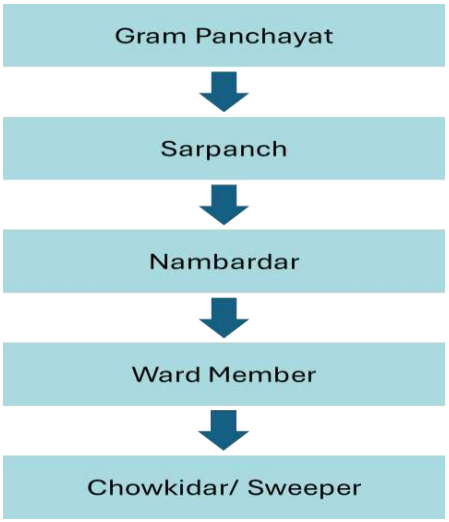


Figure 136: Village Governance Structure

Mapping of the Government Schemes

At the village level, governments often implement various schemes and initiatives aimed at addressing the specific needs and priorities of rural communities. These schemes cover a wide range of areas, including agriculture, education, healthcare, infrastructure, social welfare, and economic development. Here are some examples of village-level schemes implemented by governments in all the 3 villages.

Scheme	Role
Ujjwala Yojana / Ujjwala Yojana 2.0 (For BPL	➔ Providing LPG connections to below poverty line (BPL) households to promote clean cooking fuel and improve indoor air quality.
Beti Bachao Beti Padhao	➔ Promoting the education and welfare of girls and addressing gender imbalance through awareness campaigns and financial incentives.
Sukanya Samriddhi Yojana (LIC - Girl Child): Pradhan Mantri Mudra Yojana (Loan to Women)	➔ Encouraging savings for the girl child's education and marriage expenses by offering a high-interest rate. ➔ Providing loans to women entrepreneurs to facilitate their participation in business activities and promote financial inclusion.
Atal Pension Yojana	➔ Providing pension benefits to workers in the unorganized sector, including those in rural areas, to ensure social security after retirement
Pradhan Mantri Matru Vandana Yojana	➔ Providing financial assistance to pregnant and lactating mothers to ensure proper nutrition and healthcare during pregnancy and after childbirth.
Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)	➔ Guaranteeing 100 days of wage employment per year to rural households to enhance livelihood security and promote rural development.
National Rural Livelihood Mission (Aajeevika Yojana):	➔ Promoting self-employment and providing sustainable livelihood opportunities to rural households through skill development and capacity building.
Pradhan Mantri Awas Yojana	➔ Providing affordable housing to rural households by constructing pucca houses with basic amenities.
Ayushman Bharat Yojana	➔ Offering health insurance coverage to economically vulnerable families for secondary and tertiary healthcare services, including hospitalization expenses.
Swachh Bharat Abhiyan	➔ Promoting cleanliness, hygiene, and sanitation in rural areas by constructing toilets, promoting safe waste disposal practices, and creating awareness about the importance of cleanliness.
Apki Beti Hamari Beti	➔ Encouraging the education and welfare of girls by providing financial assistance and incentives to families who promote the education and empowerment of their daughters.
Pradhan Mantri Kisan Samman Nidhi Yojana	➔ Providing direct income support to small and marginal farmers by transferring a fixed amount of money into their bank accounts annually.

Environmental Policy Regulation

Environmental policies serve as the backbone of sustainable development, ensuring that human activities do not compromise the health and stability of ecosystems. These policies encompass a wide range of strategies, including regulatory mandates, economic incentives, and collaborative

frameworks that guide industries, communities, and governments toward environmentally responsible actions. By establishing clear legal and policy frameworks, these regulations help mitigate pollution, conserve natural resources, and protect biodiversity. Moreover, environmental policies often include mechanisms for monitoring compliance and assessing the impact of various activities on the environment, thus enabling continuous improvement and adaptation to new challenges. These policies also highlight the importance of stakeholder engagement, fostering partnerships between government agencies, NGOs, the private sector, and local communities to address complex environmental issues. Through innovative approaches and best practices, environmental policies not only safeguard the planet but also promote social and economic well-being by creating opportunities for green growth and sustainable development.

S.No.	Policy Name	Objective	Key Features	Legal Framework	Challenges & Recommendations	Case Studies/Success Stories	Benefits	Policy References
1	Green Credit	Encourage emission reduction	Credit trading, market-based	Kyoto Protocol, Paris Agreement	Market volatility, regulatory compliance	EU Emission Trading Scheme	Reduced emissions, economic incentives	EU ETS Directive 2003/87/EC, Kyoto Protocol, Paris Agreement
2	Water Neutral Village	Achieve water neutrality	Rainwater harvesting, recycling	National Water Policy	High initial investment, community engagement	Mukhyamantri Jal Swavlamban Abhiyan (Rajasthan)	Enhanced water availability, improved	National Water Policy (India), Rajasthan State Water Policy
3	Green Wall	Combat desertification, promote	Large-scale tree plantations	National and International environmental agreements	Land acquisition, high maintenance costs	Great Green Wall Initiative (Africa)	Reduced desertification, increased	UN Convention to Combat Desertification (UNCCD), African Union Strategic Plan
4	Green Bonds	Raise capital for green projects	Fixed-income securities, renewable energy	International and National regulations	Ensuring proper use of funds, high costs	Significant funds raised in the USA, China, India	Increased investment in green projects	Green Bond Principles, Climate Bonds Initiative, China's Green Bond Guidelines

5	Atal Bhujal Yojana	Improve groundwater management	Community participation, data-driven decisions	Central sector scheme under Ministry of Jal Shakti	Community participation, data accuracy	Successful implementation in Maharashtra and Rajasthan	Sustainable groundwater management,	Atal Bhujal Yojana Guidelines, Ministry of Jal Shakti Reports
6	Amrit Sarovar	Rejuvenate water bodies	Construction, rejuvenation of water bodies	Ministry of Jal Shakti, Govt. of India	Technical challenges in rejuvenation, maintenance	Various states in India	Enhanced water storage, improved local water	Amrit Sarovar Scheme Guidelines, National Water Policy (India)
7	Social Stock Exchange	Mobilize capital for social enterprises	Listing of social enterprises, impact investing	SEBI regulations for Social Stock Exchange	Regulatory compliance, transparency issues	BSE's Social Stock Exchange Pilot in India	Increased funding for social enterprises	SEBI Regulations for Social Stock Exchange, BSE Guidelines
8	Water & Carbon Offset	Offset water and carbon footprints	Reforestation, renewable energy projects	Kyoto Protocol, Paris Agreement	Accurate measurement, high costs	Clean Development Mechanism (CDM) Projects	Reduction in carbon footprint, improved water management	Kyoto Protocol, UNFCCC CDM Project Database, India's National Action Plan on Climate Change

Findings

The ownership of the project land belongs to the gram panchayat and to start the project there is a need to collect the gram panchayat Resolution from all the 3 village that is Damdama, Kherla and Abheypur gram panchayat. Total area of the project is around 500 Acres in which 420 acres belong to the gram panchayat land of Damdama and Kherla Village whereas, 80 Acres area of Damdama Lake belongs to the gram panchayat land of Damdama and Abheypur. All the resolution has been collected from the respective gram panchayats which was given by the Block Development Panchayat Officer, Sohna. The type of land as per that revenue records are under "Forest" and it comes under PLPA Section 4&5 that means non forest activities are prohibited in that area. So, As the Biodiversity Park area comes under the jurisdiction of the Haryana Forest Department. We have collected the No Objection Certificate from the Forest Department similarly; the lake area comes under the jurisdiction of Tourism department and we got the no objection certificate from the Haryana Tourism department. Apart from the permission we have engaged with around 15+ departments at district and state level.

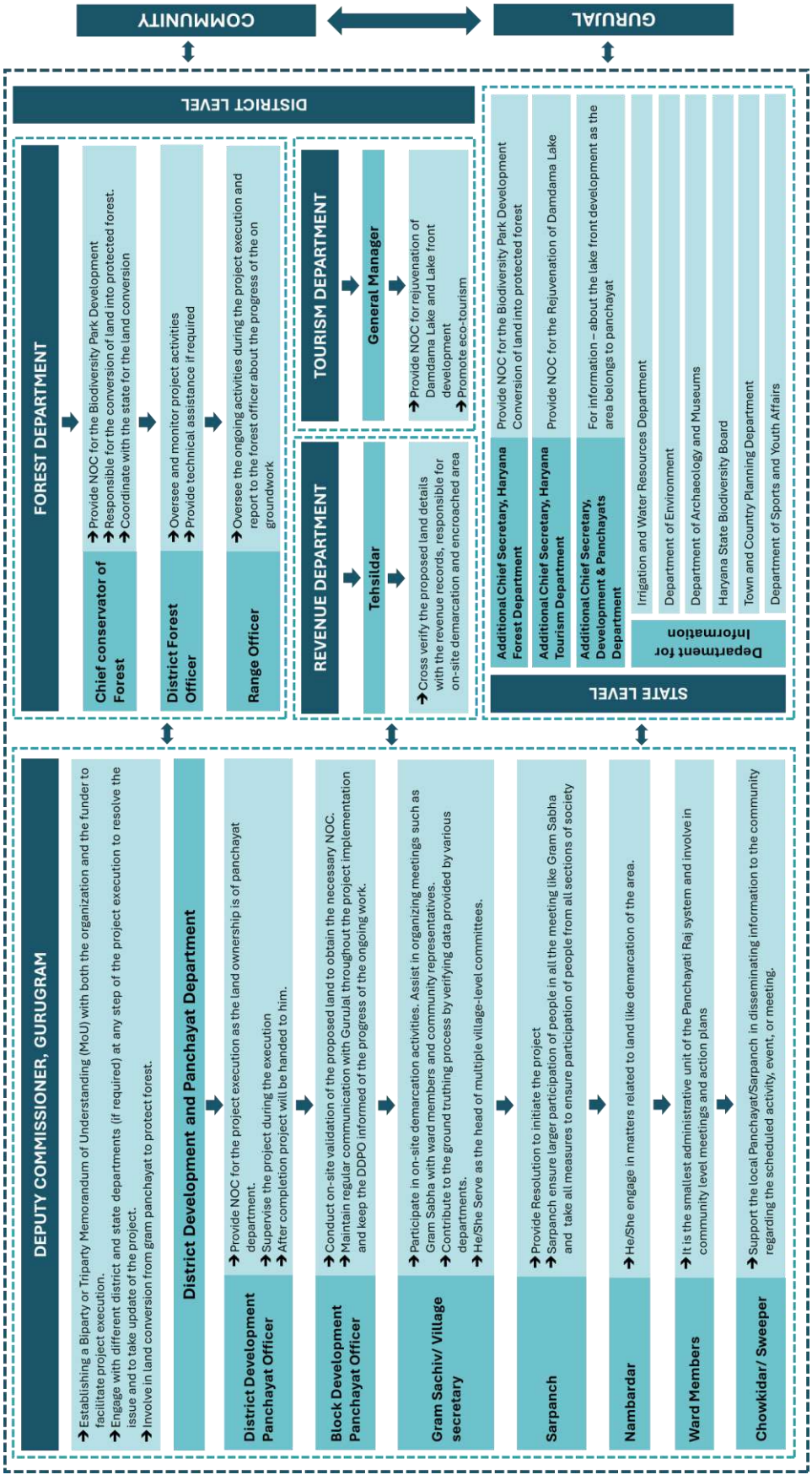


Figure 137: Representing the Alignment of the Project with Different Departments at District and State Level

Role of GuruJal in the BDP Project

District Level

- Commencing the project by signing a Memorandum of Understanding (MoU) with the Deputy Commissioner.
- Securing necessary permissions and No Objection Certificates (NOCs) at each stage of project execution.
- Providing regular reports to various departments at different project stages.
- Ensuring compliance with regulations.
- Establishing and activating the Biodiversity Management Committee (BMC).
- Managing stakeholders effectively.

State Level

- Coordinating with the Haryana Forest Department for the conversion of land into Protected Forest.
- Notifying relevant departments about project updates.
- Providing information on flora and fauna to the State Biodiversity Board.

National Level

- Liaising with the Ministry of Environment, Forest, and Climate Change (MoEF&CC) for the conversion of land into a protected forest.

Mapping of International and National Schemes and mandates

International schemes & Global Mandates

Aligning international schemes and global mandates with the biodiversity park development and lake restoration project which can enhance its sustainability, conservation efforts, and global recognition.

Also ensures its contribution to addressing pressing global challenges and priorities. Here are potential international schemes that could be aligned with the project: how the project can align with key global mandates:

Paris Agreement on Climate Change: Implementing sustainable land management practices within the biodiversity park can contribute to climate change mitigation and adaptation efforts outlined in the Paris Agreement. Emphasizing carbon sequestration through reforestation and preservation of natural habitats aligns with the Agreement's goals to limit global temperature rise and enhance resilience to climate impacts.

Convention on Biological Diversity (CBD): The project's focus on biodiversity conservation and ecosystem restoration directly supports the CBD's objectives of preserving biological diversity,

promoting sustainable use of natural resources, and ensuring equitable benefit-sharing. By creating a designated biodiversity park, the project contributes to CBD's Aichi Biodiversity Targets, particularly Target 11 on protected areas and Target 15 on ecosystem restoration.

Sustainable Development Goals (SDGs): Aligning the project with various SDGs, such as Goal 15 (Life on Land), Goal 11 (Sustainable Cities and Communities), and Goal 14 (Life Below Water), demonstrates its commitment to sustainable development and environmental stewardship.

Incorporating principles of social equity, environmental sustainability, and economic viability ensures alignment with the overarching SDG agenda to leave no one behind and achieve sustainable development for all.

2030 Agenda for Sustainable Development: By contributing to the achievement of multiple SDGs, the project aligns with the broader vision of the 2030 Agenda for Sustainable Development, which seeks to address interconnected social, economic, and environmental challenges through integrated and holistic approaches.

Bonn Challenge: The project can align with the Bonn Challenge, a global effort to restore 350 million hectares of degraded and deforested land by 2030. By incorporating reforestation and ecosystem restoration activities within the biodiversity park, the project contributes to the Bonn Challenge's goals of restoring biodiversity, enhancing ecosystem services, and mitigating climate change.

World Heritage Convention: If the biodiversity park contains unique or significant natural features, it could be considered for designation as a UNESCO World Heritage Site, leading to international recognition and support for its conservation.

Mapping of National Institutes

National institutions which have the potential to contribute to the development of a biodiversity park project and rejuvenation of lake.

Wildlife Institute of India (WII) and Centre for Ecology Development and Research

Role: WII and CEDAR could provide expertise in conducting biodiversity surveys, assessing habitat suitability for various species, and developing conservation plans for the park. They could also offer training programs for park staff on wildlife monitoring and management techniques.

Forest Research Institute (FRI)

Role: FRI could contribute scientific research on vegetation types, soil characteristics, and ecological processes within the park area. They could also provide guidance on forest management practices, including reforestation, habitat restoration, and sustainable land use planning.

Bombay Natural History Society (BNHS)

Role: BNHS could assist in conducting biodiversity assessments, identifying key species of flora and fauna, and designing interpretive materials for public education and awareness within the park. They could also collaborate on research projects and community engagement initiatives.

National Biodiversity Authority (NBA)

Role: NBA could provide guidance on legal and regulatory frameworks related to biodiversity conservation, including obtaining necessary permits and approvals for the establishment of the park. They could also advise on strategies for promoting community participation and ensuring equitable sharing of benefits from biodiversity resources.

Forest Survey of India (FSI)

Role: FSI could assist in conducting baseline surveys of forest cover, vegetation types, and land use patterns within the park area using remote sensing and GIS technologies. They could also provide technical support for developing spatial databases and monitoring systems to track changes in biodiversity over time.

Indian Council of Forestry Research and Education

Role: IC-FRE could support research collaborations with park authorities and academic institutions to address specific management challenges or research questions related to biodiversity conservation. They could also provide guidance on implementing sustainable forestry practices and integrating research findings into park management strategies.

Indian Institute of Forest Management (IIFM)

Role: IIFM could offer expertise in natural resource management, community-based conservation approaches, and eco-tourism planning for the park. They could also conduct research on the socio-economic impacts of the park on local communities and develop strategies for enhancing their livelihoods while conserving biodiversity.

Village level Institutions

Private Institutes		Damdama	Kherla	Abheypur
School	Private School	1. Chaudhary Bhikaram Genius Academy (CBR)	1. Spring field School kherla 2. Deep high school kherla 3. Shanti Niketan public school kherla 4. Sodat vashisth play school	1. Namberdar Jagraam Memory School
	Govt School	1.Shaheed Kartar singh Primary school (5th) 2. Raj Singh Khatana Middle School (12th)	1.Govt girls primary School (5th) 2. Govt boys' primary school (5th) 3. Govt. Senior Secondary School (12th)	1. Govt. Senior Secondary School 2. Govt. Girls Primary School

All three villages are equipped with both private and government schools. In Damdama, there is one private school and two government schools, with one being a primary and the other a middle school. Kherla boasts four private schools and three government schools, comprising two primary and one senior secondary institution. Abheypur hosts one private school and two government schools, including one primary and one senior secondary.

Private Institutes		Damdama	Kherla	Abheypur
Panchayat Infrastructure	Community Centre	-	-	-
	Anganwadi	4	6	5
	Panchayat Ghar	-	-	1
	Chawpal	5	6	3
	Gram Sachiwalaya (community program/ bhandara etc)	-	-	-
	yogshala/ viyayamshala	1	-	-
	Mela Ground/ Ramleela ground	-	-	-
	Govt Hospitals	-	-	1 (vetenary)

	Bank	1 (Yes Bank)	1 (Yes Bank)	1 (Sarv Gramin Bank)
	ATM	2 (Taj hotel and Yes Bank)	1 (Yes Bank)	-
	Hotel	3 (Taj Hotel, Botanix)	-	-
	Department infrastructure	Tourism Department (Saras Complex) Fisheries Department (Banjad) Indira Gandhi Holiday Home	-	-
	Recreational Space	The Blue camp	-	Bani
	Tourism	Boating Ziplining	-	-
	PHCs	-	-	-
	Sports area/ panchayat ground)		2	Aakhada - Kushti/exercise
	Pond	2	2	2
	Water Tank	-	-	1
	Tempo Stand	-	2	1
	Highway	-	-	Delhi-Mumbai expressway
	Stadium	2	2	-
	Vridha aashram	1	1	1
	Petrol pipeline	-	1	1
	Petrol pump	1	-	1
	Gas Pipeline	-	1	1
	Shamshan ghat	1	3	1
	Check dam	2	-	2
	Dumping Ground/ shed	1	1	1
	Library	-	1	1
	Common Service Centre (CSC)	1	2	1
	Post Office	1	1	-
	Gaushala	-	-	-
	CNG Pump	-	-	-
	Mandir	7	5	4

Volunteer groups are essential for community development and social cohesion. These groups typically consist of residents who volunteer their time and effort to address various needs and issues within the community. Some common village volunteer groups of all the 3 villages:

Volunteer groups ➔ Youth Club

- Eco- club
- SHGs
- Anganwadi workers
- Asha workers
- Sports club
- BMC (Biodiversity Management Committee)
- Mandir committee
- Water committee
- Panchayat committee
- Mela committee
- Market committee

Chapter 4: Recommendations

Climate linked suggestions

The water surface area of the lake helps in the temperature control in the hot arid summers and along with the biodiversity helps in maintaining balance in the evapotranspiration of the area. The temperature and oxygen levels could be monitored to determine the variation in the microclimate. In addition, the contribution of the biodiversity park in reduction of air pollution should be noted.

The following impacts are envisaged upon implementation of the recommendations:

- Implementing rooftop rainwater harvesting will be able to meet the annual water demand of 200 – 800 persons (based on current water supply) or 500 –1200 persons (based on 70 lpcd). This would reduce the pressure on groundwater and hence on the lake itself.
- There will be an increase in groundwater table by minimum 0.3m within a year if the eco-restoration measures are adopted, thus the villages will have enhanced water security.
- Protecting the eco-restoration site through soil conservation measures and check dams in the biodiversity park will help in maintaining the lake in its current state and allow the lake spread to remain at 15 hectares or more and not shrink in summers.
- The lake being an eco-tourism destination will attract more tourists (~1 lakh) in a year if the lake has minimum water level of at least 1.5-2 m throughout the year which can enable setting of water-based activities.

Hydrology and Hydrogeology

Groundwater recharge in lake catchment

Implementation of check dams and gully plugs at specific locations within the lake's catchment is proposed as a strategic intervention to address hydrological challenges. Notably, the convergence points of streams in sub-basins 1 and 2, specifically where stream order 5 and 6 intersect, are identified as critical sites for check dam installations (Figure 63). The primary objective is to extend water retention periods within the catchment. Furthermore, within sub-basin 4, check dams/gully plugs are recommended at locations denoted on the map, corresponding to areas with significant disruptions in hydrological channels. Albeit these restoration mechanisms will need time, in terms of channel restoration, but the anticipated revival of channels and lower-order streams is expected to amplify the water-holding capacity of both the catchment and the lake. A notable outcome of these interventions could be rise in elevation of the lake's water depth by one meter, ensuring perennial water availability.

The rationale behind selecting specific intervention sites within the lake's catchment, particularly at the confluence of stream orders, stems from the substantial alterations in Stream Order 6. These

interventions, in the form of gully plugs or check dams, will eventually help to increase the tributary length within Stream Order 6.

The gully plugs, designed to impede the flow of water in eroded channels, primarily address localized erosion and sedimentation issues. They serve as barriers in gullies, reducing the speed of water and allowing sediment to settle, contributing to soil conservation as well. On the other hand, check dams are structures built across watercourses to control water flow, mitigate erosion, and facilitate groundwater recharge.

The impact of these interventions on the catchment and the lake differs based on the specific challenges each address. Gully plugs can be particularly effective in preventing soil erosion and retaining sediment within the catchment, thereby improving soil quality and reducing downstream sedimentation. However, their impact may be limited in addressing broader hydrological disruptions and maintaining sustained water levels in the lake. The check dams can contribute to the restoration of channels and the revival of lower-order streams.

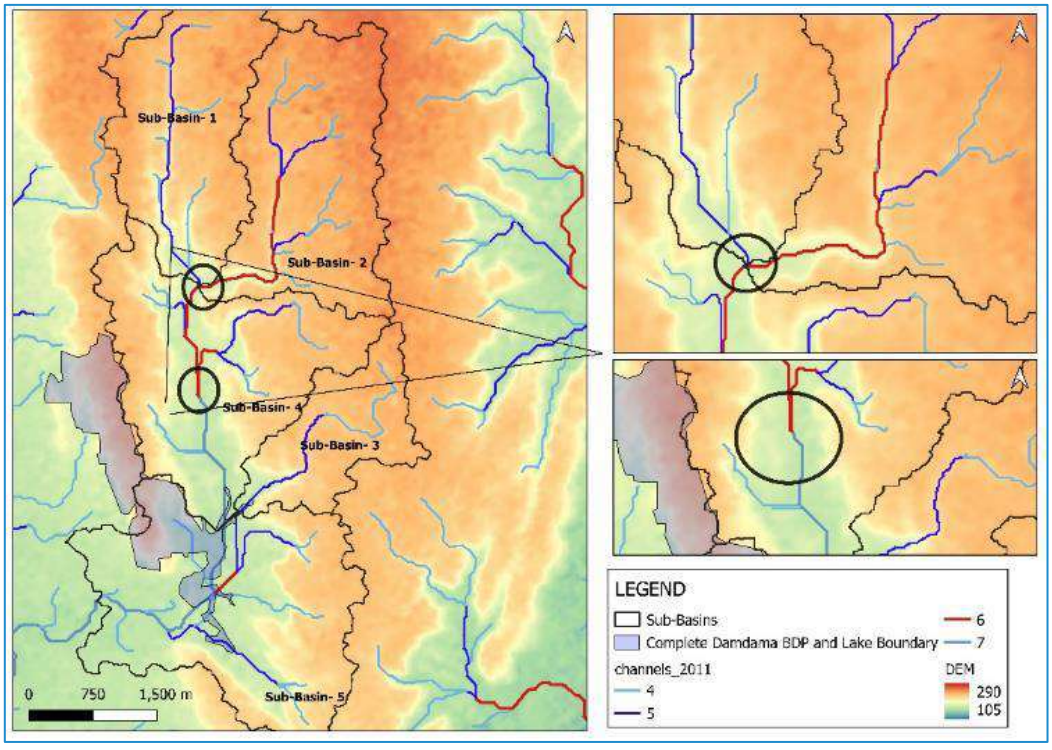


Figure 138: Location of Check Dams within the Lake Catchment

Rooftop Rainwater Harvesting

The pressure on groundwater can be reduced by implementing rooftop rainwater harvesting as Sohna block has an annual normal rainfall of 502 mm. Each village has an average concrete rooftop area ranging from 60 m^2- 90 m^2. The RWH potential is calculated based on the given formula:

*Rainwater water collected = annual rainfall (m) * roof area (m2) * runoff discharge coefficient*[5]

If rooftop rainwater harvesting is implemented Damdama, Abheypur and Kherla can harvest approximately 13.42 million litres, 19.42 million litres and 31.45 million litres of rainwater in a year respectively. This water can satisfy the annual water demand of 525, 760 and 1231 persons in Damdama, Abheypur and Kherla respectively. The annual demand was calculated based on 2011 census population and standard water demand of 70 LPCD in rural areas. When the current water supply rates are considered the annual water demand of 200, 463 and 845 persons can be satisfied.

The abandoned borewells and dug wells present within the villages can be utilized as harvesting or recharge structures. This will help in maintaining the water levels present in the lake and reduce the vulnerability of aquifer too. Initially rooftop rainwater harvesting can be taken up in the vicinity of an abandoned bore well to understand the mechanism of working of the intervention.

Interventions in Biodiversity Park area

The hill slopes in the BDP area vary between contours 200 and 180. The soil in the hill slopes in the BDP area must be conserved, this can be done by placing jute or coir based geo-textiles on the slopes. These installations act as slope erosion control measures, it is suggested that the geotextile netting needs to be put across 20 m gradient (between contours 200-180) along the length of the slope, the locations are given in Figure 138 below. The slopes in higher reaches of BDP (BDP watershed 2&3) have localized hydrological channels which carry runoff water to the villages (Kherla) in the foothills and the waterbodies it creates, jute netting must be placed along the slope for a length of approximately 1000 m in the suggested location. The slope surrounding the depression behind SARAS complex (BDP watershed 8) is crucial as the runoff from these slopes reaches the depression/valley between the hills, controlling the erosion will help in maintaining the soil and further channelise the water going to the lake; thus, the jute netting must be placed in the mentioned location for an approximate length of 850 m along the slope.

Implement micro soil moisture conservation measures.

These Aravalli hills have thin soil cover, and much has been lost due to erosion. Decreasing rainfall trends and increased extreme rain events also reduces the soil moisture availability period in the soil. Simple soil moisture conservation methods – trenching and micro-check dams along the contour will protect soil and increase the availability of soil moisture, thus enabling better regeneration and recruitment of seedlings into saplings and saplings into sub-adults.

Check dams/gully plugs need to be placed in the hills behind Kherla village in micro watershed 5 & 6. These structures will slow the flow of water by retaining it for some duration eventually leading to

[5] *(Gould and Nissen Formula, 1999)*

localized recharge in the area. This will help in recharging the localized loamy sand aquifer in the foothills. At the boundary of the BDP with Kherla village a green corridor may be created by planting natural species.

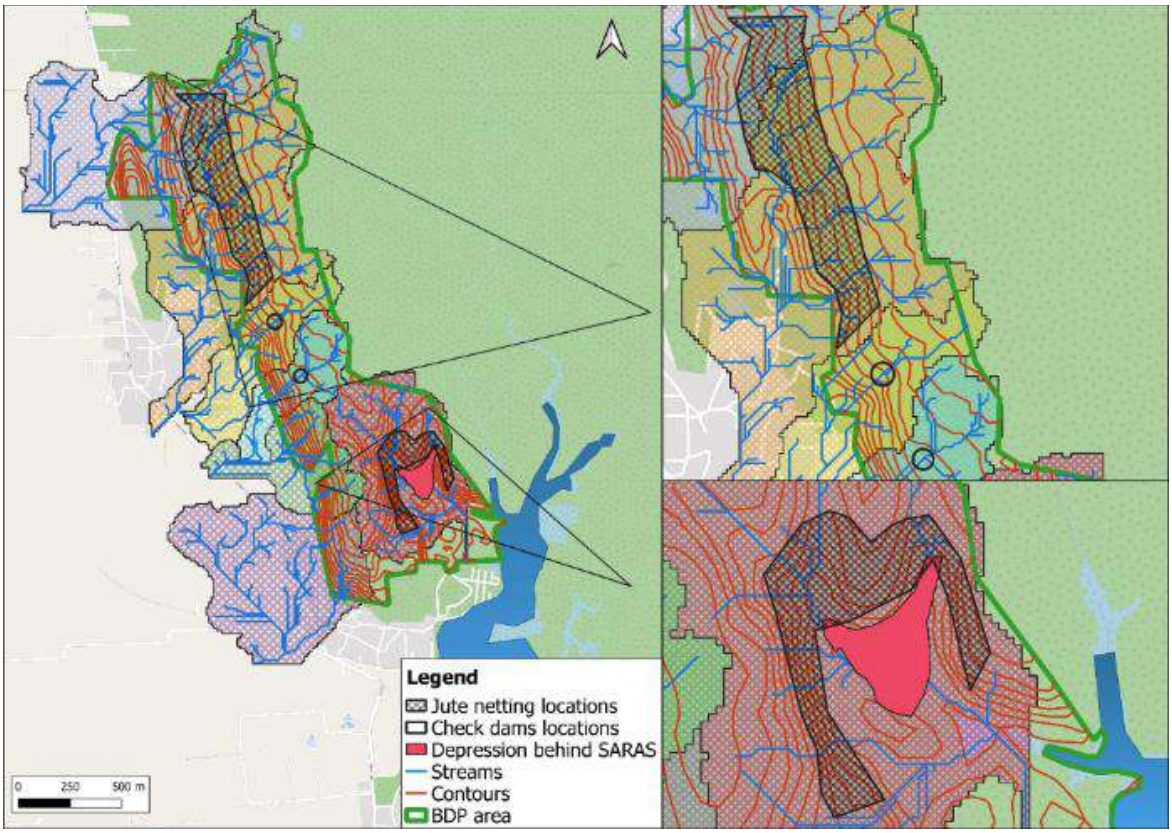


Figure 139: Location of Check Dams and Jute Nets in BDP Area

Biodiversity

Create zones for restoration planning as per the forest type, forest condition & topography and micro watersheds.

- There is a strong correlation between the topography, the pressure on the forest on the one hand, and its condition and the prevailing forest type.
- Therefore, while making the restoration plan and evaluating the species to promote and where to plant, it is important to look at the existing forest type, forest condition, and the topography and aspect and choose associate species of the current vegetation, so that we can evaluate the current successional stage of forest type and assist the natural successional processes.
- The forest plot data has helped identify these zones to a large extent in the study, based on the density of forest tree species (see the following map) e.g.-
- The degraded stage *Anogeissus pendula* (dhau) scrub forest type ($5B/E_1$-DS_1) areas are primarily on the rocky slopes it use to dominate earlier - its preferred terrain, but is now

degraded and struggling, largely in bushy form. If not protected, it will end up being further replaced by Kumuth and Vilayti Keekar.

- Similarly, the *Acacia Senegal* Forest sub-type (6B/E_2) which is prevailing in the eastern sides can be a separate zone.
- There are a few pure patches of *Balanites aegyptiaca* (Hingot) of high density, largely in the seedling stage. These can be protected as it is.
- Few patches of Jhadber (*Ziziphus nummularia*) were also found – that is a thorny scrub forest type in its own right, and should be protected as well.
- The remaining areas have a good presence of *Prosopis juliflora* (Vilayati keekar) – which can be controlled slowly.

Implement Assisted Natural Regeneration (ANR)

- Given the extensive presence of a large variety of trees on the site – and especially Dhau and Kumuth (the two major forest types), it would be appropriate to adopt an Assisted Natural Regeneration (ANR) approach to restoration. The ANR approach would involve.
    - Protecting the area (reducing grazing and lopping pressure),
    - Controlling the exotic/invasive species – especially Vilayati Keekar and Gajar ghas by gradual replacement
    - Undertake supplementary planting with tree species associated for each forest types, to promote the natural successional process.

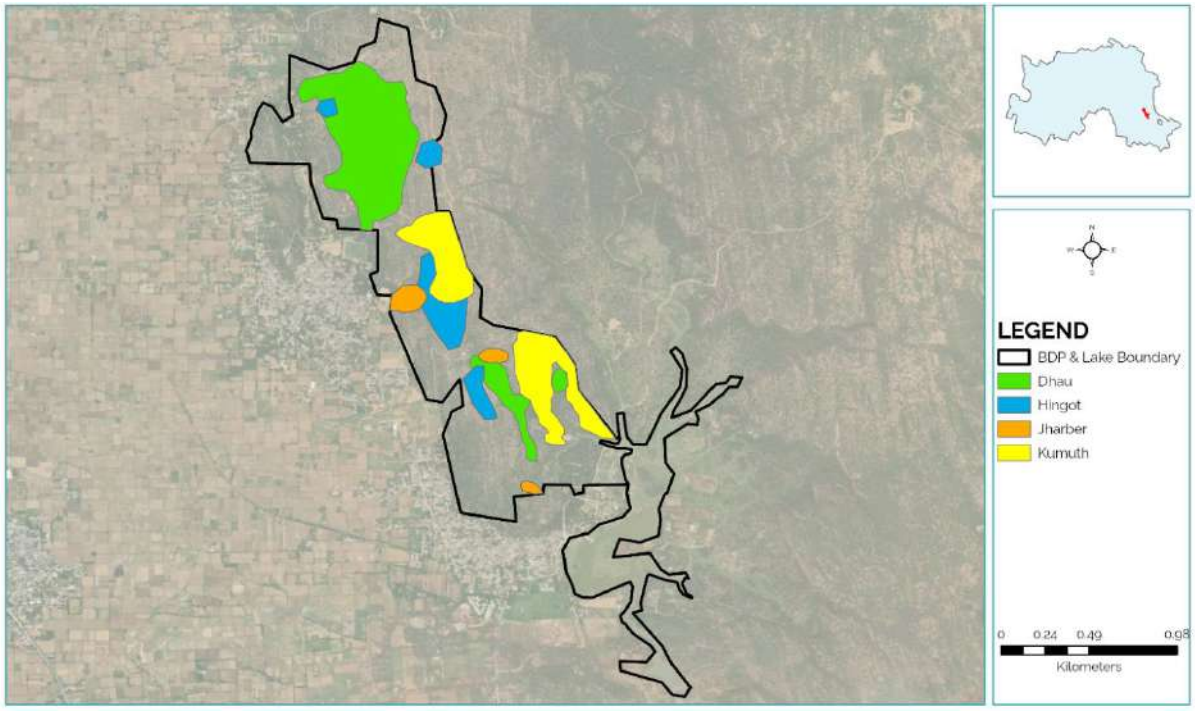


Figure 140: Forest Types

Indicative Number of Trees/Shrubs to be Planted

Current No. of trees individuals (all sizes)	2224 /ha
No. of trees (excluding vilayati keekar and hingot)	444/ha
Likely surviving trees	380/ha
Tree seedlings to be planted	320 / ha
Total area	173 ha
Total tree seedlings to be planted	55,484
Replacement planting (30%)	16645
Total Tree seedlings to be planted	72,129
Shrubs to be planted	45,081
Grass (seeds to be broadcast)	

Prioritize Grasses & Shrubs

Given the extensive degradation, particularly on the western slopes, it would be useful to initiate the succession process with seeding of grasses and shrubs, and especially those that provide habitat and food to local insects, birds & mammals.

Identify & Protect Special Micro-Habitats

- There are a range of micro-habitats in and around the site that are worthy of identification and protection. These provide specialist habitat for certain plant or animal species, and include e.g.:
    - Shallow seasonal pools (amphibians)
    - patches with high density or locally rare herbs, shrubs
    - Patches with older/heritage trees
    - archaeologically significant zones
- It is particularly important to identify such zones, so that their importance is recognized and included in the restoration zoning plan, and they are not inadvertently lost to extensive planting.

Allocate Areas for Fuelwood, Grazing

- The site is part of the panchayat lands of two villages and the village residents have a long association with these hills. There is also a considerable dependence on these areas for fuelwood collection and also for grazing. Discussions with fuelwood collectors suggested that while LPG gas connections are now available in most homes, it is still seen as luxury, for emergency or social use (guests, etc) and meets a small fraction of the domestic cooking energy needs.

- In such a scenario for the foreseeable future it would be realistic to allocate a part of the areas for fuelwood collection and grazing, while closing off the bulk of the area for regeneration. This area can be rotated over time.
- A win-win approach can be tried, where labour for site restoration is recruited from among the fuelwood collectors, and they are oriented to remove the invasive species for fuelwood use, which they collect anyway, but can now do so in a more systematic manner.

Smoothen Access for Alternate Energy Sources

At the same time, it is imperative to assess the basket of domestic energy sources and mechanisms that are in use in these two villages and undertake a participatory process of trying and enabling the use of alternatives that reduce drudgery and dependence on the forest. This would make the closure of the hill areas more acceptable and reduce their opportunity costs.

Replacement of invasive weeds

- To maintain and enhance the scope of the native biodiversity, invasive exotic weeds should be slowly replaced in a phased manner.
- Invasive exotic weeds create allelopathic conditions for native species, especially for grasses, herbs and low-heighted plants. In due course of time, number of native species starts decreasing and their space is gradually occupied by the invasive species. They are prolific seed producers, having efficient seed dispersal mechanisms. Detailed guidelines/suggestions for the same are provided separately in the box below.

Recommendations for the Lake side zone

- Removal of invasive species – primarily *Parthenium hysterophorus* – Gajar ghas, from around the lakebed area – this will give an opportunity for local species to regenerate and repopulate the area.
- Prevent dumping of remains from puja ceremonies. The lake side closer to the embankment is littered with such waste and needs to be cleared and controlled.
- There is some input of wastewater from local settlements – this needs to be treated before entry into the lake.

Waste

The recommendations outline a comprehensive approach to waste management through an Information, Education, and Communication/Behaviour Change Communication (IEC/BCC) Campaign targeting community behaviour. The key strategies involve building the capacity of Gram Panchayat (GP) functionaries and key stakeholders, enhancing infrastructure, streamlining waste collection, transportation, and processing, and establishing an effective monitoring system to ensure sustainability.

Note: General instructions before starting work on controlling invasive plants:

a. *Replacement should be done prior to the flowering season of the plant, and if late, before fruit ripening surely.*
b. *Cutting and burning should be avoided. The plants should be removed by uprooting. Cutting method is not desirable because the left out underground part of the collar zone or root may sprout again. Weeds are good coppices too; hence their stump will likely produce a flush of many shoots in the next growing season.*
c. *Uprooting is easier during the rainy season when the soil strata become wet and pulling of the root is relatively easier.*
d. *Replacement should be done is a phased manner, rather than in the whole landscape at a time, as it may increase soil erosion and disturb many species of wildlife.*
e. *In hilly areas, invasive plants should be removed from top to bottom direction.*
f. *If agricultural fields or human habitations are present near the foothills, a ditch may be excavated at the foothill areas to function as a "weed seed trap" for the seeds of weeds moving down with the runoff during the rainy season.*
g. *In the plains, removal should be done from the centre to the periphery direction.*
h. *Periphery strip can be used as a 'live fencing' for a few years till the inner eradicated zone is restored with the help of native species.*
i. *Removal should be followed by replacement – via massive sowing of native grasses, herbs and shrubs. Tree planting of suitable local tree species can be done simultaneously. This is critical as nature does not like a vacuum – leaving the area unattended will result in the same or new invasive species occupying the area.*
j. *Post removal, mopping up would be essential in the next 3-4 years in the rainy seasons, to remove any left over and re-growth and recruitment of the weed species.*
k. *It is desirable to follow a Landscape approach. Removal from a small patch only will likely result in migration of the same species from the surrounding areas into the 'vacant patch'.*

The interventions are anticipated to yield multifaceted positive impacts.

- A significant shift in villagers' behaviour, leading to the elimination of waste burning and dumping is expected. This behavioural change is anticipated to have a direct positive impact on the environment by reducing pollution and promoting cleaner practices.
- The intervention is projected to sensitize over 15,000 individuals across the three villages, fostering awareness about waste management and its proper practices.
- Approximately 2,500 households are expected to adopt source segregation, maximizing resource recovery. This includes diverting an estimated 200 kilograms of dry waste per day from landfills, contributing to a reduction in overall waste and promoting sustainable waste management.
- Wet waste will be composted and utilized as fertilizers in the villages, promoting organic farming practices and minimizing the environmental impact of waste disposal.

- The recovery of land that was previously used as dump points will not only reduce the visual and environmental impact of waste but also contribute to eco-restoration, transforming these areas into green, usable spaces.
- The initiative aims to bring about a reduction in greenhouse gas emissions and air pollution associated with improper waste disposal methods like burning leading to improvement in Environmental Quality.
- Alignment with National and Global Initiatives: The proposed waste management initiative aligns with India's Swachh Bharat Abhiyan, contributing to the national mission for a cleaner and healthier environment. It also aligns with Sustainable Development Goals (SDGs) 11 (Sustainable Cities and Communities), 12 (Responsible Consumption and Production), and 13 (Climate Action), showcasing a commitment to global sustainability objectives.

Social

The recommendations based on the outcome of the survey conducted with 40 households regarding their perception of the socio-political context are delineated below:

- **Rural Livelihoods** -Project initiatives should be meticulously designed to focus on enhancing livelihoods and socio-economic security of rural livelihoods.
- **Income Generation** -Strengthening economic ties by facilitating connections between agroforestry farmers and key stakeholders such as markets, industries, and banks. Emphasising on implementing income generation initiatives tailored to benefit and empower women within the community.
- **Local Agrarian Practices-** Community-based irrigation practices not only exemplify pre-existing synergies within the community but also highlight the potential for further development among community members in executing a shared vision for ecological conservation.
- **Cultural and Ritual Practices**-Underscoring cultural, intellectual, and spiritual dimensions in fostering community engagement for sustainable and inclusive resource management as one of the objectives of the BPD Project. Examining the expansion of the cultural economy and the spiritual enrichment of existing initiatives.
- **Social Cohesion and Recreational services**- Given the critical role of public spaces in fostering social unity, alleviating tensions, promoting urban diversity, and facilitating coordinated economic and cultural development, the project should prioritize the establishment of accessible walkways, well-paved paths, landscaped gardens, and designated social spaces. This initiative aims to create inviting environments where community members can freely stroll, exercise, and enjoy picturesque views.

- **Social Infrastructure** - The project can leverage people's social engagements to strengthen social bonds. Initiatives focused on cultural events, educational programs, and community gatherings within these ecological spaces could contribute to fostering a sense of belonging and pride. The project can explore ways to integrate local history and narratives into the interpretation of these spaces, creating educational and heritage value.
- **Resistances and Movements**- Conducting a thorough needs assessment to understand the daily life of the community, coupled with a longitudinal ethnographic study, aims to delve into the roots of existing socio-economic inequalities and their connection with ecological resources. The project should aim to establish a platform for amplifying the voices of the most vulnerable communities in the region, specifically in relation to ecological systems, their utilization, and inherent value.
- **Environment Aesthetics and Aspirations**- Investing in ecological art and aesthetic initiatives to enhance community engagement and promote environmental consciousness. Drawing inspiration from successful models near pilgrimage sites, these initiatives can create visually appealing spaces.
- **Waste Infrastructure** - Reimagining peri-urban interface for waste management systems. Conducting institutional and governmental stakeholder engagements for guiding waste disposal in peri-urban development.

Governance

Table 29: Mapping of all the Stakeholder Based on the Different Activities along with their Role and Priority Areas

Activity	Stakeholder	Role	Priority
Lake Rejuvenation	Haryana Tourism Department	Providing NoC & Integrating the Eco-Tourism & water sports activities in the Lake	High
	IWRD, Haryana	Collaboration for Wastewater Pipeline and allied interventions for the Lake	High
	Haryana Pond Authority	Reviewing the Lake Treatment Plan	Medium
	Revenue Department	Demarcation of the Lake Boundaries	High
	Namami Gange	Provide Technical Assistance	High
Biodiversity Park	MOEF&CC	Align project with the Greenwall project	Medium
	Haryana Forest Department	MoU signing, NOC for the project execution work in BDP and Lake's catchment area	High
	Haryana State Biodiversity Board	Activation of Biodiversity Management Committee	Medium
Intervention in Villages	Panchayat Department	Granting permission for any village level intervention, collaborating for joint projects	Low

	Gram Panchayat	Supporting daily basis interventions, Long-term ownership of the projects	High
	Local NGOs	Collaboration for skill-development & providing better health facilities in the region	Low
	National Rural Livelihood Mission	Providing self-employment and entrepreneurship opportunities to local women	Medium
Prevention of Diversion of Wastewater	Irrigation & GMDA	Diverting treated water from Behrampur STP to the villages	High
	Media & Activist	Collaborating for scientific protection and preservation of Aravalli's	Low
Model Village	Haryana Water Resource Department	Collaborating for the proposed interventions in the 3 villages for aquifer management	Medium
	Ministry of Rural Development	Demonstrating the Carbon Neutral & Water Positive Villages	Medium
Sustainability Plan	Architect & Experts	Integrating the community aspects in the project design	High

Table 30: Strategy Outline for the Next Phase of the Project

S.No.	Steps	Aim	Expected Outcomes	Timelines
1	Introduction	1. Introducing the Project Concept 2. Alignment with the Department's/National priority areas & Benefit to the Department & State 3. Support required from the Department to make the project successful 4. Seeking name suggestions: "Drona Van" - India's best community-based Eco restoration site in NCR	1.Clear understanding and acceptance of the project concept. 2. Alignment of the project with departmental and national priority areas established. 3. Department's commitment to support the project recognized. 4. Name suggestions for the project "Drona Van" generated and evaluated.	April
2	Rapport Building	1. Understanding the chain of command for every department 2. Identifying champions pro-project in each department & ministry 3. Identifying the best people for Technical Committee 4. Getting the notings started for the various departmental works	1.Identified hierarchy and key decision-makers within each department. 2. Champions for the project identified and engaged within each department. 3. Technical Committee members selected based on expertise and relevance. 4. Initial steps taken to initiate departmental cooperation and support.	May
3	Initiating Paperwork	1. Seeking approvals for the NOC/MoU, Name of the Project, Technical Committee Members 2. Setting context for the	1. Project officially anchored within the department's framework.	

		World Environment Day Celebration, anchoring the project		
4	Draft NOCs/ MoUs/ Technical Committee	1. Submitting the Draft NOC for the Government approvals 2. Seeking feedback and incorporating changes 3. Liasoning with Officers from bottom to top	1. MoU signing, and NOC obtained from 4 major departments that is Forest, Tourism, Water Resources and Pond Authority	
5	Follow-ups	1. Revising the strategy in case of transfers 2. Expediting the consent 3. Clarification and seeking comments from various stakeholders 4. Finalising Roundtable Details, confirming the speakers & themes	1.Contingency plan in place for personnel transfers. 2. Roundtable details finalized with confirmed speakers and themes.	June
6	Roundtable	1. Introducing the project 2. Getting comments from sector experts 3. Showcasing the project at national level 4. Media coverage and announcements 5. Initiating discussion on Combating desertification at National Level 6. Sessions on Policy, Finance, Technology, Communications, Human Resource Development 7. Sharing a benchmark and guidance manual/SOP for India's Green Wall Project - scientific Baseline	To provide a platform for diverse stakeholders to share knowledge, exchange insights on effective strategies for preserving and restoring our natural ecosystems. The conference will bring together experts from academia, government agencies, non-governmental organizations, research institute and industry to discuss the latest research, policies, and practices in the field of forest and biodiversity conservation.	
7	Formal Consent: 1. MoU Signing 2. Freezing Technical Committee Members 3. Review Format & Timelines	Preferably to be done on 5th June itself during the Roundtable	1.MoU signed with all the concern departments 2.Finalisation of roles and responsibilities of the technical committee members 3.Review format and timelines established	July
8	Monthly Check-ins	1. One-pager WhatsApp updates to the Broadcast List 2. Emails to the official email Ids	Regular updates provided to all the associated departments	Monthly
9	Technical Committee Meetings	1. Chaired by Mr. Devinder Singh, IAS 1987 / Ms. Keshni Anand Arora, IAS 1983 2. Standard update and	1.Effective leadership provided by designated chairpersons. 2.Progress updates and	Quarterly

		review PPT 3. Identifying the division of Roles and Responsibilities, setting deadlines 3. Seeking comments from all stakeholders	reviews conducted. 3.Clear roles and responsibilities assigned with set deadlines. 4.Feedback sought and incorporated from stakeholders.	
10	Updates & Reviews	1. Quarterly meeting with all key National, State and District officials		Monthly
11	Quarterly Media Publications	1. Writing an editorial column, aligned with the National/International priorities, giving example of our work in the proposed project area		Quarterly
12	Annual Publications	1. Summary for the year's deliverables, a copy with the project details to be sent to all stakeholders in collaboration with EYF and Nodal Govt. Departments	Summary of yearly deliverables compiled and shared with stakeholders.	Annual
13	Mid-term Roundtable	1. Synthesising the project plans, finding and achievements 2. Sharing the plan of action for future 3. Publishing a best-case report in collaboration with the relevant Central Ministry (NIUA/NITI Aayog/ JSM/ MoEF&CC	1.Project plans synthesized, and achievements highlighted. 2.Future action plan discussed and shared. 3. Best case report published in collaboration with relevant central ministry	

Chapter 5: Next Step

Baseline study, which is required to assess the current environment, social and governance aspect of the project area is completed to prepare the final detailed project report of the project. Immediate next step will be.

- Exploring Collaboration
- Summer Season Floral Survey
- Architectural Drawings of Project Area
- Civil Drawings of Project Area
- Bill of Quantities
- Information Education and Communication
- Economic Valuation of Project Area
- Roundtable Discussion with Experts
- Final Detailed Project Report

Chapter 6: Project Timelines

Immediate Next Step Timeline

Scope of Work	April	May	June	July	Aug	Sept	Oct
	Phase - II (April - August 2024)						
Detailed Project Report							
Architectural Drawings							
Civil Drawings							
Bill of Quantities							
Preparation of Draft Detailed Project Report							
Final Detailed Project Report							
NOCs from Tourism & Forest Departments							
Technical & Financial Committee Formulation							
Demarcation of Natural Channels during Monsoons							
Baseline ++ (Summers & Monsoon Flora & Fauna)							
Seed Collection							
Economic Valuation Studies							
Community Mobilization + WeForWater Fellowship							
Media & Activism Management Plan							
EYF Ripples (EVPs)							
Roundtable (5th June: Land Restoration & Desertification)							
Monitoring & Evaluation Plan							
Collaborations & Vendor Engagement for on-ground Implementation							
RFPs/Collaborations for: 1. Lake Restoration & Landscape Work 2. Educational & Interpretation Centres 3. Village level Interventions - Ponds, RWHs etc. 4. Nursery Development & Afforestation Programs 5. Catchment Area Interventions							
Supervision Checklist + KPIs							
Vendor/Collaboration MoUs Drafting							
Vendor Finalisation/ Collaborations							

Lake Rejuvenation Timeline

S.No.	Activities Name	Months							
		June '23 - Apr '24	4 Months	4 Months	6 Months	6 Months	6 Months	6 Months	12 Months
1	Baseline Studies (Hydrology, Biodiversity, Waste, Climate, Land, Governance etc.)								
2	Architectural Drawings								
3	Civil Drawings								
4	Bill of Quantities								
5	Preparation of Draft Detailed Project Report								
6	Final Detailed Project Report								
7	Floatation of RFP for Work								
8	Vendor Finalisation								
9	Work Allotment								
10	Cleaning & Removal of Rank Vegetation & Unwanted Shrub Periphery of Lake including solid/plastic waste								
11	Dewatering of Lake (Stage 1)								
12	Dredging/Desilting of Lake (Stage 1)								
13	Dredging/Desilting of Lake (Stage 2)								
14	Dressing/ Trimming of Earthern Bund on periphery of the Lake								
15	Slope Protection on front side of the Lake								
16	Levelling, Compaction of Land Surface, Dressing and Trimming								
17	Catchment area treatment								
18	GI/MS Fencing around the walkway of the Lake								
19	Fencing of Brickwork and Blade wire with angle on the open point near and around the Lake								
20	Laying of Turfs on Land (Green Area)								

21	Painting on the Walls and MS Items								
22	MS Iron Gates installation on entry & exit point								
23	Laying of pipeline for Sprinkler system								
24	Providing and Installing Recreational Elements								
25	Fixing of Solar Street Lights								
26	Stone/Tiles Pavements in lake front								
27	Cycle Track around the periphery of the Lake								
28	Service area development								
29	Plantation of shrubs and trees								
30	Miscellaneous/ Last Finishing Work								
31	Providing and Planting Aquatic Plants with 3 months of maintenance								
32	Community Mobilisation (IEC)								
33	Yearly Study								
34	Operation & Maintenance								

Development of Biodiversity Park Timeline

S.No.	Activities Name	Years									
		1	2	3	4	5	6	7	8	9	10
1	Baseline Studies (Hydrology, Biodiversity, Waste, Climate, Land, Governance etc.)										
2	Architectural Drawings										
3	Civil Drawings										
4	Bill of Quantities										
5	Preparation of Draft Detailed Project Report										
6	Final Detailed Project Report										
7	Floatation of RFP for Work										
8	Vendor Finalisation										

9	Work Allotment										
10	Seed Collection										
11	Nursery Development										
12	Creation of Zones										
13	Cleaning of unrank vegetation										
14	Water Conservation Activities (Creation of pools)										
15	Soil Conservation Work										
16	Manuring of the Land										
17	Laying of pipeline for Sprinkler system										
18	Pruning of Plants										
19	Plantation of shrubs, trees and grasses										
20	Development of walking trails										
21	GI/MS Fencing around walking trail and BDP area										
22	Uprooting of unrank vegetation										
23	MS Iron Gates installation on entry & exit point										
24	Providing and Installing Recreational Elements										
25	Fixing of Solar Street Lights										
26	Stone/Tiles Pavements in entry and exit gate										
27	Service area development										
28	Miscellaneous/ Last Finishing Work										
29	Yearly Study										
30	Community Mobilisation (IEC)										
31	Operation & Maintenance										

Chapter 7: References

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Chapter 8: Annexures

Annexure 1: List of Plants Encountered at the Site - Trees, Shrubs, Herbs and Climbers

*H= Herb, S=Shrub, C= Climber, T= Tree

S no. By Veg Type	S. No. Spp & Family	S.No. Family	Family	Species	Local name	Habit (Veg. Type) *
1	8	2	Capparaceae	*Crateva adansonii subsp. odora*	Barna	T
2	10	3	Salicaceae	*Flacourtia indica*	khatai	T
3	30	8	Bombacaceae	*Bombax ceiba*	Semal	T
4	40	11	Zygophyllaceae	*Balanites aegyptiace*	Hingot	T
5	41	12	Simaroubaceae	*Ailanthus excelsa*	Ullu	T
6	42	13	Burseraceae	*Boswellia serrata*	Salai	T
7	43	14	Meliaceae	*Azadirachta indica*	Neem	T
8	44	15	Celastraceae	*Maytenus senegalensis (M. emarginatus)*	Kankeda	T
9	46	17	Rhamnaceae	*Ziziphus mauritiana*	Ber	T
10	48	17	Rhamnaceae	*Ziziphus glabrata*	Ber	T
11	52	20	Moringaceae	*Moringa oleifera*	Senjna	T
12	53	20	Moringaceae	*Moringa concanensis*	Senjna	T
13	57	21	Fabaceae	*Butea monosperma*	Dhak	T
14	61	21	Fabaceae	*Dalbergia sissoo*	Shisam	T
15	76	22	Caesalpiniaceae	*Cassia fistula*	Amaltas	T
16	81	23	Mimosaceae	*Acacia catechu*	Khair	T
17	82	23	Mimosaceae	*Acacia leucophloea*	Raunjh	T
18	83	23	Mimosaceae	*Acacia nilotica cupressiformis*	Desi Keekar	T
19	84	23	Mimosaceae	*Acacia nilotica indica*	Desi Keekar	T
20	85	23	Mimosaceae	*Acacia senegal*	Kumuth	T
21	86	23	Mimosaceae	*Acacia tortilis*	Israel Babool	T
22	87	23	Mimosaceae	*Albizia lebbeck*	Siris	T
23	88	23	Mimosaceae	*Albizia odoratissima*	Kala Siris	T
24	90	23	Mimosaceae	*Leucaena latisiliqua (L. leucocephala)*	Subabool	T
25	92	23	Mimosaceae	*Prosopis cineraria*	Khejdi	T
26	93	23	Mimosaceae	*Prosopis juliflora*	Vilayti Keekar	T
27	94	24	Combretaceae	*Anogeissus pendula*	Dhau	T
28	106	29	Rubiaceae	*Hymenodictyon excelsum*	Bhorsal	T

29	107	29	Rubiaceae	*Mitragyna purviflora*	Kaim	T
30	123	32	Ebenaceae	*Diospyros cordifolia*	Pasendu	T
31	129	34	Apocynaceae	*Wrightia tinctoria*	Khirna	T
32	130	34	Apocynaceae	*Wrightia tomentosa*	Dudhi	T
33	145	38	Ehretiacae	*Ehretia laevis*	Chamraudh	T
34	169	43	Bignoniaceae	*Tecomella undulata*	Roheda	T
35	220	54	Moraceae	*Ficus racemose*	Gular	T
36	221	54	Moraceae	*Ficus religiosa*	Pipal	T
37	222	54	Moraceae	*Ficus benghalensis*	Bargad	T
38	223	54	Moraceae	*Morus indica*	shehtoot	T
39	225	56	Ulmaceae	*Holoptelia integrifolia*	Papdi	T
40	234	59	Arecaceae	*Phoenix sylvestris*	Khajur	T
41	5	2	Capparaceae	*Capparis decidua*	Kair	S
42	6	2	Capparaceae	*Capparis sepiaria*	Heens	S
43	35	9	Tiliaceae	*Grewia flavescens*	Aatan	S
44	36	9	Tiliaceae	*Grewia tenax*	Grewia tenax	S
45	47	17	Rhamnaceae	*Ziziphus nummularia*	Jhadber	S
46	89	23	Mimosaceae	*Dichrostachys cinerea*	Goya khair	S
47	91	23	Mimosaceae	*Mimosa hamata*	Babula	S
48	102	26	Cactaceae	*Opunita dillenii*	Nagfani	S
49	122	31	Plumbaginaceae	*Plumbago zeylanica*	Chitrak	S
50	125	34	Apocynaceae	*Carissa spinarum*	Jungli Karondha	S
51	131	35	Asclepiadiaceae	*Calotropis procera*	Aakh	S
52	160	41	Solanaceae	*Lycium barbarum*	Gujhi	S
53	168	43	Bignoniaceae	*Tecoma stans*	(escape)	S
54	173	46	Acanthaceae	*Adhatoda zeylanica*	Bansa	S
55	174	46	Acanthaceae	*Barleria prionitis*	Kanteela Bansa	S
56	187	47	Verbenaceae	*Clerodendrum phlomidis*	Arni	S
57	188	47	Verbenaceae	*Lantana camara*	Lantana	S
58	189	47	Verbenaceae	*Vitex negundo*		S
59	217	53	Euphorbiaceae	*Flueggia leucopyrus (Securinega leucopyrus)*	Dhaulia	S
60	218	53	Euphorbiaceae	*Jatropha curcas*	Jatrupa	S
61	7	2	Capparaceae	*Cleome viscosa*		H
62	11	4	Polygalaceae	*Polygala erioptera*		H
63	12	5	Caryopyllaceae	*Polycarpaea corymbosa*		H
64	13	5	Caryopyllaceae	*Spergula fallax*		H
65	14	5	Caryopyllaceae	*Stellaria media*		H
66	15	6	Portulacaceae	*Portulaca oleracea*	Nunkhara	H
67	16	6	Portulacaceae	*Portulaca pilosa*	Fulwadi	H
68	17	7	Malvaceae	*Abutilon indicum*	Kanghi	H
69	18	7	Malvaceae	*Abutilon ramosum*		H

70	19	7	Malvaceae	*Hibiscus ovalifolius, Syn. Hibiscus micrantha,*		H
71	20	7	Malvaceae	*Hibiscus lobatus*		H
72	21	7	Malvaceae	*Hibiscus talbotii*		H
73	22	7	Malvaceae	*Malvastrum coromandelianum*		H
74	23	7	Malvaceae	*Pavonia zeylanica*		H
75	24	7	Malvaceae	*Sida cordata*	Birmi	H
76	25	7	Malvaceae	*Sida acuta*		H
77	26	7	Malvaceae	*Sida cordifolia*	Bala	H
78	27	7	Malvaceae	*Sida rhombifolia*		H
79	28	7	Malvaceae	*Sida spinosa*		H
80	29	7	Malvaceae	*Urena lobata*		H
81	31	9	Tiliaceae	*Corchorus capsularis*		H
82	32	9	Tiliaceae	*Corchorus aestuans*		H
83	33	9	Tiliaceae	*Corchorus fascicularis*		H
84	34	9	Tiliaceae	*Corchorus trilocularis*		H
85	37	9	Tiliaceae	*Triumfetta rbomboidea*		H
86	38	9	Tiliaceae	*Triumfetta routumdifolia*		H
87	39	10	Zygophyllaceae	*Tribulus terrestris*		H
88	45	16	Oxalidaceae	*Oxalis corniculata*		H
89	50	18	Vitaceae	*Cayratia trifolia*		H
90	56	21	Fabaceae	*Alysicarpus monilifer*		H
91	58	21	Fabaceae	*Clitoria biflora*		H
92	59	21	Fabaceae	*Crotalaria burhia*		H
93	60	21	Fabaceae	*Crotalaria medicagenea*		H
94	62	21	Fabaceae	*Desmodium gengeticum*		H
95	63	21	Fabaceae	*Indigofera cordifolia*		H
96	64	21	Fabaceae	*Indigofera linnaei*		H
97	65	21	Fabaceae	*Indigofera tinctoria*		H
98	66	21	Fabaceae	*Melilotus indica*		H
99	68	21	Fabaceae	*Tephrosia pumila*		H
100	69	21	Fabaceae	*Tephrosia purpurea*		H
101	70	21	Fabaceae	*Tephrosia strigosum*		H
102	71	21	Fabaceae	*Tephrosia uniflora*		H
103	72	21	Fabaceae	*Tephrosia villosa*		H
104	73	21	Fabaceae	*Trigonella monantha*		H
105	74	21	Fabaceae	*Vigna radiata*		H
106	75	22	Caesalpiniaceae	*Cassia phyllodinea*		H
107	77	22	Caesalpiniaceae	*Cassia obtusifolia*		H
108	78	22	Caesalpiniaceae	*Cassia occidentalis*		H
109	79	22	Caesalpiniaceae	*Cassia pumila*		H
110	80	22	Caesalpiniaceae	*Cassia tora*		H

111	103	27	Molluginaceae	*Glinus lotoides*		H
112	104	28	Ficoidaceae	*Trianthema portulacastrum*		H
113	105	29	Rubiaceae	*Borreia pusilla*		H
114	108	30	Asteraceae	*Blumea mollis*		H
115	109	30	Asteraceae	*Echinops echinatus*		H
116	110	30	Asteraceae	*Glossocardia bosvallea*		H
117	111	30	Asteraceae	*Gnaphalium polycaulon*		H
118	112	30	Asteraceae	*Launnea procumbens*		H
119	113	30	Asteraceae	*Oligochaeta ramosa*		H
120	114	30	Asteraceae	*Parthenium hysterophorus*	Gajar ghas	H
121	115	30	Asteraceae	*Pullicaria angustifolia*		H
122	116	30	Asteraceae	*Sonchus oleraceus*		H
123	117	30	Asteraceae	*Synedrella vialis*		H
124	118	30	Asteraceae	*Tridax procubens*		H
125	119	30	Asteraceae	*Verbesina encelioides*		H
126	120	30	Asteraceae	*Vernonia cinerea*	Sehdevi	H
127	121	30	Asteraceae	*Xanthium strumarium*		H
128	126	34	Apocynaceae	*Catharanthus roseus*	(escape)	H
129	138	36	Gentianaceae	*Enicostema axillare*		H
130	139	37	Boraginaceae	*Arnebia hispidissima*		H
131	140	37	Boraginaceae	*Heliotropium ellipticum*		H
132	141	37	Boraginaceae	*Heliotropium strigosum*		H
133	142	37	Boraginaceae	*Heliotropium subulatum*		H
134	143	37	Boraginaceae	*Sericostoma pauciflorum*		H
135	144	37	Boraginaceae	*Trichodesma amplexicaule*		H
136	146	39	Cuscutaceae	*Cuscuta reflexa*		H
137	147	40	Convolvulaceae	*Convolvulus arvensis*		H
138	148	40	Convolvulaceae	*Convolvulus microphyllus*		H
139	149	40	Convolvulaceae	*Evolvlus alsinoides*		H
140	158	41	Solanaceae	*Datura innoxia*		H
141	159	41	Solanaceae	*Datura metal*		H
142	161	41	Solanaceae	*Nicotiana plumbiginifolia*		H
143	162	41	Solanaceae	*Physalis angulata*		H
144	163	41	Solanaceae	*Physalis maxima*		H
145	164	41	Solanaceae	*Solanum incanum*		H
146	165	41	Solanaceae	*Solanum nigrum*		H
147	166	41	Solanaceae	*Solanum surattensis*		H
148	167	42	Martyniaceae	*Martynia annua*		H
149	170	44	Pedaliaceae	*Pedalium murex*	Bada gokhru	H
150	171	44	Pedaliaceae	*Sesamum indicum*		H
151	172	45	Scrophulariaceae	*Lindenbergia indica*		H

152	175	46	Acanthaceae	*Barleria cristata*		H
153	176	46	Acanthaceae	*Blepharis repens*		H
154	177	46	Acanthaceae	*Blepharis maderaspatensis*		H
155	178	46	Acanthaceae	*Dicliptera verticillata*		H
156	179	46	Acanthaceae	*Dipteracanthus patulus*		H
157	180	46	Acanthaceae	*Elytraria acaulis*		H
158	181	46	Acanthaceae	*Indoneesiella echioides*		H
159	182	46	Acanthaceae	*Justicia procumbens*		H
160	183	46	Acanthaceae	*Justicia simplex*		H
161	184	46	Acanthaceae	*Lepidagathis cristata*		H
162	185	46	Acanthaceae	*Persitrophe paniculata*		H
163	186	46	Acanthaceae	*Ruellia tuberosa*		H
164	190	48	Lamiaceae	*Leucas aspera*		H
165	191	48	Lamiaceae	*Leucas diffusa*		H
166	192	48	Lamiaceae	*Ocimum americanum*		H
167	193	48	Lamiaceae	*Salvia santolinifolia*		H
168	194	49	Nyctaginaceae	*Boerhavia diffusa*	Saati	H
169	195	49	Nyctaginaceae	*Commicarpus chinensis*		H
170	196	50	Amaranthaceae	*Achyranthes aspera*	Lath jeera/ ulta kanta	H
171	197	50	Amaranthaceae	*Aerva lanata*		H
172	198	50	Amaranthaceae	*Aerva javanica*		H
173	199	50	Amaranthaceae	*Alternanthera sessilis*		H
174	200	50	Amaranthaceae	*Amaranthus spinosus*		H
175	201	50	Amaranthaceae	*Digera muricata*		H
176	202	50	Amaranthaceae	*Gomphrena globosa*		H
177	203	50	Amaranthaceae	*Pupalia lappacea*		H
178	204	51	Chenopodiaceae	*Chenopodium album*		H
179	205	51	Chenopodiaceae	*Chenopodium murale*		H
180	206	52	Polygonaceae	*Polygonum plebeium effuse*		H
181	207	52	Polygonaceae	*Polyganum barbatum*		H
182	208	53	Euphorbiaceae	*Acalypha indica*		H
183	209	53	Euphorbiaceae	*Croton bonplandianum*		H
184	210	53	Euphorbiaceae	*Eupborbia chamaesyce*		H
185	211	53	Euphorbiaceae	*Eupborbia clarkeana*		H
186	212	53	Euphorbiaceae	*Eupborbia granulata*		H
187	213	53	Euphorbiaceae	*Eupborbia hirta*		H
188	214	53	Euphorbiaceae	*Eupborbia hypericifolia*		H
189	215	53	Euphorbiaceae	*Eupborbia prostate*		H
190	216	53	Euphorbiaceae	*Phyllanthus simplex*		H
191	219	53	Euphorbiaceae	*Phyllanthus amarus*		H
192	224	55	Cannabaceae	*Cannabis sativa*		H
193	226	57	Liliaceae	*Asfodelus tenuifolius*		H

194	228	57	Liliaceae	*Dipcadi montana*		H
195	229	57	Liliaceae	*Drimia indica*		H
196	230	58	Commelinaceae	*Commelina bengalensis*		H
197	231	58	Commelinaceae	*Commelina erecta*		H
198	232	58	Commelinaceae	*Commelina forskalei*		H
199	233	58	Commelinaceae	*Cynotis cristata*		H
200	235	60	Cyperaceae	*Cyperus kyllingia*		H
201	236	60	Cyperaceae	*Cyperus niveus*		H
202	237	61	Poaceae	*Apluda mutica*		H
203	238	61	Poaceae	*Aristida odscensionis*		H
204	239	61	Poaceae	*Bothriochloa pertusa*		H
205	240	61	Poaceae	*Cenchrus ciliaris*	safed dhaman	H
206	241	61	Poaceae	*Cenchrus setigerus*		H
207	242	61	Poaceae	*Chloris dolichostachya*		H
208	243	61	Poaceae	*Chrysopogon fulvus*		H
209	244	61	Poaceae	*Cynodon dectylon*	Doob grass	H
210	245	61	Poaceae	*Dactyloctenium aristatum*		H
211	246	61	Poaceae	*Dactyloctenium aegyptium*		H
212	247	61	Poaceae	*Dicanthium annulatum*		H
213	248	61	Poaceae	*Digitaria adscendens*		H
214	249	61	Poaceae	*Ehinochloa colona*		H
215	250	61	Poaceae	*Eleusine indica*		H
216	251	61	Poaceae	*Eragrestis ciliarias*		H
217	252	61	Poaceae	*Erogrestis japonica*		H
218	253	61	Poaceae	*Heteropogon contortus*		H
219	254	61	Poaceae	*Melanocenchris jacquemontii*		H
220	255	61	Poaceae	*Oplismenus burmanii*		H
221	256	61	Poaceae	*Oropetium thomaeum*		H
222	257	61	Poaceae	*Penicum miliare*		H
223	258	61	Poaceae	*Perotis indica*		H
224	259	61	Poaceae	*Saccharum bengalense*	Moonjh	H
225	260	61	Poaceae	*Setaria glauca*		H
226	261	61	Poaceae	*Setaria verticillata*		H
227	262	61	Poaceae	*Sporobolus ioclados*		H
228	1	1	Menispermaceae	*Cissampelos pareira*	paad bel	C
229	2	1	Menispermaceae	*Cocculus hirsutus*		C
230	3	1	Menispermaceae	*Cocculus pendulus*		C
231	4	1	Menispermaceae	*Tinospora cordifolia*	Giloy	C
232	9	2	Capparaceae	*Maerua oblongifolia*	Hemkand	C
233	49	18	Vitaceae	*Ampelocissus latifolia*		C

234	51	19	Sapindaceae	*Cardiospermum halicacabum*	Fafotan	C
235	54	21	Fabaceae	*Alysicarpus vaginalis*		C
236	55	21	Fabaceae	*Abrus precatorius*	Rattibel	C
237	67	21	Fabaceae	*Rhyncosia minima*		C
238	95	25	Cucurbitaceae	*Coccinia grandis*	Gul Kachri	C
239	96	25	Cucurbitaceae	*Cucumis melo agrestis*	Kachri	C
240	97	25	Cucurbitaceae	*Cucumis prophetarum*		C
241	98	25	Cucurbitaceae	*Luffa cylindrica*	Tori	C
242	99	25	Cucurbitaceae	*Momordica charantia*	Karela	C
243	100	25	Cucurbitaceae	*Mukia maderaspatana*		C
244	101	25	Cucurbitaceae	*Trichosanthes cucumerina*		C
245	124	33	Oleaceae	*Jasminum auriculatum*	Juhi	C
246	127	34	Apocynaceae	*Ichnocarpus frutescens*		C
247	128	34	Apocynaceae	*Vallaris solanacea*	Hadbel	C
248	132	35	Asclepiadiaceae	*Ceropegia bulbosa*		C
249	133	35	Asclepiadiaceae	*Oxystelma secamone*		C
250	134	35	Asclepiadiaceae	*Pentatropis spiralis*		C
251	135	35	Asclepiadiaceae	*Pergularia daemia*		C
252	136	35	Asclepiadiaceae	*Telosma pallida*		C
253	137	35	Asclepiadiaceae	*Wattakaka volubilis*	Dudhbel	C
254	150	40	Convolvulaceae	*Ipomoea eriocarpa*		C
255	151	40	Convolvulaceae	*Ipomoea nil*		C
256	152	40	Convolvulaceae	*Ipomoea obscura*		C
257	153	40	Convolvulaceae	*Ipomoea pes-tigridis*	Ghiyabati	C
258	154	40	Convolvulaceae	*Ipomoea sindica*		C
259	155	40	Convolvulaceae	*Ipomoea sinensis*		C
260	156	40	Convolvulaceae	*Merremia aegyptia*		C
261	157	40	Convolvulaceae	*Rivea hypocrateriformis*	phaang	C
262	227	57	Liliaceae	*Asparagus racemosus*	Shatvari	C

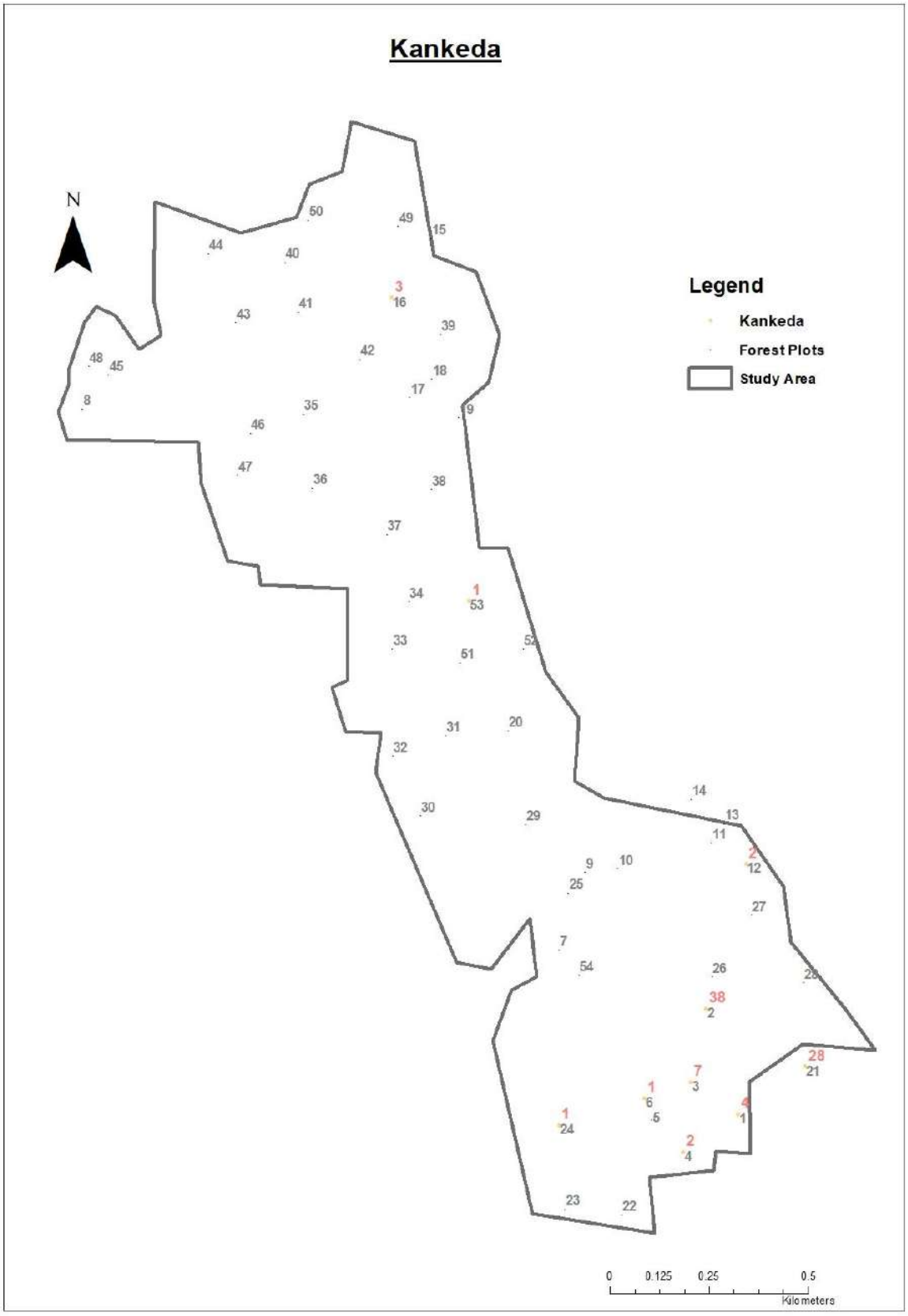
Annexure 2: Number of tree individuals (total across all plots)

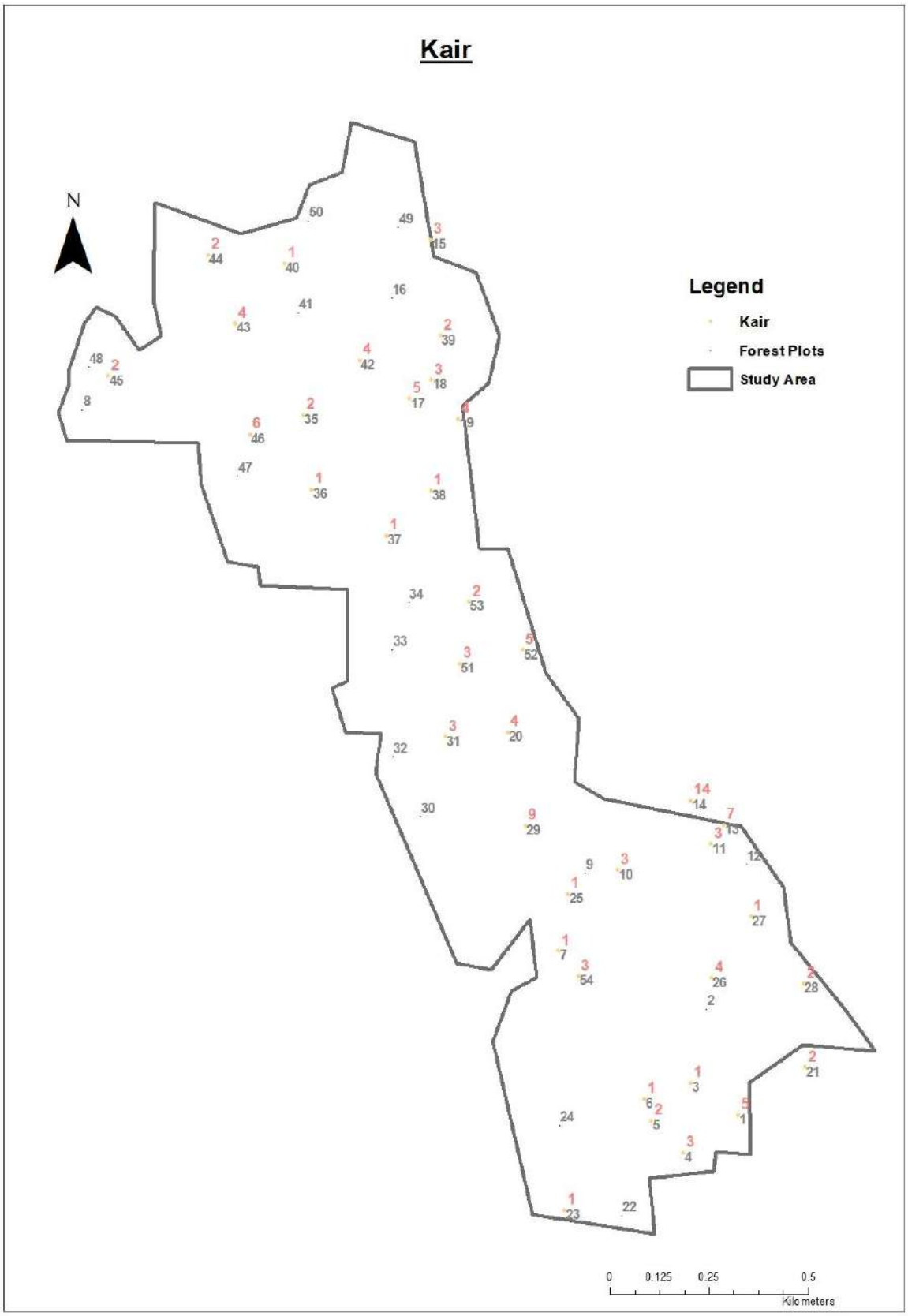
S.No.	Species	No. of Tree species individuals	Tree individuals per ha	% of total tree spp indiv	# of seedlings	# of saplings	bushy	Coppice trees	General tree	General Tree + Coppice tree	% of Tree (including coppice)	Total	Tall saplings with girth <5cm
1	Hingot	7672	1420.7	63.8%	5886	1383	0	138	265	403	12.4%	7672	291
2	Vilayti Keekar	1941	359.4	16.1%	66	182	0	1228	465	1693	52.0%	1941	638
3	Kumuth	630	116.7	5.25%	158	132	0	83	257	340	10.4%	630	70
4	Jungli Karondha	448	83.0	3.73%	124	125	0	110	89	199	6.1%	448	104
5	Dhau	435	80.6	3.62%	0	2	357	30	46	76	2.3%	435	37
6	Neem	163	30.2	1.36%	43	26	0	14	80	94	2.9%	163	21
7	Israel Babool	157	29.1	1.31%	23	29	0	24	81	105	3.2%	157	30
8	Raunjh	128	23.7	1.07%	9	10	0	15	94	109	3.3%	128	7
9	Kair	121	22.4	1.01%	6	31	0	61	23	84	2.6%	121	51
10	Papdi	121	22.4	1.01%	22	60	0	10	29	39	1.2%	121	19
11	Kankeda	87	16.1	0.72%	17	25	0	24	21	45	1.4%	87	22
12	Pasendu	42	7.8	0.35%	4	10	0	10	18	28	0.9%	42	6
13	Khejdi	19	3.5	0.16%	5	3	0	2	9	11	0.3%	19	1
14	Dhak	15	2.8	0.12%	0	0	0	8	7	15	0.5%	15	2
15	Goyakhair	15	2.8	0.12%	4	8	0	2	1	3	0.1%	15	0
16	Khinjaal	4	0.7	0.03%	0	1	0	0	3	3	0.1%	4	2
17	Subabul	3	0.6	0.02%	2	0	0	0	1	1	0.0%	3	0
18	Khatai	2	0.4	0.02%	0	0	0	1	1	2	0.1%	2	0
19	Khirna	2	0.4	0.02%	0	0	0	1	1	2	0.1%	2	0
20	Shisham	2	0.4	0.02%	0	1	0	0	1	1	0.0%	2	0
21	Siris	2	0.4	0.02%	0	0	0	0	2	2	0.1%	2	0
22	Khajoor	1	0.2	0.01%	0	1	0	0	0	0	0.0%	1	0
23	Ullu	1	0.2	0.01%	0	0	0	0	1	1	0.0%	1	0
	Total	12011	2224.259	100%	6369	2029	357	1761	1495	3256	100%	12011	1301

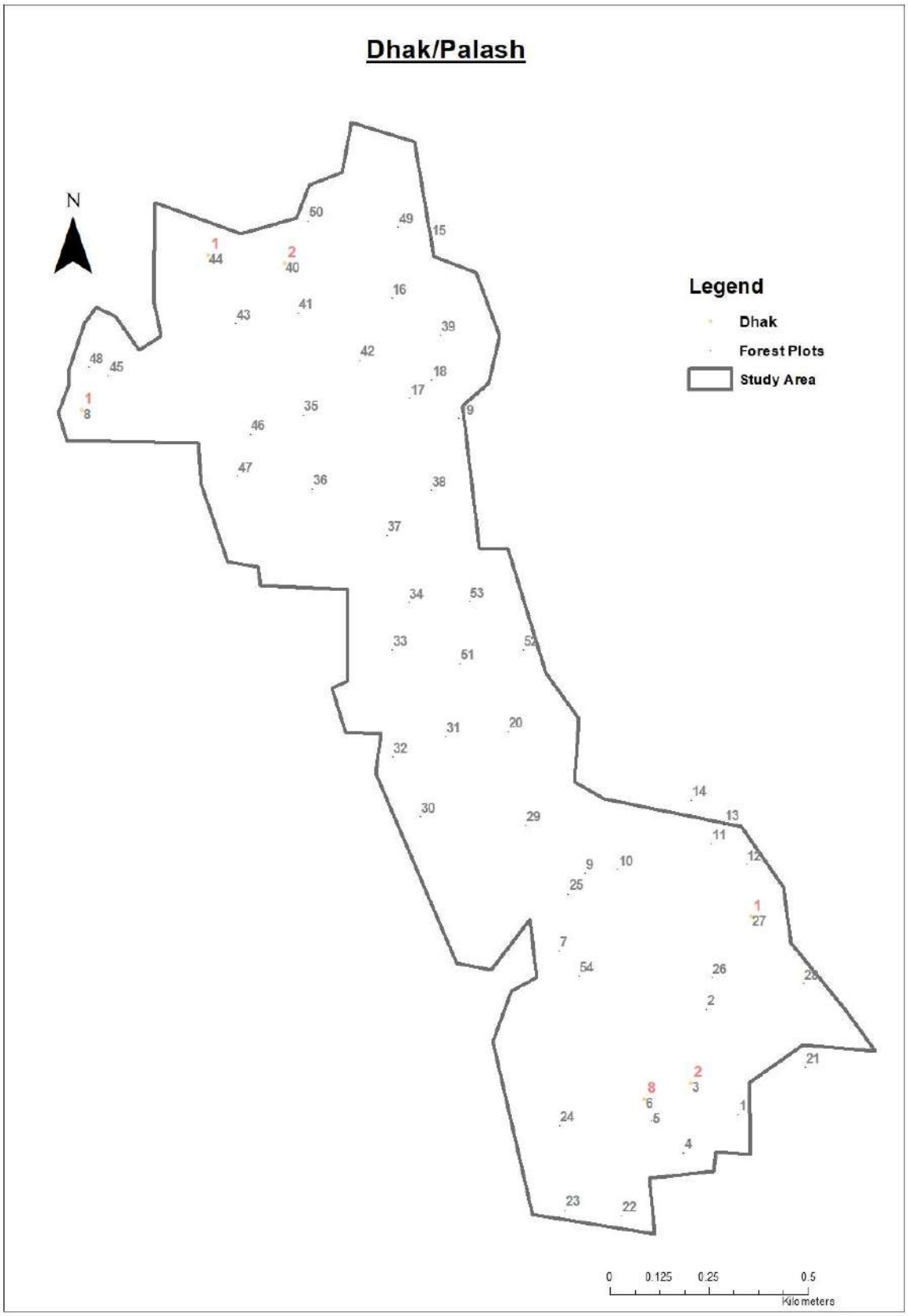
Annexure 3: Number of tree individuals across girth classes (total across all plots)

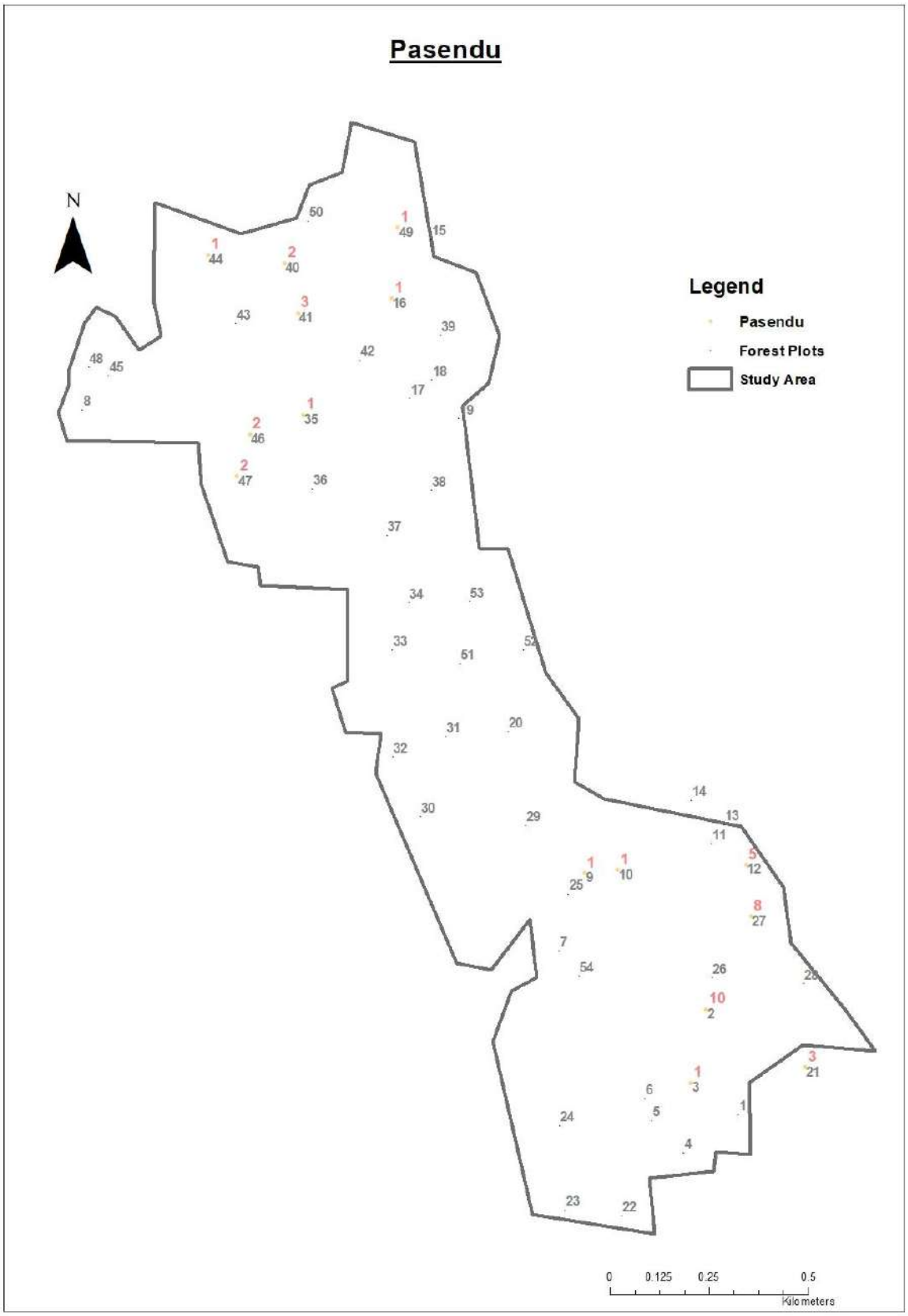
S.No.	Species	Total # of trees with girth <5cm stems	Total # of 5 to <15 cm girth Stems	Total # of 15 to 30 cm girth stems	Total # of 30 to 60 cm girth stems	Total # of 60 to 90 cm girth stems	Total # of 90 to 150 cm girth stems	Total # of 150 to 300 cm girth stems	Total
1	Hingot	291	91	13	6	0	0	0	401
2	Vilayti Keekar	638	972	84	12	1	3	0	1710
3	Kumuth	70	118	117	30	1	1	0	337
4	Jungli Karondha	104	85	6	0	0	0	0	195
5	Dhau	37	35	2	0	0	0	0	74
6	Neem	21	38	28	9	1	0	0	97
7	Israel Babool	30	30	25	12	4	5	0	106
8	Raunjh	7	25	38	32	1	2	0	105
9	Kair	51	28	3	0	0	0	0	82
10	Papdi	19	15	3	2	0	0	0	39
11	Kankeda	22	21	2	0	0	0	0	45
12	Pasendu	6	18	3	1	1	0	0	29
13	Khejdi	1	6	4	0	0	0	0	11
14	Dhak	2	9	4	1	0	0	0	16
15	Goyakhair	0	2	1	0	0	0	0	3
16	Khinjaal	2	1	0	0	0	0	0	3
17	Subabul	0	1	0	0	0	0	0	1
18	Khatai	0	1	0	1	0	0	0	2
19	Khirna	0	2	0	0	0	0	0	2
20	Shisham	0	0	1	0	0	0	0	1
21	Siris	0	2	0	0	0	0	0	2
22	Khajoor	0	0	0	0	0	0	0	0
23	Ullu	0	0	0	0	0	1	0	1
	Total	1301	1500	334	106	9	12	0	3262

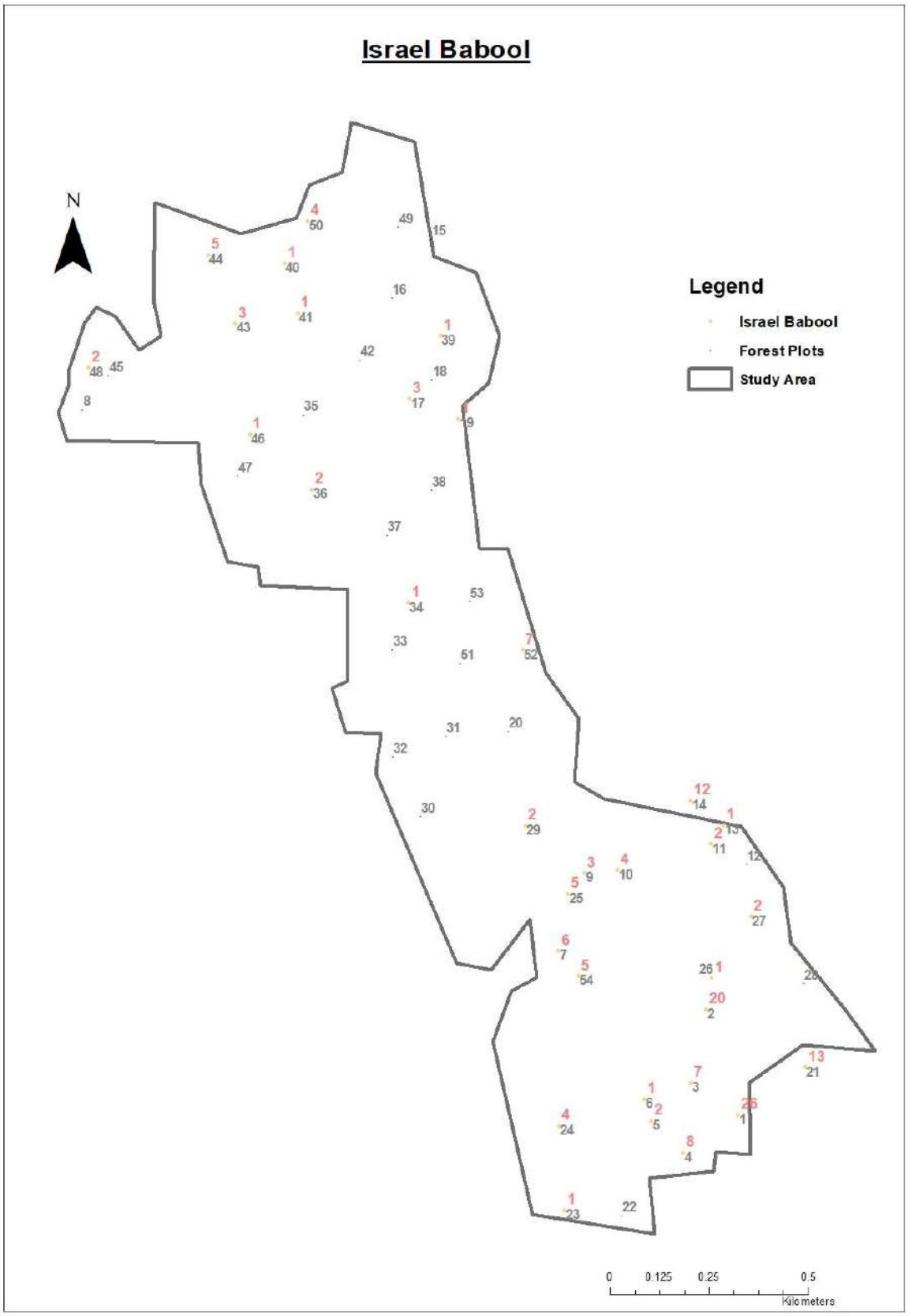
Annexure 4: Species Wise Tree Distribution Maps (data per plot of 1000 m^2)

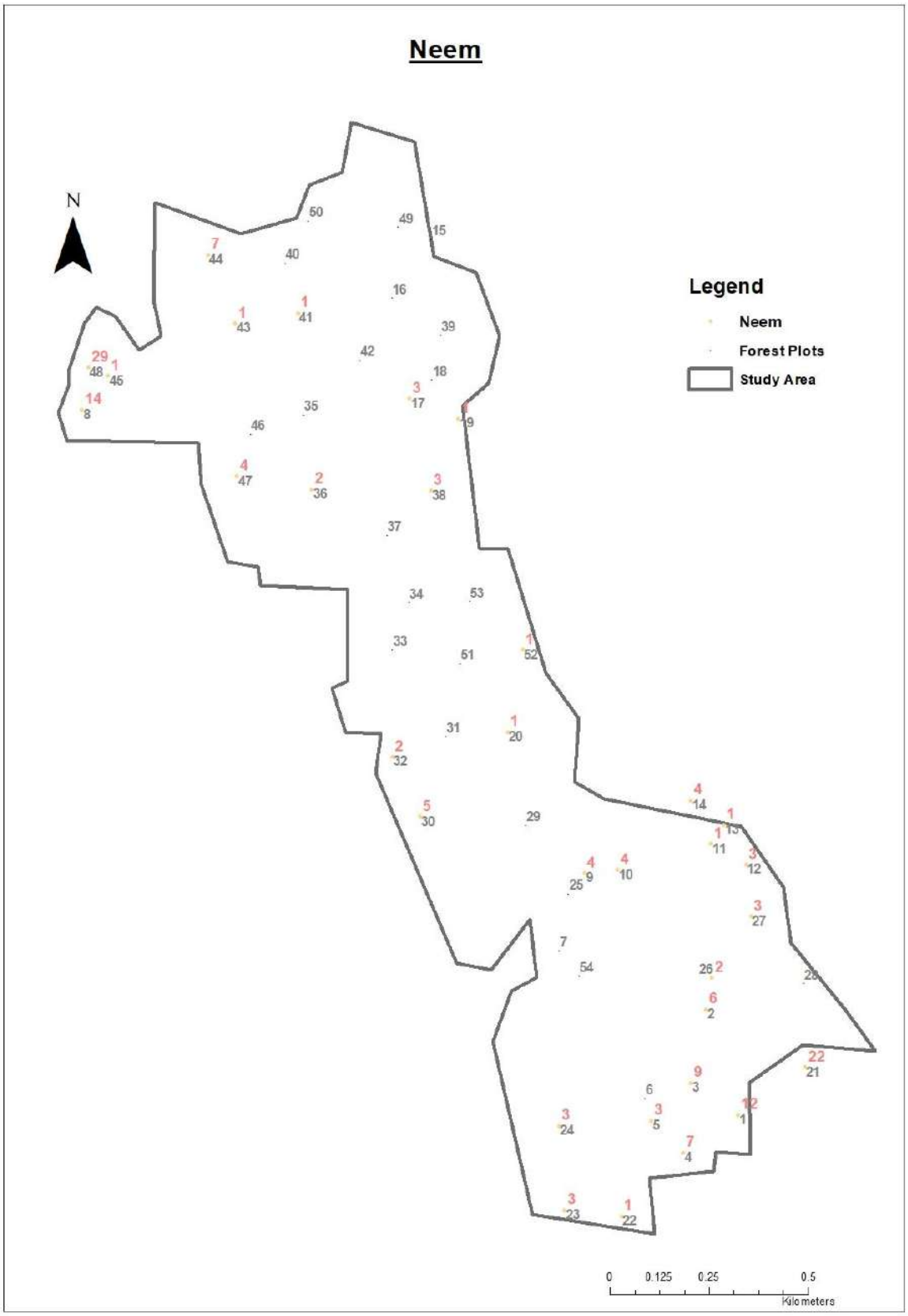


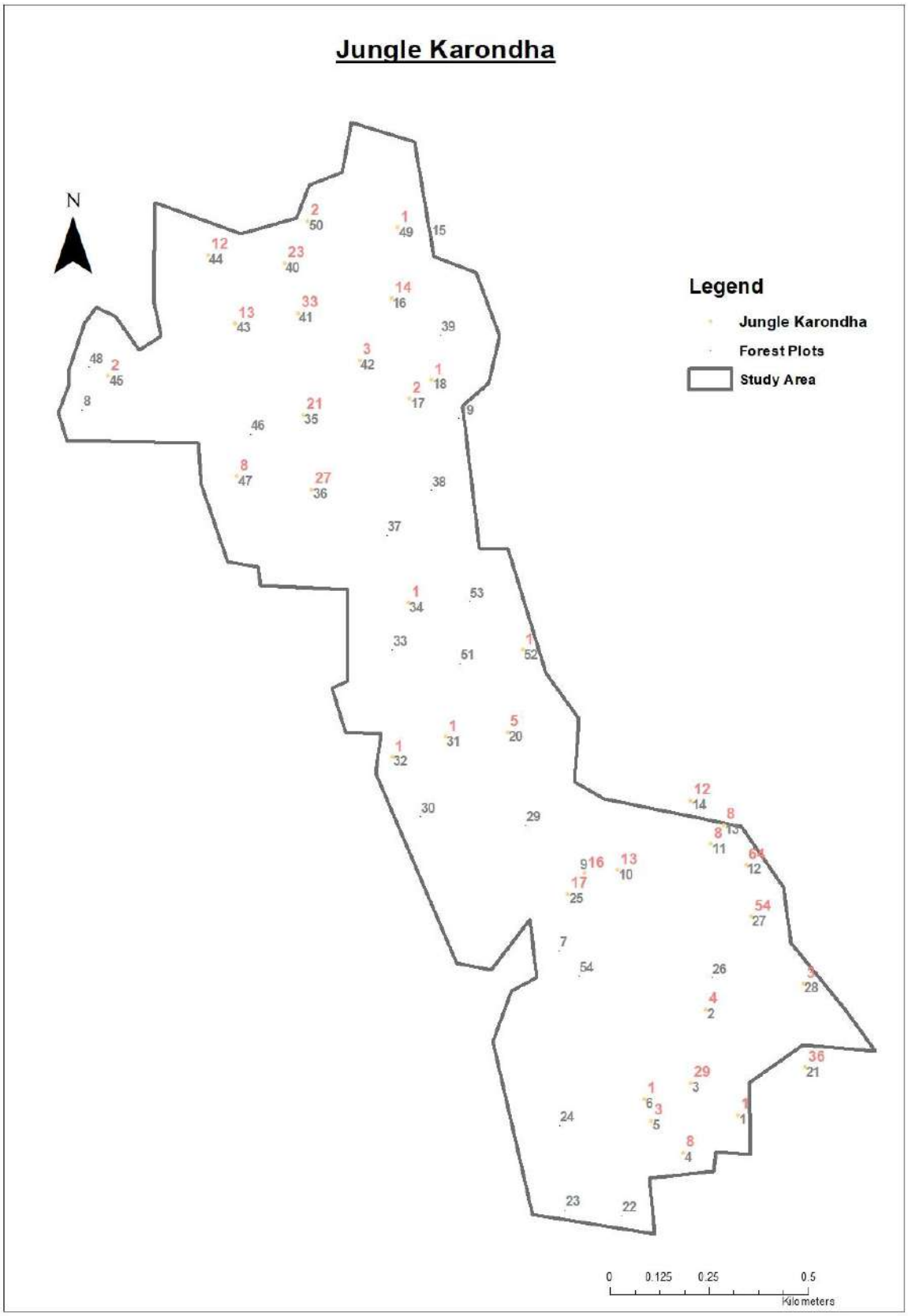

Kair
N
Legend
Kair
Forest Plots
Study Area
0
0.125
0.25
0.5
Kilometers

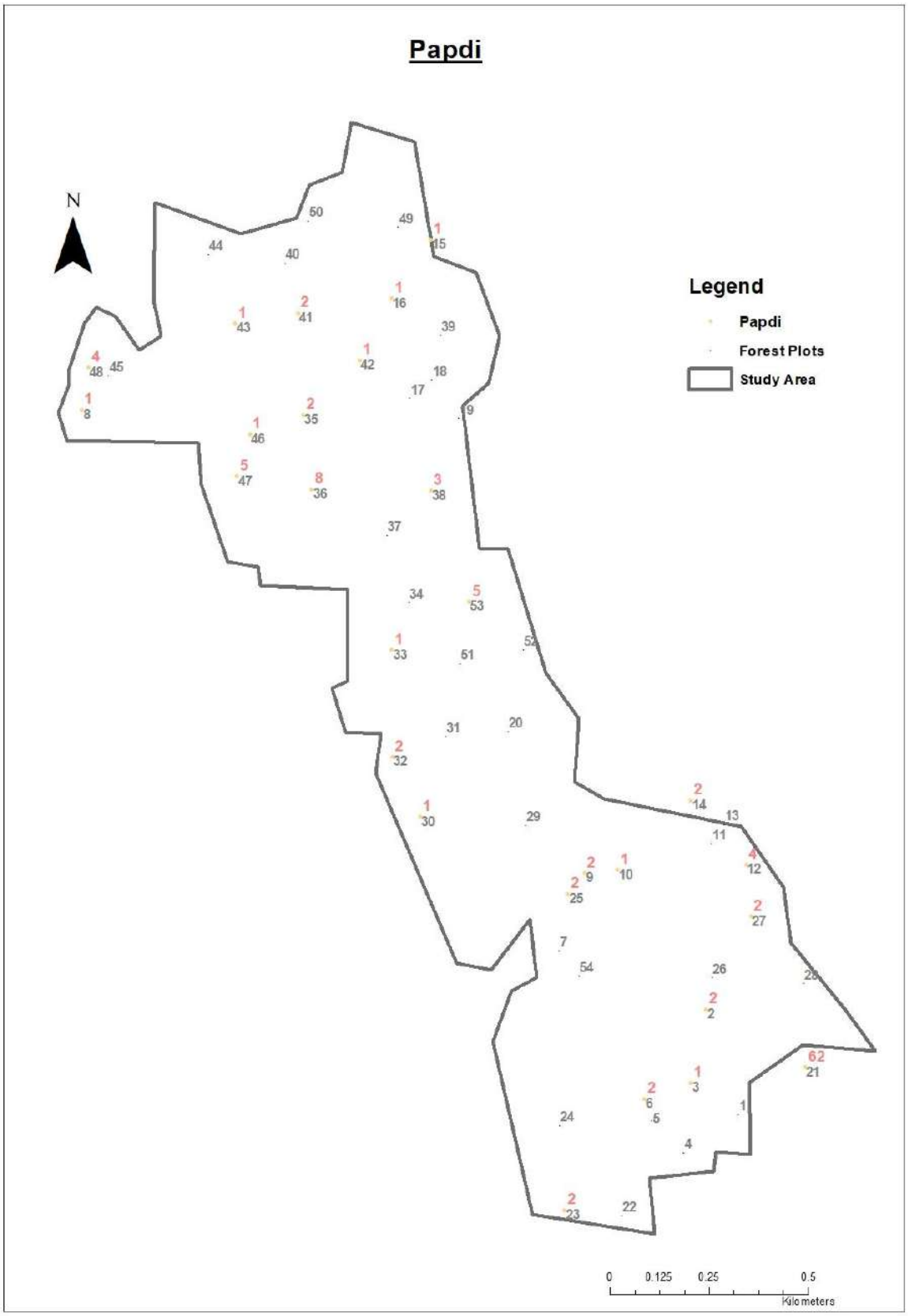

Dhak/Palash
N
Legend
Dhak
Forest Plots
Study Area
0
0.125
0.25
0.5
Kilometers

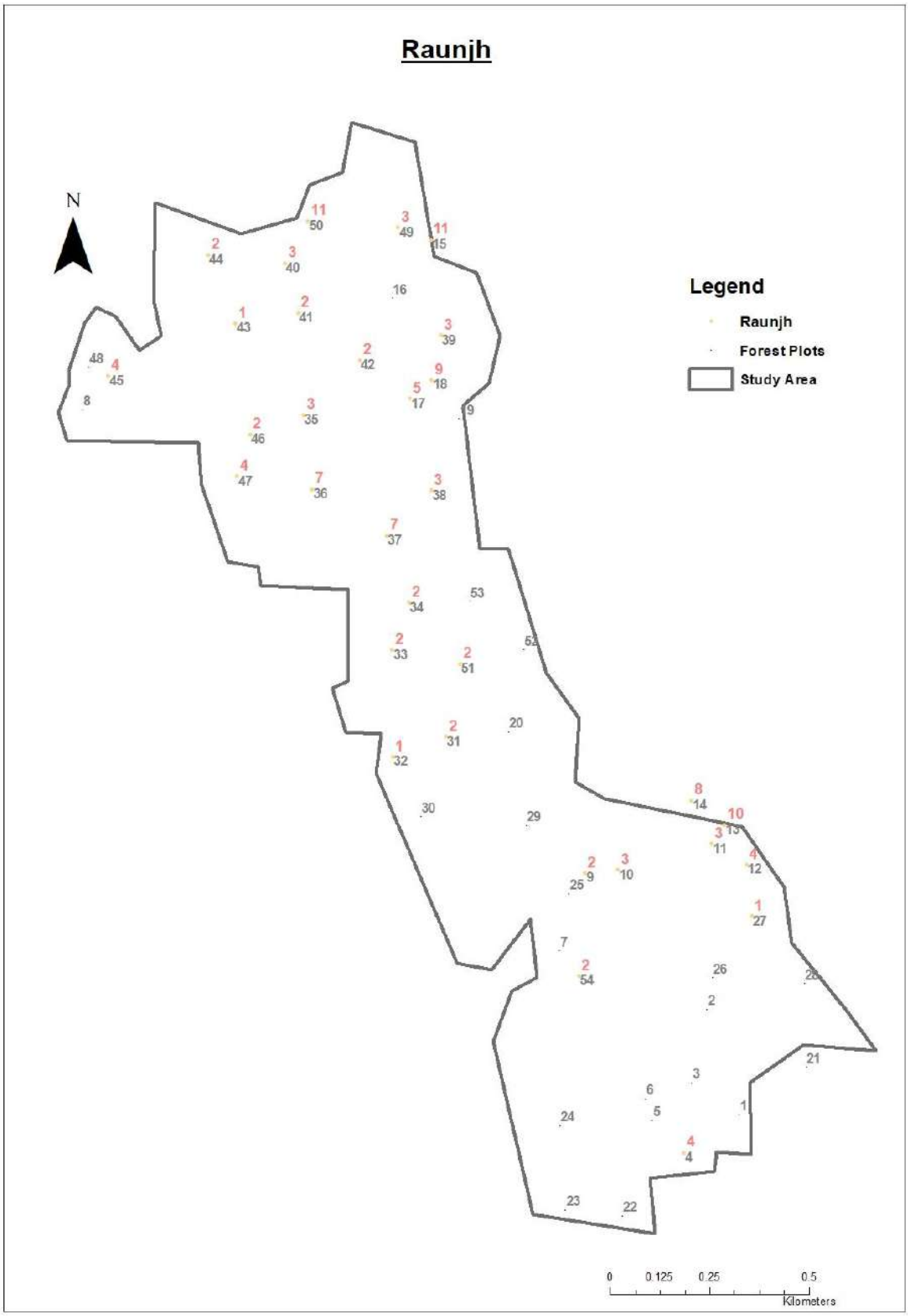

Pasendu
N
Legend
Pasendu
Forest Plots
Study Area
0
0.125
0.25
0.5
Kilometers


Israel Babool
N
Legend
Israel Babool
Forest Plots
Study Area
0
0.125
0.25
0.5
Kilometers


Neem
N
Legend
Neem
Forest Plots
Study Area
0
0.125
0.25
0.5
Kilometers


Jungle Karondha
N
Legend
Jungle Karondha
Forest Plots
Study Area
0
0.125
0.25
0.5
Kilometers


Papdi
N
Legend
Papdi
Forest Plots
Study Area
0
0.125
0.25
0.5
Kilometers


Raunjh
N
Legend
Raunjh
Forest Plots
Study Area
0
0.125
0.25
0.5
Kilometers

Annexure 5: Butterflies checklist

The checklist prepared is of the species encountered between October 22, 2023 to December 2023.

S. No.	Common Name	Scientific Name
Hesperiidae (Skippers)		
1	Common Banded Awl	*Hasora chromus*
2	Indian Palm Bob	*Suastus gremius*
3	Conjoined Swift	*Pelopidas conjuncta*
	Papilionidae (Swallowtail)	
4	Common Jay	*Graphium doson*
5	Common Mormon	*Papilio polytes*
6	Lime Butterfly	*Papilio demoleus*
Pieridae (White & Yellow)		
7	Small Grass Yellow	*Eurema brigitta*
8	Common Grass Yellow	*Eurema hecabe*
9	Common Emigrant	*Catopsilia pomona*
10	Mottled Emigrant	*Catopsilia pyranthe*
11	Small Orange Tip	*Colotis etrida*
12	White Orange Tip	*Ixias marianne*
13	Yellow Orange Tip	*Ixias pyrene*
14	Small Salmon Arab	*Colotis amata*
15	Large Salmon Arab	*Colotis fausta*
16	Common Gull	*Cepora nerissa*
17	Pioneer	*Belenois aurota*
18	Psyche	*Leptosia nina*
Lycaenidae (Blues)		
19	Common Silverline	*Spindasis vulcanus*
20	Zebra Blue	*Leptotes plinius*
21	Rounded Pierrot	*Tarucus nara*
22	Dark Grass Blue	*Zizeeria karsandra*
23	Forget-me-not	*Catochrysops strabo*
24	Pea Blue	*Lampides boeticus*
25	Common Pierrot	*Castalius rosimon*
26	Bright Babul Blue	*Azanus ubaldus*
27	Pale Grass Blue	*Pseudozizeeria maha*
28	Red Pierrot	*Talicada nyseus*
29	Plain Cupid	*Chilades pandava*
30	Small Cupid	*Chilades parrhasius*
31	Lime Blue	*Chilades lajus*
Nymphalidae (Brush Footed)		
32	Plain Tiger	*Danaus chrysippus*
33	Striped Tiger	*Danaus genutia*
34	Common Lepoard	*Phalanta phalantha*
35	Common Castor	*Ariadne merione*
36	Blue Pansy	*Junonia orithiya*

37	Yellow Pansy	*Junonia hierta*
38	Peacock Pansy	*Junonia almana*
39	Lemon Pansy	*Junnonia lemonias*
40	Great Eggfly	*Hypolimnas bolina*
41	Danaid Eggfly	*Hypolimnas misippus*

Annexure 6: Insects Checklist

S.No.	Common Name	Scientific Name
Ants		
1	Carpenter Ant	*Camponotini*
2	Tiger Ant	*Myrmecia gulosa*
Beetles		
3	Oblique-lined Flower Longhorn Beetle	*Acmaeoderella coarctatus*
4	Hermit Flower Beetle	*Aegus chelifer*
5	Alder Leaf Beetle	*Agelastica alni*
6	Blister Beetle	*Meloidae*
7	Darkling Beetle	*Gnaptor spinimanus*
8	Seven Spotted Ladybug	*Coccinella septempunctata*
9	Transverse lady Beetle	*Coccinella transversoguttata*
10	Ground Beetle	*Carabidae*
11	Metallic Wood-boring Beetle	*Catereda abdominalis*
Bugs		
12	Aphids	*Aphidoidea*
13	Treehopper	*Membracidae*
Cockroach, bees & bumble Bees		
14	Amber Wood Cockroach	*Ectobius vittiventris*
15	Giant Honeybee	*Apis dorsata*
16	Carpenter Bee	*Xylocopa*
17	Small Carpenter Bee	*Ceratina*
18	White Banded Bee	*Amegilla cingulata*
Dragonflies & Damselflies		
19	Ditch Jewel	*Indothemis limbata*
20	Golden Darlet	*Melanotaenia sp.*
21	Orange-tailed Marsh Dart	*Ceriagrion auranticum*
22	Trumpet Tail	*Pantala flavescens*
Flies		
23	Flesh Fly	*Sarcophagidae*
24	House Fly	*Musca domestica*
25	Oriental Blue Fly	*Chysomya megacephala*
26	Stiletto Fly	*Therevidae*
Grasshopper		
27	Carolina Grasshopper	*Dissosteira carolina*
28	Wood Grasshopper	*Omocestus viridulus*
29	Desert Locust	*Schistocerca*
Hobber		

30	Prominent Robber Fly	*Promachus*
31	Marmalade Hoverfly	*Eupeodes fumipennis*
32	European Hoverfly	*Eristalinus quinquestriatus*
33	Common Lagoon Fly	*Eristalinus aeneus*
Hornet		
34	Potter Wasp	*Delta pyriforme*
35	European Hornet	*Vespa crabro*
Moth		
36	Cream Wave	*Scopula floslactata*
Mantis		
37	Praying Mantis	*Mantis religiosa*
Spiders		
38	Green Lynx Spider	*Peucetia viridana*
39	Tangle-web Spider	*Theridiidae*
Water Striders		
40	Common Water Strider	*Aquarius remigis*

Annexure 7: List of Bird Species Recorded in Damdama Village, Lake, and Forests (Arranged by Family)

Abbreviations:
Seasonality: R: Resident; W: Winter migrant; S: Summer Migrant; P: Passage Migrant

Habitat Preference: FS: Forest specialist; FG: Forest generalist; OP: Open country; WL: Wetland species

Bird names as in Praveen et al. (2023)

S.No.	Family	Species name	Scientific Name	Diet Guild	Habitat Preference	Seasonal Status
1	Anatidae	Common Teal	*Anas crecca*	Plant & Seed	WL	W
2	Anatidae	Knob-billed Duck	*Sarkidiornis melanotos*	Plant & Seed	WL	R
3	Phasianidae	Grey Francolin	*Ortygornis pondicerianus*	Plant & Seed	FG, OP	R
4	Phasianidae	Indian Peafowl	*Pavo cristatus*	Plant & Seed	FG, OP	R
5	Columbidae	Eurasian Collared Dove	*Streptopelia decaocto*	Plant & Seed	OP	R
6	Columbidae	Laughing Dove	*Spilopelia senegalensis*	Plant & Seed	FG, OP	R
7	Columbidae	Red Collared Dove	*Streptopelia tranquebarica*	Plant & Seed	FG, OP	R
8	Columbidae	Rock Pigeon	*Columba livia*	Plant & Seed	OP	R
9	Columbidae	Yellow-footed Green Pigeon	*Treron phoenicopterus*	Fruit & Nect	FG	R
10	Pteroclidae	Painted Sandgrouse	*Pterocles indicus*	Plant & Seed	FG, OP	R
11	Cuculidae	Common Hawk Cuckoo	*Hierococcyx varius*	Invertebrate	FG	S
12	Cuculidae	Greater Coucal	*Centropus sinensis*	Omnivore	FG, OP	R
13	Cuculidae	Sirkeer Malkoha	*Taccocua leschenaultii*	Invertebrate	FS	R
14	Apodidae	Little Swift	*Apus affinis*	Invertebrate	OP	S
15	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	Invertebrate	WL	R
16	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	Invertebrate	OP, WL	R
17	Scolopacidae	Common Greenshank	*Tringa nebularia*	Invertebrate	WL	W
18	Scolopacidae	Common Redshank	*Tringa totanus*	Invertebrate	WL	W
19	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	Omnivore	WL	W
20	Scolopacidae	Common Snipe	*Gallinago gallinago*	Invertebrate	WL	W
21	Scolopacidae	Green Sandpiper	*Tringa ochropus*	Invertebrate	WL	W
22	Scolopacidae	Spotted Redshank	*Tringa erythropus*	Invertebrate	WL	W
23	Scolopacidae	Temminck's Stint	*Calidris temminckii*	Invertebrate	WL	W
24	Scolopacidae	Wood Sandpiper	*Tringa glareola*	Invertebrate	WL	W
25	Turnicidae	Barred Buttonquail	*Turnix suscitator*	Plant & Seed	FS	R
26	Laridae	River Tern	*Sterna aurantia*	Omnivore	WL	R
27	Ciconiidae	Asian Openbill	*Anastomus oscitans*	Invertebrate	WL	R
28	Ciconiidae	Painted Stork	*Mycteria leucocephala*	Vertebrate & Carrion	WL	R
29	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	Vertebrate & Carrion	WL	R
30	Phalacrocoracidae	Indian Cormorant	*Phalacrocorax fuscicollis*	Vertebrate & Carrion	WL	R
31	Phalacrocoracidae	Little Cormorant	*Microcarbo niger*	Vertebrate & Carrion	WL	R
32	Ardeidae	Cattle Egret	*Bubulcus ibis*	Invertebrate	WL, OP	R
33	Ardeidae	Grey Heron	*Ardea cinerea*	Vertebrate & Carrion	WL	R
34	Ardeidae	Great Egret	*Ardea alba*	Invertebrate	WL	R
35	Ardeidae	Indian Pond Heron	*Ardeola grayii*	Omnivore	WL	R

36	Ardeidae	Little Egret	*Egretta garzetta*	Invertebrate	WL	R
37	Ardeidae	Intermediate Egret	*Ardea intermedia*	Invertebrate	WL	R
38	Threskiornithidae	Glossy Ibis	*Plegadis falcinellus*	Invertebrate	WL	R
39	Threskiornithidae	Red-naped Ibis	*Pseudibis papillosa*	Omnivore	OP, WL	R
40	Accipitridae	Black Kite	*Milvus migrans*	Vertebrate & Carrion	OP	R
41	Accipitridae	Black-winged Kite	*Elanus caeruleus*	Vertebrate & Carrion	OP	R
42	Accipitridae	Egyptian Vulture	*Neophron percnopterus*	Vertebrate & Carrion	FG, OP	R
43	Accipitridae	Eurasian Sparrowhawk	*Accipiter nisus*	Vertebrate & Carrion	FG	W
44	Accipitridae	Shikra	*Accipiter badius*	Vertebrate & Carrion	FG	R
45	Accipitridae	Steppe Eagle	*Aquila nipalensis*	Vertebrate & Carrion	FG	W
46	Upupidae	Eurasian Hoopoe	*Upupa epops*	Invertebrate	OP	R
47	Alcedinidae	Pied Kingfisher	*Ceryle rudis*	Vertebrate & Carrion	WL	R
48	Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*	Vertebrate & Carrion	OP, WL	R
49	Megalaimidae	Brown-headed Barbet	*Psilopogon zeylanicus*	Fruit & Nect	FG	R
50	Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus*	Fruit & Nect	FG	R
51	Picidae	Black-rumped Flameback	*Dinopium benghalense*	Invertebrate	FG	R
52	Falconidae	Eurasian Hobby	*Falco subbuteo*	Invertebrate	FG	P
53	Psittaculidae	Alexandrine Parakeet	*Psittacula eupatria*	Fruit & Nect	FG	R
54	Psittaculidae	Plum-headed Parakeet	*Psittacula cyanocephala*	Fruit & Nect	FG	R
55	Psittaculidae	Rose-ringed Parakeet	*Psittacula krameri*	Fruit & Nect	FG	R
56	Campephagidae	Black-winged Cuckooshrike	*Lalage melaschistos*	Invertebrate	FS	V
57	Campephagidae	Small Minivet	*Pericrocotus cinnamomeus*	Invertebrate	FG	R
58	Campephagidae	White-bellied Minivet	*Pericrocotus erythropygius*	Invertebrate	FS	W
59	Oriolidae	Indian Golden Oriole	*Oriolus kundoo*	Omnivore	FG	S
60	Vangidae	Common Woodshrike	*Tephrodornis pondicerianus*	Invertebrate	FG	R
61	Aegithinidae	Marshall's Iora	*Aegithina nigrolutea*	Invertebrate	FS	R
62	Rhipiduridae	White-browed Fantail	*Rhipidura aureola*	Invertebrate	FS	R
63	Dicruridae	Black Drongo	*Dicrurus macrocercus*	Omnivore	FG, OP	R
64	Dicruridae	White-bellied Drongo	*Dicrurus caerulescens*	Invertebrate	FS	R
65	Laniidae	Bay-backed Shrike	*Lanius vittatus*	Invertebrate	FG, OP	R
66	Laniidae	Long-tailed Shrike	*Lanius schach*	Invertebrate	OP	R
67	Corvidae	House Crow	*Corvus splendens*	Vertebrate & Carrion	OP	R
68	Corvidae	Large-billed Crow	*Corvus macrorhynchos*	Omnivore	OP	R
69	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	Omnivore	FG	R
70	Alaudidae	Crested Lark	*Galerida cristata*	Plant & Seed	OP	R
71	Alaudidae	Indian Bushlark	*Mirafra erythroptera*	Omnivore	OP	R
72	Cisticolidae	Ashy Prinia	*Prinia socialis*	Invertebrate	FG, OP	R
73	Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	Invertebrate	FG, OP	R
74	Cisticolidae	Grey-breasted Prinia	*Prinia hodgsonii*	Invertebrate	FG, OP	R
75	Cisticolidae	Plain Prinia	*Prinia inornata*	Invertebrate	OP	R
76	Cisticolidae	Rufous-fronted Prinia	*Prinia buchanani*	Invertebrate	OP	R
77	Hirundinidae	Barn Swallow	*Hirundo rustica*	Invertebrate	OP, WL	W
78	Hirundinidae	Grey-throated Martin	*Riparia chinensis*	Invertebrate	OP, WL	R
79	Hirundinidae	Red-rumped Swallow	*Cecropis daurica*	Invertebrate	OP, WL	R
80	Hirundinidae	Wire-tailed Swallow	*Hirundo smithii*	Invertebrate	OP, WL	R
81	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*	Omnivore	FG, OP	R

82	Pycnonotidae	Red-whiskered Bulbul	*Pycnonotus jocosus*	Omnivore	FG, OP	R
83	Pycnonotidae	White-eared Bulbul	*Pycnonotus leucotis*	Omnivore	FG, OP	R
84	Phylloscopidae	Common Chiffchaff	*Phylloscopus collybita*	Invertebrate	FG	W
85	Phylloscopidae	Greenish Warbler	*Phylloscopus trochiloides*	Invertebrate	FG	W
86	Phylloscopidae	Hume's Warbler	*Phylloscopus humei*	Invertebrate	FG	W
87	Sylviidae	Lesser Whitethroat	*Curruca curruca*	Invertebrate	FG, OP	W
88	Paradoxornithidae	Yellow-eyed Babbler	*Chrysomma sinense*	Invertebrate	FG, OP	R
89	Zosteropidae	Indian White-eye	*Zosterops palpebrosus*	Omnivore	FG, OP	R
90	Leiothrichidae	Common Babbler	*Argya caudata*	Omnivore	FG, OP	R
91	Leiothrichidae	Jungle Babbler	*Argya striata*	Omnivore	FG, OP	R
92	Leiothrichidae	Large Grey Babbler	*Argya malcolmi*	Invertebrate	FG, OP	R
93	Sturnidae	Brahminy Starling	*Sturnia pagodarum*	Omnivore	OP	R
94	Sturnidae	Common Myna	*Acridotheres tristis*	Omnivore	FG, OP	R
95	Sturnidae	Asian Pied Starling	*Gracupica contra*	Omnivore	OP	R
96	Muscicapidae	Black Redstart	*Phoenicurus ochruros*	Invertebrate	FG, OP	W
97	Muscicapidae	Bluethroat	*Luscinia svecica*	Invertebrate	OP, WL	W
98	Muscicapidae	Brown Rock Chat	*Oenanthe fusca*	Invertebrate	OP	R
99	Muscicapidae	Indian Robin	*Copsychus fulicatus*	Invertebrate	FG, OP	R
100	Muscicapidae	Oriental Magpie Robin	*Copsychus saularis*	Invertebrate	FG	R
101	Muscicapidae	Pied Bushchat	*Saxicola caprata*	Invertebrate	OP	R
102	Muscicapidae	Red-breasted Flycatcher	*Ficedula parva*	Invertebrate	FG	W
103	Muscicapidae	Siberian Stonechat	*Saxicola maurus*	Invertebrate	OP	W
104	Muscicapidae	Verditer Flycatcher	*Eumyias thalassinus*	Invertebrate	FG	P
105	Nectariniidae	Purple Sunbird	*Cinnyris asiaticus*	Fruit & Nect	FG, OP	R
106	Ploceidae	Baya Weaver	*Ploceus philippinus*	Plant & Seed	OP	R
107	Estrildidae	Indian Silverbill	*Euodice malabarica*	Plant & Seed	OP	R
108	Passeridae	House Sparrow	*Passer domesticus*	Plant & Seed	OP	R
109	Passeridae	Yellow-throated Sparrow	*Gymnoris xanthocollis*	Omnivore	FG, OP	R
110	Motacillidae	Citrine Wagtail	*Motacilla citreola*	Invertebrate	WL, OP	W
111	Motacillidae	Grey Wagtail	*Motacilla cinerea*	Invertebrate	WL, OP	W
112	Motacillidae	Paddyfield Pipit	*Anthus rufulus*	Invertebrate	OP	R
113	Motacillidae	Western Yellow Wagtail	*Motacilla flava*	Invertebrate	WL, OP	W
114	Motacillidae	White Wagtail	*Motacilla alba*	Invertebrate	WL, OP	W
115	Motacillidae	White-browed Wagtail	*Motacilla maderaspatensis*	Invertebrate	WL, OP	R
116	Fringillidae	Common Rosefinch	*Carpodacus erythrinus*	Plant & Seed	FG, OP	W
117	Emberizidae	White-capped Bunting	*Emberiza stewarti*	Plant & Seed	OP	W

Annexure 8: Birds, sorted by Habitat preference and Seasonal Status

(with serial no. cross referenced with above table)

Abbreviations:

Seasonality: R: Resident; W: Winter migrant; S: Summer Migrant; P: Passage Migrant

Habitat Preference: FS: Forest specialist; FG: Forest generalist; OP: Open country; WL: Wetland species

Bird names as in Praveen et al. (2023)

S.No.	Family	Species name	Scientific Name	Diet Guild	Habitat Preference	Seasonal Status
13	Cuculidae	Sirkeer Malkoha	*Taccocua leschenaultii*	Invertebrate	FS	R
25	Turnicidae	Barred Buttonquail	*Turnix suscitator*	Plant & Seed	FS	R
61	Aegithinidae	Marshall's Iora	*Aegithina nigrolutea*	Invertebrate	FS	R
62	Rhipiduridae	White-browed Fantail	*Rhipidura aureola*	Invertebrate	FS	R
64	Dicruridae	White-bellied Drongo	*Dicrurus caerulescens*	Invertebrate	FS	R
58	Campephagidae	White-bellied Minivet	*Pericrocotus erythropygius*	Invertebrate	FS	W
56	Campephagidae	Black-winged Cuckooshrike	*Lalage melaschistos*	Invertebrate	FS	V
9	Columbidae	Yellow-footed Green Pigeon	*Treron phoenicopterus*	Fruit & Nect	FG	R
44	Accipitridae	Shikra	*Accipiter badius*	Vertebrate & Carrion	FG	R
49	Megalaimidae	Brown-headed Barbet	*Psilopogon zeylanicus*	Fruit & Nect	FG	R
50	Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus*	Fruit & Nect	FG	R
51	Picidae	Black-rumped Flameback	*Dinopium benghalense*	Invertebrate	FG	R
53	Psittaculidae	Alexandrine Parakeet	*Psittacula eupatria*	Fruit & Nect	FG	R
54	Psittaculidae	Plum-headed Parakeet	*Psittacula cyanocephala*	Fruit & Nect	FG	R
55	Psittaculidae	Rose-ringed Parakeet	*Psittacula krameri*	Fruit & Nect	FG	R
57	Campephagidae	Small Minivet	*Pericrocotus cinnamomeus*	Invertebrate	FG	R
60	Vangidae	Common Woodshrike	*Tephrodornis pondicerianus*	Invertebrate	FG	R
69	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	Omnivore	FG	R
100	Muscicapidae	Oriental Magpie Robin	*Copsychus saularis*	Invertebrate	FG	R
43	Accipitridae	Eurasian Sparrowhawk	*Accipiter nisus*	Vertebrate & Carrion	FG	W
45	Accipitridae	Steppe Eagle	*Aquila nipalensis*	Vertebrate & Carrion	FG	W
84	Phylloscopidae	Common Chiffchaff	*Phylloscopus collybita*	Invertebrate	FG	W
85	Phylloscopidae	Greenish Warbler	*Phylloscopus trochiloides*	Invertebrate	FG	W
86	Phylloscopidae	Hume's Warbler	*Phylloscopus humei*	Invertebrate	FG	W
102	Muscicapidae	Red-breasted Flycatcher	*Ficedula parva*	Invertebrate	FG	W
11	Cuculidae	Common Hawk Cuckoo	*Hierococcyx varius*	Invertebrate	FG	S
59	Oriolidae	Indian Golden Oriole	*Oriolus kundoo*	Omnivore	FG	S
52	Falconidae	Eurasian Hobby	*Falco subbuteo*	Invertebrate	FG	P
104	Muscicapidae	Verditer Flycatcher	*Eumyias thalassinus*	Invertebrate	FG	P
5	Columbidae	Eurasian Collared Dove	*Streptopelia decaocto*	Plant & Seed	OP	R

8	Columbidae	Rock Pigeon	*Columba livia*	Plant & Seed	OP	R
40	Accipitridae	Black Kite	*Milvus migrans*	Vertebrate & Carrion	OP	R
41	Accipitridae	Black-winged Kite	*Elanus caeruleus*	Vertebrate & Carrion	OP	R
46	Upupidae	Eurasian Hoopoe	*Upupa epops*	Invertebrate	OP	R
66	Laniidae	Long-tailed Shrike	*Lanius schach*	Invertebrate	OP	R
67	Corvidae	House Crow	*Corvus splendens*	Vertebrate & Carrion	OP	R
68	Corvidae	Large-billed Crow	*Corvus macrorhynchos*	Omnivore	OP	R
70	Alaudidae	Crested Lark	*Galerida cristata*	Plant & Seed	OP	R
71	Alaudidae	Indian Bushlark	*Mirafra erythroptera*	Omnivore	OP	R
75	Cisticolidae	Plain Prinia	*Prinia inornata*	Invertebrate	OP	R
76	Cisticolidae	Rufous-fronted Prinia	*Prinia buchanani*	Invertebrate	OP	R
93	Sturnidae	Brahminy Starling	*Sturnia pagodarum*	Omnivore	OP	R
95	Sturnidae	Asian Pied Starling	*Gracupica contra*	Omnivore	OP	R
98	Muscicapidae	Brown Rock Chat	*Oenanthe fusca*	Invertebrate	OP	R
101	Muscicapidae	Pied Bushchat	*Saxicola caprata*	Invertebrate	OP	R
106	Ploceidae	Baya Weaver	*Ploceus philippinus*	Plant & Seed	OP	R
107	Estrildidae	Indian Silverbill	*Euodice malabarica*	Plant & Seed	OP	R
108	Passeridae	House Sparrow	*Passer domesticus*	Plant & Seed	OP	R
112	Motacillidae	Paddyfield Pipit	*Anthus rufulus*	Invertebrate	OP	R
103	Muscicapidae	Siberian Stonechat	*Saxicola maurus*	Invertebrate	OP	W
117	Emberizidae	White-capped Bunting	*Emberiza stewarti*	Plant & Seed	OP	W
14	Apodidae	Little Swift	*Apus affinis*	Invertebrate	OP	S
2	Anatidae	Knob-billed Duck	*Sarkidiornis melanotos*	Plant & Seed	WL	R
15	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	Invertebrate	WL	R
26	Laridae	River Tern	*Sterna aurantia*	Omnivore	WL	R
27	Ciconiidae	Asian Openbill	*Anastomus oscitans*	Invertebrate	WL	R
28	Ciconiidae	Painted Stork	*Mycteria leucocephala*	Vertebrate & Carrion	WL	R
29	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	Vertebrate & Carrion	WL	R
30	Phalacrocoracidae	Indian Cormorant	*Phalacrocorax fuscicollis*	Vertebrate & Carrion	WL	R
31	Phalacrocoracidae	Little Cormorant	*Microcarbo niger*	Vertebrate & Carrion	WL	R
33	Ardeidae	Grey Heron	*Ardea cinerea*	Vertebrate & Carrion	WL	R
34	Ardeidae	Great Egret	*Ardea alba*	Invertebrate	WL	R
35	Ardeidae	Indian Pond Heron	*Ardeola grayii*	Omnivore	WL	R
36	Ardeidae	Little Egret	*Egretta garzetta*	Invertebrate	WL	R
37	Ardeidae	Intermediate Egret	*Ardea intermedia*	Invertebrate	WL	R
38	Threskiornithidae	Glossy Ibis	*Plegadis falcinellus*	Invertebrate	WL	R
47	Alcedinidae	Pied Kingfisher	*Ceryle rudis*	Vertebrate & Carrion	WL	R
1	Anatidae	Common Teal	*Anas crecca*	Plant & Seed	WL	W
17	Scolopacidae	Common Greenshank	*Tringa nebularia*	Invertebrate	WL	W
18	Scolopacidae	Common Redshank	*Tringa totanus*	Invertebrate	WL	W
19	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	Omnivore	WL	W
20	Scolopacidae	Common Snipe	*Gallinago gallinago*	Invertebrate	WL	W
21	Scolopacidae	Green Sandpiper	*Tringa ochropus*	Invertebrate	WL	W
22	Scolopacidae	Spotted Redshank	*Tringa erythropus*	Invertebrate	WL	W
23	Scolopacidae	Temminck's Stint	*Calidris temminckii*	Invertebrate	WL	W
24	Scolopacidae	Wood Sandpiper	*Tringa glareola*	Invertebrate	WL	W

3	Phasianidae	Grey Francolin	*Ortygornis pondicerianus*	Plant & Seed	FG, OP	R
4	Phasianidae	Indian Peafowl	*Pavo cristatus*	Plant & Seed	FG, OP	R
6	Columbidae	Laughing Dove	*Spilopelia senegalensis*	Plant & Seed	FG, OP	R
7	Columbidae	Red Collared Dove	*Streptopelia tranquebarica*	Plant & Seed	FG, OP	R
10	Pteroclidae	Painted Sandgrouse	*Pterocles indicus*	Plant & Seed	FG, OP	R
12	Cuculidae	Greater Coucal	*Centropus sinensis*	Omnivore	FG, OP	R
42	Accipitridae	Egyptian Vulture	*Neophron percnopterus*	Vertebrate & Carrion	FG, OP	R
63	Dicruridae	Black Drongo	*Dicrurus macrocercus*	Omnivore	FG, OP	R
65	Laniidae	Bay-backed Shrike	*Lanius vittatus*	Invertebrate	FG, OP	R
72	Cisticolidae	Ashy Prinia	*Prinia socialis*	Invertebrate	FG, OP	R
73	Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	Invertebrate	FG, OP	R
74	Cisticolidae	Grey-breasted Prinia	*Prinia hodgsonii*	Invertebrate	FG, OP	R
81	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*	Omnivore	FG, OP	R
82	Pycnonotidae	Red-whiskered Bulbul	*Pycnonotus jocosus*	Omnivore	FG, OP	R
83	Pycnonotidae	White-eared Bulbul	*Pycnonotus leucotis*	Omnivore	FG, OP	R
88	Paradoxornithidae	Yellow-eyed Babbler	*Chrysomma sinense*	Invertebrate	FG, OP	R
89	Zosteropidae	Indian White-eye	*Zosterops palpebrosus*	Omnivore	FG, OP	R
90	Leiothrichidae	Common Babbler	*Argya caudata*	Omnivore	FG, OP	R
91	Leiothrichidae	Jungle Babbler	*Argya striata*	Omnivore	FG, OP	R
92	Leiothrichidae	Large Grey Babbler	*Argya malcolmi*	Invertebrate	FG, OP	R
94	Sturnidae	Common Myna	*Acridotheres tristis*	Omnivore	FG, OP	R
99	Muscicapidae	Indian Robin	*Copsychus fulicatus*	Invertebrate	FG, OP	R
105	Nectariniidae	Purple Sunbird	*Cinnyris asiaticus*	Fruit & Nect	FG, OP	R
109	Passeridae	Yellow-throated Sparrow	*Gymnoris xanthocollis*	Omnivore	FG, OP	R
87	Sylviidae	Lesser Whitethroat	*Curruca curruca*	Invertebrate	FG, OP	W
96	Muscicapidae	Black Redstart	*Phoenicurus ochruros*	Invertebrate	FG, OP	W
116	Fringillidae	Common Rosefinch	*Carpodacus erythrinus*	Plant & Seed	FG, OP	W
16	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	Invertebrate	OP, WL	R
39	Threskiornithidae	Red-naped Ibis	*Pseudibis papillosa*	Omnivore	OP, WL	R
48	Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*	Vertebrate & Carrion	OP, WL	R
78	Hirundinidae	Grey-throated Martin	*Riparia chinensis*	Invertebrate	OP, WL	R
79	Hirundinidae	Red-rumped Swallow	*Cecropis daurica*	Invertebrate	OP, WL	R
80	Hirundinidae	Wire-tailed Swallow	*Hirundo smithii*	Invertebrate	OP, WL	R
77	Hirundinidae	Barn Swallow	*Hirundo rustica*	Invertebrate	OP, WL	W
97	Muscicapidae	Bluethroat	*Luscinia svecica*	Invertebrate	OP, WL	W
32	Ardeidae	Cattle Egret	*Bubulcus ibis*	Invertebrate	WL, OP	R
115	Motacillidae	White-browed Wagtail	*Motacilla maderaspatensis*	Invertebrate	WL, OP	R
110	Motacillidae	Citrine Wagtail	*Motacilla citreola*	Invertebrate	WL, OP	W
111	Motacillidae	Grey Wagtail	*Motacilla cinerea*	Invertebrate	WL, OP	W
113	Motacillidae	Western Yellow Wagtail	*Motacilla flava*	Invertebrate	WL, OP	W
114	Motacillidae	White Wagtail	*Motacilla alba*	Invertebrate	WL, OP	W

Annexure 9: SOIB Conservation priority and IUCN Red List Category (Arranged by Family)

S.No.	Family	Species name	Scientific Name	SoIB 2023 Priority Status	IUCN status 2022
1	Accipitridae	Black Kite	*Milvus migrans*	Low	Least Concern
2	Accipitridae	Black-winged Kite	*Elanus caeruleus*	Moderate	Least Concern
3	Accipitridae	Egyptian Vulture	*Neophron percnopterus*	High	Endangered
4	Accipitridae	Eurasian Sparrowhawk	*Accipiter nisus*	Low	Least Concern
5	Accipitridae	Shikra	*Accipiter badius*	Low	Least Concern
6	Accipitridae	Steppe Eagle	*Aquila nipalensis*	Low	Endangered
7	Aegithinidae	Marshall's Iora	*Aegithina nigrolutea*	Moderate	Least Concern
8	Alaudidae	Crested Lark	*Galerida cristata*	Moderate	Least Concern
9	Alaudidae	Indian Bushlark	*Mirafra erythroptera*	Moderate	Least Concern
10	Alcedinidae	Pied Kingfisher	*Ceryle rudis*	Moderate	Least Concern
11	Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*	Low	Least Concern
12	Anatidae	Common Teal	*Anas crecca*	High	Least Concern
13	Anatidae	Knob-billed Duck	*Sarkidiornis melanotos*	Low	Least Concern
14	Apodidae	Little Swift	*Apus affinis*	Low	Least Concern
15	Ardeidae	Cattle Egret	*Bubulcus ibis*	Low	Least Concern
16	Ardeidae	Grey Heron	*Ardea cinerea*	Low	Least Concern
17	Ardeidae	Great Egret	*Ardea alba*	Low	Least Concern
18	Ardeidae	Indian Pond Heron	*Ardeola grayii*	Low	Least Concern
19	Ardeidae	Little Egret	*Egretta garzetta*	Low	Least Concern
20	Ardeidae	Intermediate Egret	*Ardea intermedia*	Low	Least Concern
21	Campephagidae	Black-winged Cuckooshrike	*Lalage melaschistos*	Low	Least Concern
22	Campephagidae	Small Minivet	*Pericrocotus cinnamomeus*	Low	Least Concern
23	Campephagidae	White-bellied Minivet	*Pericrocotus erythropygius*	Moderate	Least Concern
24	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	Low	Least Concern
25	Ciconiidae	Asian Openbill	*Anastomus oscitans*	Moderate	Least Concern
26	Ciconiidae	Painted Stork	*Mycteria leucocephala*	Low	Near Threatened
27	Cisticolidae	Ashy Prinia	*Prinia socialis*	Low	Least Concern
28	Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	Low	Least Concern
29	Cisticolidae	Grey-breasted Prinia	*Prinia hodgsonii*	Low	Least Concern
30	Cisticolidae	Plain Prinia	*Prinia inornata*	Low	Least Concern
31	Cisticolidae	Rufous-fronted Prinia	*Prinia buchanani*	Moderate	Least Concern
32	Columbidae	Eurasian Collared Dove	*Streptopelia decaocto*	Low	Least Concern
33	Columbidae	Laughing Dove	*Spilopelia senegalensis*	Low	Least Concern
34	Columbidae	Red Collared Dove	*Streptopelia tranquebarica*	Low	Least Concern
35	Columbidae	Rock Pigeon	*Columba livia*	Low	Least Concern
36	Columbidae	Yellow-footed Green Pigeon	*Treron phoenicopterus*	Low	Least Concern
37	Corvidae	House Crow	*Corvus splendens*	Low	Least Concern
38	Corvidae	Large-billed Crow	*Corvus macrorhynchos*	Low	Least Concern

39	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	Low	Least Concern
40	Cuculidae	Common Hawk Cuckoo	*Hierococcyx varius*	Low	Least Concern
41	Cuculidae	Greater Coucal	*Centropus sinensis*	Low	Least Concern
42	Cuculidae	Sirkeer Malkoha	*Taccocua leschenaultii*	High	Least Concern
43	Dicruridae	Black Drongo	*Dicrurus macrocercus*	Low	Least Concern
44	Dicruridae	White-bellied Drongo	*Dicrurus caerulescens*	Moderate	Least Concern
45	Emberizidae	White-capped Bunting	*Emberiza stewarti*	Low	Least Concern
46	Estrildidae	Indian Silverbill	*Euodice malabarica*	Low	Least Concern
47	Falconidae	Eurasian Hobby	*Falco subbuteo*	Low	Least Concern
48	Fringillidae	Common Rosefinch	*Carpodacus erythrinus*	Moderate	Least Concern
49	Hirundinidae	Barn Swallow	*Hirundo rustica*	Low	Least Concern
50	Hirundinidae	Grey-throated Martin	*Riparia chinensis*	Moderate	Least Concern
51	Hirundinidae	Red-rumped Swallow	*Cecropis daurica*	Low	Least Concern
52	Hirundinidae	Wire-tailed Swallow	*Hirundo smithii*	Low	Least Concern
53	Laniidae	Bay-backed Shrike	*Lanius vittatus*	Low	Least Concern
54	Laniidae	Long-tailed Shrike	*Lanius schach*	Low	Least Concern
55	Laridae	River Tern	*Sterna aurantia*	Moderate	Vulnerable
56	Leiothrichidae	Common Babbler	*Argya caudata*	Moderate	Least Concern
57	Leiothrichidae	Jungle Babbler	*Argya striata*	Low	Least Concern
58	Leiothrichidae	Large Grey Babbler	*Argya malcolmi*	Low	Least Concern
59	Megalaimidae	Brown-headed Barbet	*Psilopogon zeylanicus*	Low	Least Concern
60	Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus*	Low	Least Concern
61	Motacillidae	Citrine Wagtail	*Motacilla citreola*	Moderate	Least Concern
62	Motacillidae	Grey Wagtail	*Motacilla cinerea*	Moderate	Least Concern
63	Motacillidae	Paddyfield Pipit	*Anthus rufulus*	Low	Least Concern
64	Motacillidae	Western Yellow Wagtail	*Motacilla flava*	Moderate	Least Concern
65	Motacillidae	White Wagtail	*Motacilla alba*	Moderate	Least Concern
66	Motacillidae	White-browed Wagtail	*Motacilla maderaspatensis*	Low	Least Concern
67	Muscicapidae	Black Redstart	*Phoenicurus ochruros*	Moderate	Least Concern
68	Muscicapidae	Bluethroat	*Luscinia svecica*	Moderate	Least Concern
69	Muscicapidae	Brown Rock Chat	*Oenanthe fusca*	Low	Least Concern
70	Muscicapidae	Indian Robin	*Copsychus fulicatus*	Low	Least Concern
71	Muscicapidae	Oriental Magpie Robin	*Copsychus saularis*	Low	Least Concern
72	Muscicapidae	Pied Bushchat	*Saxicola caprata*	Low	Least Concern
73	Muscicapidae	Red-breasted Flycatcher	*Ficedula parva*	Low	Least Concern
74	Muscicapidae	Siberian Stonechat	*Saxicola maurus*	Low	Least Concern
75	Muscicapidae	Verditer Flycatcher	*Eumyias thalassinus*	Low	Least Concern
76	Nectariniidae	Purple Sunbird	*Cinnyris asiaticus*	Low	Least Concern
77	Oriolidae	Indian Golden Oriole	*Oriolus kundoo*	Low	Least Concern
78	Paradoxornithidae	Yellow-eyed Babbler	*Chrysomma sinense*	Low	Least Concern
79	Passeridae	House Sparrow	*Passer domesticus*	Moderate	Least Concern
80	Passeridae	Yellow-throated Sparrow	*Gymnoris xanthocollis*	Low	Least Concern
81	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	Low	Least Concern

82	Phalacrocoracidae	Indian Cormorant	*Phalacrocorax fuscicollis*	Low	Least Concern
83	Phalacrocoracidae	Little Cormorant	*Microcarbo niger*	Low	Least Concern
84	Phasianidae	Grey Francolin	*Ortygornis pondicerianus*	Low	Least Concern
85	Phasianidae	Indian Peafowl	*Pavo cristatus*	Low	Least Concern
86	Phylloscopidae	Common Chiffchaff	*Phylloscopus collybita*	Low	Least Concern
87	Phylloscopidae	Greenish Warbler	*Phylloscopus trochiloides*	Low	Least Concern
88	Phylloscopidae	Hume's Warbler	*Phylloscopus humei*	Low	Least Concern
89	Picidae	Black-rumped Flameback	*Dinopium benghalense*	Low	Least Concern
90	Ploceidae	Baya Weaver	*Ploceus philippinus*	Low	Least Concern
91	Psittaculidae	Alexandrine Parakeet	*Psittacula eupatria*	Low	Near Threatened
92	Psittaculidae	Plum-headed Parakeet	*Psittacula cyanocephala*	Low	Least Concern
93	Psittaculidae	Rose-ringed Parakeet	*Psittacula krameri*	Low	Least Concern
94	Pteroclidae	Painted Sandgrouse	*Pterocles indicus*	Moderate	Least Concern
95	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*	Low	Least Concern
96	Pycnonotidae	Red-whiskered Bulbul	*Pycnonotus jocosus*	Low	Least Concern
97	Pycnonotidae	White-eared Bulbul	*Pycnonotus leucotis*	Low	Least Concern
98	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	Low	Least Concern
99	Rhipiduridae	White-browed Fantail	*Rhipidura aureola*	Moderate	Least Concern
100	Scolopacidae	Common Greenshank	*Tringa nebularia*	High	Least Concern
101	Scolopacidae	Common Redshank	*Tringa totanus*	High	Least Concern
102	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	Moderate	Least Concern
103	Scolopacidae	Common Snipe	*Gallinago gallinago*	Low	Least Concern
104	Scolopacidae	Green Sandpiper	*Tringa ochropus*	Low	Least Concern
105	Scolopacidae	Spotted Redshank	*Tringa erythropus*	High	Least Concern
106	Scolopacidae	Temminck's Stint	*Calidris temminckii*	Moderate	Least Concern
107	Scolopacidae	Wood Sandpiper	*Tringa glareola*	Moderate	Least Concern
108	Sturnidae	Brahminy Starling	*Sturnia pagodarum*	Low	Least Concern
109	Sturnidae	Common Myna	*Acridotheres tristis*	Low	Least Concern
110	Sturnidae	Asian Pied Starling	*Gracupica contra*	Low	Least Concern
111	Sylviidae	Lesser Whitethroat	*Curruca curruca*	Low	Least Concern
112	Threskiornithidae	Glossy Ibis	*Plegadis falcinellus*	Low	Least Concern
113	Threskiornithidae	Red-naped Ibis	*Pseudibis papillosa*	Low	Least Concern
114	Turnicidae	Barred Buttonquail	*Turnix suscitator*	Low	Least Concern
115	Upupidae	Eurasian Hoopoe	*Upupa epops*	Moderate	Least Concern
116	Vangidae	Common Woodshrike	*Tephrodornis pondicerianus*	Moderate	Least Concern
117	Zosteropidae	Indian White-eye	*Zosterops palpebrosus*	Low	Least Concern

Annexure 10: SOIB Conservation priority and IUCN Red List Category

Sorted by IUCN status and SoIB Status

(with serial no. cross referenced with above table)

S.No.	Family	Species name	Scientific Name	SoIB 2023 Priority Status	IUCN status
3	Accipitridae	Egyptian Vulture	*Neophron percnopterus*	High	Endangered
6	Accipitridae	Steppe Eagle	*Aquila nipalensis*	Low	Endangered
26	Ciconiidae	Painted Stork	*Mycteria leucocephala*	Low	Near Threatened
91	Psittaculidae	Alexandrine Parakeet	*Psittacula eupatria*	Low	Near Threatened
55	Laridae	River Tern	*Sterna aurantia*	Moderate	Vulnerable
12	Anatidae	Common Teal	*Anas crecca*	High	Least Concern
42	Cuculidae	Sirkeer Malkoha	*Taccocua leschenaultii*	High	Least Concern
100	Scolopacidae	Common Greenshank	*Tringa nebularia*	High	Least Concern
101	Scolopacidae	Common Redshank	*Tringa totanus*	High	Least Concern
105	Scolopacidae	Spotted Redshank	*Tringa erythropus*	High	Least Concern
2	Accipitridae	Black-winged Kite	*Elanus caeruleus*	Moderate	Least Concern
7	Aegithinidae	Marshall's Iora	*Aegithina nigrolutea*	Moderate	Least Concern
8	Alaudidae	Crested Lark	*Galerida cristata*	Moderate	Least Concern
9	Alaudidae	Indian Bushlark	*Mirafra erythroptera*	Moderate	Least Concern
10	Alcedinidae	Pied Kingfisher	*Ceryle rudis*	Moderate	Least Concern
23	Campephagidae	White-bellied Minivet	*Pericrocotus erythropygius*	Moderate	Least Concern
25	Ciconiidae	Asian Openbill	*Anastomus oscitans*	Moderate	Least Concern
31	Cisticolidae	Rufous-fronted Prinia	*Prinia buchanani*	Moderate	Least Concern
44	Dicruridae	White-bellied Drongo	*Dicrurus caerulescens*	Moderate	Least Concern
48	Fringillidae	Common Rosefinch	*Carpodacus erythrinus*	Moderate	Least Concern
50	Hirundinidae	Grey-throated Martin	*Riparia chinensis*	Moderate	Least Concern
56	Leiothrichidae	Common Babbler	*Argya caudata*	Moderate	Least Concern
61	Motacillidae	Citrine Wagtail	*Motacilla citreola*	Moderate	Least Concern
62	Motacillidae	Grey Wagtail	*Motacilla cinerea*	Moderate	Least Concern
64	Motacillidae	Western Yellow Wagtail	*Motacilla flava*	Moderate	Least Concern
65	Motacillidae	White Wagtail	*Motacilla alba*	Moderate	Least Concern
67	Muscicapidae	Black Redstart	*Phoenicurus ochruros*	Moderate	Least Concern
68	Muscicapidae	Bluethroat	*Luscinia svecica*	Moderate	Least Concern

79	Passeridae	House Sparrow	*Passer domesticus*	Moderate	Least Concern
94	Pteroclidae	Painted Sandgrouse	*Pterocles indicus*	Moderate	Least Concern
99	Rhipiduridae	White-browed Fantail	*Rhipidura aureola*	Moderate	Least Concern
102	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	Moderate	Least Concern
106	Scolopacidae	Temminck's Stint	*Calidris temminckii*	Moderate	Least Concern
107	Scolopacidae	Wood Sandpiper	*Tringa glareola*	Moderate	Least Concern
115	Upupidae	Eurasian Hoopoe	*Upupa epops*	Moderate	Least Concern
116	Vangidae	Common Woodshrike	*Tephrodornis pondicerianus*	Moderate	Least Concern
1	Accipitridae	Black Kite	*Milvus migrans*	Low	Least Concern
4	Accipitridae	Eurasian Sparrowhawk	*Accipiter nisus*	Low	Least Concern
5	Accipitridae	Shikra	*Accipiter badius*	Low	Least Concern
11	Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*	Low	Least Concern
13	Anatidae	Knob-billed Duck	*Sarkidiornis melanotos*	Low	Least Concern
14	Apodidae	Little Swift	*Apus affinis*	Low	Least Concern
15	Ardeidae	Cattle Egret	*Bubulcus ibis*	Low	Least Concern
16	Ardeidae	Grey Heron	*Ardea cinerea*	Low	Least Concern
17	Ardeidae	Great Egret	*Ardea alba*	Low	Least Concern
18	Ardeidae	Indian Pond Heron	*Ardeola grayii*	Low	Least Concern
19	Ardeidae	Little Egret	*Egretta garzetta*	Low	Least Concern
20	Ardeidae	Intermediate Egret	*Ardea intermedia*	Low	Least Concern
21	Campephagidae	Black-winged Cuckooshrike	*Lalage melaschistos*	Low	Least Concern
22	Campephagidae	Small Minivet	*Pericrocotus cinnamomeus*	Low	Least Concern
24	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	Low	Least Concern
27	Cisticolidae	Ashy Prinia	*Prinia socialis*	Low	Least Concern
28	Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	Low	Least Concern
29	Cisticolidae	Grey-breasted Prinia	*Prinia hodgsonii*	Low	Least Concern
30	Cisticolidae	Plain Prinia	*Prinia inornata*	Low	Least Concern
32	Columbidae	Eurasian Collared Dove	*Streptopelia decaocto*	Low	Least Concern
33	Columbidae	Laughing Dove	*Spilopelia senegalensis*	Low	Least Concern
34	Columbidae	Red Collared Dove	*Streptopelia tranquebarica*	Low	Least Concern
35	Columbidae	Rock Pigeon	*Columba livia*	Low	Least Concern
36	Columbidae	Yellow-footed Green Pigeon	*Treron phoenicopterus*	Low	Least Concern
37	Corvidae	House Crow	*Corvus splendens*	Low	Least Concern
38	Corvidae	Large-billed Crow	*Corvus macrorhynchos*	Low	Least Concern
39	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	Low	Least Concern
40	Cuculidae	Common Hawk Cuckoo	*Hierococcyx varius*	Low	Least Concern
41	Cuculidae	Greater Coucal	*Centropus sinensis*	Low	Least Concern
43	Dicruridae	Black Drongo	*Dicrurus macrocercus*	Low	Least Concern
45	Emberizidae	White-capped Bunting	*Emberiza stewarti*	Low	Least Concern
46	Estrildidae	Indian Silverbill	*Euodice malabarica*	Low	Least Concern

47	Falconidae	Eurasian Hobby	*Falco subbuteo*	Low	Least Concern
49	Hirundinidae	Barn Swallow	*Hirundo rustica*	Low	Least Concern
51	Hirundinidae	Red-rumped Swallow	*Cecropis daurica*	Low	Least Concern
52	Hirundinidae	Wire-tailed Swallow	*Hirundo smithii*	Low	Least Concern
53	Laniidae	Bay-backed Shrike	*Lanius vittatus*	Low	Least Concern
54	Laniidae	Long-tailed Shrike	*Lanius schach*	Low	Least Concern
57	Leiothrichidae	Jungle Babbler	*Argya striata*	Low	Least Concern
58	Leiothrichidae	Large Grey Babbler	*Argya malcolmi*	Low	Least Concern
59	Megalaimidae	Brown-headed Barbet	*Psilopogon zeylanicus*	Low	Least Concern
60	Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus*	Low	Least Concern
63	Motacillidae	Paddyfield Pipit	*Anthus rufulus*	Low	Least Concern
66	Motacillidae	White-browed Wagtail	*Motacilla maderaspatensis*	Low	Least Concern
69	Muscicapidae	Brown Rock Chat	*Oenanthe fusca*	Low	Least Concern
70	Muscicapidae	Indian Robin	*Copsychus fulicatus*	Low	Least Concern
71	Muscicapidae	Oriental Magpie Robin	*Copsychus saularis*	Low	Least Concern
72	Muscicapidae	Pied Bushchat	*Saxicola caprata*	Low	Least Concern
73	Muscicapidae	Red-breasted Flycatcher	*Ficedula parva*	Low	Least Concern
74	Muscicapidae	Siberian Stonechat	*Saxicola maurus*	Low	Least Concern
75	Muscicapidae	Verditer Flycatcher	*Eumyias thalassinus*	Low	Least Concern
76	Nectariniidae	Purple Sunbird	*Cinnyris asiaticus*	Low	Least Concern
77	Oriolidae	Indian Golden Oriole	*Oriolus kundoo*	Low	Least Concern
78	Paradoxornithidae	Yellow-eyed Babbler	*Chrysomma sinense*	Low	Least Concern
80	Passeridae	Yellow-throated Sparrow	*Gymnoris xanthocollis*	Low	Least Concern
81	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	Low	Least Concern
82	Phalacrocoracidae	Indian Cormorant	*Phalacrocorax fuscicollis*	Low	Least Concern
83	Phalacrocoracidae	Little Cormorant	*Microcarbo niger*	Low	Least Concern
84	Phasianidae	Grey Francolin	*Ortygornis pondicerianus*	Low	Least Concern
85	Phasianidae	Indian Peafowl	*Pavo cristatus*	Low	Least Concern
86	Phylloscopidae	Common Chiffchaff	*Phylloscopus collybita*	Low	Least Concern
87	Phylloscopidae	Greenish Warbler	*Phylloscopus trochiloides*	Low	Least Concern
88	Phylloscopidae	Hume's Warbler	*Phylloscopus humei*	Low	Least Concern
89	Picidae	Black-rumped Flameback	*Dinopium benghalense*	Low	Least Concern
90	Ploceidae	Baya Weaver	*Ploceus philippinus*	Low	Least Concern
92	Psittaculidae	Plum-headed Parakeet	*Psittacula cyanocephala*	Low	Least Concern
93	Psittaculidae	Rose-ringed Parakeet	*Psittacula krameri*	Low	Least Concern
95	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*	Low	Least Concern
96	Pycnonotidae	Red-whiskered Bulbul	*Pycnonotus jocosus*	Low	Least Concern
97	Pycnonotidae	White-eared Bulbul	*Pycnonotus leucotis*	Low	Least Concern
98	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	Low	Least Concern
103	Scolopacidae	Common Snipe	*Gallinago gallinago*	Low	Least Concern
104	Scolopacidae	Green Sandpiper	*Tringa ochropus*	Low	Least Concern
108	Sturnidae	Brahminy Starling	*Sturnia pagodarum*	Low	Least Concern
109	Sturnidae	Common Myna	*Acridotheres tristis*	Low	Least Concern

110	Sturnidae	Asian Pied Starling	*Gracupica contra*	Low	Least Concern
111	Sylviidae	Lesser Whitethroat	*Curruca curruca*	Low	Least Concern
112	Threskiornithidae	Glossy Ibis	*Plegadis falcinellus*	Low	Least Concern
113	Threskiornithidae	Red-naped Ibis	*Pseudibis papillosa*	Low	Least Concern
114	Turnicidae	Barred Buttonquail	*Turnix suscitator*	Low	Least Concern
117	Zosteropidae	Indian White-eye	*Zosterops palpebrosus*	Low	Least Concern

Annexure 11: Consultant Profile Summary

Name	Summary
Chetan Agarwal, Senior Fellow, CEDAR Study coordinator and Lead, Vegetation assessment	Chetan is a forest and ecosystem services analyst with extensive experience with vegetation assessments and plantation surveys including in the NCR Aravalli's. He holds a Master's in Public Affairs (MPA) from the School of Public and Environmental Affairs (SPEA), Indiana University Bloomington, USA. He is skilled in forest vegetation assessments, governance for ecosystem services and assessment, forest tenure analysis, policy analysis, land use studies and mapping. Previously he has worked with the Society for Promotion of Wastelands Development (SPWD), Win rock International India, and Forest Trends, Washington DC.
Rajesh Thadani, Senior Fellow, CEDAR Advisor, Vegetation and Ecology assessment	Rajesh is a forest ecologist and a development sector professional. He has a doctorate in Forest Ecology and physiology from Yale University, School of Forestry and Environmental Studies. His research focuses on the forests of the mid-elevational Himalaya. He is the Founder Executive Director of the Centre for Ecology Development and Research (CEDAR) an action research organization, and has been a visiting fellow at Yale University. Rajesh has been a Senior Advisor to the Tata Trusts and has worked extensively in the development sector. He has authored/ co-authored over 20 research papers and been the lead researcher for projects funded by the Department of Science and Technology, Ministry of Environment and Forests, and Cambridge University among others.
Dr. Satish Kumar Sharma (Advisor, Forest Taxonomy, Bird, Mammals and overall ecology)	Dr Sharma has served in the Rajasthan Forest Department from 1980 to 2016. Retired from the post of Assistant Conservator of Forests. He served as consultant in Foundation for Ecological Security, Anand (Gujarat) for more than 9 years in various states of India like Rajasthan, Gujarat, Madhya Pradesh, Andhra Pradesh, Telangana, Maharashtra, Odisha, Karnataka, Assam, Nagaland, Kerala, Himachal Pradesh, Jharkhand and Bihar. Services given to various government, NGOs and private agencies like JSW, Bellary; ITC Bhopal, Forest Department, Rajasthan; Living Farms, Koraput, Odisha; DST, New Delhi; TISS Hyderabad etc. Dr Sharma has extensive experience Aravalli experience in forest and grassland restoration and management, in plant/animal taxonomy and biodiversity studies and ecological impact assessment studies
Sunil Harsana, Field Associate. Mammal survey	Sunil Harsana is a local conservationist who has worked on several mammal wildlife surveys and studies in the Aravalli's of south Haryana. He has received small grants from Sanctuary, WWF and the Co-Existence consortium to undertake conservation studies in the area. He is currently working to preserve the floral and faunal diversity in the NCR Aravalli's and promote understanding of leopard ecology and enhance the coexistence of leopards and humans in the area.

Dr Robin Suyesh (Amphibian/reptile survey)	is a field biologist and has primarily worked on the herpetofauna of the South and South East Asia – (Western Ghats, Central India, Himalayan region of Indian subcontinent, Malaysian Borneo, Sri Lanka, Thailand and Indonesia). He has experience in the Delhi/Haryana Aravalli's. His research till date has focused on understanding and documenting the behaviour and ecology of some very interesting amphibian/ reptile species in these three biodiversity hotspots and also on unravelling the amphibian biodiversity in these regions through description of new species (co-authored 13 new species till date). His PhD research was on "Acoustic communication in the bush frogs of genus Raorchestes and Pseudophilautus" from University of Delhi in collaboration with University of Minnesota, USA. Currently he is working as an Assistant Professor at Department of Environmental Sciences, Sri Venkateswara College, University of Delhi.
Ishtiyak Ahamad, (Insect Survey	is a nature educator and field researcher specializing in insects and particularly butterflies of the Delhi NCR and the Aravallis. He has 13 years of experience with the Conservation Education Centre, Asola Bhatti Wildlife Sanctuary Delhi with BNHS (Bombay Natural History Society) Education wing. (Nov 2007 to October 2020) where he has led insect/butterfly walks, developed butterfly gardens and participated in insect, bird, reptile and forest ecological studies. He has undertaken several biodiversity surveys in the Aravalli habitats of Asola Bhatti Wildlife Sanctuary and other regions. He has a MSc in Fish and fisheries and a BSc in Zoology, Botany and Chemistry.
Pia Sethi, Senior Fellow CEDAR (Advisor, Bird study)	Dr Sethi is an ecologist with a Doctorate degree in Ecology from the University of Illinois, Chicago. Her research focuses on the consequences of human activity on the forest ecosystems including the dynamics of plant-animal interactions with a focus on bird-plant interactions. She has undertaken several ecological assessments including on avian-vegetation assessments. She is an avid long-time birder in the Delhi NCR. She has previously headed the biodiversity team at TERI. Her current work spans a diverse range including community-based conservation, ecotourism, impacts of hunting on ecosystems and traditional ecological knowledge & folklore, particularly in the Ladakh and North-East region of India
Dr. S.B. Ota, Joint Director General (Rtd.), ASI (Archaeology study)	Dr Ota retired as Joint Director General from the Archaeological Survey of India (ASI). His field of interest includes prehistory, field archaeology, salvage archaeology, documentation, archaeological heritage management, and structural conservation. Dr Ota has extensive experience in the aravalli region and has co-authored a monograph entitled, "Anangpur – The Paleolithic site near Delhi", that focuses on hand tools found in the area. Presently Dr. Ota is engaged with two major projects – one is the "Geo-archaeological Investigations of Acheulian Sites, District Raisen, Madhya Pradesh" and the other one is the "Understanding Early Human Occupations in High Altitude Ladakh Himalayas".

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Communication Address: 1600, Sector-15 Part-II, Gurugram, Haryana – 122001

Contact Number: +91- 9311411998

Email: management@gurujal.org | communications@gurujal.org

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