ECO-TERRARIUM: IMMERSIVE WILDLIFE PARK

Baadreni Road, Bharatpur, Chitwan

By:

SHOUMYA MALLA

760141

A thesis submitted in partial fulfillment

of the requirements for the

Degree of Bachelor of Architecture

Purbanchal University

KHWOPA ENGINEERING COLLEGE

DEPARTMENT OF ARCHITECTURE

Libali, Bhaktapur, Nepal

AUGUST 2025

An Undertaking of Bhaktapur Municipality
KHWOPA ENGINEERING COLLEGE
(Affiliated to Purbanchal University)
Estd. 2001
PAN No. 201382918

CERTIFICATE

This is to certify that the thesis entitled **ECO-TERRARIUM: IMMERSIVE WILDLIFE PARK** at ***Baadreni Road, Bharatpur, Chitwan,*** submitted to the Department of Architecture of Khwopa Engineering College by **Mr. Shoumya Malla** of Class Roll No. 41/ B.Arch./076 has been declared successful for the partial fulfillment of the academic requirement towards the completion of the degree of Bachelor of Architecture of Purbanchal University.

....
Ar. Sakar Shrestha
Supervisor

....
Ar. Rashish Lal Shrestha
Thesis Coordinator

....
Ar. Biresh Shah
(External Juror)

....
Ar. Archana Bade Shrestha
Head of Department of Architecture

Bhaktapur Municipality, Ward No:8, Libali, Bhaktapur
P.O. Box:84, Bhaktapur
Tel:977-01-5122094, 977-01-5122098
E-mail:info@khec.edu.np, URL:www.khec.edu.np

Abstract

This report explores studies related to the project: Eco-terrariums— "immersive ecosystems" in modern zoological parks, emphasizing their potential to revolutionize conservation, education, and sustainable tourism. Establishes the theoretical framework, defining eco-terrariums as tools for replicating natural habitats while balancing animal welfare and public engagement. It traces the evolution of zoos from ancient captivity to conservation hubs, contextualizing Nepal's underdeveloped zoo infrastructure against global benchmarks like Singapore's Cloud Forest and the Eden Project. A SWOT analysis highlights eco-terrariums' strengths (conservation value, tourism appeal) and challenges (costs, technical complexity), while spatial and anthropometric guidelines outline enclosure designs tailored to species-specific needs. Through research on Zoological parks, their functional elements, and similar examples of the project around the world, many problems regarding the project were counteracted.

The project will contain climate-responsive biomes and terrariums, housing over 120 species, including mammals, birds, reptiles, and aquatic life, placed in naturalistic mixed-species enclosures to simulate their native ecosystems. Key programmatic elements include a Wildlife Conservation Museum, Visitor Center, Student Conservation Organization Office, Research and Veterinary Facilities, and eco-friendly camping zones. Each component is supported by sustainable infrastructure such as solar power, rainwater harvesting, and waste and water treatment systems. Present national and international case studies to contextualize design and operational strategies. Nepal's Central Zoo, analyzed for its historical legacy and spatial constraints, contrasts with Singapore Zoo's open-concept habitats and Germany's Gondwanaland biodome, which use advanced materials (ETFE membranes) and climate control to simulate biomes. The Eden Project's repurposed quarry site and Leipzig Zoo's aerial walkways exemplify sustainable, immersive design. A comparative study underscores disparities in infrastructure, accessibility, and sustainability practices, offering lessons for Nepal. The research concludes that eco-terrariums could position Nepal as a leader in biodiversity conservation, leveraging its ecological wealth to drive eco-tourism, education, and climate resilience. By adopting phased implementation, renewable energy systems, and

community-centric models, Nepal's zoos can transcend traditional exhibition paradigms, foster ethical stewardship of endangered species while align with global sustainability goals.

The design emphasizes educational experiences, passive climate control, and barrier-free circulation to engage diverse visitors while promoting conservation awareness and animal welfare. The project serves as a model for modern zoos—balancing architecture, ecology, and education in response to the biodiversity and climatic context of Nepal.

Declaration

I hereby declare that the project work entitled "ECO-TERRARIUM" submitted to the Department of Architecture, Khwopa Engineering College, is a record of an original work done by me under the guidance of Ar. Sakar Shrestha, and this project work is submitted in fulfillment of the thesis requirements of the Bachelor of Architecture degree. I also declare that this work has not form the basis of any similar title to any candidate of any other institution or university.

Shoumya Malla

760141

Acknowledgement

The architectural thesis project would not have been possible without the constant support and help of many individuals throughout the 5 years of architecture. I would like to extend my sincere gratitude to each one of them who has guided me in the course of time.

I would like to extend my sincere gratitude to all people who have helped me through the course of the project.

I would like to thank my supervisor, Ar. Sakar Shrestha for his constant guidance and active support. I greatly appreciate the time he spent in providing valuable feedback and suggesting reading and research materials, which helped me in getting a clearer understanding of the depth of the issues.

Table of Contents

List Of Figures

List Of Tables

List Of Abbreviations

ADA – American Dental Association

ANSI - American National Standards Institute

AZA - Association of Zoos and Aquariums

CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora

COF - Coefficient of friction

CZA - Central Zoo Authority

DIN – Deutsches Institut für Normung e.V.

EIA - Environmental Impact Assessment

ETFE - Ethylene Tetrafluoroethylene

HVAC - Heating, Ventilation, and Air Conditioning

ISO – International Organisation for Standardisation

IUCN – International Union for Conservation of Nature

MEP - Mechanical, Electrical, And Plumbing

NTNC - National Trust for Nature Conservation

Sq.m - Square Meter

STP - Sewage Treatment Plant

UV - Ultraviolet

WAZA - World Association of Zoos and Aquariums

WWF - World Wide Fund for Nature

Chapter 1 Project Introduction

1.1 Eco-Terrarium: Immersive Wildlife Park

An eco-terrarium integrated into a zoo concept is a sustainable, self-contained ecosystem designed to replicate natural habitats while prioritizing conservation, education, and visitor engagement. These immersive exhibits combine cutting-edge technology, biodiversity, and ecological principles to create a model for ethical animal care, climate resilience, and public awareness.

A zoo is a facility where animals are housed, cared for, and displayed to the public for education, conservation, research, and recreation. Modern zoos aim to balance public engagement with animal welfare and environmental stewardship.

While zoos face ethical debates over animal captivity, many now focus on species preservation, habitat restoration, and global partnerships (e.g., with the IUCN). They serve as "arks" for endangered species and hubs for inspiring environmental responsibility.

History Of Zoological Park:

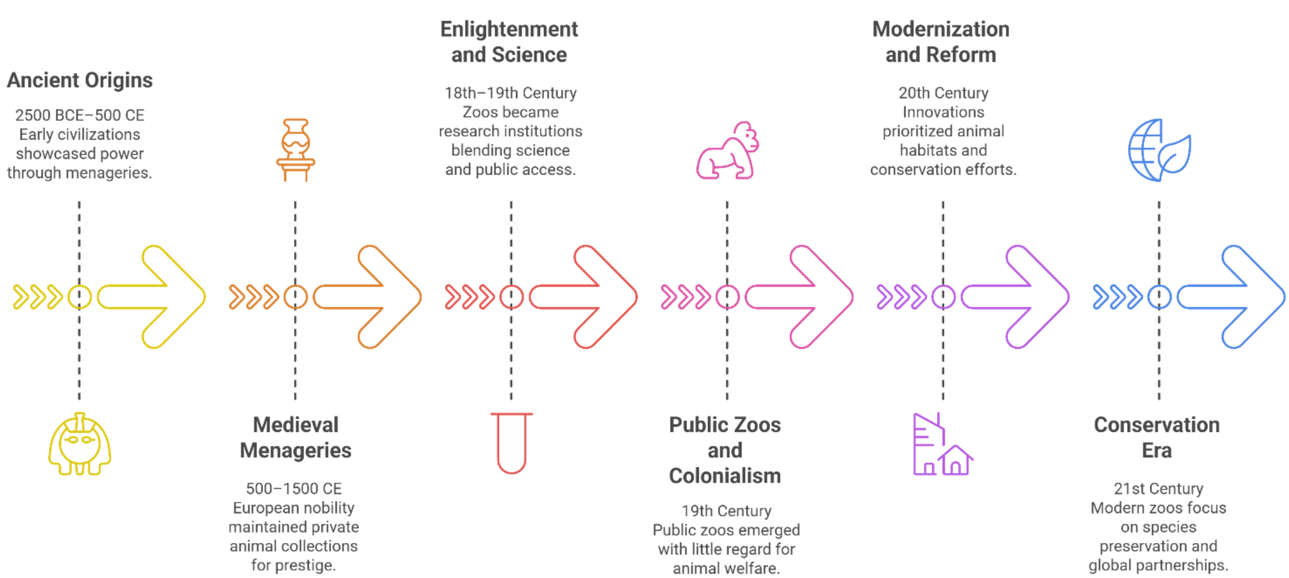


Figure 1.1 History of Zoological Park

Historically rooted in ancient royal menageries and colonial-era collections, zoos evolved from symbols of power and curiosity into scientific and conservation institutions. Today, they are more like a facility designed to showcase and educate the public about various animal species, their habitats, and conservation efforts. These centers often feature live animals, interactive exhibits, and educational programs to raise awareness about biodiversity, endangered species, and environmental protection. They prioritize:

- Education: Teaching visitors about wildlife, ecosystems, and biodiversity.
- Conservation: Breeding endangered species (e.g., giant pandas, Asian Elephants) and reintroducing them to the wild.
- Research: Studying animal behavior, genetics, and health to aid global conservation efforts.
- Habitat Replication: Creating enclosures that mimic natural environments to improve animal well-being.

Modern Development:
Inspired by large-scale projects like the Eden Project (UK, 2001), Biodôme de Montréal (Canada, 1992), and Singapore's Cloud Forest (2012), eco terrariums became tools for simulating biomes and addressing conservation challenges.

- Eden Project (UK): A network of biomes housing Mediterranean and tropical ecosystems, emphasizing education and sustainability.
- Biosphere 2 (USA): A research facility in Arizona exploring closed ecological systems, contributing insights into sustainable habitat design.
- Gardens by the Bay (Singapore): Integrates futuristic eco terrariums (Cloud Forest, Flower Dome) with urban conservation efforts.

1.2 Project Justification:

The Present Scenario of Eco Terrariums as a Concept in Nepali Zoo;

1.Current Status:

The concept of eco terrariums: self-sustaining, immersive ecosystems designed for conservation, education, and research—is largely underdeveloped in Nepal. Traditional zoos, such as the Central Zoo in Kathmandu, remain focused on animal exhibition rather than holistic habitat replication. While Nepal boasts rich biodiversity, its zoological institutions have yet to adopt modern eco terrarium models seen in countries like Singapore or the UK.

2. Existing Initiatives:

- Central Zoo: Nepal's only zoo has begun integrating basic conservation and educational programs but lacks advanced eco terrarium infrastructure.
- Godavari Botanical Garden: Focuses on plant conservation, offering a partial foundation for terrarium-style ecosystems.
- National Trust for Nature Conservation (NTNC): Engages in habitat restoration and species conservation (e.g., red pandas, Bengal tigers), but projects are field-based rather than enclosed ecosystems.

3. Potential Benefits for Nepal:

- Conservation: Protect endangered species (e.g., red pandas, Himalayan salamanders) through controlled breeding and habitat replication.
- Education: Offer immersive experiences to teach visitors about Nepal's ecosystems, climate change, and biodiversity.
- Tourism: Attract eco-conscious travelers, aligning with Nepal's growing eco-tourism sector.
- Research: Serve as hubs for studying species behavior, climate resilience, and ecosystem dynamics.

4. Challenges:

- Funding: High costs for construction, technology (e.g., climate control systems), and maintenance.
- Expertise: Limited local technical knowledge in designing/managing closed ecosystems.
- Infrastructure: Outdated zoo facilities and energy grids are ill-suited for advanced terrarium requirements.
- Public Awareness: Low familiarity with eco terrariums; potential resistance to shifting from traditional zoo models.

5. Opportunities:

- Partnerships: Collaborate with international organizations (e.g., WWF, IUCN) or institutions like Singapore's Gardens by the Bay for knowledge transfer.
- Government Support: Leverage Nepal's National Biodiversity Strategy and Climate Change Policy to secure funding.
- Pilot Projects: Start small-scale terrariums (e.g., amphibian-focused ecosystems) at NTNC centers or botanical gardens.

6. International Inspiration:

- Singapore's Cloud Forest: Demonstrates how vertical ecosystems can thrive in urban settings.
- Eden Project (UK): Highlights the role of eco terrariums in education and tourism.
- Biodôme de Montréal: A model for replicating multiple biomes under one roof.
- Bhutan's Phobjikha Valley Conservation: Community-led ecotourism that balances conservation and livelihoods — a model that Nepal could emulate.
- India's Madras Crocodile Bank: Combines breeding programs with public education, demonstrating low-cost terrarium techniques adaptable to Nepal.

7. Path Forward:

Modernize Central Zoo: Integrate terrarium sections (e.g., Himalayan cloud forest, Terai wetlands, and mid-hill ecosystems) to showcase Nepal's unique biodiversity. For example:

Capacity Building:

- Train zookeepers, botanists, and engineers in eco terrarium design through partnerships with global institutions (e.g., Singapore's Gardens by the Bay, Eden Project).
- Establish academic programs in ecological engineering and zoo management at the Universities of Nepal.

Community Engagement:

- Involve local communities in plant propagation, animal care, and guided tours to foster stewardship.
- Launch citizen science programs (e.g., monitoring microclimates or species behavior) to enhance public awareness.

Technological Integration:

- Use IoT sensors for real-time monitoring of temperature, humidity, and air quality.
- Install solar panels and biogas systems to power terrariums, reducing reliance on Nepal's unstable grid.

8. Expected Outcomes:

- Ecological: Stabilize populations of critically endangered species (e.g., Asiatic wild dogs, Himalayan newts) through captive breeding.
- Economic: Boost tourism revenue by positioning Nepal as a leader in innovative conservation.
- Educational: Become a regional hub for climate and biodiversity education, attracting students and researchers.

9. Challenges to Address:

- Technical Barriers: Partner with international zoos to access advanced climate-control technologies.
- Cultural Shifts: Gradually transition from traditional "cage-based" exhibits to immersive ecosystems through public workshops and media campaigns.

1.3 Objective:

• **Conservation:** Make a conservation-centric place that not only exhibits animals in a small cage but in a natural immersive habitat where people can get aware of the native ecosystem of Nepal and support natural behaviors, biodiversity education, and species conservation.

• **Rescue & Rehabilitation:** Integrate veterinary hospitals, quarantine zones, and rehabilitation enclosures.

• **Education:** Create a centralized wildlife conservation museum and interactive spaces (AR exhibits, canopy walkways) that educate the public on native species, ecosystem interdependence, and ongoing conservation efforts in Nepal and globally, to foster environmental stewardship. Including child-friendly exhibits and programs that can help increase students' involvement so that they can learn more, as said by Attenborough, D. (n.d.). *If children don't grow up knowing about nature and appreciating it, they will not understand it, and they don't understand it, they won't protect it.... and if they don't protect it, who will?*

• **Sustainability:** Achieve net-zero energy/water use through passive design and renewable systems.

• **Cultural Integration:** Reflect Tharu indigenous architecture and engage local communities in operations.

1.4 Scope:

This project focuses primarily on the architectural design and spatial planning aspects of the Eco-Terrarium: Ecological Biome Observatory at Bharatpur, Chitwan. It covers the following key areas:

- Site Analysis: Assessing the site's topography, microclimate, vegetation, hydrology, and access routes to inform terrarium placement, immersive landscapes, and orientation of built forms.
- Concept Development: Developing a unifying architectural concept that blends natural ecosystems, animal habitats, and visitor interaction, while promoting environmental stewardship and sustainability.

- Programmatic Zoning and Spatial Planning: Strategically defining and distributing core functions such as thematic terrariums, research labs, wildlife rehabilitation centers, educational hubs, administrative spaces, and support zones across the site area.
- Visitor Flow and Circulation Design: Creating intuitive, inclusive, and ecologically sensitive pathways that guide visitors through diverse biome zones while maintaining safe and efficient animal service routes.
- Responsive Architectural Language: Designing terrarium enclosures and support structures using context-sensitive materials, passive environmental systems, and forms that harmonize with the landscape and animal behaviors.
- Ecological Theming and Interpretation: Integrating content on Nepal's biodiversity, ecological systems, conservation strategies, and species-specific education directly into the design of enclosures and public spaces, enhancing thematic depth and learning engagement.

1.5 Limitation:

- Habitat Interpretation & Exhibit Themes: The project will outline ecological and conservation-based thematic zones inspired by Nepal's biodiversity, however will not include in-depth species-specific interpretive planning, scientific research detailing, or acquisition of educational materials.
- Exhibit Technology & Interaction: While the design proposes immersive spatial experiences and general visitor pathways, it will not cover the integration of advanced multimedia systems, interactive digital interfaces, or exhibit-specific lighting and acoustic engineering.
- Structural and MEP Integration: The design emphasizes passive design strategies and sustainability, however detailed structural engineering and the design of mechanical, electrical, and plumbing (MEP) systems fall outside the scope of this study.
- Budgeting and Management Strategy: The thesis will not provide financial analysis, cost estimations, operational workflows, or fundraising frameworks required for real-world implementation.

- Environmental & Regulatory Assessments: Formal environmental impact assessments (EIA), ecological impact studies, and wildlife regulatory approvals will not be within the project's scope, though ecological sensitivity has informed design decisions.

1.6 Methodology:

a. General Data and Literature Review

For in-depth understanding and data collection for the project regarding the functional, spatial, and technical aspects relevant to the project, was done through extensive research on relevant books, journals, articles, academic publications, and digital resources. The literature informed the planning of naturalistic habitats, sustainable architecture, and visitor-centered spatial design.

b. Case Studies

To gain deeper insight into the project, both national and international case studies were conducted. Case studies help in understanding existing projects to study spatial planning, functional zoning, and workflow. By photographic documentation and on-site building surveys or through internet browsing, case studies were done. In this phase, two types of case studies were done:

- National Case Studies – Localized examples of wildlife reserves and nature-based tourism centers within Nepal.
- International Case Studies – Globally recognized eco-parks, biomes, and immersive zoo models studied through site visits (where possible), photographic surveys, and online documentation.

c. Site Analysis

Site criteria were first researched to determine suitability for the Eco-Terrarium Zoological Park. The site was analyzed concerning:

- Land Use & Existing Conditions
- Topographical Features and Surrounding Ecology
- Microclimate, Solar Orientation, and Vegetation Patterns
- Legal Zoning, Building Regulations, and Environmental Constraints

d. Program Formulation

Based on research findings and design needs, the program was developed through:

- Program Formulation
- Spatial requirements for Animals, Visitors, and Staff
- Concept development
- Master Planning
- Alternate designs and options
- Preparation of drawings and presentation models

Methodology for the Design Phase of the project;

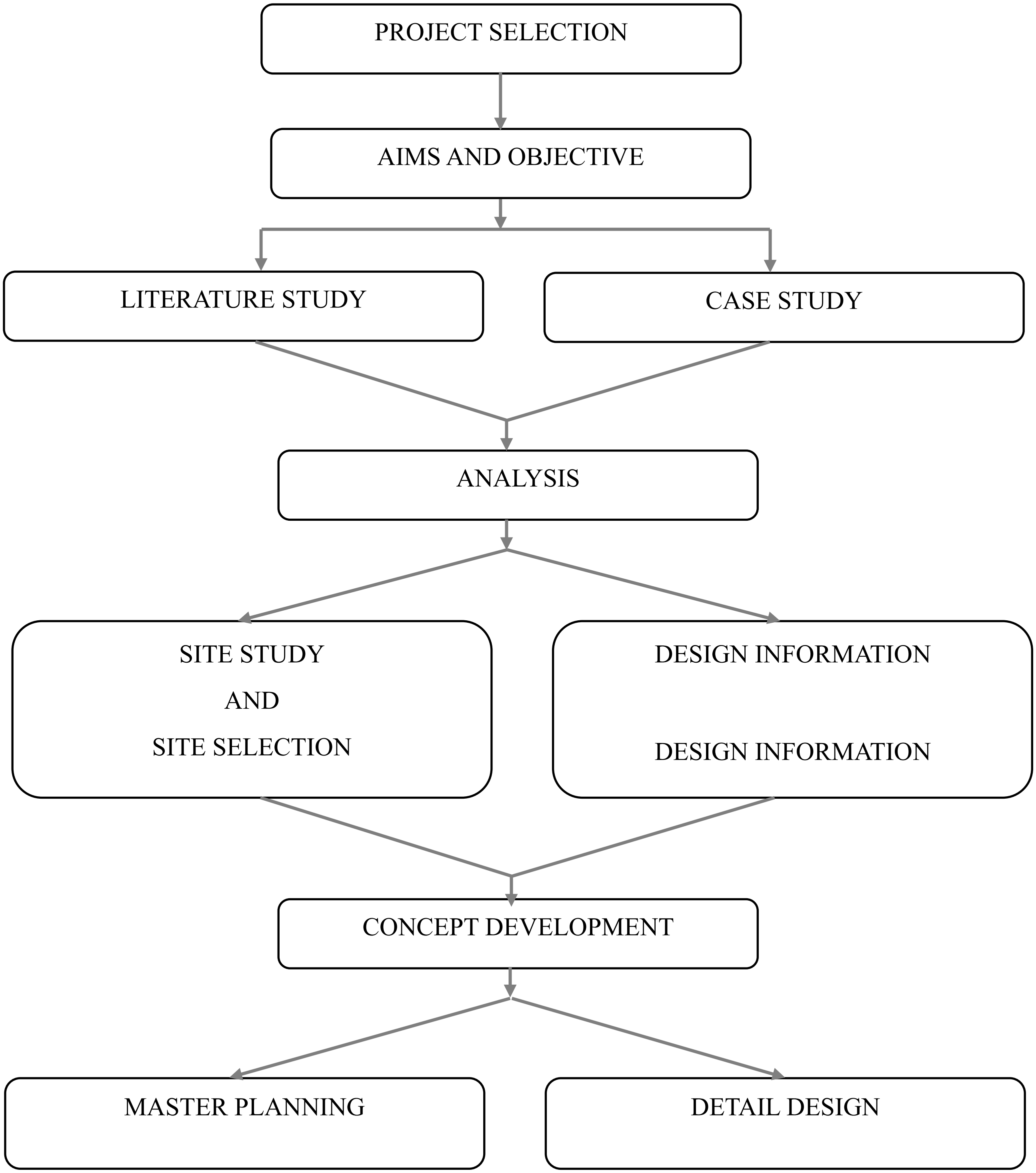


Figure 1.2 Methodology for the project

Chapter 2 : Literature Review

2.1. Introduction

The Eco-Terrarium Project aims to create an innovative and immersive space that blends natural ecosystems with modern architecture to support conservation, education, and public engagement. It is designed as a biodome-like structure where plants, animals, and humans can coexist, simulating different natural habitats under one roof. This project serves as a hub for species conservation, breeding programs, and environmental awareness, using principles of sustainability, green technology, and immersive design. Through this project, visitors will not only observe but also experience the interconnectedness of ecosystems, inspiring a deeper respect for biodiversity.

Zoo, in terms of design, is a comprehensive entity made up of various disciplines. It is composed of spaces and elements beginning from the 'approach & parking area' to 'enclosures and service buildings' besides services like plumbing and electrical.

The basic components that should be taken into consideration during the designing phase of the project are animals, visitors, human manpower and infrastructure for housing, upkeep, healthcare of animals and basic facilities for visitors. The highest importance and priority have to be given to the safety and security of the zoo animals, visitors and zoo personnel. The components of zoo design consist of requirements of living elements and non-living elements. The 'living' part introduces the element of subjectivity and judgement, same design situation will result different responses and design solutions based on the knowledge and experience of the people involved. These variations are not a negative aspect, on the contrary it is various options and differences in responses to design situations which encourage new ideas and experimentation; which are so essential for the design development of zoos.

The designing of a zoo requires expertise and knowledge in different aspects such as animal biology, behavior, etc., visitors' expectation and satisfaction, zoo caretaker and managerial personnel requirements and understanding of the local climatic factors etc.

2.2. Components Of Zoological Park:

A zoo seamlessly integrates architecture, ecology, and visitor experience, forming a self-sustaining microcosm where natural ecosystems and human interaction coexist harmoniously. According to *Mehta & Singh (2018). Design Guidelines for Zoos.* The primary components include:

2.2.1. Areas: Areas/Land Use in the Vicinity of Zoo.

a) Front area outside the gate of the Zoo.

b) Main gate and entry area

c) Visitors parking

i. Outside the main gate

ii. Inside the main gate

2.2.2. Circulation

A) Zoo Parking - inside the Zoo

b) Vehicular circulation

C) Pedestrian circulation

• Visitors & Staff

• Service Circulation for Access to Night Shelters and Kraals

2.2.3. Landscape

a) Existing vegetation

b) Gardens, planting beds, trees, plantation

c) Vegetation buffers/ Screens (between spaces and between enclosures)

d) Peripheral planting

e) Landforms

f) Grade change devices (ramps, steps, stepped planters, etc.)

G) Green pavers areas

h) Landscape Art and Sculptures

2.2.4. Elements

a) Railings and Fences

i. Along stand-off barriers

ii. Along road and paths

iii. For animal enclosures

b) Signage

i. Information: Signs conveying information about services and facilities, such as biological information of the species housed, maps, directional, or instructional signs.

ii. Directional: Signs showing the location of services, facilities, functional spaces and key areas, such as signposts or directional arrows.

iii. Identification: signs indicating services and facilities, such as room names and numbers, restroom signs, or floor designations.

iv. Safety and Regulatory: signs giving warning or safety instructions, such as warning signs, traffic signs, exit signs, or signs conveying rules and regulations.

2.2.5. Animal enclosure types:

Designing enclosures for zoo animals requires careful consideration of each species' natural behaviors, social structures, and habitat needs. Below are guidelines on minimum enclosure dimensions for the species you listed, based on global best practices (e.g., WAZA, AZA) and adapted to the context of zoos in regions like Nepal. These guidelines focus on providing adequate space, environmental enrichment, and welfare for the animals.

i. Paddock
ii. Moat/barrier
iii. Kraal
iv. Feeding cubicles/ night shelter/ retiring cell
v. Stand-off barriers
vi. Ancillary structure

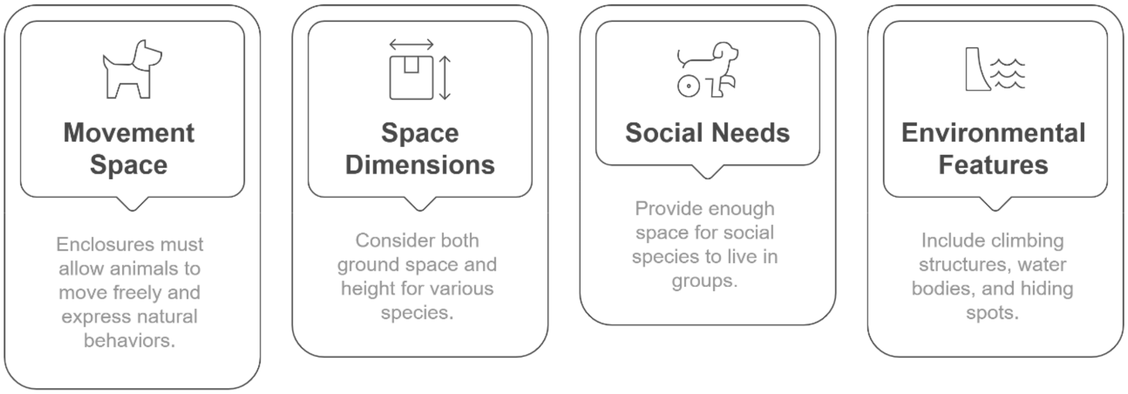


Figure 2.1 Animal Enclosure Requirements

2.2.6. Structures

a) Buildings/ Structures

i. Interpretation Centre

ii. Administrative offices

iii. Veterinary Hospital

Iv. Quarantine/Isolation facilities

V. Visitors' amenities – toilets, drinking water fountains, and troughs

B) Service Structures

I. Electric Substation

Ii. Sewage treatment plant (STP)

Iii. Pumping station

Iv. Overhead/ Underground Water Tanks

2.2.7. Services

i. Stormwater Drains

ii. Water Supply Pipes

iii. Electrical Cables

iv. Secure Digital Communication

v. Water Retention Pools

vi. Recharge Pits

2.3. Animal enclosure design:

According to *Mehta & Singh (2018). Design Guidelines for Zoos.*

Zoos are expected to provide a high standard of accommodation for all animals in their care, both on- and off-exhibit, permanent and temporary. Accommodation must take into account the welfare of the individual, species-specific needs, their space and social needs, appropriate management by staff and appropriate display to visitors. Important considerations that must be taken into account are:

1. All enclosures must provide a suitably complex living environment that considers the needs of the individual as well as species and group needs and encourages positive welfare states.

2. Design of enclosures must consider the management needs of the species. This includes:

a. Designing the enclosure such that it prevents animals from escaping;

b. Space available to allow for exhibition of the broadest repertoire of natural behaviors when reasonably possible

c. Space available to allow for normal social groups;

i. to avoid animals within herds or groups being unduly dominated by other individuals

ii. to avoid the risk of persistent and unresolved conflict between herd or group members or between different species in mixed exhibits

iii. to ensure that the physical carrying capacity of the enclosure is not exceeded; and adequate for the number of individuals and variety of species kept.

d. Management of (social) conflict through separation areas, visual barriers, and other means, including accommodation for animals temporarily separated from a group

e. Allow for animal choice of preferred enclosure space, whenever possible including indoor and outdoor free access, day and night

f. Catch up facilities or other appropriate methods for capture and restraint

g. Facilities for the management of breeding animals, such as cubbing dens, nest sites or spawning substrates

h. Introduction, quarantine and health care facilities that are Go to Contents 5 adequate for the number of individuals and species in question

i. Enclosures that allow a safe and appropriate cleaning regime to prevent an unacceptable build-up of parasites and other pathogens

j. Safe and appropriate presentation of food and water

k. Environmental and behavioral enrichment

l. Provide opportunity for animals to choose to escape visitor gaze

m. Animals should never be coerced for the benefit of visitors

n. Animals in visibly adjoining enclosures must not interact in an excessively stressful way.

3. Provision of facilities for good observation of the enclosure and its animals by staff and researchers.

4. Provision of a high standard of public viewing experience, which demonstrates fully the animals and their behaviors, and which is consistent with the educational messages and strategies relevant to the species, the organization and its mission.

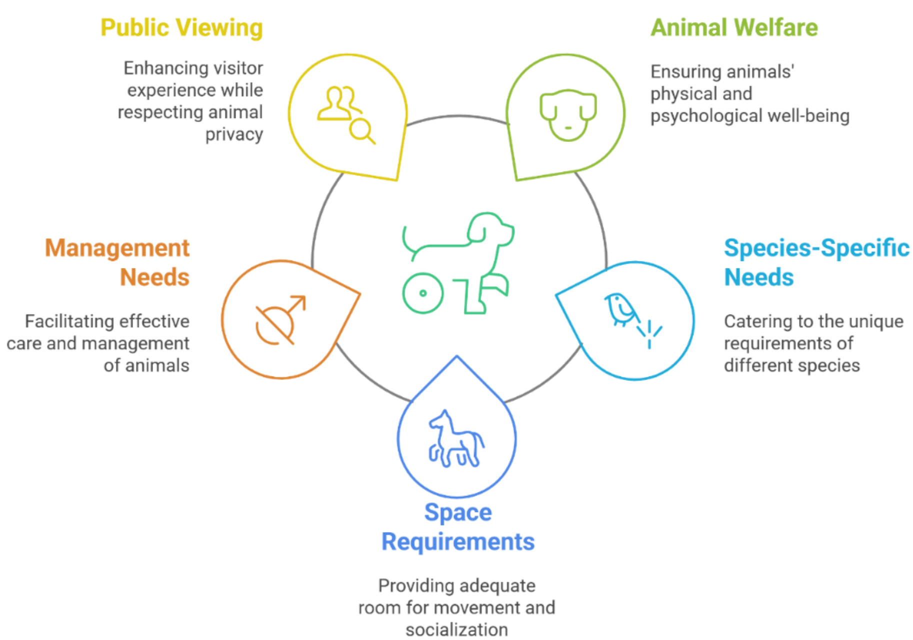


Figure 2.2 Factors for the optimization of Animal Enclosure Design

Table 2.2.1. Guidelines on minimum dimensions of enclosures for housing exotic animals of different species

S.No	Species	Minimum Size of Outdoor Enclosures (Sq.m)	Number of Animals/ Birds to be Housed (M:F)	Size of Feeding Cubicles/ Night Shelters (length x breadth x height, each in metres) for each animal or bird	Minimum Size of Water Body (if required) (Sq. M)
1	Flightless birds, emu, cassowary	500 (up to 10 birds)	1:1	3 × 2 × 2.5	--
2	Exotic pheasants	80 (with the minimum dimensions of the aviary being 3 m × 3 m × 6 m)	1:3	--	
3	Flying birds	80 (with the minimum dimensions of the aviary being 3 m × 3 m × 6 m)	2:2	Height of the aviary should be 6 m	--
4	Parrots, macaws, cockatoos, conures, rosellas	80 (with the minimum dimensions of the aviary being 3 m × 3 m × 6 m)	2:2	Height of the aviary should be 5 m	--
5	Baboons, capuchins, lemurs, exotic monkeys	500	1:1	2 × 1.5 × 2.5	--
6	Marmosets, squirrel monkeys	50	1:1	1 × 1.5 × 2	--
7	European bear	1000	1:1	2.5 × 1.8 × 2.5	--

8	Cape buffalo	1500	1:1	3 × 2 × 2.5	--
9	Chimpanzee, orangutan, gorilla	1000	1:1	2.75 × 1.8 × 3	--
10	Fallow deer, sika deer and lechwe	1000	2:3	3 × 2 × 2.5	--
11	African elephant	5000	1:1	8 × 6 × 5.5	--
12	Giraffe	1500	1:1	8 × 5.5 × 6	--
13	Hippopotamus	1000	1:1	5 × 3 × 2.5	--
14	Jaguar	500	1:1	2 × 1.8 × 2.5	--
15	African lion	1000	1:1	2.75 × 1.8 × 3	--
16	African rhino/white rhino	2000	1:1	5 × 3 × 2.5	--
17	Tapirs	500	1:1	2.5 × 1.5 × 2.5	--
18	Tigers (other than bengal tiger)	1000	1:1	2.75 × 1.8 × 3	--
19	Zebras	1500	1:1	3 × 2 × 2.5	--
20	Wallabies	300	1:1	2.5 × 1.5 × 2.5; the floor should be provided with a ramp	
21	Crocodiles/ Alligators: African dwarf alligator, American, alligator, Australian alligator, False gavial, Morelet's crocodile, Nile crocodile, Siamese crocodile, Slender-snouted crocodile, West African dwarf Crocodile, Spectacled caiman, Yacare caiman and Dwarf caiman	500	1:1	Note: Sufficient amount of sane should be provided for basking.	200 (with a depth of 2 m)

22	Iguana	100 (covered partly by chain link)	1:2	1.0 x 0.75 x1.5	Reptile house/glass terrarium type enclosure may also be provided.
23	Giant Aldabra tortoise	200	1:1	Area 20 m2 (to provide shelter from rain and heat)	
24	Small aviary birds (love birds, finches, lorikeets, Java sparrow, munias, budgerigars	15	2:3	Earthen pots of appropriate size for nesting and shelter should be provided	

Source: Mehta & Singh (2018). Design Guidelines for Zoos

Table 2.2.2. Minimum prescribed size for feeding/ retiring cubicle for important mammalian species of captive animals

Name of the Species	Size of the feeding cubicle/ night shelter for each animal (meters)	Name of the Species	Size of the feeding cubicle/ night shelter for each animal (meters)				
	Breadth	Height	Length	Name of the Species	Breadth	Height	Length
Tiger, Asiatic lion	2.75	1.80	3.00				
Common leopard, Clouded	2.00	1.80	2.5	Musk deer, Nilgiri tahr, Chinkara, Four horned,	2.5	1.5	2.5

leopard & Snow leopard				antelope, Bharal, Goral, Wild sheep and Markhor			
Small Cats	1.8	1.50	2.0	Mouse deer	1.5	1.0	1.5
Sloth bear, Himalayan black bear, Brown bear and Malayan sun bear	2.5	1.8	2.5				
Monkeys and Langurs	2.0	1.5	2.5				
Civets, Binturong, Otters, Retel, Hogbadger, Martens, Red panda, Wolf, Jackal and Wild dog	2.0	1.5	2.5				
Elephant	8.0	6.0	5.5	Slow loris and Slender loris	1.0	1.0	1.5
One-horned Indian Rhinoceros	5.0	3.0	2.5				
Wild buffalo, Yak, Indian gaur and Wild ass	3.0	2.0	2.5				

Table 2.2.3. Sizes for outdoor open enclosures for important mammalian species in captivity

Animal/ Species	Minimum size of outdoor enclosure (per pair) (Square meters)	Minimum extra area per additional animal (Square meters)
Tiger and Lion	1000	200
Panther, Clouded leopard and Snow leopard	500	100
One-horned Indian Rhinoceros	2000	400
Brow antlered deer, Hangul, Swamp deer	1500	100
Wild buffalo, Indian bison and Wild ass Bharal, Goral, Wild	1500	200
Sheep and Serow	500	100
Sloth bear, Himalayan black bear, Brown bear and Malayan sun bear	1000	100
Red panda, Jackal, Wolf and Wild dog	400	100
Monkeys and Langurs	500	100

Table 2.2.4. Minimum prescribed sizes for outdoor enclosures for important birds in captivity

Animal/ Species	Minimum size of Aviary (Square meters)	Minimum height of Aviary (Square meters)	Minimum size of the water body within Aviary (Square meters)
Birds of prey	300	8	10
Pheasant *	80	3	3
Water birds (mixed species enclosure)	300	8	60 (with a depth of 1.5m)
Flying birds (mixed species enclosure)	300	8	20

Flying birds (single species)	80	6	2

Source: Mehta & Singh (2018). Design Guidelines for Zoos

Table 2.2.5. Minimum prescribed sizes for outdoor enclosures for important birds in captivity

Animal/ Species	Minimum size of outdoor enclosure (per pair) (Square meters)	Minimum extra area per additional animal (Square meters)
Crocodile/ Gharial	400	150 (with a depth of 2 meters)
Python	80	6
Cobra, Rat snake, Vipers	40	4
Sand boas	40	4
Monitor lizards *	80	6
Chameleons and Small lizards	40	4
Tortoises	40	4
Turtles	80	40 (with a depth of 2 meters)
Amphibians	10	4 (with a depth of 0.5 meter)

In case of water monitor lizard the size of water body should be kept at 40 sq.meters with a depth of 1.5 meters.

Source: Mehta & Singh (2018). Design Guidelines for Zoos

2.5. Barrier analysis and recommendation

A. Terrestrial species / jumping & climbing

For Large carnivores: Bengal tiger and Asiatic lion

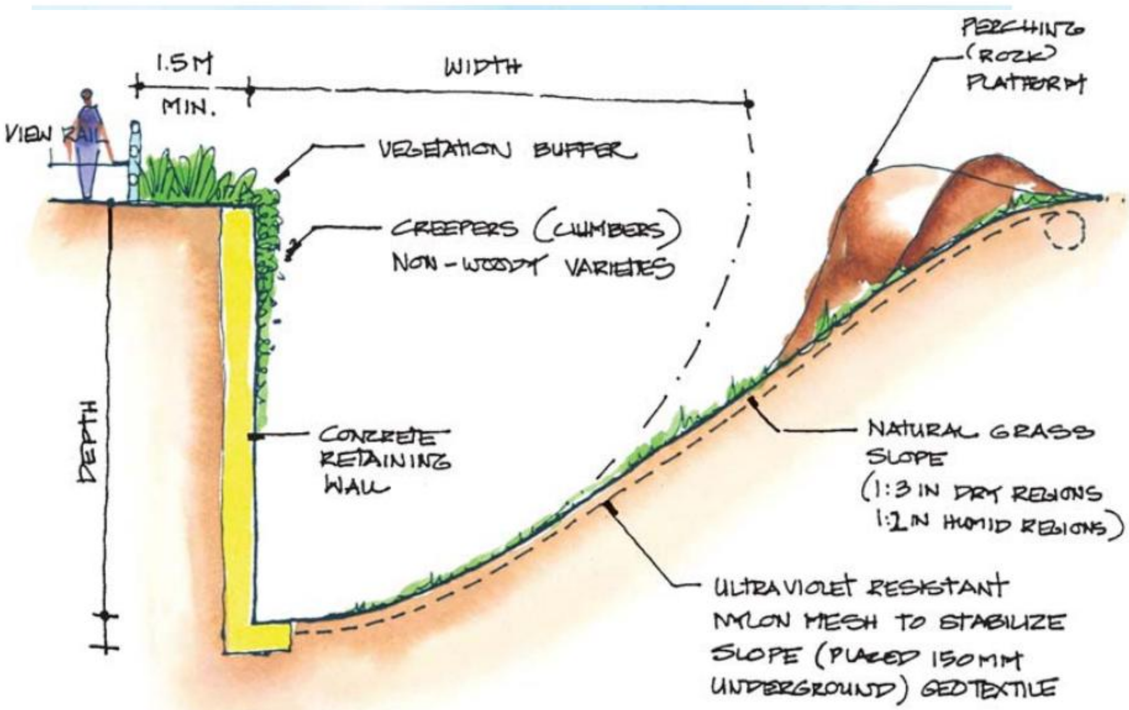


Figure 2.3 Dry moat enclosure with view tower

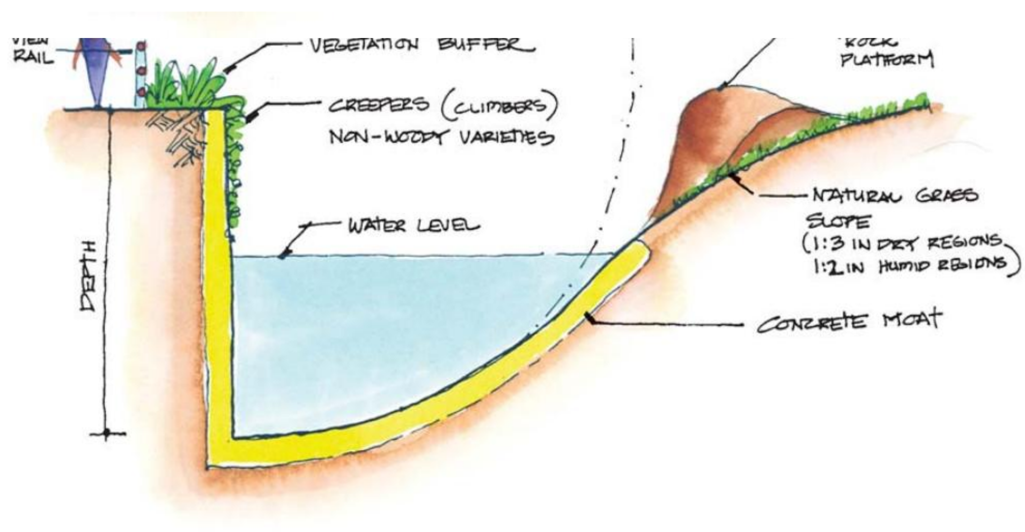


Figure 2.3 Wet moat enclosure

B. Terrestrial species / jumping

For animals like: Jackal, wolf, Hyena, Blackbuck, Spotted deer, Barking deer, Samber, Nilgai

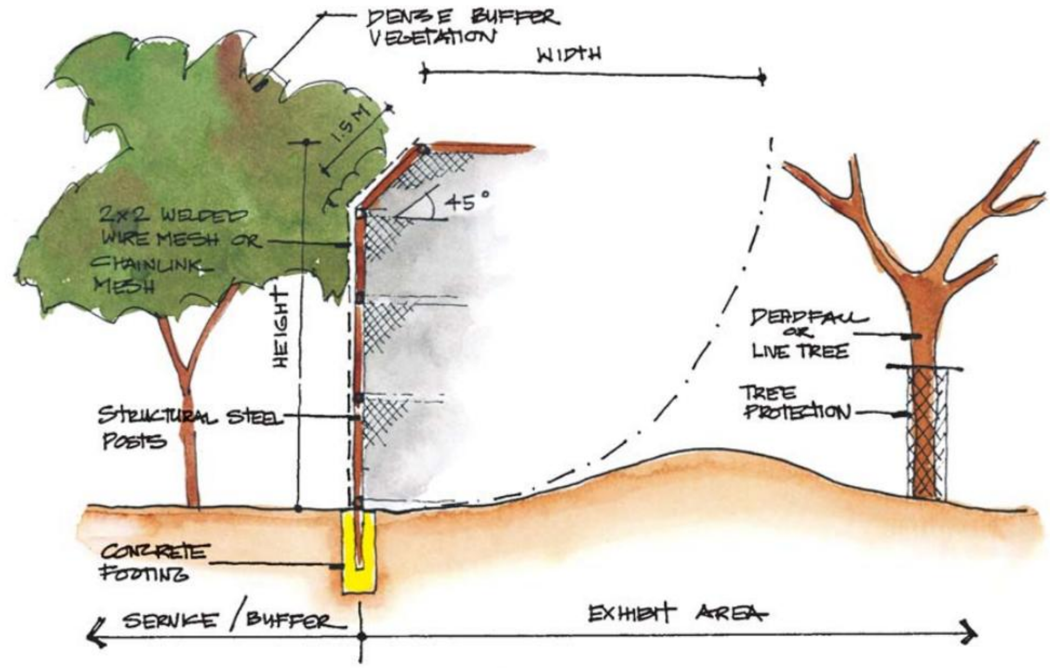


Figure 2.6 Wire mesh fence enclosure

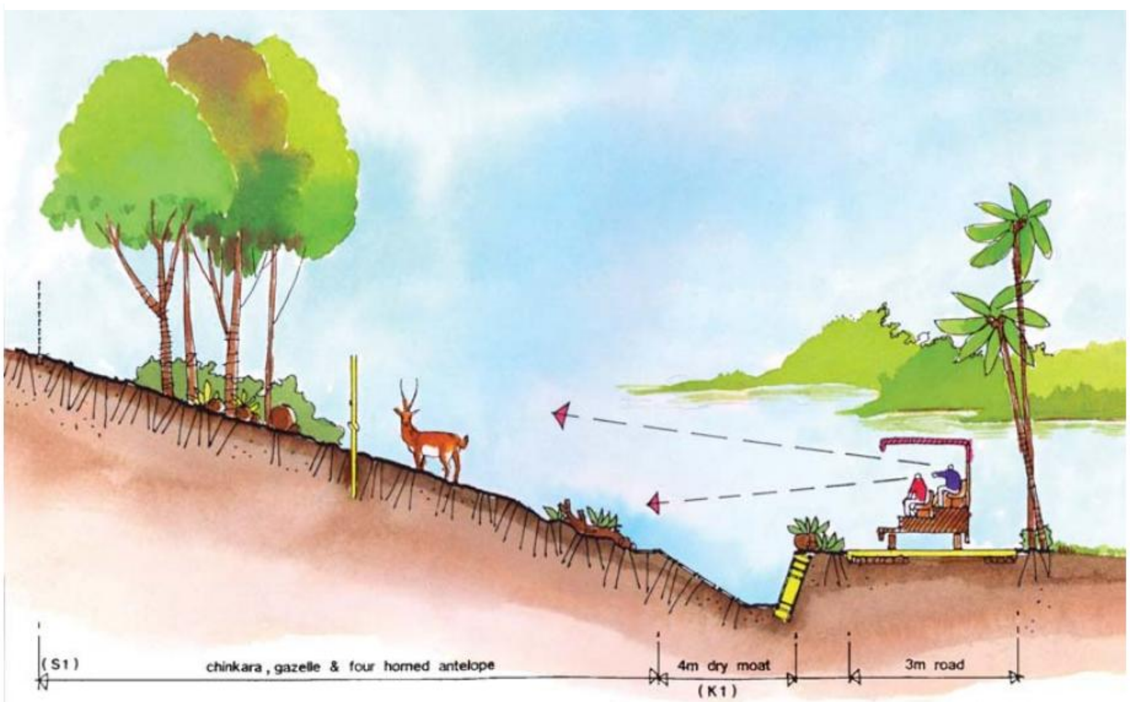


Table 2.6 Sectional drawing for Deer and Primate

Source: Mehta & Singh (2018). Design Guidelines for Zoos

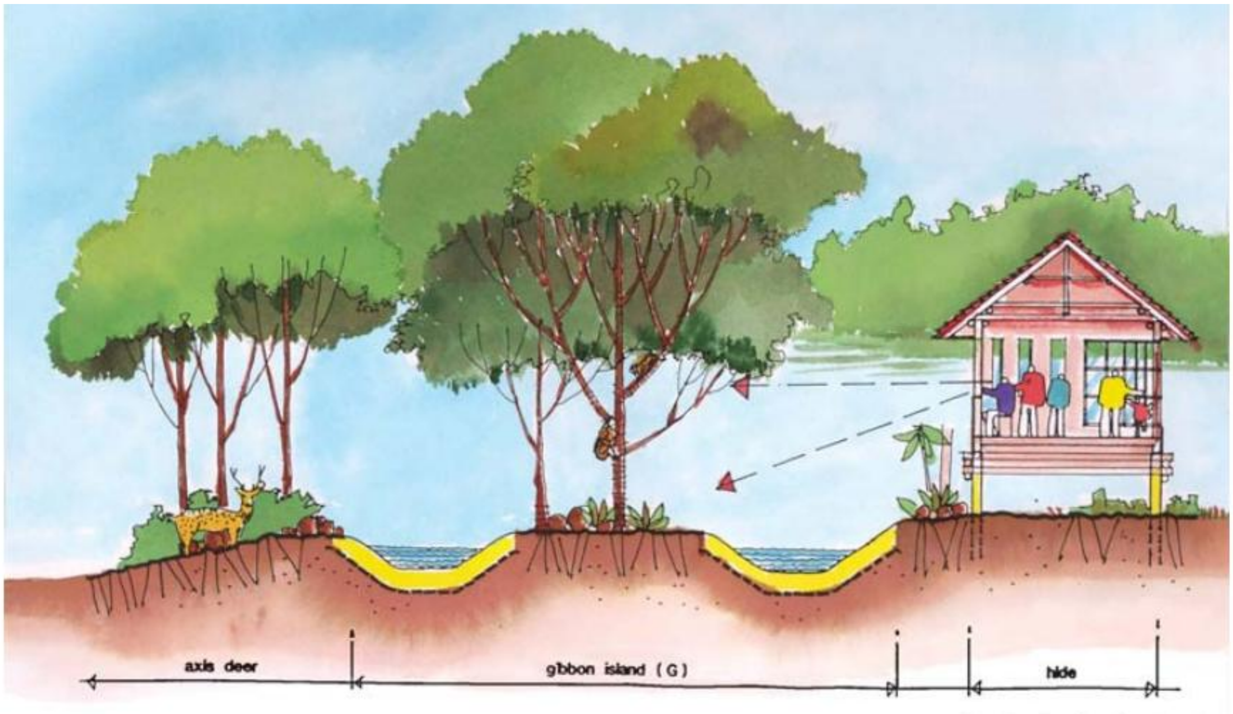


Table 2.7 Wet moats for Chinkhara and Primates

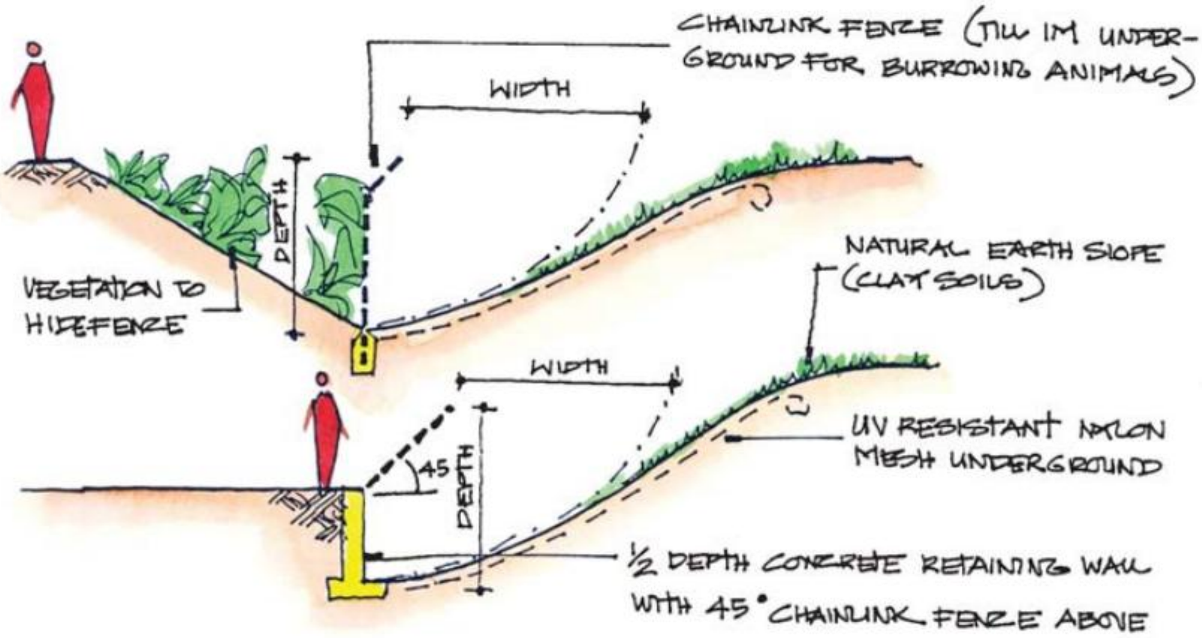


Figure 2.8 Dry moat enclosure

PHYSICAL BARRIER TYPES
Jackal, Wolf, Hyena, Blackbuck, Spotted Deer, Barking Deer, Sambar, Nilgai

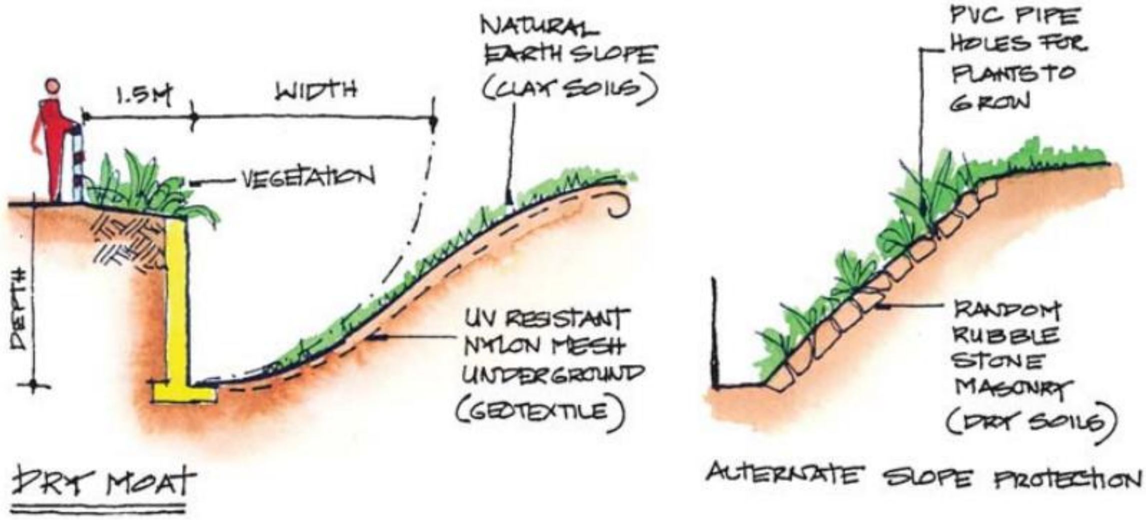


Figure 2.10.: Dry moat enclosure

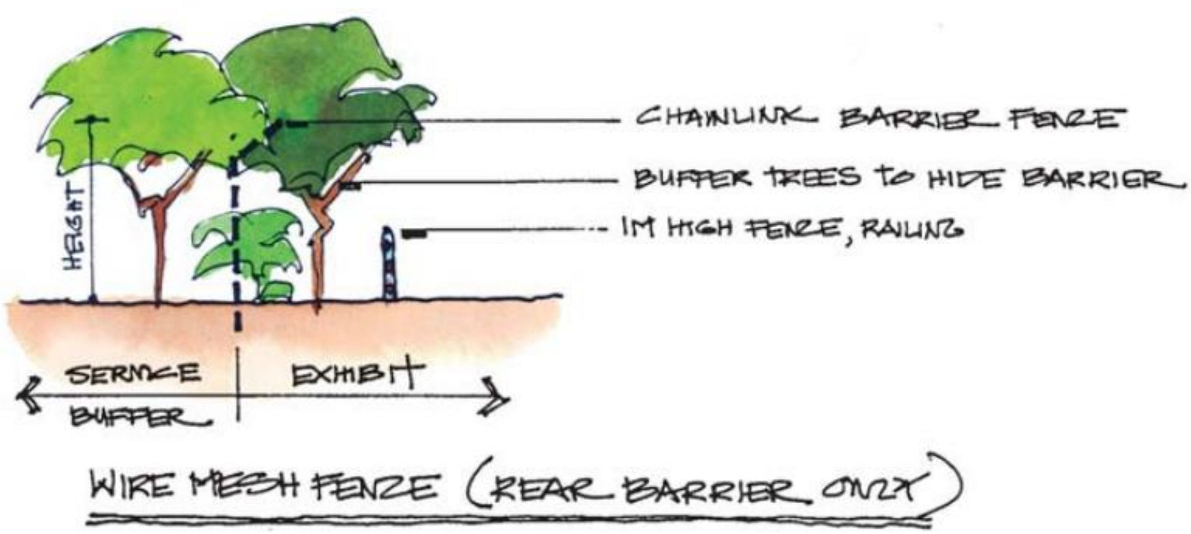


Figure 2.9 Wire mesh fence for rear barrier

Source: Mehta & Singh (2018). Design Guidelines for Zoos

C. Arboreal species – climbing

For animals like: Sloth bear/Sun bear, Himalayan black bear

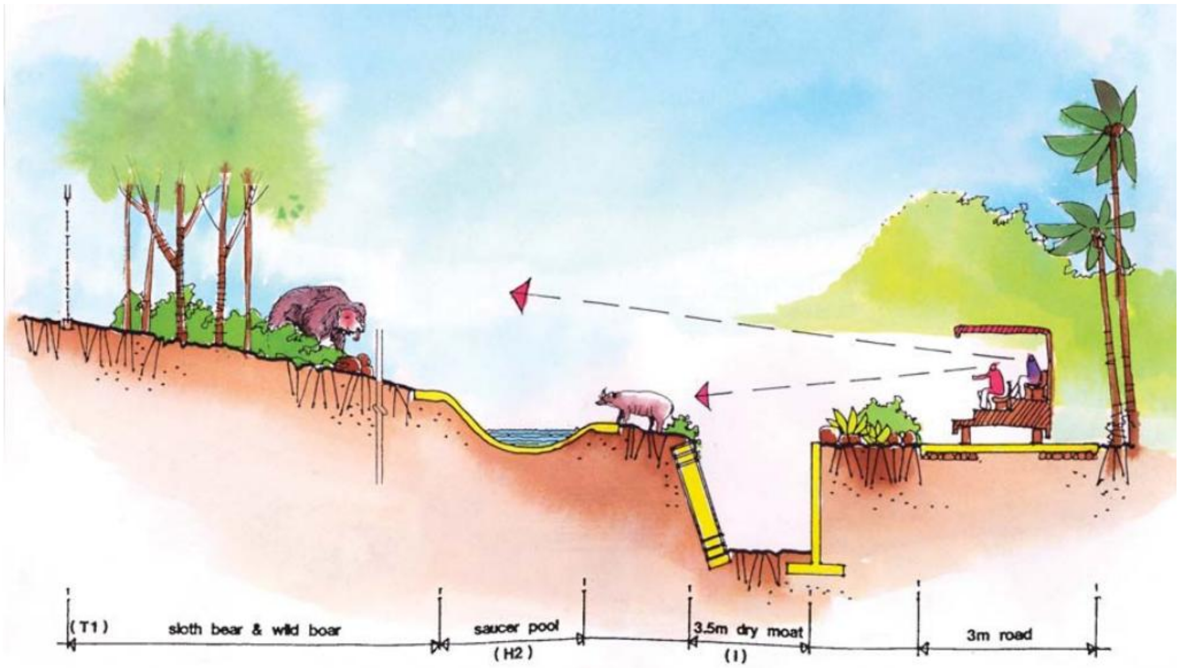


Figure 2.12 U-shaped moat

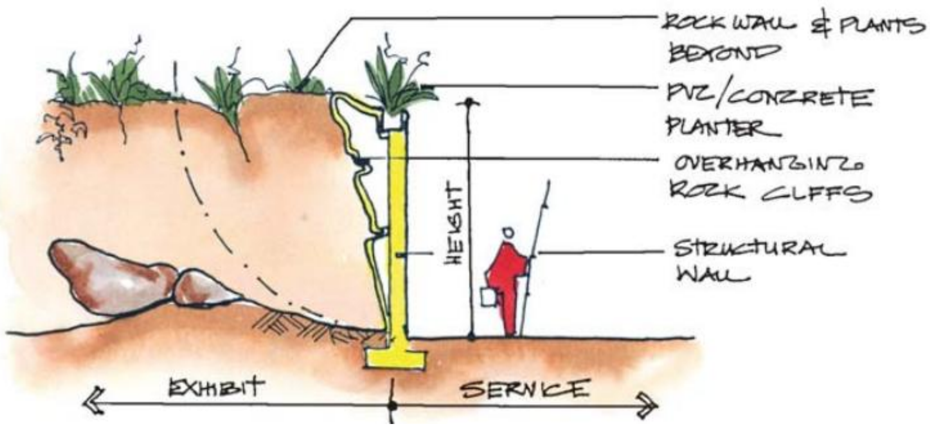


Figure 2.13 Rock Cliff Wall RearBarrier

Source: Mehta & Singh (2018). Design Guidelines for Zoos

PHYSICAL BARRIER TYPES
Himalayan Black Bear, Sloth Bear

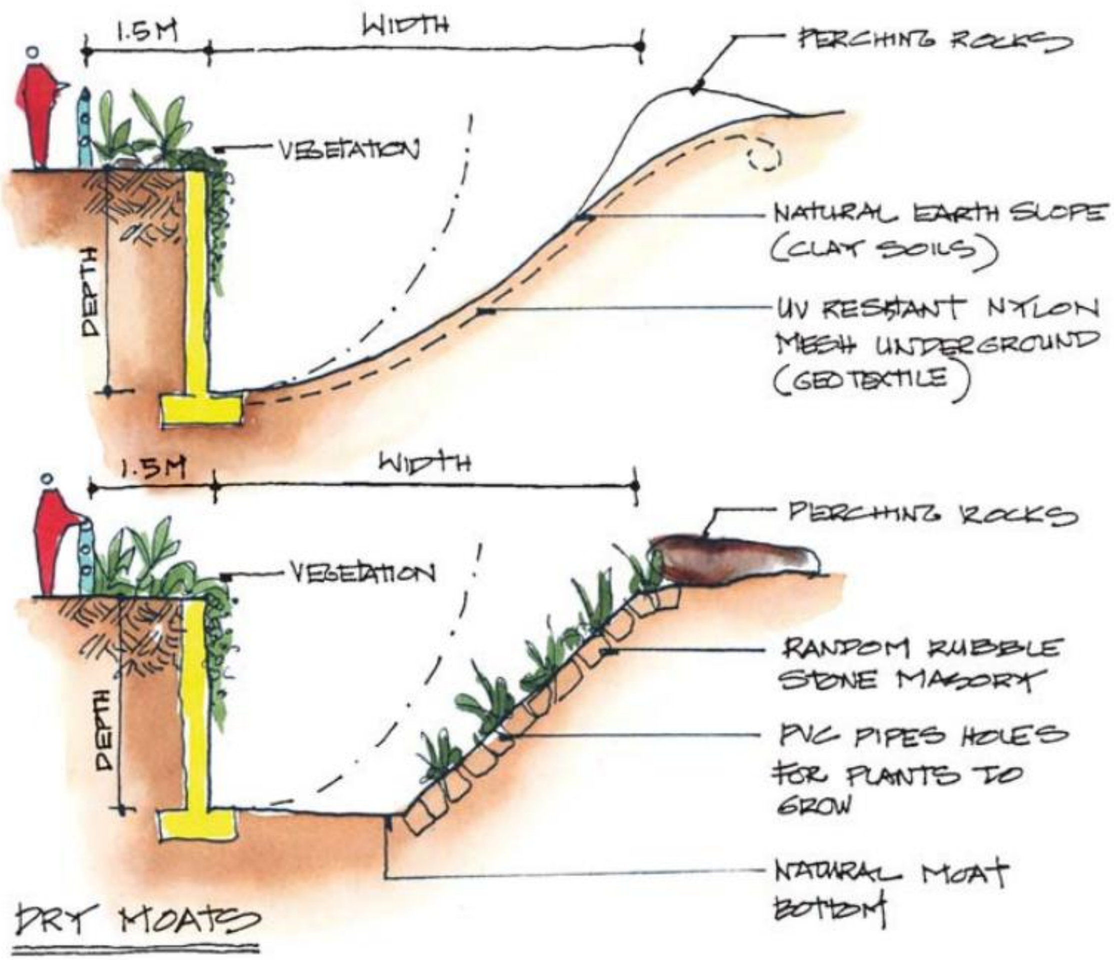
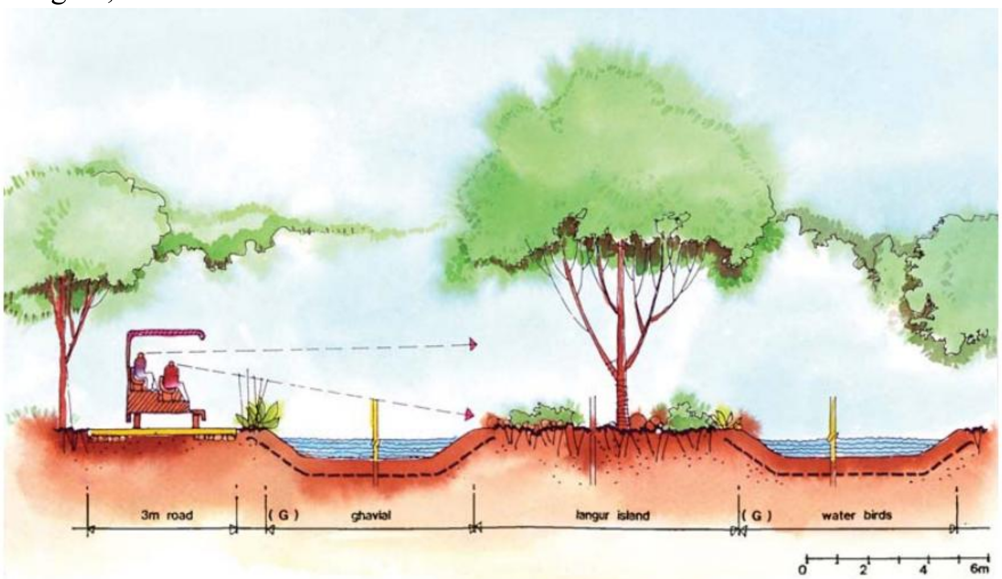


Figure 2.14 Dry moat option

Source: Mehta & Singh (2018). Design Guidelines for Zoos

D. Arboreal species – jumping & climbing

For animals like: Monkeys (Rhesus, Stump-tailed, Assamese, Crab-eating and Bonnet), Lion-tailed Macaque, Langur (Common, Capped, Golden), Nilgiri Langur, Hoolock Gibbon, Leopard/Jaguar, etc.



Illustraion showing cross section of an Island type enclosure for arboreal Primates.

It is suggested to house them in islands encircled by wet moat as is afraid of getting in to water. The moat can be 8m wide and 2m deep.

Figure 2.15 Fencing with wet moat For Arboreal Primates

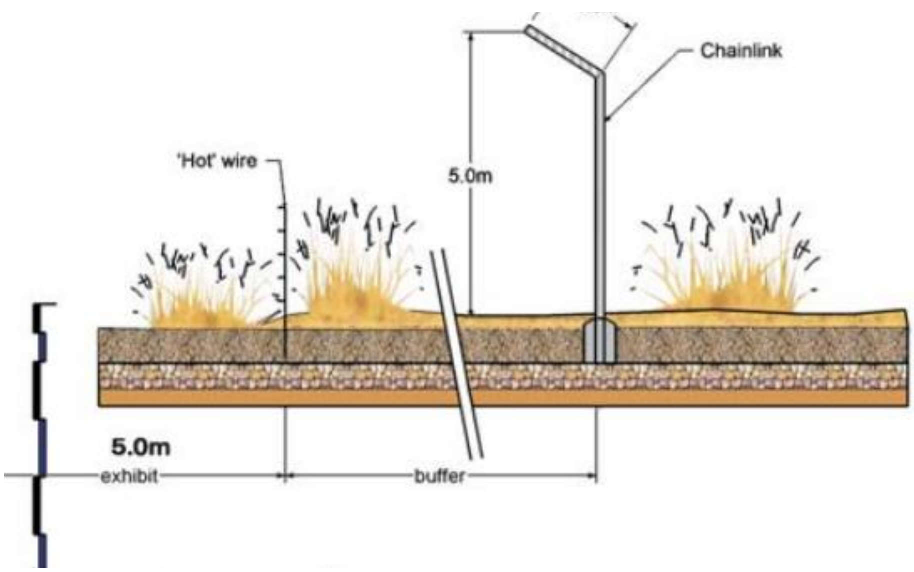


Figure 2.16.: Fence with wire and chainlink

Source: Mehta & Singh (2018). Design Guidelines for Zoos

PHYSICAL BARRIER TYPES
Monkeys, Lion - tailed Macaque, Langur, Nilgiri Langur

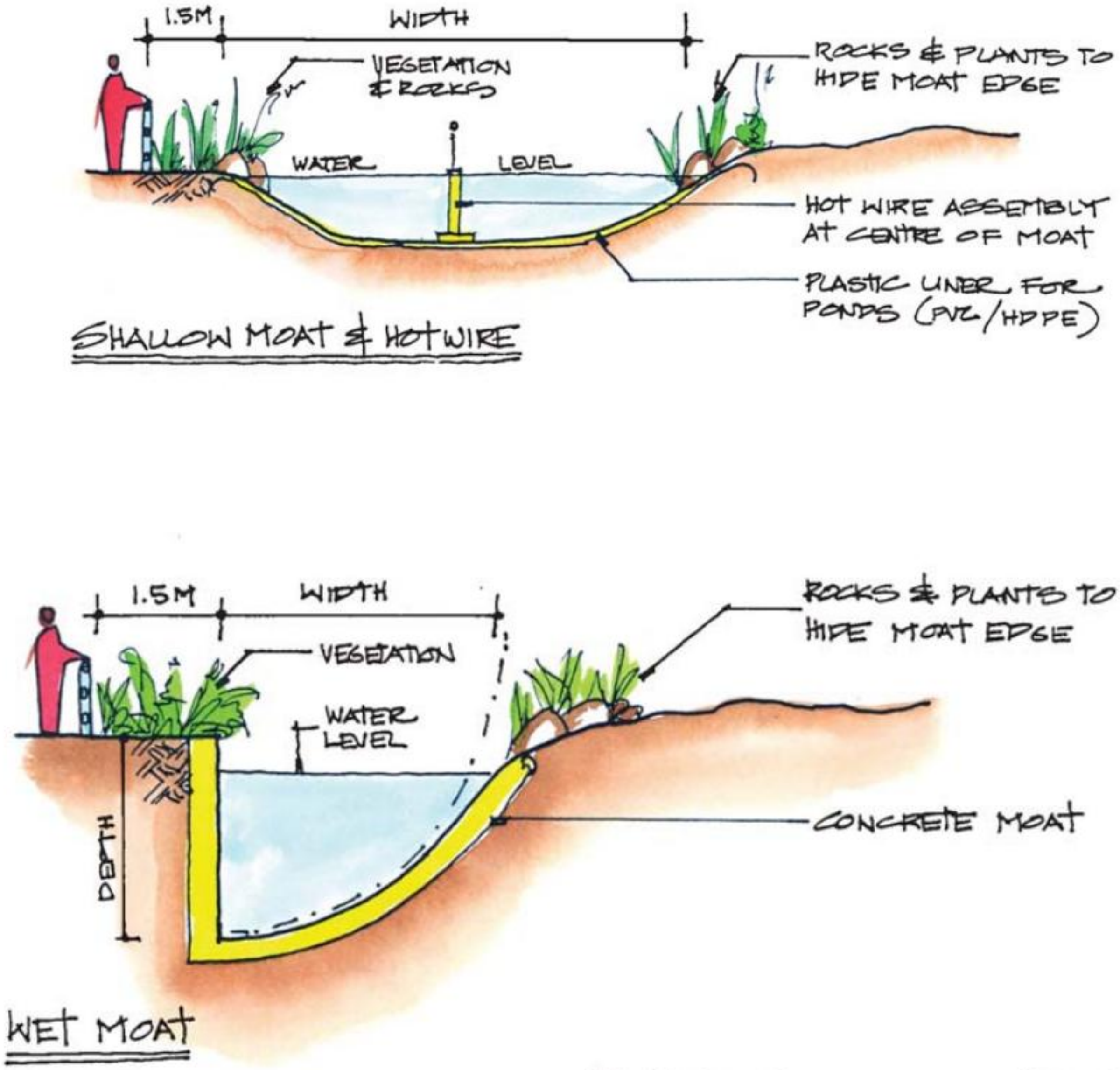


Figure 2.17 Fence and moat as a barrier

Source: Mehta & Singh (2018). Design Guidelines for Zoos

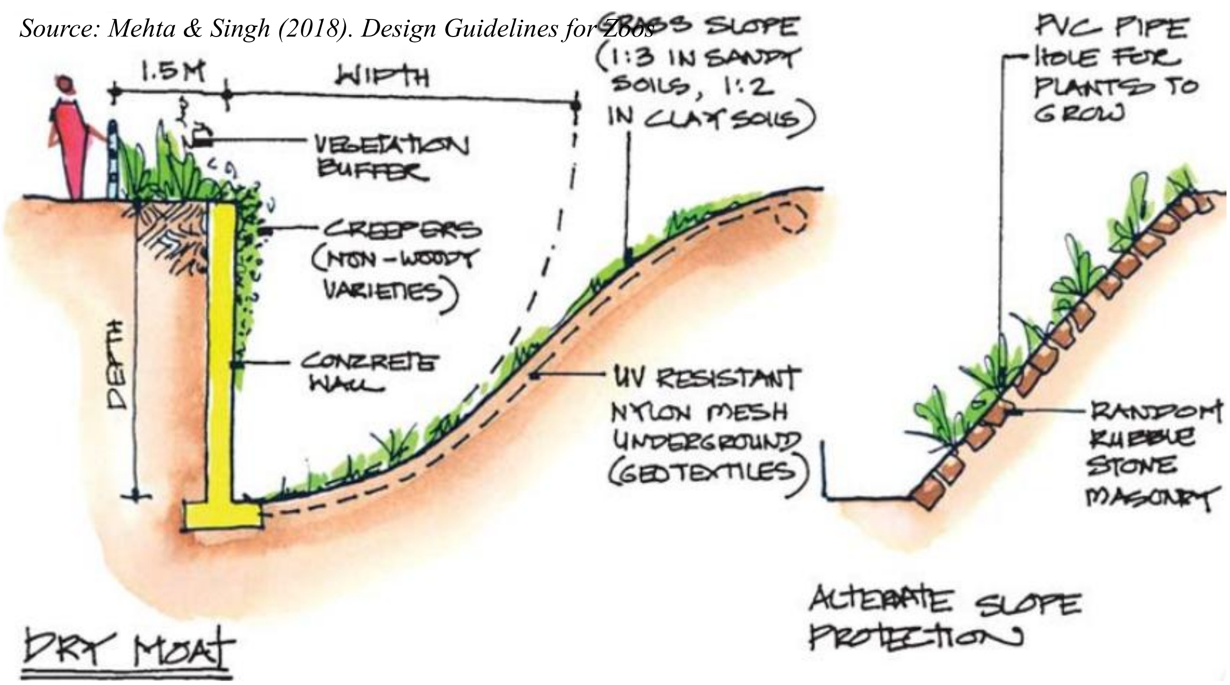


Figure 2.18 Moat option as a barrier

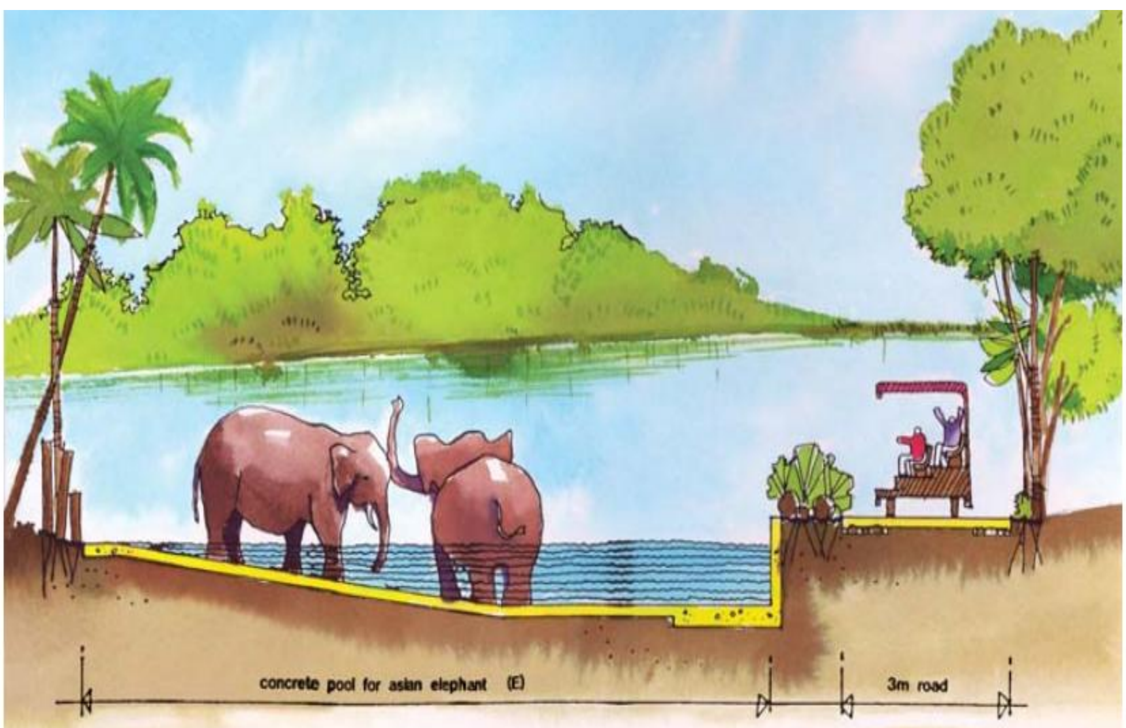


Figure 2.19 Wet moat barrier for elephants

Source: Mehta & Singh (2018). Design Guidelines for Zoos

E. Terrestrial species – non-jumping

For animals like: Gaur, Wild Boar, Rhinoceros, Asian elephant, etc.

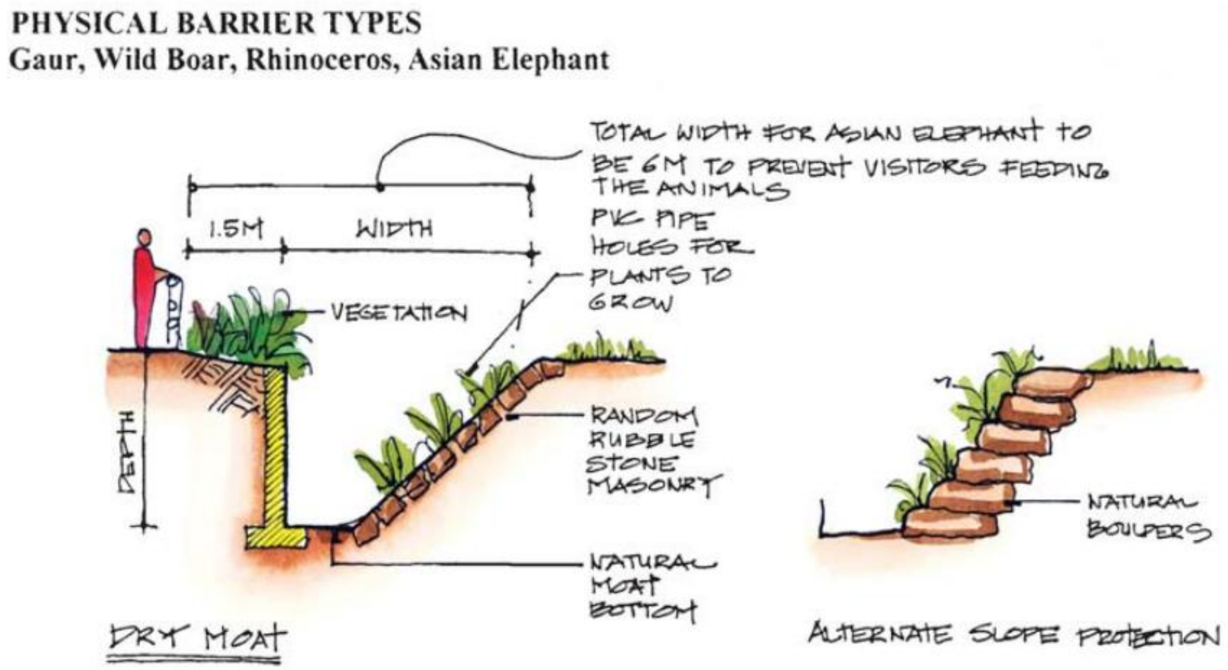


Figure 2.20 Dry moat option

E. Aquatic & semi-aquatic species – non-jumping

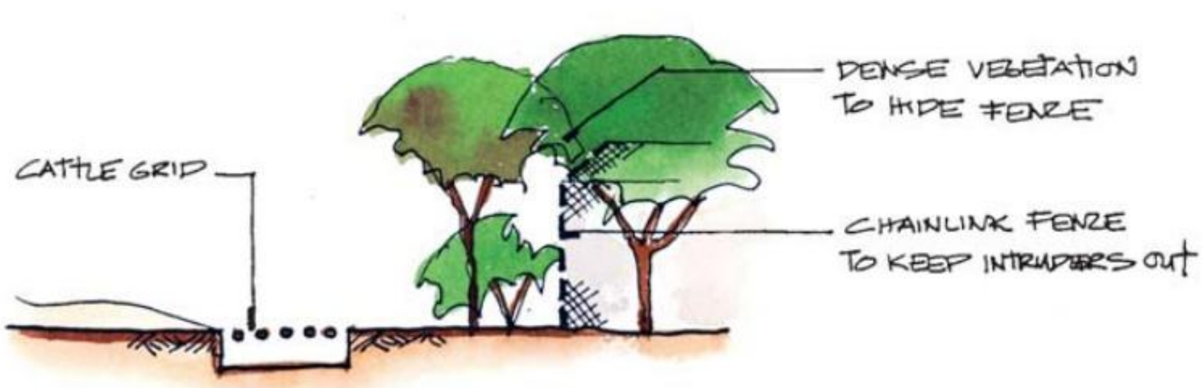


Figure 2.21 Cattle Grid and Fence for Gaur only

Source: Mehta & Singh (2018). Design Guidelines for Zoos

For animals like: Hippopotamus, Crocodile (Gharial, Mugger and Estuarine Crocodile), etc.

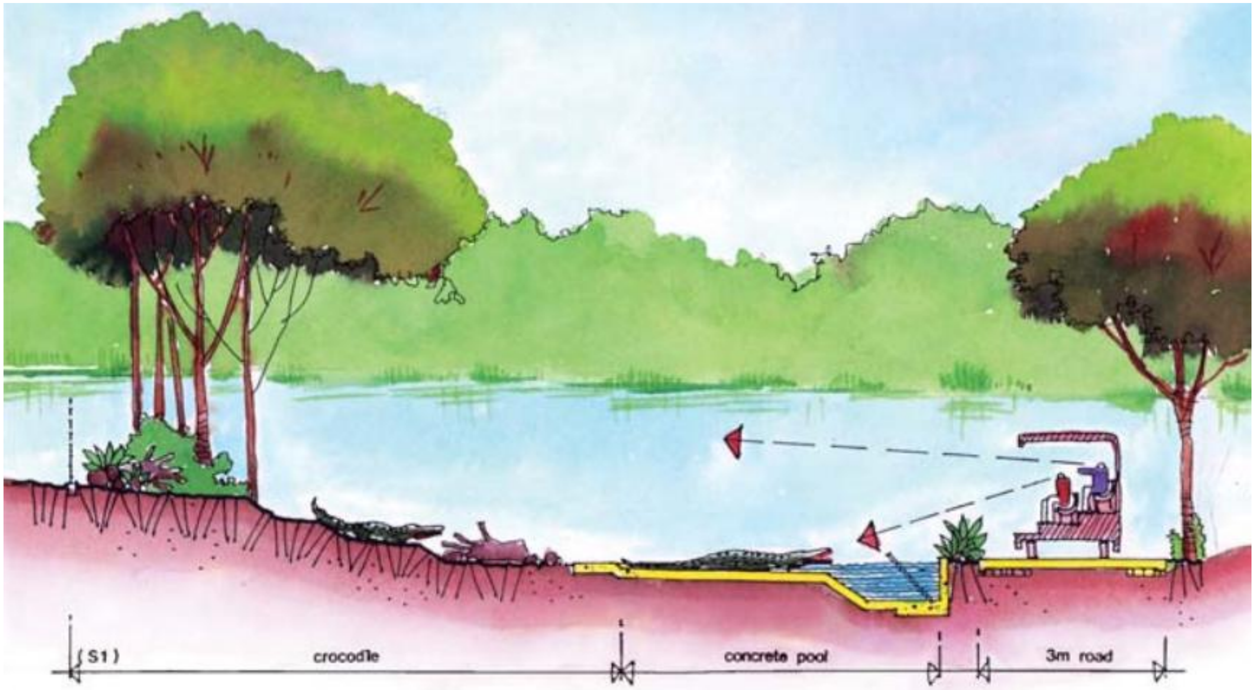


Figure 2.22 Crocodile enclosure with moat

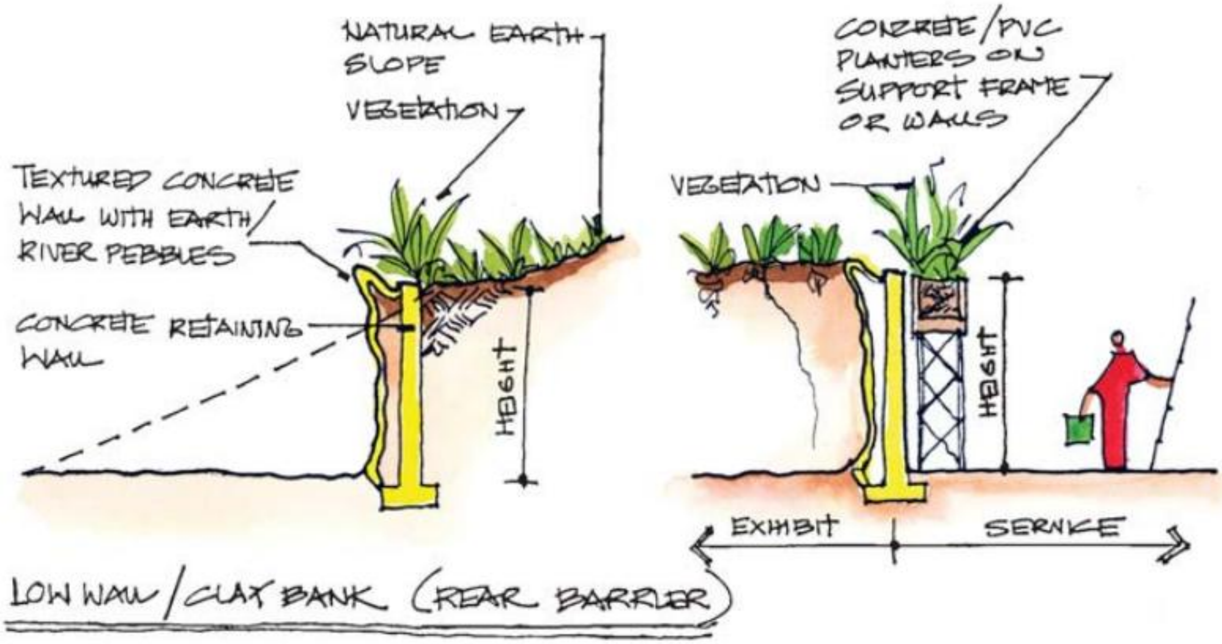
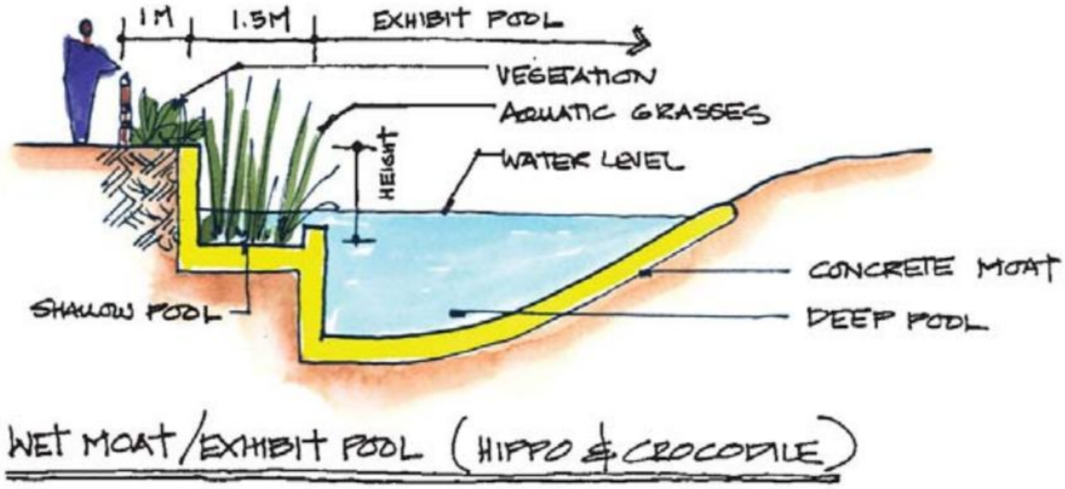


Figure 2.23 Rear clay band cliff barrier

Source: Mehta & Singh (2018). Design Guidelines for Zoos

PHYSICAL BARRIER TYPES
Hippopotamus, Crocodile, Otter



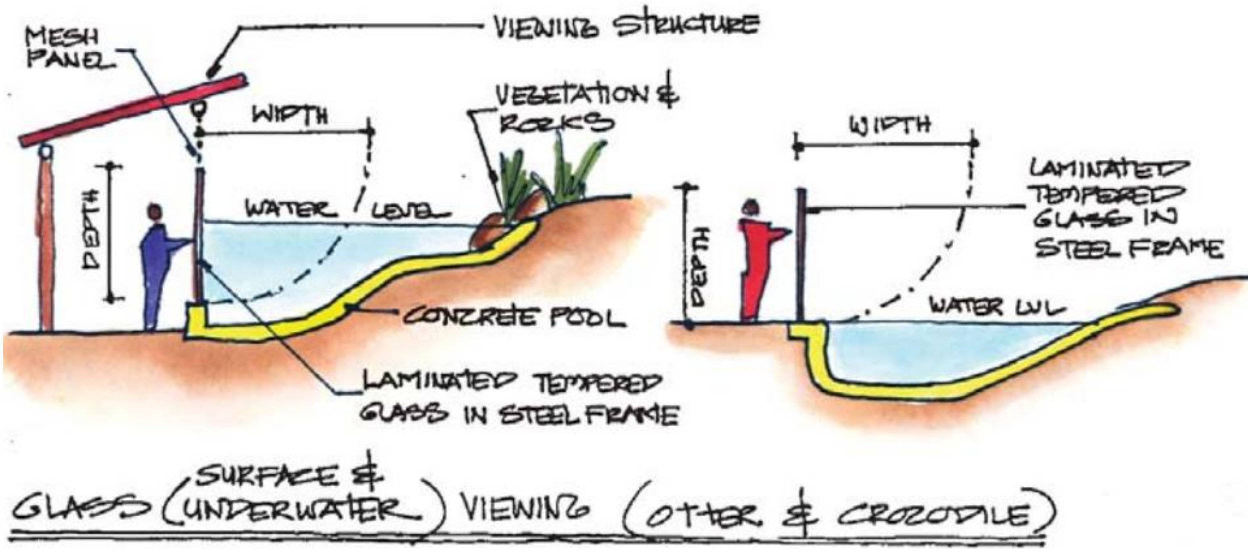


Figure 2.24 Stepped moat Barrier option

Source: Mehta & Singh (2018). Design Guidelines for Zoos

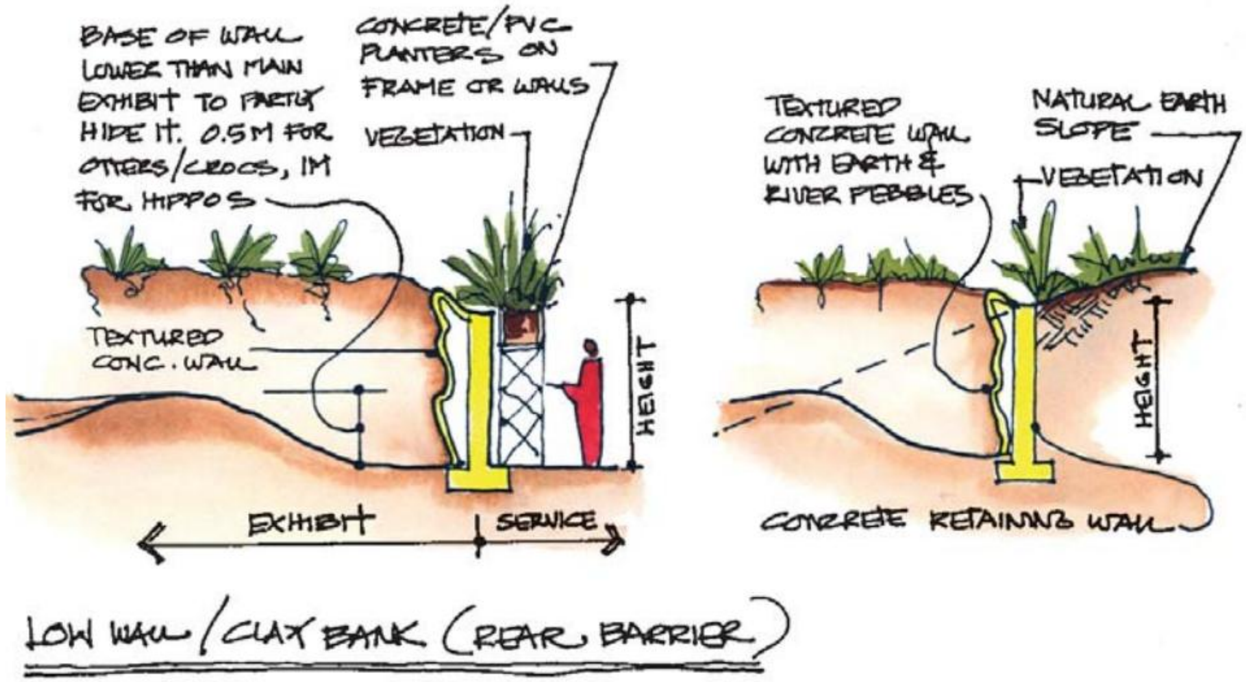


Figure 2.25 Concrete Retaining wall for rear barrier

Source: Mehta & Singh (2018). Design Guidelines for Zoos

Table 2.2.8. Choosing the correct barrier type for the enclosure:

Barrier Type	Advantages	Disadvantages
Moats – u-shaped (vertical sides)	• No contact with animals. • Less chances of transmission of infectious disease from visitors.	• Needs large areas. • Improper drainage can lead to proliferation of parasitic load. • Structural design makes these very expensive to build. • Animals can fall into moat areas hurting themselves.
Moats – v-shaped (sloped sides)	• Reduced contact with animals • Less expensive to build than • U-shaped moats. • More natural looking than • U-shaped moats.	• Needs large areas. • Improper drainage can lead to proliferation of parasitic load. • Animals can walk into moat areas making them less visible to visitors.
Fences – chain-link, welded wire mesh	• Requires much smaller area than moats. • Inexpensive to build • Can be hidden easily with vegetation.	• Visitor vandalism. • High maintenance. • Clear viewing requires expensive glass viewing areas.
Glass – laminated tempered	• Close visual connection between visitors and animals. • Provides privacy to animals by insulating from noise. • Requires much smaller area than moats.	• Reflection of light. • Off glass surfaces reduces visibility. • Frequent cleaning required. • Expensive to construct and replace. • Visitor vandalism
Low walls to simulate clay banks	• Natural looking. • Enrichment possibilities. • Nocturnal animal and reptiles may use for clinging, hibernation, aestivation. • Requires much smaller area than moats	• Authentic looking clay banks can be expensive to construct.
High walls to simulate rock cliffs	• Natural looking. • Requires much smaller area than moats	• Authentic looking rock cliffs can be very expensive to construct. • Unrealistic rockwork detracts from exhibit.

Source: Mehta & Singh (2018). Design Guidelines for Zoos

2.6. Guidelines for enclosure & exhibit design:

This design approach for the naturally immersive zoo should use natural landscape—like slopes and dips in the ground—to create invisible barriers and keep animals secure without harsh fences. Paths for visitors are carefully planned with green plants on both sides to separate viewing areas from main walkways. Natural and local materials like stone and wood with concrete, can be used to blend the zoo into the environment. The animal homes should be grouped by themes and kept apart to reduce stress, with lots of plants and rounded corners to make it look natural. Existing trees are preserved, and new plants are added to screen enclosures from paths. Animal well-being is prioritized by giving them space and privacy, while visitors can enjoy clear views of the animals surrounded by nature. Night shelters and signs should be hidden or camouflaged to maintain a natural look and feel.

1. Landform & Barriers

- Use natural terrain (e.g., slopes, depressions) to create barrier moats.
- Camouflage hot wires with vegetation or moats; avoid visible fencing.

2. Path Design

- Separate viewing paths from main paths with 2m-wide perennial vegetation buffers.
- Keep viewing paths 1.5–3m wide and level with main paths. Use ramps (max slope 1:15) if elevation differs.

3. Materials & Construction

- Use local materials (e.g., stone, concrete) for walls/moats to blend with surroundings.
- Avoid visible masonry; surfaces should mimic natural landscapes (e.g., textured concrete, not colored plaster).

4. Layout & Spacing

- Group enclosures by theme; separate predator-prey species by distance/elevation.
- Maintain 2–3m gaps between enclosures with dense vegetation.
- Avoid sharp corners; use rounded or obtuse angles.

5. Vegetation & Trees

- Preserve existing trees; align enclosures to avoid trees near boundaries.
- Plant dense screens between enclosures and paths.

6. Animal Welfare

- Elevate enclosures slightly above visitor paths to reduce animal stress.
- Design enrichment items (e.g., swings, benches) tailored to species, not human use.

7. Visitor Experience

- Ensure clear visibility of animals from all viewing angles.
- Immersive design: Surround visitors with plants to block views of man-made structures.

8. Night Shelters & Signage

- Hide night shelters behind vegetation; camouflage facades with natural textures (e.g., stone).

Avoid signs inside enclosures or obstructing views.

Table 2.2.9. ANIMAL TYPES & BARRIER RECOMMENDATIONS

Animal Type	Examples	Front barrier	Rear barrier
Terrestrial species / jumping & climbing	Tiger, Asiatic lion	U-shaped dry or wet moats, glass viewing structures at special viewing areas	U-shaped dry moats OR high steel wire mesh fences OR high rock walls
Terrestrial species / jumping	Jackal, Wolf, Hyena	V-shaped (flat bottomed) dry moats with or without chain-link fences	V-shaped (flat bottomed) dry moats OR steel wire mesh fences
Arboreal species/ climbing	Himalayan Black Bear, Sloth Bear	U-shaped / V-shaped dry moats	U-shaped / V-shaped dry moats OR high smooth walls, OR overhanging rock walls
Arboreal species/ jumping & climbing	Monkeys, Lion-tailed macaque, Langur, Nilgiri langur	U-shaped / V-shaped dry moats, shallow wet moats, netted aviaries with glass viewing	U-shaped / V-shaped dry moats OR shallow wet moats, netted aviaries
Terrestrial species/ jumping	Blackbuck, Spotted deer, Barking deer, Sambar, Nilgai	V-shaped (flat bottomed) dry moats with or without chain-link fences	V-shaped (flat bottomed) dry moats OR steel wire mesh fences
Terrestrial/non–jumping	Gaur, Wild boar, Rhinoceros, Asian Elephant	V-shaped dry moats	V-shaped dry moats OR low walls (clay banks), cattle grids (gaur)
Aquatic & semi-aquatic species/ non-jumping	Hippopotamus, Crocodile, Otter	Wet moats (exhibit pools)	Low walls (clay banks)

Table 2.2.10. VISITOR BARRIER TYPE

Barrier Type	Advantages	Disadvantages
Steel guardrail	• Long lasting. • Maintenance free if galvanized. • Safe-good for dangerous animal exhibits.	• Expensive to construct • Relatively unattractive to look at.
Hardwood guardrail	• Attractive to look at. • Fits most natural habitat themes. • Relatively safe - good for non-dangerous animal exhibits	• Expensive to construct with hardwood can rot in high humidity climates

Bamboo guardrail	• Attractive to look at – fits most natural habitat themes. • Inexpensive to construct.	• Relatively weak – should be used for non-critical areas. • Needs replacement every few years.
Eco-wud (wood substitute) guardrail	• Long lasting. • Maintenance free. • Cheaper than hardwood or steel. • Relatively safe – good for non-dangerous animal exhibits.	• More expensive than bamboo. • Appearance may not suit all theme areas.
Low hedge	• Attractive to look at. • Inexpensive to install. • Hedges can enclose a low fence.	• Not a real barrier – can be broken through easily. • Needs regular maintenance and protection from vandalism.
Nylon rope kick rail	• Very inexpensive to construct.	• Not a real barrier – should be used for landscape protection. • Needs replacement every few years.

Table 2.2.11. VISUAL AMENITIES AND EXHIBIT VIEWING

Barrier Type	Advantages	Disadvantages
Walls (brick, concrete)	• Long lasting. • Easy to construct. • Maintenance free.	• Expensive to construct. • Unattractive to look at unless hidden.
Bamboo/ cane fences	• Attractive to look at. • Fits most natural habitat themes. • Inexpensive to construct. • Easy to install.	• Needs maintenance and protection from vandalism. • Replacement every few years.
Hedges	• Attractive to look at. • Inexpensive to plant.	• Needs regular maintenance and protection from vandalism.
Green walls (moss, creepers)	• Attractive to look at. • Fits most natural habitat themes from vandalism.	• Expensive to construct. • Needs maintenance and protection.
Artificial rockwork	• Attractive to look at. • Fits most natural habitat themes. • Long lasting. • Maintenance free.	• Very expensive to construct. • Needs specialized fabricators to obtain realistic results.

Source: Mehta & Singh (2018). Design Guidelines for Zoos

2.7. Design guidelines for feeding cubicles:

1. Durable Surfaces:
   - Use firmly fixed tiles/stones to resist animal damage (scratching, hitting) and high-pressure water jets during cleaning.
2. Hygiene:
   - Ensure all surfaces (walls, floors) are easy to clean with water/chemicals.
   - Walls: Glazed or textured tiles for easy maintenance.
3. Floor Safety:
   - Textured flooring to prevent animal slipping.
4. Dimensions:
   - Follow CZA (Central Zoo Authority) minimum size standards for length, breadth, and height.
5. Aesthetics & Camouflage:
   - Hide cubicles with dense vegetation or landforms to avoid visitor sightlines.
   - Blend external walls with surroundings using local materials/textures (e.g., exposed aggregate with subdued-colored stones).

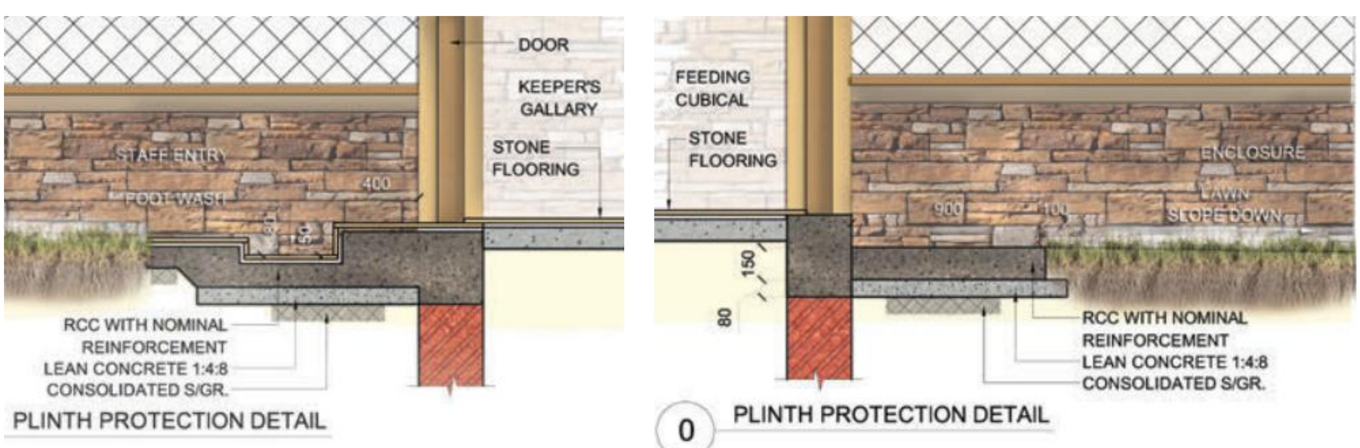


Figure 2.26 Plinth detail for Feeding Cubicles

2.8 Veterinary Hospital**:**

A Veterinary Hospital is a medical facility dedicated to the health care and treatment of animals. Staffed by licensed veterinarians and trained professionals, it provides a wide range of services, including routine check-ups, vaccinations, surgeries, emergency care, and diagnostic testing (e.g., X-rays, blood work). These hospitals cater to pets, livestock, and sometimes exotic or wildlife species, ensuring their well-being and addressing illnesses or injuries. They play a crucial role in promoting animal health, preventing diseases, and supporting pet owners with advice and education on proper animal care. Design guideline for the hospital;

1. Situate the hospital in a secluded zone near zoo boundaries, away from enclosures/offices, with dedicated entry/exit distinct from public access, with separate exit.
2. Maintain adequate distance from Quarantine, Rescue Centre, Post-mortem, and Incineration facilities.
3. Ensure parking for vehicles, two-wheelers, ambulances, and trucks (with maneuvering space).
4. If remote from zoo entrances, provide separate vehicular access (non-visitor routes).
5. Adhere to standardized room sizes for newly built/planned hospitals.

2.9. Site Selection:

A. Climate and Environmental Suitability

<u>Natural Climate Alignment:</u> Choosing regions with stable temperatures and humidity levels close to the target biome (e.g., tropical, desert, temperate) will make the project easier, consumption of energy lessens and lowers the overall budget. <u>For e</u>xample: A rainforest terrarium thrives in humid climates (e.g., Nepal's Terai) to reduce energy costs for climate control.

<u>Microclimate Analysis:</u> Avoid flood-prone, landslide-prone, or extreme weather zones to avoid problems in the future and make the project unnecessarily expensive and problematic. Use GIS mapping to assess sun exposure, wind patterns, and soil stability.

B. Proximity to Natural Resources

Water Availability: Access to freshwater sources (rivers, lakes, or groundwater) for closed-loop systems to lessen the water demands. Rainwater harvesting potential (e.g., Nepal's monsoon climate can supply 70–80% of water needs) can help sustainability of the water for the project.

Native Flora and Fauna: Sites near biodiverse regions simplify sourcing plants and animals while reducing transportation stress.For example: Chitwan (Nepal) for Terai species or Pokhara for montane ecosystems.

C. Visitor Accessibility and Footfall

Urban Proximity: Within 1–2 hours of major cities to maximize educational impact and tourism flow, therefore increases the total visitor and revenue of the project.

Transport Links: Accessible via public transit, highways, and parking facilities (1 space per 5–10 visitors), can increase the visitors flow.

Tourism Synergy: Proximity to existing attractions (e.g., national parks, heritage sites) boosts combined visitation.

D. Infrastructure and Energy Efficiency

Renewable Energy Potential:

- Solar/wind-rich sites to power HVAC, lighting, and water systems.
- Example: Solar panels in Nepal's Terai (average 5.5 $kWh/m^2/day$).

Grid Reliability:

- Backup generators or battery storage for unstable power grids.

Waste Management:

- Space for composting, recycling, and biofiltration systems.

E. Ecological and Cultural Sensitivity

Avoid Ecologically Fragile Areas: Steer clear of protected habitats, wetlands, or endangered species corridors.

Brownfield Redevelopment:

- Repurpose degraded or underused land (e.g., abandoned industrial sites) for eco-terrariums.

Cultural Relevance:

- Align with local conservation priorities (e.g., Himalayan species in Nepal).

F. Space and Layout Requirements

Minimum Area:

- 0.5–2 hectares (1.2–5 acres) for a mid-sized terrarium, depending on biome complexity.

Vertical vs. Horizontal Design:

- Vertical stacking (e.g., Singapore's Cloud Forest) optimizes space in urban zoos.
- Horizontal layouts suit rural areas with ample land (e.g., replicating savannahs).

Zoning:

- Separate zones for public access, animal habitats, staff facilities, and utilities.

G. Regulatory and Community Considerations

Legal Compliance:

- Secure permits for construction, water use, and species acquisition (CITES for endangered species).
- Adhere to zoo accreditation standards (e.g., WAZA, national guidelines).

Community Engagement:

- Involve local stakeholders in planning to ensure social acceptance and reduce conflicts.
- Example: Partner with Nepal's NTNC for conservation credibility.

H. Cost-Benefit Analysis

Construction Costs:

- Prioritize modular, scalable designs to phase investments (e.g., start with amphibian terrariums).

Revenue Streams:

- Factor in ticket sales, educational programs, and eco-tourism partnerships.

Long-Term Savings:

- Renewable energy and closed-loop systems reduce operational costs over time.

I. Risk Mitigation Strategies

Climate Resilience:

- Flood barriers, earthquake-resistant structures, and fire-resistant materials.

Biosecurity:

- Quarantine zones and UV sterilization systems to prevent disease outbreaks.

Insurance:

- Coverage for extreme weather, equipment failure, or animal-related incidents.

2.10. Spatial Standards:

1. Visitor viewing area

- Sightlines and Viewing Heights

Eye Level Ranges (for unobstructed viewing):

Adults: 1.5–1.7 m (59–67 in)

Children (5–12 years): 0.9–1.2 m (35–47 in)

Wheelchair Users: 1.1–1.3 m (43–51 in)

- Viewing Glass/Panel Design:

Height: 0.6–1.8 m (24–71 in) to accommodate all users (lower sections for children, upper for adults).

Tilted Glass: Angled at 10–15° to reduce glare and improve visibility.

Depth of Viewing Zone: Minimum 0.6 m (24 in) for wheelchair turnaround.

- Barrier Design

  Safety Railings:

  Height: 1.1 m (43 in) to prevent climbing.

  Vertical Bar Spacing: <10 cm (4 in) to prevent child entrapment.

  Glass Thickness: 19–25 mm (0.75–1 in) for structural integrity and safety.

2. Pathways and circulation

- Walkway Dimensions

  Primary Pathways:

  Width: 2.4–3 m (8–10 ft) for bidirectional flow + strollers/wheelchairs.

  Secondary Pathways: 1.8 m (6 ft) for single-direction movement.

- Slopes:

  Max slope: 1:20 (5%) for comfort; 1:12 (8.3%) for ramps (ADA compliant).

- Turning Radius:

  Wheelchair: 1.5 m (60 in) diameter.

- Tactile Guidance

  Tactile Paths:

  Width: 0.6–0.9 m (24–35 in) with textured paving for visually impaired visitors.

  Contrasting Colors: To demarcate edges (e.g., light vs. dark stone).

3. Interactive exhibit zones

- Touchscreens and Controls

  Height:

  Median: 1.2 m (47 in) for standing adults and seated children.

Adjustable mounts for wheelchair users (0.7–1.2 m / 28–47 in).

- Reach Zones:

  Forward reach (seated): 0.4–1.2 m (16–47 in).

- Educational Displays

  Signage:

  Mounting height: 1.2–1.6 m (47–63 in) for readability.

  Font size: Minimum 18 pt for text, with high-contrast backgrounds.

- Interactive Tables:

  Height: 0.75–0.9 m (30–35 in) with knee clearance of 0.7 m (28 in).

4. Seating and rest areas

- Benches and Perches

  Seat Height: 0.45–0.5 m (18–20 in) for easy sitting/standing.

  Depth: 0.4–0.45 m (16–18 in) with backrests angled at 95–105°.

  Spacing: 1–1.2 m (3–4 ft) between benches for social distancing.

- Picnic Areas

  Table Height: 0.7–0.75 m (28–30 in) with knee clearance of 0.6–0.7 m (24–28 in).

  Seat-to-Table Distance: 0.3 m (12 in) vertically.

5. Staff and maintenance zones

- Keeper Access Points

  Doorways:

  Width: 0.9 m (35 in) for staff with equipment.

  Height: 2 m (79 in) to avoid head injuries.

- Work Counters:

  Height: 0.9–1.1 m (35–43 in) for food prep or medical tasks.

- Storage and Tools

  Shelving:

  Frequently used items: 0.5–1.5 m (20–59 in) from floor.

  Heavy items: 0.7–1.2 m (28–47 in) to avoid bending/lifting.

6. Accessibility compliance

   Universal Design Features

- Ramps:

  Slope: 1:12 (8.3%) with landings every 9 m (30 ft).

  Handrails: 0.9–1 m (35–39 in) height, 3.8 cm (1.5 in) diameter.

- Restrooms:

  Stall width: 1.5 m (60 in) for wheelchair access.

  Grab bars: 0.75–0.85 m (30–33 in) above floor.

- Sensory Considerations

  Quiet Zones:

  Seating spaced 2 m (6.5 ft) apart with sound-absorbing materials.

- Lighting:

  300–500 lux for exhibits, with dimmable options for light-sensitive visitors.

7. Safety and emergency egress

- Clearances: Minimum 1.1 m (43 in) width for emergency exits.
- Handrails: Diameter: 3.8–5 cm (1.5–2 in) for grip comfort.
- Non-Slip Surfaces: Coefficient of friction (COF) >0.6 for wet/humid terrarium areas.

8. Anthropometric checklist for eco-terrariums

Table 2.2.12. Anthropometric data

Feature	Measurement	Standard
Viewing glass height	0.6–1.8 m (24–71 in)	ADA/ISO
Pathway width	1.8–3 m (6–10 ft)	ADA
Bench seat height	0.45–0.5 m (18–20 in)	DIN/ANSI
Interactive screen height 0.7–1.2 m (28–47 in)	Universal Design	
Ramp slope	1:12 (8.3%)	ADA
Tactile path width	0.6–0.9 m (24–35 in)	ISO

9. Exhibition route formation

It is necessary to organize visitor circulation for the whole zoo in order to have a successful visitor experience. It needs proper planning and careful evaluation of the site as well as the specimen to be exhibited. The layout needs a clear hierarchy like; major spaces, paths, public and staff areas.

People should be able to choose what part of zoo to see, without getting lost of missing exhibits while separating visitor areas from staff areas, and hide service routes. Adding natural scenery and immersive environments helps visitors feel like they're in real habitats, and not just walking through a zoo. Good design also makes it easy for visitors to find services like food and restrooms and helps them reorient themselves during their visit.

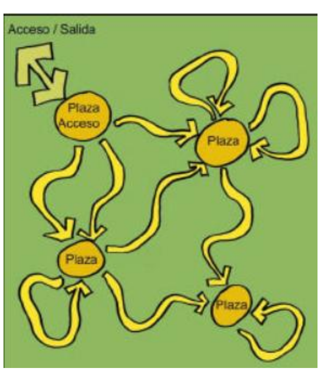


Figure 2.27 Path without Hierarchy

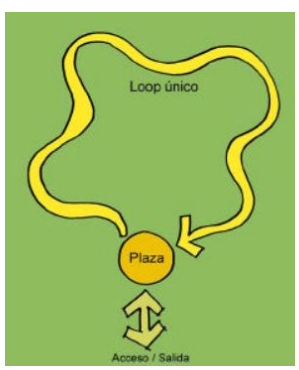


Figure 2.28 Path with Hierarchy, unique loop

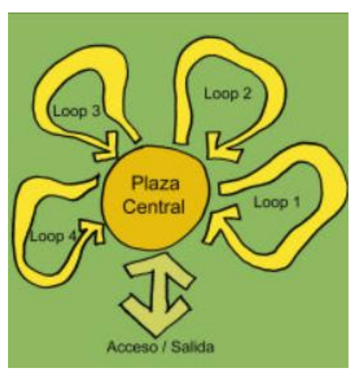


Figure 2.29 Path with Hierarchy, multiple loops

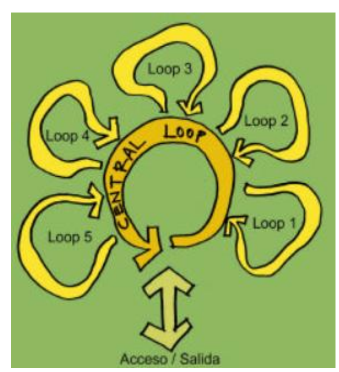


Figure 2.30 Path with Hierarchy, central main loop

Source: Yanez et al. 2007. Visitor circulation in zoos

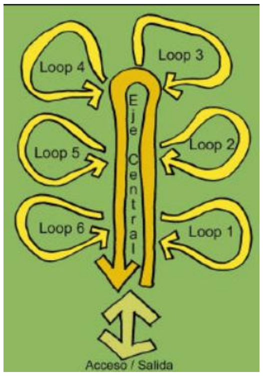


Figure 2.31 With hierarchy, central axis

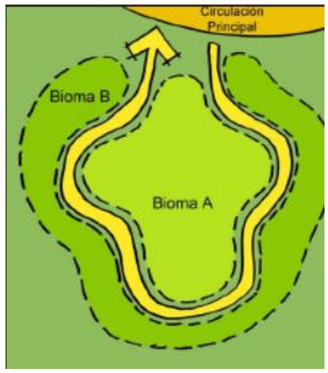


Figure 2.32 Path with sub theme zones

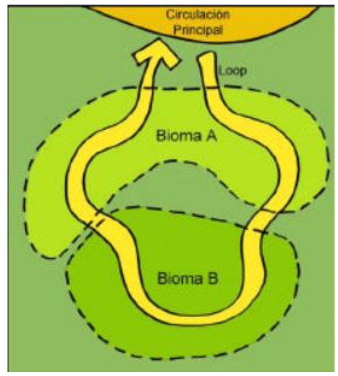


Figure 2.33 Path through different biomes

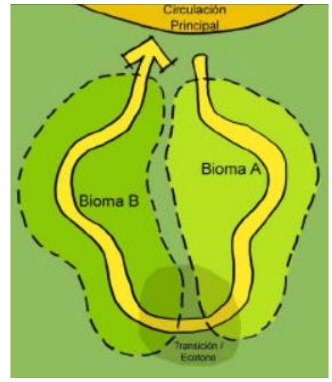


Figure 2.34 Path through different biomes

10. Required circulation for exhibition hall

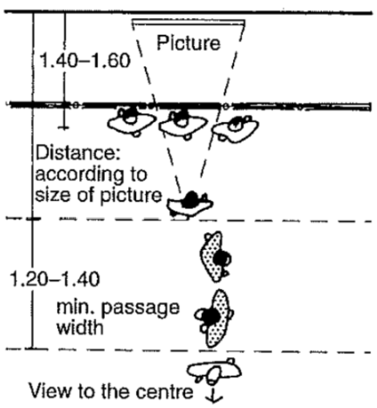


Figure 2.35 Viewing pictures on wall

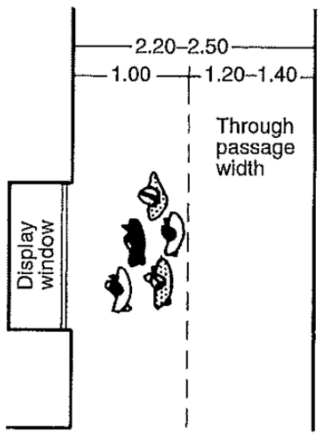


Figure 2.36 Space in front of display

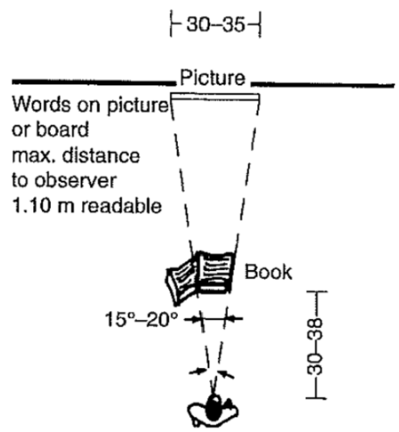


Figure 2.37 Readable commentaries

- Corridor Width: Minimum 1.2-1.4 m for general movement, 2.5m–3m for high-traffic areas.
- Staircase Width: Minimum 1.2m, with handrails on one side.
- Ramp Slope: Maximum 1:12 for wheelchair accessibility.
- Door Width: Minimum 900mm for universal access.
- Ceiling Height: Minimum 3m in exhibition areas for comfortable viewing.
- Queuing Space: 1.5m–2m depth near ticket counters or security checks.

Source: Neufert, E., & Neufert, P. (2012). Architects' data (4th ed.). Wiley-Blackwell. [Book]

11. Viewing parameter

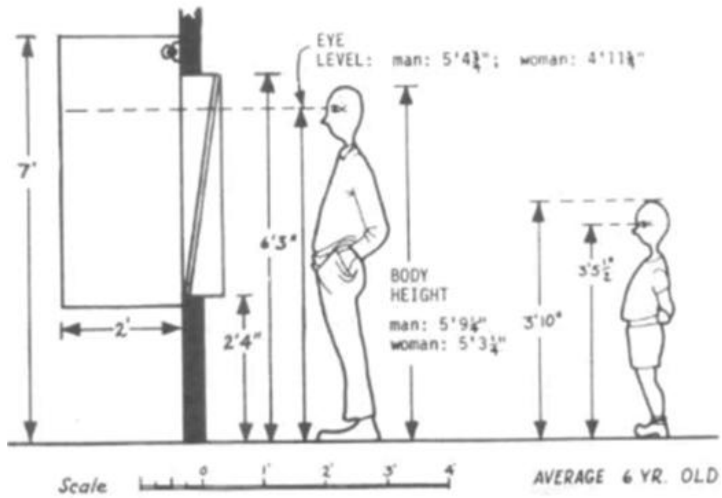


Figure 2.38 Display Height

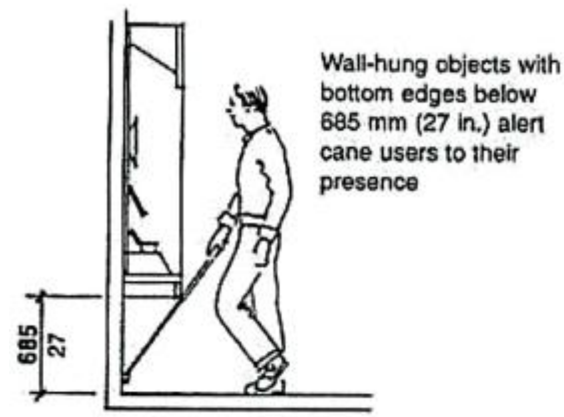


Figure 2.39 Auditory and Braile aids

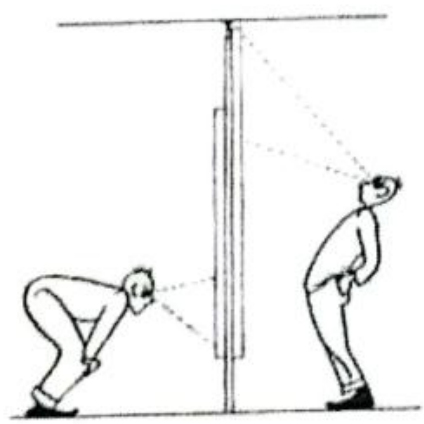


Figure 2.40 Display Placement Height

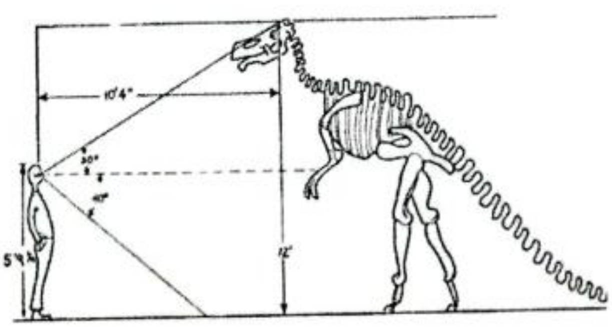


Figure 2.41 Large Display Viewing Distance

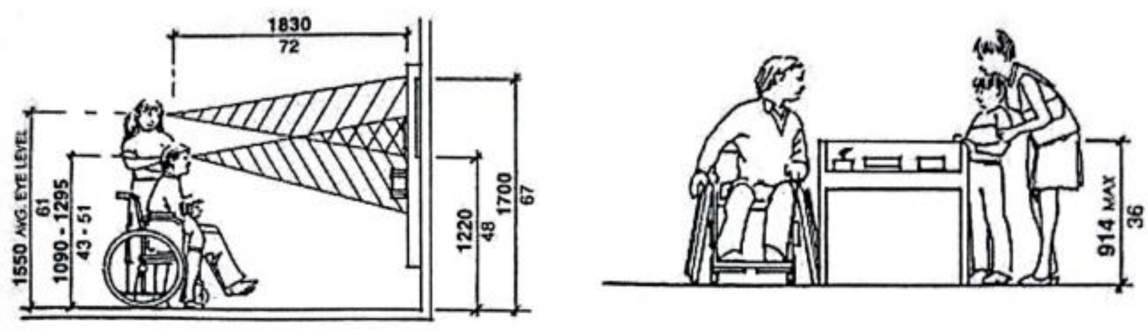


Figure 2.42 Inclusive Viewing

Source: Neufert, E., & Neufert, P. (2012). Architects' data (4th ed.). Wiley-Blackwell. [Book]

12. Lighting

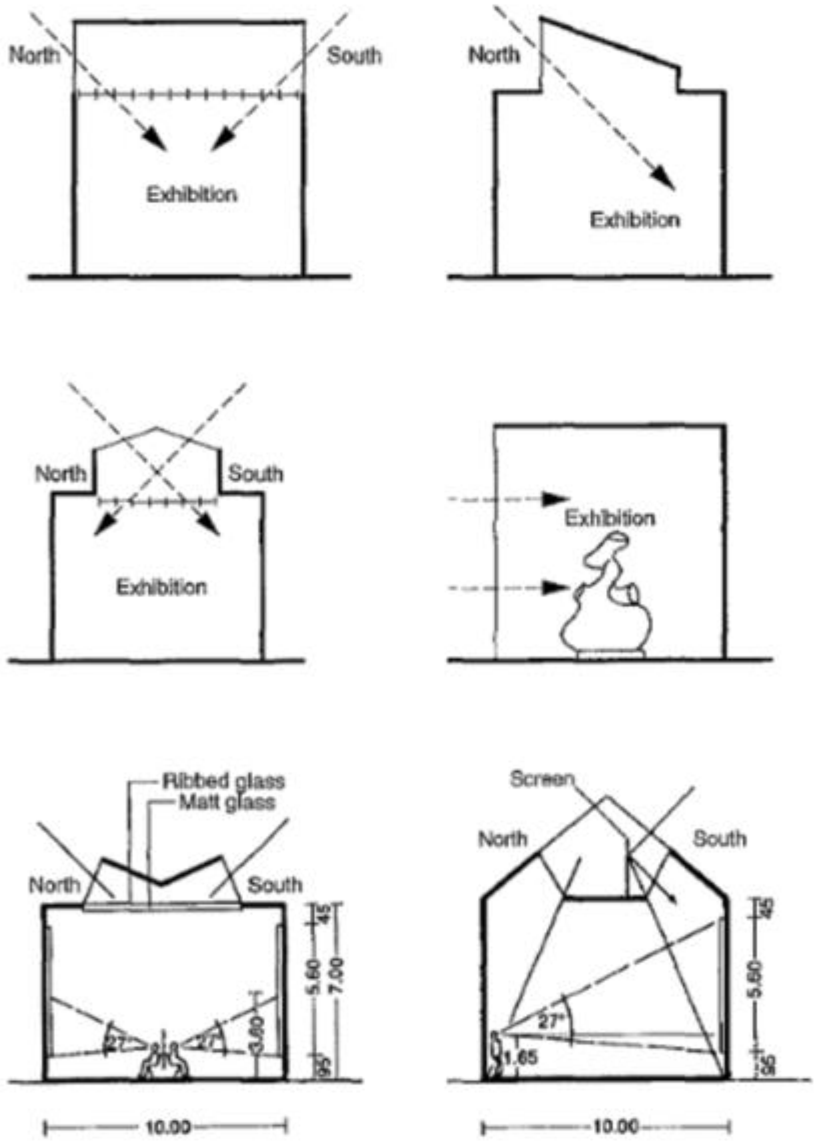


Figure 2.43 Natural Lighting Schemes

Source: Neufert, E., & Neufert, P. (2012). Architects' data (4th ed.). Wiley-Blackwell.

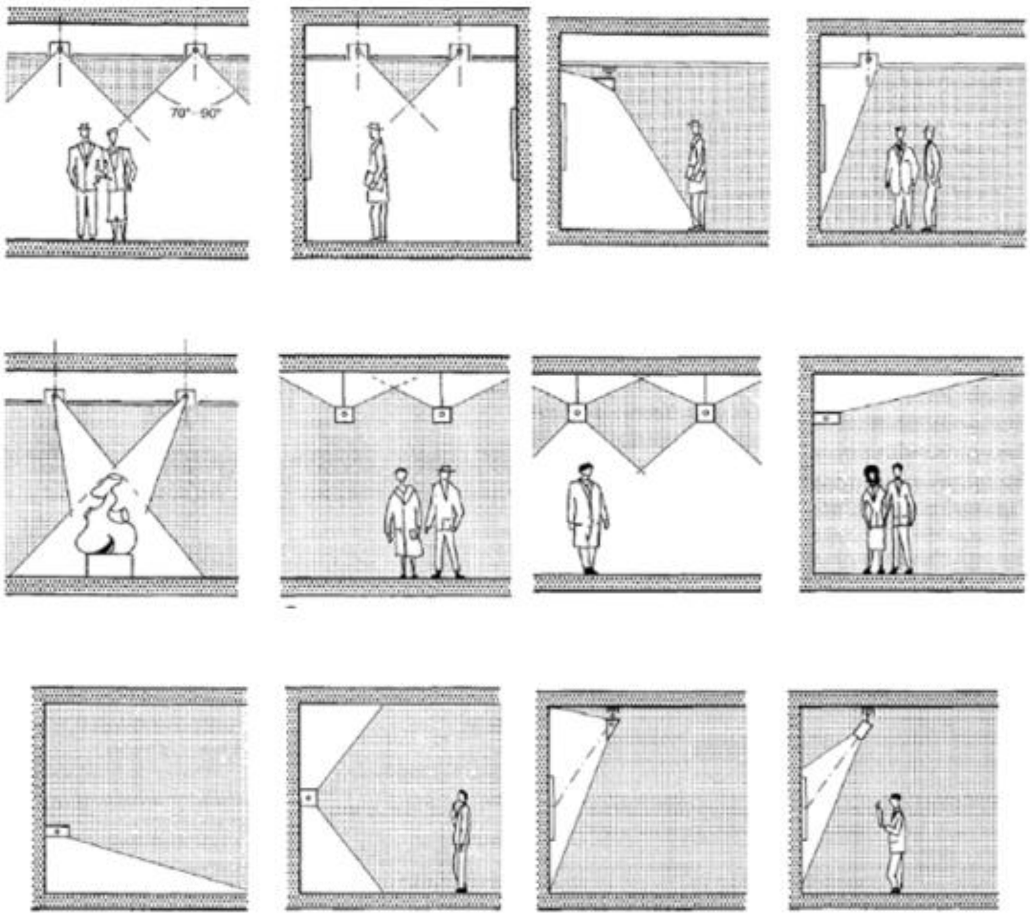


Figure 2.44 Artificial Lighting Schemes

13. Library

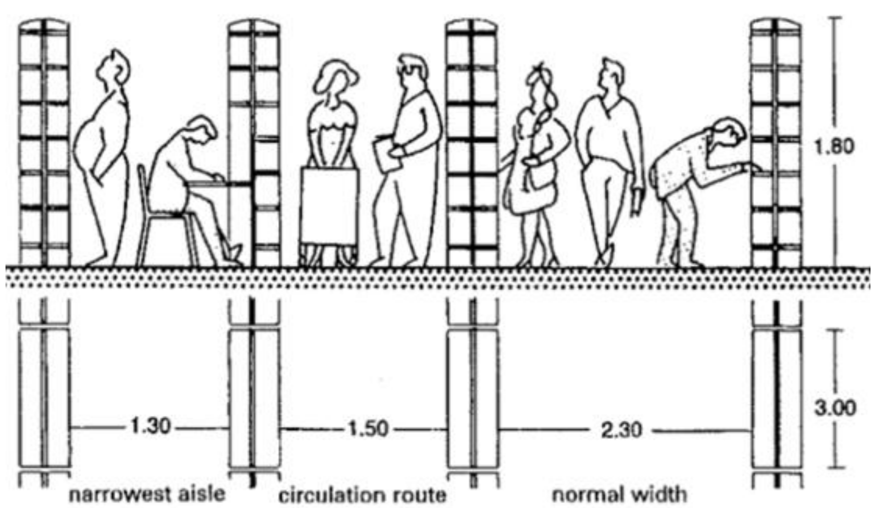


Figure 2.45 Library Circulation

Source: Neufert, E., & Neufert, P. (2012). Architects' data (4th ed.). Wiley-Blackwell.

Chapter 3 : National Case Study

3.1 The Central Zoo

3.1.1. General Introduction:

Located in Jawalakhel, Lalitpur, Central Zoo is the only National Zoo of Nepal that is operated by the National Trust for Nature Conservation. The zoo is home to 126 species and 1219 of total animals in 6-hectare area, which was opened at 1932 in private and 1956 to public. Annual visitors up to 1,000,000, which is quite high signifying its importance for the society. Zoo is multi-functional recreational area that doesn't only conserve, research and rehabilitate the rescued wildlife but also give a place for people to gather, socialize and educate themselves about the wildlife.

Future Plans:

- Digital Information Centre
- Biofact Centre
- Zoo with renovated enclosures
- Suryabinayak Rescue Centre Master Plan
- Establishment of Butterfly house
- Campaigns focusing on human wildlife conflicts
- Making Zoo inclusive

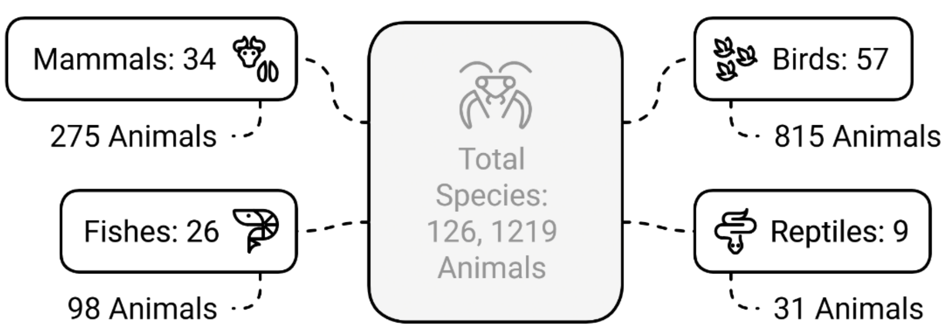


Figure 3.1. Distribution of Zoo Animal Species by Category

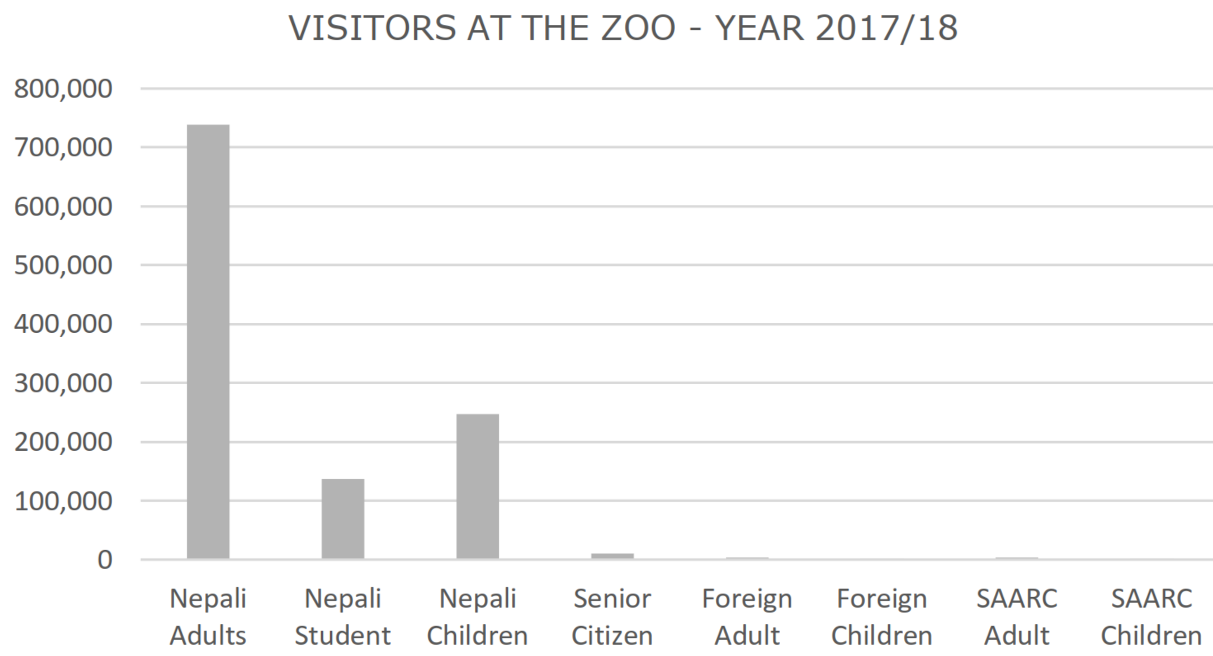


Figure 3.2. Visitors at the zoo

3.1.2. Architectural Styles And Influences

Historical Legacy:

- Rana-era Aesthetics: Original structures (e.g., the main gate and administrative buildings) reflect neo-classical Rana architecture, characterized by brickwork, arched windows, and ornamental detailing.
- Newari Craftsmanship: Use of traditional wood carvings and terracotta tiles in older structures, nodding to the Kathmandu Valley's indigenous Newari culture.
- Modern Additions: Post-1995 renovations introduced functional, minimalist enclosures with steel bars, concrete, and glass, prioritizing animal safety over aesthetics.

Figure 3.3 Entrance Sculptural Gazebo

Figure 3.4 Meeting Room in Office Zone

3.1.3. Site Layout And Spatial Organization

- Compact Footprint: The zoo occupies 6 hectares in a densely populated urban area, limiting expansion but fostering an intimate visitor experience.

Zoning:

- Animal Enclosures: Segregated into zones for mammals, birds, and reptiles, with pathways connecting exhibits.
- Visitor Amenities: Centralized facilities (entrance gate, ticket counters, rest areas) near the entrance, with picnic spots and playgrounds distributed across the site.
- Circulation: Narrow, winding pathways designed to maximize space and create a sense of discovery.

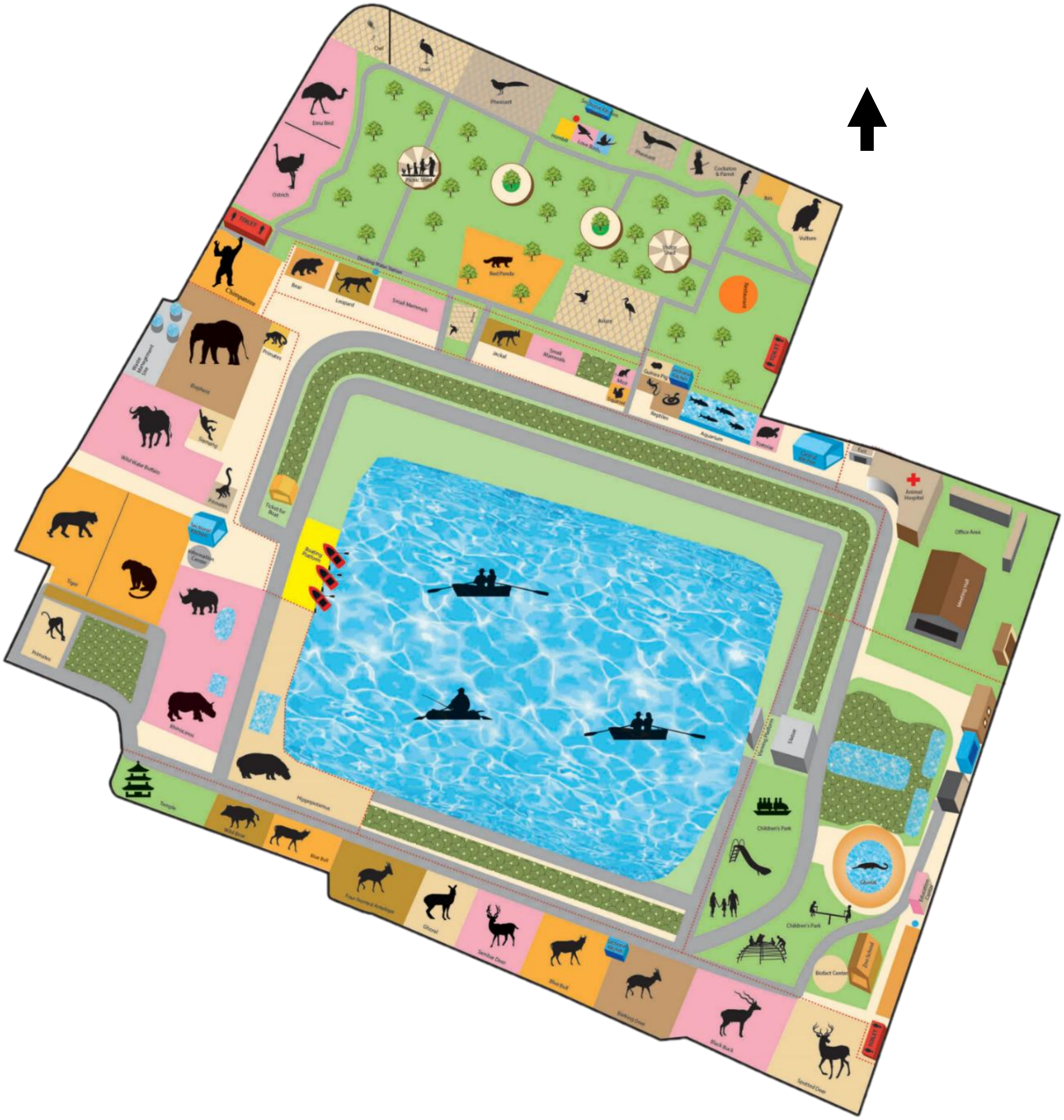


Figure 3.5 Map of the Zoo

Visitor Facilities

- Entrance Plaza: A grand neo-classical gate with ticket counters and informational boards.
- Interpretive Centers: Small pavilions with infographics on conservation, often housed in repurposed Rana-era buildings.

Figure 3.3 Digital Information Center

Figure 3.7 Wild Life Display Center

- Children's Park: A playground with animal-themed structures.
- Picnic Lawns: Shaded areas with benches and traditional pavilions (mandapas).

Figure 3.8 Children's park

Figure 3.9 Picnic area

3.1.4. Sustainability And Climate Resilience

Material Choices:

- Local Materials: Brick, wood, and stone in older structures; concrete and steel in newer ones.
- Green Initiatives: Limited solar panels and rainwater harvesting systems due to budget constraints.

Disaster Preparedness:

- Retrofitting post-2015 earthquake to reinforce enclosures and administrative buildings.
- Elevated pathways to mitigate monsoon flooding

3.1.5. Enclosure Design

Early 20th-Century Cages:

- Barred Cages: Many older enclosures (e.g., for tigers and bears) feature small, iron-barred cages criticized for their cramped conditions.
- Pits and Moats: Elephant and primate enclosures use dry moats for containment, a design common in mid-20th-century zoos.

Modern Upgrades:

Naturalistic Habitats: Recent efforts to replace cages with open-air enclosures mimicking natural ecosystems (e.g., bamboo groves for red pandas, ponds for gharials).

- Visitor Viewing Areas: Elevated platforms and glass walls to minimize human-animal stress while enhancing visibility.

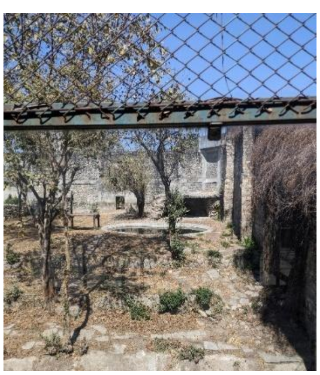


Figure 3.10 Glass viewing area

Figure 3.11 A.C. incorporated enclosure

3.1.6. Inventory Of Animals:

National Trust for Nature Conservation/ Central Zoo

Animal Inventary

Magh 2081 (January/ February 2025)

F. Y. 2081/82 (2024/2025)

Mammals

S.N.	Common Name	Scientific Name	IUCN Redlist 2020 status	NPWC status	Origin	Total	Male	Female	Infants/ Unknown
1	Asian Elephant	*Elephas maximus*	EN	*Protected*	Native	1		1	
2	Assamese Macaque	*Macaca assamensis*	NT	*Protected*	*Native*	2		2	
3	Barking Deer	*Muntiacus muntjak*	LC		*Native*	31	9	14	8
4	Black Buck	*Antilope cervicapra*	LC	*Protected*	*Native*	3	1	2	
5	Blue Bull	*Boselaphus tragacamelus*	LC		*Native*	3	2	1	
6	Burmese Ferret-badger	*Melogale personata*	LC		*Native*	1		1	
7	Common Chimpanzee	*Pan troglodytes*	EN		*Exotic*	2	1	1	
8	Common Langur	*Semnopithecus entellus*	LC		*Native*	7	4	1	2
9	Common Leopard	*Panthera pardus*	VU		*Native*	4	2	2	
10	Clouded Leopard	*Neofelis nebulosa*	VU	*Protected*	*Native*	1		1	
11	Snow Leopard	*Panthera uncia*	VU	*Protected*	*Native*	1	1		
12	Asian Palm Civet	*Paradoxurus hermaphroditus*	LC		*Native*	1			1
13	Five Striped Palm Squirrel	*Funambulus pennantii*	LC		*Native*	7	1	1	5
14	Four-horned Antelope	*Tetracerus quadricornis*	VU	*Protected*	*Native*	1	1		
15	Guinea Pig	*Cavia porcellus*	LC		Exotic	45			45
16	Asiatic Black Bear	*Ursus thibetanus*	VU		*Native*	6	3	2	1
17	Himalayan Goral	*Naemorhedus goral*	NT		*Native*	2	1		1
18	Masked Palm Civet	*Paguma larvata*	LC		*Native*	3	2	1	
19	Hippopotamus	*Hippopotamus amphibious*	VU		*Exotic*	1	1		
20	Hog Deer	*Axis porcinus*	EN		*Native*	2	1	1	
21	Jackal	*canis aureus*	LC		*Native*	12	3	7	2
22	Jungle Cat	*Felis chaus*	LC		*Native*	4	3	1	
23	Large Indian Civet	*Viverra zibetha*	LC		*Native*	2	1	1	
24	Leopard Cat	*Prionilurus bengalensis*	LC	*Protected*	*Native*	6	3	3	
25	Mona Monkey	*Cercopithecus mona*	LC		Exotic	1	1		
26	Vervet Monkey	*Chlorocebus pygerythrus*	LC		Exotic	4	2	1	1
27	Patas Monkey	*Erythrocebus patas*	LC		Exotic	3	2	1	
28	One-horned Rhinoceros	*Rhinoceros unicornis*	VU	*Protected*	*Native*	1	1		
29	Indian Crested Porcupine	*Hystrix indica*	LC		*Native*	28	1	1	26
30	Rabbit	*Oryctolagus cuniculus*	LC		*Native*	35			35
31	Red Panda	*Ailurus fulgens*	EN	*Protected*	*Native*	1	1		
32	Royal Bengal Tiger	*Panthera tigris tigris*	EN	*Protected*	*Native*	5	3	2	
33	Rhesus Macaque	*Macaca mulatta*	LC		*Native*	9	2	1	6
34	Sambar Deer	*Rusa unicolor*	VU		*Native*	3	1	2	
35	Siamang	*Symphalangus syndactylus*	EN		*Exotic*	1	1		
36	Sloth Bear	*Melursus ursinus*	VU		*Native*	2	1	1	
37	Spotted Deer	*Axis axis*	LC		*Native*	24	6	12	6
38	White Mice	*Mus musculus*	LC		*Exotic*	30			30
39	Eurasian Wild Boar	*Sus scrofa*	LC		*Native*	4	2	2	
40	Wild Water Buffalo	*Bubalus arnee*	EN	*Protected*	*Native*	10	2	6	2
	Sub-Total					**309**	**66**	**72**	**171**

Reptiles

S.N.	Common Name	Scientific Name	IUCN Redlist 2020 status	NPWC status		Total	Male	Female	Infants/ Unknown
1	Asiatic Rock Python	*Python molurus*	NT	*Protected*	*Native*	3			3
2	Common Sand Boa	*Eryx conicus*	NT		*Native*	1			1
3	Chinese Aligator	*Alligator sinensis*	CR		*Exotic*	1			1
4	Cobra	*Naja naja*	LC		*Native*	1			1
5	Gharial Crocodile	*Gavialis gangeticus*	CR	*Protected*	*Native*	3		1	2
6	Indian Roofed Turtle	*Kachuga tecta*	LC		*Native*	27			27
7	Indian Star Tortoise	*Geochelone elegans*	VU		*Exotic*	2			2
8	Red-eared Slider (Turtle)	*Trachemys scripta elegans*	LC		*Exotic*	67	1	4	62
9	Black Pond Turtle	*Geoclemys hamiltonii*	EN		*Native*	5			5
10	Tricarinate Hill Turtle	*Melanochalys tricarinata*	Vu		*Native*	1			1
11	Elongated Tortoise	*Indotestudo elongata*	CR		*Native*	7	2	3	2
	Sub-Total					**118**	**3**	**8**	**107**

Fishes

S.N.	Common Name	Scientific Name	IUCN Redlist 2020 status	NPWC status		Total	Male	Female	Infants/ Unknown
1	Black Tiger Shark(Iridescent S	*Pangasius sutchi*	EN		*Exotic*	4			4
2	Sucker Mouth	*Hypostomus sps*	LC		*Exotic*	3			3
3	Tinfoil Barb	*Barbus schwanenfeld*	LC		*Exotic*	3			3
4	Koi Carp	*Cyprinus carpio*	VU		*Exotic*	1			1
5	Suban King	*Carassius sp.*	LC		*Exotic*	2			2
6	Gourami				*Exotic*	24			24
7	Amatitlan Cichlid	*Vieja guttulatus*			*Exotic*	1			1
8	Red Belly Pacu	*Piaractus brachypomus*			*Exotic*	3			3
	Sub-Total					**41**			**41**

Birds

S.N.	Common Name	Scientific Name	IUCN Redlist 2020 status	NPWC status		Total	Male	Female	Infants/ Unknown
1	African Ostrich	*Struthio camelus*	LC		Exotic	3	2	1	
2	Alexandrine Parakeet	*Psittacula eupatria*	NT		Native	5			5
3	Barn Owl	*Tyto alba*	LC		Native	7			7
4	Little Owl	*Athene noctua*	LC		Native	3			3
5	Black-crowned Night Heron	*Nycticorax nycticorax*	LC		*Native*	2			2
6	Black headed Ibis	*Threskiornis melanocephalus*	NT		*Native*	5			5
7	Tricoloured Munia	*Lonchura malacca*	LC		*Native*	14			14
8	Black-masked Lovebird	*Agapornis personatus*	LC		*Exotic*	6			6
9	Black Kite	*Milvus migrans*	LC		*Native*	18			18
10	Brown Fish Owl	*Ketupa zeylonensis*	LC		*Native*	4			4
11	Budgerigar	*Melopsittacus undulatus*	LC		*Exotic*	26			26
12	Cockatiel	*Nymphicus hollandicus*	LC		*Exotic*	36			36
13	Common Peafowl	*Pavo cristatus*	LC		*Native*	4	1	3	
14	Common Hill Myna	*Gracula religiosa*	LC		*Native*	13			13
15	Common Quail	*Coturnix coturnix*	LC		*Exotic*	1			1
16	Diamond Dove	*Geopelia cuneata*	LC		*Exotic*	8	2	1	5
17	Emu	*Dromaius novaehollandiae*	LC		*Exotic*	10			10
18	Eurasian Collared dove	*Streptopelia decaocto*	LC		*Native*	8			8
19	Eurasian Eagle Owl	*Bubo bubo*	LC		*Native*	2			2
20	Fantail Pigeon	*Family: Columbidae*	LC		*Native*	35			35
21	Orange-breasted Green Pigeon	*Treron bicinctus*	LC		*Native*	15			15
22	Finch	*Taeniopygia sps.*			*Native*	5			5
23	Bunting	*Bunting sps.*	LC		*Native*	4			4
24	Weaver	*Ploceus sps.*	LC		*Native*	13			13
25	Domestic Pigeon	*Family: Columbidae*	LC		*Native*	42			42
26	Golden Pheasant	*Chrysolophus pictus*	LC		*Exotic*	15	4	9	2
27	Greylag Goose	*Anser anser*	LC		*Native*	31	7	6	18
28	Conure (Parakeet)	*Aratinga sps.*			*Exotic*	2			2
29	Guinea Fowl	*Numida meleagris*	LC		*Exotic*	1	1		
30	Himalayan Griffon Vulture	*Gyps himalayensis*	NT		*Native*	10	1	1	8
31	Himalayan Monal	*Lophophorus impejanus*	LC	*Protected*	*Native*	4	1	3	
32	Indian Pond Heron	*Ardeola grayii*	LC		*Native*	10	1	1	8
33	Japanese Green Pheasant	*Phasianus versicolor*	LC		*Exotic*	5	1	4	
34	Java Sparrow	*Lonchura oryzivora*	VU		*Exotic*	10			10
35	Kalij Pheasant	*Lophura leucomelanos*	LC		*Native*	10	4	4	2
36	Lady Amherst's Pheasant	*Chrysolophus amherstiae*	LC		*Exotic*	4	2	2	
37	Oriental Pied Hornbill	*Anthracocerus albirostris*	LC		*Native*	1		1	
38	Peach faced Love Bird	*Agapornis roseicollis*	LC		*Exotic*	5			5
39	Plum-headed Parakeet	*Psittacula cyanocephala*	NT		Native	43			43
40	Salmon-crested Cockatoo	*Cacatua moluccensis*	VU		*Exotic*	1			1
41	Red-brested Parakeet	*Psittacula alexandri*	NT		*Native*	7			7
42	Red Collared Dove	*Streptopelia tranquebarica*	LC		*Native*	5			5
43	Red Avadavat	*Amandava amandava*	LC		*Native*	11			11
44	Ring-necked Pheasant	*Phasianus colchicus*	LC		*Exotic*	23	3	6	14
45	Rose-ringed Parakeet	*Psittacula krameri*	LC		*Native*	78			78
46	Ruddy Shelduck	*Tadorna ferruginea*	LC		*Native*	3	1	1	1
47	Sarus Crane	*Antigone antigone*	VU	*Protected*	*Native*	2	1		1
48	Scaly-breasted Munia	*Lonchura punctulata*	LC		*Native*	280			280
49	Silver Pheasant	*Lophura nycthemera*	LC		*Exotic*	13	7	3	3

50	Sulpher-crested Cockatoo	*Cacatua galerita*	LC		*Exotic*	5			5
51	Senegal Parrot	*Poicephalus senegalus*	LC		*Exotic*	10			10
52	Speckled Pigeon	*Columba guinea*	LC		*Exotic*	2			2
53	Black Francolin	*Francolinus francolinus*	LC		*Native*	2	2		
54	Turkey Bird	*Meleagris gallopavo*	LC		*Exotic*	1	1		
55	White Cockatoo	*Cacatua goffiniana*	EN		*Exotic*	1			1
56	Great White Pelican	*Pelecanus onocrotalus*	LC		*Native*	1	1		
57	Blue & Yellow Macaw	*Ara ararauna*	LC		*Exotic*	10			10
58	Zebra Finch	*Taeniopygia guttata*	LC		*Exotic*	4			4
	Sub-Total					**899**	**43**	**46**	**810**
	Total					**1367**	**112**	**126**	**1129**

Categories	Species	Number
Mammals	40	309
Reptiles	11	118
Fishes	8	41
Birds	58	899
Total	**117**	**1367**

Abbrebiations

CR : Critically Endangered
EN : Endangered
IUCN : The World Conservation Union
LC : least Concern
NT : Near Threatened
VU : Vulnerable
NPWC: National Park and Wildlife conservation Act, Nepal

3.1.7. Some Photos Of The Site:

Figure 3.12 Entrance

Figure 3.43 Ticket Counter

Figure 3.14 Wildlife Display Center

Figure 3.15 Veterinary

Figure 3.16 Digital Information Center

Figure 3.17 Food Preparation Center

Chapter 4 : International Case Study

4.1. Ecorium, South Korea

4.1.1 General Introduction:

The Ecorium of the National Ecological Institute is a landmark facility located in Seocheon, South Korea, designed to showcase and preserve global ecosystems. It is part of the Ecoplex ecological park, a government-led initiative aimed at ecological research, education, and conservation. The Ecorium features five distinct climate zones—tropical, subtropical, Mediterranean, temperate, and polar—recreated within controlled greenhouse environments. Visitors can experience these ecosystems firsthand, observing diverse flora and fauna, including over 1,900 plant species and 280 animal species.Designed by Samoo Architects & Engineers in collaboration with Grimshaw Architects, the Ecorium emphasizes sustainability and eco-friendly design. Its innovative structure includes steel arches and lightweight glazing systems to maximize natural light and reduce energy consumption. The facility also incorporates advanced technologies, such as sun-tracking systems, to maintain optimal conditions for each climate zone.

The Ecorium serves as an educational hub, offering immersive experiences through exhibitions, interactive displays, and programs that highlight the importance of biodiversity and environmental conservation. It also includes amenities like theaters, cafeterias, and gift shops, making it a comprehensive destination for visitors

Figure 4.1 Aerial View

4.1.2 Planning And Zoning

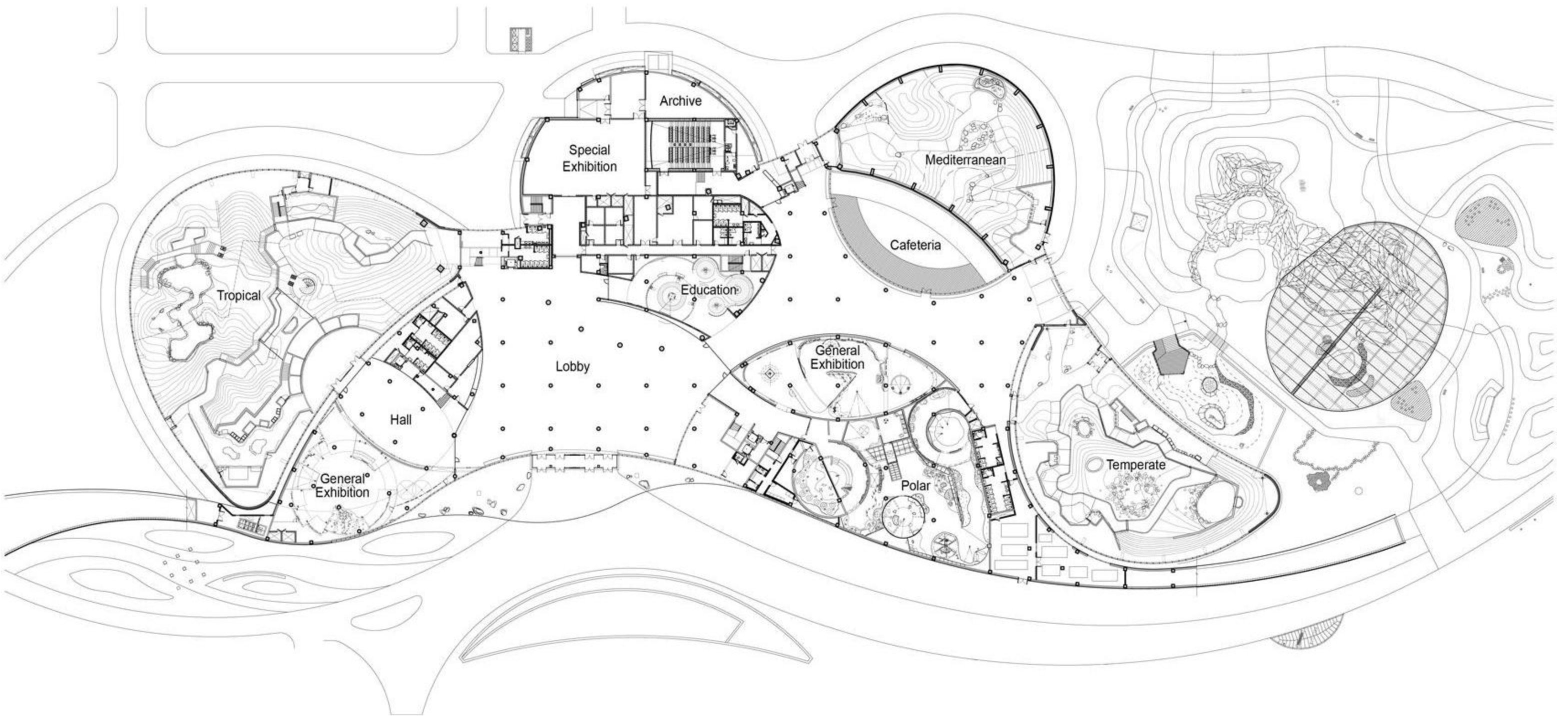


Figure 4.3 Ground Floor Plan

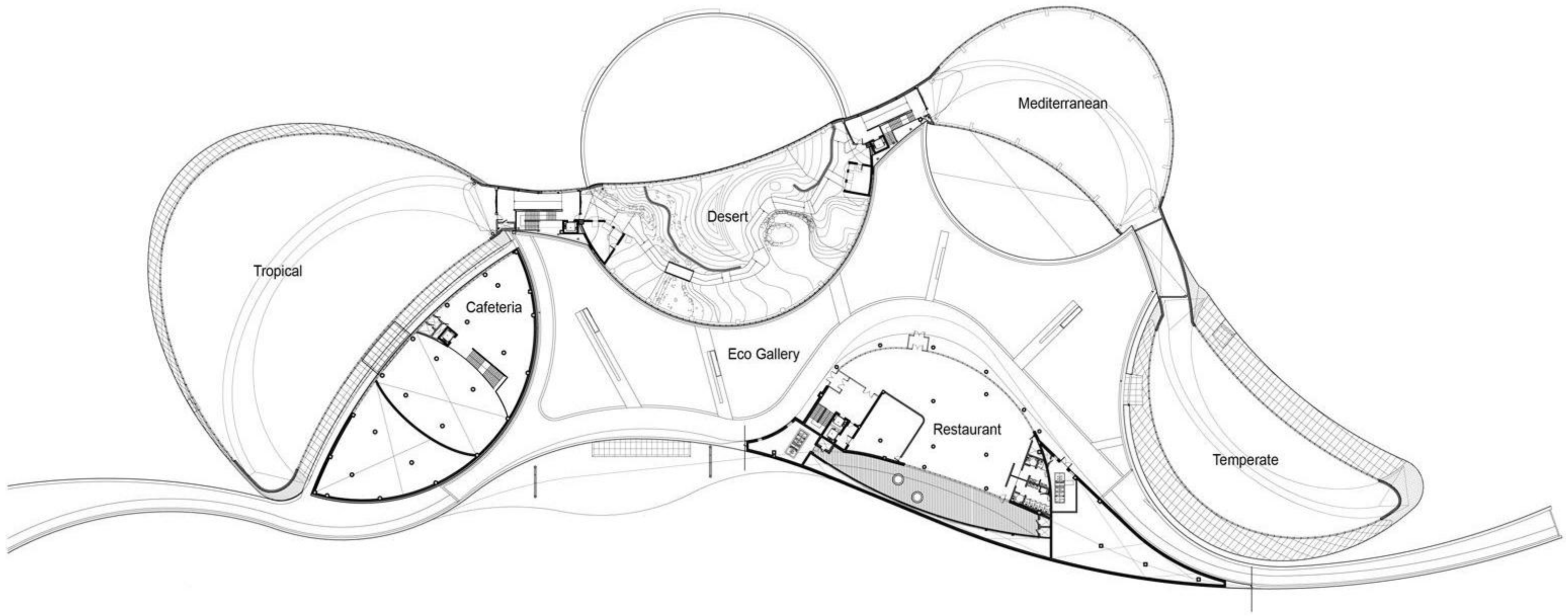


Figure 4.2 First Floor Plan

1. Design Concept and Inspiration

- The Ecorium is inspired by the form of an oxbow lake, a natural feature created by the meandering of a river, symbolizing the dynamic and evolving relationship between humans and nature.
- The project follows three key concepts: "From the Nature" (expressing organic energy), "Be the Nature" (reproducing Earth's ecosystems), and "With the Nature" (creating immersive ecological experiences).

2. Layout and Structure

- The Ecorium spans 33,090 square meters and consists of five interconnected greenhouse biomes, each representing a distinct climatic zone: tropical, subtropical, Mediterranean, temperate, and polar.
- The greenhouses are arranged in a linear sequence, connected by a central circulation path that guides visitors through the different zones, offering a seamless journey from tropical rainforests to polar ice environments.
- The structure is supported by steel arches and lightweight glazing systems, which maximize natural light and reduce the need for artificial lighting, enhancing energy efficiency.

3. Climate Zones and Exhibits

- Tropical Zone: The largest greenhouse, featuring lush rainforests, waterfalls, and aquariums, designed to immerse visitors in a realistic tropical environment.
- Subtropical Zone: Represents desert environments, highlighting the impacts of climate change and global warming.
- Mediterranean Zone: Showcases abundant greenery and contrasts with the harsher subtropical zone.
- Temperate Zone: Reflects Korea's native climate, with outdoor connections to miniature mountains and valleys.

- Polar Zone: Features sub-zero temperatures and live penguin exhibits, emphasizing the effects of global warming on polar regions.

4. Sustainability and Eco-Friendly Features

- The Ecorium is a model of sustainable design, incorporating advanced technologies such as sun-tracking systems to optimize natural light and reduce energy consumption.
- The sloped curtain walls collect rainwater for cooling and irrigation, while air-flow simulations ensure natural ventilation throughout the year.
- The facility reduces total energy consumption by approximately 10%, aligning with its goal of promoting environmental conservation.

5. Visitor Experience and Educational Role

- The Ecorium includes theaters, cafeterias, gift shops, and observatory decks, enhancing the visitor experience.
- It serves as a hub for ecological education and research, offering hands-on experiences and exhibitions to raise awareness about biodiversity and conservation.

6. Architectural Collaboration and Vision

- The project was developed through a design competition hosted by Korea's Ministry of Environment, with Samoo Architects & Engineers leading the design and Grimshaw Architects contributing to the innovative structural and environmental solutions 110.
- The Ecorium aims to become a global landmark for ecological research and public education, fostering a deeper understanding of the interconnectedness of nature and humanity.

4.1.3 Some Photos:

Figure 4.5 Aquarium

Figure 4.4 Desert Biome

Figure 4.6 Rainforest Biome

4.2 Singapore Zoo

4.2.1. General Introduction:

Location: Mandai, Singapore, within a rainforest near Upper Seletar Reservoir.

Established: 1973.

Site area: 26 hectares.

Figure 4.7 Zoo entrance

4.2.2. Site planning and analysis

Figure 4.8 Master Plan

- **Integration with Landscape:** Utilizes existing rainforest, waterways, and terrain to create natural animal zones.
- **Geographical Features:** Proximity to reservoir aids in water management; dense vegetation preserved to maintain ecological balance.
- **Zoning:** Divided into geographical regions (e.g., Australasia, Fragile Forest) with minimal visual barriers.

4.2.3 Architectural Elements

Structures:

- **Fragile Forest:** Geodesic biodome with controlled climate for free-ranging animals.
- **Elephant Enclosure:** Underwater viewing galleries using tempered glass.
- **Night Safari:** Subtle lighting simulating moonlight, enhancing nocturnal animal visibility.
- **Pathways:** Elevated boardwalks and meandering trails to minimize environmental impact.

Figure 4.11 Fragile forest

Figure 4.10 Elephant enclosure

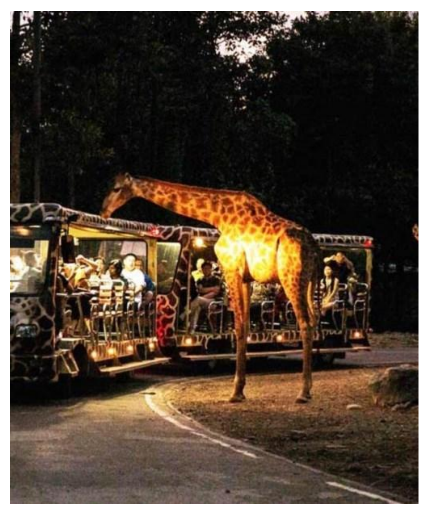


Figure 4.9 Night Sufari

4.2.4 Design Philosophy

- **Open-Zoo Concept:** Replaces cages with hidden moats, glass, and vegetation.
- **Immersive Experience:** Enclosures mimic natural habitats (e.g., Great Rift Valley's rocky outcrops, Frozen Tundra's cooling systems).
- **Visitor Engagement:** Thematic zones designed for educational interaction (e.g., Rainforest KidzWorld's water play areas).

Figure 4.12 Open zoo concept


Figure 4.13 Immersive Rainforest

4.2.5 Wildlife Considerations:

- **Habitat Design:** Enclosures with temperature control, natural substrates, and enrichment features.
- **Behind-the-Scenes:** Hidden staff pathways, veterinary centers, and quarantine zones integrated discreetly.
- **Conservation Programs:** Breeding facilities (e.g., orangutan islands) with research integration.

Innovative Features:

- **Biodomes:** Climate-controlled environments for diverse ecosystems.
- **Underwater Viewing:** Immersive galleries for aquatic species.
- **Smart Technology:** Sensor-based climate systems and energy monitoring.

4.2.6 Friendly And Calm Behaviour Of Animals:

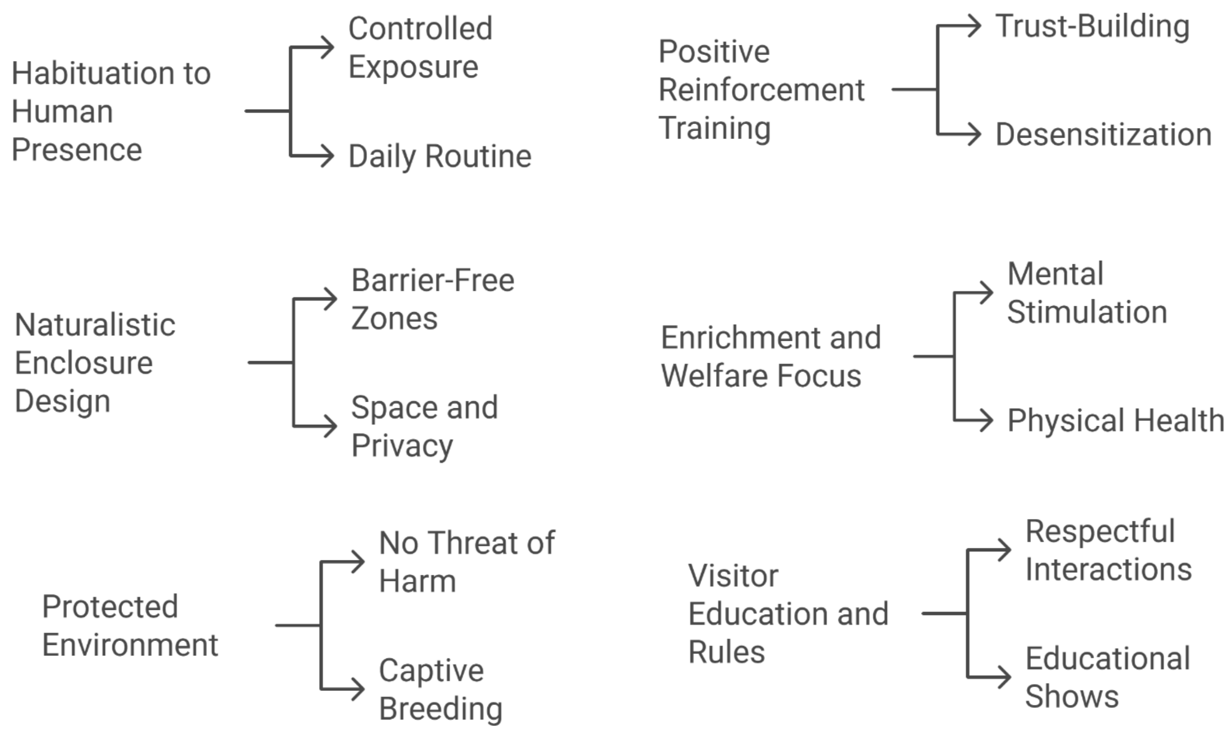


Figure 4.14 Behavior of animals

4.2.7 Sustainability Practice

- **Water Management:** Rainwater harvesting, natural filtration via wetlands, and recycled water for habitats.
- **Energy Efficiency:** Solar panels, energy-efficient lighting.
- **Materials:** Use of reclaimed wood, bamboo, and non-toxic coatings.
- **Waste Management:** Composting and biogas systems for animal waste.

4.2.8 Spatial Organization

- **Thematic Zones:** Each zone (e.g., Primate Kingdom, Reptile Garden) features distinct architectural styles and materials.

- **Circulation:** Tram routes and shaded walkways connect zones; strategic rest areas with cooling mist systems.
- **Accessibility:** Wide pathways, ramps, and tactile guides for inclusive design.

4.2.8 Materials

- **Natural Materials:** Timber, stone, and thatch for blending with surroundings.
- **Durability:** Weather-resistant composites and anti-slip surfaces in high-traffic areas.
- **Innovative Use:** Glass-reinforced concrete in artificial rock formations.

4.3. Gondwanaland Zoo

4.3.1. General Introduction:

Location: Leipzig Zoo, Leipzig, Germany

Established: 2011.

Site area: 26 hectares.

Climate: Leipzig has a temperate oceanic climate, but Gondwanaland creates a controlled tropical rainforest climate (temperature ~25°C, humidity ~65%).
Topography: The site is flat, but the indoor terrain is artificially landscaped to include hills, rivers, and valleys.

Figure 4.15 Aerial View of the biome

4.3.2 Zoning and Space Planning

Masterplan Considerations:

- Follows a whole-to-part approach, integrating multiple themed spaces within a large dome.

- The three regions (Asia, Africa, and South America) are distinctly zoned but interconnected via walking paths and boat rides.
- Animal enclosures are integrated within the visitor pathways.
- Vertical zoning includes aerial walkways for tree-top viewing.

Spatial Relationships:

- **Circulation:** Central entrance leads to a primary looped circulation path.
- **Orientation:** Enclosures and viewing areas align with natural light and ventilation.
- **Considerations for climate:** Greenhouse-like conditions maintained by advanced ventilation and shading.**Rainforest Biotope:** Houses 30+ live animal species in a controlled rainforest climate.

Figure 4.176 Master plan of the biome

4.3.3 Visual And Spatial Experience

Abstract Grid:

- The geometry of the roof creates an abstract grid when viewed from below, which disrupts the sense of perspective and scale, enhancing the immersive experience.

Column-Free Space:

- The large, open interior (free of columns) allows for uninterrupted views and flexible use of the space, accommodating diverse exhibits and visitor pathways.

4.3.4 Interior Structural Features

Rope Bridges:

- A suspended network of rope bridges allows visitors to explore the rainforest from above.
- These bridges are anchored to the roof structure and designed to be lightweight yet sturdy, with steel cables and timber or composite decking.

Boat Ride and Underground Caves:

The automated boat ride travels through the biotope at ground level and continues underground through a network of artificial caves.

- The caves are constructed using reinforced concrete to create a durable and immersive environment.

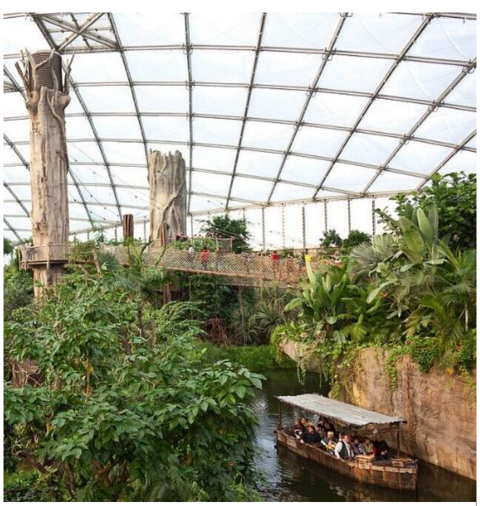


Figure 4.18 Boating and bridge

Figure 4.19 Immersive Biome zoo

4.3.5 Roof Structure:

- **Form:** A section of a sphere (40m high at the center, tapering to 7.5m at the edges).
- **Span:** 160m, with a 1m-deep shell structure for economy and efficiency.
- **Material:** Triple-layer ETFE (ethylene tetrafluoroethylene) panels heated to prevent snow accumulation, ensuring light penetration and reducing structural load.
- **Visual Effect:** The roof's geometry creates an abstract grid that disrupts perspective and scale perception.

4.3.6 Structural System

Load Distribution:

- The spherical shape of the roof ensures even distribution of loads (e.g., wind, snow, and self-weight) across the structure.
- The shell structure transfers these loads to the supporting columns at the edges, which are strategically placed to minimize obstruction in the interior space.

Foundation:

The building's foundation is designed to handle the significant vertical and lateral loads imposed by the roof structure.

- Deep piled foundations are used to anchor the structure securely into the ground, ensuring stability.

Figure 4.21 Roof detail

Figure 4.20 Structural detail

4.3.7 Sustainability And Efficiency

Lightweight Design:

- The use of a thin shell structure and ETFE panels reduces the overall weight of the roof, minimizing material usage and construction costs.

Energy Efficiency:

- The heated ETFE panels prevent snow accumulation, reducing the need for artificial lighting and lowering energy consumption.
- The transparent ETFE allows natural light to illuminate the space, further reducing energy demands.

Climate Control:

- The roof's design helps maintain a stable indoor climate for the rainforest biotope, reducing the need for mechanical heating and cooling.

4.4. The Eden Project

4.4.1. General Introduction:

Location: Cornwall, UK

Established: 2001.

Site area: 15 hectares.

Primary Function: Ecological visitor attraction, educational center, and global garden.

Key Features: Biomes (giant geodesic domes), reclaimed industrial site, and global plant collections.

Site Background: The Eden Project is built on a 160-year-old, 15-hectare china clay quarry that was exhausted and abandoned in the 1990s.The site was chosen to symbolize regeneration, transforming a post-industrial wasteland into a thriving ecosystem.

Figure 4.21 Aerial view

4.4.2 Design Concept And Philosophy

The Eden Project's design is rooted in biomimicry and ecological regeneration. Key principles include:

Reconnecting Humans with Nature:

- The biomes simulate diverse global climates, housing plants from tropical rainforests to Mediterranean regions.

Sustainability Through Innovation:

- Use of lightweight materials, renewable energy, and rainwater harvesting.

Architectural Symbolism:

- The geodesic domes represent soap bubbles or molecular structures, symbolizing fragility and interconnectedness.

Figure 4.22 Plan of Rainforest biome

4.4.3 Architectural Features

THE BIOMES

1. Structure:

Two main biomes:

- Humid Tropics Biome: The world's largest indoor rainforest (50m high, 240m long, 110m wide).
- Warm Temperate Biome: Mediterranean climate zone.

Geodesic Framework: Hexagonal and pentagonal steel frames clad with ETFE (ethylene tetrafluoroethylene) cushions.

Material Innovation:

- **ETFE Panels:** Lightweight, durable, and thermally efficient. They allow UV light penetration while insulating better than glass.
- **Steel Structure:** Minimal material use due to the efficiency of geodesic geometry.

2. The Core Building (2005)

- A later addition housing educational facilities, designed as a sunflower-inspired structure with a timber roof.
- Features interactive exhibits on sustainability and renewable energy.

3. Outdoor Gardens: Landscaped terraces with plants from temperate regions, demonstrating biodiversity and sustainable agriculture.

Figure 4.25 Biome design

Figure 4.23 ETFE roof material

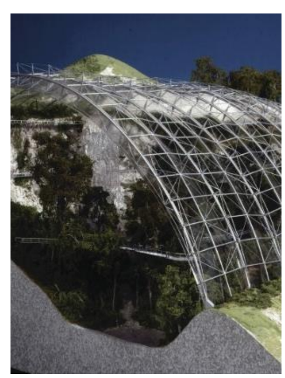


Figure 4.24 Steel Structure

4.4.4 Sustainability And Engineering

Energy Efficiency:

- **Passive Ventilation:** The biomes' shape promotes natural airflow, reducing mechanical cooling needs.
- **Renewable Energy:** On-site wind turbines and a biomass boiler (using local wood chips) provide energy.

Water Management:

- Rainwater is harvested from biome roofs and stored in a former quarry pit (now a lake) for irrigation.

Material Reuse:

- The site reused 1.9 million tonnes of waste soil from the quarry to create terraced gardens.
- Recycled materials were used in construction, including reclaimed steel.

Carbon Footprint:

- The project reduced embodied carbon through prefabrication and local sourcing.

4.4.5 Cultural and Economic Impact

Tourism:

- Attracts over 1 million visitors annually, contributing £2 billion to Cornwall's economy since opening.
- Hosts events like concerts and educational workshops.

Education and Research:

- Partners with universities for climate change and botanical research.
- The Eden Project International expands its mission globally (e.g., Eden Project Qingdao in China).

Community Engagement:

- Employs local residents and promotes Cornish heritage.
- Runs programs like the "Eden Project Communities" initiative.

4.4.6 Legacy And Influence

- The Eden Project has inspired similar projects worldwide, such as Singapore's Gardens by the Bay.
- It redefined how post-industrial landscapes can be repurposed for ecological and social good.
- Won the RIBA Award (2002) and became a symbol of 21st-century environmental optimism.

4.5. Comparative Study

Comparative case study between Central Zoo (Nepal), Singapore Zoo, Eden Project (UK), and Tropical Experience World Gondwanaland (Germany) across various architectural aspects;

Table 4.1 Background of The Projects

Aspect	**Central Zoo, Nepal**	**Singapore Zoo**	**Eden Project, UK**	**Gondwanaland, Germany**
Year Opened	1932	1973	2001	2011
Purpose	Wildlife conservation & public education	Open-concept zoo for conservation & tourism	Biodome for ecological conservation	Tropical rainforest ecosystem in a biodome
Target Audience	Local visitors, students, tourists	Families, tourists, researchers	Botanists, educators, tourists	Tourists, students, conservationists
Annual Visitors	1 million	2 million	1 million+	1.7 million

Table 4.2 Location & Accessibility

Aspect	**Central Zoo, Nepal**	**Singapore Zoo**	**Eden Project, UK**	**Gondwanaland, Germany**
Location	Jawalakhel, Kathmandu	Mandai, Singapore	Cornwall, UK	Leipzig Zoo, Germany
Accessibility	In the city center, easily reachable	Well-connected via MRT, bus, and road	Located in rural Cornwall, accessible by road & train	Integrated within Leipzig Zoo, accessible by public transport

Table 4.3 Site Study (Surroundings & Linkages)

Aspect	Central Zoo, Nepal	Singapore Zoo	Eden Project, UK	Gondwanaland, Germany
Setting	Urban, surrounded by city infrastructure	Integrated within Mandai Nature Reserve	Located in a former clay pit	Within Leipzig Zoo, blending with existing habitats
Architectural Features	Traditional enclosures with fencing	Moat barriers & open enclosures	Large geodesic biomes	Large free-standing ETFE dome

Table 4.4 Climate & Topography

Aspect	Central Zoo, Nepal	Singapore Zoo	Eden Project, UK	Gondwanaland, Germany
Climate	Subtropical, moderate winters	Tropical rainforest	Temperate maritime	Temperate
Topography	Flat urban land	Gently undulating terrain	Repurposed clay pit	Artificial terrain with water features

Table 4.5 Zoning & Space Planning

Aspect	Central Zoo, Nepal	Singapore Zoo	Eden Project, UK	Gondwanaland, Germany
Zoning Approach	Traditional layout	Habitat-based zones	Thematic biomes	Geographic habitat zones
Main Features	Caged enclosures	Open-concept habitats	Massive biomes with microclimates	River, aerial bridges, rainforest walkways
Circulation	Basic pathways	Looping pedestrian trails, tram rides	Internal pathways & aerial walkways	Boat rides, bridges, trails

Table 4.6 Circulation & Landscape Design

Aspect	Central Zoo, Nepal	Singapore Zoo	Eden Project, UK	Gondwanaland, Germany
Pedestrian Flow	Traditional walkways	Integrated paths & tram rides	Walkways over plant exhibits	High-level walkways & boats
Vehicular Capacity	Limited parking	Parking for buses & cars	Rural parking area	Parking & shuttle services
Landscape	Basic zoo layout	Dense tropical vegetation	Artificially designed ecological zones	Controlled rainforest-like ecosystem

Table 4.7 Legal Considerations

Aspect	Central Zoo, Nepal	Singapore Zoo	Eden Project, UK	Gondwanaland, Germany
Height/FAR	Limited by city regulations	Low-rise with natural integration	Dome height restrictions	35m high self-supporting dome
Animal Welfare	Basic enclosures	Strict welfare laws	No animals	Climate-controlled zones for animal welfare

Table 4.8 Unique Spaces & Special Features

Aspect	Central Zoo, Nepal	Singapore Zoo	Eden Project, UK	Gondwanaland, Germany
Special Spaces	Elephant & rhino enclosures	Orangutan Island, Fragile Forest	The Rainforest & Mediterranean Biomes	Boat ride through rainforest
Technological Features	Basic zoo structures	Hidden barriers, misting systems	Geodesic domes with climate control	ETFE dome for transparency & insulation

Table 4.9 Architectural Expression

Aspect	Central Zoo, Nepal	Singapore Zoo	Eden Project, UK	Gondwanaland, Germany
Volume & Façade	Low-rise buildings	Open-air structures	Large futuristic biomes	Transparent dome
Materials Used	Concrete & metal fencing	Natural materials, wood, stone	ETFE & steel	ETFE membrane, steel framework
Construction Technology	Basic reinforced concrete	Moats & natural barriers	Steel frame with tensile structures	Advanced ETFE construction

Table 4.10 Sustainability Strategies

Aspect	Central Zoo, Nepal	Singapore Zoo	Eden Project, UK	Gondwanaland, Germany
Environmental	Basic drainage & waste mgmt.	Rainwater harvesting, passive cooling	Renewable energy & water recycling	Climate-controlled with natural lighting
Social & Cultural	Local wildlife conservation	Conservation awareness	Botanical education & sustainability focus	Promotes rainforest conservation
Economic	Tourist-driven revenue	Strong revenue from tourism & research	Sustainable business model	Integrated with Leipzig Zoo's eco-tourism

Table 4.11 Universal & Inclusive Design

Aspect	Central Zoo, Nepal	Singapore Zoo	Eden Project, UK	Gondwanaland, Germany
Accessibility	Limited facilities	Wheelchair-friendly, multi-sensory experiences	Wheelchair ramps, inclusive trails	Fully accessible
Inclusivity	Basic provisions	Gender-inclusive restrooms, family areas	Educational programs for all	Universal access design

Table 4.12 Building Services

Aspect	**Central Zoo, Nepal**	**Singapore Zoo**	**Eden Project, UK**	**Gondwanaland, Germany**
HVAC	Basic ventilation	Passive cooling, misting systems	Biome-specific temperature control	Climate-controlled rainforest
Water Systems	Standard supply	Rainwater harvesting	Water recycling systems	Self-sustaining ecosystem
Lighting	Standard lighting	Solar & natural lighting	Natural daylighting strategies	ETFE membrane for daylight

Chapter 5 : Site Analysis

5.1.1. General Introduction of the Site:

Location: Royal Chitwan NP. Baadreni Road, Buffer Zone Forest near the Elephant Breeding Center, Khorsor, Southeast of Bharatpur, bordering Chitwan National Park.

Coordinate: HFJ7+V9, Bharatpur 44200

Ecological Context: Mixed Sal, Kyamuna, Kutmero, Debre-lahara and riverine forests, seasonal streams, and critical wildlife corridors.

Challenges: Illegal logging, human-wildlife conflict, and invasive species.

Approximate Area needed: 30 ha

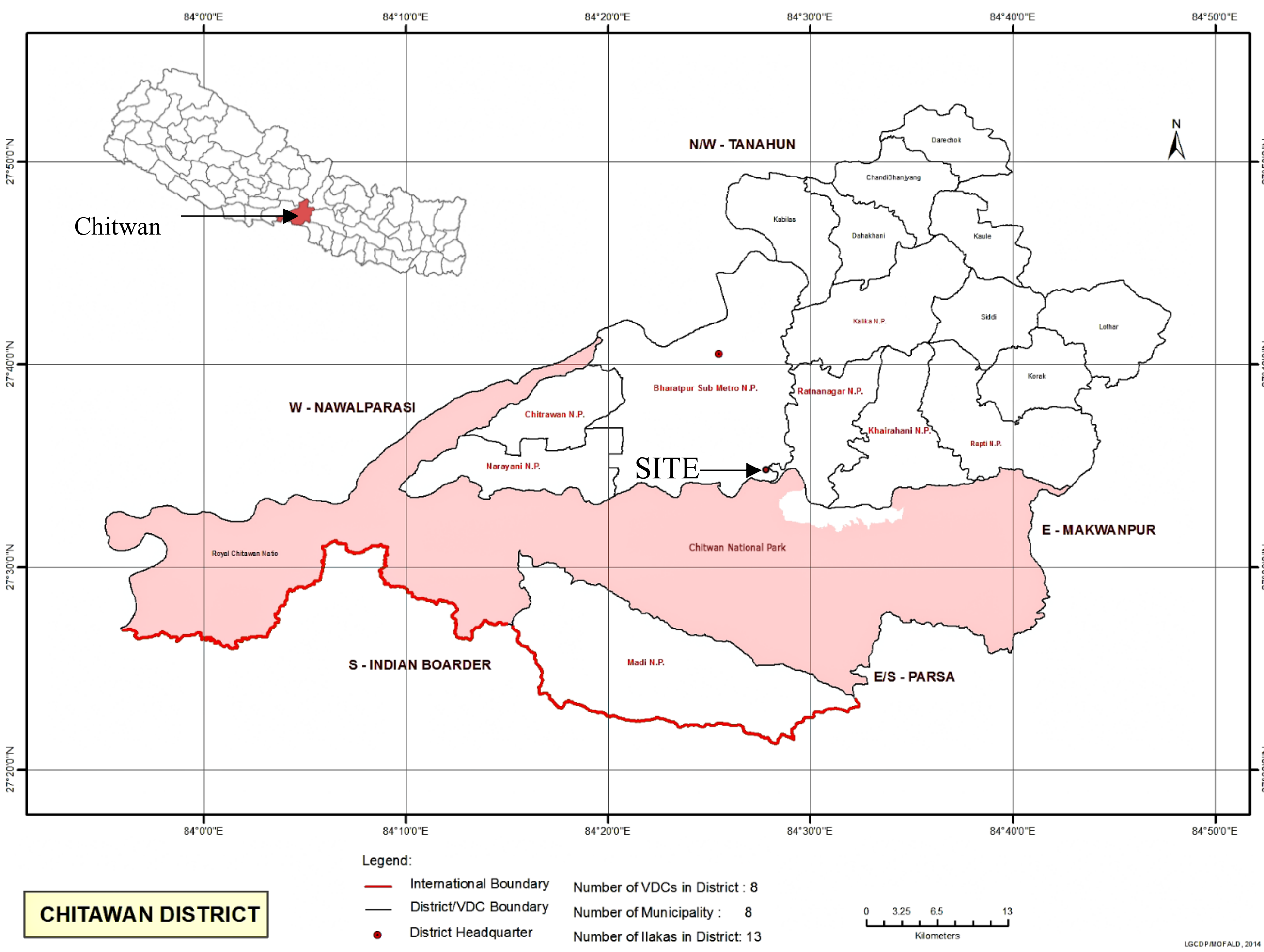


Figure 5.1 Location Map

Source: LGCDP. GIS District Map.

5.1.2. Why elephant breeding center buffer zone forest is the best site option for the project?

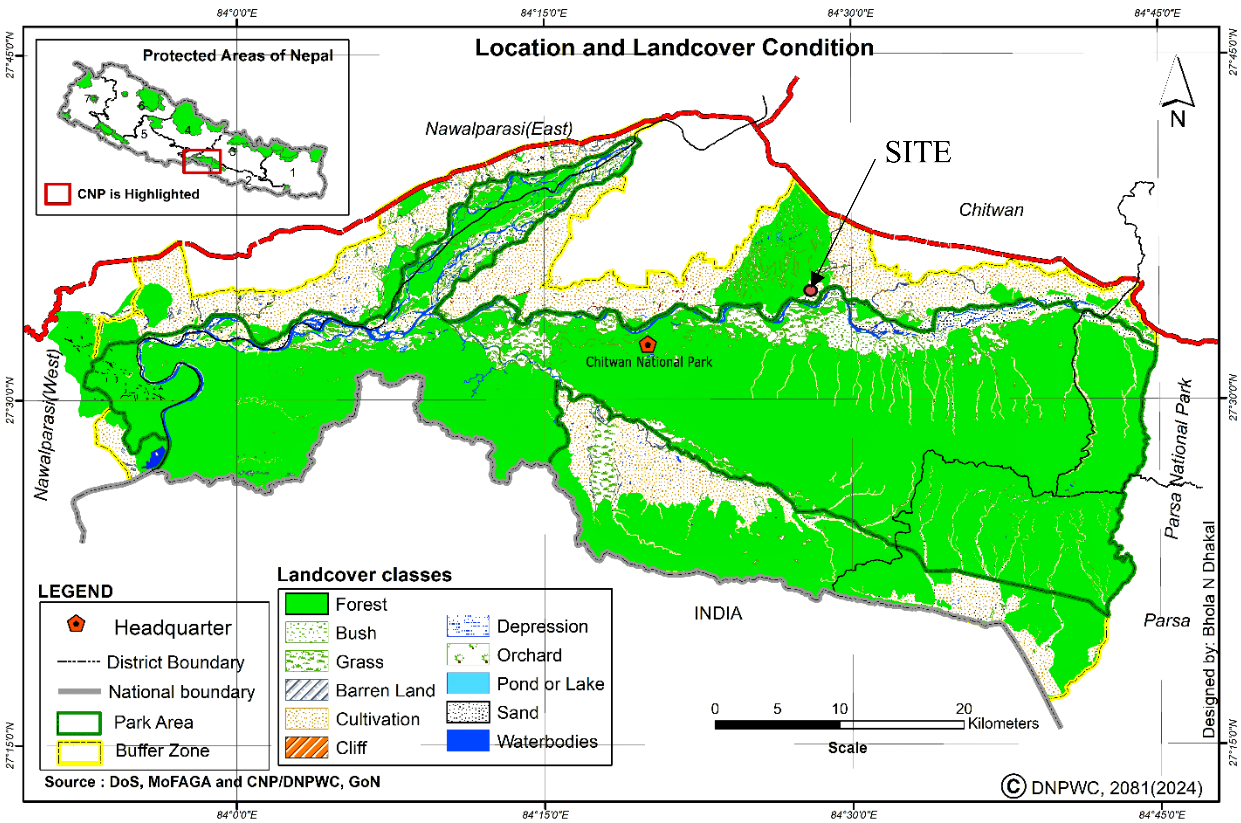


Figure 5.2 Map showing Site being located in the buffer zone of Chitwan National Park and landcover condition around the site

Source: DNPWC. (2081). Chitwan National Park and its Buffer Zone.

Ecological Suitability & Natural Habitat

- Rich Biodiversity – diverse flora and fauna, making it a perfect setting for immersive and naturalistic enclosures for endangered and exotic species.
- Existing Wildlife Presence – elephants, rhinos, tigers, deer, gharials, and birds, aligning well with conservation and rehabilitation efforts.
- Proximity to Chitwan National Park – integrate with the existing conservation strategies of the park, ensuring a sustainable and scientific approach.

Strategic Location & Accessibility

- Good Transport Connectivity
- Potential for Eco-Tourism – The site is already a popular tourist attraction, providing an opportunity to promote eco-tourism, environmental education, and conservation awareness.

Large Land Availability

- Sufficient Space for Different Facilities
- Zoning Flexibility and Future Expansion Possibilities – The project can expand over time, adding new habitats, research initiatives, and visitor experiences as needed.

Conservation & Research Potential

- Elephant Conservation Hub
- Wildlife Rescue & Rehabilitation – The buffer zone forest can serve as an ideal location for rescued and injured animals, as it mimics their natural habitat.

Environmental & Sustainable Benefits

- Natural Climate Control and Low Carbon Footprint – Using existing forests reduces construction impact, promoting sustainable building techniques and eco-friendly infrastructure.
- Water Availability – The nearby Rapti River and groundwater sources

Socio-Economic & Community Impact

- Job Creation for Local Communities – The project can employ veterinarians, conservationists, zookeepers, educators, and hospitality staff, benefiting local livelihoods.
- Education & Awareness
- Eco-Tourism & Sustainable Economy

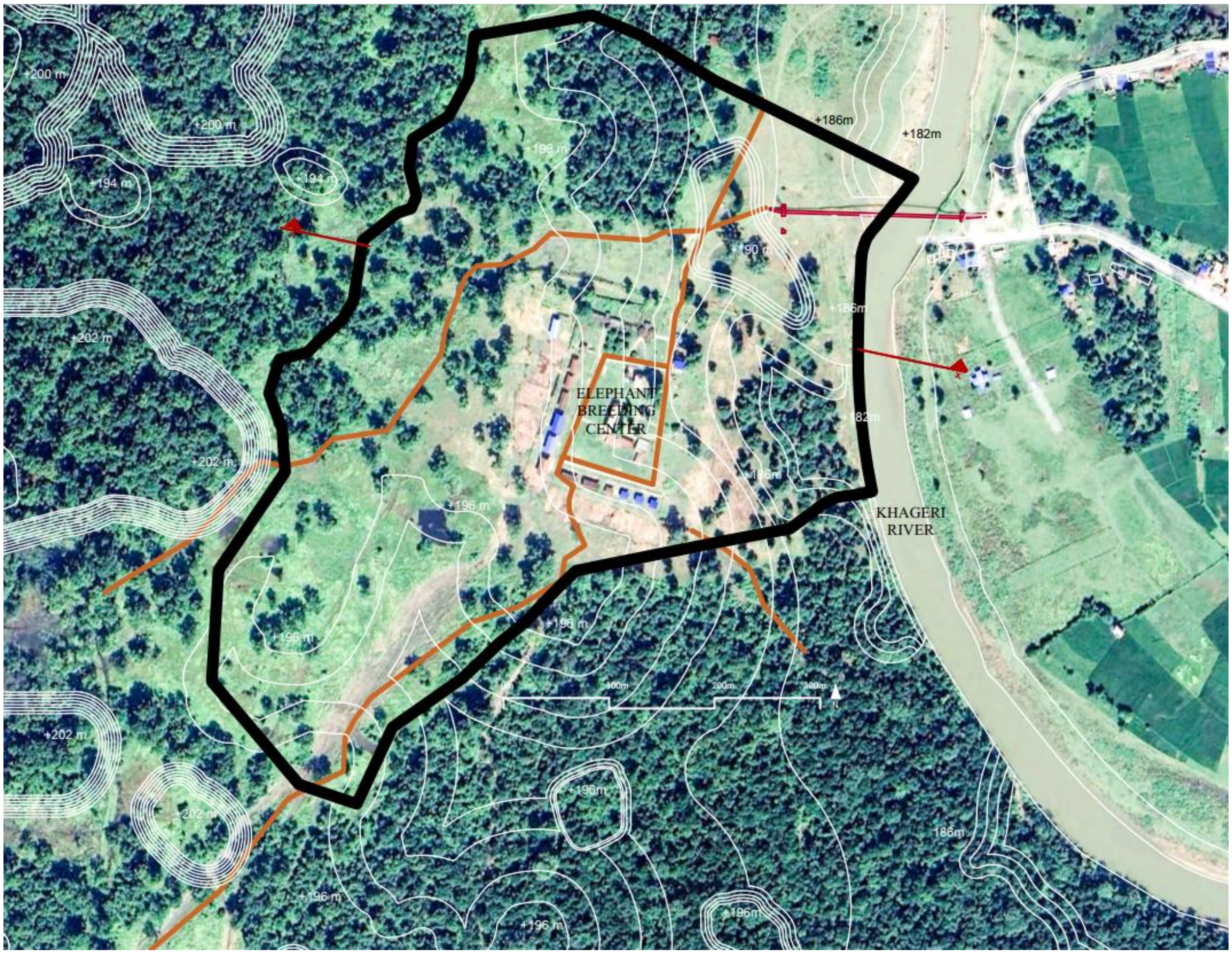


Figure 5.3 Site plot for the project

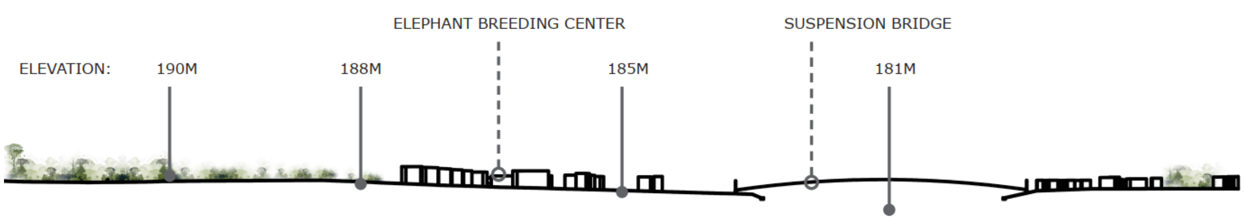


Figure 5.4 Section of site at X-X

5.1.3. Photos desicribing areas surrounding the site

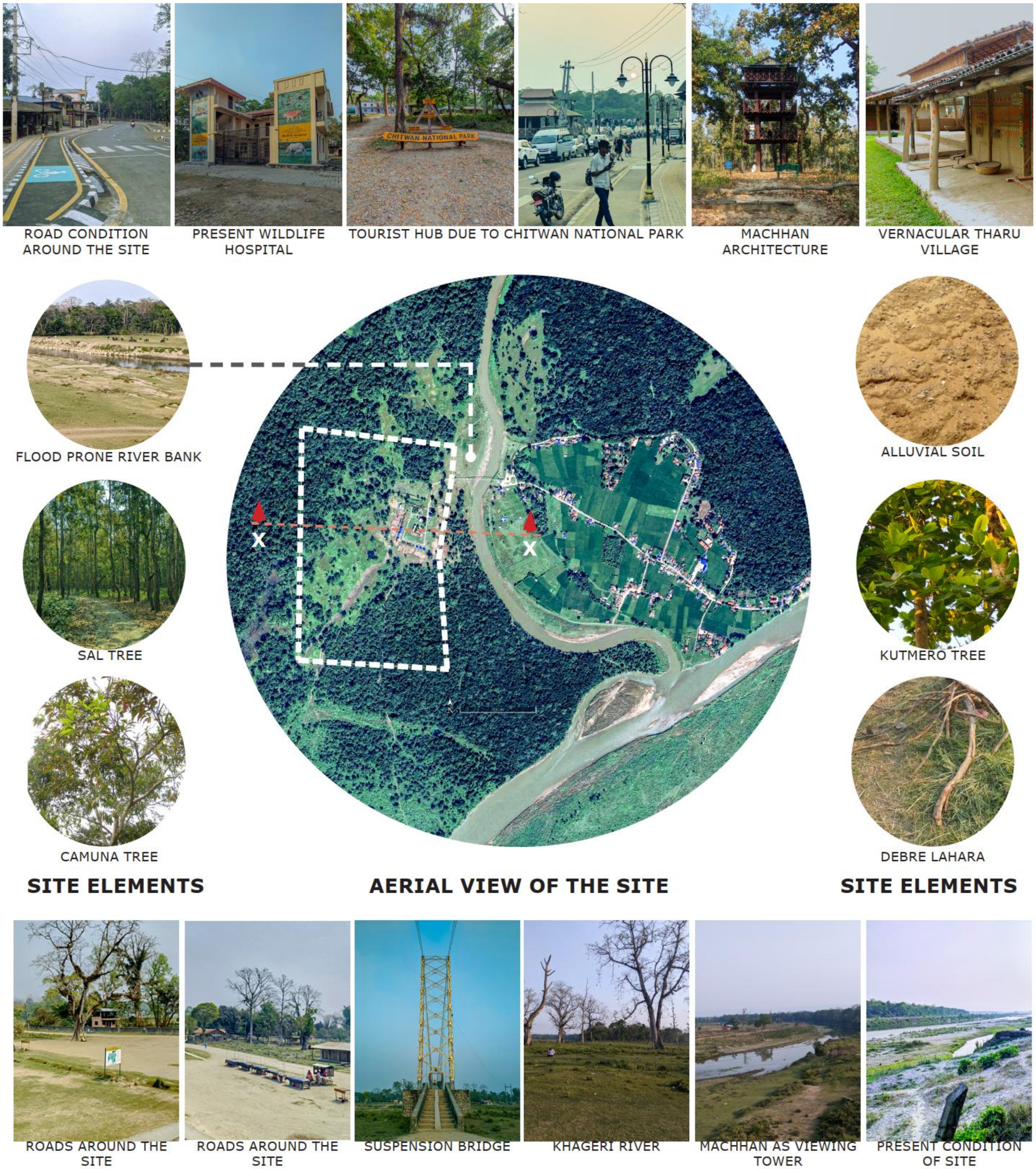


Figure 5.5 Photos describing areas surrounding the site

5.1.4. Phots showing different infrastructures and services available surrounding the site

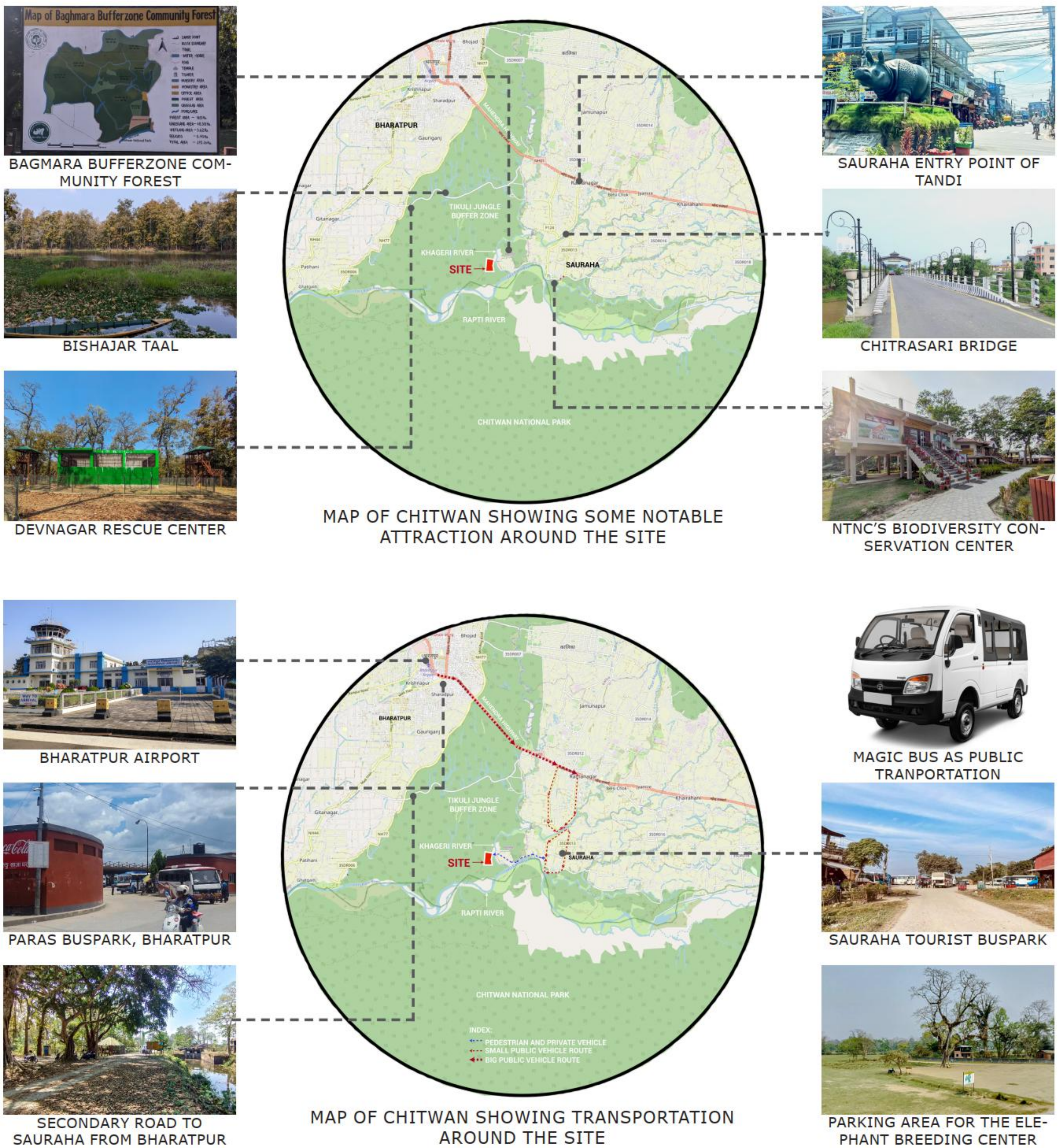


Figure 5.6 Phots showing different infrastructures and services available surrounding the site

5.1.5. Analysis of the Site

Wind Analysis:

- West: for 2.0 months, February 20 to April 19, peak percentage:35%
- South for 6.2 months, from April 19 to October 24, peak percentage: 61%
- North for 3.9 months, from October 24 to February 20, peak percentage:37%

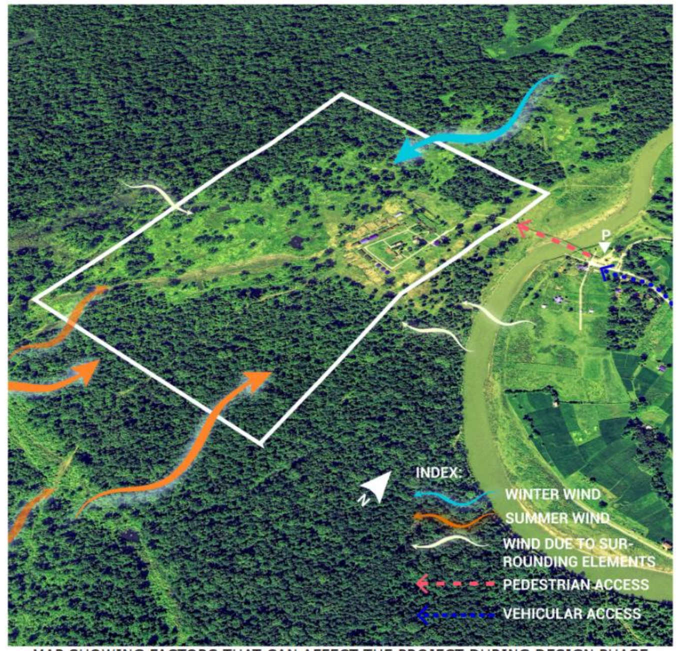


Figure 5.7 Wind flow on the site

Climate & Environmental Conditions:

- 10–38°C, Hot summers, mild winters, and heavy monsoon rains
- ~1500 - 2,000mm annual rainfall; high humidity (~80%)
- High flood risk in monsoon; requires elevated structures and proper drainage

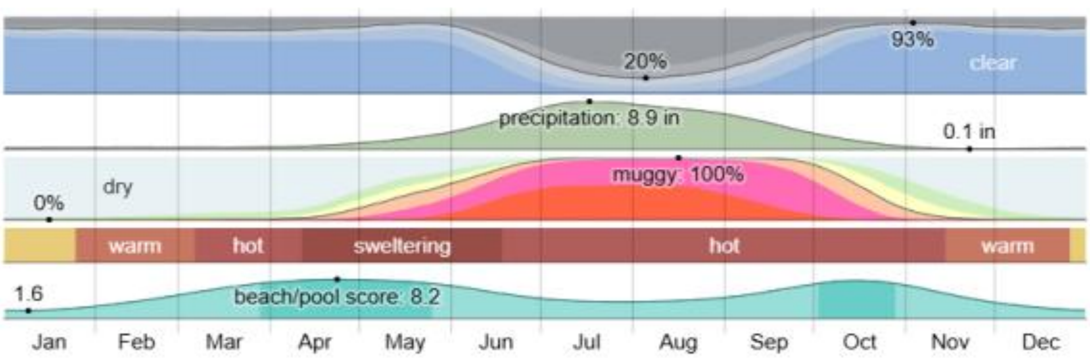


Figure 5.8Chart showing cloud coverage, precipitation, humidity, and best time of year to visit

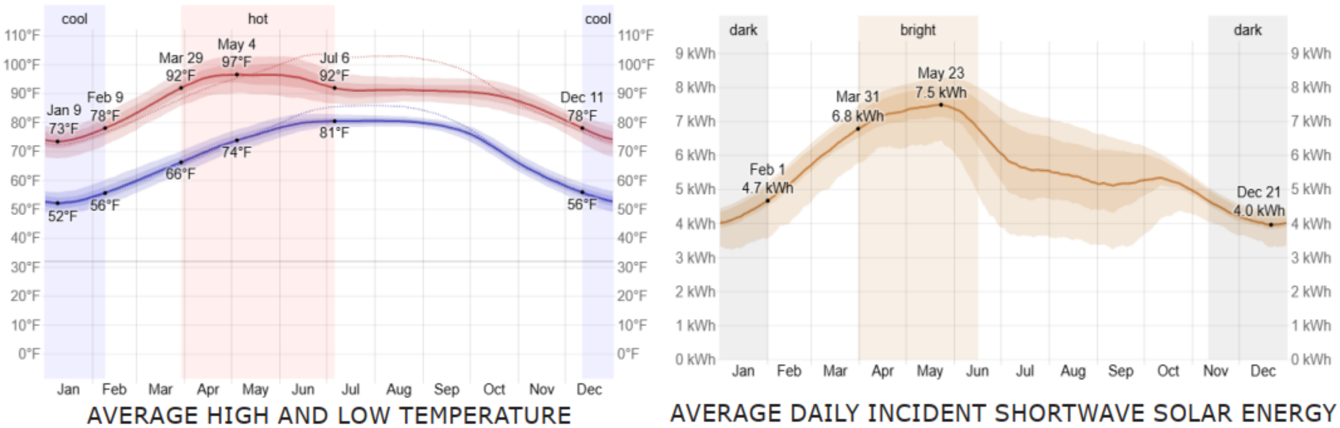


Figure 5.9 Chart showing average temperature and average incident solar energy

Topography & Land Features:

The topographic condition of the site is mostly flat terrain with slight undulations, which makes the zoning and designing of the project easier. Minimal rock formations on the site with mostly alluvial soil and primarily riverbed deposits.

Biodiversity & Existing Wildlife:

Situated on the buffer zone of Chitwan National Park, the site consists of rich biodiversity, including rhinos, deer, sloth bears, and elephants. Though there's a high risk due to wild elephants and rhinos straying into local villages, with occasional tiger attack on the farmers makes the project to prioritize on both animals and visitors safety.

Zoning & Land Use Regulations:

Being situated on the Buffer forest land under DNPWC, permissions are required for modifications or progressing into any type of planning on the site. Also, any projects to be done on the area would be subject to national park and wildlife conservation laws.

Hydrology & Water Resources:

- ~1500 - 2,000mm annual rainfall; high humidity (~80%)

Groundwater available but limited and is the primary source of water at the present condition. Proper management of water will be needed for the project as 100,000lt to 200,000lt of water would be needed for the zoo per day.

Noise & Air Quality:

- Low to moderate; occasional tourism-related noise

Socio-Cultural & Community Aspects:

- Very supportive; project must engage local communities
- High employment potential in eco-tourism, conservation, and education

5.1.6. S.W.O.T Analysis of Site:

Strength

- Rich biodiversity with native flora & fauna
- Existing natural forest ecosystem supports immersive exhibits
- Well-connected by road (near Bharatpur)
- Popular tourist hub (Sauraha nearby)
- Located within a buffer zone, allowing controlled eco-tourism
- Support from conservation bodies (DNPWC, NTNC, WWF)
- Potential for eco-tourism revenue & local employment
- Can support research & education programs

Weakness

- Seasonal flooding and high water table
- Risk of deforestation & habitat degradation if not planned sustainably
- Wildlife movement restrictions may be required

- Can be overcrowded during peak tourism seasons
- Requires government permissions & environmental clearances
- Legal restrictions on large-scale infrastructure within buffer zones
- Need for strong community involvement to prevent conflicts
- Possible resistance from local farmers if land-use changes

Opportunities

- Climate-controlled eco-domes can enhance conservation efforts
- Wildlife corridors can be integrated with sustainable enclosures
- Can attract eco-tourists & research scholars globally
- Opportunity for community-based conservation tourism
- Renewable energy solutions (solar, rainwater harvesting
- Use of low-impact, eco-friendly architecture

Threats

- Climate change impact (floods, heat waves)
- Human-wildlife conflict risks
- Economic dependency on seasonal tourism
- Competition with existing wildlife tourism setups
- Initial construction cost & infrastructure development challenges
- Maintenance & long-term sustainability costs

5.2 Program Formulation:

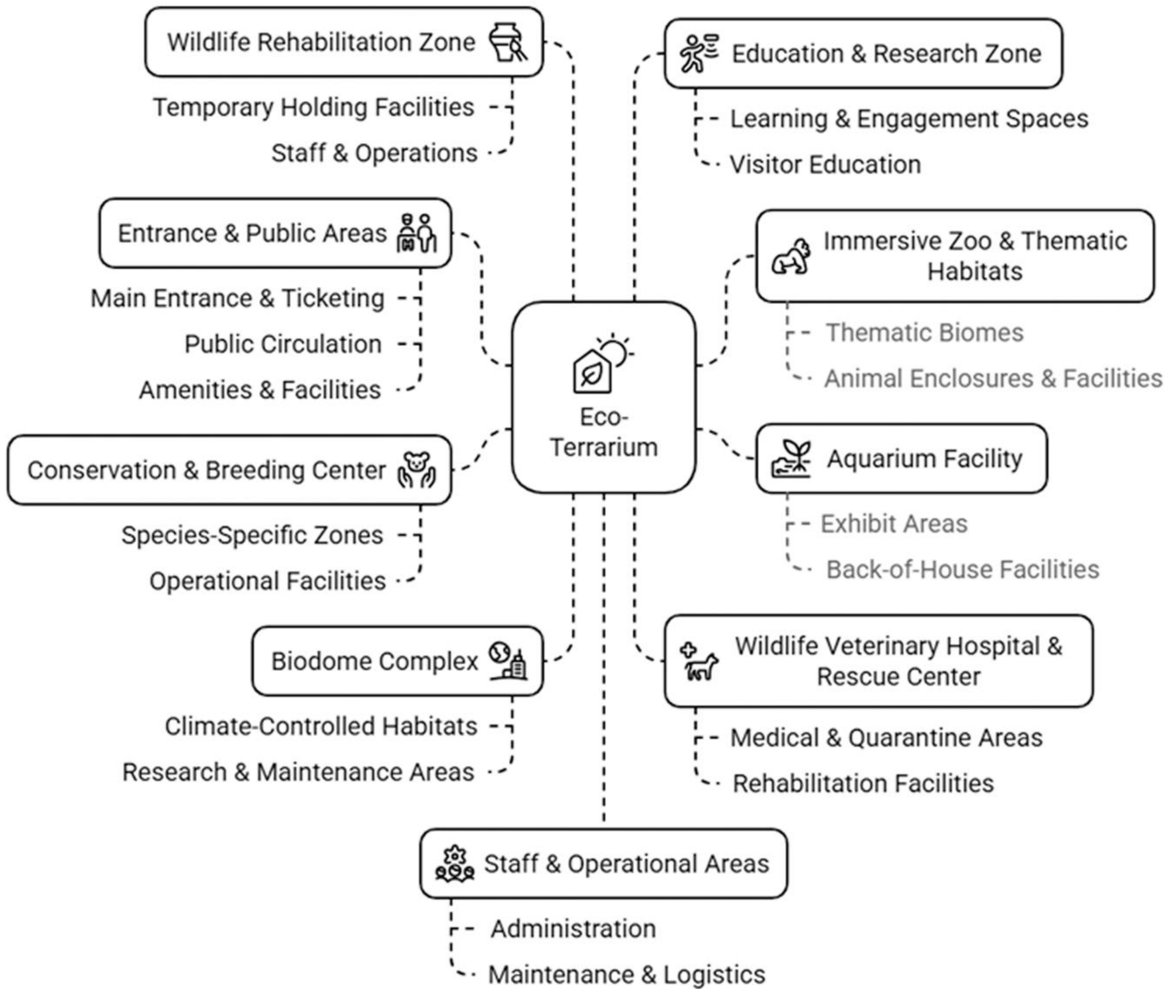


Figure 5.10 Structure and functional areas of the Eco-Terrarium

5.2.1. Minimum Site Area according to different Organization:

1. According to WAZA (World Association of Zoos and Aquariums)

- No fixed minimum site area: Focuses on animal welfare, enclosure design, and species-specific needs rather than overall zoo size.
- Key Requirements:
  a. Enclosures must meet the biological and behavioral needs of animals.
  b. Emphasis on space quality (e.g., enrichment, naturalistic habitats).
  c. Zoos must participate in conservation, education, and research.

2. Indian standards (central zoo authority, cza)

Zoo Category	Minimum Area	Notes
Large Zoo	≥ 50 hectares (123 acres)	For major cities; houses diverse species (e.g., elephants, big cats).
Medium Zoo	25–50 hectares (62–123 acres)	Common in state capitals; focuses on regional biodiversity.
Small Zoo	5–25 hectares (12–62 acres)	Urban or district-level zoos; limited to smaller species (e.g., primates).
Mini Zoo	<5 hectares (12 acres)	Discouraged by CZA; only allowed for specialized facilities (e.g., aviaries).

Key Requirements:

a. New zoos are encouraged to be ≥25 hectares (62 acres).

b. Enclosures must follow CZA's species-specific guidelines (e.g., 2,000 m^2 for an elephant enclosure).

3. AZA (Association of Zoos & Aquariums, U.S.)

- No strict minimum site area: Accreditation focuses on animal care, education, and conservation, not total zoo size.
- Typical Recommendations:
  - Small AZA-accredited zoos: ~4–10 hectares (10–25 acres).
  - Larger zoos: 40+ hectares (100+ acres) for diverse species.
- Key Requirements:
  - Enclosure size based on species needs (e.g., 500 m^2 for a tiger, 1,000 m^2 for an elephant herd).
  - Focus on visitor experience, education, and sustainability.

5.2.2. Animals to be considered for the project classified in different habitats

Table of animal inventory to be considered for the project. The table will provide an idea of the number of animals and area requirements as per various standards

Table 5.1 Animals to be considered for the project are classified in different animal groups

Animal Species	**No. of Animals**	**Paddock Area (sqm)**	**Feeding Cubicles (L×B×H in m)**	**Enclosure Type**	**Barrier Details**	**Total Area (sqm)**
Bengal Tiger	2 (1:1)	1000 + 200	3.0 × 2.75 × 1.8	Moated/open dry-moated	Dry moat, mesh wall, hotwire	1200
Common Leopard	2 (1:1)	500 + 100	2.5 × 2.0 × 1.8	Moated/screened enclosure	Chain link + buffer fencing	600
Clouded Leopard	2 (1:1)	500 + 100	2.5 × 2.0 × 1.8	Screened semi-arboreal	Climb-proof vertical mesh	600
Sloth Bear	2 (1:1)	1000 + 100	2.5 × 2.5 × 1.8	Natural terrain open enclosure	Dry moat, electric wire	1100
Bengal Fox	2 (1:1)	500 + 100	2.5 × 2.0 × 1.5	Natural substrate	Chain link + dig-proof fencing	600
Dhole	4 (1:1)	400 + 100	2.5 × 2.0 × 1.8	Forested paddock	Tall fence + under-barrier	1000
Golden Jackal	4 (1:1)	400 + 100	2.5 × 2.0 × 1.5	Shrubland paddock	Mesh with overhang	1000
Langur	6 (1:1)	500 + 100×2	2.5 × 2.0 × 1.5	Arboreal island/enclosure	Climb-proof vertical mesh + moat	1500
Chevrotains	2 (2:2)	100 + 50	1.5 × 1.2 × 1.2	Thick foliage + shaded area	Small mesh, no top enclosure	712
Lemur	2 (1:1)	500	2.5 × 2.0 × 2.5	Screened/climb-proof	Chain link dome mesh	780

Rhesus Macaque	2 (1:1)	500 + 100×2	2.5 × 2.0 × 2.5	Open arboreal island	Climb-proof mesh + dry moat	780
Macaws	3 (1:3)	80	Aviary: 3×3×6 m	Walk-in aviary	Wire mesh enclosure	400
Great Hornbill	2 (2:2)	80	Aviary: 3×3×6 m	Aviary	Mesh roof and sides	400
Mugger Crocodile	1:1	400 + 150	Basking + shaded den	Wetland + basking island	Deep moat with mesh buffer	550
Gharial	2 (1:1)	400 + 150	Shade den near water	Natural riverine enclosure	Water barrier with fencing	1000
Indian Roller, Parrots, Love Birds, Finches, Java Sparrow, Budgerigars, Cockatoos	20 total (mixed)	300	Aviary nesting (earthen pots)	Large walk-through aviary	Mesh top aviary	300
Crusted Serpent Eagle, White-tailed Eagle, Vultures	4 (1:1)	300	Raised perch areas	Tall aviary	Chain link with high perching	300
Pied Hornbill, Peafowl, Owl	4(1:1)	300	Mixed habitat aviary	Walk-through mixed aviary	Fencing + vertical mesh	300
Pygmy Hog	4 (1:1)	100	2.0 × 1.5 × 1.5	Thick undergrowth paddock	Small mesh wire, dig-proof	712
Jungle Cat	2 (4:2)	500 + 100	2.0 × 1.5 × 1.5	Grassland mimic enclosure	Fencing + canopy mesh	1500
Porcupine	4 (1:1)	100	2.0 × 1.5 × 1.5	Burrow-style dry enclosure	Mesh + moat	800
Chinese Pangolin	4 (4:4)	100	2.0 × 1.5 × 1.5	Enclosure with digging area	Subterranean protection	800

Gecko	4	40	Glass terrarium	Reptile house/glass terrarium	Sealed terrarium enclosure	80
Indian Python	4	80	Reptile terrarium	Glass enclosure with pool	Glass + metal mesh	160
Turtle Species (all types)	~8	80 + 40 each	Shaded pond with bank	Semi-aquatic zone	Aquatic fencing + sand bank	400
Cobra, Krait, Viper	4 each	40 each	Reptile house	Glass terrarium	Escape-proof enclosures	80
Asian Forest Tortoise	6 (1:1)	40	2.0 × 1.5 × 1.5	Dry forest ground paddock	Chain link + burrow-proof	240
Giant Aldabra Tortoise	4(1:1)	200	20 sqm shade shelter	Grassland paddock	Fenced paddock	200
Otters	5 (1:1)	400	Dry den + water pond	Semi-aquatic paddock	Aquatic + climb-proof fencing	1200
Hippopotamus	2 (1:1)	1000	5 × 3 × 2.5 + 200 sqm pool	Aquatic paddock	Water body + strong fencing	2240
Flamingo	15(1:1)	300	Wading pool + nesting area	Walk-through aviary	Mesh roof, shallow water	2800
Spotted Deer, Barking Deer, Four Horned Antelope, Chinkara	2(2:3) each	1500 + 100×6	2.5 × 2.0 × 1.5 per animal	Open paddock	Low fence with visual barriers	2100

5.2.3. Zoning & area breakdown

Table 5.2 Public & Visitor Zone

FACILITY / ROOM	FUNCTION	MINIMUM AREA (M²)	REQUIREMENTS
Entrance Plaza & Reception	Ticketing, visitor info, waiting area	300	• Includes ticketing counters, reception desk, waiting seating, and security checkpoint. • Designed for smooth visitor flow and ADA-compliant access.
Information/Interpretation Center	Interactive displays, VR experiences, museum	500	• Interactive displays, digital kiosks, museum-like exhibits, and briefing rooms. • Flexible layout for temporary exhibitions and workshops.
Public Toilets & Restrooms	Sanitary facilities for visitors	150	Include baby change facilities, accessible stalls, and a hygienic layout.
Cafeteria	Food service area	300	Should accommodate seating, serving counters, and circulation.
Retail/Souvenir Shop	Sales of memorabilia and essentials	200	
Botanical Gardens	Native flora, landscaped walkways, rest zones	20,000	dscaped trails with seating, shade onal signage.
Total Public Zone		~21,450 m² (~2.15 Ha)	Some areas may be interlinked with open walkways

Table 5.3 Aquarium Facility (Within Immersive Zoo)

FACILITY / ROOM	FUNCTION	MINIMUM AREA (M²)	REQUIREMENT
Aquarium Building	Indoor controlled aquatic environment (exotic & native fish)	1,000	ntrolled environments for native and d viewing panels.
Water/Tank Area	Display area for aquatic exhibits	500	• Open water space within the building complex. • For water treatment, temporary holding, and maintenance operations.
Total Aquarium		~1,500 m²	Integrated into the overall aquatic theme

Table 5.4 Biodome Complex

SUBZONE	FUNCTION	MINIMUM AREA (M²)	REQUIREMENT
Tropical Biodome	Controlled rainforest environment for exotic species	20,000	• Climate-controlled environment (temperature ~25–30°C, high humidity). • Integrated visitor pathways and plant nursery.
Total Biodome Complex		35,000 m² (5 Ha)	Bio-domes provide climate control and visitor paths

Table 5.5 Conservation & Breeding Center

FACILITY / ROOM	FUNCTION	MINIMUM AREA (M²)	REQUIREMENT
Breeding Enclosures	For endangered species (e.g., red panda, gharial, vultures)	20,000	• Secure, specialized enclosures for endangered species with isolation zones for breeding.

Hatchery & Nursery	Incubation and early rearing of birds & reptiles	10,000	• Controlled environment for incubation and early rearing (temperature, humidity control).
Research Laboratories	Genetic, behavioral, and ecological studies	10,000	• Labs for genetics, animal behavior, and conservation studies, plus offices and meeting rooms.
Total Conservation Center		40,000 m² (4 Ha)	Integrated research and breeding facility

Table 5.6 **V**eterinary, Rescue & Rehabilitation Complex

SUBZONE	**FUNCTION**	**MINIMUM AREA (M²)**	**REQUIREMENT**
Veterinary Hospital	Diagnosis, surgery, ICU, and treatment rooms	15,000	• Includes consultation rooms, diagnostic imaging (X-ray, ultrasound), operating theater, ICU, and recovery wards.
Quarantine & Isolation Units	Disease control and initial treatment zones	10,000	• Secure, bio-controlled units for treating infectious or injured animals.
Rehabilitation Enclosures	Recovery and reconditioning of rescued animals	15,000	• Naturalistic recovery spaces with minimal human interference.
Total Veterinary & Rescue		40,000 m² (4 Ha)	Fully integrated medical and rescue facilities

Table 5.7 Wildlife Rehabilitation Zone

FACILITY / ROOM	**FUNCTION**	**MINIMUM AREA (M²)**	**REQUIREMENT**
Soft-Release Enclosures	Gradual acclimatization for rewilding animals	25,000	• Gradual acclimatization zones with open space and minimal confinement.

Monitoring & Research Stations	Post-release tracking and ecological monitoring	10,000	• Observation huts, remote monitoring equipment, and control rooms.
Total Rehabilitation Zone		35,000 m² (3 Ha)	Ensures a smooth transition for released animals

Table 5.8 Education & Research Zone

FACILITY / ROOM	FUNCTION	MINIMUM AREA (M²)	REQUIREMENT
Field Research Stations	On-site ecological and behavioral research	15,000	• Dedicated labs and observation points integrated into outdoor areas.
Training Halls & Classrooms	Workshops, lectures, and practical sessions	10,000	• Multi-functional rooms for workshops, lectures, and training sessions.
Library & Archives	Conservation documentation and digital resources	5,000	• Storage for conservation literature and digital media.
Total Education & Research		30,000 m² (3 Ha)	Facilitates conservation education programs

Table 5.3 Camping & Ecotourism Zone

FACILITY / ROOM	FUNCTION	MINIMUM AREA (M²)	NOTES
Researcher & Student Camps	Sustainable eco-camping for researchers and students	20,000	• Designated tent pads with utility hookups and minimal environmental impact.
Eco-Lodges	Nature-based accommodations (treehouses, lodges)	15,000	• Sustainable, low-impact structures with natural ventilation and renewable energy integration.

Guided Safari Trails & Recreational	Visitor pathways and observation decks	15,000	• Campfire areas, outdoor kitchens, shared bathrooms, and shower facilities.
Total Camping & Ecotourism		50,000 m² (5 Ha)	Encourages low-impact tourism and research stays

Table 5.40 Sustainability & Infrastructure Zone

FACILITY / ROOM	FUNCTION	MINIMUM AREA (M²)	REQUIREMENT
Solar & Renewable Energy Installations	Energy generation, smart grid controls	10,000	• Solar panel arrays, wind turbine installations, electrical substations, and control rooms.
Water Management Facilities	Rainwater harvesting, filtration, recycling systems	10,000	• Rainwater harvesting tanks, water filtration systems, sewage treatment, and recycling centers.
Waste Management Facilities	Composting, recycling, sewage treatment systems	10,000	Total for this zone (1.0 Ha)
Total Sustainability Zone		30,000 m² (3 Ha)	Supports overall eco-friendly operations

Table 5.11 Buffer & Future Expansion Zone

FACILITY / ROOM	FUNCTION	MINIMUM AREA (M²)	REQUIREMENT
Ecological Buffer & Wildlife Corridors	Conserves native vegetation, preserves animal migration paths	30,000	• Continuous natural vegetation to support wildlife movement and serve as a safety margin for future expansion.

5.2.4. Determine Projected Annual Visitors

Based on location, accessibility, and similar projects in Nepal (e.g., Chitwan National Park, Central Zoo Kathmandu), we estimate:

- Peak Season (6 months): 3,000–5,000 visitors per day
- Off-Season (6 months): 5,00–1,500 visitors per day
- Total Annual Visitors Estimate: 800,000 – 1.2 million visitors

Calculating Base Ticket Price;

To break even, the minimum ticket price should be:

To break even, the minimum ticket price should be:

$$\text{Base Ticket Price} = \frac{\text{Total Annual Cost}}{\text{Estimated Annual Visitors}}$$

For example, if **Total Annual Cost** = NPR **200 million**, and estimated visitors = **1 million**,

$$\text{Base Ticket Price} = \frac{200,000,000}{1,000,000} = NPR200$$

Market Comparison & Pricing levels;

Table 5.5 Compare with existing wildlife attractions:

Attraction	**Ticket Price (NPR)**
Central Zoo, Kathmandu	NPR 150 - 750
Chitwan National Park Entry	NPR 200 - 2,000
Elephant Breeding Center	NPR 100 - 500

Table 5.6 Approx. Ticket pricing:

Category	**Ticket Price (NPR)**
Nepalese Citizens (Adults)	NPR 300 - 500
Nepalese Citizens (Students)	NPR 150 - 250

SAARC Nationals	NPR 800 - 1,500
Foreign Tourists	NPR 1,500 - 2,500
Children (Below 5 years)	Free

5.2.5. Building bye-laws:

The site falls on the area of Bharatpur, so will follow building bye-laws prepared by Bharatpur Municipality.

1. Setback according to the building height:

Table 5.6 Setback according to the building height

BUILDING HEIGHT	TYPE OF BUILDING	
	PUBLIC	PRIVATE
Up to 10m	1.5m	1.5m
10m – 17 m	3m	2m
17m – 24m	4m	3m
24m – 31m	5m	4m
31m – 38m	6m	5m
38m – 45m	7m	6m
45m – 52m	8m	7m

2. Ground coverage:
- for 80m long road= 90% of the site area
- for 250m long road= 70% of the site area
- for 250m+ long road= 60% of the site area

3. Floor area ratio:

Table 5.7 Floor Area Ratio

BUILDING TYPE	COMMERCIAL	RESIDENTIAL	MIXED-USE	INSTITUTIONAL
	3.5	3	3	2.5

4. According to Chitwan National Park:
- should be sustainable and should not affect the habitat of the site
- shouldn't harm the wild animals around the site
- should help ease the ecosystem and habitat around the site

5.2.6. Zoo Staff Calculation:

The project will have 515 animals, to maintain and care for the animals and their habitats large number of staffs are needed. If numbers of staff is large then we will need to calculate areas where the staffs will allocate and area they would need for work and accommodation. The calculation will be done on the basis of the field of work.

1. Animal Care Staff (Zookeepers)
- Standard: 1 keeper per 15–20 animals (CZA)

Assume 1 keeper per 17 animals
So 515 ÷ 17 = ~30.3 ≈ 30 keepers

2. Veterinary & Research Staff
- Standard:

1 vet per 300–500 animals (CZA + WAZA)

1 vet assistant per vet

So, 2 veterinarians, 2 veterinary assistants, 1 pathology/lab technician 1 research coordinator

Total: 6

3. Maintenance & Support Staff

Includes: Groundskeepers, Cleaners, Plumbing & electrical maintenance, Landscaping

- Standard: 1 per 5 ha or 1 per 3000–5000 m^2 built area

30 ha = 300,000 m^2

So ~12–15 workers (general maintenance, janitors, technicians)

Total: 15

4. Administrative & Management

Includes: Director/Manager, HR, finance, accounts, Clerical and IT staff

- Standard: 1 admin per 25–30 total staff

Estimate ~90–100 total staff
So, ~3–5 admin + 2–3 managerial posts

Total: 6–8

5. Visitor Services

Includes: Ticket counter, Information/help desk, Guides/docents, Souvenir shop

- Standard: 1 per 300–500 visitors (adjusted for daily average)

Peak 5,000 visitors/day = 10–15 frontline staff

Add 5 guides/interpreters

Total: 15–20

6. Security Personnel

- Standard: 1 per 2–3 ha or per 300–500 visitors (WAZA/CZA)

So, 30 ha → ~10–12 guards

Plus 3 night shift guards

Total: 12–15

7. Education & Research Personnel

Includes: Wildlife educators, School liaison staff, Conservation outreach

Based on 5 immersive exhibit zones and educational wing would be 5–6 educators

Total: 5–6

8. Aquarium

- 3 Aquarists, 1 Aquarium Maintenance (LSS tech), 1 Veterinary Support (aquatics), 1 Aquarium Education Staff and 2 Aquarium Public Guide/Desk

Total:10

Total number of staff for the project will be about 116 staffs.

Accommodation Requirement for the Staff: Providing housing for ~40–50% of staff (especially essential, night shift, rural postings), that would be 55 staff members

Chapter 6 : Concept and Design Development

6.1. Understanding The Site

For the project, the structure should seamlessly blend with the surroundings. For that, sustainable and local materials are needed. Also, the site is plain and to create habitats for different animals of Nepal, structures can be used to make terrains and also reintroduce the deforested vegetation. But also conserve and preserve the existing vegetation.

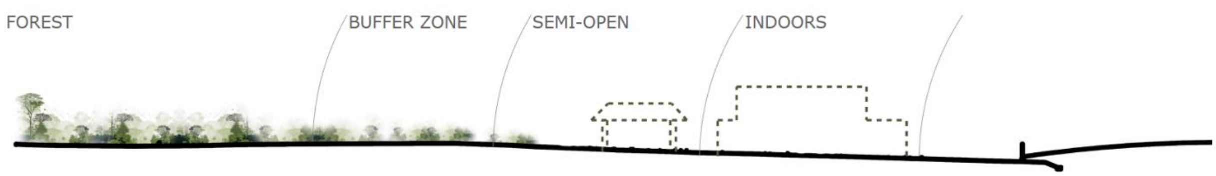


Figure 6.2 Planning of the structures in response to the existing vegetation

For that, planning the buildings on the open spaces and following the access and pathways in the existing site will help in lessen the disturbance on the site.

Figure 6.1 Local architecture of Sauraha

Site being on Terai Region of Nepal, Chitwan experiences hot temperature and high humidity, leading to uncomfortable environment of the people. So for the project, we can incorporate vernacular architecture of the place. Mostly Tharu people can be see, and high influence of their architecture can be seen on the area. Tharu architecture include breathable envelopes; mud wall with wattle and daub, bamboo reinforcements and structures, which can lessen the budget of the project as well as helps to make the project sustainable. Eco-terrarium concept would explain putting multiple species of animals in an enclosed space, recreating a self-sustaining habitat, but for the project, it would be difficult to maintain self-sustaining ecosystem, so it would only replicate the eco-system but maintained by humans to conserve and preserve the flora and fauna.

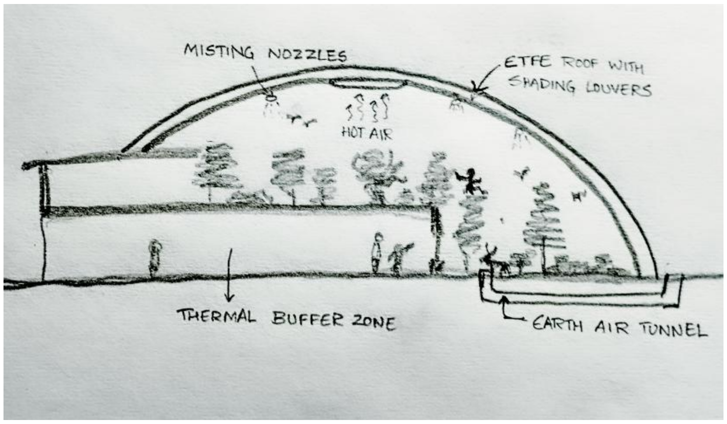


Figure 6.3 Working mechanism of a biodome

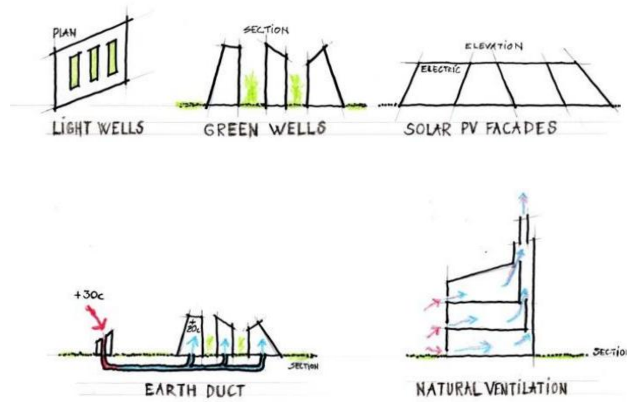


Figure 6.4 Strategies for passive energy

6.2. Concept Development

There are many programs on the project, and it is especially important to plan the flow and circulation of the visitors and staffs for smooth running and operation of the Zoo. Visitors need proper management system, since site for the project is 50ha so, it would take many hours to complete the exhibits so there should differently programs with respect to the packaging per price of tickets. So, with the planning of circulation flow, two different types of programs can be formed;

i. Only biodomes and thematic habitats
ii. Breeding Centers with Educational Blocks

For the Planning, Aquarium would be taken as the point of reference. Aquarium would be at the center from where people would be directed to different thematic habitats. The concept came about with the context of site, as there are presence of many huge trees, which can not be cut down, so with reference to open ground on the site, pathways are formed and designating specific areas of thematic habitat exhibits.

Also, elevated viewing pathways or view towers would be very important for the project so, we can incorporate local viewing towers, Machan, which has earned architectural and historical importance in Chitwan. For incorporating it into the design, we need to bring out some concept on it.

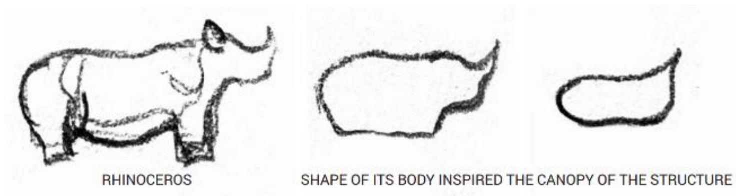


Figure 6.6 Concept development for Machan

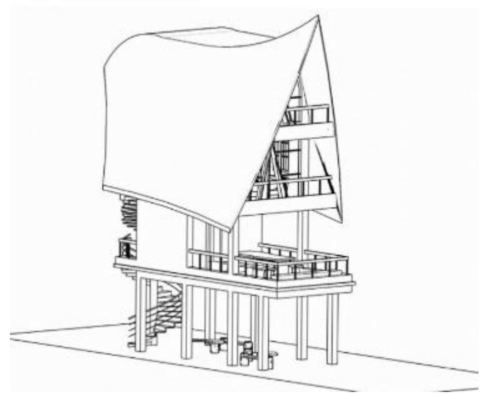


Figure 6.5 Imagined View Tower

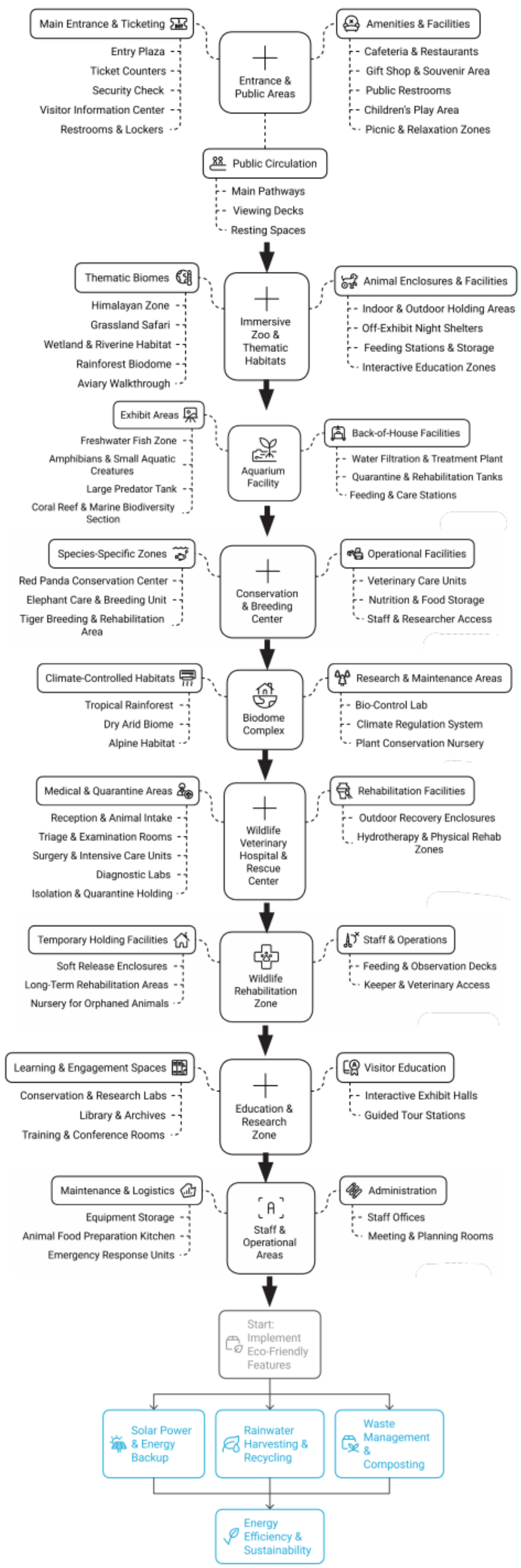


Figure 0.7 Circulation Flow in the Eco-Terrarium

Conclusion

The Eco-terrarium zoo in Nepal's Terai region would represent a transformative approach to zoological design - one that harmonizes ecology, animal welfare, sustainability, and recreation. This zoo will serve not only as a sanctuary for endangered and native species, but also as a center for education, research, and conservation. Its carefully planned zoning of habitats, strategic integration of native flora and fauna, and the use of sustainable support systems (such as renewable energy, water recycling, and closed-loop waste management) demonstrate a commitment to environmental stewardship.

Ultimately, this project is not just about showcasing animals, it's about showcasing the delicate balance of life, inspiring sustainable coexistence, and empowering future generations to cherish and protect the natural world.

Reference

Bahne, R. (2015). *Ethics and code of conduct in zoo management*.

EAZA, T. (2013). *The modern zoo:* foundations for management and development.

Grimshaw, (2001). The Eden Project: The Biomes / Grimshaw. https://grimshaw.global/projects/culture-and-exhibition/the-eden-project-the-biomes/

Gupta, B. K. (2006). *Master Planning of Zoos Training Programme.* ZOO'S PRINT.

Henchion Reuter Architects, (2011). Tropical Biome, Zoo Leipzig / Henchion Reuter Architects. https://www.henchion-reuter.com/projects/gondwanaland-zoo-leipzig

LGCDP. GIS District Map.

http://lgcdp.gov.np/GIS_district?page=3

Mehta, R., & Singh, D. N. (2018). *Design Guidelines for Zoos. Central Zoo Authority*.

Michael Graetz, (1995). A Study of Zoo Exhibit Design with Reference to Selected Exhibits in Singapore Zoological Gardens. https://designforlife.com.sg/thesis/1summary.html

Neufert, E., & Neufert, P. (2012). *Architects' data* (4th ed.). Wiley-Blackwell.

Obermeyer, (2011). Gondwanaland tropical experience world / Henchion Reuter Architects. https://www.obermeyer-group.com/en/references/detail/gondwanaland-tropical-experience-world/

P.C. Tyagi, Indian Zoo Master Plan for Wildlife Institute of India. https://www.slideshare.net/pradeepdey8/zoo-master-planppt

Pickard, Q. (Ed.). (2002). *The architects' handbook*. Blackwell Science.

Ripple, K. J., Sandhaus, E. A., Brown, M. E., & Grow, S. (2021). Increasing AZA-accredited zoo and aquarium engagement in conservation. *Frontiers in Environmental Science*, *9*, 594333.

Yanez, L., Collados, G., & Harrison, B. (2007). Visitor circulation in zoos. *ZOO'S PRINT*, *22*(2), 7-9. https://zoolex.org/media/uploads/2018/07/30/collados_visitor_circulation.pdf

Yee, M. (2021). The City as Zoo: Seeking Coexistence Through Architecture.

Annex