



नेपाल सरकार  
भौतिक पूर्वाधार तथा यातायात मन्त्रालय  
**सडक विभाग**  
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फोन नं. ५००५५२९  
हाल: पाटन, ललितपुर  
ई-मेल: gesunit@dor.gov.np  
वेब साइट: www.dor.gov.np

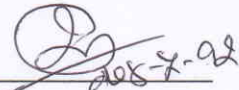
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श्री सबै सडक कार्यालय हरू,

विषय: नेपालको लागी तैयार गरिएको *Guidelines for Construction of Eco-friendly Linear Infrastructures* मा राय सुझाव बारे

उपरोक्त सम्बन्धमा यसै साथ संलग्न नेपालको लागी तैयार गरिएको *Guidelines for Construction of Eco-friendly Linear Infrastructures* मा के कस्ता प्राबधान राखेमा उपयोगी तथा जंगली जनावर मैत्री सडक निर्माण कार्य प्रभावकारी बनाउन सकिन्छ सो बारे अगामी आश्वीन १५ भित्र राय सुझाव यस भु वातावरण तथा सामाजिक शाखामा उपालब्ध गराईदिनुहुन अनुरोध गरिन्छ ।

  
(शिव राज अधिकारी)  
**शिव राज अधिकारी**  
इकाई प्रमुख/सि.डि.ई.  
भू-वातावरण तथा सामाजिक शाखा

*Guidelines  
for  
Construction  
of  
Eco-friendly  
Linear Infrastructures*



## FOREWORD

Overground linear infrastructures create suites of concerns to conservation organizations and wildlife conservationists who seek to ameliorate the impacts of the infrastructures as these divide wildlife habitats and hydrological regimes of the landscapes. The effects of linear infrastructures on wildlife populations, dispersal and genetic issues have been creating concerns. For example, the roads, one of the major linear structures, affect wildlife in numerous ways, from habitat loss and fragmentations, to barriers to movements, and cause of their mortality.

Wildlife crossing structures are intended to establish habitats connectivity, facilitate movements, keep maintaining genetics and populations of wildlife and loss of lives due to collisions and other reasons. So, the conservation value of wildlife crossing structures, and adequate mitigation measures are gaining attention slowly worldwide. Yet, there is limited knowledge and technical guidance on planning, designing and construction of such mitigation measures.

To meet this requirement, particular of Nepal and south Asia region, WWF Nepal has worked to prepared these guidelines for construction of wildlife friendly sustainable linear infrastructure with focus on construction of wildlife friendly passes and related structures. The guidelines are the first endeavor of the process, and so needs further improvements on the subject along with evaluating performance their expected outcomes. Yet, it is expected that this will provide a quick reference for planning, designing and construction of wildlife friendly linear infrastructure.

## ACKNOWLEDGEMENTS

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## Acronyms and Abbreviations

ADT	Average Daily Traffic
BBOP	Business and Biodiversity Offsets Program
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on Migratory Species
CNI	Confederation of Nepalese Industries
CoP	Conference of the Parties
DBH	Diameter at Breast Height
DoLIDAR	Department of Local Infrastructure Development and Agricultural Road
DoR	Department of Roads
DNPWC	Department of National Parks and Wildlife Conservation
EIA	Environmental Impact Assessment
GoN	Government of Nepal
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature and Natural Resources
MoFSC	Ministry of Forests and Soil Conservation
NBSAP	National Biodiversity Strategy and Action Plan
NPWC Act	National Parks and Wildlife Conservation Act
PCU	Passenger Car Unit
RoW	Right of Way
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHC	World Heritage Convention
WWF Nepal	World Wildlife Fund Nepal

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# CHAPTER ONE

## CHAPTER ONE

### INTRODUCTION

#### 1.0 Linear infrastructure and its effects on wildlife

Adequate Infrastructure works as the backbone for a prosperous nation by provide service facilities to maintain productive activities and vibrant economy of a nation. It has direct influence on environment, ecology and overall wellbeing of human being. The present day need is to design, build and operate sustainable infrastructure that enhance the existing social, economic and ecological states and processes and thus help sustaining and promoting the functionality of natural systems. The infrastructure build today should not only meet today's need but shape and nurture future ecological processes.

Broadly speaking, infrastructure can be of two types – linear and spatial or nonlinear. Linear infrastructures are those civil engineering works or their components with linear geometry such as roads, railways, pipelines, high voltage lines or similar structural work or work components with significantly more in length than width implying border line effect, whereas nonlinear or spatial infrastructures or their components are the ones that do not follow the linear pattern but proceed in space in a geometric nonlinearity pattern such as buildings and water reservoirs.

Linear infrastructures are essential part of the development, providing vital needs of transportation, irrigation, drainage, communication, electricity, etc. However, when these infrastructures development activities extend through areas of environmentally and ecologically importance, these carries severe multifaceted ecological, environmental, social and cultural negative impacts along with the beneficial fruits of developments, and often the negative impacts might overweigh the beneficial fruits. So, the linear infrastructure extension or development should be done considering the values and impacts to the natural areas and their ecosystem services. The challenge is to balance the developmental benefits and conserving ecological services and have the ecological benefits as well.

As far as practicable, attempt should be to avoid the natural areas or habitat while developing linear infrastructure.





**Figure 1.1:** Increased human activities due to infrastructures through natural areas

If the linear infrastructure could not be avoided the natural areas, one or more of the following approaches can be adopted depending on the site and other boundary conditions to get the benefits of the linear infrastructures with minimum ill-effects on the environmental or ecological system:

minimize utilization of critical areas

avoid core areas

detour the alignment

use protective barriers

use underpasses/over passes

Some of the obvious negative-impact of the linear infrastructures on wildlife habitat and their movements are:

barrier effect due to raised embankments, noise and light pollution,

kills and injuries of wildlife due to change of alignment, raised embankment, change in slope and other features along the path of their movement,

change of land profile including changes in existing eco-services

habitat reduction, change in forest cover or natural resources and fragmentation

edge effects and increased human activities.

Often, it may create permanent fragmentation of prime habitats and obstruct movements or seasonal migrations of wildlife. Some linear structures such as irrigation canals often reduce and fragment habitats and cause animal trapping and drowning in the canals; the electricity high tension lines cause forest fires,

electrocution, obstacles to the birds, and climbing animals. The severity of these effects depends on a number of factors including the type of structure, traffic volume, speed and the ecological characteristics of a given species.

## 1.2 Scope of guidelines for construction of eco-friendly linear infrastructure

It has been recognized that there exists pressing need of information on best practices of construction, maintenance and mitigation of wildlife friendly infrastructure. These guidelines are to meet, though partially, the need for standards for improvements in design, construction, maintenance and mitigation processes and practices of construction of wildlife friendly structures. Indeed, efficient and effective, use of the guidelines yield not only intended wildlife friendly structures but also produce financial, environmental and ecological benefits. The specific objective of this guideline is to provide with a compendium of best practices, designs, drawings with basic technical guidance, procedures and parameters for integrating wildlife friendly elements into conceptualizing, pre-construction, designing, construction, operations, maintenance or mitigation of wildlife friendly structure. In this way, it is expected to provide reference and guidance to engineers and planners and the users largely to understand basic design principles, data, standards and specifications for linear structure and help design and construct wildlife friendly sustainable linear infrastructures in general conditions along with some information on behaviors of wildlife. It is not meant to replace or substitute the work of environment impact analyses or similar studies that are generally carried out inherently for projects in ecologically sensitive areas.

## CHAPTER 2

### CHAPTER 2

## Linear Infrastructure

### 2.1 Types of linear infrastructures and their impacts

Of the various types of structures, linear infrastructures are the key driver of anthropogenic influence on the natural system, environment and ecology affecting the movement, population growth and structure of wildlife species unless timely adequate and sustainable measures are taken to mitigate or avoid the negative influences these drivers. Each type of the structure has particular effects, and some do have common effects as well. The land use pattern, existing habitat near and around the infrastructure, type of infrastructure, human activities and settlements near and around the habitats, traffics on the road, etc. have effects on wildlife's living and movements. Continual forest loss not only fragment habitats, it might change the watershed altering the river system and drainage pattern but also can be the cause of floods and landslides. Changes in land use patterns and increased erosions invite erroneous and unpredictable weather patterns. Increased traffic speed and volume in the road and railways cause noise and light pollution leading to increased kills and accidents of wildlife. Irrigation canals fragment and reduce habitats of wildlife whereas electric high tension lines might obstruct birds, crawling and climbing animals. These often are cause of forest fires and their electrocution. Indeed, obstruction to or change in pattern of environmental and eco-services leads manifold direct, indirect and rippled consequences. Increased human activities including encroachments of the habitats are to add to aggravate the situation. Linear infrastructure should be sustainable to our natural environment, create and maintain the symbiosis of coexistence of human being, wildlife and nature with productive harmony and manageable by our resources.

Five of the major types of linear infrastructures- roads, railways, transmission lines and irrigation canals and their influences on a country's overall development and biodiversity have been briefed below.

#### 2.1.1 Roads

Roads are keys of transport infrastructure. They are critical in enabling and securing sustainable economic goal. Roads not only provide accessibility to the world outside your place but contribute to the environment, safety, economy, integration and social inclusion in various ways. In short, roads play the most important role for the overall development of a country. But, unless taken rightly, its construction and use can have detrimental effects to the nature leading to its loss, conversion, and disturbance. It also may cause degradation, fragmentation and habitat loss, barrier to wildlife movement, spread of alien species, and pollution. It may cause accidents injuring or killing native wildlife species (plants and animals).

Also, it may change the topography (slopes and drainage/hydrological modification) and trigger landslide and soil erosion (mainly due to increasing slope and concentrating drainage towards valley), environmental contamination and increase human activities (colonization induced nuisances, pollutions-noise, exhaust, temperature, and wastes).

Highways passing through forests take a huge amount of area as its right of way. This along with the surface material, noise, air pollution, vibration, artificial light due to the traffic and human activities including encroachment and wildlife trade, wildlife mortality and injury due to collision add to natural habitation fragmentation and corridor restriction directly and indirectly. It facilitates spread of alien species. In the plain formation, levels of roads are generally raised which changes the sheet flow (i.e. shallow-depth, slow-velocity flow) with hydrological impacts and dries the downstream areas with concentration of cross-drainage that floods at certain points in the sloped terrains. This condition might help habitat sustainability, shape and preserve the landscape but often cause problems to wildlife around due to the increased slope along and near the roadside.

#### *2.1.2 Railways*

Railways have fundamentally the same effects as that of roads on ecology, geology, and wildlife movements. Bird collisions due to overhead electrical lines are more common in the case of railways. Moreover, rail locomotives produce louder noise. They are larger and heavier and take longer to deaccelerate and stop at within a short sight distance resulting in gruesome mortality of wildlife in case of collision.

#### *2.1.3 Irrigation Canals*

An irrigation canal is another important linear infrastructure. It enables rapid agricultural, industrial and settlement development. However, it may cause a huge negative impacts - change in landscape, land use and water use dramatically alter surface and underground hydrology and ecology of the catchment in general.

Like highways, canals also cause habitat fragmentation and decrease of connectivity. Hydraulic regime including river morphology change, localized landslides, alien species invasion, increased human activities at the hinterland affect biological diversity, and animal migration. These create a barrier effects as do the highways. Often these are the cause of wildlife mortality. They are at serious risk of falling and drowning in irrigation canals for various reasons such as while moving carelessly around their home ranges or entering into the canals for drinking water and unable to exit by climbing the inside slope back. Sometimes, the service roads along the canals might also affect the wildlife movement. Drainage and canal substantially alter the hydrology of the region as the natural flow pattern might get interrupted. Ecological alteration might occur due to disruption of sheet flow. Canals can act decrease connectivity at the local scale. As barriers, they limit and redirect surface water flow and limit the movements of species, energy, and ecosystem processes. Canals can enhance exchange of surface water and groundwater and facilitate the spread of nutrients, pollutants, and non-native species. In addition, canals fragment and

compartmentalize the landscape which may degrade the ecosystem. Also, the excavation of canals through the permeable aquifer increases groundwater-surface water interactions, which may damage sensitive biological communities.

#### *2.1.4 Overhead Power Lines (Transmission Lines)*

It goes without saying that electrical energy which is transmitted through an overhead power line, a linear structure, over long distances has become fundamental requirements to maintain quality life today. It is a key for growth and prosperity of modern economy. Albeit, it has a lot of detrimental effects to the nature leading to its loss (mostly in the tower site), accidents (mainly with electrified wire), or disturbance. It also may cause fire and electrocution accidents injuring or killing wildlife (plants, birds, climbers, and large animals<sup>1</sup>) as the insulation to the conductors are provided by air only to reduce the cost of transmission. Trees and plants are cleared off or pruned away over wide area along the transmission lines as the right of way for the transmission lines. Human activities during construction and periodic maintenance may impact on ecosystem. Above all, the effects of electromagnetic fields are unavoidable and will remain as the residual impact. It obstructs birds and their flight path.

#### *2.1.5 Ropeways/ Gondola Lifts/ Aerial Tramways*

Unlike Transmissions lines carrying electrical energy, the ropeways, gondola or aerial tramways cables carry vehicles with passengers. These linear infrastructures might interact with wildlife movement or dispersion. Moreover, construction of these infrastructures cause aligned deforestation and habitat fragmentation.

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<sup>1</sup> Animals with deer sizes or larger have been termed as large animals.

## CHAPTER 3

### CHAPTER 3

#### Short brief on biodiversity of Nepal

##### 3.1 Flora and Fauna

Nepal has diverse physiographic zones ranging from alluvial plains of tropical lowland in the south to extremely rugged mountains and snow covered Himalayas in the north. The country is rich in floral and faunal diversity due to its unique location of being the meeting point of Eastern and Western Himalayas and transition zone of Palearctic and Indo-Malayan biogeographic regions. Thirty-five types of forests, 75 types of vegetation and 118 types of ecosystems have been identified in the country. Nepal covers about 0.1 percent of the global area but harbors over 3.0 of flora. About 11,971 species of flora is known to occur in Nepal and of which 284 flowering plant species and 160 animal species are endemic to Nepal (NBSAP 2014).

Nepal is home for 5 percent of the mammals found in the world. It harbors 208 species out of 5,513 mammal species found in the globe. Among wild mammals found in Nepal, 9 species are 'Critically Endangered', 25 'Endangered', 14 'Vulnerable' and 7 'Near Threatened' as per the IUCN Red List. Similarly, 867 species of birds are recorded in Nepal and most of the forest birds inhabiting in the depleted tropical, subtropical and lower temperate forests are threatened. 50 species of mammals, 108 species of birds, 2 species of crocodiles, 2 species of Sauria, 8 species of serpents, 17 species of turtles and tortoise, 2 species of amphibian and 3 species of butterfly are listed in CITES Appendices.

Some of the major species found in Nepal are: Royal Bengal Tiger *Panthera t. tigris*, Greater One-horned Rhinoceros *Rhinoceros unicornis*, Asian Wild Elephant *Elephas maximus*, Snow Leopard *Panthera uncia*, Himalayan Musk Deer *Moschus leucogaster*, Himalayan Black Bear *Ursus thibetanus*, Indian Pangolian *Manis crassicaudata*, Chinese Pangolin *Manis pentadactyla*, Large Indian Civet *Viverra zibetha*, Swamp deer *Rucervus duvaucelli*, Nilgai *Boselaphus tragocamelus*, Wild Boar *Sus scrofa*, etc. Among the reptiles: Asiatic Rock Python *Python molurus molurus*, Gharial Crocodile *Gavialis gangeticus*, Marsh Crocodile *Crocodylus palustris*, and Monitor lizard *Varanus flamescens*, found in Nepal.

Thirty-five types of forests found in Nepal have broadly been classified into 10 groups; (i) Tropical, (ii) Subtropical broadleaved, (iii) Subtropical conifer, (iv) Lower temperate broad leaved, (v) Lower temperate mixed broadleaved, (vi) Upper temperate broad leaved, (vii) Upper temperate mixed broadleaved, (viii) Temperate coniferous, (ix) Subalpine and (x) Alpine scrub. Some of the major species found in these

forests are Sal *Shorea robusta*, Khair *Acacia catechu*, Sissoo *Dalbergia sissoo*, Asna *Terminalia spp*, Chir pine *Pinus ruxburgii*, Blue pine *Pinus wallichiana*, Fir *Abies specatbilis*, Spruce *Picea smithiana*, Gurash *Rhododentron spp.*, Oak *Quercus species*, Bhojpatra *Betula utilis*, etc. Eighteen tree species of mountains are threatened. Nine plant species are included in IUCN Red List and 474 plant species, mostly of Orchidaceae family are listed in the CITES Appendices (NBSAP 2014).

### 3.2 Major Species

Detailed description of fauna, their characters and behaviors are beyond the scope of the guidelines. As stated in the beginning, the guidelines are for construction of wildlife and eco-friendly green linear infrastructure. Below are the pieces of basic information of some major faunal species found in Nepal and in this region.

#### 3.2.1 Asian Wild Elephant (*Elephus maximus*)

The Asian Wild Elephant is the largest animal in Asia and the second largest in the world. Its height ranges from 245 to 275 cm at shoulder and weights from 3000 to 4000 kg. It bears pendent trunk and curious dentition. The male has large tusk and the female has small dental protuberance known as a *tush*. Male elephants having no tusk are called Makuna. Single adult males are usually aggressive when they are in periodical paroxysms of excitement called *musth*. The recorded length of tusk is 279.5 cm from Assam, India (Stracey 1960). Females are approximately one foot smaller than males. They mostly live in herd of 5 to 60 or more and different herds do not mix but stray females or young males may join another herd.

#### Distribution in Nepal

They occur in grasslands, riverine forests mixed with hardwood forests throughout 22 districts of Nepal ranging from Tarai to Chure hills upto 500 m height. But they have not been reported from Kapilvastu, Rupandehi and Nawalparashi districts. They often come out to agriculture land for food. They are generalists, and browse and graze on a variety of plants, fruits and barks.

*Saccharum spontenium*, *Saccharum bengalensis*, *Arundo donex*, *Mallotus phillipinensis*, *Bombax ceiba*, *Acacia catechu* and *Bahunia Valhi* are the main species of elephants' diet. A full grown elephant can eat from 250 to 320 kg of green fodder a day. They have poor eye sight but their senses of smell and hearing are highly developed compare to other wild animals (Prater 1971). Female elephants usually become sexually active between nine to twelve years of age and produce one offspring after 20 to 22 months of gestation period. They can travel a lot in search of water and food. It is estimated that wild elephants can live up to 70 years of age.

#### Conservation and legal status

The Asian Wild Elephant is in CITES Appendix I, and listed as endangered in IUCN Red List and as a protected species in Protected mammals of Nepal by NPWC Act 2029 (1973).



### 3.2.2 Greater One-horned Rhinoceros (*Rhinoceros unicornis*)

The Greater One-horned Rhinoceros is an umbrella species and is 170 to 186 cm tall at shoulder height. It weighs about 1500 to 2100 kg. Its large folds of skin across the flanks and tubercles that look like bumps on the skin, gives it an armor-plated look. They use their canine teeth rather than horn in fighting. They are solitary animals and have particular places for dropping their excreta.

#### **Distribution in Nepal**

They occur at an elevation ranging from 100 to 300 m. They are found in forests, grasslands, riverine forests and wetlands. They are found in alluvial plain habitats consisting of tall grasslands and swampy areas. They eat wide varieties of plants with a strong seasonal variation. They mostly spent their time in waterholes during summer. Females come to sexual maturity at approximately five to seven years of age and produce one offspring after about 16 months of gestation. Their breeding takes place at all times of the year. Chitwan National Park, Bardia National Park and Shuklaphanta Wildlife Reserve are the three rhino bearing protected areas in Nepal. The rhino populations are restricted to above mentioned protected areas due to loss of connectivity.

#### **Conservation and legal status**

The greater one-horned rhinocero is in CITES Appendix- I, and listed as vulnerable in IUCN Red List but is still in endangered in the National List of Nepal and as a protected species in Protected mammals of Nepal by NPWC Act 2029.

### 3.3.3 Royal Bengal Tiger (*Panthera tigris tigris*)

The Royal Bengal is the most well-known and charismatic animal of Nepal. They have orange coat pattern with broad black stripes and white underneath. They have black ears with a winking white spot on the back and a long banded tail. Their body lengths vary from 2.6 to 3.0 m and weigh 135 to 230 kg. Males are larger than females approximately by 45 kg. Tiger, sometimes, becomes man-killing or man-eater when they are unable to predate on their natural preys due to their physical weakness or injuries. Female tigers with cubs are more aggressive in protecting their cubs from intruders.

#### **Distribution in Nepal**

Tigers are found below 2,000 m of elevation. They live in humid evergreen forests, dry and open forests and grassy swamps of Tarai grasslands. Their main diet comprises of chitals, hog deers, sambars and wild boars. The tiger mostly hunts between sunset and dawn, and eat the game of all kinds. They also predate on livestock coming to jungle. Females mostly become sexually active at the age of three years and produce litters of two to five cubs after a gestation period of 103 days. The overall life span of a tiger is estimated at 20 years. The Tarai Arch Landscape is the major tiger habitat extending from Bagmati river in the east to Mahakali river in the west of Nepal. Chitwan, Bardia and Banke National Parks, and Parsa and Suklaphanta Wildlife Reserves are the tiger bearing protected areas in the country.



### **Conservation and legal status**

The Royal Bengal Tiger is listed in CITES Appendix- I, and listed as endangered in IUCN Red List and as a protected species in Protected mammals of Nepal by NPWC Act 2029

#### **3.3.4 Snow Leopard (*Panthera uncia*)**

Snow leopards have luxuriant pale smoky-grey coats with dark grey rosettes, black spots on the limbs and faces. Its body length varies from 1.0 to 1.3 m with the tail of 100 cm long. It weighs 35 to 55 kg. They are modestly smaller than common leopards in size. They have relatively big heads and long tails, and big paws.

### **Distribution in Nepal**

They reside in high mountains at an elevation of 2700 to 5600 m from Kanchenjunga in the east to Api-Nampa Conservation Areas in the far west of Nepal. Their habitats are mostly steep terrains such as cliffs, gullies, ridges, rocky outcrops, and alpine and subalpine areas, forests and grasslands. They can live even under -40°C harsh climatic conditions because of their thick fur. Their main prey species are blue sheep and Himalayan tahrs, and often predate on livestock such as yaks, goats and sheep. Female snow leopards usually become sexually active at the age of two and a half years and produce litters of two to three cubs after a gestation period of 90 to 103 days. Snow leopards can live about 10 to 12 years in wild.

### **Conservation and legal status**

The snow leopard is listed in CITES Appendix- I, and listed as endangered in IUCN Red List and as a protected species in Protected mammals of Nepal by NPWC Act 2029.

#### **3.3.4 Arna (Wild Water Buffalo) (*Bubalus arnee*)**

The Arna is a large, black and robust mammal with flat sweeping horns and have dirty white stockings down the knees. They are about 155 to 180 cm high at shoulder height and weigh about 800 to 1200 kg. They are sleeker and heavier than the domestic buffaloes. Both males and females bear horns and they have the largest horns on any animal in the world. The size of its head is about 275 cm across the forehead. The record horn of female measured is 197.6 cm. They are considered dangerous animal because they attack instantly when encountered.

### **Distribution in Nepal**

They inhabit at about 250 m elevation in grasslands, swampy and cold water areas and nearby riparian forests. In Nepal, they are only found in Koshi-Tappu Wildlife Reserve. They feed chiefly on grasses and eat fruits, herbs, and barks. They also raid crops such as sugarcane, rice, and jute. Females reach sexual

maturity at the age of three years and give birth to a single offspring after a gestation period of 10 to 11 months. The known lifespan of Arna is 25 years in the wild.

### **Conservation and legal status**

The Arna is listed in CITES Appendix- III, and listed as endangered in IUCN Red List and as a protected species in Protected mammals of Nepal by NPWC Act 2029.

#### **3.3.5 Gaur (*Bos gaurus*)**

The Gaur, or Indian Bison, is the largest bovine in the world. Its shoulder height ranges from 165 to 195 cm and weighs 600 to 1000 kg. It has massive head, deep chest, and muscular shoulder ridge. Both males and females grow horns curving upwards with yellow-white color and black tips. Adult males are glossy black but young and females are coffee brown. They have white legs below knees and have a pair of horns with a spread of 85 cm. Old bulls are mostly solitary and females are gregarious. They are highly susceptible to rinderpest and food-and-mouth diseases.

### **Distribution in Nepal**

Gaurs inhabit below 800 m elevation in mixed evergreen, semi-evergreen and mixed deciduous forests of *Chure*, grasslands and Sal forests. Their habitat is characterized by large and relatively undisturbed forest tracts, hilly terrains, availability of water and abundance of forage. They appear to breed all year around. Females become sexually active at the age of three and produce a single calf after a gestation period of nine months. They are found in Chitwan National Park, Parsa Wildlife Reserve and Trijuga forests in Udayapur district.

### **Conservation and legal status**

Gaur is listed in CITES Appendix- I, and listed as vulnerable in IUCN Red List and as a protected species in Protected mammals of Nepal by NPWC Act 2029.

#### **3.3.6 Common Leopard (*Panthera pardus*)**

The common leopard is smaller than a tiger. Their body lengths vary from 1.85 to 2.15 m and weigh 30 to 80 kg. They have a clear yellow coats marked with black rosettes, and have small spotted heads and long tails with underside whites. The colors of the coat vary considerably in intensity from gold to tawny in commoner forms.

### **Distribution in Nepal**

The common leopard is widely distributed from Tarai to high mountains. They have been found up to around 4,400 m elevation and most adaptable among the large cats. They mostly occur in the fringe areas of forests or close to settlements. They are found in deciduous and evergreen forests, shrubs, and open areas. They are opportunistic animals and have variety of species in their diet such as mice, hares, deer, and antelopes. They take their kills up to the tree to avoid competition with other carnivores and predate on goats and sheep too. The female reproduces at the age of 34 months and gives birth of a litter of two to three young after a gestation period of just over three months. They breed all the year round.

#### **Conservation and legal status**

The common leopard is listed in CITES Appendix- I, and recognized as vulnerable nationally and protected by NPWC Act, 2029 in Nepal.

#### **3.3.7 Sloth Bear (*Melursus ursinus*)**

The Sloth Bear is a shaggy black animal with a long grey color snout and cream ring around eyes and cream horseshoe on chest. It can be lethal when confronted alone on foot since they have long claws. The bear shoulder height varies from 140 to 170 cm and weighs 65 to 145 kg. They, often, can attack when surprised. They, usually, attack human beings by standing on two feet and starts biting and inflicting serious wounds with its long claws. They are rather poor of hearing and sight.

#### **Distribution in Nepal**

The species occurs in Sal forests, moist evergreen forests and riverine forests, and thorn scrubs and grasslands at 100 to 800 m elevation in Tarai. They eat termites, ants, insects, berries, roots, carrion, fruits and honey bee combs. Their mating time is usually in the hot weather and most of the young are born between December and January. They hibernate during winter to avoid cold and problem of food scarcity by giving up active life. They have a litter size of two cubs after a gestation period of about five months. They are found in Chitwan and Bardia National Parks, Parsa Wildlife Reserve and west of Bhalubang of Banke district, Bara, Kailai and Dang Districts. Their population is in decreasing trend.

#### **Conservation and legal status**

The sloth bear is listed in CITES Appendix- I, and listed as vulnerable in IUCN Red List. The species is endangered nationally and protected by NPWC Act 2029 in Nepal.

#### **3.3.8 Sambar deer (*Rusa unicolor*)**

The sambar is the largest deer found in Nepal. They are shaggy and have dark brown coats with large spreading antlers. Its shoulder height is about 150 cm and weighs approximately 225 to 320 kg. The

recorded length and span of an antler are 127 cm and 61 cm respectively from Bhopal, India (Stracey 1960).

### **Distribution in Nepal**

They are generally found in dense Sal and riverine forests of the lowland Tarai and in sub-tropical forests at the elevation ranging from 75 to 3000 m. They are grazers and browsers, and feed on grasses, fruits and leaves. They are mainly nocturnal but often sighted during day time. Females give first birth of a single offspring at the age of around 23 months after a gestation period of eight months. Their population is sharply decreasing in the country.

### **Conservation and legal status**

The sambar deer is listed as vulnerable species nationally and protected by NPWC Act 2029 in Nepal.

#### **3.3.9 Chital (*Spotted Deer*) (*Axis axis*)**

The Chital is a commonly known species in Tarai, Nepal. They are about 90 cm high at shoulder height and weigh about 85 kg in average. They have orange rufous coat with white spots. A darker stripe runs along the back. Males have large antlers and dark facial markings, and are bigger than females in body size.

### **Distribution in Nepal**

Distribution of the Chital ranges from 75 to 1000 m elevation. They are found in the sub-tropical forests and grasslands. They prefer riverine forests during hot dry season and Sal forests in Monsoon period. They feed mainly on fruit, browse and grasses. They can breed all year round and give first birth at the age of 13 months after a gestation period of roughly 235 days. Their total population is not known in Nepal but their population is observed to be in decreasing trend due to illegal hunting and increasing predators' populations.

### **Conservation and legal status**

The Chital is listed as vulnerable species nationally and protected by NPWC Act 2029 in Nepal.

#### **3.3.10 Barking Deer (*Muntiacus vaginalis*)**

Barking deer are wide spread. Their shoulder height ranges from 50 to 75 cm and weighs 14 to 28 kg. They have glossy chestnut coats with no under fur and have dark brown-black facial markings with small antlers. Their front legs are longer than hind legs. They have a dog like bark.

### **Distribution in Nepal**

They are common forest deer. They occur in dense tropical and sub-tropical forests, and thickly wooded hills. They prefer ravines, stream gorges, dried up stream beds and thick under-growths for cover. They feed on fruits, buds and new grass shoots. Females become sexually active within a year and give birth of a single fawn after a gestation period of about six months. Their breeding occurs throughout the year. Their population is found to be in decreasing trend.

### **Conservation and legal status**

Barking deer is listed as least concerned in IUCN Red List but the species is vulnerable nationally in the country and protected by NPWC Act 2029.

#### **3.3.11 Wild boar (*Sus scrofa*)**

Wild boars are found widely. Their body length ranges from 90 to 180 cm and weight 90 to 100 kg. They are the ancestor of domestic pig. They are dark grayish-brown coats with black manes and stiff bristles. Males have a set of strong tusks. Their piglets are light brown with pale stripes.

### **Distribution in Nepal**

They are highly adaptable and occur along the fringes of forests close to agricultural field at an elevation ranging from 63 to 4000 m. They prefer ravines, stream gorges, dried up stream beds and thick undergrowth for cover. They are omnivorous and mostly feed on roots and ground tubers. Females give birth of a litter of four to eight young after a gestation period of about four months. Their breeding occurs throughout the year.

### **Conservation and legal status**

The wild boar is listed as least concerned in IUCN Red List and the species is protected by NPWC Act 2029.

### **3.4 Small mammals and Herpetofauna**

Small mammals include Hispid hare *Caprolagus hispidus*, Indian hare *Lepus nigricollis*, Indian pangolin *Manis crassicaudata*, Chinese pangolin *Manis pentadactyla*, Himalayan pika *Ochotona himalayana*, Black giant squirrel *Ratufa bicolor*, long tailed field mouse *Apodemus sylvaticus*, Indo-Chinese shrew *Crocidura attenuata*, Himalayan Marmot *Marmota himalayana*, etc.

Herpetofauna includes both reptiles and amphibians. The diversity of herpetofauna is wide ranging from the fingernail-sized bush frog to the rock python weighing 100 kg in Nepal. A total of 206 species of herpetofauna has been reported of which 59 are amphibians and 147 reptiles. Eleven species of those are endemic to Nepal (9 frogs and toads, a lizard and a snake). Fifteen species of amphibians found in Nepal are globally threatened. The IUCN Red Data Book includes 2 species of crocodiles, 7 species of turtle, 2

species of tortoise and 2 species of serpent including rock python as threatened species of Nepal. Three species of reptiles, namely Asian rock python *Python molurus*, gharial crocodile *Gavialis gangeticus* and golden monitor lizard *Varanus flavescens* are listed as protected species by NPWC Act, 2029.

The crocodile salamander *Tylotriton verrucosus* Anderson, Himalayan toad *Duttaphrynus himalayanus*, Gunther black-throated frog *Microhyla ornate*, Bengal spadefoot toad *Megophrys robusta*, dark-throated leaf turtle *Cyclemys oldhamii*, three-striped roofed turtle *Kachga dhongoka*, Indian roofed turtle *Pangshura tecta*, yellow headed tortoise *Indotestudo elongata*, oriental garden lizard *Calotes versicolor*, common krait *Bungarus caeruleus*, banded krait *Bungarus fasciatus*, spectacled cobra *Naja naja*, king cobra *Ophiophagus hannah*, and Russell's viper *Daboia russelli*, etc. are some of the herpetofauna found in Nepal.

Table 1 below summarizes the common names, and scientific names, conservation status, and legal/protected status of some mammals found in Nepal.

**Table 1: Mammal Species**

Common Name	Scientific Name	Conservation Status	Legal Status	
		IUCN	CITES Appendices	NPWC Act 2029 Protected List
Asian Wild Elephant	<i>Elephas maximus</i>	E	I	P
Greater One-horned Rhinoceros	<i>Rhinoceros unicornis</i>	Vu En/n	I	P
Tiger	<i>Panthera tigris tigris</i>	E	I	P
Snow Leopard	<i>Panthera uncia</i>	E	I	P
Common Leopard	<i>Panthera pardus</i>	Vu/n	I	-
Arna (Wild Water Buffalo)	<i>Bubalus arnee</i>	EN	III	P
Gaur	<i>Bos gaurus</i>	VU	I	P
Sloth Bear	<i>Melurus ursinus</i>	VU, EN/n	I	-
Sambar Deer	<i>Rusa unicolor</i>	VU/n	-	-
Chital (Spotted Deer)	<i>Axis axis</i>	VU/n	-	-
Barking Deer	<i>Muntiacus vaginalis</i>	LC, VU/n	-	-
Eurasian Otter	<i>Lutra lutra</i>	NT	I	-
Indian Pangolin	<i>Manis crassicaudata</i>	NT	II	P
Chinese Pangolin	<i>Manis pentadactyla</i>	NT	II	P
Assam Macaque	<i>Macaca assamensis</i>	VU/n	II	P

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## CHAPTER 4

### CHAPTER 4

## GUIDELINES FOR REDUCING IMPACTS OF LINEAR INFRASTRUCTURES

### 4.1 Mitigation Principles

As elaborated above habitat fragmentation by linear infrastructure impacts heavily on a large number of ecological process across wildlife habitable landscapes. To mitigate these impacts, mitigation principles based on the application of a mitigation hierarchy prioritizing- avoidance, minimization, and compensation of impacts may be followed. The principles should be followed in managing risks and potential impacts related to biodiversity and ecosystem services. These should represent the best international practices when planning and implementing projects to provide rational approach in assessing occurrence of events or conditions, identifying, quantifying and planning ahead for protecting and conserving biodiversity and maintaining important ecosystem services. The principles hold true in linear infrastructure development and extension projects as well.

The mitigation hierarchy formalized by the Convention on Biological Diversity (CBD 1992) are milestones in this regards. The promotion of the mitigation hierarchy along with the principles developed in this section are consistent with assessment of event specific conditions and impact management principles. Some other works and standards on the subjects are the International Finance Corporation (IFC) – Performance Standard 6 on Biodiversity Conservation and Sustainable Management of Living Natural Resources<sup>2</sup>, the Business and Biodiversity Offset Programme (BBOP) -Standard on Biodiversity Offsets<sup>3</sup>, the International Council on Mining and Minerals (ICMM), the International Association of Impact Assessment (IAIA), Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)- Conservation Guidelines and the decisions and results of the Conference of the Parties to the Convention on Migratory Species of Wild Animals (COP 9).

### 4.2 Mitigation Hierarchy

All other principles described in these guidelines should maintain strict adherence to the mitigation hierarchy of i) avoidance, ii) mitigation and/or minimizing, and iii) compensation. These principles have been explained briefly below.

#### Avoidance

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<sup>2</sup>

[http://www.ifc.org/wps/wcm/connect/bff0a28049a790d6b835faa8c6a8312a/PS6\\_English\\_2012.pdf?MOD=AJPERES](http://www.ifc.org/wps/wcm/connect/bff0a28049a790d6b835faa8c6a8312a/PS6_English_2012.pdf?MOD=AJPERES)

<sup>3</sup> [http://www.forest-trends.org/documents/files/doc\\_3078.pdf](http://www.forest-trends.org/documents/files/doc_3078.pdf)



The first option is always to avoid impacts to the extent wherever possible to the migration routes and critical habitats for residential and migratory species, even if the total length of the intrusion is increased, to ensure avoidance is achieved. This applies to policies, plans, programs and projects.

This principle recognizes that linear infrastructure has unavoidable short-term (during construction) and long-term impacts but in almost all cases, an appropriate and sustainable alternative can be found.

Detailed consideration of alternative alignments and construction options for linear infrastructure must be considered in the strategic and project level design and assessment practices.

### **Mitigation and/or Minimization**

Minimization includes measures to reduce the duration, intensity and/or extent of short-term and long-term impacts due to the linear infrastructure development on the ecology including the wildlife living in and around as well as the migratory species.

Where avoidance is not possible investigation of all possible alternative designs and construction standards and options that reduce and mitigate ill-impacts should be done.

The decision that avoidance is not possible practically must be taken in transparent decision-making processes, with inputs from wildlife experts, and other stakeholders.

Further, decisions must be based on objectively verifiable, clear and convincing evidences that avoidance is practically impossible.

Project planning, design, budget and assessment processes should include all proposed measures aiming to minimize impacts including alternative mitigation measures, and be based on data, science, and local knowledge. The objective is to reduce project impacts to the extent possible.

### **Compensation**

Compensation includes all measures to offset the adverse impacts to migratory species after all avoidance, minimization and other mitigation measures have been taken. Compensation or offset is a measure of last resort to achieve no net loss of biodiversity.

The project must show how the linear infrastructure's residual impacts can and will be offset through specific measures and commitments describing the level of risks and uncertainties regarding the offset.

## **4.3 Upfront Planning and Design**

For adequate management of risks and potential impacts related to biodiversity and ecosystem services due to implementation of linear infrastructure, an upfront planning and design is needed. The process of planning and design may vary depending on a number of factors including organizational planning and implementation processes, availability of resources and other geo-physical constraints. The following processes or steps are meant for generic guidance only.

#### 4.3.1 Planning

##### Land use plan

Land use plans are necessary for advancement of balanced development through right synchronization of infrastructure development and nature conservation through arresting unplanned and haphazard development at the cost of degeneration of eco-services.

For development of sustainable and eco-friendly linear infrastructure in or along a landscape, a land use plan of the region should be developed to guide primary and secondary development for planned and sustainable development that avoids negative impacts on communities, wildlife and the natural environment and foster balanced development. The plan must show the existing transportation system, other infrastructure and future development in the project area/landscape, existing ecology - water sources, species/wildlife movement, distribution at local, and landscape,

The land use planning follows through the site investigation, alternative designs options to meet structure structural safe, meeting the limiting conditions of services over the intended service life period. A study advisory group comprising of a multi-disciplinary technical team including planners, engineers, civil society, wildlife and ecology experts should involve in the process. The design should avoid negative impacts to eco-system, communities, wildlife, and environment.

##### IEE/EIA

During this phase, an initial environmental examination (IEE) or environmental impact assessment (EIA) the presence of wildlife in the landscape where the linear infrastructure is proposed is assessed. Along with the assessment of social and environment impacts, wildlife mitigation measures - wildlife crossings, their locations, types with evaluation connectivity are assessed with measures to avoiding, minimizing, mitigating, offsetting environmental impacts, ecological negative impacts. Cost implications and risk/responsibility matrix are also prepared. The IEE/EIA report should be supplemented with the environment management plan (EMP) and a natural resource management plan (NRMP) providing detailed guidance for ecosystem and forest management, including planning, costs, risk and responsibility identifications for conservation of wildlife habitat and up-keeping of ecosystem services such as bioengineering works for controlling and protection of river sediment, slopes, river-bed erosion, river banks, unscientific mining, sand/gravel extraction, construction works/habitations along river sides, debris/muck disposal, road-side chemical, deforestation, and making provision for plantation for slope protection, creation of healthy riparian edges, storm water management, underpasses/overpasses for wildlife movements, imposing traffic calming measures, etc.

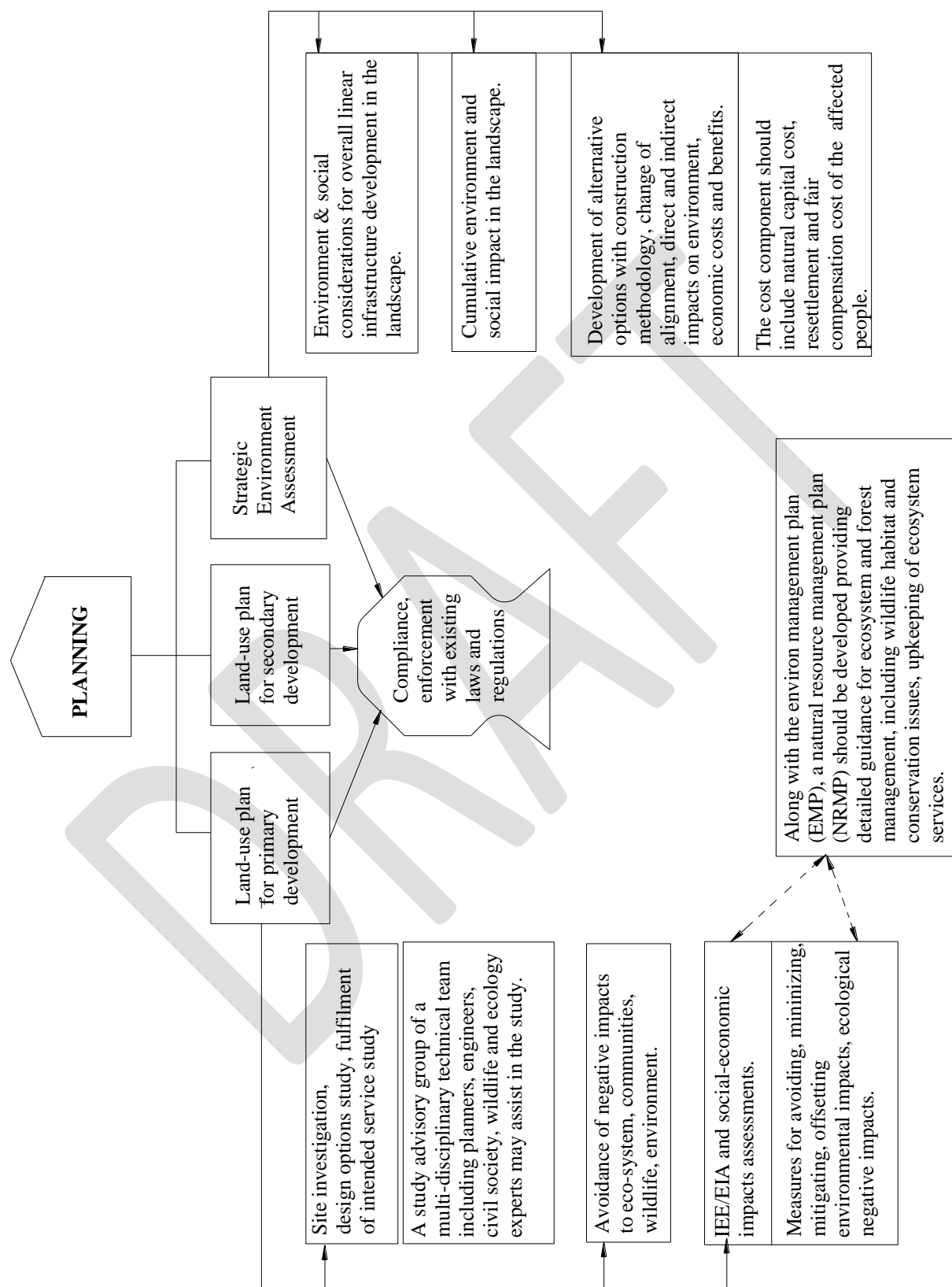


Figure 4.1: Planning Process

## SEA

Alongside the land use map creation, a strategic environment assessment (SEA) should be in place will all environmental & social considerations for overall linear infrastructure development at least in the landscape under consideration, but preferable with a larger horizon. Cumulative impacts of developments on environment and society on the landscape and at larger level, maybe, at national level should be studied.

### Option development

Alternative scenario options should be developed with possible future outcomes under different developments with their social, environmental, ecological effects along with structural, geo-technical, constructional parameters, site specific other feasibility issues and cost before going for implementation of the project. The cost component should include natural capital cost of the landscape, resettlement and fair compensation cost of the affected people.

The land-use planning including all above studies and measures must comply and enforceable with the existing laws and regulations, policies and programs, and have community-based initiative and support as far as practicable.

### 4.3.2 Design

#### Structure Selection and Design

At this stage the species (single or multiple) that might be affected due to the linear infrastructure are already been identified. After this, it is now to further decide the primary and targeted species for practical and sustainable mitigation measures. Based on the critical species identified appropriate mitigation structures are selected. Preliminary designs of the structures are done by professionals considering the exact site location, movement of the targeted wildlife and ecological flows in the landscape. As far as practicable, the structure should so designed that it serves not only the targeted species but multiple species. It must provide seamless eco-services and simulate the natural conditions including the ambient habitat environment.

The aspects of species specific, site specific and sustainability should also be taken care. Each of three has been explained briefly below:

#### Species Specific

Each species is unique with different physiology, nutritional needs, behavior, and so its movement patterns and responses to linear infrastructure. So, all avoidance, minimization and compensation measures desirably be designed and adopted on a species-specific basis with inputs from wildlife experts

and infrastructure planners and designers whose competency includes the species potentially affected by the nature and purpose of the proposed linear infrastructure. The mitigation and compensation measures must be designed to contribute to the conservation, rehabilitation, and reintroduction of target species. To develop such species-specific designs, publicly available baseline and monitoring studies, independent study data and EIA reports that cover the status, ecology, and trends of all residential and migratory species should be taken into consideration.

#### Site Specific

Measures appropriate for species in one area may not be appropriate in other as the same species may be affected by different conditions across its range (e.g. climate, topography, habitat abundance, and/or pressure, exposure to human being, etc). So, all the mitigation measures must be adapted suitable to the place as well as to the species. Mitigation measures should be designed to allow for adaptive management in response of conditions and sites changes. No waste should be dumped in and around the site as the dumped waste may attract some animals which in turn will attract more others. For example, the waste along the roadside attracts wild boars, which in turn might attract tigers.

#### Sustainability

At least two aspects - planning and physical structure itself should be considered for sustainability of the measures taken. The physical aspects of mitigation measures must meet or exceed physical standards that ensure its viability over the life-span of the infrastructure. The government and/or implementing agency must ensure that all avoidance, mitigation, and compensation measures have been incorporated to the possible extent for development of linear infrastructures. The project should be designed and implemented taking into consideration other likely developments that might trigger commensurate with these measures. Mitigation and compensation measures must target outcomes that are better than the calculated and/or expected losses.

For a generic crossing structure, the following factors may be considered:

Height and width of crossing structure: Head clearance as enough for jumping

Bottom surface of structures

Light and moisture considerations

Noise levels and human activity

Location

Natural appearance

Required safety measures

Spacing of a crossing structure (may vary from 1.5 km to 5.0 km depending on the factors above)

Moreover, while designing the selected structure (type, size and the spacing for a crossing), the present and probable changing dynamics of habitat conditions, present and future wildlife distribution, population and their dispersal at least over a period of 70 years should also be understood and or estimated.

Finally, the precise and elaborate final engineering designs and detailing are done that meet the structural limits and serviceability and yet are wildlife friendly. The mitigation structure so designed may be a single structural unit or a combination of them. Furthermore, the material specifications, site development plan, construction methodology are prepared based on sizes of the wildlife, their movements, habitat, and expected behavior with the structure.

Detailed monitoring, evaluation and maintenance plans are established.

Monitoring the use of corridors by target wildlife species is an important step in corridor planning, to allow for adaptive management.

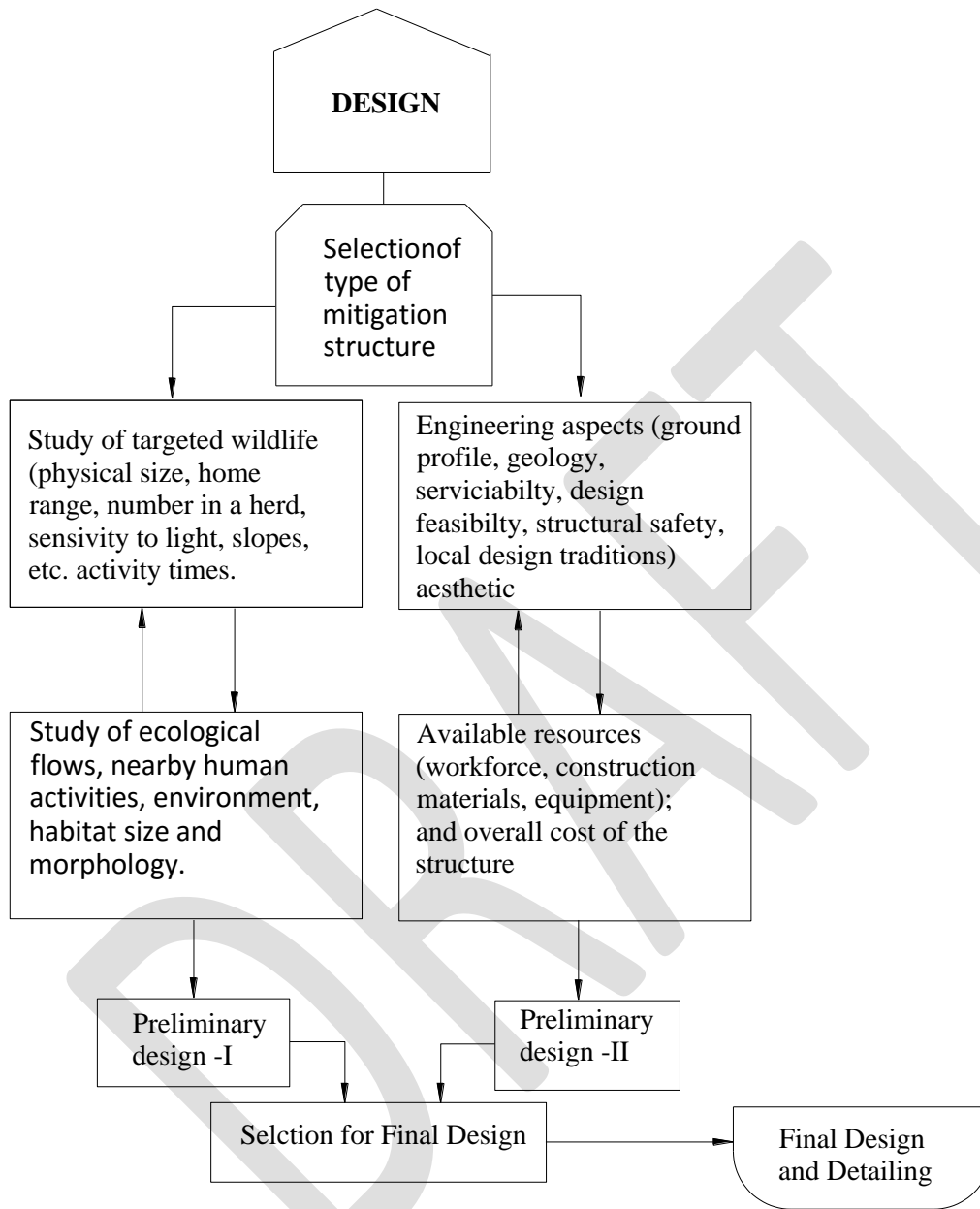


Figure 4.2: Design Process

#### 4.4 Design Guidelines

The dimensions and other parameters of the crossing structure may vary depending upon the targeted species and types of crossing structure. Therefore, to design a linear structure wildlife friendly, we need to understand characteristics of targeted wildlife with regards to dimensional and site specific parameters of the proposed structure. These aspects have been further discussed below under the headings of (a)

wildlife characteristics and minimum recommended dimensions of crossings, and (b) types of crossings and general guidelines.

#### 4.4.1 Wildlife characteristics and minimum recommended dimensions of crossings

Tables 2 and 3 give some physical characteristics, preferences for movement or migration, sensitivity to, and comfortable slopes, obstacle heights/slopes, recommended passage heights, widths respectively for some flagship wildlife found in the region for planning, designing and construction of mitigation structures specific to the species.

**Table 2:** Wildlife characteristics

Wildlife	Height (m)	Weight (kg)	Preference for movement or migration	Sensitivity
Asian Elephant	2.75	4,000	Underpass or overpass with wide opening and height.	Sensitive to swampy area and rough gravel road. Comfortable with <i>khaakee</i> color.
Royal Bengal Tiger	1.10	220	Bushy	Sensitive to white color, spiny or thorny areas.
Greater One-horned Rhinoceros	1.98	2,100	Bushy crossing	Sensitive to curved path.
Arna (Asian Water Buffalo)	1.90	1,200	Open swamps	Aggressive to humans; Nocturnal.
Gaur (Indian Bison)	1.95	1,000-1,500	Bushy crossing	
Sambar deer	1.50	180	Open crossing	Irritated to light and noise. Avoids dark spaces.
Barking deer	0.65	40-50		
Spotted deer	0.90	85		
Bear	1.70	145	Less open	Attacks possible predators; a good swimmer.
Himalayan Serow	1.10	85-140	Open crossing	Difficult to approach; shy; easily startled.
Himalayan Tahr (Jharal)	1.00	90-160		
Himalayan Goral	0.50	35-42		



Wild Boar	1.80	100	Open or swampy crossing	Light
Salak (Chinese pangolin)	0.30	2-7		Sound, burrow animal, nocturnal
Amphibians and reptilians	0.10	0.022	Swampy and/or shady crossing.	Provide swamps/ponds in stepping-stone pattern.

Table 3: Minimum Recommended Dimensions for Wildlife Crossings

Animal	Comfortable max. slope (deg.)	Passage		Openness Index Height(m)x Width(m) Length (m)	Obstacle	
		Clear height (m)	Width (m)		Height (m)	Slope (deg.)
Asian Elephant	20	8.0-10.0*	8.0-10.0	1.4	3.0	> 30
Royal Bengal Tiger	30	4.5	4.5	1.35	3.0	
Greater One-horned Rhinoceros		4.5	4.5	1.32	2.0	
Arna (Asian Water Buffalo)	20	4.5	6.0	1.30	2.0	
Gaur (Indian Bison)	20	4.0	4.0	1.25	2.8	> 20
Sambar deer	25	5.0	5.0	1.15	2.8	> 20
Barking deer		3.5	4.0	0.50	2.5	
Spotted deer		3.5	6.0			
Bear	30	3.0	4.0	0.90	3.0	
Himalayan Serow <sup>4</sup>	14		4.0	0.90	2.5	
Himalayan Tahr (Jharal)				1.0		
Himalayan Goral				0.60		
Wild Boar	20			0.50	2.0	30
Salak (Chinese pangolin)	30					
Amphibians and reptilians	20	Minimum dia. (Ø) 0.2			0.6	

<sup>4</sup> High altitude animals are used to with slopes

## Notes

1. The animal passage should in addition consider other site specific variables such as vegetation, topography, hydrology, disturbance and target species.
2. The Openness Index for smaller wildlife such as lizards, rats, mustelidae may be between 0.04 -0.09.
3. In case of culverts or bridges, each individual cell may be added together to arrive at the Openness Index of the structure.
4. Herbivores generally respond with caution to underpasses that are tunnel-like or appear dark and closed. Carnivores are more likely to use underpasses smaller than those typically used by ungulates.

### 4.4.2 Types of crossings and general guidelines

Wildlife crossings can be of two types: underpasses and overpasses. In an underpass crossing the wildlife passes through under the pass - tunnel, viaduct or flyover, modified culverts or underneath the structure with or without water flow, whereas, in an overpass the wildlife passes through the stretch or route, often provisioned above-grade the structure.

The underpasses are economical in the plains and valleys in general, while the overpasses are so at the ridges. Different species are more likely to prefer an underpass or an overpass, albeit all species use both types of passes. Yet, the design and construction of an underpass or overpass is largely governed by the topography of the area such as valleys, plains, water courses, road alignment (usually designed at right angles to the road centerline), subsoil stability, and associated road structures such as nearby bridges, culvert, retaining walls, breast walls, hedgegrows, etc, and species using it.

Table 3 gives the recommended head clearance and widths of the crossings for some major species. While designing a crossing, care should be taken to round off the corners and edges of the structure to reduce the tunnel effect and widen the mouth to facilitate directing and attracting the species to use it. Its location should be selected in the usual animal crossing points. The width of an overpass may vary from about 30 m to a few hundred meters depending upon the above aspects.

Moreover, the maintenance cost should be minimal. There should be no effluent pollution or other pollution risks. The underwater and surface effluents should not accumulate the underpass. The floor should be good ground without any pot-holes or difficult terrain-like with sharp turns or narrow races.

A mild gradient of maximum 1:10 is possible. Other factors that needs to be considered are wildlife movements including their trails, migratory patterns, mortality locations, habitat and vegetative

cover, variability and density of species. Sometimes, water table (high water table is avoided lest water may drain out to effluent collection system, if the collection system is nearby) or spring on ground.

If the targeted wildlife is a seasonal migratory one, the construction period of the structure should be so chosen that it is away on the migration. As far as practicable, the structure or components of structure should be fabricated outside the project side so that the construction period of the site is minimum. Construction equipment is so chosen that it emits minimum noise and vibration. This will reduce disturbance to the wildlife.

Some other aspects to be considered are overall cost of the structure, aesthetics, local design traditions, available resources (workforce, construction materials, equipment), specific site conditions including existing/proposed structure, nearby human activities, environment, ground profiles and ground geology.

In short, proper structural and non-structural design of the crossings are equally crucial to the selection of location to meet the functional or intended need of the structure. Refer to Table 3 for species specific sizes of the crossings.

#### 4.4.2.1 Types of overpasses

##### Landscape bridge

A landscape bridge is, generally more than 100m width. Its size is such that, it enables the restoration of habitats, and designed and integrated for habitat continuity. The optimum width depends on the diversity and conservation importance of the habitats that have to be connected. In areas of high importance, a landscape bridge may need to be several hundred meters wide to preserve the connectivity of the landscape.

##### Wildlife overpass

A wildlife overpass is, generally 50 to 70 meters in width, designed for large animals (excludes elephants, rhinos etc.). A standard width of 40-50 m (between the fences) is recommended. For larger mammals, the width and location of an overpass are more critical than the design details, substrate or vegetation. Overpasses have also been shown to act as guiding lines for birds, bats and butterflies enhancing the movements of flying animals that may be reluctant to cross open surfaces. The required width increases with the length of the overpass, i.e. an overpass across a six-lane motorway has to be wider than the one over a two-rail high-speed railway line. The

minimum width to length ratio should, in general, be greater than 0.8. Figure 2 shows a typical underpass.



Figure 4.3: A typical overpass

#### Multipurpose overpass

Similar design to wildlife overpass a multipurpose overpass allows for humans as well. In general, its width is 15 to 25 m, but may be as narrow as 10 m depending upon the site conditions and requirements. The structure is used to cross semi arboreal, semi aquatic, and amphibious species.

#### Canopy Bridge or Tree-Top Overpass

For arboreal and small animals, a canopy bridge (ropes or net) or other walkway may be provided if the road is wide and the animals are not able to move from tree to tree. Its height should be at 7 m or more from the ground. The canopy bridge or walkway should be wide enough for animals to walk on. The width or diameter of the bridge depend on the animals targeted. The population of the climber traffic governs the number of bridges to be provided. Protection from predators is an important accompanying measure for canopy bridge. An additional thin rope may be provided above the open rope or walkway to prevent attack by birds of prey on crossing animals. These type of bridges can further be attached with sensors and cameras for studies and population enumeration. Figure 3 is an typical example of a canopy bridge.





Figure 4.3: A typical canopy bridge

#### Bird-flight diverters

As mentioned in Article 3.1.4, the overhead power lines are often the cause of collisions and casualties or electrocution of birds and many other aerial species by obstructing their flight paths. Wind turbine with large blades may also be cause of bird collisions and mortality. The rate of such collisions and fatalities can be reduced by placing bird flight diverters (i.e., wire markers in the form of, e.g., spirals, swivels, plates, or spheres) on static and some electrified wires to increase their visibility

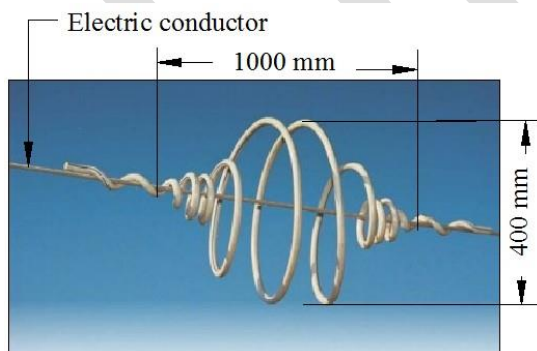


Figure 4.4: A typical bird-flight diverter

An economical Bird Flight Diverter, made of rigid solid high impact polyvinyl chloride or similar light-weight materials offering little wind resistance and possessing excellent chemical and strength properties can be designed and installed bare or jacketed to the phase conductor carrying upto 40 kV, and on earth wire on high voltage wire to make overhead lines visible to birds. The flight driver must stay in the applied position. Figure 4.4 shows a typical flight diverter with typical dimensions. The spacing of 10 to 15 metres may be provided depending upon the concentration of targeted species. Other devises such as Wind chimes, reflector chimes, and 1 feet diameter orange fiber glass balls may also be used as deterrent for many aerial species. The size and type of deterrent is to be determined based on the terrain type, forest type and most targeted species.

The reflective diverters may also be clipped to the top strand of fences to help low flying birds avoid the fences in dim light.

#### 4.4.2.2 Types of underpasses

##### Viaducts and river crossings

In hilly areas a viaduct<sup>5</sup> can be a good solution to connect valleys, and make passage for vehicular or pedestrian traffic from above and crossing for animals from bottom. This is more significant when there is a watercourse. While constructing or maintaining such passes, existing movements of animals are to be preserved. Viaducts are preferred by invertebrates and small vertebrates which have special bonds with the vegetation types around. So, these should be covered with the plants found around the site.

##### Underpasses for medium-sized and large animals

For large mammal the size of the underpass must be at least 10 m wide and 4 m high. Whereas for medium sized animals, these can be in the range of 3.5 – 7.0 m wide and 2.5 to 4.0 m high.

The exact dimensional parameters are to be decided based on the sizes of the targeted species, their behaviors, and depth of crossing.

These structures may be adapted for use of humans, amphibians, reptiles, semi amphibian species as well. It is advisable for bio-engineering works including vegetative cover along the walls, fences and bottom of such structures. Figure 4 shows a typical underpass for medium-sized and large animals.

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<sup>5</sup> A **viaduct** is a type of long bridge composed of several small spans<sup>[1]</sup> for crossing a waterway, road, valley or a gorge, and thus provides overhead passage.



Figure 4.5: A typical underpass for medium-sized and large animals.

#### Underpass with water flow

Underpasses with water flows are designed and constructed for mix use of water passage and wildlife crossing. These structure can be modified for movement of even large mammals. The size of the underpass may vary from 2 to 3 m wide and 3 to 4m high. The exact dimensional parameters are to be decided based on the sizes of the targeted species, their behaviors, and depth of the crossing. As these structures can be modified for use of different wildlife including amphibians, and semi-aquatic life, it is advisable to provide vegetative or natural cover along the walls, fences and bottom of such structures.

#### Modified Culverts and Bridges

Culverts and bridges can be modified for movement of wildlife. The level, form and amount of modifications depend upon the particular requirements. As most of the bridges narrow down the Right of Way to river course and the river depth and speed increases at the span of a bridge, it is necessary to provide shoulders on both sides under the bridge as shown in the Figure 5 that facilitate animals to walk along the banks and avoid crossing through the road. But, if the wildlife habitat is on one side only, the passage may be provided to only one side of the culvert or bridge. The clear head under the shoulders should be kept suitably as given in the Table 3. The soil of the platforms or banks shall be above high seasonal water-mark and stabilized through natural means such as the bioengineering work. The platforms should be connected to the habitats with ramps of mild inclination (not more than 1:10). As most of the small mammals, amphibians, reptiles, and insects need vegetative cover for security, bridges with under-crossings should extend to uplands beyond the scour zone of the stream, and should be high enough to allow enough light for vegetation to



grow underneath. The modification must not reduce the culvert's or bridge's hydrologic capacity, structural safety or other functional aspects for which the culvert or the bridge is there.



Figure 4.5: A typical modified bridges

#### Amphibian and/or Reptile Tunnels

Amphibians and reptiles, known as *herps*, generally migrate between breeding ponds/places, winter hibernation sites and warm upland areas within a short distance of about 2 km or less. An effective tunnel system or passages with specific drift fences or wall to guide them from the places they are moving from would reduce their traffic-related deaths.

The design of tunnels is governed by a number of factors including the location of crossing site, population of amphibians, their migration direction and commonly used routes, mortality rate, traffic speed, volume on the road section, and the geometry of the road.

Often the best solution is to convert the existing drainage culverts with required modifications and drifting fences. A PVC pipe or concrete hume pipe with diameter equal to or more than 100 cm that permits enough light leading to see another area, air and humidity (moist natural floor conditions along the passage, especially for amphibians) may be provided. The moist conditions should not be contaminated with vehicle run-off. The entrances should be designed for their easy access. The drift



fences often provided on both sides are more than 200 m length of the short walls of concrete or stone masonry or wire netting of 25 to 45 cm height at an angle of 45° to 60° with the entrance. The entrance may be slightly lowered than the ground level for easy of entrance. The number of tunnels should be provided to cater the entire length of the migration corridor.

#### Fish and other Aquatic Passes

Fish and other aquatic species undertake migrations from one part with certain kind of habitats in the river to another part with different type of habitats over their life cycles to maintain their genetics and viable populations. So, crossings or passes are very important for restoration of habitats of fish and other aquatic species in rivers.

Bridges, culverts, irrigation diversion structures or hydropower dams/barrages are some of the important structures that intersect waterways. Improperly designed, constructed or maintained such structures create potential barriers to their movements. Crossings or their ways can be constructed in a technically sound way that meets the ecological requirements. Moreover, zones should be demarcated above and below crossing or path in order to protect migrating fish and other aquatic life from any disturbances such as swimming, boating, etc. Detailed design of passes/crossings with hydraulic dimensions, evaluation/testing of their effectiveness are beyond the scope of this guidelines. The bottom line is that the passes so designed and constructed must function for the restoration of free passage to the fish and aquatic species in rivers.

### 4.5 Miscellaneous Mitigation Measures

There are other interventions that can be recommended as mitigation measures. These are aimed primarily at modification in engineering design of structure, influencing drivers' and wildlife's reaction and behavior, and dissuading or obstructing the animals from crossing or approaching the linear structure. Different types of signaling, signs and barriers are put or erected on the roadways to this effect, though, the effectiveness of many of them are still uncertain and needs to be established for a particular site and species. Some of the common mitigation measures are explained briefly below:

#### 4.5.1 For Irrigation Canals trap-in

Irrigation canals may serve as water source for some aquatic life, but they often give negative impacts to wildlife if not properly designed and implemented. The canals may not only cause barriers to wildlife movements but may work as death traps for animals such as deer, and sheep. These animals go for drinking water and cannot transcend back the side-slopes of the canals.

To avoid these mishaps, the canal segments that pass through the wildlife movement areas can be covered with concrete slabs and buried under soil with vegetative cover, or provided with underground siphons in the form of reinforced pipes and box conduits with natural grade of landscape, provided the canal width is small. If the canal widths are too large in view of structural safety or cost, fencing of adequate height

should be provided. In such a situation, alternative safe water sources, say, by diversion along catchments, adjacent to the canals, should be provided.

In the case of very wide canals, or canals without fencing or crossing structure, escape or egress ways with stairs or ramps with a dam or siphon with gratings in the canal course should be provided for escaping. The spacing of such a structure should not be spaced more than 1 km apart.

#### 4.5.2 Public Education

This is aimed at creating awareness in public including the drivers through publicity campaigns and other forms of information dissemination about the road safety and avoiding collision with wildlife and generating public support for adopting mitigation measures.

#### 4.5.3 Speed Reduction- Lower speed limits

This measure is to reduce designed speed to a safe limit over the stretch of the road with high wildlife concentration and expected movements. This is particularly to warn drivers ahead of the presence of animals and reduce speed accordingly. Figure 6 is a typical sign showing maximum speed of 40 km/h for the next 3 km road section.



**Figure 4.6:** A typical speed reduction sign

The speed of the vehicles using the elevated highway may be restricted to reduce the disturbance between particular hours of wildlife movement. The time slot can help the wildlife cross to the other side of forest. Complete ban should be imposed on blowing of horns along the section of the highway.

#### 4.5.4 Road Sign Installation

Road signs are installed along roadways in sufficient numbers where exposure to wildlife is considered high, and aimed to help reduce wildlife-vehicle collisions. They warn drivers of the possibility of crossing the road by wildlife, and so collision with them.

Caution signs are constructed with high visibility colors such as yellow with black reflective images of the animal(s) which a driver may expect to encounter on the road. There must be a signage fixed at least 500 m away from the crossing point in local languages.

Figures 7 is a typical example of such signs.

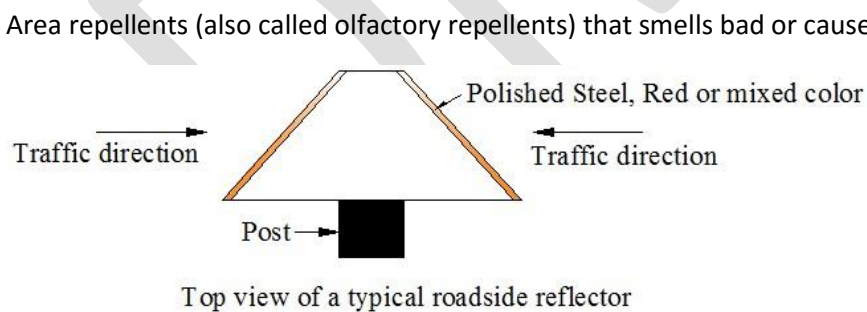
A variable message sign (VMS) or dynamic message sign can be used to display messages to drivers. The signs may be permanent, or can be changed or tailored to suit requirements of the drivers' or the road conditions or wildlife in the landscape.



**Figure 4.7:** A typical caution sign

#### 4.5.5 Roadside reflectors and mirrors

These are applied as potential wildlife vehicle crash countermeasures. These devices reflect the light from oncoming vehicle headlights and dispersed into adjacent roadside habitat areas or the road ahead and frighten, distract or alarm animals from crossing or coming on to the road. Figure 8 shows a cross section of a typical roadside reflector.



**Figure 4.8:** Cross section of a typical roadside reflector

applied across the area to be protected. Pesticides should not be used as olfactory repellents.

Other measures such as increasing visibility of road ahead with adequate provisions of lighting, clearing vegetation,

reducing traffic volume or modifying the road alignment may be adopted as mitigation measures.

Depending on the site conditions, and the presence of wildlife, the types of measures are to be ascertained.

#### 4.5.6 Maintaining slopes

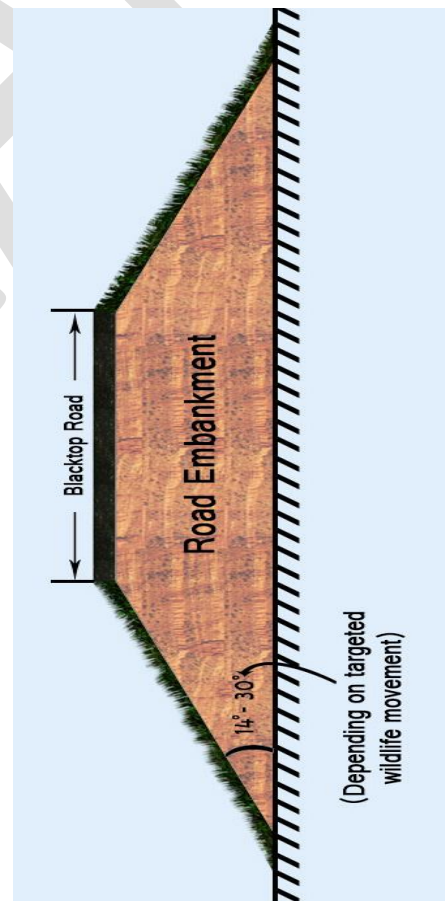
Formation of embankments for roads, rails or canals are common with slopes of varying degrees. These slopes must be designed not only with the structural safety and drainage management point of view but also to facilitate negotiation by the targeted wildlife. Cross-sloped path may be provided to reduce the angle of wildlife passing. For slopes appropriate to particular species, refer to Table 3. Generally, a slope of less than 14 degrees is good for most wildlife. Figure 9 shows a typical slope of a road embankment.

**Figure 4.9 (a):** A typical slope for road embankment

If the level difference is more than 4.0 m suitable landing should be provided for the targeted species. Such crossings should be provided at the interval of 500 to 1,000 m depending on the structure type, habitations, topography of the area, and targeted species. This is also relevant to canals in cutting slopes, embankments and canal lining slopes. Depending upon the situations, animals should be facilitated or barred from entering into and out of canals.

#### 4.5.7 Barriers and fencing

Where appropriate crossings are provided in the roads, railways or canals, we may fence or obstacles the right of way of such a structure. Fencing is important to guide the targeted wildlife use the prescribed path towards the crossing structure and funnel them with appropriate barriers. The fencing should be suitably tied at the end of the forest areas so that the wildlife does not get trapped outside the fenced areas. The formation height and its slope also work as obstacles to many wildlife. The length of the fence depends upon the home range of the targeted species. The obstructing heights and slopes for different wildlife are given in Table 3. Figure 10 shows a typical fence of random rubble stone.



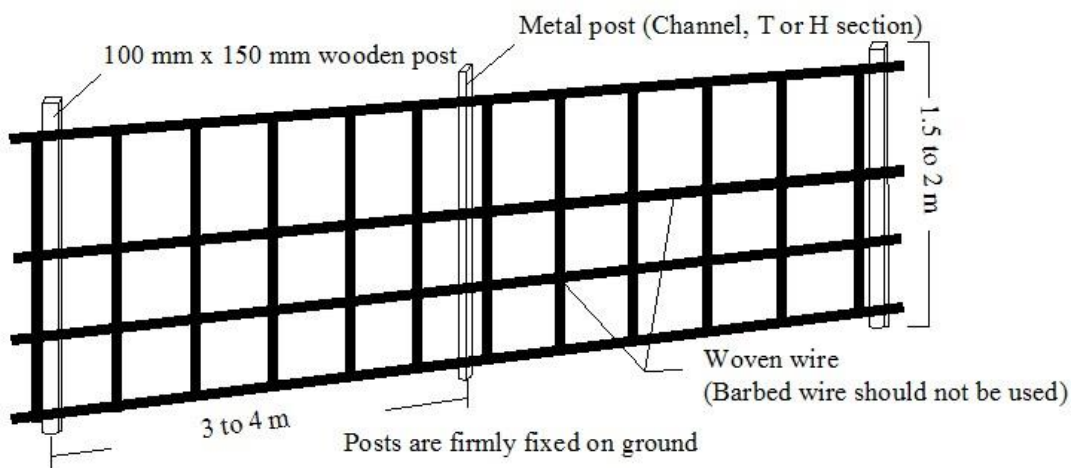
**Figure 4.9 (b):** X-section of typical slope for an embankment





**Figure 4.10:** A typical fence of random-rubble stone.

High 'page wire' fencing of wooden or steel posts may be used for large and medium sized animals to barricade them to reach the highways or railways. Different types, sizes and designs may be used to guard the targeted wildlife from reaching the roadways or railways. A typical sample of a fencing for large wildlife (Figure 11) has been shown. Barbed, razor or concertina wire shall not be used for the mesh of such fencings. A shallow channel with egresses alongside the outer periphery of the fence may be provided. Care should be taken lest the wildlife should be trapped inside the fenced area. Appropriate gates/doors, jump outs or egresses must be provided. Fences may be combined with the light screen and noise barrier.



**Figure 4.11:** A typical page wire fencing

Electric fences with high voltage, low amperage charge that delivers short pulses are in use to guard off wild animals. The high of such a fence may be 1.2m to 2.1m depending on the species. Such fences shall only be used for creating psychological fear in animals but not to cause any sort of injury to them. Should there is any risks of physical injury or behavioral change of the animals, it should be avoided. Moreover, installation of any electric fence requires regular inspection for damage and monitoring the supply of current.

#### *4.5.7 Light Screen, Noise Barrier and Side Railing*

Road traffics and trains cause light pollution and so it is desirable to block the light from wildlife, especially at the meadows, crossing underpasses/overpasses, or other intense use areas like water holes, salt liches, etc. Side railings of elevated highway bridge should be made sufficiently high so that glare of head light of vehicle should not fall on wildlife movement track. Also the look of the structure should match to the surrounding landscape which can be achieved by using different coloring patterns on the outer side of the structure. Certain creepers could also be planted on the side railings with hump of earth at the bottom as a vegetative cover. The humps and walls help block the noise. The barrier wall or railing should be at least 2.5 meters high. The thickness of the wall vary depending upon the prominent noise sources and sound coefficient of the materials used. Panel board of wood, steel, concrete (precast or cast-in-situ), plastic, brick and masonry block, gabion wall (stone crib), etc. can be used for wall material. The design or construction of the horizontal joints and connections between panels must be sound to preclude sound leaks due to gaps or opening. Other aspect to be considered for selection of particular type of the barrier are: ease of installation, structural stability, aesthetic, drainage and other utilities, safety, ease of maintenance, availability of material and cost effective. Figure 12 shows a typical gabion wall for sound and vibration control.



**Figure 12: A typical gabion wall for noise barrier**



#### *5.5.8 Animal Jump-out*

The fences or obstacles provided, may sometimes trap animals. Similarly, the long cutting slopes of irrigation or other canals where the structure itself may trap the wildlife, it is necessary to provide animal jump-outs. It should be one at every km or two. It is comprised of an animal trap whereby there will be wider section of slopes that can be negotiated by the animals and the landing from where the animals can jump-out from the right-of-the-way. Figure 13 shows a typical animal jump-out.



Figure 4.13: **A typical animal jump-out**

#### *4.5.9 Factors to be considered for upgrading structure*

Environment impact assessment, feasibility and detailed study conducted for upgrading a linear infrastructure should consider factors such as the type and nature of the infrastructure to be upgraded with respect to the natural features, distribution of wildlife, their mobility, and sensitivity to disturbances due to construction activities and possibility of post-construction increase in traffic density and vehicle, existing and possible fragmentation of their habitats, and the structure to be upgraded with all possible mitigating measures.

#### *4.5.10 Water flow maintaining*

Due to roads, railways or canals construction, formation cutting or filling may obstruct the sheet flow of storm-water and even change the drainage pattern of the landscape. So provide adequate cross drainage based on discharges, desirably at 100 to 200 m interval. Preferably, place cross-drains at the ridges so that erosion does not trigger. These structures can also be designed to accommodate small mammals and Herpetofauna.

#### 4.5.10 Lighting

Lighting should be designed for the minimum light spillage beyond the roadways or railways to minimize its impact on wildlife movements. For further details, refer to Sections 5.10.

#### 4.5.11 Drainage

The drainage system should be designed as per the requirement of the surrounding lands and the landscape. The concrete or blockwork system, if there is any, should be concealed with vegetation cover. Locally available natural materials should be used for construction of the system as far as practicable. The system components should be so designed that these add to nature conservation. The system must protect the watercourse and must not pollute ground water. It should help reduce flooding effects and control erosion. Properly designed and constructed balancing ponds with natural contours, flow and shallow edges that allow vegetation growth may work for migration of amphibians but weep holes, filter drains, deep gullies carrying erosions, and catch pits for carrying sediment are potential traps for amphibians and reptiles. So the system must be designed and constructed to avoid such structures.

#### 4.5.12 Raising high tension electric lines

The cable and towers of electricity system should be raised to protect from climbing animals and creepers.

Nepal Road Standard, 2070 states that vertical clearance for high voltage electric cables from the road surface shall be as follows:

Table 3: Vertical Clearance for High electric cables

Cable Voltage (kV)	1	110	132	220	330	550	720
Minimum Vertical Clearance (m)	6.0	7.0	7.5	8.0	8.5	9.0	16.0

If there is any tree by the side of the cable, it should not fall on or swing closer to the cable. The minimum gap between the cable and swinging cable is 3.7 m for 33KV line. For higher voltage cable the gap should be 3.7 m plus 0.3 m for every additional 33 KV.

Similarly, the Indian Electrical Rule, 1957 recommends the vertical clearance for high voltage electric cables railways as given in Table 3

Table 3: Minimum height above railway as per IE-1957

Voltage	Above 66 KV -132 KV	Above 132 KV - 220 KV	Above 220 KV – 400 KV	Above 400 KV - 500KV	Above 500 KV - 800KV
Broad Meter & Narrow Gauges (m)	14.60	15.40	17.90	19.30	23.40



#### *4.5.13 Cost consideration*

Planning, design, construction and maintenance of wildlife crossing structures are largely variable and dependent on the overall cost for them which largely depends on construction cost. Too high cost of construction of wildlife crossings compared to the construction of the roadway can be a deterrent factor as the decision is often based on the expected return on investment (RoI). RoI calculation should base on ecological benefits, increased safety, and saving cost for reduction on human-wildlife conflict measures. Ecological benefits may include creation of wildlife corridors, reduced effects of fragmentation, reduced road mortality, and overall improvement in environment. Reduction in animal-vehicle collisions leading to reduction in deaths, injuries, and property damage may be counted as cost saving.

## CHAPTER 6

### CHAPTER 6

#### Conclusion

With this and similar backdrops, it goes without further justification that while constructing such linear infrastructures, the aspects of environment, ecology and biodiversity must be integrated from the inception stage through project design, formulation, and construction stages of infrastructure projects to conserve the environment, ecology and biodiversity through maintaining connectivity of eco-corridors affected by the structures. Early involvement with various stakeholders, and experts in the subject is essential to avoid and minimize impacts. Moreover, adopting environment friendly construction activities such as disposing of spoil materials safely with minimum disturbance to environment, using least pollutant equipment, using local and environment friendly materials, resorting to bio-engineering works as mitigation measures, taking due care for protecting water sources including water holes and conserving eco-services will add on to the construction and maintenance of sustainable and wildlife friendly structure.

# APPENDIX

## APPENDIX

### LEGAL FRAMEWORK

#### A. INTERNATIONAL LEGAL FRAMEWORKS

##### *A-1 International Conventions and Agreements*

There have been a number of international conventions related to or focusing on biodiversity issues. Each of the convention works to implement some set of actions having national, regional, multilateral/global scopes that are implemented by member countries and signatories to the Conventions at the local level to achieve common and/or shared goals and objectives of conservation and sustainable use of nature and eco-systems.

The major international conventions have been briefed below:

##### *A-1.1 International Plant Protection Convention, 1952.*

The International Plant Protection Convention (IPPC) is an international plant health agreement, established in 1952 under Food and Agriculture Organization of the United Nations. It aims to protect cultivated as well as natural flora and plant products by preventing and controlling the introduction and spread of their pests. The convention has 182 Parties.

##### *A-1.2 Convention on Migratory Species or Bonn Convention, 1983*

The Convention on Migratory Species Convention (CMS) is one of the first biodiversity-related Conventions. It aims to conserve terrestrial, marine and avian migratory species throughout their range by building and strengthening global conservation efforts.

The Convention provides a global platform for the conservation and sustainable use of migratory animals and their habitats. It assembles the States through which migratory animals pass, the Range States, and lays the legal base for globally concerted conservation measures throughout a migratory range. Currently, a total of 553 species of migratory animals including mammals, birds, fish, and reptiles have been included in Appendix I and II of CMS for conserving the species and their habitats by range countries and species passing through the countries.

#### *A-1.3 Convention on Biological Diversity, 1993 -1994*

Biological resources are vital to humanity's economic and social development. It has great value to present and future generations but extinction of species is at alarming rate due to various anthropogenic activities. In response to halt this frightening situation, the Convention on Biological Diversity entered into force on 29 December 1993 after the Rio "Earth Summit" in June 1992. It has 3 main objectives:

- i) Conservation of biological diversity,
- ii) Sustainable use of the components of biological diversity, and
- iii) Fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

The Convention have two major protocols known as

- i) Cartagena Protocol for Bio-safety, and
- ii) Nagoya Protocol for access to benefit sharing received from the biological resources.

The Convention has 196 State Parties. The Meeting of the Conference of the Parties is the apex body of the Convention for providing guidance and making decisions. Nepal joined the Convention in 1994 and has prepared National Biodiversity Strategy and Action Plan 2014-2020 for meeting the Aichi Targets set by the Convention by 2020.

#### *A-1.4 UNESCO World Heritage Convention, 1972*

In November 1972, World Heritage Convention was adopted by the UNESCO General Conference. It aims at increasing awareness for shared responsibility by all nations of the world for protection and conservation of natural and cultural heritages and their transmission to future generation. The Convention has become internationally instrumental to identify and protect world's heritage of outstanding universal values. The most significant feature of the Convention is that it associates the concepts of nature conservation with the preservation of cultural properties. There are 191 Parties of the Convention. There are all together 911 world heritage properties in the world comprising of 704 Cultural, 180 Natural and 27 Mixed Categories. General Assembly is the apex body of the Convention for making policy and decision concerning the world heritage properties.

#### *A-1.5 Convention on Wetlands of International Importance (Ramsar Convention), 1972*

The Convention on Wetlands of International Importance, also known as the Ramsar Convention, is an intergovernmental agreement that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The wetlands are the prime habitats for wetland birds, forest and migratory birds, and wild animals. It promotes wise-use of wetlands and their resources and livelihood enhancement of wetland dependent communities. The Convention was adopted in the Ramsar city of Iran in 1971 and now it has 169 Contracting Parties. Almost

90% of the UN member countries have acceded to become the Contracting Parties of the Convention. Currently, there are 2,240 Ramsar Sites in the world covering about 215,240,1 km<sup>2</sup>, about 15 times the area of Nepal. The Meeting of the Conference of the (Contracting) Parties is the apex body of the Convention for making policy decisions.

#### *A-1.6 Convention on International Trade in Endangered Species of Wild Fauna and Flora – CITES, 1975*

The Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Appendix I of CITES includes species threatened with extinction, and any trade in specimens of these species is permitted only in exceptional circumstances. Similarly, Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival, and Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade. In this way, the Convention accords varying degrees of protection to more than 30,000 plant and animal species. It has 183 Parties or States as of now.

#### *A-1.7 International Treaty on Plant Genetic Resources for Food and Agriculture, 2004*

The treaty recognized the enormous contribution of farmers to the diversity, distinctive features of crops that feed the world, and established a global system to provide farmers, plant breeders and scientists with access to plant genetic materials to ensure sharing of benefits to the recipients they derive from the use of these genetic materials. The treaty also aims for sustainable agriculture and food security along with promotion of Farmers' Rights at national and international levels.

### **B. Relevant Acts, Rules and Regulations of Nepal**

#### *B.1 Constitution of Nepal, 2015*

Clause 51 (g) under State Policies of the Constitution of Nepal outlines policy regarding the conservation, management and use of natural resources as “The State shall pursue a policy of conserving the natural resources available in the country by imbibing the norms of inter-generation judicious use of it and for the national interest. It shall also be about its sustainable use in an environmental friendly way...”. “The State shall pursue a policy of making a sustainable use of biodiversity through the conservation and management of forests, fauna and flora, and by minimizing the negative impacts of industrialization and physical development by promoting public awareness on environmental cleanliness and protection. The State shall pursue a policy of keeping necessary landmass as forest area in order to strike an environmental balance. The State shall pursue a policy of adopting appropriate ways of minimizing or stopping negative effects on environment if it is there, or if there is a possibility of such an impact on nature, environment, or biodiversity. The State shall formulate policies and enact laws on the basis of the principle of sustainable environment development based on early warning and pre-informed agreements regarding environmental protection.”

### *B.2 National Parks and Wildlife Conservation Act, 2029 (1973 AD)*

National Parks and Wildlife Conservation Act, 2029 promulgated in 1973 is the main legal base for wildlife conservation and management of protected areas in Nepal. The Act, following the IUCN category of protected areas, has defined various types of protected areas, listed number of endangered species of wild fauna found in Nepal as protected species. Currently, there are 10 National Parks, 3 Wildlife Reserves, 6 Conservation Areas, one Hunting Reserve, and 12 Buffer Zones of national parks and wildlife reserves. The Act includes 27 species of mammals, nine species of birds and three species of reptiles in the protected species list of Nepal. The Act and the related rules explicitly prohibit any action in protected areas that damages or is detrimental to wildlife and their habitats such as blocking or diverting the water sources, construction of amenities, hunting/poaching, removal of wildlife or forest products, poisoning, forest fires, grazing, etc. Some of the Rules framed under the Acts are: National Parks and Wildlife Conservation Rules, 2030; Conservation Area Management Rules, 2053; Himalayan National Park Rules, 2036; Kanchenjunga Conservation Area Management Rules, 2064; Khaptad National Park Rules, 2044 and Wildlife Reserve Rules, 2034.

### *B.3 Plant Protection Act, 2064 (2007 AD)*

The Plant Protection Act, 2007, and the Plant Protection Rules, 2066 ensures legal provisions for preventing the introduction, establishment, prevalence and spread of pests while importing and exporting plants and plant products, promoting trade in plants and plant products by adopting appropriate measures for their effective control in the country.

### *B.4 Forest Act, 2049 (1993 AD)*

In Nepal, different types of forests such as national forests, community forests, leasehold forests, religious forests and protection forests are managed under this Act and forest rules framed under it. The Clause (68) Use of Forests under the Act states that the Government of Nepal shall approve to release certain forest areas from the above mentioned forest types for national priority plans only which have no significant impact on forests under the condition that there is no any other alternative. The government has banned cutting, transportation and export of *Sal*, *Khair* and *Chap* among tree species along with several other medicinal plants and herbs.

### *B.5 Environment Protection Act, 2053 (1997 AD)*

Environment Protection Act 2053 and the Environment Protection Rules 2054 require to have Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) depending upon the nature and size of the proposed project. The Rule (3) of the Environment Protection Rules 2054 has classified the projects depending upon its nature and size that requires IEE in Appendix I and EIA in Appendix II. The Clause (7) of the Appendix II mentions about the need for EIA of those projects falling within forests, national parks, reserves, buffer zones and environment conservation areas.

#### *B.6 Animal Health and Livestock Services Act, 2055 (1999 AD)*

The Animal Health and Livestock Services Act, 2055 and Animal Health and Livestock Services Rules, 2056 set legal provisions for establishing quarantine check posts with specific mention of international points for export and import of animals, product materials covering international airports, points transportation of animals, products of animal origin or livestock products.

#### *B.7 Aquatics Protection Act, 2017 (1961 AD)*

The Aquatics Protection Act, 2017 and Aquatics (Contract) Rules, 2019 make legal provision for sole authentication for the Government of Nepal to give or not to give a particular type of water or aquatics on contract basis. The Act emphasizes on the need and value of wetlands and aquatic animals. Section 3 of the Act provisions punishment to any one or party introducing poisonous, noxious, or explosive materials into water sources and/or destroying, damaging dams, bridges, or water systems with the intent of watching or killing aquatic life.

### **C Relevant Working Policies, Standards and Guidelines**

#### *C.1 National Conservation Strategy, 2045 (1988 AD)*

The National Conservation Strategy, 2045 stresses on sustainable use of natural resources and compatible land-use. It aims to satisfy the basic needs of the people by ensuring sustainable use of land and renewable resources and preserving and maintaining the biological diversity and ecology of the country.

#### *C.2 Forest Policy, 2071 (2015)*

The Forest Policy aims to maintain the environmental balance through conservation and management of forest, wetlands, wildlife and conservation areas. It also envisages to increase the forestry products and enhance livelihood of the community dependent on forest resources.

#### *C.3 Nepal Road Standard, 2070 (2013 AD)*

Nepal Road Standards, 2077 (Second Revision 2070) classifies roads for assigning national importance and level of government responsible for overall management and methods of financing as National Highways, Feeder Roads, District Roads and Urban Roads. Overall management of National Highways and Feeder Roads comes within the responsibility of the Department of Roads (DOR). These roads are collectively called *Strategic Roads Network (SRN)*. District Roads are managed by Department of Local Infrastructure Development and Agricultural Roads (DOLIDAR) and Urban Roads by municipalities.

Based on technical parameters and functionally, the roads are classified as:

Class I: These are motor ways or express ways. They will have divided carriageways and control accesses with average daily traffic (ADT) of 20,000 passenger car unit (PCU) or more, and the design speed (DS) is 60 to 120 km/h.

Class II: These are arterial roads with ADT of 5,000 - 20,000 PCU and DS of 40 to 100 km/h.

Class III: These are collector roads with the ADT of 2,000-5,000 PCU and DS of 30 to 80 km/h.

Class IV: These are local roads with the ADT of less than 2,000 PCU and DS of 20 to 60 km/h.

#### **Some other technical parameters of the Nepal Road Standards:**

Vertical clearances, measured from the crown of the road surface, for whole roadway width should be provided with 5 m on all roads. No obstructions shall be made on this space. Outlets from the side drains should be provided at no more than 500 m intervals. In rural open areas, it is desirable to plant trees at a distance of 12m from the edge of carriageways. All roads should be designed and constructed with proper assessment of all Environmental and Social aspects and their impacts following Environment Protection Acts and Rules. Road alignment should avoid preserved zones like national parks and other sensitive to flora, fauna and people. Bio-engineering techniques should be applied on road slope stabilization. All design elements of highways should properly blend with the surrounding elements of nature. Proper provisions of path should be made for migration of animals across the roads located in forest areas.

#### *C.4 EIA Guidelines for Forestry Sector, 2052 (1995)*

GoN has implemented a separate EIA guideline for the forestry sector. The guidelines facilitate the sustainable use of forest resources for the socio-economic development and meeting the basic needs of the communities. The positive and negative impacts of any development project in forest areas are to be identified and plans must be developed to minimize environmental damage and conserve genetic resources and bio-diversity. It encourages the proponent to identify likely impacts of the projects on the forests and propose mitigation measures for minimum impacts on forests and biodiversity.

#### *C.5 Environmental Management Guidelines (Road), 2054 (1997 AD)*

This guideline prepared by Department of Road explains the process and methods of study in different cycles of environmental studies and matters to be included in the EIA report. All the new and upgrading road development projects are mandated to comply with the guideline provisions to ensure that the road development project is environmentally sustainable.

#### *C.6 Guidelines on Use of Forest Area for Other Purposes, 2063 (2006 AD)*

The Guidelines stress the use of the forest area only if other options are not available. The projects requiring the forest land area have to make alternative studies to minimize the forest land use areas. Development project with national priority will be allocated such lands on the discretion of the Ministry of Forest. To compensate the forest area and resource loss, the project proponent has to comply with the following provisions:

The proponent has to afforest the area equal to the forest area lost at the minimum, if the forest area occupied by the project is a barren land. The land area for afforestation will have to decide based on the



discussion with the district forest office. Or, the proponent could deposit the required amount as per forest norm to the district forest office.

The proponent should plant 25 trees for every lost tree of above 30cm diameter at breast height (DBH) in areas designated by the district forest office and look after the plantation for 5 years to ensure their protection and growth of every planted tree. Or, the proponent deposits the required amount for plantation and protection for five years to the district forest office.

The proponent will have to compensate the lost forest land for 30 years. The compensation amount for the forest land per hectare will be as per the provisions of leasehold forest.

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## BIBLIOGRAPHY

A.S Kelly (2016), Wildlife Crossing: Locating species movement corridors in Tanintharyi: WWF Myanmar, Myanmar.

Baral, H.S. and Shah, K.B. (2008). Wild Mammals of Nepal: Himalayan Nature: Kathmandu, Nepal.

Bhattarai, G.P., and Rupakheti, N. (2071). Flora and Fauna of Nepal in CITES Annexes: Government of Nepal/Ministry of Forests and Soil Conservation/Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.

Beckmann J P and et.al. (2010) (Edited), Safe Passage: Highway, Wildlife and Habitat Connectivity: Osland Press, Washington/Covel/London.

CMS (2014), Guidelines On Mitigating The Impact Of Linear Infrastructure And Related Disturbance On Mammals In Central Asia: UNEP/CMS/COP11.

DNPWC (2015). Collection of Policies and Legislations related to Protected Area Management and Wildlife Conservation in Nepal (Act, Regulation, Policy, Working Policy, Working Procedure and Guidelines), Government of Nepal/Ministry of Forests and Soil Conservation/Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.

DNPWC (2014). Status of Tigers and Prey in Nepal: GON/MoFSC/DNPWC, Kathmandu, Nepal.

DNPWC (2013). Annual Report F. Y. 2069 Shrawan- 2070 Asar (2012 July – 2013 July), Government of Nepal/Ministry of Forests and Soil Conservation/Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.

Helsingen Hana & et.al.(2015), An overview Report: A better raod to Dawei: WWF Myanmar.

ENGLISH NATURE, Rail Construction and Operational Effects on Biodiversity and Geological Interests, English Nature Research Reports (Report No. 473b).

GoN(2013); Nepal Road Standards 2070, Government of Nepal, Ministry of Physical Infrastructure & Transport, Department of Roads, Planning and Design Branch, Road and Traffic Unit, Babarmahal, Kathmandu, Nepal.

GoN(2006), Guidelines for use of Forest areas for other purpose: Ministry of Forest and Soil Conservation & Department of Forest, Nepal.

GoN (2015). Collection of Forests, National Parks and Environment related Acts and Regulations, Government of Nepal/Ministry of Law, Justice, Constitution Assembly and Constitutional Affairs, Law Book Management Committee, Kathmandu, Nepal.

GoN (2015). Collection of Nepal Regulations Part 13, Government of Nepal/Ministry of Law, Justice, Constitution Assembly and Constitutional Affairs, Law Book Management Committee, Kathmandu, Nepal.

GoN (2015). Constitution of Nepal, Government of Nepal/Ministry of Law, Justice, Constitution Assembly and Constitutional Affairs, Law Book Management Committee, Kathmandu, Nepal.

GoN/MoFSC (2014). Nepal Biodiversity Strategy and Action Plan 2014-2020: Government of Nepal, Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

Jnawali, S.R., Baral, H.S., Lee S., Acharya, K.P., Upadhyay, G.P, Pandey, M., Shrestha, R., Joshi, D., Lamichhane, B.R., Griffiths, J., Khatiwada, A.P., Subedi, N., and Amin, R. (compilers) (2011). The Status of Nepal Mammals: The National Red List Series, Kathmandu, Nepal.

MMM Group Limited, Canada (2015), EIA report of Narayanghat Muglin Road, Nepal.

National Board for Wildlife, Ministry of Environment and Forests, India (2011), Guidelines for linear infrastructure intrusions in natural areas: roads and power lines: Government of India, India.

Prater, C.M.Z.S. (1971). The book of Indian Animals: Third (Revised) Edition, Bombay Natural History Society, Hornbill House, Bombay, India.

Scott Wilson Nepal (2014), Beyond Investment: Developing Sustainable Green infrastructure in Nepal: WWF Nepal.

Shah, K.B. and Tiwari, S. (2004). Herpetofauna of Nepal: A Conservation Companion IUCN- The World Conservation Union, Nepal.

Sharma, B.K. (2014). Bioresources of Nepal. Subidhya Sharma, Kathmandu, Nepal.

Sharma DK, (2019). An assessment of Impact of rail and road project in biodiversity conservation in Chitwan National Park: B.Sc. Thesis, Institute of Forestry, Nepal.

Stracey, P.D. (1963). Wild Life In India: Its Conservation and Control, Ministry of Food and Agriculture, Department of Agriculture, Government of India, India.

University of Hong Kong (2016), Design Manual: Building a sustainable Road to Dawei: WWF Myanmar.

WILDLIFE CROSSING STRUCTURE HANDBOOK Design and Evaluation in North America, Publication No. FHWA-CFL/TD-11-003, March 2016.

RTA WILDLIFE LINKAGES PROJECT FUNDING PROPOSAL, La Cholla Boulevard Widening from Overton Road to Tangerine Road OV Project No. OV 30 04/05 26; June 23, 2016

Heather R. Chasez, Ray Emmett, Ph.D., Daniel J. Smith, Ph.D., AICP, Tom Roberts, Stephen Tonjes. DESIGN ELEMENTS OF WILDLIFE CROSSING STRUCTURES, A LITERATURE REVIEW

P. García, 2009. Animal Biodiversity and Conservation- Mortality of vertebrates in irrigation canals in an area of west-central Spain.

[http://www.iene.info/wp-content/uploads/COST341\\_Handbook.pdf](http://www.iene.info/wp-content/uploads/COST341_Handbook.pdf). Accessed on 16 August 2016.

<http://www.conservationevidence.com/actions/884>. Accessed on 25 November 2016.

<https://escholarship.org/uc/item/6m2252jz#page-1>. Accessed on 06 December 2016.

<https://www.cbd.int/countries/?country=np>. Accessed on 20 September 2016

[http://www.gabions.co.nz/gabion\\_erosion\\_control.htm](http://www.gabions.co.nz/gabion_erosion_control.htm). Accessed on 06 December 2016.

<http://www.lawcommission.gov.np/>. Accessed on 25 September 2016.

[http://www.fao.org/docrep/v8350e/v8350e0b.htm#biological and ecological change](http://www.fao.org/docrep/v8350e/v8350e0b.htm#biological%20and%20ecological%20change). Accessed on 2 September, 2016.

[http://www.virginiadot.org/vtrc/main/online\\_reports/pdf/06-r2.pdf](http://www.virginiadot.org/vtrc/main/online_reports/pdf/06-r2.pdf). Accessed on 05 December 2016.

[http://www.icoet.net/ICOET\\_2013/documents/papers/ICOET2013\\_Paper401C\\_ConnollyNewman\\_et\\_al.pdf](http://www.icoet.net/ICOET_2013/documents/papers/ICOET2013_Paper401C_ConnollyNewman_et_al.pdf). Accessed on 25 December 2016.

[http://www.dairynz.co.nz/media/256080/8-7\\_Road\\_underpasses\\_2012.pdf](http://www.dairynz.co.nz/media/256080/8-7_Road_underpasses_2012.pdf). Accessed on 05 December 2016.

<http://www.deercrash.org/Toolbox/CMTtoolboxCrossings.pdf>. Accessed on 28 October 2016

[http://www.carcnet.ca/english/tunnels/amph\\_tunnels.php](http://www.carcnet.ca/english/tunnels/amph_tunnels.php). Accessed on 22 November 2016

[http://corridordesign.org/designing\\_corridors/linkage\\_designs/mitigating\\_barriers](http://corridordesign.org/designing_corridors/linkage_designs/mitigating_barriers). Accessed on 04 Oct. 2016.

<http://wildliferoadsharing.tirf.org/research/mitigation-measures/>. Accessed on 30 November, 2016

<http://wti.org.in/oldsite/publications/right-of-passage.pdf>. Accessed on 07 October 2016.

<http://www.fao.org/docrep/010/y4454e/y4454e00.htm>. Accessed on 30 November 2016.

[https://roadecology.ucdavis.edu/files/content/projects/DOT-FHWA\\_Wildlife\\_Crossing\\_Structures\\_Handbook.pdf](https://roadecology.ucdavis.edu/files/content/projects/DOT-FHWA_Wildlife_Crossing_Structures_Handbook.pdf). Accessed on 28 October 2016.

<http://www.currentresults.com/Environment-Facts/Plants-Animals/number-species.php>. Accessed on 14 December, 2016

<http://www.wildlifeandroads.org>, Accessed on 29 Sept. 2016.

[http://www.fhwa.dot.gov/environment/noise/noise\\_barriers/design\\_construction/design/design04.cfm#sec4.1.2.1](http://www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/design/design04.cfm#sec4.1.2.1). Accessed on 18 December, 2016.

<http://www.in.gov/dnr/fishwild/2718.htm>. Accessed on 28 December 2016.

<https://www.google.com/patents/US5939987>. Accessed on 28 December 2016.

<https://www.ncbi.nlm.nih.gov/pubmed/21676031>. Accessed on 28 December 2016.

<http://www.preformedsa.co.za/PDF/Enviro/Double%20Loop%20Bird%20Flight%20Diverter%20%20E%20-%203.pdf>. Accessed on 28 December, 2016.

[http://www.nature.org/cs/groups/webcontent/@web/@panama/documents/document/prd\\_258473.pdf](http://www.nature.org/cs/groups/webcontent/@web/@panama/documents/document/prd_258473.pdf). Accessed on 29 December, 2016.