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Training Resource Material

Content Module 1
An Introduction to Human-Wildlife Conflict Mitigation: Taking a Holistic and Harmonious Coexistence Approach

A Holistic Approach to Human-Wildlife Conflict (HWC) Mitigation in India

Imprint
Training Resource Material: A Holistic Approach to Human-Wildlife Conflict (HWC) Mitigation in India

Module HWC-01:	An Introduction to Human-Wildlife Conflict Mitigation: Taking a Holistic and Harmonious Coexistence Approach
Module HWC-02:	The Overall Context: Understanding HWC in a Development Context
Module HWC-03:	Legal, Policy, and Administrative Framework for HWC Mitigation in India
Module HWC-04:	Tools and techniques for effective and Efficient Human-Wildlife Conflict Mitigation
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Module HWC-08:	A Primer on Developing Leadership and other Non-technical Competencies for HWC Mitigation
Module OH-01:	An introduction to the One Health Approach, Zoonotic and Other Emerging Diseases

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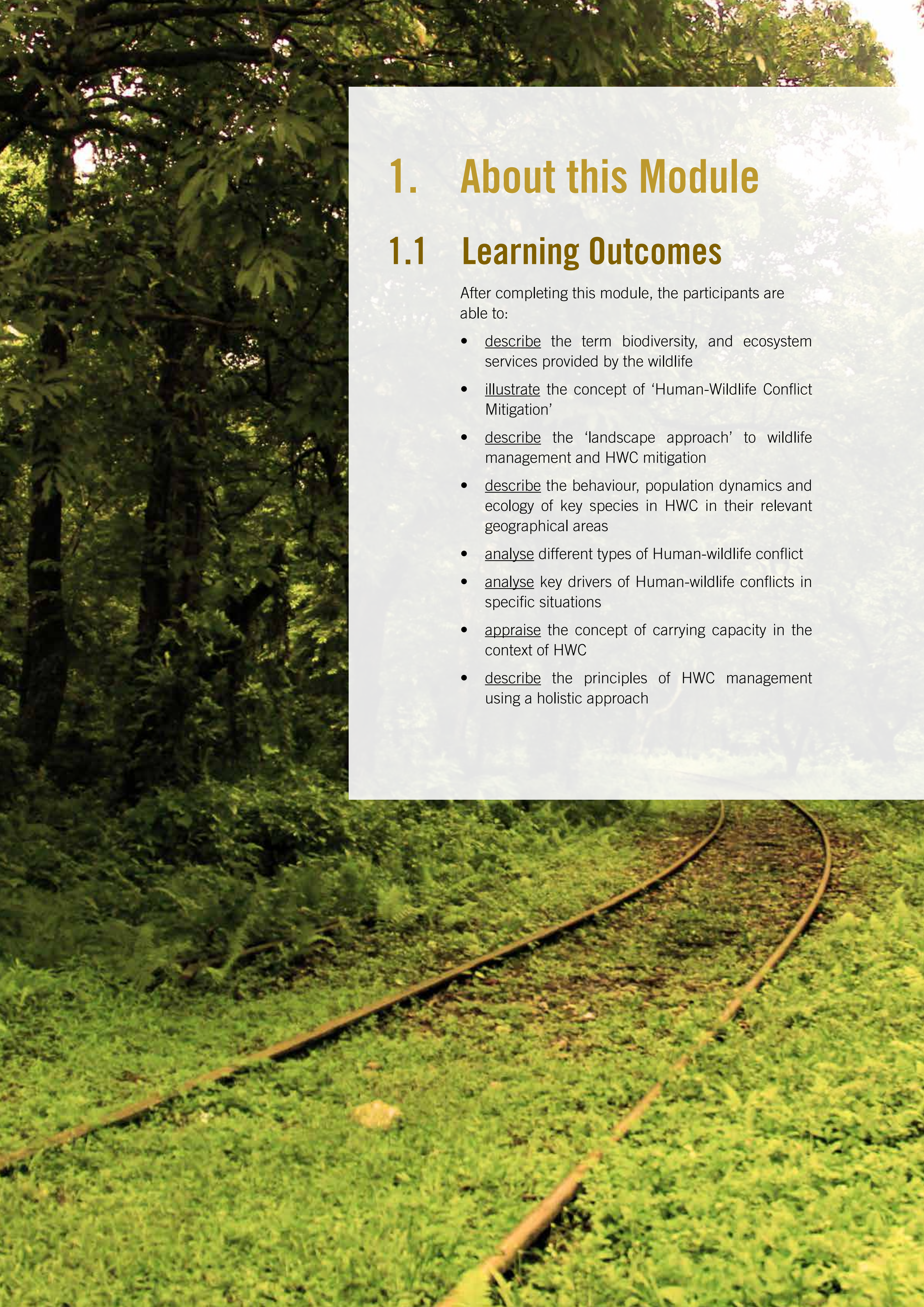


1. About this Module

1.1 Learning Outcomes

After completing this module, the participants are able to:

- describe the term biodiversity, and ecosystem services provided by the wildlife
- illustrate the concept of 'Human-Wildlife Conflict Mitigation'
- describe the 'landscape approach' to wildlife management and HWC mitigation
- describe the behaviour, population dynamics and ecology of key species in HWC in their relevant geographical areas
- analyse different types of Human-wildlife conflict
- analyse key drivers of Human-wildlife conflicts in specific situations
- appraise the concept of carrying capacity in the context of HWC
- describe the principles of HWC management using a holistic approach

1.2 Summary

This module facilitates understanding of the basic concepts of biodiversity, wildlife and ecosystem services leading to the fundamentals of human-wildlife conflict (HWC), its drivers and pressures, current state and trends, impacts, and current response measures. At the same time participants will be encouraged to think and discuss a holistic approach to HWC mitigation, i.e. the drivers, prevention and reduction of impacts, traditional and indigenous measures, and the relevant sectors and key stakeholders in India. The first section facilitates the participants in getting a deeper and more comprehensive understanding of the harmonious co-existence approach, holistic approach to mitigating human–wildlife conflict and One Health. Section two of the module provides HWC profile of selected wildlife species-in-conflict, intended at preventing accidental encounters and for designing effective and wildlife-friendly mitigation measures that are aligned with animal behaviour and ecology.

1.3 Key messages

- 'Biological diversity' means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes the diversity within species and between species and the diversity of ecosystems

- There are two ways to conserve biodiversity: (1) by measuring and managing functional biodiversity and (2) by using biodiversity surrogates. In an ecological context, a 'surrogate' is a component of the entire biodiversity that one can more easily measure than others, and is used as an indicator of the greater biodiversity in a given area. Keystone species, umbrella species, indicator species and flagship species are examples of surrogate species.

- Wildlife provides a wide range of ecosystem services to human society, including supporting, regulating, cultural and provisioning services. The consequences of biodiversity and wildlife loss and the resulting impacts on ecosystem services affect human livelihoods and overall well-being.

- The term Human-Wildlife Conflict refers to the negative interaction between humans and wild animals, leading to adverse impacts such as injury or loss of human lives, crop, livestock and other properties, or even their emotional well-being, and equally negative impacts on wild animals and / or their habitats.

- When HWC is not adequately addressed, it generates a negative attitude towards overall wildlife conservation as people see all wild animals as a threat to their survival; the support for the conservation of forests reduces and a rift develops between the community and the Forest Department.

- HWC has immense physical, economic and ecological impacts on both humans and wildlife. It results in crop damage, property damage, livestock loss, disease, injury and loss of both human and wildlife. The indirect and hidden impacts of HWC are often not taken into consideration. Rural poor and women are the most vulnerable sections of society affected by HWC. The negative interactions with wild animals can cause a fear psychosis, which can prevent people from living normal lives. As the perceived threat is more pronounced in the mornings and evenings, the fear can impact the timings of work, social gatherings, markets, places of worship and children's schools.

- HWC mitigation refers to the interventions to reduce the negative impact of human-wildlife interaction on humans or their resources and on the wildlife or their habitats; it includes strategies to address the drivers and pressures of conflict, reducing the vulnerability of humans and wildlife, and institutional capacity development.

- In the absence of a comprehensive database on HWC at the national and state level, an assessment of its financial impact at the individual, community and population level is difficult. A national HWC mitigation database and monitoring system in India facilitates information management on HWC situation and strengthens our understanding on the drivers and pressures of HWC and effectiveness of the mitigation measures. It also supports evidence-based decision-making and policy formulation for HWC mitigation at the national and state level, and facilitates states in implementing state HWC mitigation strategies and action plans, as well as division/ landscape level planning leading to further strengthening of capacity development measures and prioritization of HC mitigation measures through long-term analysis.

- Harmonious coexistence is defined as a dynamic but sustainable state in which humans and wildlife adapt to living in shared landscapes, with minimal negative impacts of human-wildlife interaction on humans or on their resources and on wildlife or on their habitats. The mitigation measures designed using this approach maintain a balance between the welfare of animals and humans, giving equal importance to both. Overlaps in space and resource use are managed to minimise conflict. To find a balance, and to look towards 'harmonious co-existence' between human beings and wildlife, it is crucial to keep in mind that the issues of HWC arise from conflicting needs in a landscape, and therefore it is essential to take a landscape approach while designing mitigation measures.

- A holistic approach addresses the issue of HWC from three angles: (1) Addressing the drivers and providing a conducive policy environment through policy-making and cross-sectoral cooperation; (2) effective use of instruments, traditional knowledge and modern technology to prevent incidents of conflict and (3) reducing the impact of HWC on both humans and wildlife by way of compensation and awareness-raising. Improved exchanges on innovations in conflict mitigation and capacity development are foundation and continuing element of the holistic approach towards mitigating HWC.

2. Basics of Biodiversity

2.1 Definitions of biodiversity

‘Biological diversity’ refers to the diversity of life in all its forms and at all levels of organization. According to the Convention on Biological Diversity (CBD) of 1992, ‘biological diversity’ means the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes the diversity within species and between species and the diversity of ecosystems.

The biologist E.O. Wilson (1988) has a more detailed definition: ‘The variety of life at every hierarchical level and spatial scale of biological organizations: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, and biomes within the biosphere.’

2.2 Three levels of biodiversity

Biodiversity can be described at three levels: the diversity within a species (genetic diversity), the diversity of species (species diversity) and the diversity of ecosystems (habitat or ecosystem diversity).

2.2.1 Genetic diversity

'Genetic diversity' is the total number of genetic characteristics in the genetic makeup of a species. It is distinguished from 'genetic variability', which describes the tendency of genetic characteristics to vary.

Genetic diversity allows species to survive and adapt to changing environmental conditions. The greater the genetic diversity, the higher the likelihood that some individuals in the population will have the ability to adapt to the changing environment. Genetic variations enable changes to occur in an organism's anatomy or physiology to occur between generations that are subsequently instrumental in adaptation and survival.

A species that has high genetic diversity will have more variations, that can respond in many different ways. Genetic diversity is essential for survival in situations where there are external stresses in the form of disturbances, natural disasters, diseases, pollution, climate variability and climate change. Large populations generally retain higher genetic diversity, while small populations tend to experience the loss of diversity over time due to genetic drift, a random chance process in which an allele (a variant form of a gene) gets fixed and other alleles at the same locus are lost. Mutations are random and create genetic variation. They can have a negative, neutral or positive impact on fitness, and generally, the ones that have a positive impact are the ones that persist due to selection pressures. Larger populations will generate more mutations than smaller populations. 'Gene flow' is the movement of genetic material (through the movement of an individual or individuals) from one population to another. It increases the genetic variation in the receiving population by introducing novel alleles into it. In fragmented landscapes, corridors facilitate movement between patches or translocation of individuals between populations.

2.2.2 Species diversity

'Species diversity' refers to the number of species within a given context, which is generally an ecological community but can also be a geographical region, a landscape or a place. Species diversity consists of three components: species richness, taxonomic or phylogenetic diversity and species evenness.

Richness is a measure of the number of different species present in a particular area. For example, the number of different species present in each of communities A and B in Figure 1 is three, and so the richness of each community is three. Evenness compares the similarity of the population size

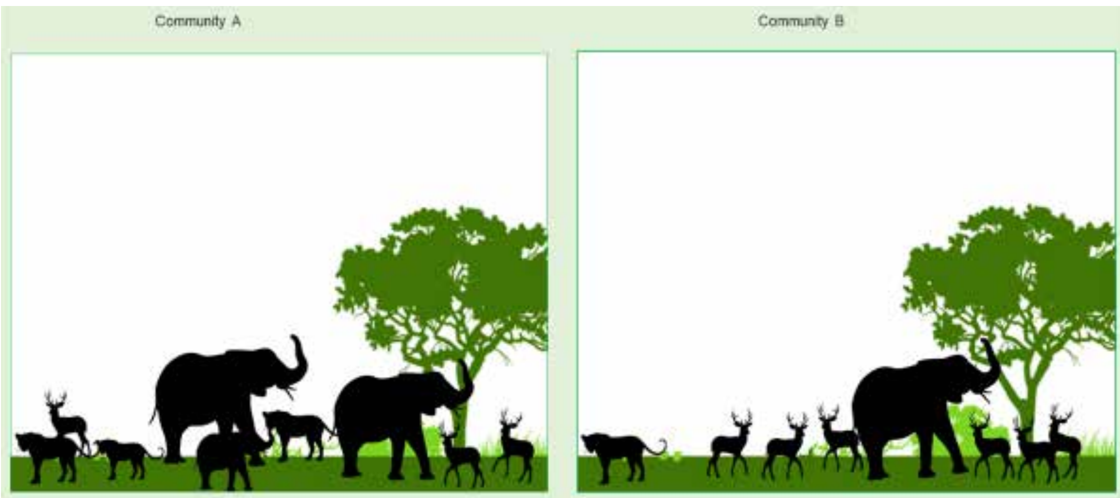


Figure 1. Species diversity and its relationship with species numbers (richness) and evenness (spread)

of each of the species present. Community A, with three individuals of each species, has a higher evenness than community B, which has three species with only one individual of each of two species and one species with six individuals. The product of richness and evenness shows that the total 'species diversity' of community A is higher.

2.2.3 Ecosystem diversity

'An ecosystem is made up of a community of organisms, their environment and the interactions between them. Ecosystems are formed on very different scales, ranging from microsites to the biosphere. A forest constitutes an ecosystem, as does a dead tree-trunk, a river, a pond, a mountain, a sea and even the entire planet'.

Depending on the scale, ecosystem diversity would then imply that a greater number of ecosystems within a specified area would result in greater species diversity. A community consists of the assemblage of populations of plants and animals that occupy an area and their interactions with each other and their environment.

'Habitat' means the space where an organism or population naturally occurs. 'Habitat diversity' refers to the distribution and abundance of habitats in a given geographical space. A region possessing a wide variety of habitats supports a much greater diversity of species than a region where there are few habitats. A variety of habitats also supports a different set of species exhibiting different genetic variations in that region/space. 'Ecosystem diversity' is a term that incorporates both habitat and community diversity. An increase in the number of habitats or an increase in the structural complexity of the habitats leads to increased species diversity. Different ecosystems maintain different material and energy cycles, with interconnected threads with other ecosystems and habitats. Maintaining ecosystem and habitat diversity, therefore, is crucial for ensuring the overall health of all ecosystems.

2.3 Three forms of biodiversity

The levels of biodiversity have been discussed in the previous section. Each of the three levels can be described further: What types of elements are there and in what numbers (composition), how are they arranged (structure) and what role do they play in the system (function).

2.3.1 Compositional biodiversity

'Compositional biodiversity' describes the types of biodiversity elements (at all the levels, i.e., gene, species and habitat) present in an area. The genetic composition of populations, the identity and relative abundance of species in a natural community and the types of habitats and communities distributed across the landscape are examples.

2.3.2 Structural biodiversity

'Structural biodiversity' describes the variety of arrangements of these components, i.e., the variety of ways in which different habitats, species or genes are arranged over space (spatial biodiversity) or time (temporal biodiversity). The different species assemblages found in different patches in an ecosystem offer examples of spatial diversity.

Like spatial heterogeneity, temporal fluctuations in environmental factors also regulate the biodiversity of a specific space. An example for the importance of time in relation to biodiversity is the dependence of fish breeding patterns on water availability, changing water temperature or seasonal flooding events, which are necessary for entire ecosystem functionalities. These temporal fluctuations support different species over different seasons/timescales and have a critical influence on ecosystem dynamics.

2.3.3 Functional biodiversity

Functional biodiversity is the variety of biological processes, functions or characteristics of a particular ecosystem. Functional biodiversity, therefore, describes the enormous variety of processes that occur due to the interaction of different species with each other and the interactions of the species with their physical environment. These processes include the climatic, geologic, hydrologic, ecological and evolutionary processes that generate biodiversity and continuously change it, e.g., nutrient cycling, pollination, predation, parasitism and germination.

Functional biodiversity is one of the main factors determining the long-term stability of an ecosystem and its ability to recover from major disturbances.

2.4 Conservation shortcuts

There are two ways to conserve biodiversity:

1. Measuring actual processes (functional biodiversity), e.g., pollination rate and pattern, rates of productivity, species interaction and securing all the processes. However, this would not be easy and would be time-consuming.
2. Using surrogates, which is simpler and based on certain assumptions like the conservation benefits of surrogate species, extends to a larger set of species and/or habitats. These are called 'conservation shortcuts.' Some conservation shortcuts are keystone species, umbrella species, indicator species and flagship species.

2.4.1 Keystone species

A keystone species has a disproportionately large impact on its community or ecosystem relative to its abundance. The Asian Elephant *(Elephas maximus)* is an excellent example of a keystone species that plays a key role in the health and diversity of an ecosystem. Elephants push down trees and disperse seeds, thus modifying the forest structure. Some tree species are solely dependent on Elephants for dispersal. Elephants also create paths, wallows, salt licks, and waterholes in their habitat which are then available for other species. All these actions then create new niches or enhance the habitat for other species. Thereby, their conservation facilitates increased biodiversity, its maintenance and conservation.

2.4.2 Umbrella species

Species whose spatial needs are quite large and that are ideally associated with many types of habitats and ecosystems confer protection to a large number of naturally co-occurring species in several ecosystems and habitats. Conserving and monitoring such a species and managing the ecosystem for its continued stability results in the maintenance of high-quality habitat for other species in the area. Good examples of this are the Asian Elephant (*Elephas maximus)* and the Royal Bengal Tiger (*Panthera tigris tigris*). Both occur in the tropical forests of South and Southeast Asia, from semi-arid dry thorn forests to wet evergreen forests. In terms of conservation, their spatial needs are very large, extending to several thousand square kilometers, although several protected areas are only a few hundred square kilometers in size. Therefore, the carrying capacity of these small and very small, protected areas is quite small, and the number of individuals they can support may not be genetically viable for long-term conservation.

2.4.3 Indicator species

Indicator species are organisms that are very sensitive to changes in their habitat, and hence their presence or absence or changes in their abundance reflect a specific environmental condition. Indicator species can quickly and positively signal a change in the biological state of a particular ecosystem. They may, therefore, be used as a proxy to monitor and diagnose the health of an ecosystem. These species are very valuable in conservation monitoring and management as they can be used to indicate the status of an environmental condition. Indicator species are generally smaller species such as some plants, lichens, insects, amphibians, birds, fishes and small mammals. It is important to identify species that are suited for the most vulnerable processes or that are likely to be impacted by anthropogenic actions and to monitor them.

2.4.4 Flagship species

Flagship species are popular, charismatic species that serve as symbols and rallying points to stimulate conservation awareness and action. A flagship species acts as an ambassador for less recognized or less-loved animals and organisms in a habitat. For example, Tiger and Elephant are major flagship species that drive conservation. Flagship species may or may not be keystone species or good indicators of biological processes.

3. Why conserve wildlife: Ecosystem services provided by wildlife

Biodiversity is fundamental to sustaining ecosystem processes, functions and the continued delivery of ecosystem services, which are the foundation of livelihood security, health and overall well-being of human societies. Conservation of biodiversity, including wildlife, is essential for India, not only because the consequences of biodiversity loss and the resulting loss of ecosystem services have a far-reaching impact on livelihoods and overall well-being of human communities but also to preserve the cultural heritage in areas where co-existence is the natural way of living.

Ecosystems provide a variety of benefits to people, including provisioning, regulating, cultural and supporting services. These benefits are termed 'ecosystem services.' These services illustrate the link between interactions of species with each other and with the physical environment as well as the usefulness of these functions for the well-being of people in terms of wealth, nutrition and security.

Changes in biodiversity can influence all these functions (e.g., pollination, nutrient cycling) and the products arising out of these functions (e.g., food, medicinal plants). The concept of ecosystem services is becoming popular as a way to encourage discussion about the dependence of people on nature and what this means socially and economically.

The Millennium Ecosystem Assessment (MEA) of 2005 was a global exercise carried out to assess the ecological impact of biodiversity. In its report (finalised in 2005), the MEA lists the ecosystem services arising from biological diversity.

3.1 Provisioning services

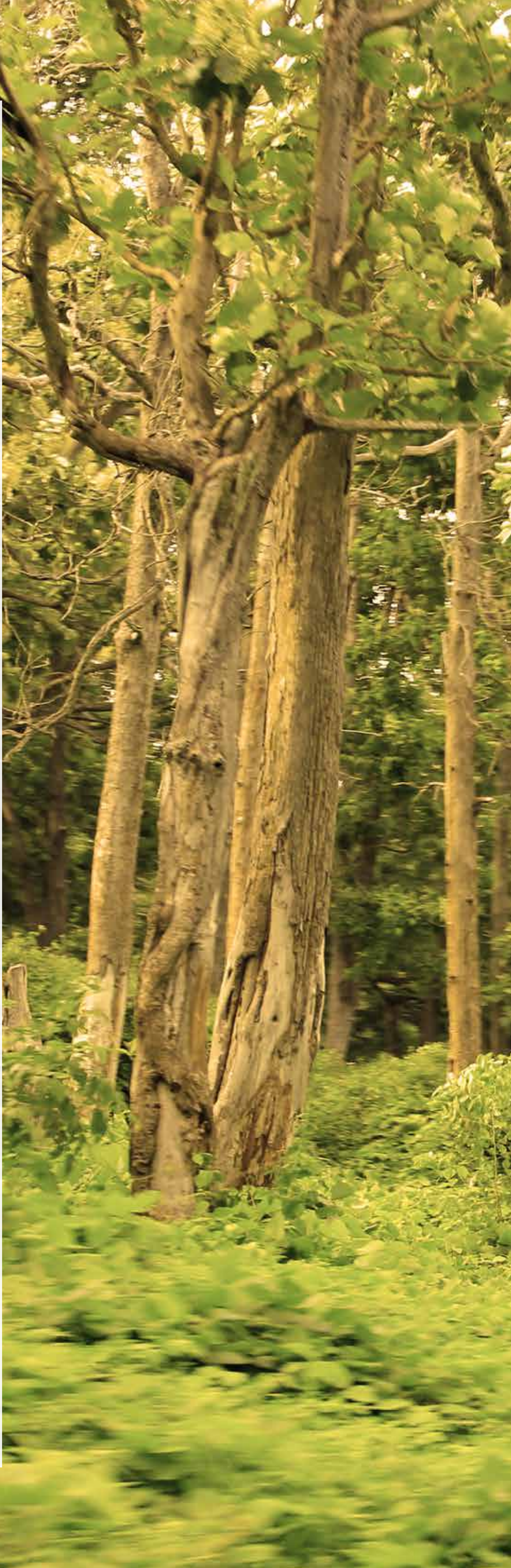
Provisioning services are the products people obtain from ecosystems, such as food (agriculture and horticulture crops, livestock, fish), medicinal, aromatic plants, fuel, fiber, fresh water, gums and resins, minerals and genetic resources.

3.2 Regulating services

Regulating services are the benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, carbon sequestration, regulation of human diseases, plant pest and disease control, pollination, water purification, disaster risk reduction (mitigating the threats of landslides, floods and even tsunamis) and pollination.

3.3 Cultural services

Cultural services are the non-material benefits people obtain from ecosystems, such as spiritual enrichment, religious and cultural values (sacred sites), knowledge systems, educational values, aesthetic values, social relations (in urban green spaces), recreation and ecotourism. 'Spiritual and religious values' refers to religious bonds to sacred landscapes, groves and species (Butler, 2006), and these are often connected to different religions.



3.4 Supporting services

Supporting services are those that are necessary for the production of all other ecosystem services, such as biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling and provisioning of the habitat. They differ from provisioning, regulating, and cultural services as their impacts on people are often indirect or occur over a long time. In contrast, changes in the other categories have relatively direct and short-term effects on people.

Looking practically at the concept of ecosystem services, a large population is dependent on forests for their livelihoods, either fully or partially. Estimates of the figures related to forest-dependent communities in India vary from 200 to 350 million people. This dependence is in the form of a collection of non-timber forest produce for subsistence and livelihood purposes, collection of fuel and fodder for subsistence and livelihood purposes, and lifestyles such as shifting cultivation or pastoral nomadism—which are dependent on natural resources.

At the same time, local communities have been continuing with diverse sets of ownerships, rights, and concessions relating to the use of natural resources such as forests, inland waters, coastal areas, alpine meadows, etc. Thus, the ecosystem services, as characterised by the framework of the Millennium Ecosystem Assessment, form an integral part of the association of local communities with the ecosystems in India[1].

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) performs regular and timely assessments of knowledge on biodiversity and ecosystem services and their interlinkages at the global level. Global assessment report on biodiversity and ecosystem services of IPBES provides an insight into the ecosystem services.

Access the report here https://www.ipbes.net/global-assessment

1 Conservation of biodiversity and ecosystem services by REDD+ project in India, TERI, Re-trieved from https://www.teriin.org/projects/nfa/2008-2013/pdf/Policy_Brief_Conservation_biodiversity.pdf

4. What is human-wildlife conflict?

The National Human-Wildlife Conflict Mitigation Strategy and Action Plan for India (HWC-NAP) defines Human-wildlife conflict as follows:

> HWC refers to the negative interaction between humans and wild animals, leading to adverse impacts such as injury or loss of human lives, crop, livestock and other properties, or even their emotional well-being, and equally negative impacts on wild animals and or their habitats.

The National Wildlife Action Plan of India (2017–2035) stresses that it is important to understand that HWC is largely a human-induced phenomenon and, therefore, all the HWC mitigation measures must be developed in a truly participatory manner, engaging all key stakeholders. The welfare of wild animals involved in conflicts should be given equal importance when planning and implementing any HWC mitigation measures.

HWC can be perceived or real. For example, attacks by carnivores such as the Tiger and Lion are relatively less frequent, but the attacks are sometimes lethal and lead to a strong community reaction. On the other hand, human–snake conflicts and garden pests are more common; yet they provoke less concern (Nyhus 2016).

Box 1: Origin of human–wildlife conflict (HWC)

HWC has always existed since humans and wildlife have shared the same resources (habitat, food, water, etc.) and landscapes.

The first recorded incidence of HWC dates back to 2.0 million years ago. A fossilised skull of a young hominid from Taung was found with distinct signs of having been killed by an eagle (Berger, L.R. & Mcgraw, William, 2007). Likewise, large carnivores and humans initially would have started with a predator–prey relationship until humans developed weapons to hunt the animals. Later the conflict extended to livestock loss and crop damage. The first recorded instance was about 10,000 years ago (Gordon, 2009). Earlier HWC was mainly of concern to the rural populations staying in and around forest areas (Messmer, Terry, 2000) but with an increasing human population and related developmental activities, the incidences of HWC became common in both urban and suburban areas (Soulsbury, Carl & White, Piran, 2015).

Today, HWC occurs in diverse contexts and spans a range of animal groups and countries. Though HWC existed since prehistoric times, its increasing complexity and severity have made it a global concern now.

However, with the increase in human population and the conversion of natural habitats for human use, biodiversity conservation has become an important issue as numerous species face extinction threats due to human actions. In the changed situation, there is a need for coexistence, and wildlife cannot be simply eliminated whenever it comes into conflict with people. HWC management, therefore, needs to strike a balance between conservation and human needs.

HWC is an increasing global issue that is not restricted to specific locations or landscapes but is common to all the areas where human and wildlife populations exist together and compete for limited resources or share the same resources. The dense human population in and around forest areas seems to pose a major challenge in the developing countries with HWC.

4.1 Drivers and Pressures: factors that create a situation of human-wildlife conflict

As HWC is a multidimensional problem, mitigation response also needs to be holistic, addressing all dimensions of the problem, from following five angles: addressing the drivers, reducing the pressures, assessing the situation, reducing the impact on humans and wildlife, and developing institutional, human and financial capacities for effective implementation.

Anthropogenic and ecological drivers of HWC lead to increased pressures on landscape features, with consequences to the state of both, wildlife and humans. These changed situations generate negative impacts on the livelihoods and well-being of humans and the existence of wildlife species. It is these negative impacts on both, humans and wildlife, which indicate a need for response.

The key drivers of HWC are human population increase, changing lifestyle and economic aspirations, reduced appreciation of wildlife among humans, climate change, disasters, land use change, policies in linear infrastructure, mining, urban development and other sectors, habitat fragmentation, loss & degradation.

These drivers lead to pressures such as creation of constriction in habitat which remain linked by narrow corridors which may also be lost due to degradation, disturbance or further loss of habitat. Construction of linear infrastructures through forest areas results in habitat fragmentation and causes disturbance, leading to decreased availability and quality of habitat for wildlife species. Linear infrastructure could also facilitate the spread of invasive weeds, as well as increased frequency of wild animals moving out in human-dominated landscapes. It can also facilitate widespread mining for resources within forests, which results in further loss of habitat and severe disturbance to wildlife. Increased dependency on forests for resources results in the degradation of forests through unsustainable grazing, fuel wood removal, NTFP collection and also setting of forest fires to facilitate grazing or NTFP collection. Where securing natural habitat is seen as a hindrance to wildlife, it can lead to reduced appreciation and support for forests and wildlife.

These pressures then create a state or situation of altered carrying capacity[2] of the natural habitats which further results in an increased number of wild animals residing in human-dominated landscapes. This leads to increased human-animal interactions and a higher chance of accidental encounters between humans and wildlife. The status of mitigation measures and their effectiveness in preventing HWC or reducing the impact of HWC greatly alter the overall perception of humans towards wildlife species-in-conflict in their area in particular and of the wildlife species. People's perception of wild animals-in-conflict is a critical factor that governs the overall HWC situation in any area.

2 Carrying capacity is the natural limit of a population, set by resources in a particular environment. It is one of the equilibrium points that a population tends towards through density-dependent effects from a lack of food, space (e.g., territoriality), cover or other resources. If the environment changes briefly, it deflects the population from achieving its equilibrium and so produces random fluctuations about that equilibrium. A long-term environmental change can affect resources, which in turn alters the carrying capacity. Furthermore, the population may undergo changes by following or tracking the environmental trends. There are other possible equi-libria that a population might experience through regulation by predators, parasites or disease. Assessment of carrying capacity of key habi-tats and protected areas, which provide refuge to the key wildlife species-in-conflict, is significant for developing appropriate HWC mitigation measures

4.2 Impacts of human-wildlife conflict (HWC)

4.2.1 Impacts on Humans

HWC has multi-faceted impacts on local communities, viz., physical (death and injury), economic and psychological impacts. The economic burden on state forest departments and threats to wild species from retaliatory killings by people are major concerns.

The direct impacts of HWC on humans include the following:

4.2.1.1 Loss of human life and injury to people

Loss of a human life generates negative sentiments towards the species, often resulting in pressure from local communities for removal of problem animals from the vicinity of their villages. The death of an earning member in rural areas with limited livelihood opportunities puts a substantial burden on the household, forcing young kids to drop out from school or start earning at an early age. Fear of an elephant or a large cat in the vicinity and the associated perceived conflict often limit people's movement, particularly after sunset. This affects the social relations of locals within a community.

The threat to human life arises from accidental encounters that occur when wildlife enters human-use areas or when people enter forests. In extremely rare cases, human casualties occur when a particular wild animal becomes predisposed to treating humans as prey, in the case of carnivores, or as a threat, in the case of others.

4.2.1.2 Crop losses

In terms of crop losses, damage can take the form of consumption of standing crops, trampling of crops or consumption of stored grain and fodder.

Across the country, various herbivore and omnivore species forage in crop fields resulting in huge losses to an agricultural economy. The impact of HWC on the agricultural economy is so grave that the Union Ministry of Agriculture and Farmers Welfare has recognised HWC as one of the factors to be covered under the *Pradhan Mantri Fasal Bima Yojana*. As the quantum loss of crops damaged by wild animals is a States/Union Territories subject, States have been given the liberty to consider providing add-on coverage for the same wherever the risk is perceived to be substantial and identifiable from Rabi 2018-19 onward. The DARE program on pest control also deliberates on the issues like crop damage by wildlife, particularly blue bull and wild pig.

> The most recognized impact of HWC is the economic implication of losses. Among all the HWC events, highest numbers of cases are reported for crop loss and property damage. At times, almost 100% harvest is lost due to foraging by wild species such elephant, blue bull, wild pig and rhesus macaque

4.2.1.3 Property damage

Damage to property takes the form of damage to agricultural infrastructure, to houses and storage buildings, to vehicles, etc

In Himachal Pradesh, loses reported due to rhesus macaques were 10-100% by farmers and 40-80% by horticulturists. In villages around three PAs in Arunachal Pradesh, livestock death by wild dog in two years caused loss of around 20.3% of the total monetary value of livestock which was around INR 7,365,000. Local communities in Bhadra Tiger Reserve landscape lost an approximate 11% of their crop to elephants and 12% of livestock to large cats annually, resulting in an overall annual loss of 11% of their productions. Species such as rhesus macaque, blue bull and wild pig often cause up to 50% crop losses in high conflict areas in Rajasthan, Punjab, Himachal Pradesh, Bihar, Uttarakhand, Kerala, and Tamil Nadu.

4.2.1.4 Livestock losses and injury

In terms of livestock, cattle, goats and sheep are the main animals preyed upon, but domestic dogs and cats are also hunted at times.

4.2.1.5 Loss in quality of life

The quality of life deteriorates due to adverse impacts on health because of psychological stress, sleep deprivation due to night guarding and financial stress brought about by crop or livestock losses

A less understood but important dimension of human-wildlife interaction is the spread of zoonotic diseases, which can be transmitted from wildlife to people. Disease transmission in both directions is a problem that cannot be underestimated. Approximately 60 percent of diseases causing pathogenic illnesses in humans originate in animals. The emergence or re-emergence of zoonotic and vector-borne diseases poses considerable risks to public health, the environment and the economy across the globe.

4.2.1.6 Loss or reduction of livelihoods and economic opportunities

Due to abandoning or reduced inputs in agriculture (Appayya and Desai, 2007), inability to collect NTFP, physical disabilities due to animal attacks, costs of mitigation efforts and increased labour costs due to HWC, the livelihoods and economic opportunities can take a major set-back in some HWC hotspots

The hidden economic costs associated with HWC include transaction costs for *ex gratia* claim applications, treatments, buying rations after crop loss or loss of income from surplus harvest etc. The cost of HWC escalates if people have to invest in putting barriers or engage more human resources to monitor the wildlife movement or guard against them. In Uttarakhand, one of the reasons stated for abandoning farming and migrating to urban centres to seek livelihood is the increase in HWC.

4.2.2 Impacts on Wildlife

The direct impacts of HWC on wildlife include the following:

4.2.2.1 Retaliatory Killing and injuries:

Animals in conflicts are often persecuted by local communities in retaliatory actions including deaths due to poisoning or electrocution by live wires.

During the period 2009 to 2019, 1,025 elephants died due to unnatural reasons, with over 700 animals dying due to electrocution and poisoning. Carnivores such as leopard, wolves and wild dogs are most persecuted species across the country. In 2018, at least one animal died an unnatural death every day due to reasons such as falling into wells, beaten to death by people, run over by vehicle or train, and electrocution.

4.2.2.2 Electrocution from live wires:

Electrocution from live wires powered through high-tension lines is another dimension where animals, especially large animals such as elephants crossing through the human-dominated landscape, are affected fatally.

The indirect impacts of HWC on wildlife include the following:

- In many cases, the animals involved are living under sub-optimal conditions. Degradation and fragmentation of habitats reduce the population size and cause the animals to frequent agricultural areas or even villages.
- Leopards get used to living in agricultural and village areas because of the easy availability of prey there. This is a significant change in their ecology and behaviour. In the short run, the easy prey may support individuals and populations; in the long run, the resentment of communities might lead to retributive actions and affect the conservation of these species, going beyond the individuals involved in the conflict.
- Changes in migration routes may force them to go to even less optimal places. Elephants living in or migrating through a mosaic of habitats interspersed with plantations are known to change their foraging behaviour and feed in the tea and coffee plantations.
- Stress caused by frequent incidents may change the animals' behaviour.
- Translocation, which is one of the mitigation measures, may take the animals-in-conflict to new areas where they compete with the local populations in areas where the carrying capacity has been reached. The survival rates under these conditions are often low.

Human-Wildlife Conflict has adverse impacts on the capacity of the rural poor to break out of the poverty cycle, and this also impacts the achievement of Sustainable Development Goal 1 'No Poverty'.

5. State of HWC mitigation: Knowledge and Data sharing on HWC at national, state and local levels

To be able to formulate effective plans and measures for mitigating HWC, it is critical to bring clarity on the extent, magnitude and trends of the conflict in a given area. So far HWC related data and information is being collected and compiled at various levels, with differential success in systematizing it in different states. The HWC data was focusing primarily on human death and injury and compensation.

5.1 National Knowledge and Data Platform on HWC Mitigation

Since 2018, the Indo-German Project on Human-Wildlife Conflict Mitigation has actively worked with the MoEFCC to develop a National Knowledge and Data Portal, where all the information and knowledge products such as national, state and division-level plans, guidelines, training materials, awareness material, Implementer's toolkit and a dialogue forum will facilitate in knowledge and information management. The database section will facilitate in data sharing from division, which can be reviewed and consolidated at CCF level and eventually approved by CWLW for submission on the portal.

Primary aim of a National Portal in India is to facilitate knowledge and information management, and to act as a cross-sector and multi-stakeholder dialogue platform. This is expected to strengthen our understanding on the drivers of HWC and effectiveness of the mitigation measures, and strengthen cross-sector cooperation and stakeholder engagement. **This will eventually support evidence-based decision-making and policy formulation for HWC mitigation at the national and state level.**

The national Portal will **facilitate the states in implementing state HWC strategies** and state action plans by generating detailed state-level reports, and updated status of all indicators, helping them in monitoring of drivers of conflict in their states, and also assessing the effectiveness of the plans. This will also help state in planning and monitoring the HWC-Management Action Plans at divisional level. The long-term analysis and results coming from the national portal can also be used for further **strengthening capacity development measures** for specific target group, species, and sites/ landscapes. This will also help the government in **prioritizing the research needs** for the country, and research agenda for national training institutions.

Purpose of a National Knowledge and Data Platform on HWC Mitigation

1. To facilitate information management on HWC situation and strengthening our understanding on the drivers and pressures of HWC and effectiveness of the mitigation measures.
2. To support evidence-based decision-making and policy formulation for HWC mitigation at the national and state level
3. To facilitate the states in implementing state HWC mitigation strategies and action plans, as well as division/landscape level planning
4. The long-term analysis and results coming from the database and monitoring system can also be used for further strengthening capacity development measures in the states
5. To support the national and state governments in prioritizing HWC mitigation measures

Long-term expected Outputs from the Data generated by the National Portal:

1. Immediate results will include hotspot maps, real time movement data of animals through collars which will also help in understanding inter-state movement of animals.
2. Short term trend analysis will show how HWC is linked with drivers.
3. Conflict maps (hotspots maps, these are determined by statistics and heat maps are determined by distribution)
    a. Incident heat maps – these will be maps that show the concentration of cases. Useful for reporting incidents in parliament.
    b. Predictive hotspot maps – these maps will be used along with other factors (physical, human, and political geographies), this uses statistical analysis in order to define areas of high occurrence versus areas of low occurrence. To also determine which factors are more responsible for the incidents which are different in different geographies.
4. Use of database in EIA, Strategic Environmental assessment process, and spatial planning – consecutively these datasets could also contribute to planning of roads and railway line alignments, proposed changes in land use and many such exercises.
5. Use of database to support the planning and management of ESZ – as the data gets richer, more thematic layers are added and it is all analyzed on the national database portal, it will give a scientific basis for determining ESZs.
6. Wildlife corridor analysis- when combined with radio collars and other radio telemetry. This will give users more detailed high-resolution data for localized planning.
7. Training instrument for the forest department personnel – this national database and the portal will be very useful for training of people on the ground. Analytical training material could be developed from real life cases on the ground in different geographies across the country.
8. As an instrument for cross-sector coordination by providing a better decision support system for all.

5.2 HWC Hotspots

The National Human-Wildlife Conflict Mitigation Strategy and Action Plan of India (HWC-NAP) (2021-26) defines HWC Hotspot as the areas with actual or predicted repeated occurrence of HWC incidents resulting in crop loss, livestock death, human death and injury, wildlife death and injury over temporal and spatial scales. It can be static (repeated in the same place or time) or dynamic (shift in space and time over years). In addition to counting statistics, the magnitude of the incidents is subjected to interpolation or extrapolation techniques to define the hotspots in space and time.

Identification of conflict hotspots provides a direction towards the drivers of conflict and is critical to provide site-specific solutions to mitigate human-wildlife conflict. Conflict hotspots of HWC can be mapped through geospatial assessments, by using both primary and secondary data including time-series data. The hotspots can be identified and mapped as follows:

- **Incident Hotspot:** Frequency of occurrence of incidences over past specific years such as previous five or ten years, mapped over the target area. The data include the number of incidents of injury and death and the attack/ killing of domestic animals.

- **Vulnerability Hotspot**: Cumulative index by overlaying past incidents, vulnerability of local community and potential risk of the area.

6. HWC mitigation, taking a holistic and harmonious co-existence approach

6.1 Holistic Approach to HWC Mitigation

HWC is a multi-faceted challenge and thus requires an integrated and holistic strategic plan to find ways of mitigation. The conceptual framework on which the HWC-NAP is built works under the assumption that systems are never static. In fact, systems are evolutionary and can continuously change, adapt and respond to inevitable changes and recurring events. This ‘systems thinking’ enables us to find the root causes of a problem, rather than only treat its symptoms, and thus can be helpful to perceive new opportunities. The HWC-NAP uses the concept of Drivers-Pressures-State- Impact-Response (DPSIR) as the basic conceptual framework (Figure 1)

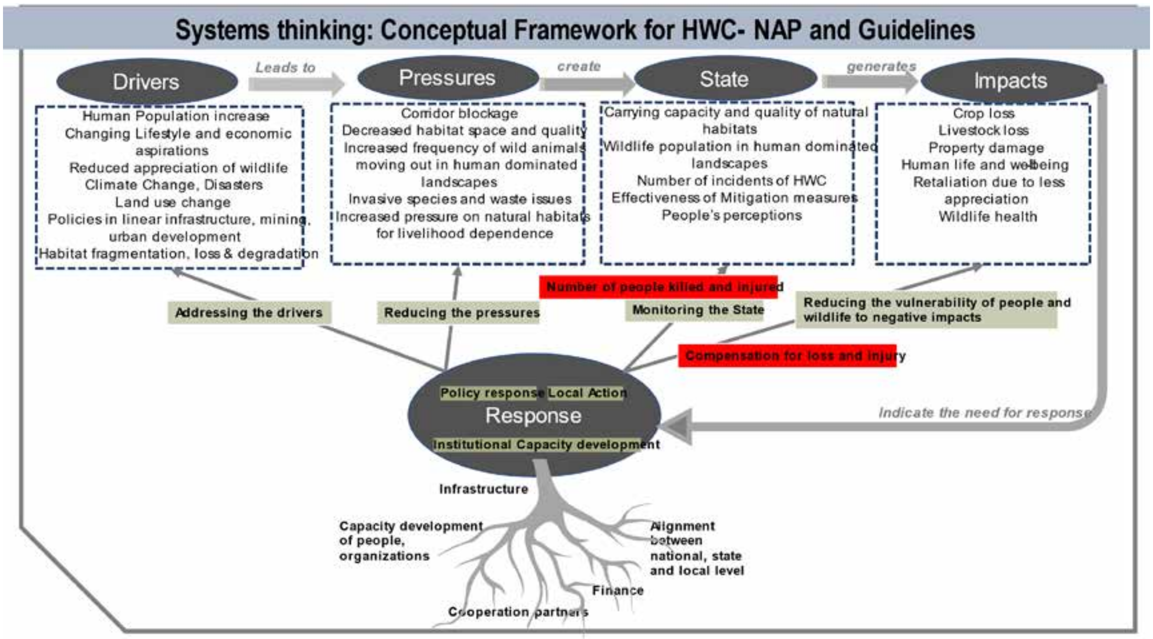


Fig 1: Drivers-Pressures-State-Impact-Response Framework (Khera 2019)

Anthropogenic and ecological drivers of HWC lead to increased pressures on landscape features, with consequences to the state of both wildlife and humans. These changed situations generate negative impacts on the livelihoods and well-being of humans and on the existence of wildlife species. It is these negative impacts on both humans and wildlife which indicate a need for response.

As HWC is a multidimensional problem, these responses need to be holistic, i.e., addressing all dimensions of the problem from the following five angles:

1. addressing the drivers,
2. reducing the pressures,
3. assessing the situation,
4. reducing the impact on humans and wildlife, and
5. developing institutional, human and financial capacities for effective implementation.

A holistic approach involves taking a step back to understand the whole situation and respond in a way such that the entire system is considered when designing the response.

Drivers can be addressed through macro-economic policy and sector-specific policy as multiple sectors are involved. Addressing pressures requires a clear environment, forest and wildlife policy and also institutional capacity. Pressures and the state that pressures create need to be addressed through preventive measures and this requires adequate institutional capacity. Institutional capacity is also important for developing HWC management plans that help manage and reduce the adverse impacts of HWC.

Furthermore, the responses need to be well-informed and backed by appropriate financial means and operational infrastructure, strong organisational capacity and cooperation partners. Strategically aligned national, state and local policies build the basis for efficient responses.

Systematic knowledge and experience sharing on innovations in conflict mitigation and capacity development are foundation and continuing element of a holistic approach towards mitigating HWC.

The mitigation tools and measures in a holistic approach include strategic environment assessment (SEA), land-use planning, landscape-level planning, early warning and rapid response systems, competence-based training for key stakeholders, awareness and communication measures for local communities, effective and wildlife-friendly barriers for preventing human–wildlife interaction, management action plans, a cross-sector and multi-stakeholder forum for HWC mitigation, inter-state/international dialogues to understand the issues and seek cooperation for mitigation of HWC, scientific management of wildlife population and payment of compensation to owners of crops and livestock.

For addressing the drivers of HWC at the landscape level, it is important to regulate land use by integrated land-use planning that considers the needs of both wildlife and local populations; promote the respect of stakeholders for land-use planning through communication programmes; and enforce the respect for land-use planning through effective rules and regulations, derivates such as environmental impact assessments (EIA), strategic environment assessments (SEA) and environmental management plans (EMP) and surveillance and law enforcement.

Prevention of HWC at the landscape level is achieved through effective monitoring and management of the distribution and dispersal of wildlife using physical measures (protected area fencing, ditching, wildlife (ecological) corridors, livestock corridors, etc.) and by controlling wildlife populations (capture, immunocontraception, etc.).

Reducing the impact of HWC on humans is achieved through crop and livestock protection measures, raising the awareness of local stakeholders, etc., and reducing the impact on wildlife is achieved through education, creation of awareness among people about animal behaviour, the use of early warning systems, the use of advanced and fast animal rescue vehicles and modern equipment in the early warning and rapid response systems, training key members of rapid response teams (RRTs), etc.

Division-level HWC management action plans that adopt a landscape approach are being developed in India through a participatory process. These plans consider the active engagement of all sectors involved in the HWC mitigation process.

The effectiveness of HWC measures requires to be monitored in order to adapt to changing contexts and to improve their effectiveness.

6.2 Harmonious co-existence Approach

Harmonious Coexistence is defined as a dynamic but sustainable state in which humans and wildlife adapt to living in shared landscapes, with minimum negative impact of human-wildlife interaction on humans or on their resources and on the wildlife or on their habitats. The mitigation measures designed using this approach maintain a balance between the welfare of animals and humans where both are given equal importance. Overlap in space and resource use is managed in a manner that minimizes conflict.

Harmonious co-existence approach to HWC mitigation entails a systematic and comprehensive assessment of all the mitigation plans and mitigation measures in the field, to ensure that these are effective and at the same time wildlife-friendly, i.e., a balanced way is developed to reduce the conflict, rooted in the philosophy that no measure should unnecessarily harm a wild animal. Adopting a pro-active approach using early warning systems and efficient field response teams, high awareness among people sharing the landscape with wild animals are some of the strategies that can operationalise the harmonious co-existence approach.

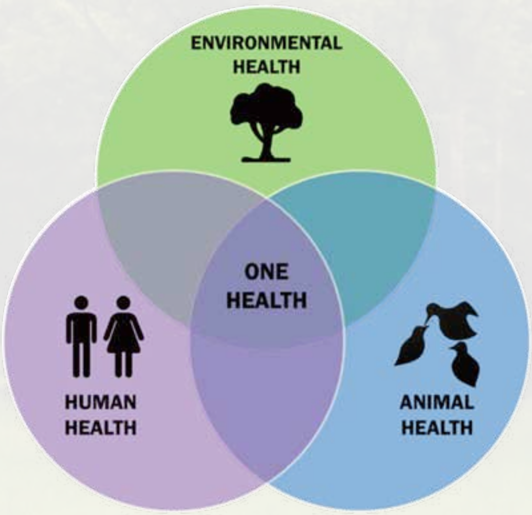
6.3 One Health

Over 30 new infectious diseases have been detected globally in the last three decades, around two-thirds of which were zoonotic in origin. The interface between animals and humans is constantly increasing, primarily due to habitat fragmentation and loss, the global trade in wildlife and increasing demands of ecotourism and other forest-dependent livelihoods. This has led to a growing number of people and livestock living close to wildlife, resulting in disease spillover. This situation has the potential to grow out of proportion, and the resulting health risks can undermine the conservation and development efforts in such areas. The present situation and associated socio-economic and ecological impacts need to be urgently addressed keeping in mind that human, animal and ecological health are interconnected.

The One Health concept is based on the understanding that human, animal and environmental health are closely interconnected and interdependent. One Health is a collaborative, multi-sectoral, and transdisciplinary approach–working at the local, regional, national and global levels–animals and with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants and their shared environment

Areas of work in which the One Health approach is being adopted increasingly include food safety, the control of zoonoses and combating antimicrobial resistance (AMR). In the context of wildlife management and protected area management, the work on zoonoses is of relevance. It also addresses the other modes of disease transmission, such as between domestic animals and wildlife and (around protected areas and HWC hotspots) between humans and domestic animals. Indicative situations where the risk of zoonotic and other emerging diseases is high include:

- People and domestic animals entering or living in wildlife habitats
- Increasing tourism in protected areas
- Wildlife entering human-use areas
- *Ex-situ* conservation areas
- Interaction of mahouts and assistants with *kumkis*
- Snake rescue operations
- HWC mitigation measures such as animal capture and translocation, treatment of injured animals, and post-mortem examinations
- Human-wildlife conflict (HWC) hotspots such as water holes in forest landscapes and, livestock pens on the fringes of forested areas



SECTION 2

7. HWC profile of Key Species-in-Conflict: Overview

HWC in India involves 88 species belonging to nine taxonomic groups (Anand and Sindhu, 2017) ranging over different geographical areas. This HWC assumes various degrees and forms. The top four species in terms of the number of reports were the Asian Elephant (*Elephas maximus*, 16.5%), Leopard (*Panthera pardus*, 7.00%), Tiger (*Panthera tigris tigris*, 7.00%) and Rhesus Macaque (*Macaca mulatta*, 5.25%).

HWC occurs in several different contexts and spans a range of animal taxonomic groups and countries (Walpole et al. 2003; Okello, 2005; Baruch-Mordo et al. 2008; Hoffman and O'Riain, 2012). Incidences of HWC involving numerous species have been reported from different places across the country. The geographical extent of conflict also showed a dramatic increase over time: during the period 1976–1995, HWC was reported only from 11 states and union territories in India, whereas the number increased to 31 regions in the period 1996–2005.

7.1 Mega herbivore: Asian Elephant *(Elephas maximus)*

7.1.1 Occurrence and Distribution

The Asian Elephant formerly ranged over vast areas, but the present distribution is limited. Elephants are distributed in four major regions of India: south, north, central and north-eastern India.

Country occurrence. Bangladesh; Bhutan; Cambodia; China; India; Indonesia (Kalimantan, Sumatra); Lao People's Democratic Republic; Malaysia (Peninsular Malaysia, Sabah); Myanmar; Nepal; Sri Lanka; Thailand; Vietnam. In India, Elephants are found in 16 states, and there is some conflict in all these states.

7.1.2 Population structure and dynamics

India holds by far the largest number of wild Asian Elephants, estimated at about 29,9647, this is nearly 60% of the population of the species. The Elephant is placed under Schedule I and Part I of the Indian Wild Life Protection Act (1972), which confers it the highest level of protection. However, Elephants and humans are now often in conflict in our country because of varied reasons.

7.1.3 Basic morphological information:

The highest point on the top of the shoulder is used for measuring the height of an Elephant. At birth, calves vary in height from 85 to 105 cm and are most often around 90 cm. Elephants grow all through their lives if on a good diet. Adult females range between 225 cm and 255 cm and rarely reach 270 cm. Females stop growing once they start calving as the stress of pregnancy and suckling by calves takes a lot of energy. Adult males, however, grow through most of their lives and range in height from 255 cm (young adults) to 330 cm (older males).

At birth calves can weigh around 90–100 kg, while adult females weigh between 2500 and 4500 kg, adult males can weigh between 3000 and 6000 kg. The weight of adults depends both on body shape, structure and diet. While Elephant body shape and structure has been categorized into different classes by some authors, it is difficult to distinguish clear categories as there is a lot of admixtures in shape types. The differences in body size between the calves, juveniles, sub-adult, adult females and adult males give differential advantages and disadvantages to the different age–sex classes. The large body size of adults gives them better tolerance to heat, food and water stress, while the calves have less tolerance. Hence, we see the high calf and juvenile mortalities during drought years.

The height of an Elephant can be determined by measuring the forefoot circumference and multiplying it by 2. The circumference can also be measured from clear tracks. The forefoot has a circular shape, while the hindfoot has an oval shape. The two shapes are very distinct. This measurement is important because it allows us to not only measure the height of the Elephant indirectly—the height is also an indicator of an Elephant's age. As growth rates and overall height vary in adults, height is not accurate beyond the young adult stage and is best used in classifying individuals into broader categories such as calf, juvenile, sub-adult and adult. Height combined with other characteristics can be used in identifying individual Elephants.

Elephants have six sets of molars, of which only one is fully in use, while another (following the one in use) may be partially in use. The molars grow downwards and forward, starting from just below the jaw hinge and moving down and forward into the jaw, the new one gradually pushing the older one forward and out of the front of the jaw. As the molar in use is pushed forward, it gets more and more worn down and consequently shorter in length till it eventually falls off as a small piece. The molars are made up of many lamellae, and each molar has a fixed number of lamellae. The molar number can be identified on the basis of the number of lamellae. The age of an elephant can be determined by the molar(s) that are in use. After the last set of molars (sixth) gets worn out and falls, the elephant can no longer chew food and eventually dies of starvation—this usually happens when it is in its 60s.

Elephants do not have sweat glands, and therefore, to cool their bodies, they use their large ears as radiators. Warm blood enters the ear, gets cooled due to the fanning of the ears and returns as cooler blood into the body. Another method of cooling the body involves the use of water or wet mud (spraying on body or bathing/wallowing). Elephants may also toss mud/dust onto their backs, which then protects the skin on their backs from being directly exposed to the sun's heat. Water and shade are therefore important for elephants, especially herds with young calves.

7.1.4 Habitat requirements

Elephants use hindgut fermentation to extract nutrients from the food they eat. This is an inefficient method, which extracts only 40–50% of the nutrients in the food. However, Elephants compensate for this by feeding on bulk food and with a constant food intake. Thus, lower digestive efficiency is compensated by higher food intake. Elephants have a very varied diet and feed on both grass and browse. Their preferred food is grass, which is why they are found at their highest densities in grass-rich habitats. But they can survive in a grass-poor and browse-rich habitat. Elephants are therefore extreme habitat generalists and are found in habitats ranging from semi-arid habitats with an annual rainfall of 650 mm to wet evergreen forests. However, they reach their highest population densities in grass-rich dry and moist deciduous habitats. Their densities are lower in semi-arid thorn forests and in high-rainfall semi-evergreen and evergreen forests.

Elephants are sometimes destructive feeders as they may ring debark a tree or they may push down an entire tree to feed on a few square feet of bark. They also uproot tall grass species in the dry season and eat only the moist basal part and discard the upper grass blades, which have more silica and are less palatable. In a short grass habitat, they may resort to scalping (scraping) the grass off the ground and feeding on it. Both actions remove grass from the site, and this disturbed soil may facilitate establishment of exotic weeds such as *Lantana camara*. Local overabundances of elephants have been known to have adverse impact on their own habitat.

Elephants are known to range from coastal areas up to 4000 m. Thus, their use of almost all vegetation types and their altitudinal distribution range makes them extreme generalists who can occupy any type of area, including heavily human-modified habitats. While water is critical for their survival, they can range for two days without water in water-stressed habitats, where they may return to a water source only once in two days (or possibly more). While adults can tolerate such conditions, calves and juveniles may get adversely impacted and may even die due to stress. Elephants use natural salt licks and also human-made salt licks (mostly in wildlife tourism areas). They are also attracted to salt stored in houses and may break walls to get at such salt.

7.1.5 Food habits

Elephants eat between 149 and 169 kg (330–375 lb.) each day. Sixteen to eighteen hours, or nearly 80% of an elephant's day, is spent feeding. Elephants consume grasses, small plants, bushes, fruits, twigs, tree bark and roots. Tree bark is a favorite food source for elephants. It contains calcium and roughage, which aids digestion. Tusks are used to pierce the trunk and tear off strips of bark. Elephants require about 68.4 to 98.8 liters (18–26 gallons) of water each day but may consume up to 152 liters (40 gallons). An adult male elephant can drink up to 212 liters (55 gallons) of water in less than 5 minutes. Elephants dig up the earth to obtain salt and minerals to supplement the diet. The tusks are used to churn the ground. The Elephant then places dislodged pieces of soil into its mouth, to obtain nutrients. Frequently these areas result in holes that are several feet deep, and vital minerals are made accessible to other animals. Hills have been carved by Asian Elephants in forest areas searching for salt and minerals. These carved areas in the landscape provide valuable food and shelter resources for a diverse array of native wild animals.

7.1.6 Ecosystem services

The Indian Elephant (*Elephas maximus*) is a keystone species affecting habitats and ecosystems in significant ways, ensuring ecological balance and resulting ecosystem services for human well-being. Elephants are referred to as ecosystem engineers due to their transformative role in the ecosystems where they create water holes that are also used by other wildlife for their survival during dry season, clear understories to promote new plant growth in forests, and facilitate seed dispersal of several important tree species, due to their highly mobile nature.

The Elephant is recognised as a National Heritage animal and is deeply rooted in our culture. India holds by far the largest number of wild Asian Elephants, estimated at about 29,964 (MoEFCC, 2017), this is nearly 60% of the population of the species. The Elephant is placed under Schedule I and Part I of the Indian Wild Life Protection Act (1972), which confers it the highest level of protection.

7.1.7 Human–Elephant conflict (HEC) and its mitigation

Elephants and humans are in conflict in our country because of varied reasons. Human-Elephant Conflict (HEC) refers to the negative interaction between humans and Elephants, leading to adverse impacts such as injury or loss of human lives, crop, livestock and other properties, or even their emotional well-being, and equally negative impacts on the Elephant or its habitats.

The general drivers of HEC include a human population increase, changing lifestyle and economic aspirations, reduced appreciation of wildlife, climate change, disasters, land use change, policies in linear infrastructure, mining, urban development, habitat fragmentation, loss and degradation including local overabundance of Elephants. Among these, the increase in human population, land use change, changing lifestyle and economic aspirations, policies in linear infrastructure, mining, habitat fragmentation, loss and degradation have the greatest impact.

The intensity of HEC is highly variable, ranging from very occasional to chronic, and depends on the density of Elephant populations; the nature of the interface between human areas and Elephant habitats; an irregular and diffuse boundary with a long perimeter; highly fragmented Elephant habitats interspersed with human-use areas; dispersing herds; railway tracks passing through forests with sizeable Elephant populations; etc.

HEC is prevalent in many states and is particularly high, relative to the number of Elephants involved, in areas where Elephants have dispersed and areas that Elephants have colonised. It is estimated that approximately 500 persons and more than 100 Elephants are killed annually. Nearly 0.8 to 1 million ha of agricultural land may be impacted by crop damage due to Elephants, and nearly a million families are adversely affected due to HEC. The challenge extends to the transboundary Elephant populations of Bhutan, Nepal and Bangladesh.

Elephants also pose a very different challenge in terms of conflict mitigation as their large body size, strength, longevity and the threat they pose to human life make it very difficult to contain them even with barriers.

Project Elephant is a dedicated project of MoEFCC focussed on Elephant conservation and HWC mitigation

https://moef.gov.in/en/division/forest-divisions-2/project-elephant-pe/introduction/

HEC is particularly intense in Assam, West Bengal, Odisha, Jharkhand, Chhattisgarh, Karnataka and Tamil Nadu.

Elephant females have a well-developed social organisation in which dominance hierarchies govern spacing. They also have fixed home ranges and movement paths as a consequence of ecological requirements and dominance hierarchies. Hence significant loss, degradation and fragmentation of habitats will bring them into serious conflict (Baskaran et al. 1996) and may even result in the affected Elephants dispersing out of a forest in search of better habitats (Sivaganesan, 1991; Kumar et al. 2010), which usually results in a severe conflict.

Males disperse from the family when they reach puberty, and often, they follow older males and learn about habitats outside their natal range. In the absence of older males (due to poaching), they may disperse into human-use areas and cause conflicts. Not all Elephants feed on crops, and only some clans and males can be predisposed to crop foraging.

Furthermore, with their large body size and immense strength, even slight physical interactions with humans can lead to severe injuries and fatalities. Their strength, combined with their intelligence, also allows Elephants to breach most barriers easily.

Males are more prone to coming in conflict with humans as they can easily survive in degraded habitats around villages or in the forest periphery. They have no calves or juveniles to protect, and they can find shelter in minimal cover, all of which the herd cannot do. They soon learn to breach barriers and ignore typical guarding tactics and become chronic or habitual crop foragers.

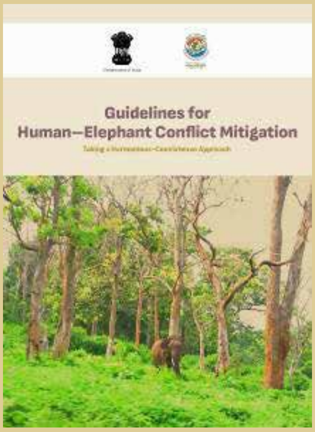
Poaching of males for tusks and the higher mortality they suffer due to retaliatory killing result in female-biased sex ratios (Sukumar, 1985; Daniel et al. 1987). Therefore, removal of a potential elephant-in-conflict from the HEC site is not an ideal option, as it will further make the ratio skewed. Alternatives such as negative or aversion conditioning need to be tested.

In spite of being habitat generalists, and their longevity and adaptability, many fragmented populations that persist today face extinction as they do not have adequate habitats. Such populations are involved in high levels of conflict as they are dependent on crops for their survival.

HEC mitigation so far has largely focused on the use of barriers, short-distance drives, and *ex gratia* payments or compensation for loss and damages. While these efforts have helped contain HEC, the problem continues to grow as a holistic approach has not been incorporated into the mitigation effort (MoEFCC 2023a).

A holistic approach to HEC is elaborated in the “Guidelines for Human-Elephant Conflict Mitigation’.

Website link: https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682406350.pdf



7.2 Wild Pig *(Sus scrofa)*

7.2.1 Occurrence and distribution

The Wild Pig is the most widespread herbivore in India and the conflict possibly involves the most significant crop damage among all herbivores. The distribution of the Wild Pig extends significantly into non-forest areas.

7.2.2 Population structure and dynamics

Wild Pigs can establish and expand their populations in new areas (Ahmed 1991)

7.2.3 Food habits

Wild Pigs are omnivorous, opportunistic foragers and extreme generalists. In natural habitats, their diet consists of tubers, roots, fruits, leaves, insects, etc. In human-use landscapes, they thrive on garbage dumps and crops. They are known to bring damage to agricultural fields by rooting, trampling and eating crops.

7.2.4 Group size and social organization

Group sizes of Wild Pigs in southern India range from 2 to 30 individuals, with an average of 4–13 among different populations. Wild Pigs are gregarious, with groups called sounders often comprising adult females, sub-adult males, yearlings and piglets. The size of a sounder depends on the season, habitat, water availability, etc. Adult males are usually solitary and sometimes move in all-male groups. The basic social unit is a nucleus of one or more females and their last litters. Animals peripheral to this are sub-adults from previous litters and, during the mating season, adult males. Dispersal of young (males) from these family groups is a passive process, occurring at about 5–10 months' age, with females generally remaining with the mother after weaning.

7.2.5 Wallowing and thermoregulation

Wild Pigs lack sweat glands and have sparse hair coats. They do not tolerate a wide range of temperatures. Therefore, thermoregulation is a major component of their daily activities. Wild Pigs like to live near mud wallows, in which they spend several hours. This wallowing is an important activity, helping to remove parasites and protect sensitive skin from the harmful rays of the sun.

7.2.6 Nesting and resting sites

Wild Pigs spend most of their inactive daylight hours in characteristic day beds. They construct temporary sleeping nests or use burrows dug by other mammals. Adults or immature individuals use these beds for resting. One bed, mostly made to be in close contact with conspecifics, can have up to 15 individuals.

7.2.7 Reproduction

The reproductive activity in Wild Pigs tends to be seasonal and positively correlated with the relative availability of food or climatic factors. In central India, the majority of the young ones are born in two periods, shortly before and shortly after the rains.

7.2.8 Ecosystem Services provided by Wild Pig:

Wild pigs are a very specialized and ecologically important species. Their exclusive morphological make-up indicates the same. They have a large head (one-third of the body's entire length) that has evolved to be most suited for digging. The snout acts as a plough, and the powerful neck muscles help them turn up or excavate considerable amounts of topsoil and rocks in search of food. This burrowing or ploughing of topsoil serves as an important ecosystem service, as it loosens hard soil and improves aeration, similar to a farmer tilling her/his fields. Such diggings by wild pigs enable the roots of several plants to penetrate deeper into the soil, thus holding them more firmly. This digging activity enhances the water retention capacity of the soil. Moreover, this gregarious digging uproots and exposes roots of several plants and underground fauna for other herbivores and omnivores, respectively. This upheaval also aids in the sudden growth of soil microbes by exposing them to air (and oxygen). Thus, the wild pig's physical characteristics have not only evolved to help it to survive on both above-ground and underground food, but its mode of feeding also helps its ecosystem sustain itself.

Wild pigs are a classical example of multi-speciality ecosystem engineers. They help in ploughing, seed dispersal, form an important prey base for large carnivores, and play an important role as scavengers. No other species have this combination of specializations. With all the above-mentioned benefits, the presence of wild pigs is an indication of the true functional value of an ecosystem. Their high rate of reproduction and widespread distribution helps in maintenance of these functions in different types of ecosystems that they are found in.

7.2.9 Human–Wild Pig conflict (HWPC) and its mitigation

Human-Wild Pig conflict (HWPC) refers to the negative interaction between humans and Wild Pigs, leading to adverse impacts, such as injuries to humans, loss of human lives, crops, livestock and other properties or even impacts on the emotional well-being of humans and to the equally negative impacts on Wild Pigs and/or their habitats (MoEFCC 2023b).

The Wild Pig's highly adaptable nature, along with its capacity to cope with landscape changes, and alterations of habitats, allows its populations to survive and thrive in human-dominated landscapes. An increase in the number and intensity of instances of Wild Pigs foraging on crops is an indicator of an increasing local Wild Pig population. With the availability of a variety of food resources, and high fecundity rates, a Wild Pig population can multiply at a rapid rate. Food crops and waste dumps aid the growth of Wild Pig populations. Another reason for the increase in Wild Pig populations in recent years is also linked to declining or low populations of natural predators and consequent increases in HWPC. Habitat loss and fragmentation are the major threats faced by the species. Wild Pigs are among the most aggressive and persistent crop foragers. Wild Pig populations close to agricultural areas have become dependent on crops and agricultural produce. Human food waste also contributes to their increasing presence in forest-fringe areas. Humans also get injured when they encounter Wild Pigs accidentally. Isolated cases of Wild Pigs interacting negatively with livestock and causing injuries, and in rare cases death of livestock, have also been reported. The Wild Pig has been notified as vermin in Bihar, Uttarakhand, Gujarat and Himachal Pradesh in different time periods, impact of which on the overall HWPC mitigation in these states is yet to be analysed.

A key factor of HWPC may be the availability of only a limited number of effective mitigation measures. Therefore, the desired solution may involve a holistic approach that addresses the drivers and pressures, along with effective preventive measures, while reducing the vulnerability of local communities and Wild Pigs.

A holistic approach to HWPC is elaborated in the "Guidelines for Human-Wild Pig Conflict Mitigation'.

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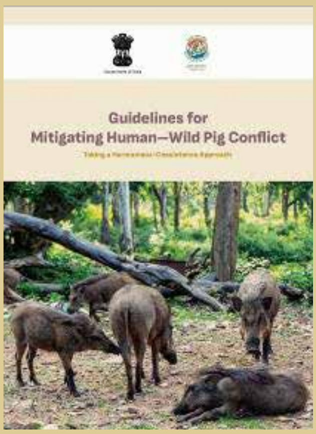

7.3 Bluebull *(Boselaphus tragocamelus)*

7.3.1 Occurrence and distribution

The Bluebull is widely distributed in India. It is common to abundant in the agricultural areas of north India, mainly Haryana, Uttar Pradesh, Rajasthan and Gujarat.

7.3.2 Population structure and dynamics

70,000–100,000 mature individuals

7.3.3 Herd composition

No fixed pattern of social structure or hierarchy is observed in the species, with herds being flexible and dynamic, changing throughout the year as influenced by reproductive cycles. The prevalence of males in groups during breeding in Nepal is 1 male, 37%; 2 males, 28%; 3 males, 20%; and 4 males, 15%. Outside the breeding season in India, the herd composition constantly changes (small groups of one or two adult females and their offspring; mixed herds of 3–6 adult females, yearling females and an occasional calf; male groups of 2–18 individuals.

7.3.4 Reproduction

The Bluebull is polygynous. Solitary breeding males are not 'spatially fixed' but maintain an 'area of dominance' around themselves as they move among different groups of females. This system results in 'mutual avoidance' and temporary dominance among breeding males. Bluebull seems to have no regular rutting season. As the rut approaches, the bulls move about in search of breeding cows, and upon finding one, defend the area around her from intrusions by other males—a system described as 'roving territoriality'.

Female Bluebull typically attains sexual maturity at 2 years of age, with the first parturition taking place after 3 years of age. Males aged 4–5 years are the most active breeders. The gestation period is 243–247 days. Most breeding activity occurs from October to February, with a peak in November and December. As with several species of ungulate, Bluebull calves remain hidden for a while after birth, a habit called 'lying out.' The transition from lying out to the continued association and travelling with the mother appears to occur gradually over 10 days to a month.

7.3.5 Food habits

The feeding habits of Bluebull indicate that they are browsers or mixed feeders. Dietary selection varies seasonally and includes grasses, woody vegetation and herbaceous species. Frugivory also occurs seasonally in India. During the monsoon, the diet of the Bluebull is dominated by grasses, whereas in winter Bluebull largely depends on fallen leaves, flowers and fruits. Animals in areas adjacent to human-dominated landscapes also forage crops in search of richer nutrition compared with what is available in their refuge sites. The availability of surface water is believed to influence the distribution and movements of ungulates, including Bluebull. The creation of irrigation canals and the availability of artificial water sources meant for agriculture, however, have had a drastic influence on this pattern.

7.3.6 Habitat use

The Bluebull is a habitat generalist but tends to occur in 'thin bush with scattered low trees or alterations of scrub and open grassy plains" with 'either level or undulating' topography, rarely in the thick forest but often in cultivated areas. In agricultural areas, it feeds throughout the night in open fields and retreats to the cover of forests during the day. The species is nonmigratory, although individuals and groups are capable of considerable movements if the ambient conditions (e.g., drought) dictate them.

7.3.7 Ecosystem services provided by Bluebull:

This antelope is partially social and not as gregarious as other herding ungulates with seasonal variability in group sizes. Bluebull consume grasses, seeds, desert succulent leaves, flowers, fruits and stems and they are also capable of reaching the highest branches of trees by standing on their hind legs. This combination of grazing and browsing leads to a significant form of ecosystem services and bluebull can be assuredly considered as an indicator of habitat quality and a balancing act in the ecosystem.

7.3.8 Human–Bluebull conflict (HBLC) and its mitigation

The species co-occurs with another antelope, the Blackbuck, in some parts of the country. The Blackbuck is a Schedule I species under WPA-1972, and therefore, differential mitigation strategies need to be designed for the Blue Bull and the Blackbuck, as per the level of protection given to these species under the act. Human-Blue Bull Conflict (HBLC) refers to the negative interaction between humans and Blue Bulls, leading to adverse impacts such as injury of humans, loss of crops and other property and creating obstacles in emotional well-being, and equally negative impacts on Blue Bulls or their habitats. All-India population estimates are required for the species.

HBLC mitigation is being addressed by the agricultural sector in India under the All India Network Project on Vertebrate Pest Management of the Indian Council of Agricultural Research (ICAR) under the Ministry of Agriculture and Farmers Welfare, Government of India. Chemical capture methods are available, particularly for single animals or small herds. However, the drug of choice and the capture, handling and transportation of Blue Bulls is yet to be standardized.

To ensure effective HBLC mitigation, there is a need for further information and knowledge management on effective crop guarding methods against Blue Bulls, and standardization of capture and translocation methods for the Blue Bull in India (MoEFCC, 2023c). A holistic approach to HBLC is elaborated in the "Guidelines for Human-Blue Bull Conflict Mitigation'.

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7.4 Gaur *(Bos gaurus)*

7.4.1 Occurrence and distribution

The Gaur occurs in scattered areas in Bhutan, Cambodia, China, India, Lao PDR, Malaysia (peninsular Malaysia only), Myanmar, Nepal, Thailand and Vietnam. The species distribution is now seriously fragmented within its range, and the mapped distribution is generalised, especially in India, Lao, Myanmar, China and Malaysia (IUCN, 2016).

In India, four major and two minor priority areas have been identified as 'Gaur conservation areas'. The major priority areas are the Western Ghats, Eastern Ghats, central India and North-East India. The minor priority areas are Bihar and West Bengal (Sankar et al 2000).

7.4.2 Population structure and dynamics

6000–21,000 mature individuals worldwide (IUCN, 2016).

7.4.3 Morphology

The Gaur is the tallest living cattle and the second heaviest of them. Gaur bulls weigh 600–1000 kg and stand 1.6–1.9 m at the shoulder, whereas cows are about 10 cm shorter and weigh about 450–800 kg. Gaur is sexually dimorphic, and both sexes have horns. In males, the horns are larger, especially at the base, with more outward swath, and the curving is less at the tips. Adult males have a pronounced muscular crest between the shoulders, a large dewlap hanging between the forelegs and a smaller one under the chin. Adult bulls have a shiny black, short-haired pelage, except for white stockings, a grey boss between the horns and rusty-coloured hairs on the insides of the thighs and forelegs. Young bulls are dark brown like the cows. The horns of young bulls are smooth, yellow orange in colour and tipped with black, whereas the old bulls are corrugated, dull olive and sometimes frayed at the tips.

The cows are considerably smaller than the bulls, and their dorsal ridges and dewlaps are not prominently developed. The pelage of a cow is dark brown, and the horns are thinner, upright and more inward curved than those of bulls. The juveniles are brownish with spike horn. Young calves weigh about 43 kg, have a light brown coat and lack the conspicuous white stockings, which do not appear until they change into a dark brown pelage at the age of about 3 months.

7.4.4 Habitat of Gaur in India

In India, four major Gaur conservation areas (Western Ghats, Central India, Eastern Ghats and North-East) and two minor areas (Bihar and West Bengal) "Gaur conservation areas" have been identified.

7.4.5 Ecosystem Services from Gaur:

Gaur is the tallest living ox and one of the four heaviest land mammals. Gaurs are important modifiers of physical structure of habitats, ecosystem structure and function because they can trigger trophic cascades, increase spatial heterogeneity, accelerate successional processes and influence nutrient cycling and primary productivity. As ecosystem landscapers, gaurs play an important role in the moist and dry deciduous forests in India, in ensuring the provisioning of ecosystem services and in maintaining biodiversity.

7.4.6 Human–Gaur conflict (HGC) and its mitigation

In recent years, increasing numbers of HGC cases have been reported from north-eastern India (especially in northern West Bengal) and central and southern India. Incidences of aggression towards humans and frequent Gaur encounters cause fear and panic in humans' minds.

Widespread and frequent instances of Gaur damage to crop fields, kitchen/backyard gardens and property and injury to humans (death of humans in a few extreme cases) have been reported. Thus, the intensity of Human-Gaur conflict (HGC) is increasing in the Gaur distributional range. HGC refers to the negative interaction between humans and Gaurs, leading to adverse impacts such as injury or loss of human lives, crops, livestock and other properties, or even the emotional well-being of humans, and equally negative impacts on Gaurs or their habitats.

The key drivers of HGC include the human population increase, greater local dependency on biomass in forest-fringe areas, land use changes, linear infrastructure, mining, urban development and habitat loss, fragmentation and degradation.

Gaur population increase at the forest interfaces and human-dominated areas; forest fires leading to habitat degradation; inadequate alternative livelihood options for local communities in and around forest areas; and insufficient awareness of gaur behaviour and garbage management among humans exert further pressures resulting in HGC.

HGC is expressed in the form of crop foraging by gaurs, rare livestock encounters and human death/injury in the forest fringe villages, human habitations and tea estates. Gaurs are shy animals. Hence, large-scale damage from their foraging of crops in the fringe areas has not been reported. In recent years, owing to the shrinkage and fragmentation of forests, the conflict has, however, increased. There are instances of death of a few Gaurs every year, especially near smaller and fragmented habitats.

HGC mitigation so far has been largely focused on the use of barriers, short-distance drives and *ex gratia* payments for damages. While these efforts have helped in mitigating HGC to some extent, a holistic approach to HGC mitigation is required to ensure effectiveness and sustainability in the mitigation efforts (MoEFCC, 2023d).

A holistic approach to HGC mitigation is elaborated in the “Guidelines for Human-Gaur Conflict Mitigation’.

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7.5 Blackbuck *(Antelope cervicapra)*

This medium-sized ungulate is an antelope species native and endemic to the Indian subcontinent (Jhala and Isvaran, 2016). The species gets its common name from the dark brown- to black-coloured dorsal coat of the male individuals. The states of Punjab, Haryana and Andhra Pradesh have declared this species as their state animal.

7.5.1 Occurrence and distribution

There are two subspecies of Blackbuck (Colin P. G, 1980):

Antilope cervicapra Linnaeus, C. (1758), which is mainly distributed in the eastern parts of India, such as Bengal and Orissa, except for the northeastern parts. It can also be easily spotted in the southern Indian states of Tamil Nadu and Karnataka.

Antilope cervicapra rajputanae, (Zukowsky, L. 1929) distributed in parts of north-western India, such as Punjab, Haryana, Rajasthan and Gujarat (Meena et al 2017).

According to Groves and Grubb (2011), the two subspecies may actually be two different species. Therefore, taxonomists are investigating their behaviour.

7.5.2 Population structure and dynamics

Around 35,000 mature individuals in India

7.5.3 Behavioural ecology

Blackbuck are considered to be diurnal in their activity pattern. However, the activity reduces during the noontime as the days turn scorching towards summer. Whereas, wandering lone males can often be seen, the species shows an extraordinary social organisation and prefers living in herds of approximately 10–30 individuals that can even grow up to 110 individuals in favourable habitats. The social organisation of the Blackbuck includes the following:

1. *Mixed herds.* These consist of males and females of different age groups.
2. *Harem herds or territorial herds.* These herds consist of one territorial male and females from all age groups.
3. *Bachelor herds.* All-male members
4. *All-female herds.*

The foraging opportunity and the availability of resources in the habitat influence the group size. Large herds are active grazers as, in these, a predator can be spotted faster with a cascade of alarms produced by all the individuals of the group. Hence very less time goes into individual vigilance and therefore is utilised in foraging activities. Herd size often shrinks in summer compared with the monsoon or winter.

7.5.4 Habitat preference and overlap

The primary competition experienced by Blackbuck in their habitats is offered by the local livestock for food resources. Studies have shown that they usually prefer forest fringes where there is rich agricultural activity. Overall, the maximum overlap of the habitats of Blackbuck and livestock is observed in large open areas where rich forage is available. The least preferred habitats are scattered forests and bushes. The preference of a given habitat type is largely determined by the available vegetation, food, water, minerals, shelter from climatic extremes and cover from predators (Jarman and Sinclair; 1979). Food resources, however, not only vary between different habitat types but also show marked seasonal variations within a given habitat, in response to changes in rainfall patterns (Sinclair, 1975). It has been recorded that in summer Blackbuck prefer croplands over grasses and bushes, in which a few lone males may be observed browsing at times. The reason behind this seasonal shift in habitat is the size and thickness of the bushes during different seasons, these affect the chances of predation.

7.5.5 Food habits

Blackbuck graze on low grasses, occasionally browsing as well. Dietary selection varies seasonally, grasses, herbs and shrubs are included in the diet. Blackbucks prefer sedges, fall which grass, mesquite and live oak. The digestion of nutrients, especially crude proteins, is poor in summer but more efficient in the rainy and winter seasons, and therefore the food consumption is lower in summer. The fruits of *Prosopis juliflora* are often eaten, and Blackbuck may play a role in their dispersal. *Prosopis* becomes a significant food item if grasses are scarce. Water is a daily requirement of the Blackbuck.

7.5.6 Ecosystem Services from Blackbuck:

Blackbuck prefers open and flat landscapes in the thorny and dry deciduous forests with a high degree of adaptation in the adjoining wastelands, marginal agricultural fields and cultivated areas. They are principally grazers and forage in small areas; can thrive on a low-quality forage source (grasses); has an evolved mechanism for water conservation when deprived of water; and has an imperative role in the grassland ecosystem.

7.5.7 Human–Blackbuck conflict (HBBC) and its mitigation

Grassland–scrubland loss and habitat destruction are the primary causes of the slow recovery of Blackbuck populations. Protected areas are a relatively small proportion of the remaining grassland–scrubland landscape. And the majority of Blackbuck populations today are found in fragmented, human-dominated landscapes that are interspersed with remaining patches of degraded grasslands or scrub habitats.

Thus, Blackbucks have to move between protected habitat patches, grazing lands and agricultural lands. Thus, the conservation of this species depends on managing and protecting such habitats in human-dominated landscape matrices. At present, the Blackbuck populations are larger in countryside farmlands and village commons than in any nearby protected areas.

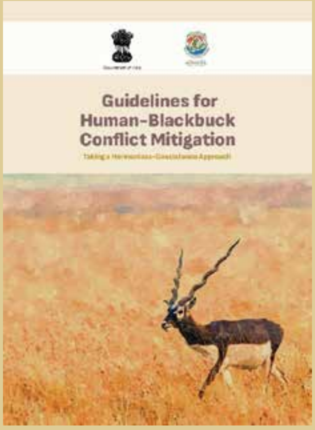
‘Human–Blackbuck conflict (HBBC) refers to the negative interactions between people and Blackbucks that lead to negative impacts on people or their resources, such as human injury, crop damage and loss of property. It also refers to the negative effects of the interactions on the emotional well-being of humans and Blackbucks or their habitats.

Crop damage due to HBBC is not extensive across the range of the species; it is very localised. However, the damage can be heavy. In some areas, there has been a drastic decline in the Blackbuck population and local extinction. The total population of the Blackbuck is recovering. It was 22,000 in the 1970s and had increased to over 50,000 by 2000. The total number of mature individuals in India is believed to be 35,000 (IUCN 2017), which is the reason for the change in the International Union for Conservation of Nature (IUCN) Red List status of the Blackbuck from Vulnerable (1994–96) to Near Threatened (NT) (2003–08) and Least Concern (LC) (2017). There is a need to now conduct systematic population estimation to gain information on the population size across the range of the species, and to assess population trends.

HBBC is resulting in damage to crops in some states such as Rajasthan, Haryana, Maharashtra, Gujarat and Andhra Pradesh. The Blackbuck population in some states/regions within the state is declining rapidly along with the HBBC incidences, while it is increasing in some other states/other regions. The two contrasting cases can be seen in Rajasthan, where the population has increased greatly; however, Blackbucks have become extinct in some places in the western part of Rajasthan. The Blackbuck has thus become a species that needs strong conservation measures and conflict mitigation strategies to be protected in its habitat. Illegal hunting, habitat loss due to conversion of the habitat to other land-use classes and fragmentation are the primary threats to the species. Linear infrastructure is a major factor responsible for the fragmentation of natural habitats. Road networks in the landscape result in mortality due to collisions with vehicular traffic in the short term, while fragmentation and population isolation result in mortality in the long term. Road accidents are responsible for the deaths of many individuals.

HBBC mitigation measures that are effective and wildlife-friendly, need to be developed and further improved towards crop protection, including fencing, as well as procedures for capture, handling, transportation and translocation, identification of suitable habitats for relocation, and required capacity development of the personnel (MoEFCC, 2023e).

A holistic approach to HBBC mitigation is elaborated in the “Guidelines for Human-Blackbuck Conflict Mitigation’.



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7.6 Rhesus Macaque *(Macaca mulatta)* and Bonnet Macaque *(Macaca radiata)*

7.6.1 Occurrence and distribution

The distribution range is across northern and central India (for the Rhesus Macaque) and across southern India (for the Bonnet Macaque).

7.6.2 Food habits

The macaques thrive near human settlements in both urban and agricultural areas, having adapted exceptionally to coexist with humans. Considering the anthropogenic influence on their habitat and behaviour, it is difficult to characterize their 'natural' diet. A substantial part of the macaques' diet is derived, both directly and indirectly, from human activities, with the species being found in higher densities in areas of human disturbance compared with forests. Up to 93 per cent of their diets could be from anthropogenic sources (direct food provisioning by humans, food from agricultural sources). The omnivorous habits of these macaques allow them to feed on a wide variety of plants, invertebrates and processed human food, including meat. Crop foraging allows them access to a huge variety of cultivated fruits and vegetables, while they resort to foraging on garbage in highly urban areas. They are often found to inhabit temples throughout their range, where they are actively fed by the local people as a form of worship. Some common foods given to macaques in temples include bread, bananas, other fruits, peanuts, other seeds, vegetables and assorted miscellaneous foods such as ice cream and fried bread. In less human-influenced areas, they focus on fruits, flowers, leaves, seeds, gums, buds, grass, clover, roots and bark, and they supplement their diet with termites, grasshoppers, ants, beetles and mushrooms. Rhesus Macaques also eat bird eggs, shellfish and fish. At higher elevations, the macaques are restricted to eating leaves of evergreen trees and bark as well as a few winter-growing berries, as seasonal snowfall limits food resources.

7.6.3 Home range and movements

The habitat determines the home range size and daily movement patterns of the macaques. Temple, village and urban macaques derive almost all their food from human offerings, crop foraging or opportunistic foraging on anthropogenic resources, as a result of which their home ranges are smaller. The daily movements in urbanized areas are variable. The home ranges of macaques overlap irrespective of season, with high frequencies of intergroup contact, which is characterized by generally mild social interactions.

7.6.4 Activity patterns

The Rhesus and Bonnet macaques are both diurnal species that devote considerable portions of their active hours to resting. They shift their activity patterns in response to seasonal changes in day length, ambient temperature and rainfall patterns, which affect the food availability. In the warmest times of the year, Rhesus Macaques spend more time resting than they do during cooler months. The major activities of a macaque troop include resting, grooming, huddling, travelling and other activities such as feeding, drinking, object manipulation and self-grooming. Sex, aggression, play and vocalization combined usually account for less than 3 per cent of the activity time budget. Individuals tend to be in proximity to other animals almost two-thirds of the time.

7.6.5 Group dynamics

In general, macaque troops comprise large multi-male, multi-female associations with an average of 10–80 individuals, regardless of habitat type. In mountainous areas and regions of high human food provisioning levels or agricultural habitats, their groups may number in the hundreds. A large group may have distinct sub-groups formed by other dominant males and associated females. Some peripheral males may follow the main troop from a distance. A group may break up during foraging and fuse together later in the day, giving rise to fission–fusion groups that are difficult to differentiate from other nearby troops without prior knowledge about the troop. Aggression is sometimes used to establish and reinforce social position, and aggressive behaviours seen in macaques include slapping, pushing, pulling fur, tail yanking and biting as well as noncontact behaviours such as displays and threats.

7.6.6 Ecosystem Services from macaque:

The intricate association of macaques with tropical ecosystem has its roots in the evolutionary history rather a mere coincidence where both of them seem to have evolved together facilitating each other's survival. Numbers of amazing adaptive traits in macaques have enabled them to perform crucial mandatory ecological services for tropical environment. The preference for predominantly vegetarian diet, propensity for arboreal life, opportunistic tendencies, and extended socialization periods are some of the unique ecological and behavioural traits in macaques that have contributed to the rapid evolutionary success of these animals, especially in the tropical environment.

In having a large home area and social group living, the macaques are at a definite advantage in the performance of some of the vital ecological functions over other sympatric mammals of similar size. Some crucial ecological services that they perform are as seed dispersers, pollinators, and as food for top predators, especially hawks, eagles and mammalian carnivores.

Macaques are notable consumers of plants and therefore exert a very important feedback control on the vegetation regeneration and survival that is so much critical for the maintenance of homeostasis of the tropical forest ecosystems. Their role in pollination is very discreet since they pay back the cost of feeding from plants by helping in their pollination. Their contribution in seed dispersal has a definite edge over other seed-dispersers since percentage of viable seeds gets maximized as they consume the fleshy part of the fruit and range over larger home ranges in numerous social-groupings.

It is a common perception that macaques are 'wasteful feeders' as they pluck leaves, flowers, and fruits in larger quantities than consumed, but this seemingly 'destructive' activity plays a discreet ecological role through trimming undesired twigs, branches and roots, as well as pollination and seed dissemination. Furthermore, since they use both terrestrial (land) and arboreal (trees) habitats, they exploit more plant resources for food purposes, and hence scatter more species of seeds.

Various studies in Neotropics, Africa, and Asia do indicate that primate richness (macaques inclusive) is correlated strongly with the biodiversity richness including other non-primate mammals.

The current concept of landscape approach for biodiversity conservation also fits well with macaques. The ubiquitous presence of macaques over large habitat types both inside and outside the notified forests and protected area networks coupled with their direct interface with humans in urban and semi-urban areas, can well serve as a wider platform to coalesce and integrate practically all possible issues facing biodiversity conservation.

Therefore, the macaques, as a commensal and generalist species and having no immediate risk of entering into endangered category or extinction due to its large population, are one of the best indicators of biodiversity rich ecosystems capable of meeting social, cultural, and economic needs of the people with whom they share larger part of their habitats. This would entail looking at macaques in totality rather as a conflict-species, an approach that has not yielded desired dividends for the last many years of efforts.

7.6.7 Human-Rhesus Macaque conflict (HRMC) and its mitigation

In rural areas, with an interspersion of agricultural lands and fragmented forests, semi-commensal macaques forage on agricultural/horticultural crops. The generalist and omnivorous habits of the Rhesus Macaque, its adaptable nature and its capability to forage in both urban and rural areas are some of the traits of this macaque that have led to the survival of the species in higher densities within human-dominated landscapes compared with forests, subsequently leading to conflicts between humans and Rhesus Macaques.

HRMC refers to the negative interaction between humans and Rhesus Macaques, leading to adverse impacts on humans or their resources, such as death and injury, crop damage and loss of property, apart from affecting emotional well-being, and on the Rhesus Macaques or their habitats.

HRMC is driven by fragmentation and degradation of habitats, expansion of agricultural lands and localised increases in Rhesus Macaque populations. Increased food availability, through crop fields, in human-dominated areas, inadequate garbage management and behavioural factors of the Rhesus Macaque have exacerbated the pressure and resulted in increased HRMC over the past few decades in specific areas. Contrary to popular belief, the macaque presence in human-dominated landscapes is not entirely due to unavailability of food in the forest but due to the adaptive behaviour of the Rhesus Macaque and to the availability of easy and high-energy food and absence of natural macaque predators in such areas.

HRMC affects human societies in terms of loss of livelihood opportunities, economic losses, negative emotional impacts and human deaths and injuries, while the macaques are affected in terms of the growing intolerance of humans towards Rhesus Macaque leading to retaliatory actions.

Capture and translocation of macaques-in-conflict have often only resulted in the transfer of the problem to newer areas—the original conflict spot is occupied due to immigration or expansion of neighbouring troops into vacated areas. Rather than being a mitigative measure, translocation may have become an HRMC intensifier in most instances. In some instances, the translocated troops have mixed with populations of the endemic peninsular Bonnet Macaque (*Macaca radiata*). Similarly, some largescale translocations have even led to expansion of the range of the species in peninsular India, thereby increasing the geographic spread of HRMC. Further information and data need to be generated (in terms of numbers and trends in HRMC cases, crop damage assessment criteria, etc.), to ensure the development of effective mitigation measures.

Periodic estimation of the Rhesus Macaque population across the distribution range in India is the highest priority. In states where Rhesus Macaques were declared vermin, permitting their hunting as a measure to reduce HRMC, effectiveness of such measures may be studied and further strengthening of these measures may be done; capacity needs assessment of the local community as well as the frontline staff may be done in order to assess the capacity development needs for effective HRMC. Some states have used non-lethal mitigation measures with considerable success, but the long-term effectiveness of these measures is yet to be assessed (MoEFCC, 2023f).

A holistic approach to HRMC mitigation is elaborated in the

“Guidelines for Human-Rhesus Conflict Mitigation’.

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7.7 Indian Leopard *(Panthera pardus fusca)*

7.7.1 Occurrence and distribution

Widely distributed in India except for deserts and *Sundarban* mangroves Daniel JC (1996).

7.7.2 Population structure and dynamics

Highly adaptable and widely distributed, Leopards can persist in areas where other large carnivores have been extirpated. The known range of the Indian Leopard has increased compared to the previous assessment, but this is likely due to more intensive surveys conducted in previously unstudied wild and suburban environments (Leopard status report 2018 NTCA). A rigorous evaluation is recommended for the Indian Leopard *Panthera pardus fusca* as it will potentially qualify as Vulnerable. This is because the population is suspected to be declining and has fewer than 10,000 mature individuals (Stein *et al* 2016).

The Leopard density varies with prey availability, habitat type threat presence and intensity. The density can range from one individual/100 km² to over 30 individuals/100 km². The highest densities are found in the protected areas of the mosaic woodland savannahs in east and southern Africa. The Leopard`s geographic range is quite wide. It inhabits Africa and Asia and ranges from most of sub-Saharan Africa (with remnant populations in North Africa), over the Arabic peninsula and Sinai/ Judean Desert, south-western and eastern Turkey, through southwest Asia and the Caucasus up to the Himalayas, India, China and the Russian Far East. It can also be found on Java and in Sri Lanka.

7.7.3 Morphology

There is a high degree of variation in the size and colouration of Leopards across the broad geographical range of the species. The Leopards in Africa are typically the largest and can weigh up to 90 kg; but Leopards in the mountains of Iran and Central Asia can also attain similar large sizes. Usually, the Leopard's fur is yellowish with black markings, known as rosettes. The pattern of rosettes on Leopards is unique to individuals. In Africa, melanistic individuals are rare, but in humid forest habitats, such as in Java and Malaysia, melanism is more common. The colour and patterns of the Leopard's fur seem to be associated with habitat type. For example, in Africa the Leopards inhabiting the savannah have a rufous to ochraceous colour, Leopards in deserts are paler to yellow-brown in colour, with a more greyish colour in cooler areas. Individuals from the rainforests are darker and have a golden colour, while Leopards inhabiting high mountains are even darker than the ones from the rainforests.

The Leopard has very muscular and relatively short legs with broad paws. It has a long body and tail that help tree-climbing. The sexes show marked differences in size and physical features, which indicate different feeding ecology. Despite its relatively small body size, the Leopard is still capable of taking large prey. Its skull is massive, giving ample room for the attachment of powerful jaw muscles. Its whiskers are particularly long, and often there are several extra-long hairs in the eyebrows, protecting the eyes and assisting movement through vegetation in darkness. The scapula is adapted for the attachment of powerful muscles that raise the thorax, enhancing the ability of the Leopard to climb trees. The Leopard can live independently of water for periods of time, satisfying its moisture requirements entirely through its prey.

7.7.4 Behaviour

The Leopard is solitary and territorial. On the basis of prior studies conducted in savannahs and woodlands, it was described as being mainly active between sunset and sunrise, but populations in undisturbed rainforest areas in Gabon were largely diurnal. The Leopard uses scent marks and vocalisation to communicate. Less frequently, in some regions, it scratches trees to mark its territory.

The Leopard is a visual hunter in open habitats and uses high points such as trees to locate prey. In such open habitats, the Leopard hunts by stalking from a very low position, resting motionless for long periods of time if needed. In dense tropical forests, the Leopard predominantly seems to hunt from an ambush, targeting well-used game trails or fruiting trees that attract ungulate prey. It attacks from very close range with a short burst of speed and a powerful strike of the front paw. Leopards prefer hunting in habitats where prey animals are easier to catch, rather than where they are more abundant.

The probability of making a kill is highest in habitats with intermediate cover. Studies suggest that Leopards select their prey in accordance with energy expenditures and may have a certain specialisation in regard to the habitat where they prefer to hunt as it seems that they do not only need high prey abundance, but appropriate vegetation cover as well to ensure successful hunting. Leopards show a preference for hunting in mixed closed woodland and tall open woodland and not in the grasslands, with the highest prey biomass estimates. Forest Leopards are mainly diurnal and crepuscular hunters that follow the activity patterns of their main prey species.

The Leopard is an excellent climber, and in areas where it occurs sympatrically with larger carnivores such as the Tiger (*Panthera tigris*), Lion (*Panthera leo*), Dhole (*Cuon alpinus*) and Striped Hyaena (*Hyaena hyaena*), it often drags prey up into trees for eating. The Leopard also retreats up a tree in the face of direct aggression from such competitors.

The breeding may take place throughout the year. Generally, there may be birthing peaks during the breeding season of the Leopard's main prey species, the small- to medium-sized ungulates. Usually, most females give birth during the wet season, especially in December. The age at first reproduction for females is on average 35 (24–46) months and for males 36–48 months. The inter-birth interval ranges from 15 months to over 2 years. Siblings may remain together for several months before separating. The age at the last reproduction is on average 8.5 years, but reproduction can take place up to the age of 16 years.

7.7.5 Leopard habitat

The Leopard is highly adaptable and can inhabit a wide range of different ecosystems, with extreme variations in conditions and habitat types. These ecosystems range from tropical rainforests to temperate deciduous and alpine areas, The Leopard is found on high mountain slopes and in savannah, bushlands, dry scrub, grasslands and deserts. In northwest Africa, Iran and the Caucasus, pine forests and Mediterranean scrub are also suitable habitats. In Africa, the habitats that support the highest densities are woodland, grassland savannah and forest, but Leopards also inhabit mountain areas, coastal scrub, swampy areas, semi-desert and deserts. In Morocco, the Leopard has been recorded up to 3000 m, in sub-Saharan Africa up to 4600 m, in Mt Kenya, and the Himalayas up to 5200 m.

7.7.6 Ecosystem services provided by Leopard:

Leopard plays a crucial ecological role in the landscapes where it is present and helps in maintaining ecological stability and maintaining ecosystem services required for livelihoods and overall human well-being. Leopard conservation ensures the conservation of a large number of other co-occurring species of plants and Leopard, further accentuating the conservation significance of this species.

Leopard is an important predator offering multiple ecosystem services as its dietary spectrum ranges from small rodents to large herbivores. It continues to remain an important predator even in the areas where other large carnivores such as Tiger (*Panthera tigris*) and Lion (*Panthera leo*) exist. Over the past decade, due to habitat fragmentation and expansion of human-dominated areas, the increased interface of leopards and humans has been observed, sometimes leading to conflict.

7.7.7 Human–Leopard conflict (HLC) and its mitigation

In India, the most significant threat to human life posed by large carnivores comes from Leopards. Human-Leopard Conflict (HLC) refers to the negative interactions between humans and Leopards, leading to adverse impacts on humans or their resources, such as human injury and death, loss of property (cattle, poultry, etc.) and effects on their emotional well-being, and on Leopards or their habitats.

HLC is more common than human–Tiger conflict because of the much wider distribution and larger population of the Leopard.

The drivers of HLC emanate from biological, socioeconomic, behavioural and developmental aspects, and each of these has independent repercussions and combined effects, depending on the space and time. The general drivers of HLC include a disproportionate growth of the human population density, habitat fragmentation and degradation, development activities such as the creation of linear infrastructure, disruption of connectivity/corridors, continued forest-dependence of humans for livelihoods, inadequate stakeholder engagement and current gaps in understanding.

Leopard behaviour in human-dominated landscapes.

Loss of livelihood opportunities, other economic losses, negative emotional impacts and human deaths and injuries are key impacts on humans that result in growing intolerance towards Leopards in specific and wildlife in general, subsequently leading to retaliatory action from humans towards Leopards.

Several measures are being implemented to mitigate HLC, including making *ex gratia* payments for human injuries and losses, establishing Rapid Response Teams (RRT), using early warning equipment (such as camera traps and radio collars/chips), carrying out forensic investigations and capturing and translocating or confining Leopards (MoEFCC, 2023g).

A holistic approach to HLC mitigation is elaborated in the

“Guidelines for Human-Leopard Conflict Mitigation’.

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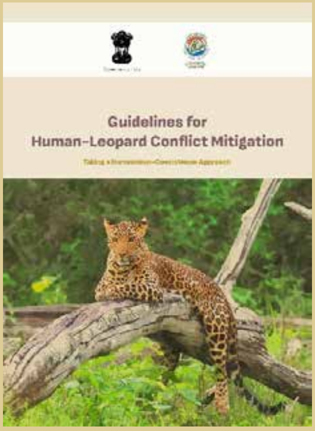

7.8 Royal Bengal Tiger *(Panthera tigris tigris)*

7.8.1 Occurrence and distribution

Patchy distribution across India (forests, shrublands, grasslands, mangroves, etc.)

7.8.2 Morphology and behaviour

Tigers are territorial and are usually solitary in nature. Their social system is connected through visual signals, scent marks and vocalisations. A male or female usually interacts with the opposite sex briefly only for mating purposes and occasionally to share a kill. However, there have been a few rare instances documented in which Tigers have collaborated on a hunt, similar to the manner in which a pride of Lions would collaborate.

The sizes of Tiger territories vary significantly with locality, season and prey density (the amount of prey in a given area). In areas with high prey densities, Tiger territories tend to be smaller in size because ample prey may be found in the closer vicinity. In India, the prey concentrations are high and male Tigers have territories that range in size from 5 km^2 to 150 km^2. In Siberia, the prey concentrations are much lower, and male Tiger territories range in size from 800 km^2 to 1200 km^2. The seasonality of prey migrations, food availability and weather may also affect prey populations and therefore the sizes of Tiger territories. Males have larger territories than do females. An adult male's territory will usually overlap several females' territories. The larger area contains more food, water and shelter resources than necessary. It is large to accommodate more females territories. Therefore, females are the most coveted resource of males.

7.8.3 Activity patterns

Tigers are mainly active at dawn and dusk (they are crepuscular) and less active during the mid-day heat. However, this pattern may vary with habitat type. Tigers, unlike many other cat species, readily enter the water to cool themselves and to pursue prey. They are powerful swimmers and are capable of traversing lakes and rivers. Tigers assert and maintain their control over their territories by continuously patrolling them. Aggression amongst adult male Tigers can be influenced by the number of Tigers in a given area (density) and social disruptions in which males competee to take control of a territory. The intensity of aggression increases when there are high Tiger densities because there is more competition for resources and mating opportunities. Resident male territory-holders may be challenged by other young males for possession of their territories, or the young males may challenge each other for ownership if the resident male has vacated or died. The strongest male will take possession of the territory. These times of social disruption may also cause aggression between females. Tigresses' territories are smaller than those of males but focus on the vital resources required for rearing young. Tigresses usually occupy territories adjacent to or take over parts of their mothers' territories.

Tigers coexist with other predators such as Leopards, Dholes, Sloth Bears and Wolves throughout most of their range. Usually, there is little interaction between species, especially since Tigers are mostly crepuscular (active at dawn and dusk), while the other species are mainly diurnal (active during the day) and nocturnal (active late in the night).

7.8.4 Population structure and dynamics

2154–3159 worldwide

7.8.5 Habitat

In India, the Tiger is found practically throughout the country, from the Himalayas to Cape Comorin, except in Punjab, Kutch and the deserts of Rajasthan. In the northeast, its range extends into Burma. Tigers occupy a variety of habitats, including tropical evergreen forests, deciduous forests, mangrove swamps, thorn forests and grass jungles.

7.8.6 Ecosystem services from Tiger:

Conservation of the tiger, an umbrella species, ensures the protection of habitats of several other species while ensuring the continuity of ecological and evolutionary processes in the wild.

7.8.7 Human–Tiger conflict and its mitigation

The conflict with Tigers is responsible for a lower number of human deaths (30–40 annually, NTCA report) than human–leopard conflict. Still, livestock losses are significant around the Tiger reserves and other areas where they are present at higher densities. While human casualties due to conflicts with Tigers are rare, their presence around human habitations can create a fear psychosis because they are large carnivores. If not addressed appropriately, this psychosis negatively affects the well-being of people living in the area in the long term. The human–Tiger conflict results in significant livestock loss in Uttarakhand, Maharashtra, Karnataka, Madhya Pradesh, etc. This, in turn, generates antagonism among local communities towards conservation (Goodrich et al 2015).

Institutional set-up—the National Tiger Conservation Authority (NTCA)—and guidelines for managing human—Tiger conflict in India:

Standard operating procedure (SOP) for disposing of Tiger/Leopard carcass/body parts, https://projecttiger.nic.in/WriteReadData/CMS/SOP_carcass-disposa25Feb2013.pdf

Standard operating procedure to deal with emergency arising due to straying of Tigers in human-dominated landscapes, https://projecttiger.nic.in/WriteReadData/CMS/Final_SOP_11_01_2013.pdf

Dealing with Tiger depredation on livestock,
https://projecttiger.nic.in/WriteReadData/CMS/SOP%20carcass.pdf

7.9 Sloth Bear *(Melursus ursinus)* and Himalayan Black Bear *(Ursus laniger)*

7.9.1 Occurrence and Distribution

Indian Subcontinent

7.9.2 Population structure and dynamics

<10,000 to >20,000 bears

7.9.3 Behaviour

Sloth Bears are synanthropic species as they can easily adapt to human-use landscapes, where agriculture and forests are the major land-use types. Sloth Bear habitats are getting fragmented and degraded due to encroachment for agriculture, mining, settlement, livestock grazing and collection of forest produce. Similarly, the excessive collection of wild fruits for local consumption or markets has resulted in the decline of natural fruit resources for bears.

A decline in food resources may sometimes force Sloth Bears to enter human settlements in search of food. These activities increase the likelihood of human–Sloth Bear encounters, which can lead to conflict. Most of the Sloth Bear populations occur in dry deciduous forests, where water is a limiting factor in summer. This also forces bears towards the villages in search of water. Accidental confrontations between forest dwellers and Sloth Bears in the forest may also become the cause of human casualties, especially during the collection of NTFP and with females carrying cubs.

Sloth Bears are omnivorous and show myrmecophagy, feeding on social insects (ants, termites, honey bees, etc.). They also consume sugar-rich fruits, roots and tubers. However, the relative proportions of fruits or insects in the diet vary between seasons and geographical areas. Sloth Bears are opportunistic scavengers. They are generally nocturnal and crepuscular and use dens or bushes to rest during the day.

7.9.4 Habitat

In India, Sloth Bears are widely distributed in a range of natural and human-dominated landscapes. They are reported to be present in 174 of India's PAs, including 46 national parks and 128 wildlife sanctuaries. The Sloth Bear populations inside these PAs appear to be reasonably well protected, but significant populations live outside the PAs in highly fragmented habitats.

7.9.5 Ecosystem services from bears:

Bears are excellent seed dispersers and seed destroyers, and hence play a significant role in the regeneration and regulation of many plant species in the forests. Therefore, bears are considered as an indicator of habitat quality. In India, bears have been associated with people since ages, as evident from mythology, folklore, culture, customs and traditions.

7.9.6 Human–Bear conflict (HBC) and its mitigation

India is home to four species of bear, viz., the Himalayan Brown Bear, Asiatic Black Bear, Sloth Bear and Sun Bear.

Although they are classified as carnivores, bears are largely omnivorous, feeding on a variety of fruits/nuts, ground layer vegetation and insects and scavenging on dead animals. They are excellent seed dispersers and hence play a significant role in the regeneration and regulation of the populations of many plant species in forests. Hence, bears are considered as indicators of habitat quality. In India, bears have been associated with humans since time immemorial, as evident from mythology, folklore, culture, customs and traditions.

Of the four bear species in India, two are in conflict with humans, viz., the Sloth Bear and Asiatic Black Bear. The Himalayan Brown Bear too conflicts with humans but is primarily confined to the upper regions of the Western Himalaya. There have been no reports of conflicts associated with Sun Bear.

HBC refers to the negative interaction between humans and bears, leading to adverse impacts on humans (such as injuries to humans, loss of human life and impacts on emotional well-being) and their resources (crops, livestock and other properties) and on the bears or their habitats. The drivers of HBC include the exponential growth of human populations in forest-fringe areas; habitat fragmentation and degradation; development activities such as linear infrastructure construction; a continued dependence of communities on forests for their livelihoods; a mismatch of conservation goals with human aspirations and changing lifestyles; and inadequate stakeholder engagement.

Increasing human-bear interface areas, inadequate alternative livelihood options in forest-fringe areas and limited awareness among humans living in and around bear habitats about bear behaviour creates further pressures, leading to injuries and loss of human lives and livestock injury/loss.

HBC primarily takes place when humans enter bear habitats for non-timber forest produce (NTFP) collection or for grazing their cattle or when bears enter human habitations in search of forage. Bear populations that occur outside protected areas (PAs), share space with humans, thereby increasing the probability of accidental encounters.

The Sloth Bear (*Melursus ursinus*) is a myrmecophagous species (specialized for feeding on termites and ants) that is very widely but patchily distributed in India. The Sloth Bear is found in forested as well as rocky and scrub habitats. The densities of Sloth Bear populations in India vary across the distribution range of the species. The conflict associated with the Sloth Bear is increasing rapidly.

The Asiatic Black Bear (*Ursus thibetanus*) is distributed in the forested habitats of the Himalayan region and the hills of the Northeast. The human–Asiatic Black Bear conflict is spread all across the distribution range in India, and it results in crop damage and livestock loss/injury.

The current response to HBC includes measures to prevent retaliatory killings of bears by humans, creating awareness amongst local communities to reduce accidental encounters and rescuing stranded bears or bears-in-conflict. As HBC leads to a changed perception of humans towards wildlife, the overall support for conservation declines. Therefore, it is important to address the issue holistically, i.e., address the drivers and pressures, further develop prevention and emergency response measures and reduce the vulnerability of humans and bears to HBC is in the interest of the overall need for the conservation of wildlife/biodiversity in the country (MoEFCC, 2023h).

A holistic approach to HBC mitigation is elaborated in the

“Guidelines for Human-Bear Conflict Mitigation’.

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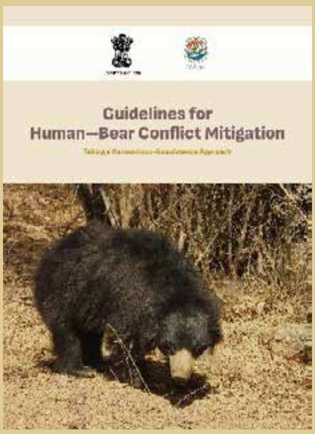

7.10 Other carnivores

In the Trans-Himalayan region, Snow Leopards and Himalayan Wolves are known to prey on livestock. The communities in the region own large numbers of livestock, which compete with the wild prey species of these predators and, in certain areas, can even outnumber them. This inadequacy of wild prey, combined with poor herding and penning practices, leads to high levels of losses. Consequently, losing large numbers of livestock to carnivores can cause resentment in the communities and lead to retributive actions.

There are several mitigative actions being tried by local communities with the help of the forest department and conservation.

7.11 Crocodiles

7.11.1 Occurrence and distribution

Crocodiles are aquatic species that inhabit freshwater and brackish water ecosystems. There are about 24 species of crocodile in the world. Of these, the Gharial *Gavialis gangeticus*, Saltwater Crocodile *Crocodylus porosus* and Mugger Crocodile *Crocodylus palustris* occur in India. The Mugger Crocodile is distributed inland in rivers and other water bodies, while the distribution of the Saltwater Crocodile is restricted to the coastline, particularly on the eastern coast of India.

Saltwater Crocodiles are found on the eastern coast of India (main populations in the Sundarbans and *Bhitarkanika*) and the Andaman & Nicobar Islands. Bhitarkanika National Park has a large population of Saltwater Crocodiles, which has been boosted by a reintroduction programme between 1977 and 2009. Saltwater Crocodiles are widely distributed in the Andaman Islands, but increased human occupation of freshwater swamps might have affected the availability of suitable breeding habitats in these islands. There are historical records of the occurrence of all three species of Indian crocodile in West Bengal. But it is only the Saltwater Crocodile that is known to occur in the wild now. With numerous freshwater wetlands, major and medium-sized rivers (Ganga, Teesta) and the world's largest contiguous mangrove system (Sundarbans), West Bengal still harbours good habitats for the crocodilians. The extensive mangrove region particularly, with its numerous river and creek systems, provides a suitable habitat for the Saltwater Crocodile.

The Mugger, formerly widespread and very abundant, was significantly depleted in numbers until it was considered rare in most, if not all, of its former range. It was considered that in south India (Tamil Nadu, Karnataka and Andhra Pradesh), the remnant populations could show a rapid response to management combined with protection and this could also be the case in Rajasthan and Gujarat. As with the other species of crocodilian in India, the pressures of a large human population, and hunting in the past, reduced the numbers of *C. palustris*. In India, wild Mugger populations have been boosted by a conservation programme involving the restocking of depleted rivers with juveniles raised in captivity.

7.11.3 Behaviour

Mugger females lay their eggs in sandbanks between February and April, and hatching occurs between April and June. One of the unique features of Muggers is that they appear to be the only species of living crocodilian that regularly breeds twice in a year, with different clutches being laid between 30 and 57 days apart. In the Andaman Islands, Saltwater Crocodiles are widely distributed, but their population expansion through intrinsic breeding appears to be constrained by the lack of suitable breeding habitats (freshwater swamps).

7.11.4 Ecosystem Services from Crocodiles:

Crocodiles play a key role in aquatic ecosystems as top predators, maintaining aquatic ecology and a healthy balanced ecosystem. Because of their specialized habitat needs in terms of habitat characteristics and water chemistry, they are also excellent indicators of aquatic biodiversity.

7.11.5 Human–crocodile conflict (HCC) and its mitigation

Human–crocodile conflict' (HCC) refers to negative interactions between people and crocodiles, leading to negative impacts on people or their resources, such as human death and injury, loss of livelihoods and impacts on the emotional well-being of humans, and on the crocodiles or their habitats

People and crocodiles have co-existed and have shared a long history of living together, in some cases for millennia, without much conflict. However, with increased human activities in crocodile habitats as well as the spillover of crocodile populations, as a result of conservation efforts, HCC has been escalating in many areas. There has been an increase in the number of human fatalities over the last few years in India due to HCC.

HCC involves two species of crocodile, viz., saltwater crocodile and Mugger, with key impacts on humans in the form of human injury and death, livestock injury and death. HCC is a serious issue in rural and semi-rural environment.

Human–crocodile conflict is reported in seven states (Odisha, West Bengal, Andaman and Nicobar Islands, Gujarat, Maharashtra, Karnataka and Tamil Nadu). The drivers of HCC include an increase in the human population close to crocodile habitats, changing lifestyles and economic aspirations; reduced appreciation of wildlife; land-use changes; tourism policies; aquaculture; fishing; and wetland habitat fragmentation, loss and degradation (MoEFCC, 2023i).

A holistic approach to HCC mitigation is elaborated in the “Guidelines for Human-Crocodile Conflict Mitigation’.

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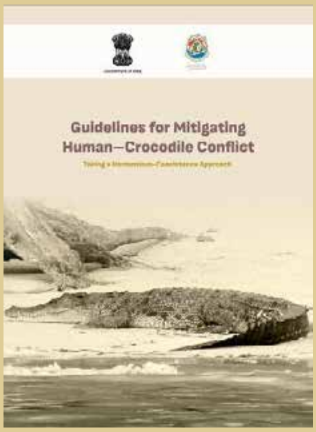

7.12 Snakes

7.12.1 Occurrence and distribution

Widely distributed across six continents except Antarctica.

There are nearly 3500 described species of snake, and of the 1518 listed on the IUCN Red List of Threatened Species, 185 are listed as Threatened.

7.12.3 Behaviour

Snakes are ectotherms, which means that they cannot regulate their body temperature from within, as humans do. Instead, they use their environment, basking in the sun to keep warm or slipping underground to cool off. Snakes prefer to avoid people and will generally only bite when they are picked up, stepped on or otherwise provoked. Though most of the snakes are harmless, several species have defensive displays, such as exuding a smelly musk or rattling their tails,

7.12.4 Food habits

All snakes are carnivores, which means they eat meat. Their diet varies with size and species and can include insects, worms, amphibians, fish, small mammals and, occasionally, birds.

7.12.5 Ecosystem Services from Snakes:

Snakes are an integral part of the ecosystems in which they operate and are related to humans in direct as well as indirect ways. Snakes play a significant role by feeding on a wide range of animals. At the same time, they also serve as prey to other animals. Some snakes are expert rodent hunters, controlling a significant population of rodents that are otherwise inaccessible to other predators. Even many lifesaving drugs, including the anti-snake venom, are prepared from the venom of some species.

7.12.6 Human–snake conflict (HSC) and its mitigation

Snakes, unlike most wild animals, are more likely to share the living space with humans in rural and urban landscapes alike, in extremely close proximity. Notably, some of these snake species are potentially dangerous to humans. Close encounters of humans with snakes are, for the most part, inevitable, as these animals (including venomous species) have successfully adapted to live close to human habitations that provide easy prey.

These species are either pulled into such habitations in search of prey or are pushed out of natural habitats due to fragmentation and destruction of the same. The abundance of a particular species of snake varies spatially and temporally. Young snakes (just after hatching, till they get settled in a particular territory) are naturally more abundant than adults. Similarly, highly adaptable species tend to be more abundant than habitat specialists. The distribution and abundance of snakes also vary across landscapes and habitat types. They also vary with the adaptability of a snake to rapidly changing habitats.

In ideal conditions, snakes are secretive and are mostly encountered randomly/accidentally inside human settlements, or they may get detected when their microhabitats are disturbed through earth-moving, construction, farming activities, etc. In rural areas humans very often encounter resting snakes when removing fuelwood, cow dung or bricks from piles. Such spots offer warm and safe microhabitats for many snakes. Temporally, the chance of an encounter is high during the rainy season, when snakes come out of their burrows/hideouts due to flooding. Snakes are encountered more frequently when they find human habitations to be safe and warm places for over-wintering or egg-laying or easy prey-hunting (house rodents).

Venomous species, such as Russell's viper, the Binocellate cobra and the common krait prefer dry areas, while the Monocellate cobra and banded krait prefer moist areas such as wetlands, water-logged areas and swampy habitats. The saw-scaled viper prefers dry, rocky terrain, scrub forests, rock piles, etc. On the basis of their activity, snakes can be classified as diurnal, nocturnal or crepuscular. However, most HSC incidents happen when humans encounter snakes outside their actual activity period. In a natural ecosystem, snakes do have inter-species competition for food and resources, and they avoid encounters. For example, rat snakes and cobras, being the most common snakes encountered near human habitations and being competitors for food and resources, often avoid each other. Hence, sensitising humans to coexist with the non-venomous rat snake might save them from the deadly cobra.

The Big Four venomous snakes, causing the maximum morbidity are the spectacled cobra (*Naja naja*), common krait (*Bungarus caeruleus*), Russell's viper (*Daboia russelli*) and saw-scaled viper (*Echis carinata*). Other than these, in general, any snake (of any species) encountered by the public is likely to be harmed in retaliation, out of fear. Among the Indian snakes, some species of harmless snake mimic the venomous ones, and some even display various intimidating defensive behaviours. In such cases, if such harmless snakes are not rescued immediately by a trained rescuer, they may also be at high risk of being killed in retaliatory action by humans or out of fear.

Snakebite affects more humans than many other 'neglected tropical diseases' and often causes death, disability or disfigurement. At a global scale, the World Health Organization (WHO) has included snakebite as a neglected tropical disease. WHO's global strategy emphasises a combination of approaches, such as empowerment and engagement of communities, improved access to modern health facilities and better cooperation and coordination among stakeholders at the local, regional and national levels.

Challenges in mitigating HSC are more complex than any other species-in-conflict. With the enormous increase in the human population, coupled with habitat loss and habitat degradation, the frequency of human–snake interactions has also increased rapidly (MoEFCC, 2023cj).

A holistic approach to HSC mitigation is elaborated in the "Guidelines for Human-Snake Conflict Mitigation'. These guidelines have been developed by MoEFCC together with the National Center for Disease Control (NCDC), and Ministry of Health and Family Welfare (MoHFW), under the Indo-German Project.

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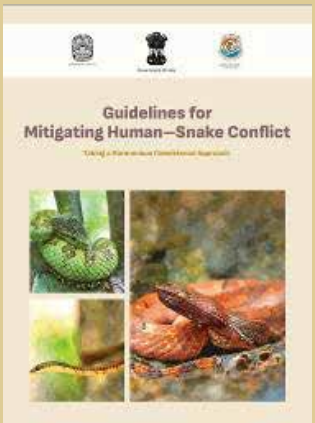

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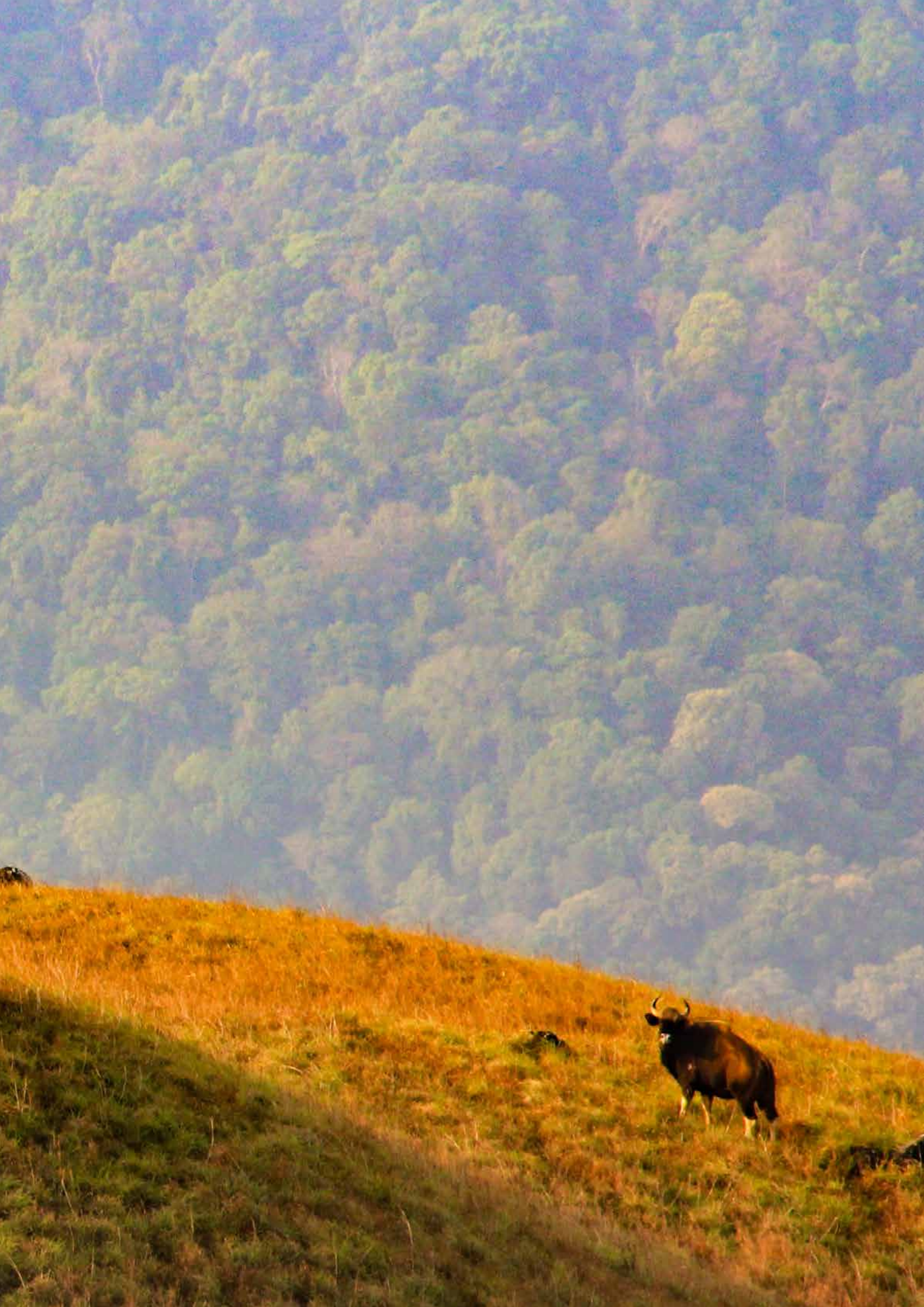

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