german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Ministry of Environment, Forest and Climate Change, Government of India

Forest Department Karnataka

Directorate of Forests Government of West Bengal

Training Resource Material

Content Module 4

Tools and techniques for effective and Efficient Human-Wildlife Conflict Mitigation

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
Module HWC-05:	Strengthening Community Engagement for Effective and Sustainable Mitigation of Human-Wildlife Conflict
Module HWC-06:	Operationalizing the Holistic and Harmonious coexistence Approach to Mitigate Human-Wildlife Conflict through Cross-sector Cooperation
Module HWC-07:	Holistic, Effective and Ethical communication on Human-Wildlife Conflict Mitigation: Taking a Harmonious Coexistence Approach
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

June 2023

Published by:
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Registered offices
Bonn and Eschborn
A2/18, Safdarjung Enclave
New Delhi- 110029, India
T +91-11-4949 5353
F +91-11-4949 5391
E biodiv.india@giz.de
I www.indo-germanbiodiversity.com

Project description:
Indo-German Project on Human-Wildlife Conflict Mitigation

Responsible:
Dr. Neeraj Khera, Team Leader
E neeraj.khera@giz.de

Module developed by:
Mr Aritra Kshettry,
Dr Floris Deodatus, DFS Germany,
Dr Subhadeep Bhattacharjee,
Dr Dibyendu Mandal,
Dr K Ramesh, Wildlife Institute of India,
Ms Abhilasha Shrivastava, GIZ India,
Mr Vimarsh Sharma, GIZ India,
Sh. Ajay Desai

With contributions from:
Ms. Bhawna Yadav
Ms. Arushi Lohani

Language editing and proof reading:
Mr Kumaran Sathasivam, Palladium Documentation
Ms. Babita A.

Design:
Aspire Design

Photo credits:
GIZ/Neeraj Khera

On behalf of the
German Federal Ministry for Economic Cooperation and Development (BMZ)
GIZ is responsible for the content of this publication.

New Delhi, 2023

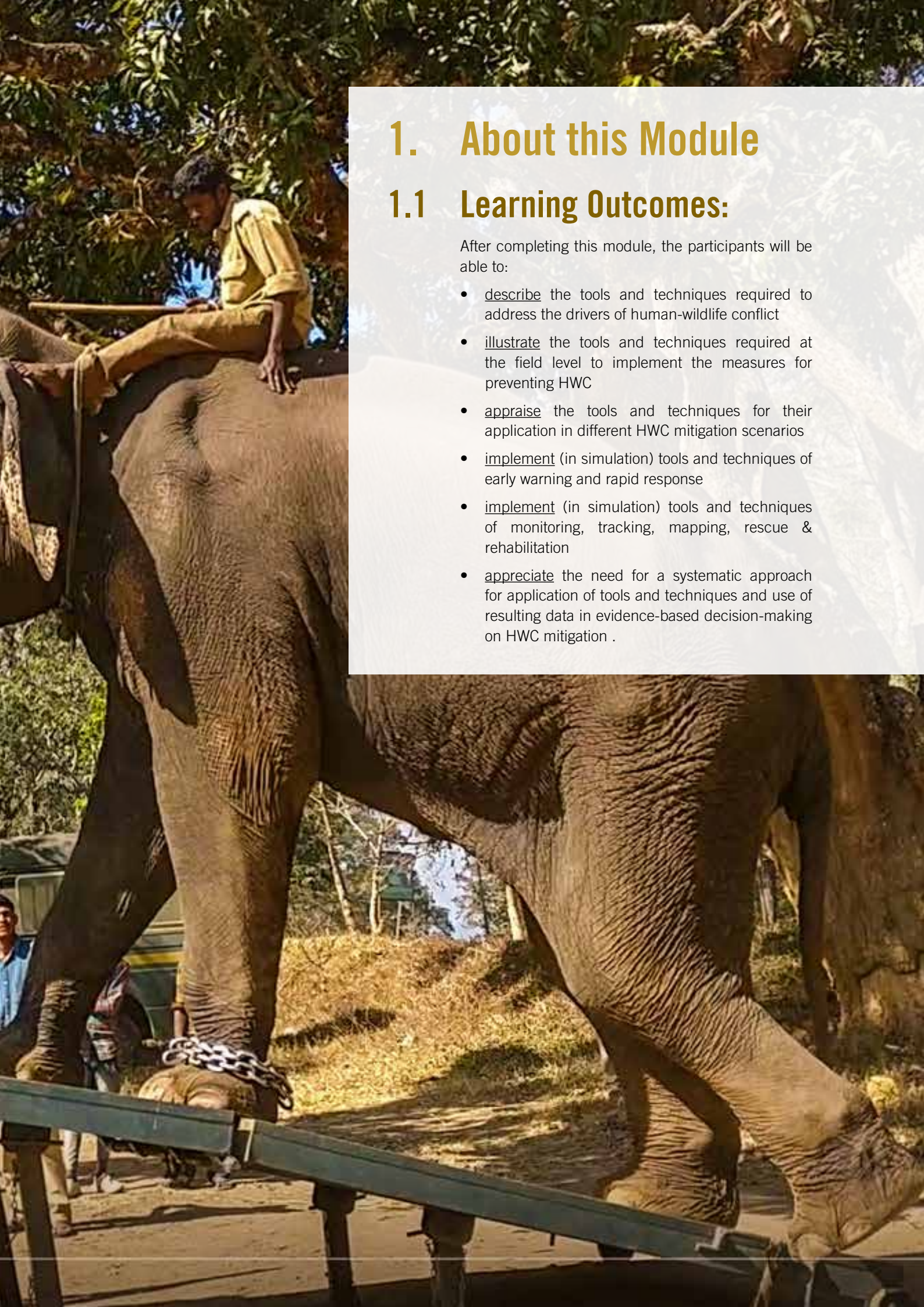
Table of Contents

List of Figures

List of tables

List of Boxes


KA-05

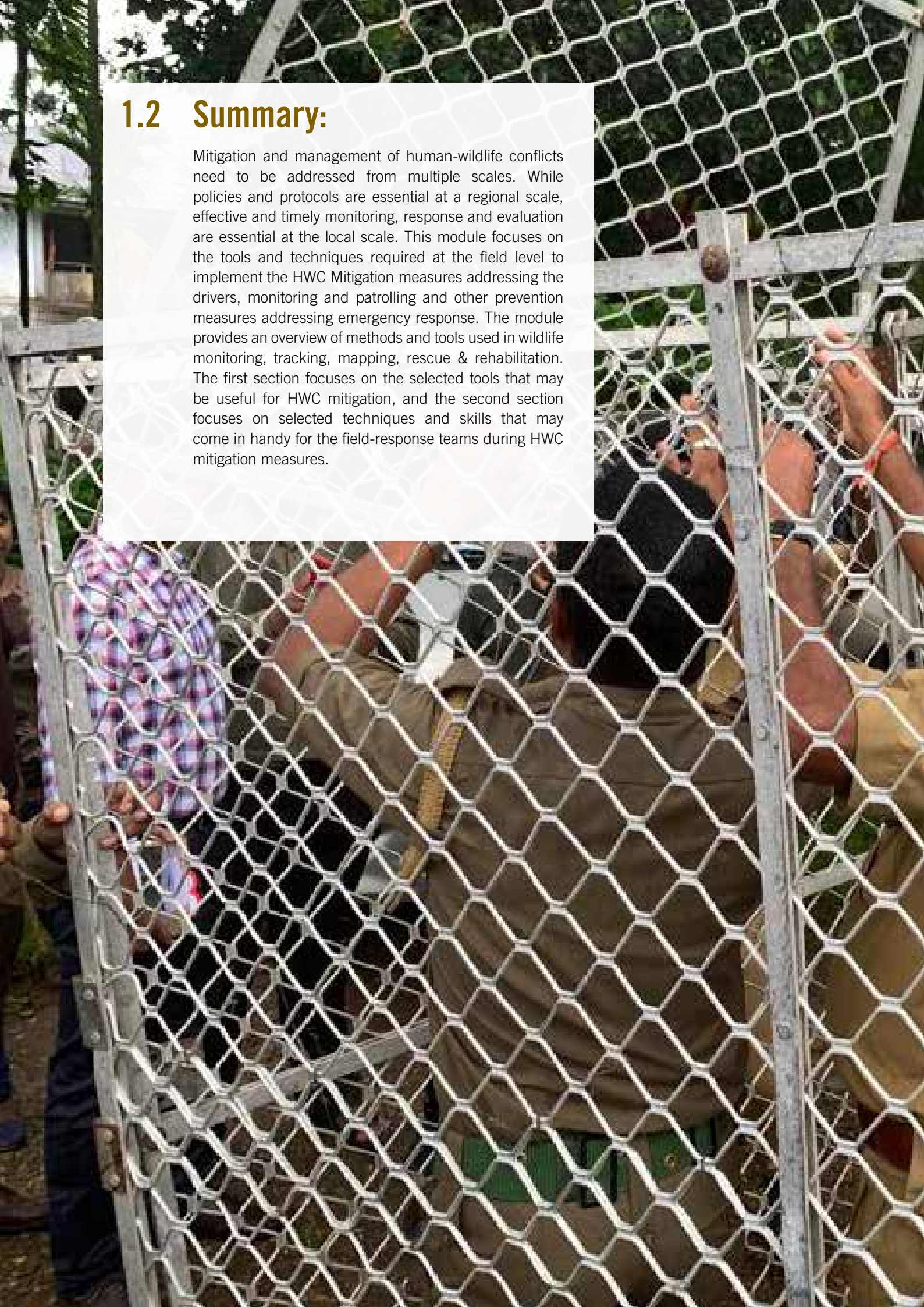


1. About this Module

1.1 Learning Outcomes:

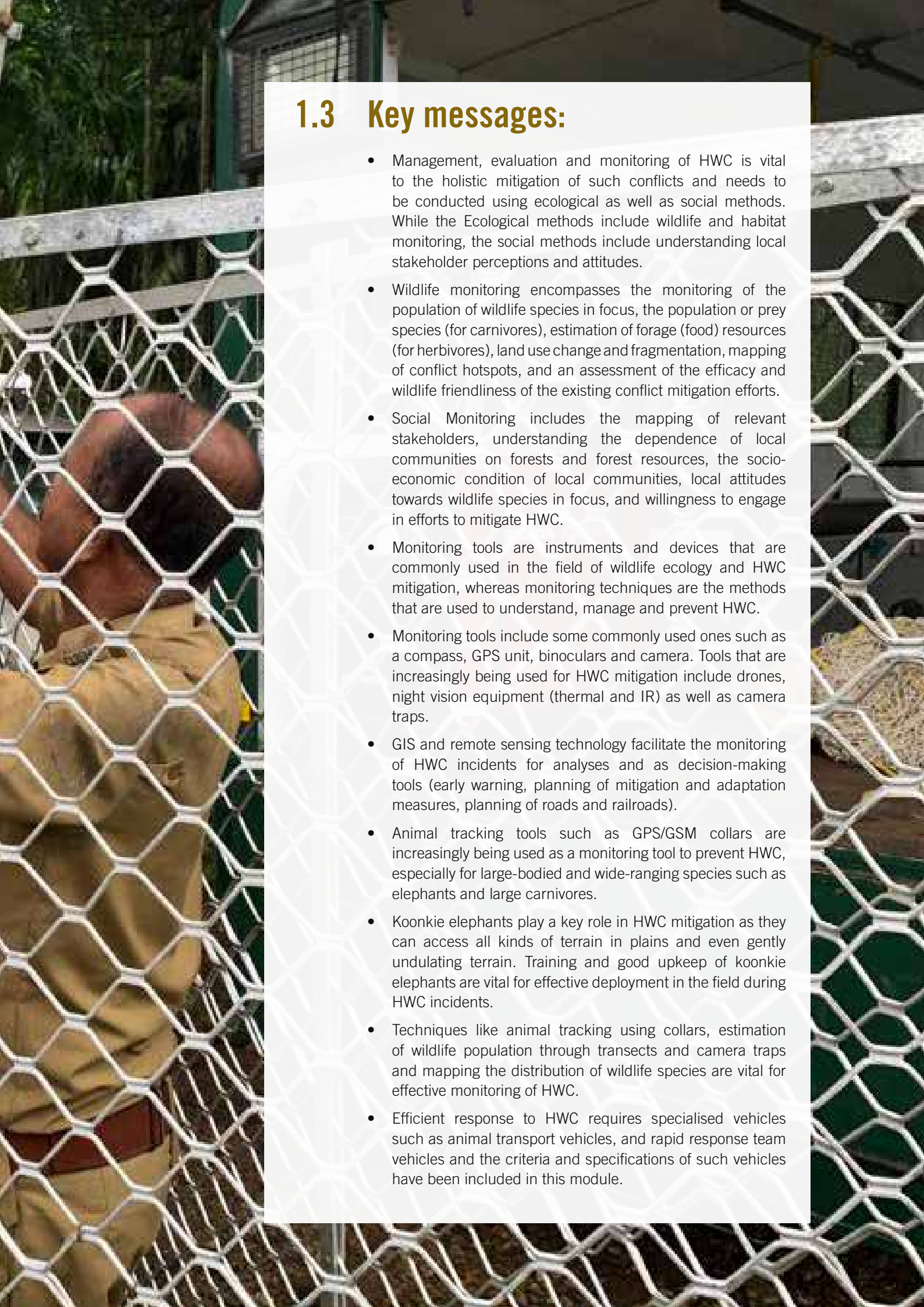
After completing this module, the participants will be able to:

- describe the tools and techniques required to address the drivers of human-wildlife conflict
- illustrate the tools and techniques required at the field level to implement the measures for preventing HWC
- appraise the tools and techniques for their application in different HWC mitigation scenarios
- implement (in simulation) tools and techniques of early warning and rapid response
- implement (in simulation) tools and techniques of monitoring, tracking, mapping, rescue & rehabilitation
- appreciate the need for a systematic approach for application of tools and techniques and use of resulting data in evidence-based decision-making on HWC mitigation .



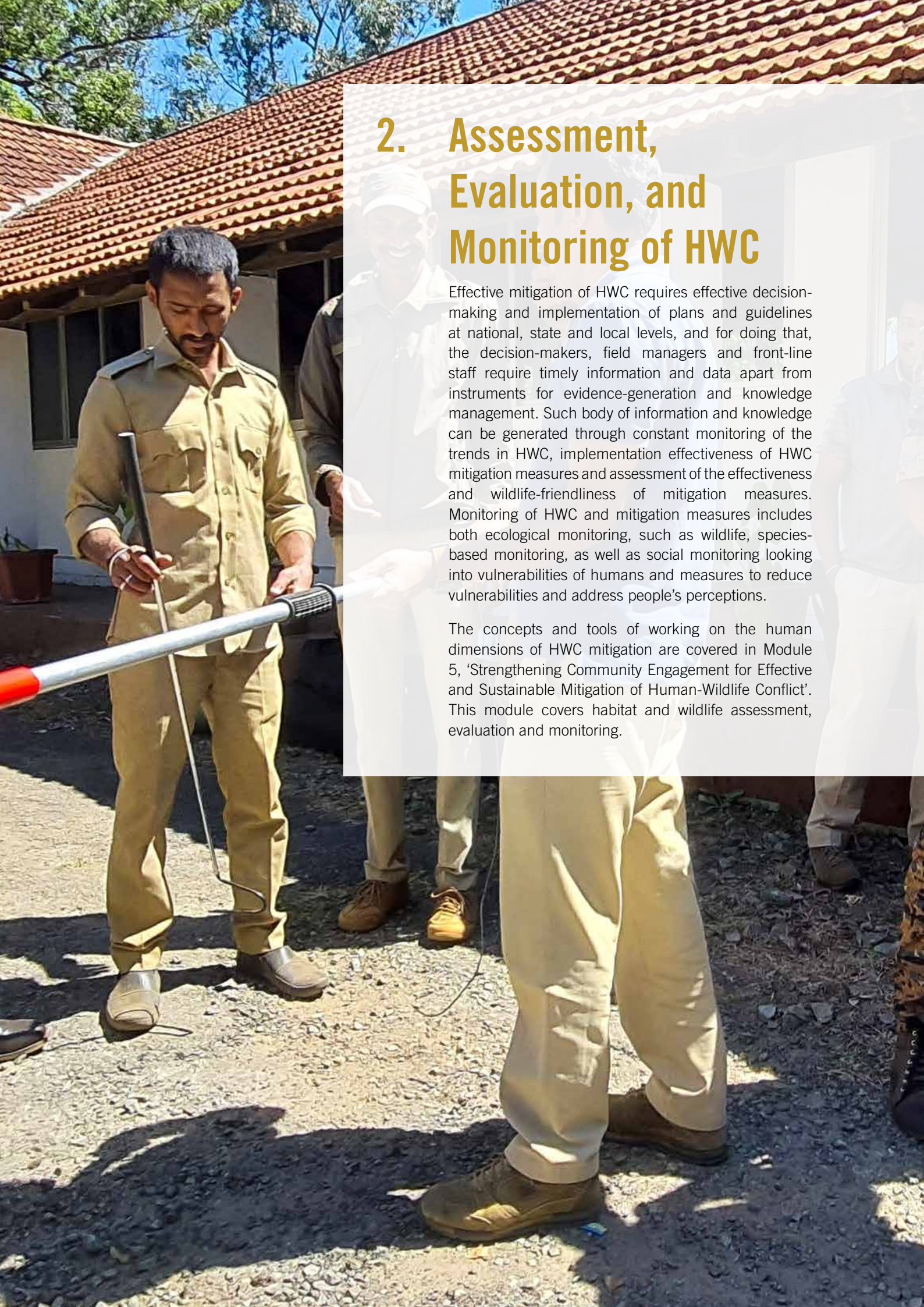
1.2 Summary:

Mitigation and management of human-wildlife conflicts need to be addressed from multiple scales. While policies and protocols are essential at a regional scale, effective and timely monitoring, response and evaluation are essential at the local scale. This module focuses on the tools and techniques required at the field level to implement the HWC Mitigation measures addressing the drivers, monitoring and patrolling and other prevention measures addressing emergency response. The module provides an overview of methods and tools used in wildlife monitoring, tracking, mapping, rescue & rehabilitation. The first section focuses on the selected tools that may be useful for HWC mitigation, and the second section focuses on selected techniques and skills that may come in handy for the field-response teams during HWC mitigation measures.



1.3 Key messages:

- Management, evaluation and monitoring of HWC is vital to the holistic mitigation of such conflicts and needs to be conducted using ecological as well as social methods. While the Ecological methods include wildlife and habitat monitoring, the social methods include understanding local stakeholder perceptions and attitudes.
- Wildlife monitoring encompasses the monitoring of the population of wildlife species in focus, the population or prey species (for carnivores), estimation of forage (food) resources (for herbivores), land use change and fragmentation, mapping of conflict hotspots, and an assessment of the efficacy and wildlife friendliness of the existing conflict mitigation efforts.
- Social Monitoring includes the mapping of relevant stakeholders, understanding the dependence of local communities on forests and forest resources, the socio-economic condition of local communities, local attitudes towards wildlife species in focus, and willingness to engage in efforts to mitigate HWC.
- Monitoring tools are instruments and devices that are commonly used in the field of wildlife ecology and HWC mitigation, whereas monitoring techniques are the methods that are used to understand, manage and prevent HWC.
- Monitoring tools include some commonly used ones such as a compass, GPS unit, binoculars and camera. Tools that are increasingly being used for HWC mitigation include drones, night vision equipment (thermal and IR) as well as camera traps.
- GIS and remote sensing technology facilitate the monitoring of HWC incidents for analyses and as decision-making tools (early warning, planning of mitigation and adaptation measures, planning of roads and railroads).
- Animal tracking tools such as GPS/GSM collars are increasingly being used as a monitoring tool to prevent HWC, especially for large-bodied and wide-ranging species such as elephants and large carnivores.
- Koonkie elephants play a key role in HWC mitigation as they can access all kinds of terrain in plains and even gently undulating terrain. Training and good upkeep of koonkie elephants are vital for effective deployment in the field during HWC incidents.
- Techniques like animal tracking using collars, estimation of wildlife population through transects and camera traps and mapping the distribution of wildlife species are vital for effective monitoring of HWC.
- Efficient response to HWC requires specialised vehicles such as animal transport vehicles, and rapid response team vehicles and the criteria and specifications of such vehicles have been included in this module.



2. Assessment, Evaluation, and Monitoring of HWC

Effective mitigation of HWC requires effective decision-making and implementation of plans and guidelines at national, state and local levels, and for doing that, the decision-makers, field managers and front-line staff require timely information and data apart from instruments for evidence-generation and knowledge management. Such body of information and knowledge can be generated through constant monitoring of the trends in HWC, implementation effectiveness of HWC mitigation measures and assessment of the effectiveness and wildlife-friendliness of mitigation measures. Monitoring of HWC and mitigation measures includes both ecological monitoring, such as wildlife, species-based monitoring, as well as social monitoring looking into vulnerabilities of humans and measures to reduce vulnerabilities and address people's perceptions.

The concepts and tools of working on the human dimensions of HWC mitigation are covered in Module 5, 'Strengthening Community Engagement for Effective and Sustainable Mitigation of Human-Wildlife Conflict'. This module covers habitat and wildlife assessment, evaluation and monitoring.

2.1 Wildlife monitoring

Wildlife observation and monitoring are essential as cumulative effects of any changes in wildlife habitats and in wildlife populations and their behaviour and response to anthropogenic land-use changes eventually shape HWC. HWC mitigation cannot be carried out in isolation and should take wildlife conservation into account, and this, too, requires continual information on wild animals and their habitats. Knowledge about the ecology and the social and ranging behaviour of the species-in-conflict, when coupled with knowledge about the habitat, population, anthropogenic impacts on the habitat and land-use changes, allows managers to identify the ultimate and proximate causes of HWC and thus address the problem using short- and long-term solutions.

When collected, stored, and analysed systematically, this valuable information can be used to formulate a comprehensive Human-Wildlife Conflict Management Action Plan for that area. It will allow the manager to assess where and how they need to deploy conflict mitigation resources. It will also help predict trends in conflict, identify areas where conflict is likely to increase and monitor the individuals that are more prone to creating conflict. This can be done by keeping track of the animal's behaviour, movement patterns, habitat utilisation and the population demography within the area, keeping in mind the movements of species across jurisdictional boundaries and how drivers of conflict beyond the boundaries can influence HWC within the jurisdiction.

It is essential to identify monitoring needs, whether long-term or short-term monitoring is required, and for what purpose. For example, a leopard entering a human habitation may require urgent and short-term monitoring to initiate action to capture it if required (using direct observation, camera trapping, sign surveys, etc.). However, assessing why leopards are entering human-use areas may require a more detailed long-term study that would need to cover the population- Is local overabundance leading to dispersals out of the area? Or is a reduction in the prey base driving the animals out? or is the availability of alternate habitats in human-use areas (scrub and prey in the form of dogs and pigs) attracting them? Or have they just displaced leopards (due to old age or injury)? Such monitoring will address the larger challenges that could lead to HWC repeatedly in the area.

Holistic wildlife monitoring for HWC mitigation would include:

- Monitoring wildlife habitat quality and extent, including prey base (for carnivores), vegetation and fodder (for herbivores) and other anthropogenic pressures such as encroachment of habitat, fragmentation of habitat and human activity inside habitats that could exacerbate HWC.
- Monitoring of land use/land cover in the periphery of wildlife habitats, such as cropping patterns and livestock husbandry practices that could attract wildlife to these areas, thereby leading to HWC.
- Monitoring of population and distribution of focal species in the area to predict future HWC areas and hotspots. Such monitoring needs to be carried out at a landscape scale, especially for wide-ranging species.
- Monitoring and mapping of HWC incidents at a landscape scale to identify hotspots.
- Monitoring poaching and local hunting that could adversely impact wildlife populations, leading to increased HWC.
- Effectiveness and wildlife-friendliness of HWC mitigation instruments and their effect on wildlife populations and species.

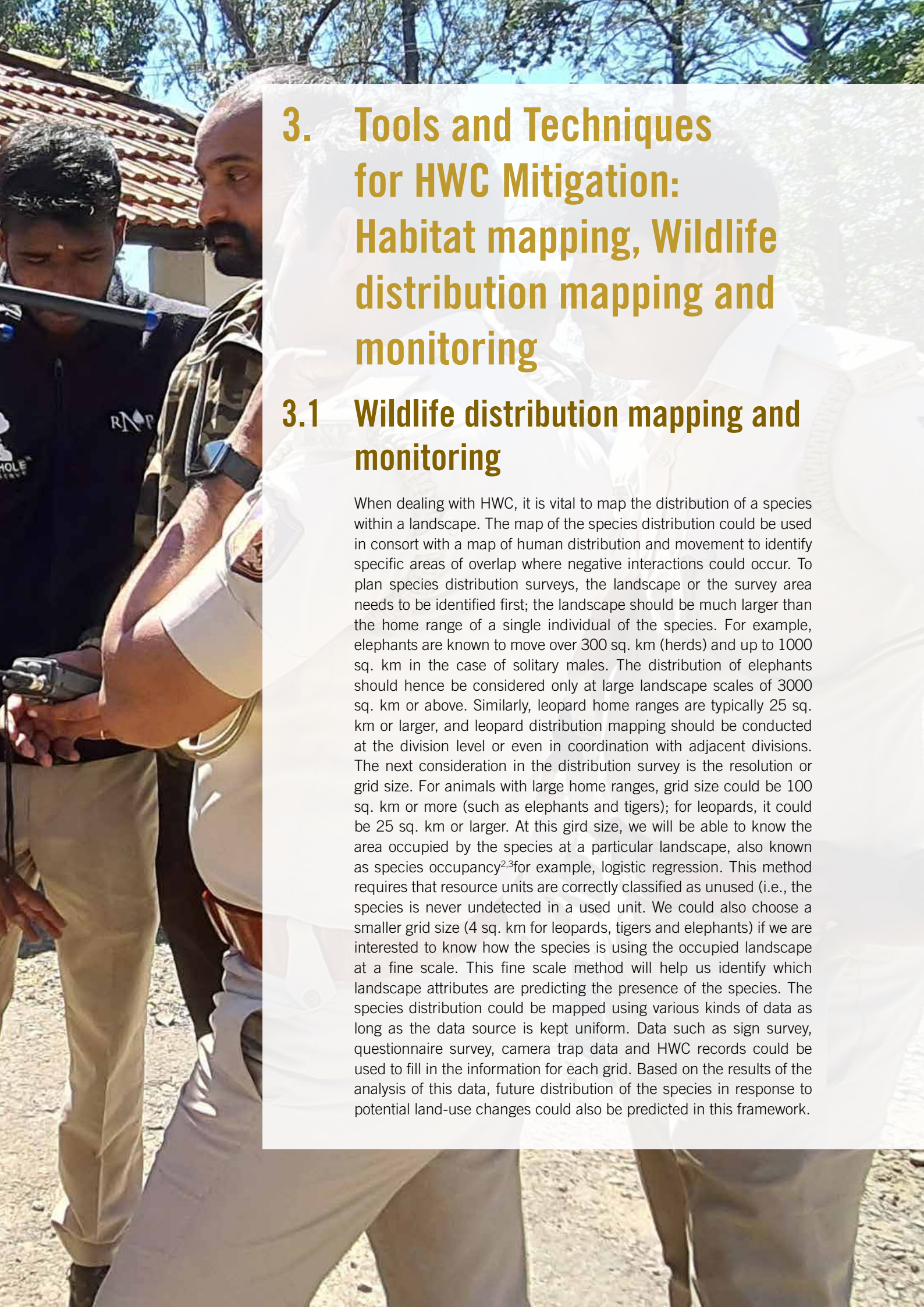
2.2 Social monitoring

Human-wildlife conflict is as much a social issue as it is a wildlife management concern. Hence, the social monitoring of HWC is as important as wildlife monitoring and management. Social monitoring refers to the human aspect of human-wildlife conflict. It can range from understanding attitudes towards wildlife species to assessing losses or documenting religious, cultural and traditional relationships with nature[1] A holistic understanding of the social dimension of human-wildlife conflict could go a long way in devising effective interventions to ensure coexistence.

Holistic social monitoring for HWC would include:

- Status of the efficacy of HWC mitigation instruments and its effect on local communities sharing space with wildlife
- Demographic and socio-economic status of local communities at human-wildlife interface areas, including dependence on forest resources such as NTFP (non-timber forest produce)
- Understanding local attitudes towards critical species involved in HWC
- Understanding willingness to engage in HWC mitigation for all relevant stakeholders
- Stakeholder mapping
- Understanding local beliefs regarding wildlife species, especially the ones involved in HWC, including traditional coping mechanisms and mitigation methods used by locals.

The concepts and tools of working on the human dimensions of HWC mitigation are covered in Module 5, “Strengthening Community Engagement for Effective and Sustainable Mitigation of Human-Wildlife Conflict”.



3. Tools and Techniques for HWC Mitigation: Habitat mapping, Wildlife distribution mapping and monitoring

3.1 Wildlife distribution mapping and monitoring

When dealing with HWC, it is vital to map the distribution of a species within a landscape. The map of the species distribution could be used in consort with a map of human distribution and movement to identify specific areas of overlap where negative interactions could occur. To plan species distribution surveys, the landscape or the survey area needs to be identified first; the landscape should be much larger than the home range of a single individual of the species. For example, elephants are known to move over 300 sq. km (herds) and up to 1000 sq. km in the case of solitary males. The distribution of elephants should hence be considered only at large landscape scales of 3000 sq. km or above. Similarly, leopard home ranges are typically 25 sq. km or larger, and leopard distribution mapping should be conducted at the division level or even in coordination with adjacent divisions. The next consideration in the distribution survey is the resolution or grid size. For animals with large home ranges, grid size could be 100 sq. km or more (such as elephants and tigers); for leopards, it could be 25 sq. km or larger. At this gird size, we will be able to know the area occupied by the species at a particular landscape, also known as species occupancy[2,3]for example, logistic regression. This method requires that resource units are correctly classified as unused (i.e., the species is never undetected in a used unit. We could also choose a smaller grid size (4 sq. km for leopards, tigers and elephants) if we are interested to know how the species is using the occupied landscape at a fine scale. This fine scale method will help us identify which landscape attributes are predicting the presence of the species. The species distribution could be mapped using various kinds of data as long as the data source is kept uniform. Data such as sign survey, questionnaire survey, camera trap data and HWC records could be used to fill in the information for each grid. Based on the results of the analysis of this data, future distribution of the species in response to potential land-use changes could also be predicted in this framework.

Illustration: Leopard distribution mapping

Leopard distribution estimation is a method to assess the area occupied by leopards in a greater landscape, and such assessments are vital to map the extent of leopard presence in any landscape. Distribution study differs from population estimate because the former only estimates the proportion of a landscape with leopard presence, whereas the latter estimates the number of individual leopards in a particular area. Distribution studies are low-cost compared to population estimation and are useful in drawing inference over vast areas (>1000 sq. km).

Method:

Once a landscape is identified where leopards are present outside protected areas, the entire landscape is overlaid with a grid of 4 sq. km. The 2kmX2km grid size is used as standard based on prior studies, the home range of leopards and mean daily movement rates. When covering landscapes greater than 10000 sq. km, the grid size may be increased to 10km X 10km (100 sq. km). A smaller grid size of 4 sq. km may be used to assess habitat selection of leopards and identify factors that affect where a leopard resides. The greater grid size may be used to find out the proportion of the entire landscape occupied by a leopard (leopard occupancy). The appropriate and relevant grid size may be decided in consultation with trained leopard ecologists for a particular landscape and would normally span multiple forest divisions.

Once the landscape has been identified and gridded, trained field staff may walk in each grid cell to record the presence or absence of leopard signs. A minimum of 2 km walk effort must be ensured in each grid cell covering all parts of the grid cell by perambulation. After every 500 mt walk, the presence or absence of leopard signs needs to be recorded. So, one grid cell of 4 sq. km would consist of 4 segments of 500 mt each. Village roads, river beds, plantation roads, agriculture fields paths may be covered to record leopard signs such as scat, scrape, pugmark, claw mark, and kills. The GPS location at the beginning and end of each 500 mt segment needs to be recorded. Signs of other animals such as livestock and prey may also be recorded for each 500 mt segment. If leopard sign is found, then entry against that particular segment will be '1', if not recorded, the entry will be '0'. Similar entries may be made against prey types as well. The detailed methodology may be found in the article by Kshettry et al., 2020. The survey of all the grids needs to be carried out in a single season. For instance, if the survey started in December, then the data collection must be completed by March. Ecologists trained in carnivore population estimation with a proven track record of peer-reviewed publications should be consulted for the design of datasheets and analysis of data.

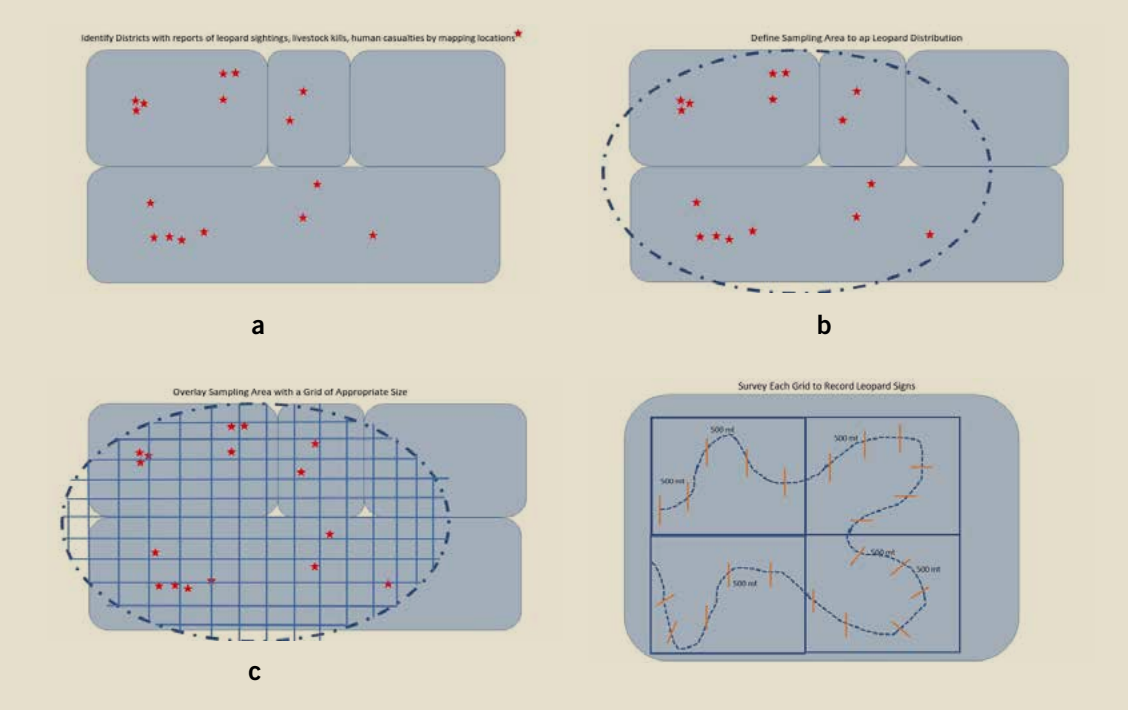


Figure 1: Leopard distribution mapping

Watch video tutorials here

How to create forest area map on Qgis https://www.youtube.com/watch?v=Q4kmmtpR5hM

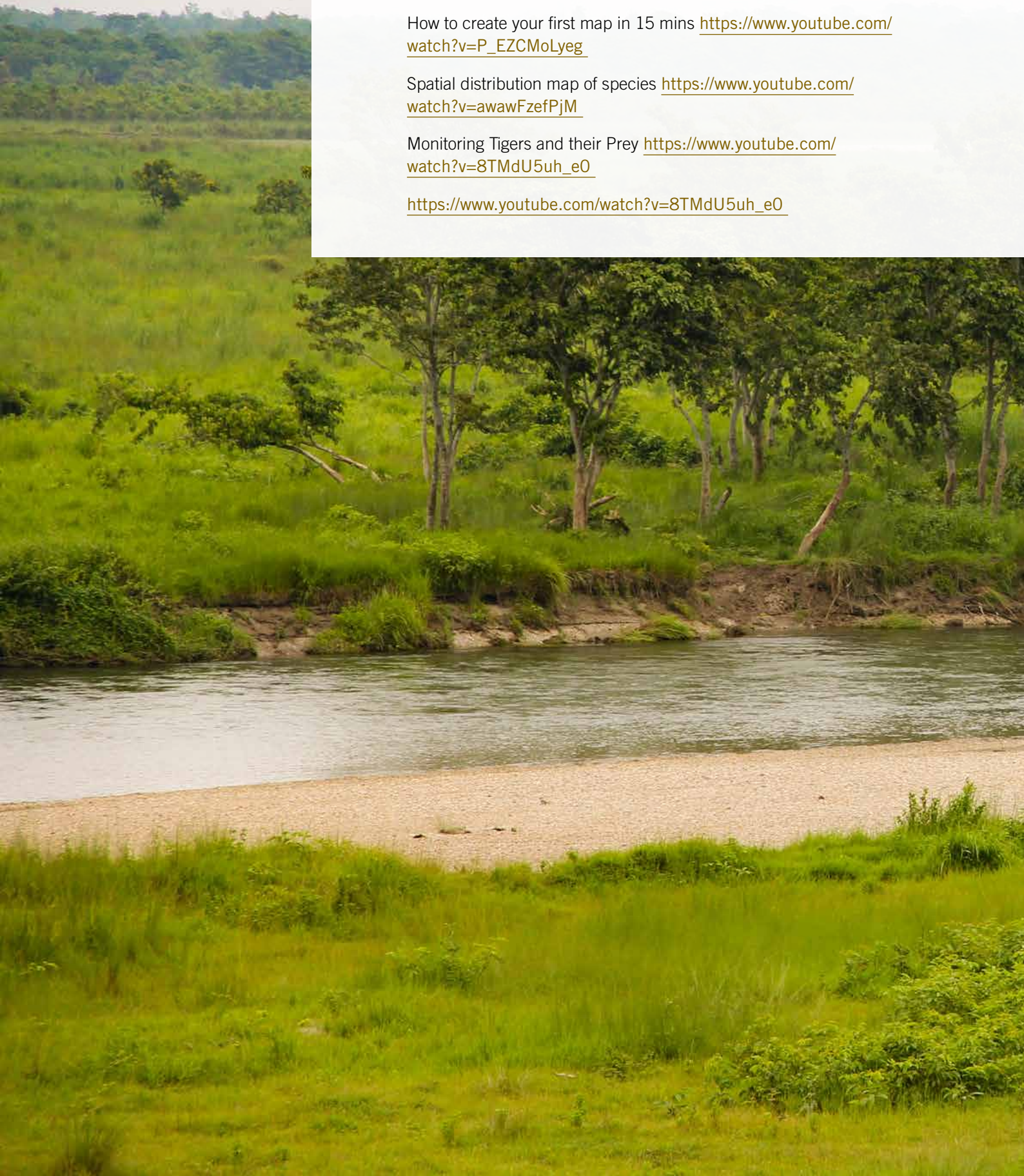
Prepare Study Area Map Easily |QGIS https://www.youtube.com/watch?v=x-rNnIAiCFY

How to create your first map in 15 mins https://www.youtube.com/watch?v=P_EZCMoLyeg

Spatial distribution map of species https://www.youtube.com/watch?v=awawFzefPjM

Monitoring Tigers and their Prey https://www.youtube.com/watch?v=8TMdU5uh_e0

https://www.youtube.com/watch?v=8TMdU5uh_e0



3.2 Wildlife population estimation

While species distribution surveys let us understand how much area a species is using in a particular landscape, an estimation is carried out to count how many individuals of a species are present. The different methods of estimation for different kinds of species are outlined below.

Techniques used to estimate populations.

Indices of abundance

- Trail- or transect-based survey for estimating populations of reptiles, amphibians, birds, and mammals (mostly primates and ungulates)
- Estimation of relative abundance on the basis of indirect evidence or signs

Estimation of abundance

- Line transect survey: Line transects are imaginary straight lines in the focussed habitat along which, generally, direct observations of animals are recorded. During such recording of information, parameters such as the number of animals, their sex (if identifiable), the distance from the transect can be included (by providing the radial distance and animal-angle information), and details of the micro-habitat (vegetation, terrain, climate and disturbance) should be included on the field for further analysis. The length of the line transect should be decided according to the species, habitat and available logistic support[16].

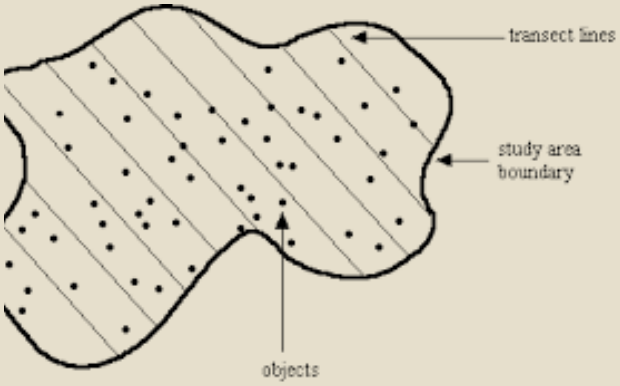


Figure 2: Outline of Line Transect Method

- Dung based counts[17] —A process similar to a line transect survey in which, instead of direct observation, one has to record the indirect evidence (mostly faecal matter—dung/pellets) of animals. The length of the transect/belt (a rectangular area) should be much less for this process in comparison with the transect surveys conducted to record direct observations. However, this method is not as robust as a direct observation-based estimation.

Figure 3: Elephant dung count method

- Capture-Mark–Recapture: Camera traps are used to estimate the populations of animals with individually identifiable markings[4] (tiger, leopard, striped hyaena, etc.), and presence–absence-based techniques can be used to estimate populations of animals that are without any such markings (jungle cat, fox, jackal, bear, etc.).
- DNA-based survey (minimum population estimate)—In several landscapes (such as in the rain forests or inaccessible mountain areas), conducting camera trapping may be logically difficult. In such situations, faecal samples can be collected and DNA extracted from the samples, which will provide the basis for estimating the population of the species whose faecal samples were collected[5]reestablishment of large carnivores entails a recovery of their most important ecological role, predation. On the other hand, societies are struggling to relearn how to live with apex predators that kill livestock, compete for game species, and occasionally injure or kill people. Those responsible for managing these species and mitigating conflict often lack fundamental information due to a long-standing challenge in ecology: How do we draw robust population-level inferences for elusive animals spread over immense areas? Here we showcase the application of an effective tool for spatially explicit tracking and forecasting of wildlife population dynamics at scales that are relevant to management and conservation. We analyzed the world's largest dataset on carnivores comprising more than 35,000 noninvasively obtained DNA samples from over 6,000 individual brown bears (Ursus arctos.

Figure 4: Scat collection technique

- Point count: This is a population estimation process used mostly for the avifauna. The observer moves along a fixed route and stops at pre-determined intervals and counts birds for a predetermined time at each point. The species, number and distance from the sampling point to the bird are recorded, and these data are used to estimate the numbers and densities of the birds. Bird calls can also be recorded as indirect evidence of the presence of birds to estimate their relative abundances.

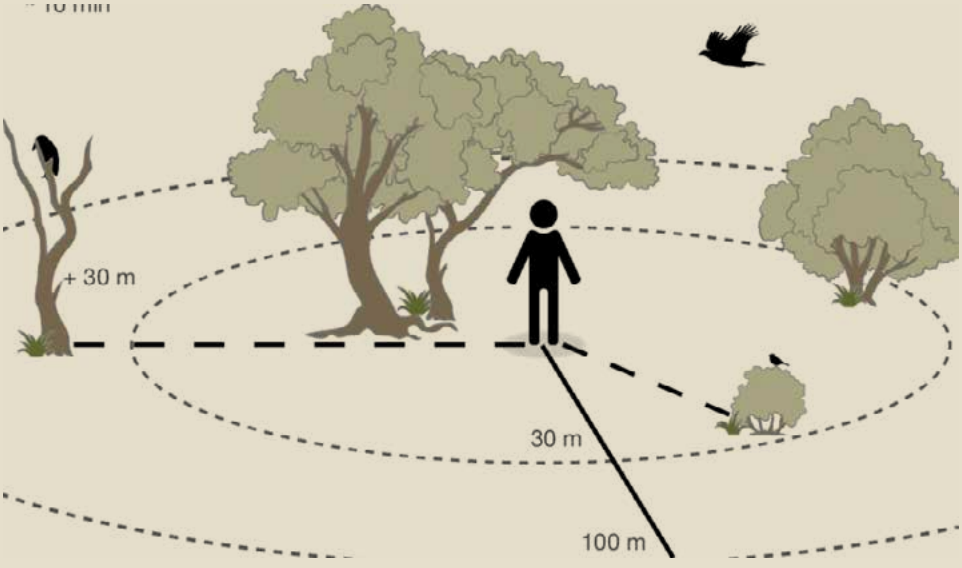


Figure 5: Point Count Method

Illustration of carnivore population estimation method: Camera trap-based mark-recapture technique for naturally marked species, the Indian leopard.

The distribution mapping exercise will reveal areas where leopard occupancy/habitat-use is high and also areas where occupancy or estimation is low. A population estimation may be carried out by identifying one or more areas (200-400 sq. km in size) within the landscape where leopard occupancy is high. Camera-trap based population estimation may be carried out in these areas for regular monitoring of population trends within the survey area. Ideally, the population estimation area needs to be a combination of protected areas, reserve forests and areas outside forests such as plantations, agriculture fields and tea/coffee estates. In case leopard population estimation is already available from the protected area within this survey area, then population estimation may be carried out in the reserve forests and other areas where leopard occupancy is found to be high.

Once the area of high occupancy is demarcated based on sign surveys, blocks to estimate leopard densities may be defined. To reliably estimate leopard densities, an area of 150-200 sq. km needs to be sampled to allow for multiple leopard territories within the sampling area. As a thumb rule, one pair of camera traps are required for every 4 sq. km, and the average distance between camera traps can be 2 km. When sampling large areas with a limited number of camera traps. A single block of 200 sq. km may be sampled in 4 blocks of 50 sq. km each or two blocks of 100 sq. km each. Cameras may be deployed for 20-25 days to record flank images of leopards. The placement of camera traps needs to be perpendicular to the trail and placed 20-30 cm above the ground.

The array of camera trap locations must be such that there are no major holes in the array where a leopard may have a territory but is not exposed to a trap[6]. Holes can be avoided by maintaining a uniform distance between traps and voiding the clustering of traps in one section of the sampling block. Details such as the location of the camera and date of operation must be recorded for every location. In case the cameras are not operational for a few days at any location, the records should indicate likewise.

Structuring of the data and analyses needs to involve a trained researcher with prior experience in camera trap-based density estimation and history of peer-reviewed publications on the subject.

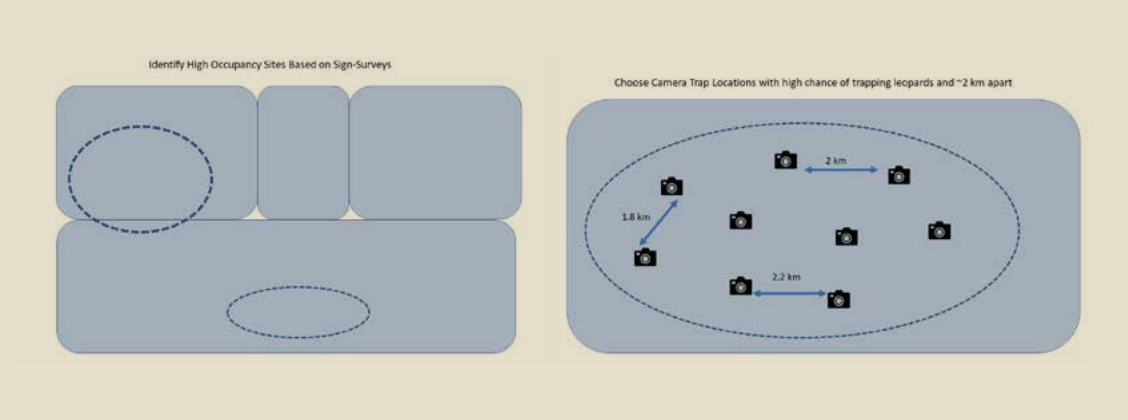


Figure 6: Illustration of carnivore population estimation

3.3 Habitat monitoring

Habitats consist of a variety of abiotic and biotic factors such as the soil, water–moisture conditions, microclimate and diversity of flora and fauna. Therefore, monitoring habitats is very important for monitoring biodiversity. The major purpose of habitat monitoring is to generate information on the functions and distributions of species across various parts of similar habitats and on the threats that natural habitats are continuously facing due to sudden modifications or gradual changes.

Vegetation sampling

Distribution—The distribution of the vegetation depends on the interaction of climatic, biotic, edaphic and historical factors. Commonly, climate and soil are considered as being the main driving forces of vegetation distribution, while biotic factors (grazing, seed dispersal, human disturbances—felling, lopping, introducing exotic species) contribute towards the distributions of several species or categories of plant[18]

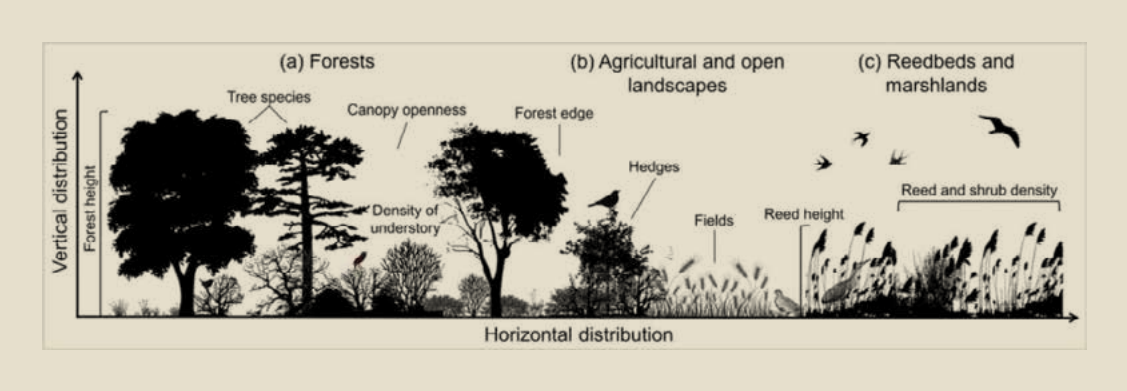


Figure 7: Vertical and Horizontal distribution of plants

Habitat status: One-off surveys (transects, plots, PCQ techniques)—Surveys can be conducted in rectangular (or square) quadrats (for example, 10 m × 15 m quadrats or 10 m × 10 m quadrats for recording the number of large trees) or circular plots (for example, circular plots of radius 15 m for recording the number of large trees). Smaller quadrats/plots may be used for shrubs, herbs, or ground cover estimates.

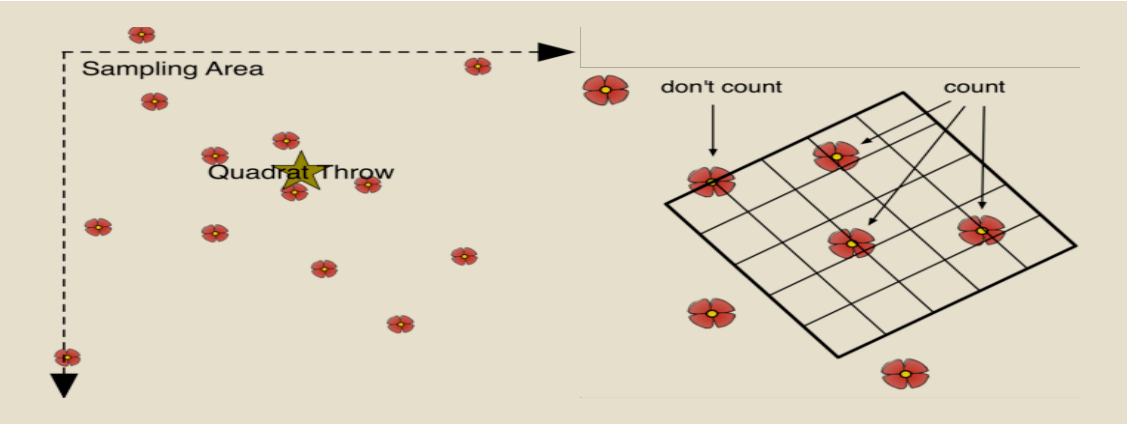


Figure 8: Quadrant Method

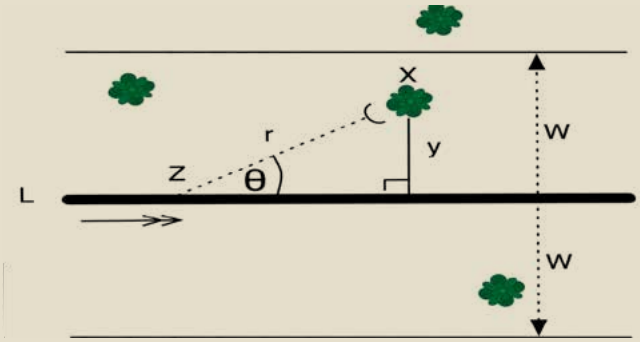


Figure 9: Line Transect Method

Figure 10: Plot based sampling by university of IDHAO

Long-term monitoring (plots): Properly marked plots or quadrats can be monitored for long durations (more than a decade) to study the changes in the vegetation structure and composition within a specific habitat. Control plots can be maintained to record the natural changes, and plots can be monitored after providing specific treatments (additional nutrition through fertilisers, pest control using pesticides, providing water, modifying the amount of light through the shade, herbivory, etc.) to study the contribution of the various factors influencing the vegetation growth, composition and distribution as a whole.

Assessing anthropogenic pressures on the habitat (human disturbance surveys)

Human disturbances (infrastructure and recreational use)—linear infrastructures such as roads and railway lines going through natural habitats can be mapped to understand habitat fragmentation and

related threats. Similarly, the gradual progression of human habitations can also be mapped.

Resource collection (NTFP, fuelwood) can be measured within the habitat quadrats or circular plots.

Livestock grazing and fodder collection can be measured within the habitat quadrats or circular plots.

The presence or absence of fires may be recorded and their impact estimated as the area within the natural habitat.

Poaching (including fishing) can be recorded on the basis of the official data recorded at the range or division level from the forest departments. The information can be correlated with the habitat change function to understand the impact of such events.

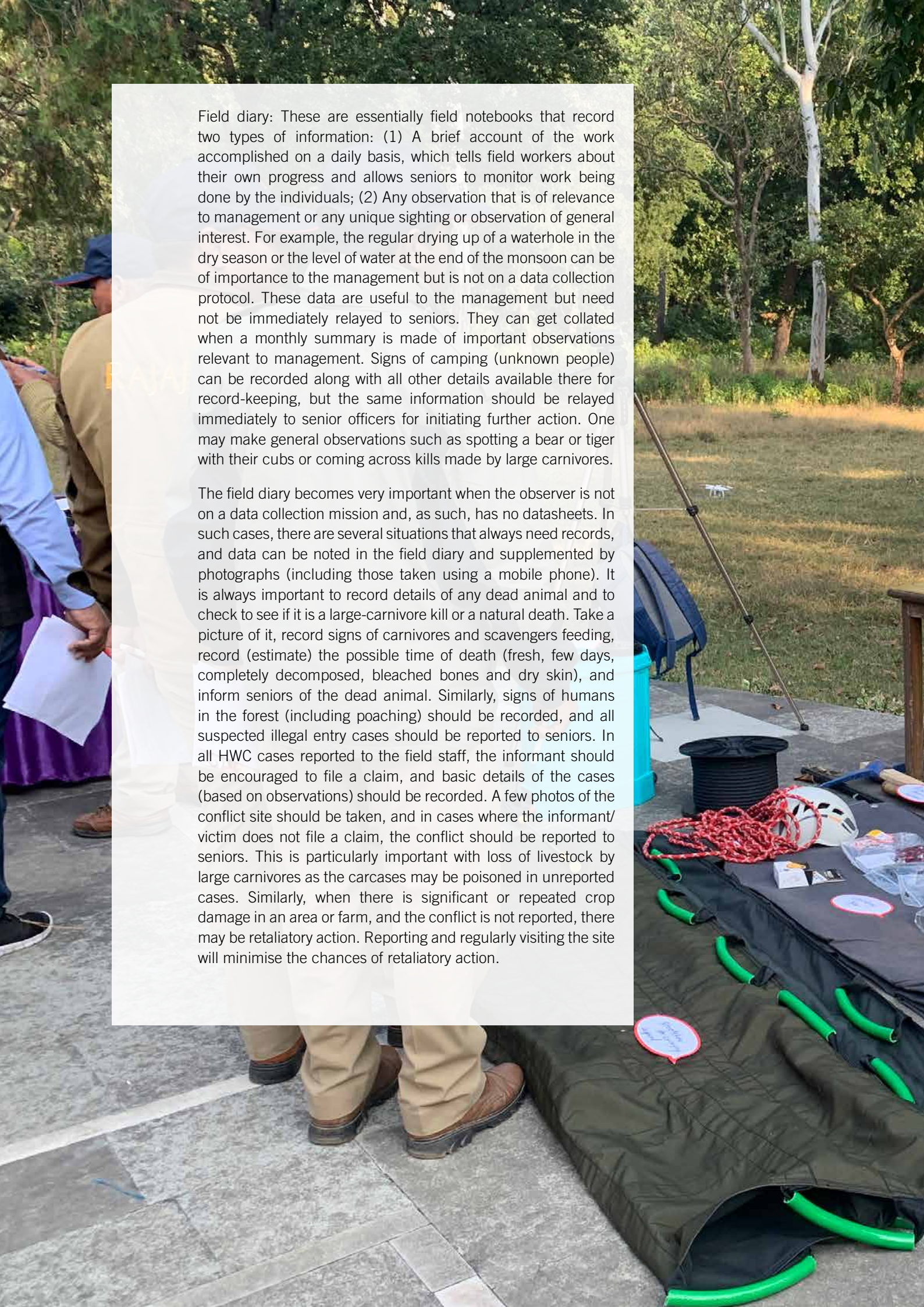
4. Tools and Techniques for HWC Mitigation: Digital Tools

4.1 Datasheets and digital data recorders (automated data collection—smartphones/ tablets)

Recording information (data) is very important for wildlife management and also to the individual recording the data as it helps them improve their observations, articulate their work and improve their understanding of the HWC situation and status. It helps the management by generating information that can be used for improved management planning. The old forest department practice of maintaining a field diary with daily notes allowed fieldwork to be monitored and was based on enhancing knowledge and data collection.

In a natural habitat, there is an endless amount of data, and if one starts recording everything, no work will be accomplished, and the staff will spend the day only gathering random information. It is therefore important that we have clarity about the need, the uniqueness and significance of an information\, and then decide what to record and how to record it so that it can be used effectively.

Data recording should be based on actual observation and limited to what is observed and should not go into assuming or predicting things beyond what is actually observed. One example of this is watching animal movements; when observers see an animal moving straight in a particular direction without feeding, they assume that it is migrating from one location to another, especially if they know there is no waterhole in the immediate vicinity along that direction. The animal may be moving from one feeding area to another, it may be in search of a mate or a herd member, it may have been disturbed by the presence of a carnivore at the previous site, or there may be any other reason. However, the wrong observation gets perpetuated by others repeating it over time and stating that species A migrates from location X to location Y in whatever season the observation was made. This is clearly seen with elephants, where few people understand the scale of their ranging, which exceeds the area of most forest divisions and the knowledge of the area of most local people, including tribal people. Officials usually ask local residents, particularly tribal and field staff, about the range of elephants, and they are given very general answers on the basis of assumptions that may not be true. When management planning is based on such observations, it can be highly flawed. It is important that field staff restrict their observations to what they actually see. In the example cited, there may be nothing strange about an elephant moving without feeding, especially as the distance moved is not being observed. If the observer senses something unusual, the logical next step would be to determine the animal's movement range or the source of any disturbance in the place where it came from.



Field diary: These are essentially field notebooks that record two types of information: (1) A brief account of the work accomplished on a daily basis, which tells field workers about their own progress and allows seniors to monitor work being done by the individuals; (2) Any observation that is of relevance to management or any unique sighting or observation of general interest. For example, the regular drying up of a waterhole in the dry season or the level of water at the end of the monsoon can be of importance to the management but is not on a data collection protocol. These data are useful to the management but need not be immediately relayed to seniors. They can get collated when a monthly summary is made of important observations relevant to management. Signs of camping (unknown people) can be recorded along with all other details available there for record-keeping, but the same information should be relayed immediately to senior officers for initiating further action. One may make general observations such as spotting a bear or tiger with their cubs or coming across kills made by large carnivores.

The field diary becomes very important when the observer is not on a data collection mission and, as such, has no datasheets. In such cases, there are several situations that always need records, and data can be noted in the field diary and supplemented by photographs (including those taken using a mobile phone). It is always important to record details of any dead animal and to check to see if it is a large-carnivore kill or a natural death. Take a picture of it, record signs of carnivores and scavengers feeding, record (estimate) the possible time of death (fresh, few days, completely decomposed, bleached bones and dry skin), and inform seniors of the dead animal. Similarly, signs of humans in the forest (including poaching) should be recorded, and all suspected illegal entry cases should be reported to seniors. In all HWC cases reported to the field staff, the informant should be encouraged to file a claim, and basic details of the cases (based on observations) should be recorded. A few photos of the conflict site should be taken, and in cases where the informant/victim does not file a claim, the conflict should be reported to seniors. This is particularly important with loss of livestock by large carnivores as the carcases may be poisoned in unreported cases. Similarly, when there is significant or repeated crop damage in an area or farm, and the conflict is not reported, there may be retaliatory action. Reporting and regularly visiting the site will minimise the chances of retaliatory action.

Data collection: This is targeted information gathering and is based on management requirements. For such information gathering, it is critical that a suitably designed datasheet be prepared and used. While there is no such thing as too little data, too much data can be a nightmare to collect, and irrelevant data may even jeopardise the entire operation. Data collection should be very specific and targeted, taking into account the time and resources available.

The use of a data sheet allows the collection and processing of data in a standardised and orderly manner. A datasheet ensures that all relevant information is collected without missing out on any important aspects. It also ensures that data are recorded quickly and easily.

Datasheets should have three parts: (1) basic information, (2) a data section, and (3) a remarks section. The basic information, which is a must in all data sheets, includes the title of the study, name(s) of the observers, date/time (sometimes start/end time), location (name of forest division/range/best, and GPS location—where available, sometimes the start and endpoints), vegetation type and weather (it may change over the day). The data section has the different data that the observer is supposed to gather. The remarks section is the most important section, but it is generally ignored. Here the observer can record data that impact the main category, not considering which will bias the analysis. For example, when walking a transect to record or count herbivores, a part of the transect may have been burnt, and no herbivores may have been seen in that burnt sub-section. If there is no column in the data section to record these details, the analysis can get thrown off course. In such cases, the information needs to be recorded in the remarks section.

Smartphone-based apps are now replacing field notebooks and data sheets and are accomplishing their functions. They bring greater flexibility, higher speeds of recording, greater accuracy, greater detail and rapid data transfer to the analysis platform. For example, multiple types of data can be rapidly collected without juggling through multiple datasheets. In the case of weeds, pictures help field staff easily identify them, and data entry is just a tap on the screen. Photos can be used to quantify abundance coarsely and can be linked to the location. Costs, maintenance and power sources are the main challenges to the use of smartphones, but the advantages will soon make these the standard devices of the frontline field staff.

4.2 Map reading

A map is a 2D representation of the 3D Earth. Maps show the landscape as it would be seen from above, looking directly down. Besides showing the landscape, maps usually also show features such as rivers, lakes, and roads. At a time when mapping apps are widely used, the reader may think that there is no need any more to learn how to read a map. But in the field, a map is still useful as smartphones or GPS devices may not receive signals, or the batteries may be discharged. So, it still makes sense to learn about the fundamental components of maps and how to read them.

There are a lot of special maps, such as vegetation maps or geological maps. In this module, we deal with topographic maps. These show geographic features in detail and are available in a wide range of scales (1:25,000, 1:50,000, 1:100,000, 1:250,000 or smaller). The scales indicate what distance on the map corresponds to the actual distance on the ground. For a 1:25000 scale, 1 unit distance on a map would correspond to 25000 units on the ground.

Topographic maps usually show:

Relief: mountains, valleys, depressions, slopes

Hydrography: rivers, streams, lakes

Land cover: forests, open areas, settlements

Constructed features: roads, railways, airports, buildings, cities, towns, villages, names of places and geographic features

It is obvious that small-scale maps show less detail than do large-scale maps.

As features of the Earth (ellipsoid/spheroid) have to be projected to a flat plane, no map is without distortion. Different systems are used to project maps. The Indian Grid uses the Lambert Conformal Conic Projection system, with 2 Standard Parallels. This is of special importance when we deal with GPS and GIS as the wrong projection delivers the wrong locations. Any location in the Indian Grid is denoted numerically by a grid reference. This is an easting-northing pair, two seven-digit numbers, that gives a resolution of 1 m. As India occupies a large expanse, the area is divided into nine zones to keep the distortion to a minimum. This means that besides knowing the easting and northing, we have to know the zone to which the grid reference belongs. Most maps show the deviation of the grid north and the magnetic north at the centre of the map. This is important when we want to use a compass to walk in the terrain.

Contour and relief

To understand the shape of the landscape, especially in mountainous terrain, we have to deal with contour lines. These are usually orange or brown in colour and are interrupted by numbers that indicate the altitude. Contour lines are drawn between points of equal height. The altitude difference between contour lines varies from 5 m, in flat areas, to 100 m or more, in the mountains. If we are able to visualise the landscape by looking at the contour lines, we get a good impression of it. This also gives us an idea of where creeks or rivers areas as these are at the deepest parts of a valley. Areas with few contour lines are flat. Mountainous areas have a very dense set of contour lines: the steeper the slope, the denser the contour lines.

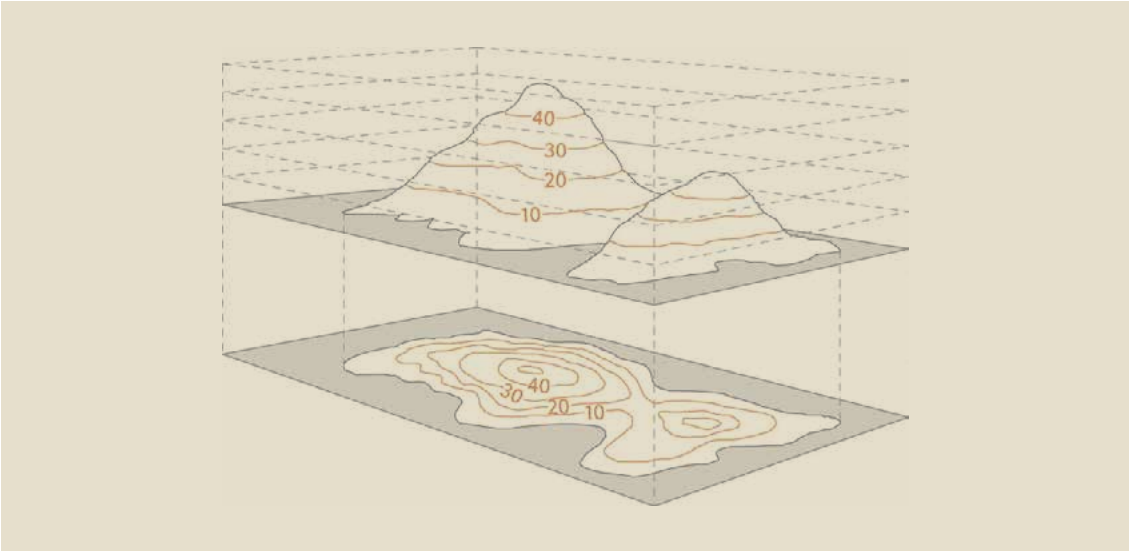


Figure 11: Contours Mapping

4.3 Use of compass

It is useful to orient a map before reading and interpreting it. To do this, we hold the map horizontally and rotate it to the direction of a feature that we see before us on the ground. To accurately navigate a map, it's important to use a compass as not all real-world features are easily identifiable on the map alone. We hold the map flat and place the compass on the map so that the long edge of the base plate is parallel to a north-south grid line. Usually, the red end of the needle of the compass points north and the black end points south. If the needle meets the letter N, the map is oriented to the north. Now we should be able to identify special features in the landscape. Compass readings are affected by iron and steel objects. So, it is important to stay away from metallic items such as knives and mobile phones.

Eyesight for orientation

When we see striking points in the landscape, we also can use eyesight to orientate the map. We can locate ourselves next to a feature in the landscape and place our fingers on the map at the point where we are standing. We need to rotate the map so that features on the map line up with the ones we can see in reality. This way, we are oriented in the landscape. Of course, this is not as precise as orientation using the compass.

Setting a course

Once we have oriented our map and identified our position, we can set a course. We can lay a straight line across the map towards our destination. In the landscape, we identify a feature that is cut by the line on the map, and we walk towards this feature. When features are sparse, we can use a GPS receiver. On the map, we identify the coordinates of the target point and enter them into the GPS receiver. Now we can walk towards the direction of our destination using the GPS to point us in the right direction. It is important to have the right reference system in the GPS receiver (see the foregoing).

There is another option when you use a map and compass to set a course (this depends on the type/model of the compass):

Place the compass on the map so that the baseplate is in line with the line drawn to your destination. The travel arrow has to point in the same direction.

Now the compass dial has to be turned so that the orienting arrow and the orienting lines are parallel with the north lines of the grid of the map.

Take the reading of the dial at the index line: this shows the grid bearing. Subtract the magnetic/grid angle from this bearing and turn the dial to show the magnetic bearing at the index line.

Now walk with the compass held steadily in front of you. Walk in the direction of the travel arrow when the red end of the needle is directly over the orienting arrow (pointing to 'N' on the dial). Spot a feature in the direction of the travel arrow and walk towards it. This may have to be repeated if the final destination is not visible.

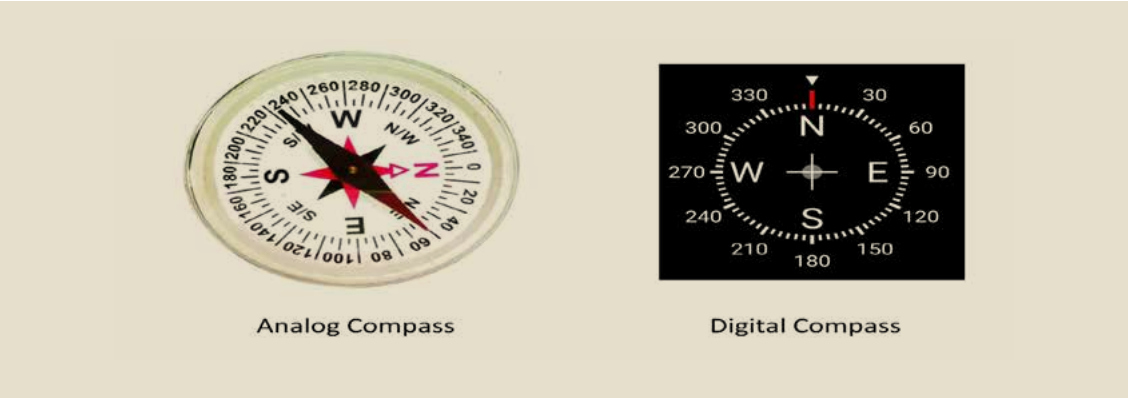


Figure 12: Types of compass

The compass is widely used as a simple device to gauge the direction. The device uses the earth's magnetic field to identify the North and South poles. A magnetic compass is critical for orienting maps and navigation in the area. With the invention of the GPS, the navigation task has been largely taken over by the GPS. However, since the GPS is dependent on battery power, it is always advisable to keep a magnetic compass for emergencies. More importantly, a compass is essential for most research in wildlife monitoring. Studying vegetation or sampling animal populations requires a compass to set transect lines, establish monitoring plots, record sighting angles when estimating animal populations, etc.

The compass usually has a free-floating needle with one end painted red, which signifies the North Pole; the North Pole is marked at 0 degrees on the compass, the south pole is marked at 180 degrees, and the markings can range from 0-359 degrees for a complete circle. While using the compass, the device needs to be placed on a flat surface parallel to the ground. In field conditions, the compass has two primary uses, first, to move in the field in a particular fixed direction (straight line) and second, to read directions on a map.

The compass needs to be held on the palm such that it is parallel to the ground. The compass has to be rotated such that the red marker arrow coincides with the 0 (zero) degree reading. Now let us assume that one needs to walk 2 km due East. Since the North is 0 degrees, the East would be 90 degrees; the South would be 180 degrees; and West would be 270 degrees. The person holding the compass should move till the marker (not the needle) on the compass points to the designed direction (90 degrees), and one needs to make sure the angle does not change while walking.

Smartphones also have an inbuilt compass, and any compass or navigation application may be downloaded. Once the digital compass is calibrated, the phone needs to be placed on the palm parallel to the ground, and the direction of the phone will show the observer the angle of the compass. If the phone is directed to the north, the reading will be 0 degrees; any other direction will show the corresponding angle. The angle needs to be constantly maintained while walking to make sure one is walking in a straight line. A compass is commonly used while marking line transects to estimate herbivore density and is also used to record the angle of observation for animal sightings (angular distance). This aspect has been covered in detail in the techniques section.

4.4 Use of GPS Device (Global Positing System-Unit)

Figure 13: Global Positing System-Unit

The Global Positioning System is an advanced tool for locating and mapping any point on the Earth's surface. The positioning is achieved using artificial satellites and a Coordinate Reference System (CRS). A coordinate reference system is a unit used to locate any point on the Earth. The commonly used one is the Latitude/Longitude system using degree, minute, second or decimal-degree units. A GPS unit is a handheld device that can connect to the satellites and indicate the precise location of the unit using the specified CRS; the CRS should always be set to Degree decimal latitude-longitude (Lat-Long) system; the code for the same is WGS-84. Modern-day smartphones also have inbuilt GPS, and any GPS application may be downloaded to avail of all the functionalities of the GPS unit.

A GPS-Unit or Smartphone GPS may be used in the field in the following ways:

- Mark a location (Waypoint): A waypoint is a feature that records the current location of the GPS unit or any location on a map. The Waypoint has a Latitude component (Such as 86.80098 N) and is always measured in South or North units, and it has a longitude component (such as 26.67007 E) and is always measured by East or West units. The waypoint also has an accuracy component (how accurate the location is), and this should ideally be within 10 metres. Waypoints can be used to record the location of HWC incidences and communicate the location of the central database or concerned officers.
- Record a location: The precise location of the GPS device can also be recorded from the location screen using the Latitude and Longitude information.
- Reach a location: A GPS unit may be used to reach a particular location using the navigation feature.
- A GPS device may be used to track a route, calculate area and perimeter.

Tutorial videos of each of these uses are commonly available online for common GPS devices.

Marking Waypoint in Garmin https://www.youtube.com/watch?v=apasD09xdPk

Transferring Track from GPS to Map https://www.youtube.com/watch?v=aqP0-WSIJi8

Creating Routes from Garmin Tracks https://www.youtube.com/watch?v=9CPjzoit040

4.5 Use of Range Finder

Figure 14: Range Finder

Laser range finders help calculate the distance to an object and are useful in line transect-based population estimation methods. They are also useful for calculating distances in immobilisation operations, especially those involving large carnivores, that require precise distance estimation to avoid injuries from darts travelling with excessive velocities. In a laser range finder, the observer aims at the object through the viewfinder. Holding the range finder steady, the observer depresses the laser button. The range finder then measures the distance and displays it in the viewfinder. Since the system is based on measuring the distance by calculating the distance travelled by the laser beam to and from the object, the object should have some reflectance. If not, the laser will not bounce back properly, and this can give false readings. If the reflectance of the object is very poor, the laser should be aimed at an object with good reflectance nearby and the distance measured.

4.6 GIS for HWC mitigation

GIS or Geographic Information System is a vital tool to monitor HWC. GIS data may be collected using handheld GPS units or even smartphones with inbuilt GPS sensors. GIS data may also be obtained from maps after suitable conversion to GIS format. GIS helps us map data over space to understand patterns of HWC and also the factors that lead to HWC. The commonly used GIS software includes ArcGIS and QGIS. While ArcGIS is a paid program, QGIS is an open-source platform and is freely available for download and use. Google Earth and Google Earth Engine are also GIS platforms, and google earth may also be used for basic visualisation of spatial data.

Application of GIS in HWC mitigation:

1. Making heatmaps of HWC incidents to identify conflict hotspots and also to predict future hotspots based on correlates of conflict.
2. Plotting animal sighting records/movement records to identify activity centres.
3. Plotting home range of problem animals based on camera trap data (for naturally marked species such as tiger, leopard, snow leopard, clouded leopard, elephant and rhino.
4. Plotting movement data obtained from tracking collars.
5. Visualising any form of spatial data (data with latitude/longitude) on a map
6. Mapping of forest area, fragmentation and forest classification.
7. Identifying encroachment and critical habitats for species connectivity
8. Planning landscape-level conservation based on habitat matrices, connectivity, threats and opportunities.

Types of GIS data:

Vector: A vector data is any point, line, or a polygon on the surface of the earth with location information (latitude/longitude) and other supplementary information about the feature (also known as an attribute). In vector data, one single feature (point, line, or polygon) can have several attributes such as location, dimensions, elevation, temperature, etc., and we could add as much information to the vector as we like. For example, if we digitise records of human casualties due to elephants as points, the resultant vector file will be a combination of point locations and each location will have details such as the name of the victim, location of the incident, time of the incident, whether herd or solitary elephant involved in the incident, etc.

Raster: Raster data is two-dimensional data which is an assortment of smaller units called pixels. Each pixel represents one data point, and hence, a raster can only hold one kind of data. For example, if we divide our forest area into a raster of elevation, each pixel of the raster will signify the elevation of that particular point. Another common example is a digital photograph where the photo that we see is a combination of pixels and if we keep zooming in, we will eventually see a single pixel representing a single colour. All the pixels together form the digital image that we see, and hence the image from a digital camera is similar to a raster file except that the pixels on a digital photo do not represent any location on the earth but a raster pixel will always signify some location on the earth.

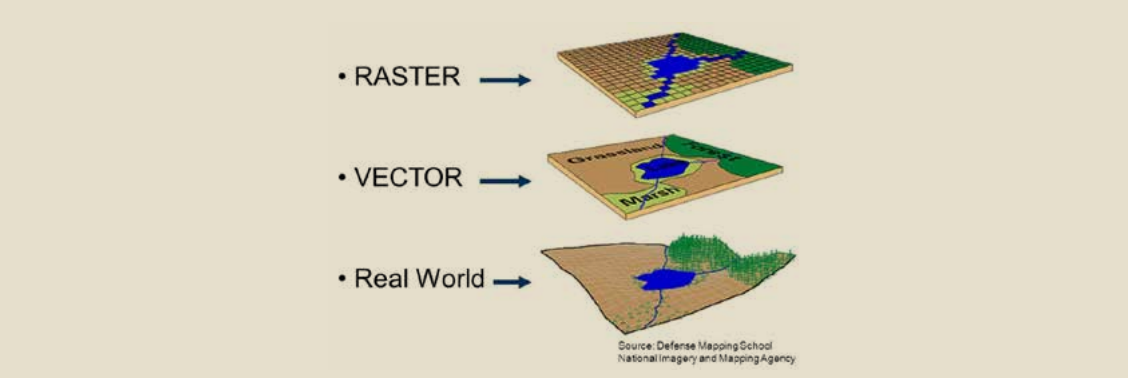
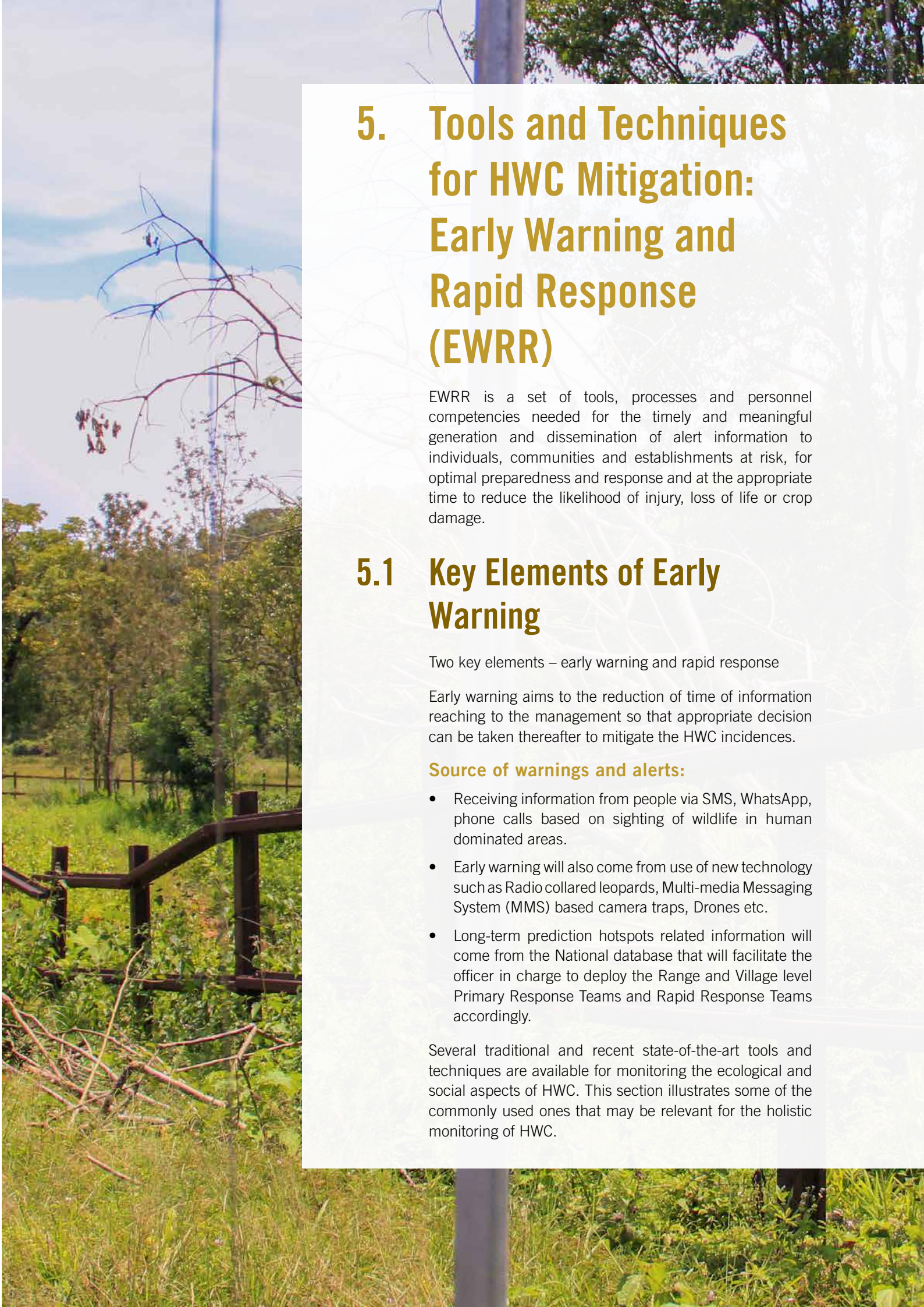


Figure 15: Types of GIS layers



5. Tools and Techniques for HWC Mitigation: Early Warning and Rapid Response (EWRR)

EWRR is a set of tools, processes and personnel competencies needed for the timely and meaningful generation and dissemination of alert information to individuals, communities and establishments at risk, for optimal preparedness and response and at the appropriate time to reduce the likelihood of injury, loss of life or crop damage.

5.1 Key Elements of Early Warning

Two key elements – early warning and rapid response

Early warning aims to the reduction of time of information reaching to the management so that appropriate decision can be taken thereafter to mitigate the HWC incidences.

Source of warnings and alerts:

- Receiving information from people via SMS, WhatsApp, phone calls based on sighting of wildlife in human dominated areas.
- Early warning will also come from use of new technology such as Radio collared leopards, Multi-media Messaging System (MMS) based camera traps, Drones etc.
- Long-term prediction hotspots related information will come from the National database that will facilitate the officer in charge to deploy the Range and Village level Primary Response Teams and Rapid Response Teams accordingly.

Several traditional and recent state-of-the-art tools and techniques are available for monitoring the ecological and social aspects of HWC. This section illustrates some of the commonly used ones that may be relevant for the holistic monitoring of HWC.

5.2 Animal Tracking

Tracking animal movement, especially individuals of a species regularly involved in negative interactions with people, is essential for HWC mitigation. There are two broad approaches for animal tracking: the first approach involved field tracking using animal signs, and the second involved individual tracking using tracking tools such as tracking collars, trail cameras or RFID microchips.

Field Tracking:

Tracking of animal movement in a particular geographic area can be conducted based on signs and marks left by the species in the field. These could be in the form of pugmark, footprints, hoof marks, scat (faeces), dung, pellet, claw mark, feeding trails, kills, or direct sighting and following. In the case of large herbivores, direct observation-based tracking is possible from a safe distance, either on a vehicle or on foot. In the case of elusive carnivores, direct observation is difficult, and we have to rely on animal signs. An overview of the various animal tracks and signs is provided below. Members of the dog family and cat family have distinct differences in their pugmarks; cat family members such as tigers, leopards, snow leopards, etc., will never have nail marks as they have retractile claws. Whereas members of the dog family such as dhole, jackals, and hyena will have nail/claw marks in their pugmark.

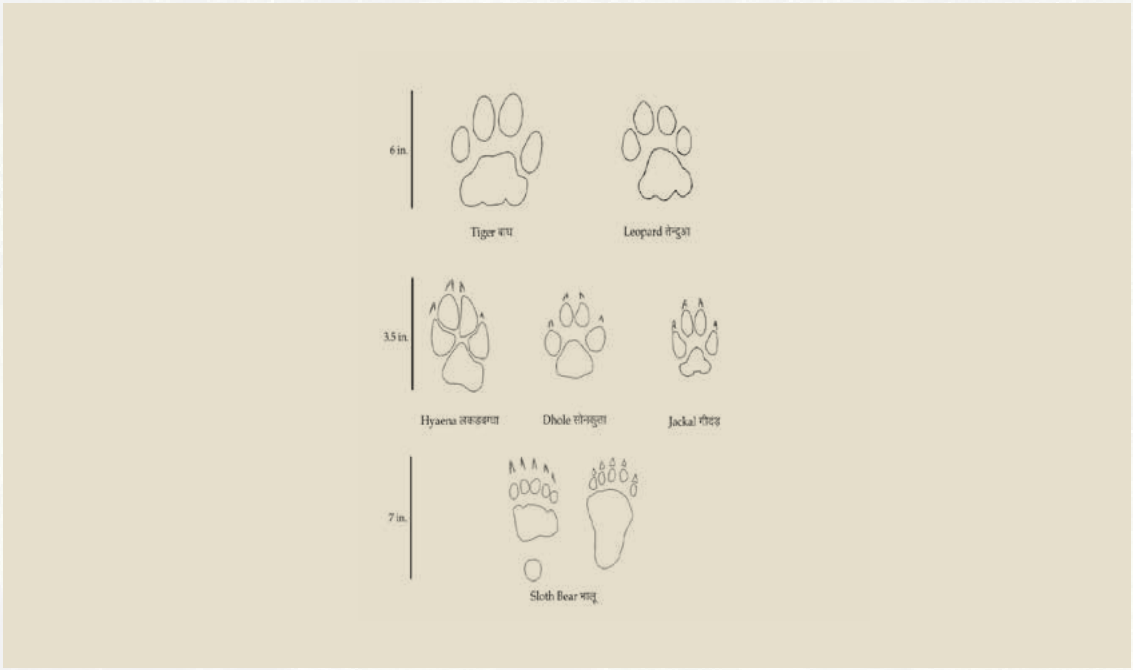


Figure 16: Pug mark sign for Identification of species

5.3 Binocular

Figure 17: Binocular

Binoculars are primarily used for making detailed observations from a distance and have numerous uses in the field. They can be used in population estimation work as they allow clear observation of an animal detected along a transect. However, the primary use in HWC work is in the observation of conflict animals by field teams, especially dangerous animals of species, in order to record identification characteristics. Binoculars can also be used by veterinary teams to make close observations of individuals for signs of injury or ill health prior to capture and to observe animals injured due to retaliatory action by local communities.

Binoculars are referred to by their magnification and the size of the objective lens. Hence a 10 × 40 pair of binoculars magnify ten times (the image is ten times as large as what the unaided eye sees) and has an objective lens of diameter 40 mm. Magnification is one aspect of the binoculars, and the greater the magnification, the closer the subject appears. However, the brightness, which is determined by the exit pupil size, is also important, as a very small exit pupil size means poor performance in low light. The exit pupil is calculated by dividing the objective lens size by the magnification; hence a 10 × 40 pair of binoculars would have an exit pupil of diameter 4 mm (40/10). This is not a problem in bright daylight, when the diameter of the pupil of the human eye may be reduced to 2–3 mm. But in the evening, in low light, the human eye has a pupil size of 7 mm, and the same binoculars, which appeared bright during the afternoon, will appear very dull and dark. Hence, in low light, for example, when trying to identify elephants coming to raid crops late in the evening, it is best to use binoculars of specifications 7 × 50 or 8 × 56. They lose out on magnification, but they are the brightest you can get. However, trying to get high-magnification binoculars with very large objective lenses is not practical due to their sheer size and weight. Binoculars of magnifications beyond 10 are also very difficult to hold by hand, and image-shake due to shaking hands will result in poor results. Hence, 8 × 40 or 10 × 40/42 binoculars are best suited for daytime observations; for evenings, 7 × 50 or 8 × 56 binoculars would be best suited.

5.4 Camera Trap

Figure 18: Types of cameras

Cameras are useful for recording data/evidence in the field. They can be used for recording sightings, identification of individual animals, recording evidence of crop/property damage, recording injuries borne by animals, etc. Specialised cameras can be used as camera traps to make recordings remotely for population monitoring, identification of conflict animals, detecting illegal entry into forests, etc. Long zoom cameras (also called prosumers or bridge cameras) are ideal for field conditions since they have a long zoom (24mm to 1000mm) and may be used to record video or photos from a safe distance.

Trail cameras or camera traps are used to monitor wildlife populations as they are automatically triggered and do not involve the presence of people near them. Trail cameras are extensively used to estimation of species densities for species that have unique natural markings on their body, such as tigers, leopards, etc. Trail cameras come in a variety of detection and lighting systems, including white flash (best clarity but easily detected by animals and people), Infrared (cannot be detected by people, but some animals can see infrared, more useful for night-time videos), low glow and black flash (less alarming to animals and unlikely to be detected by people as well).

To identify individuals, camera trapping is done by deploying a set of cameras, one on each side of the trails, that are regularly used by animals. In the area of high human-wildlife conflict, a camera trap can help identify the individual involved in the conflict and monitor their movement regularly. This is especially being used to identify animals such as tigers, leopards, hyenas, etc., as they have a unique pattern on body surfaces and can be identified through it. Once installed, camera traps are tested and regularly monitored by researchers and forest staff. Studies show camera trapping exercise has revealed fascinating and unexpected results in the form of new discoveries and unusual behaviours.

General Instructions for camera trapping

- Given the rapid pace at which new camera trap models are released, it is not possible to recommend specific camera trap models
- The best approach to identifying what camera trap to choose is to identify the broad type of camera that you require and then the specific features required in order to achieve your specific aims
- Most research and monitoring purposes call for a mid-to high-end camera trap, equipped with an infrared flash, large detection zone and fast trigger speed
- Important exceptions to this broad recommendation include: a white flash (in most cases) for capture-recapture studies and a video or ‘near-video’ mode for studies intending to use random encounter modelling

- In hot environments, passive infrared sensors may fail to detect a difference between the surface temperature of target animals and the background; a camera setup with a direct trigger may be more effective.
- In open environments, and when camera-trapping in trees, a high-end camera trap which is less prone to misfires from moving vegetation will be beneficial. It may also be helpful to use cameras which allow the sensitivity of the infrared sensor to be reduced.
- For camera trapping in areas that come with a high risk of theft, consider the security options that are compatible with a given camera trap model (e.g., cable locks and security cases)
- you should not buy as many camera traps as you can but, certainly, at least as many as your area demands in order to be robust and useful; you can estimate the minimum number of cameras you'll need based on your area of forest division and information about how long it will take to install, move and collect cameras in the field

Benefits of Camera Trap for monitoring animals-in-conflict

- Camera trap provides non-invasive sampling, which can record a large amount of data with the least labour cost and with minimal impacts on wildlife.
- Detections are made with an electronic sensor, reducing human observer biases and increasing the potential for replicability and repeatability.
- It can help in continuous 24-hour monitoring of a broad range of species, especially mammals.
- Camera trap images provide data on behaviour, body condition, activity patterns of animals and even local habitat characteristics.
- Using camera traps, we can capture images of a species at a specific place and time. These images act as digital specimens that are verifiable and can be stored indefinitely. Camera trap raw data is highly captivating and can be used to raise awareness or support for a cause.

Product	Advantage	Image
White flash Camera	LED white flash (for colour); fast trigger speed; large detection zone (i.e., excellent detection capabilities); consider active infrared sensor. Ideal for individual identification due to the high clarity of images. It may be used for the identification of individuals in species that have unique natural markings, such as tigers, leopards,	
Camera Traps with Black Flash	Same operations as the cameras with infrared flash. Specially used in areas with high human pressure and poaching. Helps capture photos without flash, and can also be used in the area of elephants as flash sometimes may irritate animals, and they retaliate by damaging the cameras. This is detecting the presence or absence of some species in a landscape, which can be used for identifying individual elephants.	
Camera Traps with IR or Infra-Red Flash	Infrared flash; fast trigger speed; multiple images per trigger; 'near-video' mode; wide field of view. This is ideal for video recordings during the day and night. These models may be used to document animal behaviour at a particular site, such as carnivore kill sites etc. Some cameras are also built-in data transfer technology (via sim card), and these may be used to monitor the movement of a real-time animal.	

Table 1: Conventional Camera Traps with different categories of Flash Options

Figure 19: Innovative Camera Trap, which can act as an Early Warning Equipment

These types of camera traps are fitted with sim cards, and by GPRS or GSM systems, they can send the captured photographs as MMS to pre-ascertained mobile numbers and as email attachments to pre-loaded email addresses; these are with IR flash – black and white pictures in the night-time. Thus, these are suitable to be deployed in elephant-occupied landscapes and human-dominated landscapes.

Operational Details

The camera traps will be operated by the PRT or rural community people, but the RRT personnel need to supervise the deployment, utilisation and maintenance of the camera traps. The batteries and SD cards should always be checked before each of the camera traps is deployed. The power of the batteries should be more than 30%, and there should be adequate space available in the SD cards (minimum 1 GB before each day of deployment – otherwise, the content of these cards needs to be downloaded to create space for the images). Any battery with a power level of less than 30% should not be used as it may stop working within the trapping session. Similar condition is applied for the storage capacity of the SD card (space should not be less than 1 GB). The camera traps must be cleaned externally every day before deployment to get rid of dust / mud, especially from the camera aperture area, flash and the sensors.

Study Type for Monitoring of Species-in-conflict	Key Camera Trap Considerations
Rapid inventory	*Xenon or LED white flash; large detection zone; consider video*
Diversity	*Infrared flash; fast trigger speed; large detection zone*
Relative abundance	*Infrared flash; fast trigger and recovery speed; large detection zone; multiple images per trigger; "near-video" mode*
Capture-recapture	*Xenon white flash; consider white LED flash; fast trigger speed; large detection zone;*

Study Type for Monitoring of Species-in-conflict	Key Camera Trap Considerations
Random encounter modelling	*Infrared flash; consider 'no-glow' infrared flash; fast trigger and recovery speed; large detection zone; multiple images per trigger; 'near-video' mode*
Occupancy	*Infrared flash; fast trigger speed; large detection zone*
Behaviour	*Infrared flash; consider 'no-glow' infrared flash; video mode; fast trigger and recovery speed; consider 'near-video' mode; consider time-lapse; consider non-standard lenses (telephoto, macro or wide-angle); consider if programmable schedule is needed*
Monitoring of people or their activities (e.g., antipoaching)	*Infrared flash; fast trigger and recovery speed; multiple images per trigger; 'near-video' mode; consider the feasibility of wireless or cellular; long battery life or external power; small size; camouflaged; consider video*

Table 2: Camera type for different studies for regular monitoring of conflict zones

Species Type	Type of Camera	*Key Camera Trap Considerations*
Individually Identifiable species (e.g., Leopard, Tiger)	white flash; fast trigger speed	*Pair of the camera trap on regularly used trails, Helps capture both body side patterns for individual recognition.*
Medium and large mammals	Infrared flash; fast trigger speed; multiple images per trigger; 'near-video' mode	*The camera should be kept in a way that it is camouflaged*
Small mammals	Xenon or LED white flash (for colour); fast trigger speed; large detection zone (i.e., excellent detection capabilities); consider active infrared sensor	*Has to place very close to the trail/ground for better captures*
Arboreal mammals	Infrared flash; fast trigger speed; multiple images per trigger; 'near-video' mode; wide field of view	Ball-head mounting, which is screwed or strapped to a tree branch; consider setting the sensitivity of the infrared sensor too low to minimise misfires
Reptiles (Snakes)	Direct trigger (active infrared sensor or pressure sensor); consider if the passive infrared sensor or time-lapse are viable	

Table 3: Camera type for different studies for regular monitoring of conflict zones

Watch videos and refer to other resource material on camera traps here:

Use of camera traps for assessing wildlife populations https://www.youtube.com/watch?v=MioiFTxqg-k

Camera trapping wildlife surveys https://www.youtube.com/watch?v=d_CEEjupGT4

Setting camera trap https://www.youtube.com/watch?v=oLudNbo1R44

Field work with camera trap https://www.youtube.com/watch?v=2Azv_L1aIBQ

For Individually identifiable animals (Tiger, Leopard, etc.,) Refer to protocol by NTCA. https://ntca.gov.in/assets/uploads/Reports/AITM/Phase_III_CT%20Manual.pdf

5.5 Night Vision Equipment

Night vision equipment is a useful tool for monitoring HWC and is increasingly used by field personnel in several countries. Night vision can be infrared (IR) based or thermal based, and it can be in the form of handheld scanners, trail cameras, attachments to smartphones and scopes. These devices can be used to operate in total darkness at night without relying on any external light source. These night-vision equipment are ideal for locating wildlife species during HWC at night and also for detecting the illegal human presence in wildlife habitats at night.

Figure 20: Night Vision Equipment

Thermal and night vision binoculars: Thermal and night vision binoculars are quite sensitive equipment. The batteries for these equipment should be checked periodically so that no leakage would occur. These instruments must always be maintained as clean, devoid of dust and mud, to ensure the optimum functions of the sensors.

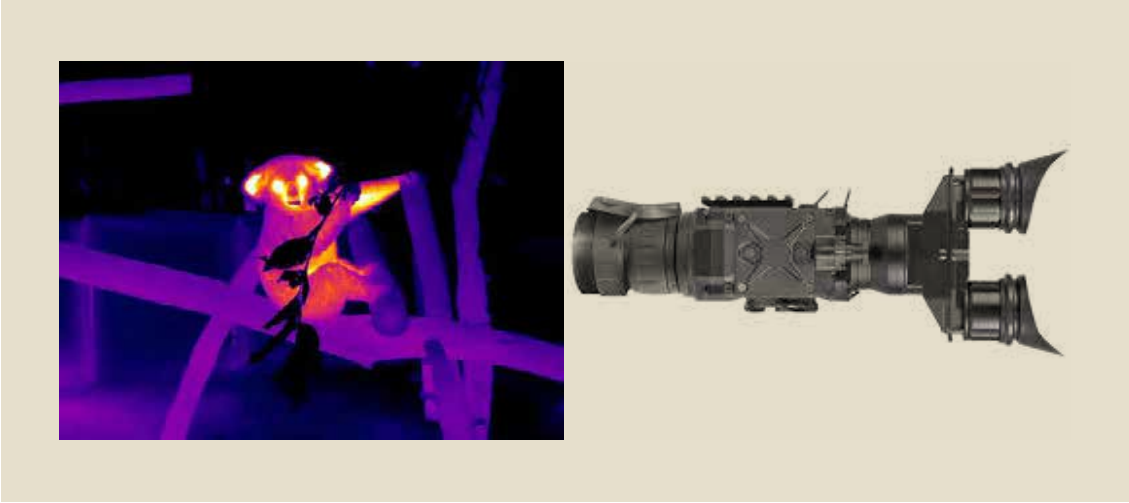


Figure 21: Example of a thermal image and the Thermal or Infra-Red Binocular:

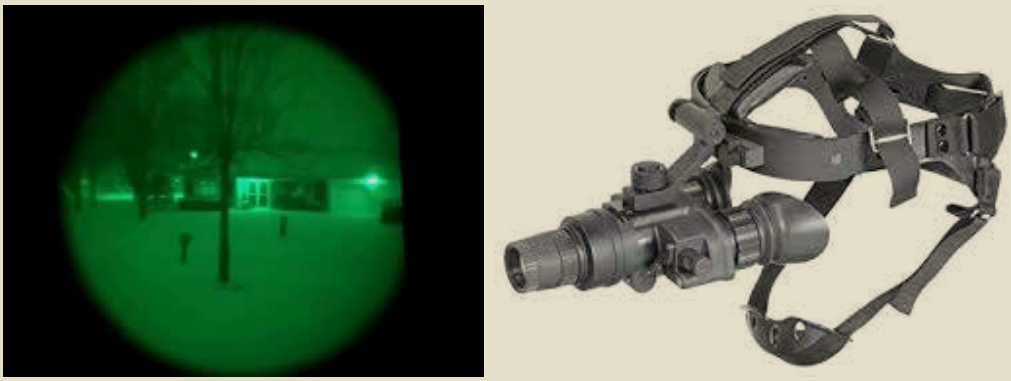


Figure 22: Example of a night vision image and the night vision binocular

Except for these major instruments and equipment, safekeeping and proper maintenance of all other articles provided to the RRTs and PRTs (detailed list can be found in Annex 1 and 2) should be ensured their each and every member. It must be understood that maintenance and proper safekeeping of these equipment will only facilitate them to conduct their tasks (HWC mitigation) effectively and efficiently. Therefore, utmost care should be given to the protection and proper maintenance of these equipment.

Topic	Video Material Link
Night Vision Binocular for wildlife Monitoring	https://www.youtube.com/watch?v=IS8BVMu0kHE https://www.youtube.com/watch?v=Izvzy6bAG6o

5.6 Unmanned Aerial Vehicles (UAVs) or Drones

Figure 23: Drone Unit

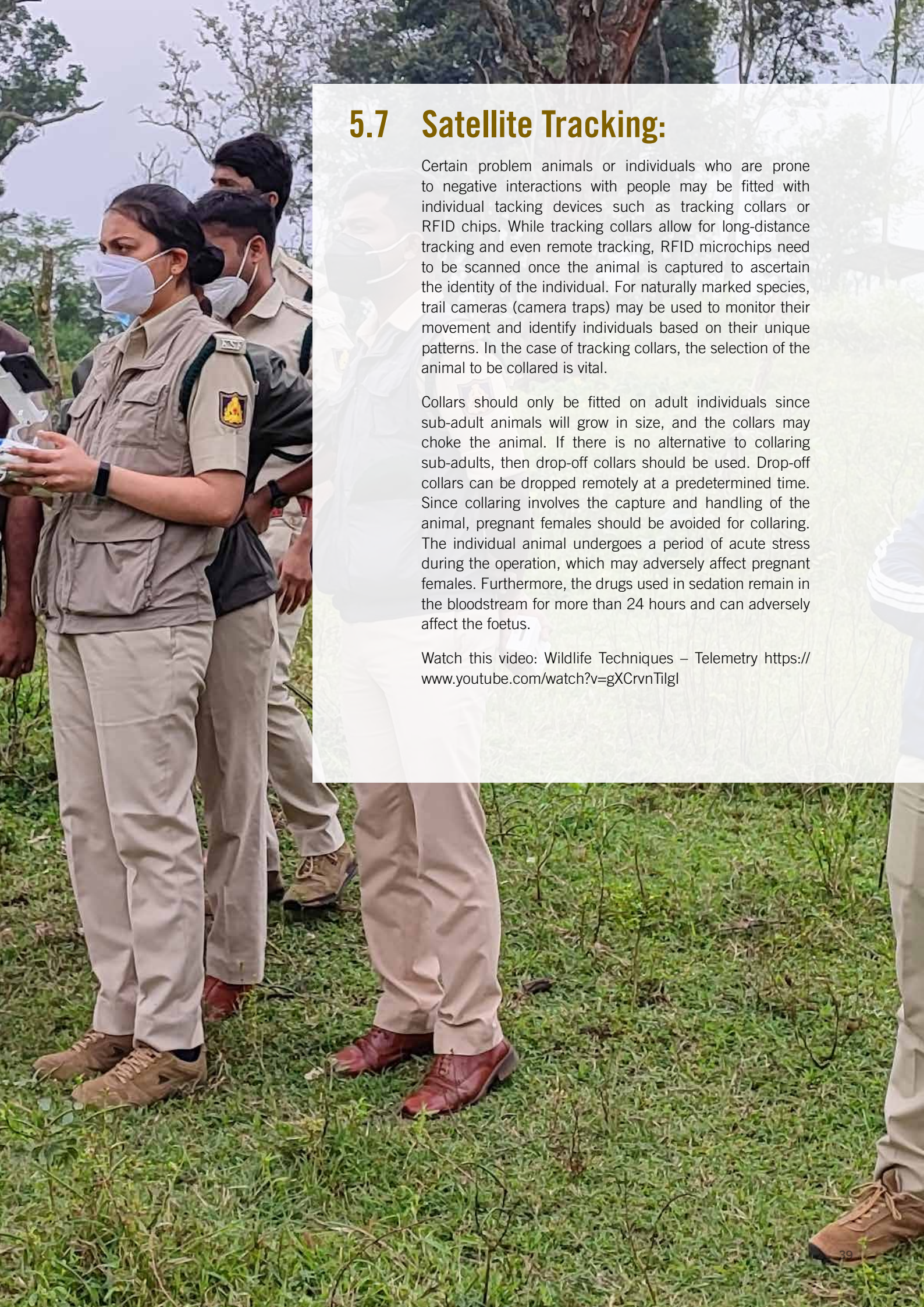
Drones or remote-controlled cameras are increasingly being used in wildlife and HWC monitoring. Drones may be used to monitor wildlife in human-use areas during wildlife emergencies or even to locate particular individuals within open canopy habitats. Drones may also be used to assess crop damage, livestock damage, or other economic damage by wildlife species. In some cases, a drone may also be used to drive away damage-causing animals from crop fields since the noise made by the rotors mimics bees and certain wildlife species, such as elephants, are averse to such sounds.

Drone cameras may be found in various sizes, such as nano drone, micro-drone, and full-sized drone, and these devices have unique advantages and disadvantages. Micro and mini-drones may fit into small spaces such as dense canopy forests or buildings to locate trapped animals, but these have low flight durations. Full-sized drones can fly several kilometres from the operator and may be used in aerial surveys in open habitats or to assess economic damages due to wildlife.

Watch videos on UAVs here:

Use of thermal drones for anti-poaching and HWC Mitigation https://www.youtube.com/watch?v=_MKXMdQkNPI

Mitigating Human-Elephant Conflict in Gadchiroli https://www.youtube.com/watch?v=H1vi-OmdJc8



5.7 Satellite Tracking:

Certain problem animals or individuals who are prone to negative interactions with people may be fitted with individual tacking devices such as tracking collars or RFID chips. While tracking collars allow for long-distance tracking and even remote tracking, RFID microchips need to be scanned once the animal is captured to ascertain the identity of the individual. For naturally marked species, trail cameras (camera traps) may be used to monitor their movement and identify individuals based on their unique patterns. In the case of tracking collars, the selection of the animal to be collared is vital.

Collars should only be fitted on adult individuals since sub-adult animals will grow in size, and the collars may choke the animal. If there is no alternative to collaring sub-adults, then drop-off collars should be used. Drop-off collars can be dropped remotely at a predetermined time. Since collaring involves the capture and handling of the animal, pregnant females should be avoided for collaring. The individual animal undergoes a period of acute stress during the operation, which may adversely affect pregnant females. Furthermore, the drugs used in sedation remain in the bloodstream for more than 24 hours and can adversely affect the foetus.

Watch this video: Wildlife Techniques – Telemetry https://www.youtube.com/watch?v=gXCrvnTilgI

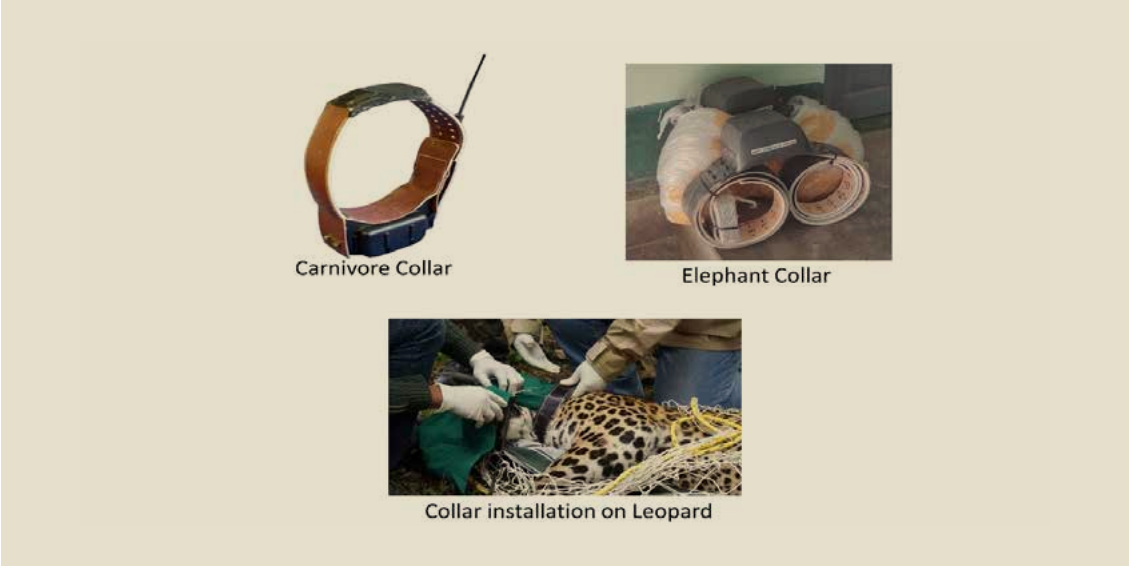


Figure 24: Animal Tracking Devices

Animal trackers are useful for monitoring individuals in the case of solitary species and for monitoring groups of animals for group-living species. The trackers can be in the form of collars fitted with a tracking system or can be in the form of chips implanted surgically. However, these trackers are highly invasive in nature and involve the capture and sedation of the animals. Recent advances in tracker technology include GPS trackers that can be monitored remotely in addition to field tracking using VHF (Very High Frequency) signal and antenna.

The most commonly used collars for wildlife tracking include Vetronics, Telonics, and AWT (Africa Wildlife Tracking). The collars can be of various sizes depending on the species and need to be imported from the country of origin. The location information recorded in GPS collars can be transmitted to the monitoring team using two technologies. The first kind is the direct uplink to satellite, and the second is using a GSM sim card for data transmission. The former is independent of mobile network coverage but is battery-intensive; the latter consumes less battery but is dependent on the availability of GSM network coverage; for systems, the trackers can be monitored on a computer. These trackers could be useful to monitor a home range of individuals to better understand the distribution of a species. The trackers can also be used to monitor the movement of specific individuals to a prone to be involved in HWC incidents. The information from the trackers could be used as an early warning system to prevent HWC incidents.

Types of tracking collars:

- VHF (Very high frequency) radio collars are inexpensive, have a very long battery life and are suitable for animals with small home ranges, which makes searching easy. Wide-ranging animals are difficult to locate when they move far away.
- GPS collars (with add-on VHF transmitters)
    - GSM collars are suitable for areas with good GSM coverage. The location of the animals is collected using a GPS sensor, and the data is transferred using the GSM network. These collars work best in human-dominated landscapes where network coverage is sound. The GSM data transfer technology ensures the high battery life of the collars.
    - Satellite collars are suitable for all conditions and for all types of tracking work and are particularly suited for monitoring translocations and for work in areas with poor GSM coverage.
    - UHF (Ultra high frequency) collars are used to maximise the battery life of the collard as the data is stored in the tracking collar and may be downloaded with within a 100 m radius of the animals. However, the data access is dependent on tracking the animal in the field, and this method is useful for open scrub forests or grasslands.

All three types of tags have facilities to gather data on the environment (temperature), monitor the animal (body temperature and heart rate), motion (3D accelerometers), etc. However, for a better understanding of the HWC and the factors that lead to it, basic data on the habitat, ecology, ranging behaviour and social organisation of the species and the individual involved in the conflict are needed. These are best studied through direct observation. So trained researchers who regularly follow and monitor such tagged animals are critical for getting quality data and cannot be replaced by technology alone.

Radio-telemetry equipment: Radio-telemetry equipment consist of four components – radio-collar or transmitter, Radio-receiver, antenna and cable. The different types of radio telemetry techniques include very high frequency (VHF) transmitters / radio-collars, global positioning system (GPS) tracking radio-collars, and satellite tracking radio-collars. Recent advances in technology have improved radio telemetry techniques by increasing the efficacy of data collection and transmission using the satellite network as well as by using GSM or Global System for Mobile communications networks to send the GPS locations and related information of the transmitters to the users. Radio-transmitters with only VHF system need to be tracked on ground for obtaining their locations whereas Satellite-GPS-GSM transmitters can themselves communicate their locations to the users via satellite network / GSM network. For this, Satellite-GPS-GSM transmitters are more effective for the long-ranging animals while VHF transmitters can be conveniently used for territorial or short ranging animals.

Figure 25: Radio - collars and Different Components

Figure 26: Radio Collars

- **Housing strategy of the radio-collars:** The radio-collars has a magnet attached to it to switch it off so that the battery should not get drained out. Thus, the radio-collars should not be kept within any iron almirah / trunk as the iron walls all around will nullify the effect of the magnet and the radio-collar will get switched on. So, radio-collars should always be kept within the wooden almirah or cement made racks as well as away from any metallic object to ensure that the effect of the magnet should not be nullified.
- **Checking of VHF collar battery and working function:** All the radio-collars should be switched on (by removing the magnets) every month to check their beeping patterns using the receiver. The VHF collars should be kept on for 30 minutes (not more than that) once in every month (before they are deployed on the animals) to check the beeping patterns. Any discrepancy in the beeping pattern should be reported to the technical expert at the earliest as they may have significant effect on the battery life of the radio-collars.
- **Checking of Satellite collar battery, GPS accuracy and working function:** Similar to the VHF collars, the satellite collars need to be kept open for at least a full day in every month. They should be placed somewhere having the full access of open horizon. Any discrepancy in the beeping pattern should be reported to the technical expert at the earliest as they may have significant effect on the battery life of the radio-collars. After every two to three hours the collar needs to be shaken for a few minutes otherwise mortality signal will start to transmit, and this may drain the battery a lot if kept unchecked. The GPS locations uploaded by these satellite radio-collars should be downloaded from the online platform and compared with handheld GPS to check the working status and GPS accuracy of these collars.

Figure 27: Various Radio-Receivers for UHF – Ultra High Frequency or VHF – Very High-Frequency electro-magnetic transmission

Watch video tutorial on radio collars here:

Animal Tracking: Advanced and Emerging Technologies https://www.youtube.com/watch?v=THGhNrfbK_M

How are drones used to reduce human-animal conflicts? https://www.youtube.com/watch?v=yDfSZbIC0Vs

Use of collars for wildlife monitoring https://www.wildlifeact.com/blog/gps-and-vhf-tracking-collars-used-for-wildlife-monitoring/

Maintenance of Tracking Equipment

- **Maintenance of the receiver:** The receiver should always be kept within the protective cover and should never be taken out except the times when the batteries need to be replaced. The receivers are usually non-water resistant and are also sensitive towards extreme heat or cold if taken out of the pouch. The batteries of the receiver should always be checked – good quality batteries should only be used to operate the receivers and local made batteries should never be used as they have no credibility for working life. Usually, a red light gets on when the battery level becomes low. The batteries need to be changed after this blinking of the red lights as low powered batteries may not function properly to receive electromagnetic frequencies.

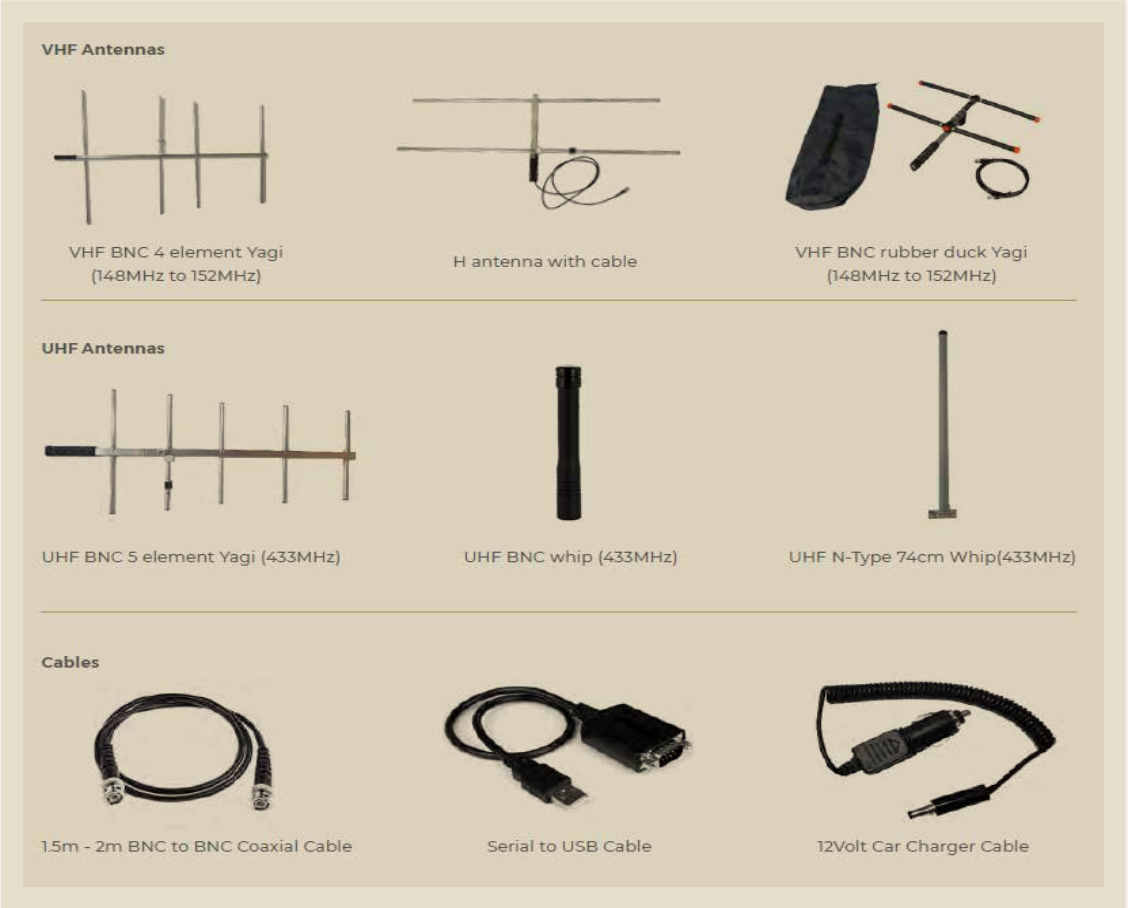


Figure 28: Various types of Radio-Antenna (Yagi and H types) and Radio-Cables

- **Maintenance of the antenna:** Similarly, the antenna should also be operated in a careful manner and any parts of it should not be scratched or rammed through any hard surface or dense bush or thorny vegetation (especially the rubber H type antenna). Any deformity in any of the four limbs of the H antenna will make it defunct. The entire equipment should be cleaned periodically from the outside to remove all the dust / mud from this.
- **Maintenance of the cable:** The second component – 'cord' should be maintained very carefully as small to smaller twitch or cuts in the wire (any small to smaller wear and tear), would disable the operations of the entire equipment. Too much coiling of the cord should not be done.

5.8 Animal detection and alarm devices

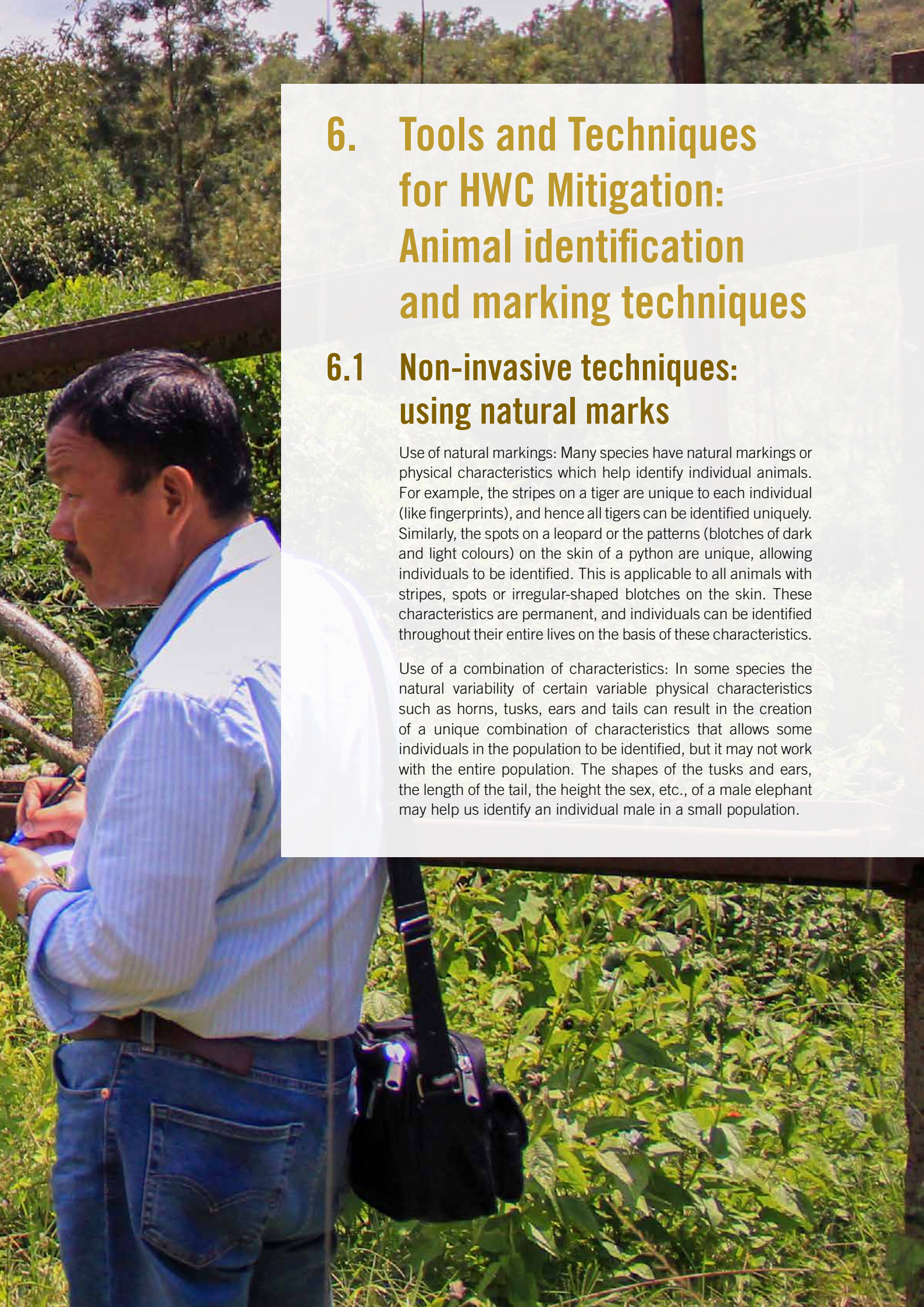
ANIDERS by Kyari Innovation

EleSense by SNAP Foundation

Figure 29: Animal detection and Alarm device

The use of technology to mitigate HWC is increasingly being explored with several technology companies and NGOs in India offering animal detection and alarm devices using Artificial Intelligence, Machine Learning, Thermal and Infrared Sensors coupled to alarms and flashing lights. The technology is still in its development stage, and field studies are required to test the efficacy of the same. Fox lights have been found to be effective against leopard entry into human habitations in Uttarakhand. Animal sensors coupled with warning alarms and flashlights have been installed in several locations in West Bengal to mitigate human-elephant conflict by the NGO SNAP (www.snapindia.org); such devices have also been developed by Kyari Innovations.

Animal entry detection and alarm-based devices may be effective in warding off damage-causing species from human-use areas such as crop fields and livestock sheds. However, the devices need to adapt to learning behaviour in wildlife. Such adaptations may be enabled with variable alarm sounds, variable lighting mechanisms and changing the location of these sensors from time to time.



6. Tools and Techniques for HWC Mitigation: Animal identification and marking techniques

6.1 Non-invasive techniques: using natural marks

Use of natural markings: Many species have natural markings or physical characteristics which help identify individual animals. For example, the stripes on a tiger are unique to each individual (like fingerprints), and hence all tigers can be identified uniquely. Similarly, the spots on a leopard or the patterns (blotches of dark and light colours) on the skin of a python are unique, allowing individuals to be identified. This is applicable to all animals with stripes, spots or irregular-shaped blotches on the skin. These characteristics are permanent, and individuals can be identified throughout their entire lives on the basis of these characteristics.

Use of a combination of characteristics: In some species the natural variability of certain variable physical characteristics such as horns, tusks, ears and tails can result in the creation of a unique combination of characteristics that allows some individuals in the population to be identified, but it may not work with the entire population. The shapes of the tusks and ears, the length of the tail, the height the sex, etc., of a male elephant may help us identify an individual male in a small population.

One bull may have long tusks and a short tail and be 2.4 m tall, while another bull may have short tusks and be 3 m tall and a third may have long tusks but have a long tail and be 2.4 m tall. All three can be separated based on these three characteristics: length of tusk, height and length of tail. There is, however, a constraint when the population is large as there are bound to be similar sets of characteristics in some other individuals as only a limited number of permutations and combinations will be available to create a unique identity.

Use of natural and unnatural characteristics: In some cases, deformities (natural or accidental) can help create further marks for distinguishing between individuals with similar basic characteristics. When natural characteristics are modified by deformities or injuries, identification can be refined. For example, continuing from the example in the foregoing, assume two bulls have long tusks, are 2.4 m tall and have short tusks, so that there is a situation where we cannot distinguish between them. Assume one of them has a hole in its left ear and the other does not have a hole. This hole in the left ear, coupled with the other three characteristics of tusk length, tail length and height will help identify these bulls. This is a very simplistic example, and the situation is far more complex and difficult in real elephant populations, but there is an option to create unique identities. This has been used by researchers to create identification profiles of hundreds of elephants on the basis of observations over years.

Use of association for identification: Despite the use of the multiple characteristics and deformities to identify individuals, in a large population of elephants it may still not be possible to separate all individuals, particularly the sub-adults and young. Hence, we also take into account association and age-sex category into consideration. Here a calf can be linked to its uniquely identified mother, or a juvenile/sub-adult linked to its uniquely identified cohesive social group can be identified when it is found in the presence of a uniquely identified individual. In conflict mitigation, it may not be necessary to identify all the individuals in a population. Only those involved in serious conflicts need be identified. Hence, if the individual animal (or group of animals) involved in the conflict has unique physical characters then the identification can help implement targeted management action. Such markings may also be present in antelopes/cervids/bovids, primates and some large carnivores that do not have colour patterns, like bears.

6.2 Invasive marking techniques

In all these techniques, the animal has to be handled to fix a tag or mark it in a unique way. Handling may require chemical or physical restraint of the animal for the purpose of tagging or marking it.

- Ear tags: These are brightly coloured and numbered tags that are attached to the ear of an animal. They are sufficiently large to detect at a distance, and the number can be read using a pair of binoculars. These are mostly used for herbivores (antelopes, cervids and bovids), which do not interfere with the tags. There is a tag applicator that helps attach the tag to the ear quickly and easily. As the attachment requires puncturing the ear lobe, selection of a site to avoid blood vessels is important. Treatment of the attachment site with antibiotics is important.

Figure 30: Livestock with ear tags

Tissue removal: This marking requires clipping of a body part and when used in reptiles, in which scales are clipped or shell edges are notched, it causes no pain or injury and is harmless. The number of scales clipped and the location help create a numeric code that allows the individual to be identified uniquely. This method is ideal for marking and monitoring crocodiles.

- The use of tiny RFID tags, which are inserted subcutaneously using a syringe applicator, is suitable for marking individuals that are likely to be recaptured. There are standard and agreed locations where the RFID tags are placed, this system allows the unique ID numbers of the tags to be read quickly using a scanner. This method has been used to mark leopards that have been captured and translocated. Recaptures will allow the detection of a leopard that had been captured and released previously. Although photographs too will aid such operations, the use of RFID tags allows error-free identification and can also be used to identify wildlife species without unique patterns to aid individual identification.

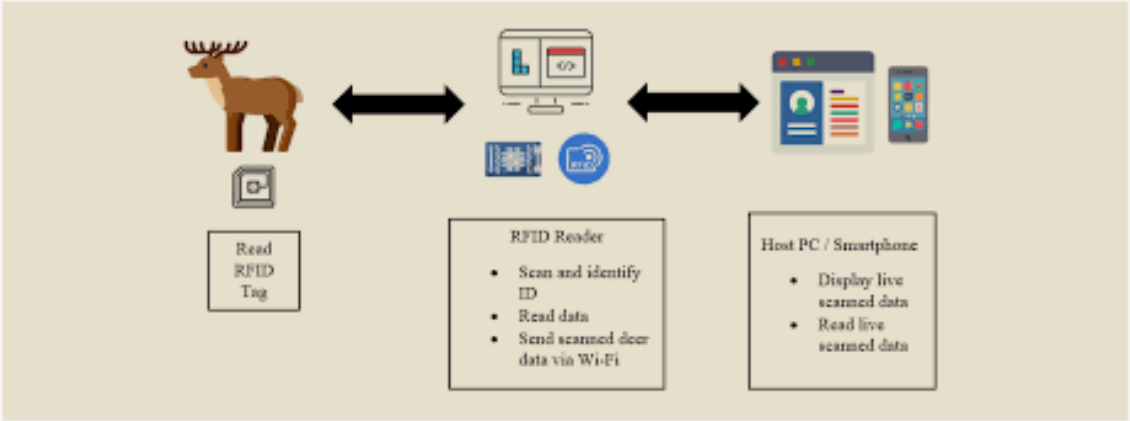


Figure 31: Architecture diagram of the system

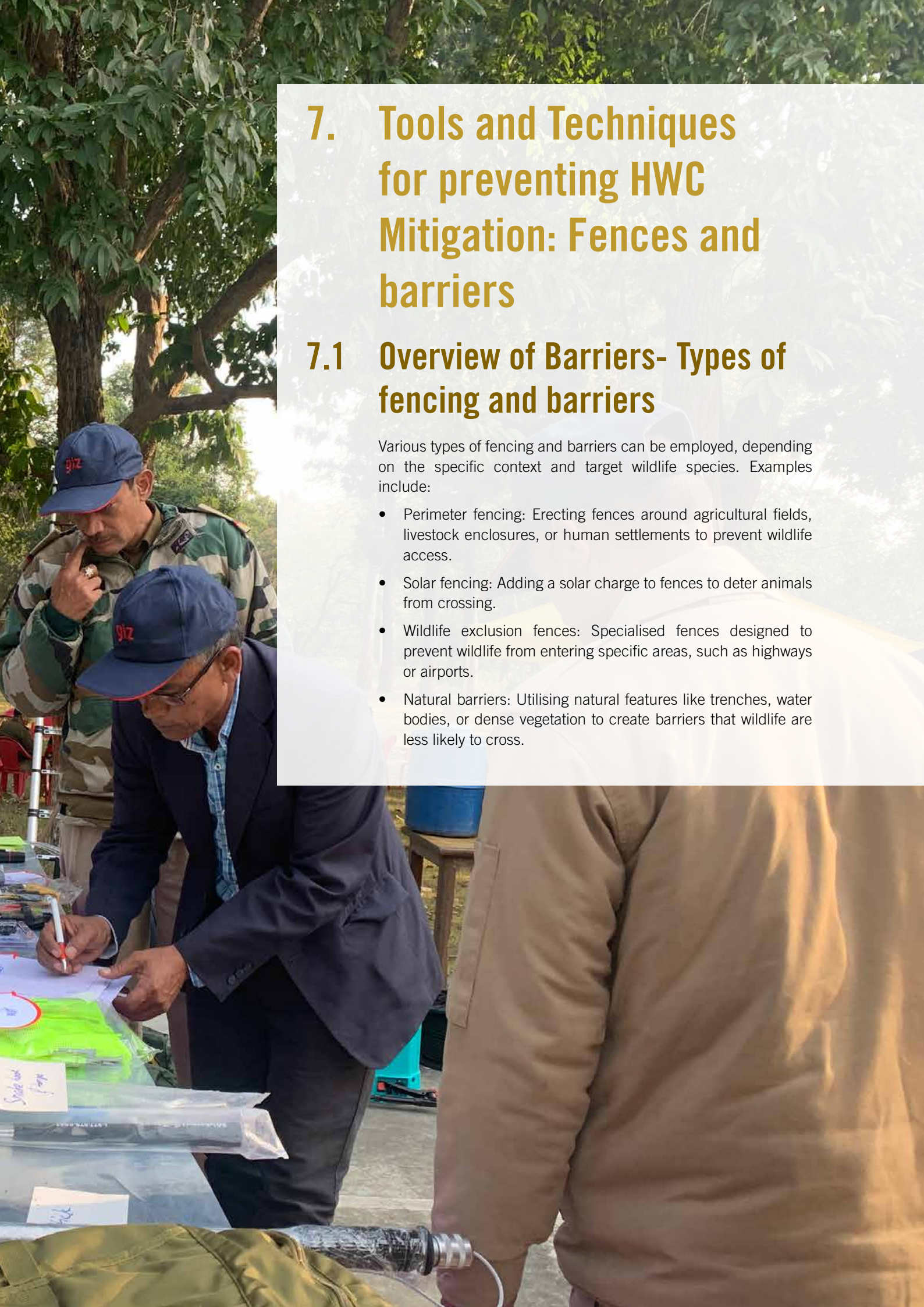
- Neck collars: These can be basic collars and are used like tags (with numbers) for identifying animals.

Figure 32: GPS-VHF Tracking collars for monitoring wild dogs

- **Radio/satellite collars**: The most common use of neck collars is attaching radio/satellite transmitters or radio/satellite/GSM transmitters linked to a GPS unit for the purpose of tracking animal movements[7]economic losses, human injury, or other human-wildlife conflicts can occur when wildlife use these resources; however, few studies have examined urban wildlife resource selection at fine scales to guide conflict mitigation.We studied black bears (Ursus americanus. Such tagging and gathering of location data can be for the purpose of conflict or conservation management, where it can facilitate and help monitor management interventions. Such actively transmitting tags have also been attached to the tails and legs of larger animals. In the case of reptiles, they have been inserted into the body surgically or orally (for short durations as it is ultimately voided during defecation). They have also been attached by being stuck to the body/ fur of aquatic animals. They have been stuck to the feathers near the tails of birds (they drop off when the birds moult) or fitted to the body using a body harness. Some tags are also attached to the legs of birds.

Figure 33: Ring tags for birds

- Leg rings or bands: These are largely used for tagging birds and only carry a number (the unique identification number given to a bird) and contact details so that the person who recaptures the bird or recovers the tag can inform the original person who tagged the bird about the recovery point and status of the bird. In larger birds the tag number may be seen using a pair of binoculars. In the case of smaller birds these details can only be obtained when the bird is handled. This can be done through deliberate capture (study) or through the recovery of a dead body. Even in the case of larger birds, the leg bands will not be large enough to show the contact details, and hence the details will be available only when the birds are handled. Sometimes leg bands with different colours in combination are used to create a unique identification for each bird. Smaller birds can also be identified, but, again, the contact details will not be available to all viewers.



7. Tools and Techniques for preventing HWC Mitigation: Fences and barriers

7.1 Overview of Barriers- Types of fencing and barriers

Various types of fencing and barriers can be employed, depending on the specific context and target wildlife species. Examples include:

- Perimeter fencing: Erecting fences around agricultural fields, livestock enclosures, or human settlements to prevent wildlife access.
- Solar fencing: Adding a solar charge to fences to deter animals from crossing.
- Wildlife exclusion fences: Specialised fences designed to prevent wildlife from entering specific areas, such as highways or airports.
- Natural barriers: Utilising natural features like trenches, water bodies, or dense vegetation to create barriers that wildlife are less likely to cross.

Design considerations: Effective fencing and barrier design should consider the behaviour, size, and capabilities of target wildlife species. Factors to consider include:

Height and strength: Fences should be tall and sturdy enough to prevent wildlife from jumping over or breaking through. The height requirement depends on the target species.

Burrowing prevention: Measures may be needed to prevent wildlife from digging underneath fences. Installing barriers underground or extending fences partially underground can address this issue.

Visual cues: Incorporating visual cues, such as flagging or reflective materials, can enhance the visibility of barriers and help deter wildlife.

Strategic placement: Proper placement of fences and barriers is crucial to their effectiveness. Consider the following factors:

Wildlife movement patterns: Understanding the typical movement routes and behaviour of wildlife species in the area can help identify key locations for fence placement.

Targeted resources: Fencing should be strategically positioned to protect valuable resources like crops, livestock, or human settlements that are most vulnerable to wildlife damage.

Connectivity and wildlife corridors: It is essential to maintain connectivity between habitats and consider the movement needs of wildlife. Designing wildlife-friendly crossings or providing alternative routes can minimise habitat fragmentation.

Maintenance and monitoring: Regular maintenance and monitoring of fencing and barriers are necessary to ensure their long-term effectiveness. This includes checking for damages, repairing any breaches, and adapting the design, if necessary, based on wildlife behaviour and changing circumstances.

Considerations and limitations: While fencing and barriers can be effective HWC mitigation tools, they may have limitations and considerations to keep in mind:

Cost and logistics: Building and maintaining fences can be expensive and may require significant resources and expertise.

7.2 Overview of barriers- current challenges

Barriers are essentially used to keep wildlife out of human-use areas, and the basic principle of erecting barriers is to establish them at the interface between human-use areas and wildlife habitats. A barrier must never cut through a wildlife habitat and fragment it. However, an exception is where a barrier may cut off a very small portion of a wildlife habitat to rationalize the boundary and make it more conducive to conflict mitigation. Such locations are present where the perimeter of the habitat is convoluted and creates an unduly long interface facilitating HWC, the extent of the habitat is very small and the habitat is degraded, as a result of which the habitat is not very important for conservation. Wildlife habitats in India are essentially patches of habitats within a sea of human-use areas. As such, when a barrier is placed on the perimeter, it does not result in further habitat fragmentation. Where human settlements are present within a wildlife habitat, they can be enclosed within barriers as this too will not fragment the habitat.

In the case of species such as the Tiger, which may disperse through human-use areas, barriers need to be large and carnivore-proof. While Tiger-proof barriers have only been tried in Sundarban Tiger Reserve, there is a need to look at the dispersal aspect, and one possible solution is to capture and translocate to alternate habitats Tigers that are likely to disperse.

It is not recommended that barriers that can cause injury to animals to be used as this would be both unethical and harmful. However, a barrier cannot be considered to be harmful where there may be a rare case of injury or mortality of an animal in abnormal circumstances.

When erecting Elephant- or herbivore-proof barriers, it is very important to take into consideration the forest resource requirements of the local communities. Even in cases where they may not have rights, they may continue to use forests to get some resources. Often such forest-dependent segments of the community are not as adversely impacted by HWC as segments that practise agriculture. This kind of disconnect may result in one section of the community creating breaches in a barrier for cattle grazing, fuelwood collection or NTFP collection and thus allowing Elephants and other herbivores access to crops at night. Simple mechanisms such as gates or cattle-proof barriers at entry points will allow people to move freely but will stop Elephants and other herbivores.

Fencing and barriers are commonly used as mitigation measures to reduce human-wildlife conflict (HWC) by creating physical separation between humans and wildlife. Here are some key points regarding fencing and barriers for HWC mitigation:

One major challenge with barriers, one that causes failures, is challenges in its effective monitoring and maintenance. Often, once a barrier is erected, ownership for its monitoring or maintenance becomes a challenge, and this results in the failure of the barrier. It is important that the local community be made responsible for monitoring and reporting on the effectiveness of the barrier as they are the main beneficiaries. Maintenance can be sough form the community-level Primary Response Teams, or EDCs, women's self-help groups (SHGs) or such other community-based organizations, to ensure that there is ownership, responsibility and accountability in the system. The capacities for such operations certainly need to be built up within the community and the concerned group.

Another major challenge in the use of barriers is the inability to deal with weak spots, many of which are common to all barriers, but some weak spots are unique to certain barriers.

- Roads and paths cutting across barriers result in openings, will be used by wildlife for foraging crops if the openings are not monitored. In many cases, the local community can be made responsible for managing the opening by using a gate or by guarding the entrance at night. As roads lead into forests at such locations, the forest department itself has manned check posts, but these may not be manned at night if there is no traffic. Hence, they would require night guarding too.
- Streams/rivers, that cut across barriers create openings that wild animals can exploit to raid crops. The Karnataka Forest Department has been testing several solutions and has largely narrowed down the options to the use of rail fences or concrete pillars placed close together. These allow water to flow through but stop Elephants from crossing.
- In rocky areas that do not allow the construction of barriers (trenches or even electric fences), alternate barriers such as strong stone walls that can be used to block difficult sections. While such barriers are costly, the distances involved are not too large and they become acceptable options because they are the only solutions.

7.3 Barbed wire fence

It is not advisable to use barbed or razor wire fences as they can cause severe injuries to animals that may attempt to cross them. Animals are also known to get entangled in such fences when they struggle to pass through.

7.4 Mesh fences

These fences are generally useful for smaller species, including the Wild Boar, but they are expensive. However, individual farmers often use nets for fencing against Wild Boars and claim that they are successful. However, there is no systematic study to prove if this method works along longer stretches. Often, at the individual farm level, such barriers work as Wild Boars are deflected to adjoining unprotected crop fields. Such fences cannot be used in areas where Elephants are present as they will easily damage them when they raid crops. They can be used in combination with another barrier that stops Elephants. In most cases they are linked to solar fences, with the solar fence acting as a barrier against Elephants and the nylon net (about a metre high) stopping Wild Boar. This becomes cost effective as multiple closely placed wire strands are required at the lower end of an solar fence to stop Wild Boar. This additional cost of wires and the difficulty of maintaining the lower strands free of vegetation that causes short-circuits make the use of nylon nets a better option.

Metal mesh or nylon net fencing linked with other barriers such as rails or solar fences can be used/tested against Wild Boars.

7.5 Solar fences, Tentacle fences

In a solar fence, a pulsed high-voltage current generated by an energizer passes along a wire. This is not harmful to wild animals or humans, but it does give a short shock. It is generally powered by a battery that can be charged either by a solar panel, as is commonly done because electricity is generally not available at peripheral locations where such fences are installed, or by an AC current.

Solar fences were largely developed to contain domestic livestock but have been adapted to deal with wild species. They can be very effective against most herbivores, but the height is critical as most deer and antelopes can jump very high and can easily cross fences. The width of the strands also needs to be narrow as deer can jump through gaps between power strands.

Solar fences have been used successfully in Africa, particularly South Africa. Solar fences, in general, have not been very effective in India in managing Elephants. A large part of the problem lies with poor implementation at the start, which allowed Elephants to experiment and overcome these fences. In most areas in south India, Elephants have learnt to breach these fences using various tactics. Some males have learnt that their non-conducting tusks can be used to hook the fence wire and pull it back till it breaks. Both males and females in dry areas have learnt that the sole of their feet are non-conductors and hence use them to press down on the fence post and push it down. They also use their trunks to pull/push fence posts if they are not protected with sufficient guard wires. They have also learned to throw objects (logs/stones) at fence posts and damage them. In addition, some have learnt that the shock is just a temporary jolt and as such just push through the fence. Such Elephants become habitual crop raiders as they easily break through fences. Elephants also transmit such learning to other Elephants when they associate with each other, and thus such fence-breaking behaviour spreads.

Solar fences in the Indian condition cannot be seen as 100% Elephant-proof barriers and need to be viewed as tools that significantly reduce conflict if properly used. The following should be taken into consideration when using solar fences.

- The solar fence is, in reality, a psychological barrier, and as such it works best if other psychological challenges are also present. For example, when Elephants raid crops they need to overcome the fear of moving into human-use areas, are wary of human presence and are also scared of moving into an open area when human presence is suspected. Hence a solar fence should always be at the edge of an agricultural area or human settlement as moving into such areas is already a psychological barrier to Elephants. The fence therefore adds to the barrier effect. Where there is fallow land or scrub along the fence line, all the vegetation should be cleared so as to create an open space that again acts as a psychological barrier to Elephants. Fence lines that run through scrub or along a forest edge can be easily broken.
- The fence posts should be adequately guarded so that Elephants do not have access to them and hence are unable to damage them.
- Various fence designs have been developed to overcome Elephants' ability to break through fences, and these include the hanging fence (see figure 34 below) or tentacle fence. The overall efficacy relative to the regular fence has yet to be tested on a larger scale (to ensure that deflection is not an issue) and after a sufficient period of exposure to the fence so that the novelty effect wears off and the fence is seriously tested.
- In dry areas, the conductivity of the dry soil will be poor, and hence the fence will become less effective as the shock will be very weak. In such areas, it is very important to have adequate earthing at closely spaced places to ensure good conductivity.
- Solar fences need to be maintained as recommended if they are to function effectively. It is most important to check a solar fence daily for any short-circuit caused by vegetation touching the fence line. This will render the fence ineffective, and it is important that the fence line be checked daily for any growing vegetation touching it and that the vegetation be cleared. Often this is done once a month or once in six months, and this period is often too long as grasses and herbs can grow rather rapidly. Sometimes insects, lizards and small snakes can cause short-circuits and die, resulting in continuous draining of power. The battery, charging system and earth connections should also be checked regularly. Any failure that is not attended to on the same day will make the fence non-operational and liable to damage by Elephants.

- Solar fences are not 100 per cent effective barriers against Elephants, and unfortunately, this aspect is rarely understood by forest departments nor communities. Hence, whenever a fence is breached, they see it as a failure and proof of the ineffectiveness of the fence as a tool. They fail to repair it quickly, as a result of which more sections of the now-defunct fence are damaged. Eventually the fence is abandoned. It is very important that as and when a breach is detected it is repaired during the normal daily maintenance. Once people recognize this and the barrier is effectively maintained, most of the crop foraging will be stopped. Only foraging at a low level, involving habitual raiders, will remain, and that level may be acceptable to the community and can be compensated for by the government.

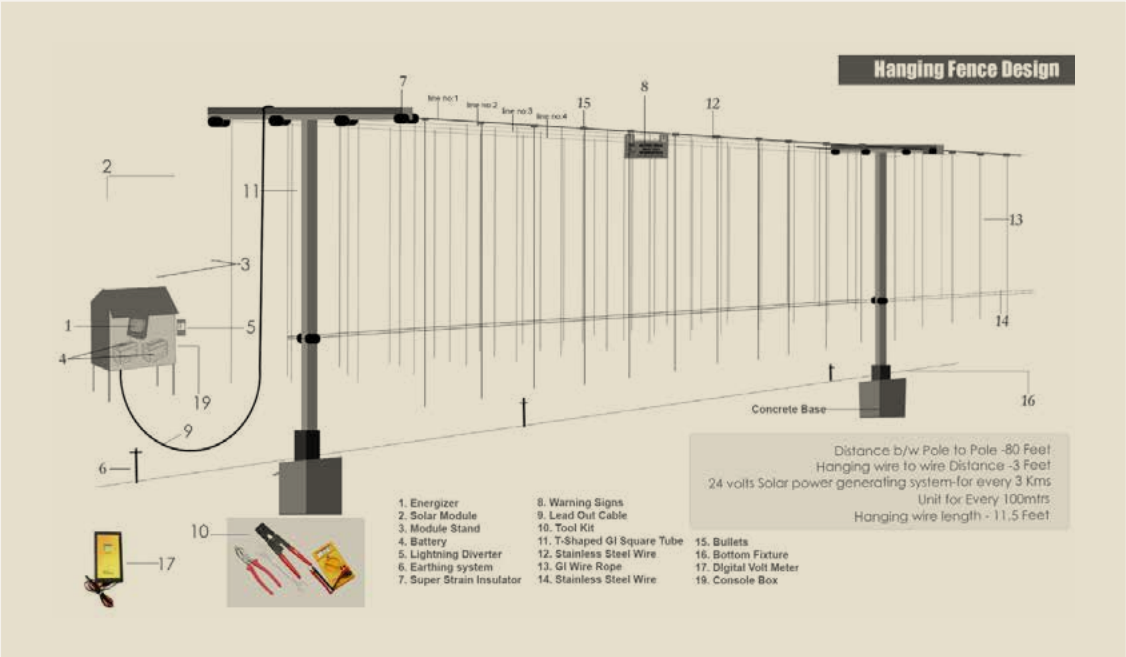


Figure 34: The design of the hanging fence, or tentacle fence

If night guarding is used to support the solar fence, then the fence becomes a very potent barrier. To achieve this, the community has to work together. A simple tripwire early-warning system will allow Elephants approaching the fence to be detected, and this will allow the guarding team to wake up and take preventive action. The tripwire early-warning system allows the guarding team to sleep and wake up only when needed, thus avoiding sleep deprivation. A community-based system allows rotational guarding, which requires fewer people on any given night, thus minimizing the manpower requirements. Elephants will not breach a fence when confronted by it and the people guarding it.

Such a system will work even in areas with high levels of conflict if it is effectively implemented.

7.6 Trenches

Trenches are physical barriers and are primarily used to stop Elephants from intruding into human-use areas. They are known as Elephant-proof trenches. They have been used widely but with limited success in most areas. The reasons for failure are largely poor construction and failure to maintain the fences. There are several challenges that need to be addressed when using Elephant-proof trenches as barriers.

- They are generally very ineffective against other herbivores as these animals are able to jump down and scramble/jump up on the other side. Herbivores may actually jump across a trench as it is only about 3 m wide. While Wild Boars cannot jump, they scramble into and out of a trench using the footholds created by other herbivores as they scramble up and down the trench. If these footholds are left unrepaired, they will expand and then be exploited by Elephants to cross the trench.
- The basic flaw in most trenches is in the sloping walls, as a result of which the top width of the trench is twice the width of the bottom of the trench. While this design is ideal for preventing the walls of the trench from collapsing, it is easily breached by wild herbivores and Elephants as they tend to slide down the slope and create footholds in the process. An ideal design is one that has vertical walls, with the width of the top and bottom being the same. Vertical walls are the most difficult for wild animals to negotiate. However, vertical walls crumble more easily than do sloped walls. Hence, regular maintenance is required to ensure the integrity of the trench. Securing the walls using stones or cement has been attempted at a few vulnerable locations and has proved effective. If such a lining is used, it is best to apply it to only one side of the trench, the one that is on the side of the Elephants. This is a very expensive solution, but it can be very effective. A completely cement-lined trench would cost in the region of Rs.40 lakhs per kilometre.
- The soil type and the quantum of rainfall and its intensity can damage the trench through soil erosion. In certain loose-soil areas with heavy rainfall, trenches get washed away. So managers need to take consider this aspect. Sandy soil is not very conducive to trench construction because walls collapse easily. Further, erosion is always a big problem with such soil types. Rocky areas are not suitable as they make digging a trench very difficult and costly.
- Maintenance remains a challenge and cannot be carried out by a few people as with solar fences. Maintenance of trenches requires a lot of labour and sometimes even machinery, and all these require significant resources.
- One study conducted in Wayanad Wildlife Sanctuary indicated that Elephant-proof trenches alter the hydrology locally, and hence it is important trenches be used with

caution. At the very least, trenches divert the normal flow of surface (rain) water and channel it into a few concentrated streams, depending on the contours.

- Trenches also act as perfect barriers to all the smaller terrestrial animals and thus separate forests from agricultural areas. Most of the smaller animals do not cause conflicts, and their occupation of niches in agricultural areas is harmless and beneficial for conservation.

Box 1: Changing response of wild animals-in-conflict to people and HWC mitigation methods

Loss of fear of humans and consequently of normal scaring tactics

In the absence of hunting and with effective wildlife protection, many species are losing their natural fear of people and intruding into human-use areas.

Habituation to scaring and driving tactics

Many species are losing their fear of normal scaring tactics that are harmless, thus making guarding ineffective. They are also getting habituated to driving tactics and now tend to return quickly to the original site.

Physical and learning abilities (including cultural learning) that need to be considered

Methods that work with one species may not necessarily work when other species are present in the same habitat. For example, nylon nets, the use of which is being tested to keep Tigers out of human habitations in Sundarban Tiger Reserve, will not function in a Tiger habitat that also has Elephants because Elephants can break through them easily. Similarly, electric fences, which may work against Elephants in areas with low levels of conflict, will not stop antelopes and deer, which can jump over. Learning of electric fence breaching tactics by Elephants will eventually defeat the purpose of such fences. Similarly, the young of large carnivores could be habituated by their mothers to human-use areas or to preying on livestock. Loss of fear of humans or scaring tactics can also spread culturally across a population, rendering normal guarding or scaring techniques ineffective.

7.7 Walls

Walls have been used as barriers primarily to stop Wild Boars from foraging crops. These walls are made of rubble and are about a metre or a metre and a half in height. They are mostly used in areas where a lot of stones are readily available. They also act as barriers that stop domestic cattle from damaging crops where crop fields are left unguarded. They work effectively against Wild Boars but require stones and cheap labour.

Walls were also been used as barriers against Elephants in Uttarakhand. But these proved to be ineffective as the design and construction quality were not good enough and Elephants broke through easily. People too breached the walls at several places to enter the forest to collect fuelwood or to allow cattle to enter forests for grazing.

Walls have been used in small sections to block the movements of Elephants along sections of Elephant-proof trenches where the trenches could not be dug effectively. These walls were structurally adequate to stop Elephants.

In Hosur Forest Division, in Tamil Nadu, waste rocks (boulders) from granite quarries near the forest have been used to create strong wall-like barriers. The rocks were acquired free of cost from the owners of the quarries, and the main cost involved was in the transport and aligning of the rocks into wall-like structure. This strategy was considered to be feasible where the transport distance is short and enough waste material is available.

These are structures constructed on the bank of rivers or beaches to exclude crocodiles from the area. Traditionally, bamboo barricades have been used in parts of India, such as Orissa, but galvanised Iron is also being used to increase the life of these structures. These structures are partially submerged in water, and the dimensions are selected on the basis of the depths at high and low tides and the number of people who will be using the area.

7.8 Infrastructural features that provide additional support to barriers

In some cases, there may be infrastructure at the edge of a forest that acts as a barrier. It could be linked to other barriers to make them more effective, or it could serve as a stand-alone barrier. Some examples are listed in the following. The needs of the infrastructure development plan and the HWC mitigation plan need to coincide and be compatible.

7.9 Water canals

Water canals with cement-lined walls can act as physical barriers against most species if they are wide and deep enough. However, access to the water should be provided at regular intervals so that animals do not fall into the canal and get trapped in it when attempting to drink water. Elephants and other animals have been known to have gotten trapped in such canals.

7.10 Roads

Roads running parallel to barriers such as solar fences and Elephant-proof trenches act as strong secondary barriers (psychological) that stop the movement of wild animals into human-use areas. A very good example of this is seen in Udawalawe National Park, in Sri Lanka, where a section of the southern boundary of the park has a solar fence with a road running parallel to it. In addition, houses have been built all along the roadside. This three-tiered psychological barrier of a solar fence, a road and houses acts as a very effective barrier. However, the effectiveness could be due to the fact that at that location Elephants were not used to crossing the boundary. The present forest area within the boundary was created by resettling people outside the area.

7.11 Crocodile-Exclusive Barricades

During the rainy season, especially during high tide, the small *nallahs* and creeks are flooded, submerging nearby low-lying forest land, agricultural fields and even the premises of individual houses used by people for routine work and, therefore, making the habitation accessible to the crocodiles. People wade through submerged area for commuting from one place to other place and even enter flooded creeks for fishing. There are regular reports of such brackish creeks being used for washing, bathing and cleaning utensils despite continuous sensitisation. Domestic animal also wades through such stretches of the creeks for grazing/foraging and drinking.

To avoid conflict, efforts should be made to isolate such stretches from the main creek/*nallah*. Such efforts will not guarantee crocodile-proof landscapes, but will help in restricting crocodiles moving in/from the creeks. Deeper and wider creeks should generally be negotiated by the boats. FD should also facilitate movement of people by relaxing restrictions on movement of people through RF for their *bona fide* purpose.

Isolation of these stretches should be carried out by way of:

Setting up of grill gates: Wherever roads are crossing such creeks or the mouth of the creek is narrow, movable grill gates should be fixed at the bridges/culverts to check the entry of the crocodiles into the stretches of the creek closer to habitations. The grill gates will be designed in consultation with the village panchayat and the PWD. Grill gates should be operated by the youths of the concerned village/s either engaged by the panchayat or district administration or by the concerned forest division.

Crocodile-proof nets and bamboo fences: During rainy season, submerged forest lands, agricultural fields and other low-lying areas close to the creek should be separated from the main creek by erecting the crocodile-proof nets or the bamboo fences to restrict the entry of the crocodiles in these

areas. At shallow and narrow portions of the creeks, which are generally dry prior to rains, nets or bamboo fences can be used to segregate upstream stretch of the flooded creek.

Segregation of the habitation from the creeks: In the areas, where the habitations are very close to the perennial creeks even during non-rainy season, the habitation should be permanently segregated from the creek by erecting the plastic-coated chain link fences. In the area where such permanent fences have not been erected or it is not possible to erect it immediately, temporary bamboo fence supported with the wooden jungle posts should be erected prior to start of rains and flooding of the creeks.

Installation of Crocodile Exclusion Enclosure (CEE): A crocodile exclusion enclosure is a physical structure made within the water body along the banks of a crocodile inhabiting area. Such a physical structure made of locally available material or even chain link or iron fences is designed to exclude crocodilians from the area and to reduce the risk of attack by crocodilians. Such CEEs have been used in India and Sri Lanka successfully. Since local inhabitants depend on use of creeks/streams/ lakes/ponds/rivers for washing, fishing and other daily uses, it is proposed to erect large four sides durable crocodile exclusion enclosures (CEE) with single entry (that also needs to be closed during unused time) in identified vulnerable areas with human and crocodile presence. Such CEEs can be used for safe fishing by locals. Simultaneously, forest department can support locals in erecting small CEEs in their individual backyards for their daily needs of water requirement.

Box 2: Crocodile Exclusion Enclosures in Sri Lanka

Traditionally, Crocodile Exclusion Enclosures have been used in the southern 'wet' zone of Sri Lanka to reduce risk of attack by Saltwater Crocodiles (C. porosus) (De Silva 2011). Known as 'kimbap kotuwa', in the Sinhala language these are relatively simple structures, with three sides, often constructed using wooden poles. Beginning 2007, more elaborate structures constructed with steel poles and wire mesh have been established. Interestingly, CEEs are not used by people living in most parts of the 'dry' zone inhabited by large populations of mugger crocodiles (C. palustris).

CEEs are used by people for personal use (e.g., bathing, washing clothes and household utensils) and occupational needs (e.g., laundrymen, brick makers) (Samarasinghe 2013).

CEEs in Sri Lanka are categorised into 3 main types. **Type 1**: small (3 x 3 m) enclosures are used for personal use by the respective householders. **Type 2**: built for communal use, constructed of thick *kitul* palm *(Caryota urens)* planks or long hardwood poles driven into the river bed. **Type 3**: large public CEEs erected by government authorities (Disaster Management Coordination Unit, Matara). While three sides of the CEE are covered, the bank side is open to permit users enter in. On occasions, crocodiles have been known to walk around this and enter enclosures. De Silva (2008) recommended 4-sided CEEs, with a gate, to reduce the risk of crocodiles entering from the land area.

In Matara, the DMCU is currently engaged in a project to build 45 Type 3 CEEs. The biggest constraint is the lack of funding, with each CEE costing around $US2500-3200. During the monsoon, all types of CEE get damaged. Some Type 1 CEEs are destroyed. Mud and leaf litter accumulate on Type 3 CEEs.

Interestingly, most—if not all—attacks occurred where people were bathing or washing outside a CEE, or where there was no CEE at all, or where CEEs had not been maintained properly (Somaweera and De Silva 2013). In the Nilwala River, there had been no attacks on people using Types 2 and 3 CEEs, but in 2012 there was an attack on a young girl in a Type 1 CEE (Samarasinghe 2013). This is because some poles were missing from this personal CEE, facilitating the entry of the crocodile into the CEE (Anslem de Silva, pers. comm.).

Figure 35: Secure CEE (Type 2)

Figure 36: Tradition CEE (Type 1)

Figure 37: Metal & wire CEE (Type 3)

Figure 38: Accumulated debris (Type 1 CEE)

Box 3: CEEs in India

6.2 CEEs in India

Protected bathing ghats are used in India to exclude crocodiles. The concept of exclusion enclosures, although old (e.g., Australian Town and Country Journal, 26 November 1898), is not widespread in India, and is being promoted by researchers and managers alike as a mitigation measure against attacks by Saltwater and Mugger Crocodiles (Whitaker 2008b). Interestingly, the use of enclosures in the Andaman Islands is not mentioned by Whitaker (2008c).

Government authorities have established enclosures constructed of chain mesh wire and metal supports in some areas (Whitaker 2007, 2008a, 2008b). However, although these are stronger in the short-term, they are expensive to repair and maintain over time (Tarun Nair, pers. comm.). In the longer-term, the best option may be to provide local communities with a range of designs and allow them to choose the one that they believe would be the best for their situation. In addition, they should invest in locally available materials and labour to construct and maintain enclosures, and thus provide a sense of ownership that is currently lacking.

Figure 39: CEE in the state of Rajasthan

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.

Segregation of footpath from the creeks/rivers/streams: Villagers of many villages and small hamlets away from rural vehicular roads are still using footpaths as means of commuting. These footpaths are intercepted by the seasonal/ perennial creeks, rivers and *nallahs* in many places. Villagers have to wade through these small creeks, rivers and *nallahs* which are flooded during rainy season, and, therefore, the chances of encountering crocodile increase. The following measures can be taken to avoid such encounters with crocodiles:

- **small log bridges/culverts** can be constructed by FD or administration facilitating villagers to cross over such *nallah/*creeks. However, construction of such log bridges should be taken as a stop gap arrangement till the regular bridges are constructed by PWD or Rural Development Department.
- **Check Dams:** In the areas where fresh water streams are draining into the back waters, upstream area can be segregated by constructing vegetative, semi-vegetative check dams.

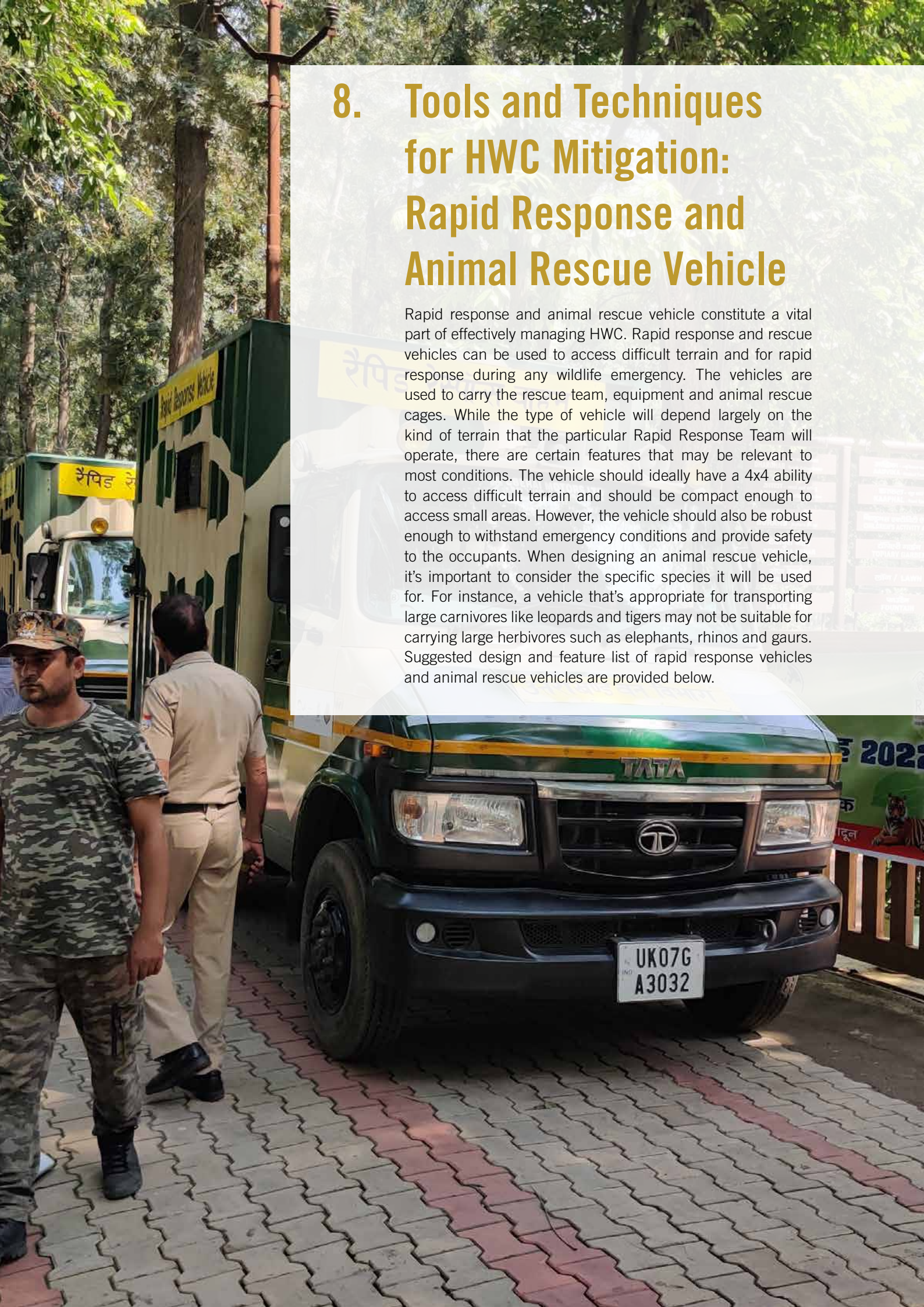
Figure 40: A traditional corral in the Tost Mountains in southern Mongolia, with a fence built around it to reduce livestock depredation by snow leopards *Panthera uncia* and wolves *Canis lupus*. The purpose of the traditional corrals is not to keep wild animals out but to keep the herd together and to provide shelter from the wind.

It's important to note that the effectiveness of fencing and barriers can vary depending on the specific wildlife species and their behaviour. Additionally, local regulations and guidelines should be considered when implementing wildlife exclusion measures to ensure they are ethically and legally sound.

Figure 41: Leopard-proof fencing used around herbivore enclosures in Maharashtra, height of fences is usually more than 12feet above ground and 1 feet below ground

8. Tools and Techniques for HWC Mitigation: Rapid Response and Animal Rescue Vehicle

Rapid response and animal rescue vehicle constitute a vital part of effectively managing HWC. Rapid response and rescue vehicles can be used to access difficult terrain and for rapid response during any wildlife emergency. The vehicles are used to carry the rescue team, equipment and animal rescue cages. While the type of vehicle will depend largely on the kind of terrain that the particular Rapid Response Team will operate, there are certain features that may be relevant to most conditions. The vehicle should ideally have a 4x4 ability to access difficult terrain and should be compact enough to access small areas. However, the vehicle should also be robust enough to withstand emergency conditions and provide safety to the occupants. When designing an animal rescue vehicle, it's important to consider the specific species it will be used for. For instance, a vehicle that's appropriate for transporting large carnivores like leopards and tigers may not be suitable for carrying large herbivores such as elephants, rhinos and gaurs. Suggested design and feature list of rapid response vehicles and animal rescue vehicles are provided below.



Rapid Response Vehicle:

Example Vehicle Model: TATA SFC 407 EX 31 CABIN Chassis TT BS IV

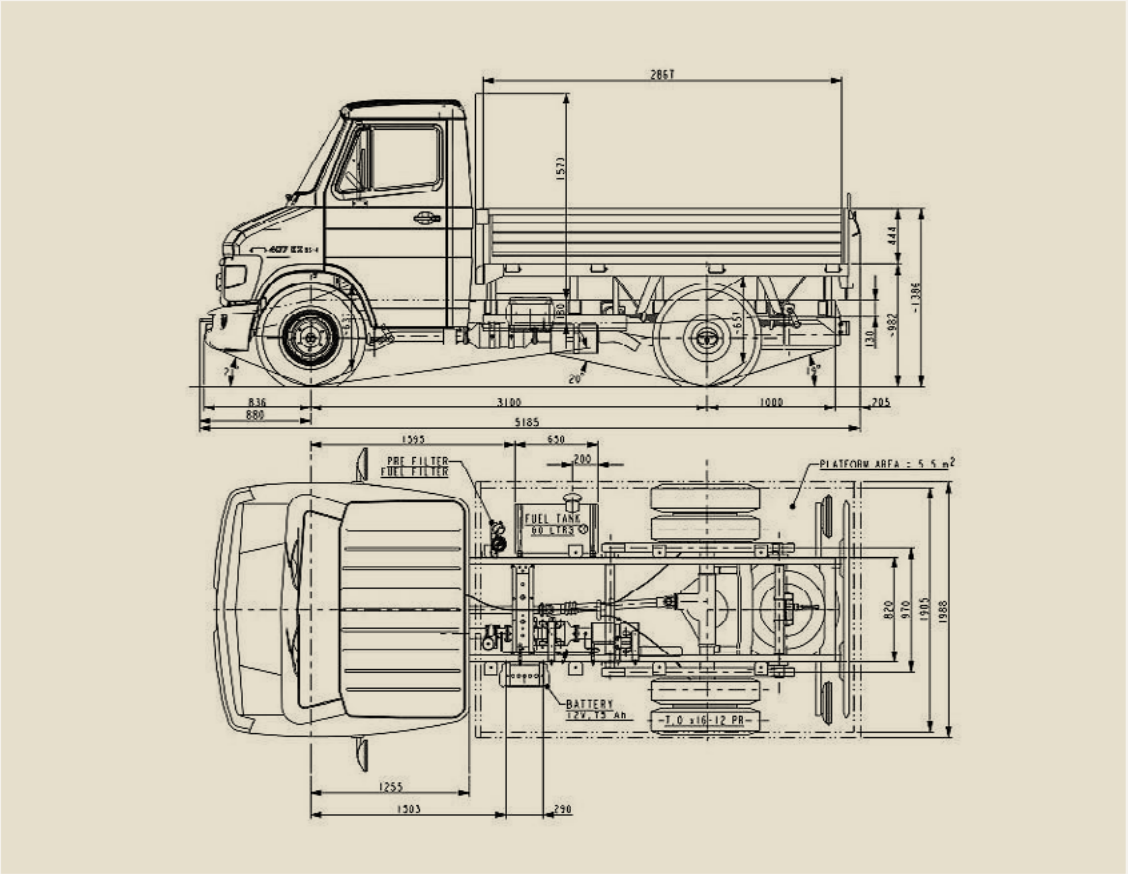


Figure 42: Rapid Response Vehicle for herbivores

Table 4: Technical specification of an herbivore rescue vehicle

S. No	Detail of work	Specification
1.	Body	Body Dimension: Length 9ft X Width 6.5ft X Height 6.5ft Body Floor: MS 3.00 mm Side Panel /wall and Roof: MS 16 gauge ribbed Rear Door/Ramp: Width 6.5ft X Height 2ft MS 2 mm with MS angle reinforced Mudguard: 1.6 mm with a rubber flap Lighting facility on the interior roof of the vehicle to illuminate the entire cabin for general viewing (well laid out arrangements for lights). Rear door is to be used as a ramp with rails fixed for loading and loading/unloading the transport cage.
2.	Ventilation system	• Windows with stone-pelting proof grills and slider window of fiberglass. Two 12-inch Coach fans were placed inside for thermoregulation. • Sunroof window option in driver's cabin for ventilation, animal search and tranquilizing
3.	Seating	• Foldable seats with non-absorbent military-grade padding(weatherproofed) fixed on both sides inside the vehicle. Dimension: sitting plank Length: 8ft, Width 1ft, Height 1.5ft Load bearing capacity: 600 KG • Seating facility for veterinary staff in front cabin (for emergency purposes)

S. No	Detail of work	Specification
4.	Toolbox	Placed in the driver's cabin: • Automatic motorised air-pump • Mechanical Jack & puncture repair kit • 3 pieces Double Open-End Spanner of size (8x10, 13x16, 18x21 mm). • one piece Hexagonal Key 08. • one piece Screwdriver 806. • one piece Wheel Spanner 24x27 A/F. • one piece Tyre Lever (Chrome Plated).
5.	List of accessories installed in the vehicle	• First Aid Kit with basic life-saving drugs and self-hygiene kits for animals and humans (drugs including face masks, PPE kits, sanitiser, face shields, etc.). • Vehicle GPS Tracker with remote tracking option • Two fire extinguishers (one for electrical control and one for general purpose) of 9 kg capacity installed in the inner side of the carrier • Special dedicated box for ropes, nets and other accessories for easy accessibility (free from obstruction). It can be fitted on the lower side to balance. • Loudspeaker for public announcement • Hooter on top above the front cabin • Searchlight on top • Arrangement of towing hooks (to tow other vehicles) on both front and back side • Arrangement to keep walkie talkie • Power plug option for charging inside driver cabin and back cabin • Rails for loading cages inside the vehicle and to ground
6.	Pulley arrangement	• Pulley fitted with rope to open the rear gate of the cage from driver's • cabin for safety • 2 pulley system should at the posterior of the truck for lifting of the cage
7.	Cage holders	• Provision of hooks and chains at the sides for keeping the cage firm (as per cage specification). Two hooks on either side
8.	Water tank	• A metal water tank of 100 liter capacity installed on top of the vehicle for captured animal • Small HP pump fitted to the outlet to increase the water pressure • Provision for 10 liter portable water (Milton container) for staff

Figure 43: Rescue vehicle used by West Bengal Forest Department

Carnivore transport vehicle:

Example Vehicle Model: TATA SFC 407 EX 31 CABIN Chassis TT BS IV

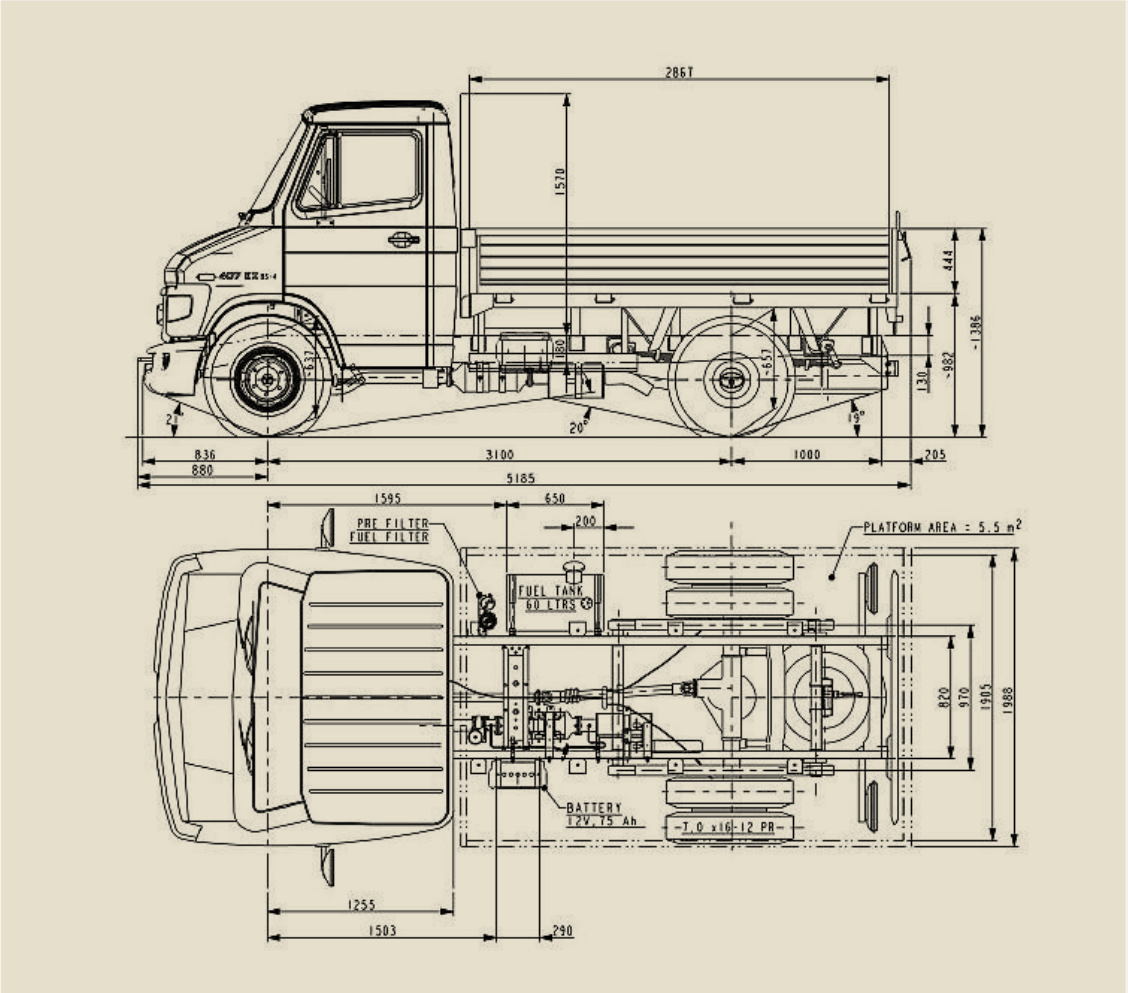


Figure 44: Rapid Response Vehicle for carnivores

Table 5: Technical specification for carnivore rescue vehicle

S. No	Detail of work	Specification
1.	Body	Body Dimension: Length 9ft X Width 6.5ft X Height 6.5ft Body Floor: MS 3.00 mm (chequered) with MS pipe support (2.5- 3-inch pipe) Side Panel /wall: MS 1 mm rib sheet with MS pipe support (2.5- 3-inch pipe) with windows covered mesh (for stone pelting proof) and slider window of fiber glass. Roof: Tarpaulin soft roof (length 10 feet, width 11 feet), roof mesh with MS angle 5mm, angle size 1.25inch, angle length 7.4 feet, angle width 6.6feet. mesh size 1.5 sq. Feet. Rear Door/Ramp: MS 2 mm with MS pipe reinforced (2.5-3-inch pipe) Mudguard: 1.6 mm with rubber flap Floor of the vehicle to have rails with locking system for facilitating movement of the cage from ramp to body while loading/ unloading. Door (4 feet) to open vertically as a ramp with rails fixed for loading and unloading the transport cage.
2.	Seating	Foldable seats with non-absorbent military grade padding(weatherproofed) should be fixed on both sides inside the vehicle. They should be folded to the body of the container conveniently. Dimension: sitting plank Length: 7ft, Width 1.5ft, Height 1.5ft Load bearing capacity: 600 KG

S. No	Detail of work	Specification
3.	Tool box	To be placed in the driver's cabin: • Automatic motorized air-pump • Mechanical Jack • Puncture repair kit • 3 pieces Double Open-End Spanner of Size (8x10, 13x16, 18x21 mm). • 1 piece Hexagonal Key 08. • 1 piece Screw Driver 806. • 1 piece Wheel Spanner 24x27 A/F. • 1 piece Tyre Lever (Chrome Plated).
4.	List of accessories to be installed in the vehicle	• First Aid Kit for humans. • Vehicle GPS Tracker with remote tracking option

Vehicle indicative sketch

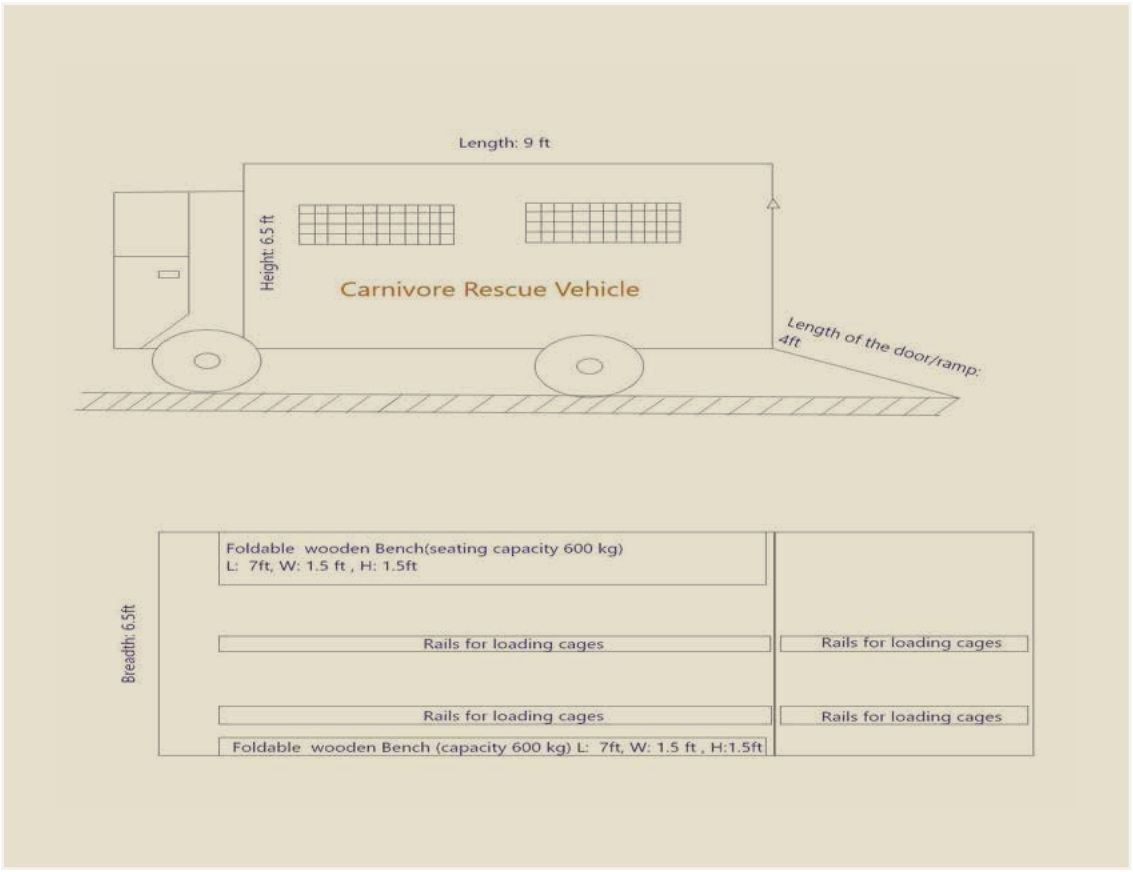


Figure 45: Indicative vehicle sketch

Watch this video Leopard Rescue Vehicle, Maharashtra Forest Department https://www.youtube.com/watch?v=c-g-IzePIVk

9. Tools and Techniques for HWC Mitigation: Tools and Techniques for HWC Mitigation: Animals Rescue Techniques

Animal capture and translocation have become specialised and well-organised procedures in wildlife conservation and management. Animal capture can be carried out using traps, nets, or snares (known as physical restraint) or by using chemical agents/drugs that are injected into the body to control wild animals (known as chemical restraint/ immobilisation).

3.1.10.1 Using physical restraints

Live-restraining traps are designed to capture an animal alive and unharmed. Simple procedures such as brief examinations, injections, or venipunctures can be carried out using physical restraints alone. Physical restraints are also used for small-sized animals in the wild that are difficult to chemically immobilize from a distance due to the small flank area.

- Setting up padded jaw traps

  Padded foothold traps have rubber pads on the jaws. Some foothold trap designs use offset jaws. The offset creates a space between the gripping surfaces when the jaws are closed. The offset ranges from 1/8 inch to 1/4 inch.

- Setting up snares

  Snares can also be used to capture problematic animals but they need to be monitored for extended periods to relieve animals immediately after they are trapped and to prevent strangulation.

- Setting up nets

  A variety of nets (mist nets, drive nets, projection or cannon nets, bait nets) can be used to capture aggressive or injured animals.

3.1.10.2 Chemical restraint

Chemical restraint is an animal restraint technique in which a drug or a chemical is used to restrict the movements (walking, running, aggression) of an animal or sometimes just to sedate or calm down the animal. When used correctly and with due precautions, chemical restraint is a safe and effective capture method. Chemical restraint is advantageous over physical capture because it allows animals caught in snares or traps laid in the wild by poachers to be examined and treated when they are sick or injured. Chemical restraint permits the restraining of selected animals within a group of animals, and the equipment required for chemical restraint is easy to transport from one place to another in the field. However, chemical capture has disadvantages, such as occasional failure of the equipment in the field, undesirable side effects of the drug in excited or diseased animals and improper darting of an animal due to occasional operators' mistakes. Further, the chemical capture method cannot be used for mass capture of animals of a group.

- Immobilising drugs and their reversal agents—A variety of drugs have been used for the chemical restraint of wild animals. As such, there is no perfect drug or anaesthetic that will suit a variety of animal species. However, the characteristics of an ideal drug may serve as a guide for evaluating available immobilising drugs. Due to import licensing restrictions in India, several immobilisation drugs are not available in the country. Therefore, an Indian veterinarian has the challenge of optimising the drug combination with the limited availability of drugs for use with wildlife.
- Drug delivery—Anaesthetic drugs are generally administered using remote darting systems with aluminium or plastic syringes called darts. The darts are fired from a distance using dart guns or blowpipes for administering immobilizing and tranquillising drugs intramuscularly into wild animals from a reasonable distance. Pole-syringes are used to inject animals that are in close proximity, such as animals in squeeze cages, crates, or passageways of crushes. The drugs can also be injected using ordinary syringes or other mechanical means after the animals have been captured in nets.

Various routes of drug administration:

» Oral—drugs can be mixed in water and food

» Hand-held syringes—Regular syringes, jab-sticks

» Remotely projected syringes or darts—blow-pipes, blow-guns, guns, pistols

- Tranquilisation guns—These are commercially available. The dart is similar to a blow-pipe but larger in size. Some dart guns have interchangeable barrels, and depending on the barrel diameter, darts of 2 ml, 3 ml, and 5 ml capacity can be used.
- Jab sticks—A jab stick is a modified syringe that allows the operator to keep away from an animal while injecting the drug. The stick has a syringe and needle attached. The drug is administered using pressure. Different types of jab-sticks, made of aluminium, plastic, or fiberglass, are available. An extendable jab-stick of length 4.5 m is preferred for delivering anaesthetics to captive animals or partially anaesthetized animals. Even repeated injections of desired doses can be injected using modern jab-sticks.

- Blow-pipe—The blow-pipe is the commonest dart projector. It is made of PVC or aluminium. The length of the blow-pipe tube is generally 1–2 m. It can propel a plastic dart of 5 ml capacity (maximum) over a short distance (10 m). It is mainly used for wild felids and for ungulates in captivity. The physiological results of delivering immobilisation drugs using darts depend on the dosage, the site of darting, the success of dart placement, and drug delivery in the muscle, as well as the physiological state of the animal prior to and during induction of anaesthesia. The key to success in anaesthesia and analgesia in wildlife is being flexible and adapting to changes.

Oral drug delivery—Immobilising drugs can be mixed in food or water as bait. However, it has limitations, especially in free-ranging animals: the bait may be consumed by non-targeted animals, an aggressive animal may consume more than the desired dose, or, if the drug gives an undesirable smell, the animal may reject the bait or regurgitate the food. This form of drug delivery can be used with a captive or trapped animals.

Topic	Links
Tranquillising Wild African Elephants	https://www.youtube.com/watch?v=oPlOfskfk2I

3.1.10.3 Use of *Koonkie* elephant in capture and Immobilisation:

Koonkie elephants are captive elephants which have been trained in certain basic skills that allow them to assist with the capture of wild elephants. This includes carrying the capture team to the wild elephant(s) that are targeted for capture, restraining the wild elephant, assisting in roping the wild elephant, being able to stand up to charging wild elephants, protecting the capture/roping team and driving away unwanted herd members that try to interfere with the capture. They are also being increasingly used to chase away wild elephants from agricultural areas to minimise human-elephant conflict.

In the past, during capture operations the task of *koonkies* was very complex and difficult. It involved restraining wild elephants while they were being roped (tied), moving them from the capture site to the training site without sedation and assisting with the training. While chemical immobilisation has made the capture and handling of wild elephants much easier, the role of *koonkies* in captures and training remains important. Providing protection during the capture operation, moving and loading the captured elephant into a truck for transport, supporting training, etc. are all activities that are made significantly easier when *koonkies* are available. Their use in driving operations has increased as wild elephants get increasingly used to the noise of people and firecrackers.

Figure 46: Elephant at Kodagu Elephant Camp in Karnataka

Characteristics of a *koonkie*: The very basic character of a *koonkie* is its ability to approach and work with a wild elephant that may be larger than itself and, in the case of a wild male elephant, in musth. Generally captive elephants will hesitate to approach a wild elephant that is larger than to handle larger wild elephants. The *koonkie* should also have the ability to learn complex tasks and execute them effectively when commanded. Generally, *koonkies* will allow people to work close to or even under them (during roping) during capture, roping, loading or driving operations. However, some *koonkies* that are very aggressive may not allow people to work close to them and may even attack people other than their mahouts. Such *koonkies* cannot be used in crowded places or used in roping operations where other people have to work close to them. They can be used for specific tasks, particularly dealing with aggressive wild elephants and other tasks that do not require people to be close to them. While certain external characteristics such as size and general behaviour may help identify an elephant as being suitable to be a *koonkie*, it is only training and exposure to wild elephants and testing that will help determine this.

Types of *koonkie* elephants: *Koonkies* play multiple roles, and hence, according to their temperaments, they can specialise in a few or all tasks. Female *koonkies* can be used to approach and dart or noose wild elephants or even tigers. Wild elephants are less likely to panic and run when approached by a strange elephant with a mix of human scent, especially, if the *koonkie* is a female. *Koonkies* are also used for restraining wild elephants and for training them. They are particularly important and useful when handling younger wild elephants. Size determines roles where strength and physical challenges are involved. Mild or non-aggressive *koonkies* are useful for loading and pushing operations as they are not likely to injure the captured wild elephant by attacking it instead of just pushing it. *Koonkies* that have mastered various restraining tasks are useful during roping operations. *Koonkies* that are agile and fast are useful for drive operations.

Role of *mahout:* First and foremost, the *mahout* should know elephants, their behaviour and his own role and responsibilities. The *mahout* plays a very important role and as both the elephant and the *mahout* have attitudes, temperaments, likes and dislikes. It is very important that the right combination of *mahout* and *koonkie* be brought about. The two should be compatible with each other and have a good working understanding between themselves. Some elephants will listen to only one person, to the point of attacking any other *mahout* who tries to command them. Other elephants may be less temperamental and will work with other *mahouts*. However, it is very important that *mahouts* who have developed working relationships with an elephants be retained as the *mahouts* of those elephants throughout their working lives. It is a very bad practice to change *mahouts* unless it is very essential, and it is an extremely bad practice to keep rotating *mahouts* at regular or frequent intervals as this not only results in them not being confident of their elephants but also not having adequate control. The elephants too become less tractable and less confident in such situations. Such changes are particularly dangerous when they involve aggressive *koonkies* or *koonkies* that are used in dangerous situations. Where a *mahout* has a very good working relation with the *koonkie* and the *koonkie* is well trained, there is very little use of commands, and most commands are primarily by means of touch (using the toes to guide the elephant by touching the back of its ear). And even the most aggressive *koonkie* will listen to its *mahout* and respond. Good *koonkies* and *mahouts* will work even when the *koonkie* (if it is male) is in full *musth*.

Training of *koonkies*: *Koonkies* are initially trained like all other captive elephants and are selected for *koonkie* work only through trial and error by exposing them to wild elephants over a period of time and mostly in combination with trained *koonkies*. Other than the regular training, special training for use as *koonkies* would involve handling of ropes, tactics and actions needed for restraining wild elephants (roped or otherwise), dragging, pulling and pushing captured elephants to move them to the loading site, loading, working with other *koonkies* in combined operations and working in close proximity with people who may be even under them for roping operations. Ideally, they also need to be given training in working in crowded and noisy areas as capture sites often generate such situations. The trainings should be repeated at regular intervals to ensure that they knows exactly what is expected of them. They should also be exposed to the noise of firecrackers and gunshots as these are often used when wild elephants become aggressive or charge at the capture or drive team.

Use of *koonkies*—dos and don'ts: *Koonkies*, other captive elephants and wild elephants are elephants, and hence their behaviour and responses to situations are best known to the people who deal with elephants, namely the *mahouts*. Regular members of the forest department staff who are in charge of elephant camps and officers in charge of the area may not know the finer differences between different captive elephants and *koonkies* or the field situation and the wild elephants operating there. Hence it is always important to let the *mahouts* decide on the best elephants needed for an operation as also the best approach to an operation in the field. These people generally will not speak up in the presence of even lower-level uniformed staff members unless explicitly asked. Often, rather than disagree, they may just nod their heads in deference to authority and get on with what has been asked. Such an approach will invariably result in a poor operation or even a disaster. It is therefore, important to build the decision and planning capacity of mahouts and then seek their advice on the operation before advising on the course of action to take.

- Never overwork *koonkies*: As *koonkies* are well trained and very good at working, there is often a tendency to use them for all the work in and around the camp. This could involve tourist rides, moving heavy equipment, etc. When using them as *koonkies* for driving operations in hot areas, especially those with poor habitats, make sure that the *koonkies* are rotated so that a single or a few *koonkies* are not overworked. Depending on the workload and the local habitat conditions, rotate the *koonkies* between the operational area camp and the main elephant camp on a regular basis.
- Regular training: While all elephants have good memories and remember commands, it is important that training in specialised tasks such as handling of ropes and working with people on the ground be carried out regularly as these are otherwise rarely used skills because capture operations do not take place regularly. Regular training hones the skills of a *koonkie* and the rapport with the *mahout*. It prevents the skills from growing rusty.
- Proper feeding: Since the effectiveness of *koonkies* is dependent on their size and strength to a large extent, it is critical that they be given adequate cooked food and allowed enough time to forage in a natural habitat. It is very important that cooked food be provided as this is easily digestible. Uncooked grains are difficult to digest as elephants have an inherently poor digestive system, and hence 50 per cent or more of uncooked food is generally not digested and goes waste in the dung.
- A regular camp for *koonkies* is critical and has to; be established at a site that is suitable for elephants. Such a camp, which is sometimes referred to as a "rest camp", allows the *koonkies* to rest and build their body condition. Such a camp needs to have a veterinary clinic attached to it, with a regular veterinary doctor attached to it. It is important not only to keep elephants in good health but also to have a good and experienced veterinary doctor with all facilities, as *koonkies* can be injured during operations.
- Handling *koonkies* in *musth*: Some well-trained *koonkies* can be handled when they are in *musth*. Despite this, it is important to remember that the high testosterone levels during *musth* will make the male aggressive and less responsive to commands. It is likely to attack people or the captured wild elephant or other captive elephants involved in the operation, and hence suitable precautions should be taken. Additionally, when more than one *koonkie* is in *musth*, even more care has to be taken as they may engage in fighting if they are not managed properly. The temperament of the individual elephants and their equations with other elephants (in and out of *musth*) need to be known before they are selected for operations. In this situation, it is crucial that the expertise of the *mahouts* is taken into account, and their recommendations should be considered.
- Pregnant *koonkies*: Females are generally used as decoys or to make a close approach for darting. Wild elephants will tend to run when approached by a male *koonkie*, and wild males may try and challenge it (particularly when they are in musth). Females in advanced pregnancy, particularly after one year of gestation, should not be used in operations.

Field operations

- Before the operation starts, it is important to survey the local area so as to have a good understanding of the human-use areas, the challenges crowds can pose, the terrain, water sources, dangerous points (railways/roads/wells), capture site, drive route, etc.
- Check that all safety measures for the deployment of the *koonkie* are taken care of. This involves getting information about the crowds, who is managing them, threats likely to arise when trying to capture or drive the wild elephant, threats from the *koonkies* to the crowds and the availability of an experienced veterinary doctor with the necessary equipment and a clear plan of action.
- Wild elephants are larger or stronger than the *koonkie* in many cases. Therefore, it is important that the *mahout* also intervenes by shouting and hitting the wild elephant with a stick if it engages the *koonkie*. The supporting staff, particularly the other *mahouts*, also need to intervene as a combination of *koonkie* and people will be more effective.
- Avoid carrying out the operation in the hot part of the day and ensure that the *koonkies* get rest during the operations. *Koonkies* in *musth* should not be used when it is very hot (at which time they would wish to stay in the shade). They should also not be made to do work such as pushing through the bush or weeds as they soon get tired of doing what they would normally not do and may disobey the commands.
- It is also important to have transport (trucks) to move the koonkies from one point to the other and avoid making them move long distances during operations.

10. References and Further Reading:

BBC Earth (29 July 2016)Tranquillising Wild African Elephants https://www.youtube.com/watch?v=oPlOfskfk2I

Bischof, R. et al. Estimating and forecasting spatial population dynamics of apex predators using transnational genetic monitoring. Proc. Natl. Acad. Sci. U. S. A. 117, 30531–30538 (2020).

Burnham, K.P., D.R. Anderson, and J. L. Laake. 1980. Estimation of density from line transect sampling of biological populations. Wildlife Monographs No. 72.

Bourgeois S, Kaden J, Senn H, Bunnefeld N, Jeffery KJ, Akomo-Okoue EF, et al. (2019) Improving cost-efficiency of faecal genotyping: new tools for elephant species. PLoS ONE 14(1): e0210811. https://doi.org/10.1371/journal. pone.0210811

Conservation India (23 June 2021) Monitoring Tigers And Their Prey https://www.youtube.com/watch?v=8TMdU5uh_e0

Chatterjee, N., Schuttler, S. G., Nigam, P. & Habib, B. Deciphering the rarity–detectability continuum: optimizing survey design for terrestrial mammalian community. Ecosphere 12, (2021).

Department of Energy, Environment and Climate Action,(21 Aug, 2015) Camera Trapping Wildlife Surveys, https://www.youtube.com/watch?v=d_CEEjupGT4

de la Torre, J. A. et al. There will be conflict – agricultural landscapes are prime, rather than marginal, habitats for Asian elephants. Anim. Conserv. (2021). doi:10.1111/acv.12668

eHowTech,(7 Dec,2012) How to Create Routes From Garmin Tracks : Garmin GPS,https://www.youtube.com/watch?v=9CPjzoitO40

Eco India(28 jun 2020), Scroll.in, At The Epicentre Of Human-Elephant Conflict In Karnataka, Mobile Alerts Are Saving Lives https://www.youtube.com/watch?v=Sb6nXWEasUg

GPSCity,(21 Oct,2011) Marking a Waypoint on the Garmin Etrex 30(Video) .Youtube, https://www.youtube.com/watch?v=apasD09xdPk

GoI (2012). National Training Policy of India 20

GIS & RS Solution (22 Aug 2021) How To Create Forest Area Map On Qgis

https://www.youtube.com/watch?v=Q4kmmtpR5hM

ITV(28 Aug, 2019) Setting Camera Trap https://www.youtube.com/watch?v=oLudNbo1R44

IOP Conf. Series: Earth and Environmental Science540 (2020) 012072 IOP Publishing doi:10.1088/1755-1315/540/1/012072

Kshettry, A., Vaidyanathan, S., Sukumar, R. & Athreya, V. Looking beyond protected areas: Identifying conservation compatible landscapes in agro-forest mosaics in north-eastern India. Glob. Ecol. Conserv. 22, e00905 (2020).

Kshettry, A., Vaidyanathan, S. & Athreya, V. Leopard in a tea-cup: A study of leopard habitat-use and human-leopard interactions in north-eastern India. PLoS One 12, (2017).

Kissling WD, Seijmonsbergen AC, Foppen RPB, Bouten W (2017) eEcoLiDAR, eScience infrastructure for ecological applications of LiDAR point clouds: reconstructing the 3D ecosystem structure for animals at regional to continental scales. https://doi.org/10.3897/rio.3.e14939

Learn GIS & R (29 APR 2021) Spatial Distribution Map Of Species https://www.youtube.com/watch?v=awawFzefPjM

Lewis, D. L. et al. Foraging ecology of black bears in urban environments: guidance for human-bear conflict mitigation.

Ecosphere 6, art141 (2015).

Lamichhane, B. R. et al. Spatio-temporal patterns of attacks on human and economic losses from wildlife in Chitwan National Park, Nepal. PLoS One 13, (2018).

Mongabay India (4 Oct,2022) How are drones used to reduce human-animal conflicts? https://www.youtube.com/watch?v=H1vi-OMdJc8

Madhuraj P.k, (20 Sept 2020) Prepare Study Area Map Easily lQGIS, https://www.youtube.com/watch?v=x-rNnlAiCFY

MacKenzie, D. I. Modeling the probability of resource use: The effect of, and dealing with, detecting a species imperfectly. J. Wildl. Manage. 70, 367–374 (2006).

Mfunda, I. M. & Røskaft, E. Wildlife or crop production: The dilemma of conservation and human livelihoods in Serengeti, Tanzania. Int. J. Biodivers. Sci. Ecosyst. Serv. Manag. 7, 39–49 (2011).

Ministry of Environment, Forest and Climate Change, 2023, National Human-Wildlife Conflict Mitigation Strategy and Action Plan of India, www.moef.gov.in, Govt. of India, Accessed 21 May 2023 https://moef.gov.in/wp-content/uploads/2022/01/National-Human-Wildlife-Conflict-Mitigation-Strategy-and-Action-Plan-of-India-2.pdf

Ministry of Environment, Forest and Climate Change, 2023, Supplementary Framework on Establishment and Capacity development of HWC Mitigation Response Teams: National Human-Wildlife Conflict Mitigation Strategy and Action Plan of India www.moef.gov.in, Govt. of India, Accessed 21 May 2023, https://moef.gov.in/wp-content/uploads/2022/01/National-Human-Wildlife-Conflict-Mitigation-Strategy-and-Action-Plan-of-India-2.pdf

MoEFCC (2017). The National Wildlife Action Plan of India (2017- 2035)

MoEFCC (2021). National Human-Wildlife Conflict Mitigation Strategy and Action Plan of India. 78 pp. Ministry of Environment, Forest and Climate Change Government of India, 2021

MoEFCC (2021b). Advisory to deal with Human Wildlife Conflicts, Ministry of Environment, Forest and Climate Change, Government of India

MoEFCC (2022). Guidelines on managing Human Wildlife conflict including damage to crops, Ministry of Environment, Forest and Climate Change, Government of India

MoEFCC (2023a). Guidelines for Human–Elephant Conflict Mitigation, Taking a Harmonious-Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682406350.pdf

MoEFCC (2023b). Guidelines for Human–Gaur Conflict Mitigation, Taking a Harmonious-Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682406426.pdf

MoEFCC (2023c). Guidelines for Human–Leopard Conflict Mitigation, Taking a Harmonious-Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682406668.pdf

MoEFCC (2023d). Guidelines for Human–Snake Conflict Mitigation, Taking a Harmonious-Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682406724.pdf

MoEFCC (2023e). Guidelines for Human–Crocodile Conflict Mitigation, Taking a Harmonious-Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682406786.pdf

MoEFCC (2023f). Guidelines for Human–Rhesus Macaque Conflict Mitigation, Taking a Harmonious-Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682406854.pdf

MoEFCC (2023g). Guidelines for Human–Wild Pig Conflict Mitigation, Taking a Harmonious-Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682406891.pdf

MoEFCC (2023h). Guidelines for Human–Bear Conflict Mitigation, Taking a Harmonious-Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682406931.pdf

MoEFCC (2023i). Guidelines for Human–BlueBull Conflict Mitigation, Taking a Harmonious-Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682406971.pdf

MoEFCC (2023j). Guidelines for Human-Blackbuck Conflict Mitigation, Taking a Harmonious-Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682407037.pdf

MoEFCC (2023k). Guidelines for Addressing Health Emergencies and Potential Health Risks Arising Out of Human-Wildlife Conflict Situations, Taking a One Health Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682407526.pdf

MoEFCC (2023l). Guidelines for Cooperation between the Forest and Media sector in India Towards effective communication on Human-Wildlife Conflict Mitigation Taking a Harmonious Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682407333.pdf

MoEFCC (2023n). Guidelines for Occupational Health and Safety in the Context of Human–Wildlife Conflict Mitigation Taking a Harmonious Coexistence Approach. Accessed on May 25, 2023 https://indo-germanbiodiversity.com/pdf/publication/publication25-04-2023-1682407397.pdf

National Tiger Conservation Authority(2023) Phase III Camera Trapping Protocol,https://ntca.gov.in/assets/uploads/Reports/AITM/Phase_III_CT%20Manual.pdf

Noble Reseach Institute (6 April,2016) Animal Tracking: Advanced And Emerging Technologies https://www.youtube.com/watch?v=THGhNrfbK_M

Plot based or quadrant sampling technique for vegetation ,2009, univerty of idhao , https://www.webpages.uidaho.edu/veg_measure/Modules/Lessons/Module%205%28Density%29/5_2_Plot-based_Techniques.htm

Pooley, S. et al. An interdisciplinary review of current and future approaches to improving human–predator relations. Conserv. Biol. 31, 513–523 (2017).

Rating ARK Gadgets(10 Dec, 2020) Best Night Vision Binoculars For Wildlife

<https://www.youtube.com/watch?v=IS8BVMu0kHE> <https://www.youtube.com/watch?v=Izvzy6bAG6o>

Royle, J. A., Nichols, J. D., Karanth, K. U. & Gopalaswamy, A. M. A hierarchical model for estimating density in camera-trap studies. 118–127 (2009). doi:10.1111/j.1365-2664.2007.0

Reilly, Derek,MacKay, Bonnie,2013/08/27;35,44, Annotating ecology: looking to biological fieldwork for mobile spatial annotation workflows, https;//do.orgi - 10.1145/2493190.2493245

Sanva Motors, (30 aud,2015) Govt. of Maharashtra, Leopard Rescue Vehicle, Maharashtra Forest Department https://www.youtube.com/watch?v=c-g-IzePIVk

TrackMaps(11 Oct 2017) How to transfer a track from your Garmin GPS unit to Garmin BaseCamp,(Video), https://www.youtube.com/watch?v=aqP0-WSIJi8

Teledyne FLIR(18 Sept 2017) Protecting and Herding Elephants with FLIR Thermal Drones - World Wild Life Fund, https://www.youtube.com/watch?v=_MKXMdQkNPI

Tarleton Student Chapter of The Wildlife Society(16 oct 2020) Wildlife Techniques Telemetry<https://www.youtube.com/watch?v=gXCrvnTilgI>

The Contour (22 July 2020) QGIS Part4 -How to create your first map in 15 mins https://www.youtube.com/watch?v=P_EZCMoLyeg

Universiteit Leiden,(6 June , 2018) Field Work With Camera Trap , https://www.youtube.com/watch?v=2Azv_L1aIBQ

Vidya, T. N. C., Prasad, D. & Ghosh, A. Individual Identification in Asian Elephants. 40, 3–17 (2014).

Wild Cat Science (9 Nov, 2020) Use Of Camera Traps For Assessing Wildlife Populations, https://www.youtube.com/

watch?v=MioiFTxqg-k

Wildlife ACT Conservation and Research(17 Apr,2014),www,wildlifeact.com https://www.wildlifeact.com/blog/gps-and-vhf-tracking-collars-used-for-wildlife-monitoring

WILDECO Explorers (21 Jun 2021) A Story Of Elesense || How To Mitigate Human-Elephant Conflict https://www.youtube.com/watch?v=EXJ_y2eCegE

WILDECO Explorers (21 Jun 2021) Innovative Wildlife Fencing || How To Make Effective Low Cost Community Based Wildlife Fencing ||, https://www.youtube.com/watch?v=IiN6pHUsYMk

Webber, a. D., Hill, C. M. & Reynolds, V. Assessing the failure of a community-based human-wildlife conflict mitigation project in Budongo Forest Reserve, Uganda. Oryx 41, 177 (2007).

Whitakar, Whitaker 2008, Crocodile exclusion enclosure, Australia city and town journal 2007.

https://indo-germanbiodiversity.com/training-materials.html

Directorate of Forest Education
Ministry of Environment, Forest and Climate Change, Government of India

DFS

DW Akademie
Made for minds.

ICAR

नार्म
naarm