Conflict Tiger Management Guidelines for the Sundarbans



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ABBREVIATIONS USED IN THE TEXT

BFD	Bangladesh Forest Department
CMC	Co-Management Committee
CPG	Community Patrol Group
ETRT	Emergency Tiger Response Team
FTRT	Forest Tiger Response Team
HTC	Human Tiger Conflict
NGO	Non-governmental Organisation
SRF	Sundarbans Reserve Forest
VTRT	Village Tiger Response Team

EXECUTIVE SUMMARY

The Bangladesh Sundarbans is one of the most conflicted tiger habitats in the world. Human tiger conflict (HTC) is a common phenomenon where tigers persist resulting in deaths and injuries of both people and tigers, as well as livestock losses. Such incidents have led to negative attitudes towards tigers among local communities, making the implementation of tiger conservation actions challenging. With respect to the objectives and strategic actions of Bangladesh Tiger Action Plans (2009-2017 and 2018-2027), it is necessary to determine the response steps and improve coordination among actors for better quality and speedier responses in real-time HTC situations.

This manual provides a set of guiding principles and clear direction by clarifying roles and responsibilities across all actors for conflict management situations. The guiding principles are: In a conflict situation, (i) a human's life takes priority over a tiger's life, complying with existing legislation; and (ii) a tiger's life takes priority over a livestock animal's life; (iii) the level of conflict will remain at a minimum level; (iv) conflict management aims to reduce further human suffering; and (v) tiger suffering; and (vi) successful conflict management requires the positive participation of all actors.

To provide clear direction and processes for managing conflict situation, the guidelines define conflict tigers based on certain criteria such as whether: (i) the tiger has killed two or more people inside the forest; (ii) the tiger has injured or killed one or more people inside the village as a result of an unprovoked attack; (iii) the tiger has injured or killed two or more livestock inside a village; and (iv) the tiger has entered into a village on two or more occasions. In addition, the manual provides systematic diagrams that clarify roles and responsibilities of all actors in each step of managing conflict situations, following the guiding principles and possible scenarios based on field experience. While the set processes can be adjusted to suit unique situations, the guiding principles must be followed, with clear justification for adjusting process communicated and agreed by the involved parties.

The manual also highlights potential challenges and provides recommendations for improving the knowledge base to better manage HTC and other emerging situations like climate change and disasters. Overall, the manual aims to improve the quality and speed of responses to real-time HTC situations by clarifying response steps for all actors, promote tiger conservation, and reduce negative attitudes towards it.

1. INTRODUCTION

The coexistence of tigers and humans has a long-standing history (Bhattarai 2009), with human tiger conflict (HTC) being a common phenomenon in areas where tigers persist (Schwerdtner and Bernd 2007, Bhattarai 2009). The Sundarbans (Fig. 1), a naturally occurring continuous mangrove forest in the Ganges-Brahmaputra delta, is a prime example of this, with a particularly high level of HTC in the region (Barlow 2009). Spanning over 10,263 km^2, the Sundarbans is the largest continuous mangrove forest in the world distributed across Bangladesh and India. The Sundarbans Reserve Forest (SRF) of Bangladesh covers approximately 6,017 km^2, constituting nearly half of Bangladesh's remaining natural forest. While there is no permanent human habitation inside the SRF, about 2 million people live alongside the SRF in 8 sub-districts (upazilas), with most villagers from the 76 border villages directly relying on the SRF's natural resources, such as fish, crabs, and honey, for their livelihood (Dhar 2011, Inskip *et al*. 2013).

Due to the dependency of local communities on SRF resources, and the close proximity of villages to the SRF, HTC is the major issue for tiger conservation in this landscape (Fig. 1). Every year in the region approximately 50 people, 60-80 livestock, and 1-3 tigers are either injured or killed as a consequence of HTC (Rahman *et al*. 2009, Barlow *et al*. 2013). These incidences have reduced to a very low level in recent times (Fig. 2). However, any loss of human life and livestock can have a devastating impact, both emotionally and economically, on the affected family. The impact of HTC leads to negative attitudes towards tigers within local communities and thus makes the implementation of tiger conservation actions challenging (Löe and Röskaft 2004, Goodrich 2010, Goodrich *et al*. 2011).

The Bangladesh Forest Department (BFD) formulated the Bangladesh Tiger Action Plan (BTAP), to outline conservation goals, objectives, and activities for 2009-2017 (Ahmad *et al*. 2009), this has since been updated for the subsequent 10 years (Khan *et al*. 2018). One of the BTAP objectives is to minimize human tiger conflict, with an associated strategic action to develop HTC mitigation activities and supporting protocols to reduce tiger, human, and livestock killings (Ahmad *et al*. 2009). With respect to the BTAP's objectives and strategic actions, it is necessary to dramatically improve the quality and speed of response to deal with real-time tiger incidents. Increasing the efficiency and speed of responses in real-time HTC situations can be achieved by determining the response steps (Figs. 3 and 4) and improving coordination amongst actors (Box 1) by clarifying, agreeing, and communicating roles and responsibilities.

Box 1. Actors for managing HTC situations:

- Bangladesh Forest Department (BFD)
- Community Patrol Group (CPG)
- Co-Management Committee (CMC)
- Village Tiger Response Team (VTRT)
- Forest Tiger Response Team (FTRT)
- Emergency Tiger Response Team (ETRT)
- Local community members
- NGO staff

The objective of this document is, therefore, to provide:

- A set of guiding principles to give overall direction across all actors in all conflict management situations.
- A set of processes for managing each type of conflict incident.
- Clear direction regarding roles and responsibilities for conflict tiger situations.

This document does not include technical details on first aid for human injuries caused by tigers, tiger capture, immobilization, collaring, or euthanasia. Neither does this document cover the other aspects of HTC management such as compensation support, medical assistance, livelihood support, or preventative measures such as awareness activities, work safety knowledge, and livestock management.

The guidelines outlined in this document are based on existing knowledge and can be updated periodically to reflect changes in the knowledge base and management approaches.

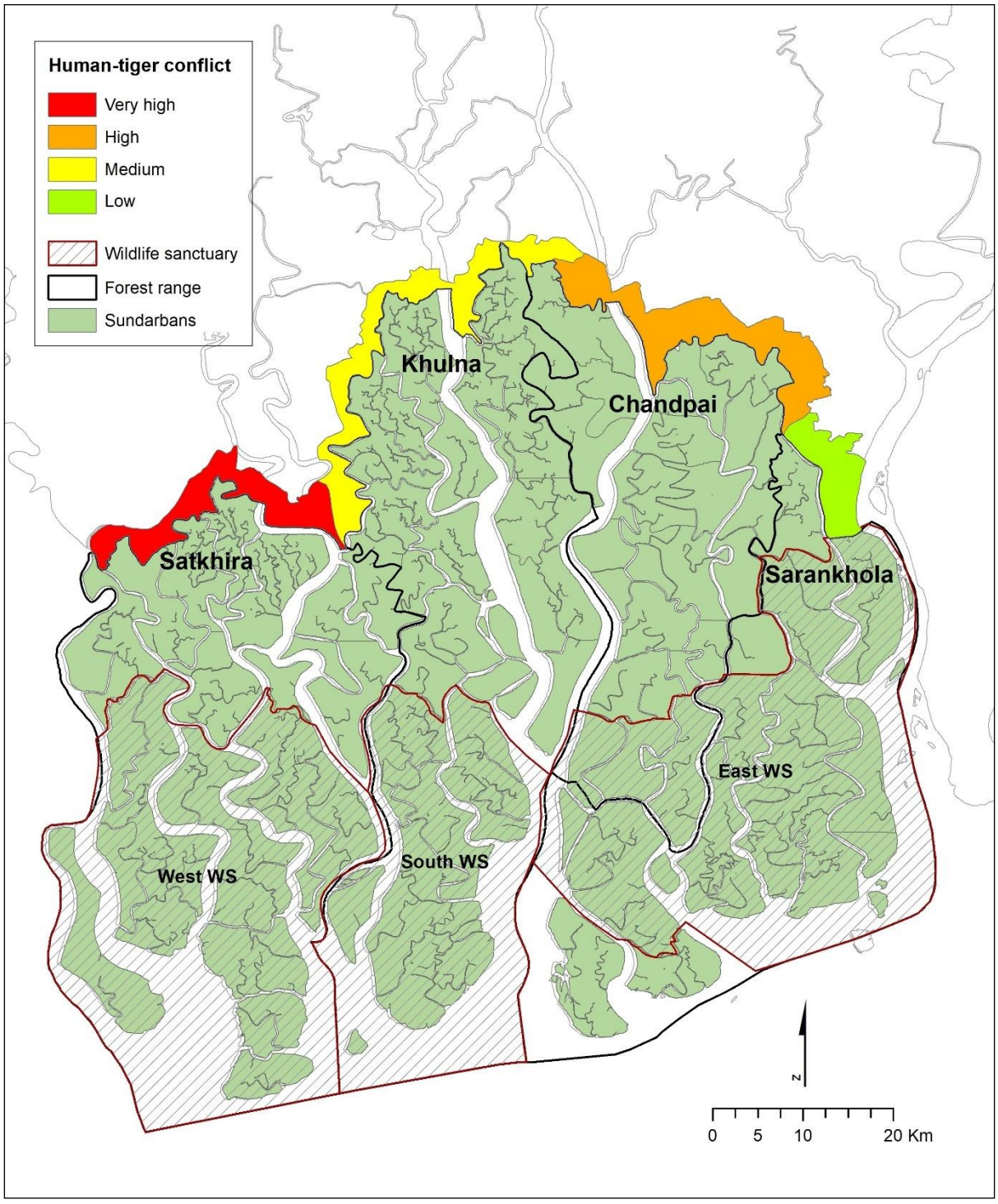


Figure 1. Levels of HTC around the Sundarbans (data recorded 2008-2022 by WildTeam).

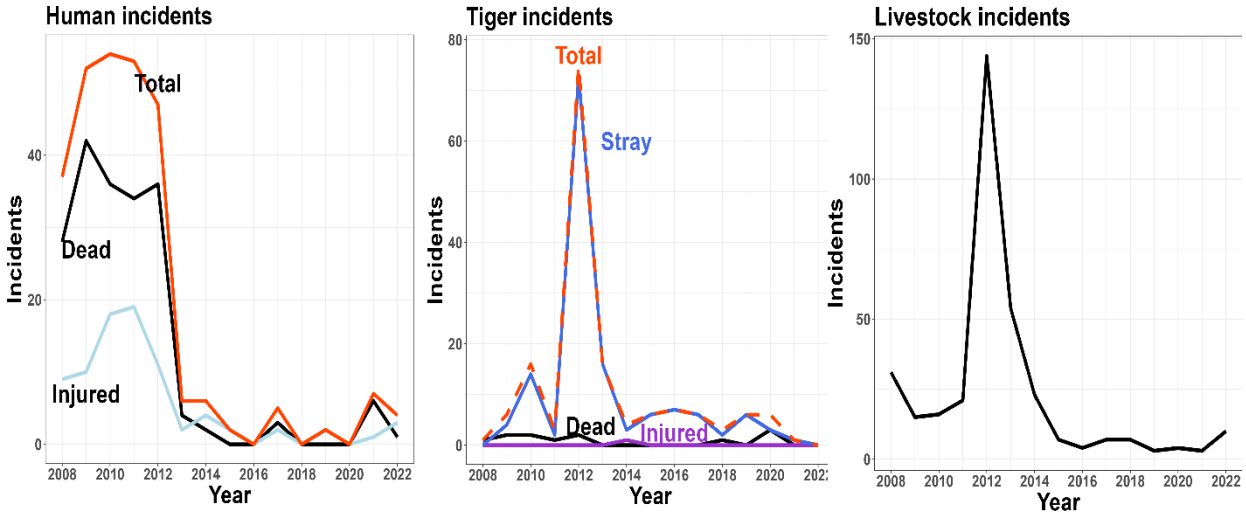


Figure 2. HTC related incidents around the Sundarbans (data recorded 2008-2022 by WildTeam).

2. GUIDING PRINCIPLES

These principles underpin all conflict management activities. They also provide guidance in new scenarios that might arise, and which are not included in the decision trees in this document. The guiding principles are outlined in Box 2.

Box 2. Guiding principles for conflict management activities.

- **A human's life takes priority over a tiger's life in a conflict situation:** However, actions must comply with existing legislation such as the Wildlife Act.
- **A tiger's life takes priority over a livestock animal's life in a conflict situation.**
- **Conflict management aims to reduce further human suffering:** For example, active management of the tiger must be started at the first opportunity to prevent further attacks on humans and to prevent the death of the tiger where possible. Delay in response costs human lives and tiger lives.
- **Conflict management aims to reduce tiger suffering**: Through the application of animal welfare practices and by starting active management of the tiger at the first opportunity to prevent the tiger from being killed or from being killed inhumanely.
- **Successful conflict management requires the positive participation of all actors:** This is necessary to ensure effective, collaborative conflict management between actors.



The first ever rescue of a female tiger from a village called Kadamtala of Satkhira range of Sundarbans on February 19, 2011. The tigress strayed into the village which was then successfully rescued and released back to the forest by the Forest Department and Village Tiger Response Team (VTRT).

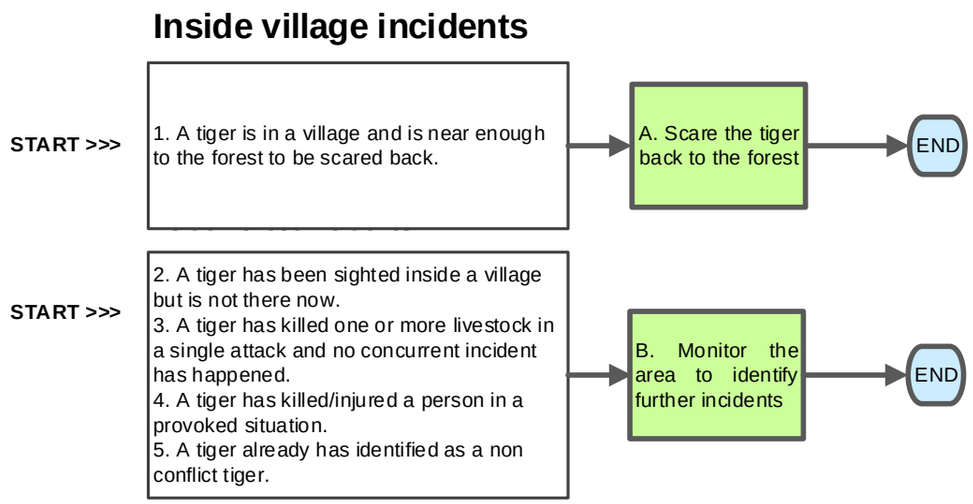
3. CONFLICT TIGER DEFINITION

A tiger is defined as a conflict tiger if it meets **any** of the below criteria:

- **The tiger has killed two or more people inside the forest:** Results of a study in the SRF suggest that approximately 50% of the tigers that kill people, kill only one person (Barlow 2009). It is possible that the tigers that only attack once are doing so as a result of a tiger protecting itself, its cubs, or its food. Alternatively, a tiger may kill a person opportunistically, rather than hunting humans (McDougal 1987). Whatever the reason, these tigers are not classed as "conflict tigers" as they may not reoffend, so there is no benefit from taking further action to manage them. If the tiger kills more than two humans inside the forest, however, then this may be an indication that the tiger is actively hunting humans and is likely to attack humans again, and therefore should be classified as a conflict tiger (Barlow *et al*. 2013).
- **The tiger has injured or killed one or more people inside the village as a result of an unprovoked attack:** Tigers that have injured or killed people inside the village in response to a crowd of people taunting the tiger or trying to harm it are not counted as a conflict tiger, because in this case the tiger is acting in self-defense. However, a tiger is classified as a conflict tiger if it has entered a village and injured or killed a person as a result of an unprovoked attack, because (considering the circumstances) it is likely that this tiger will attack again.
- **The tiger has injured or killed two or more livestock animals inside a village:** The threshold of killing two or more livestock animals is set to allow for the chance that the tiger that injures or kills one livestock animal may not continue to kill another. Once a tiger has killed two or more livestock animals, however, then that is an indication that the tiger is likely to attack again and can therefore be classed as a conflict tiger. The definition includes only livestock that are killed inside the village. If a tiger kills livestock that is inside the forest, then (a) the livestock is in the tiger's territory so the tiger cannot be blamed for killing the livestock and (b) the livestock should not be in the forest in the first place because livestock grazing is illegal.
- **The tiger has entered into a village on two or more occasions:** If the tiger has entered a village on two or more occasions it is classed as a conflict tiger because it is likely to continue to enter the village and possibly attack a human or livestock.

4. PROCESS FOR MANAGING TIGERS IN CONFLICT SITUATIONS

The following process diagrams outline the steps to follow for each type of tiger conflict incident that occurs either inside a village (Fig. 1) or inside the forest (Fig. 2).Indicative "time elapsed" has been included for some of the process steps.



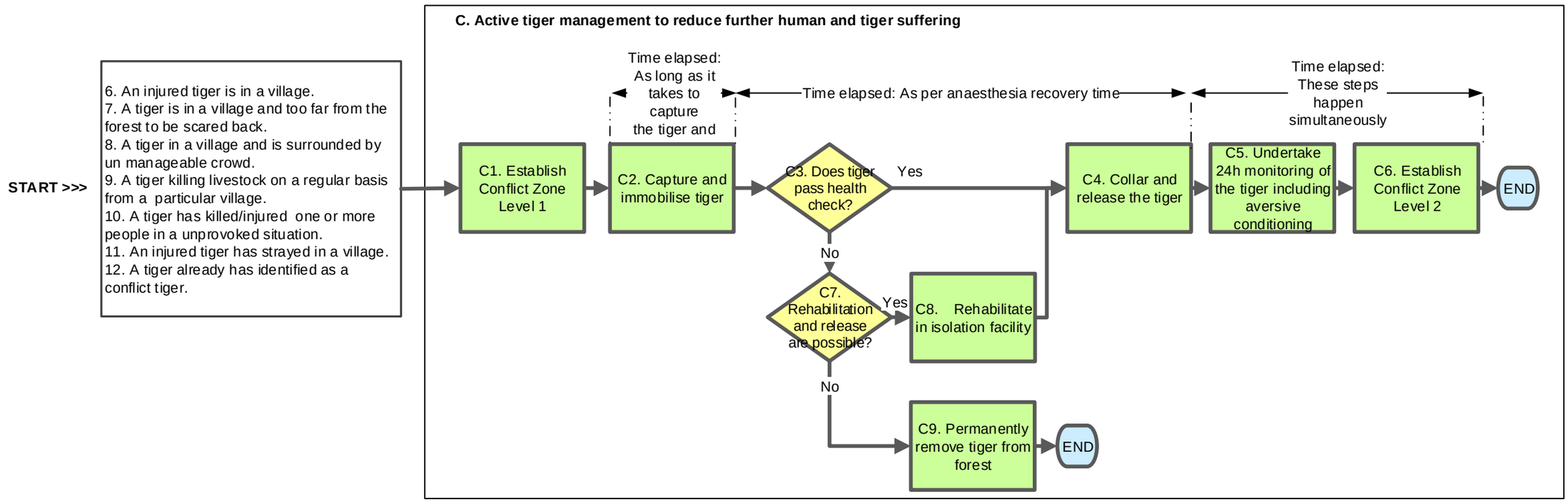


Figure 3. Process diagram for managing conflict tiger situations that occur inside a village.

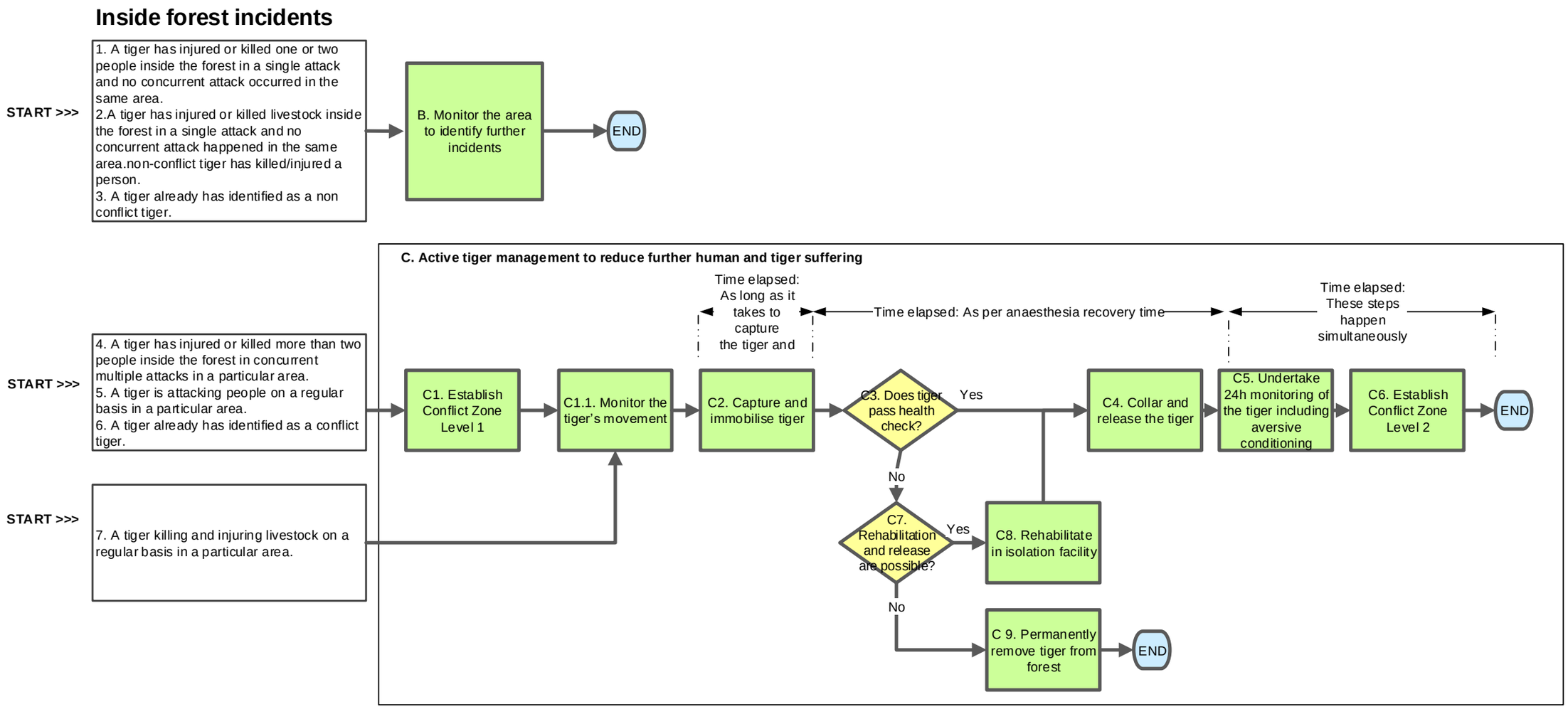


Figure 4. Process diagram for managing conflict tiger situations that occur inside the forest.

It is important to note, however, that there are many factors influencing each conflict tiger situation, so the process to be followed may sometimes need to be tailored to a specific situation as long as the guiding principles are still followed and there is clear justification for adjusting a process. So, a discussion would help to make people aware of this.

Additional information to explain each process step is as follows:

A. Scare the tiger back to the forest

This option is carried out if the tiger in the village is close enough to the forest to be scared back to the forest without causing danger to people and the tiger. Best practice is to keep the crowd well away from the tiger and to first clear the area between the tiger and the forest before trying to scare it back to the forest using hazing techniques. The roles and responsibilities for this option are listed in Table 1. If a tiger is too far from the forest or there are people in between the tiger and the forest, then scaring the tiger back to the forest becomes dangerous for humans and the tiger alike.

Table 1. Roles and responsibilities for scaring the tiger back to the forest

Designation	Responsibilities	Responsible actor
Crowd managers	Physically (but peacefully) keep the crowd at a safe distance from the tiger.	VTRT, CMC, local law enforcement agencies, BFD
Crowd communicator	Instruct the villagers to support the management action by dispersing from the crowd or keeping a safe distance away. Inform villagers about the situation and management response as they develop.	Local government (chairman and members)
Tiger scarers	Communicate with crowd managers. Scare the tiger back to the forest.	VTRT, CMC, BFD

B. Monitor the area to identify further incidents

If the tiger is not a conflict tiger, then there is no benefit in managing the tiger directly. Data from all incidents will be recorded in a central database and monitored to watch for patterns which could lead to the identification of a conflict tiger. The roles and responsibilities for this management option are listed in Table 2. See Appendix 1 for guidance about how to determine if two incidents belong to the same tiger or separate tigers.

Table 2. Roles and responsibilities for monitoring the area to identify further incidents

Designation	Responsibilities	Responsible actor
HTC data collectors	Record all HTC incidents	BFD, VTRT, CPG, Experts, Experienced NGO
HTC data managers	Collate, analyse, and report on HTC data	BFD, Experienced NGO, Experts

C1. Establish conflict zone level 1

This activity happens when intensive management of an area is required to prevent further loss of humans, livestock, and the tiger's life. This activity includes:

- Defining a "conflict zone" and setting rules to stop people from entering this zone at any time, day, or night (Box 3).
- Placing prominent markers to mark the boundaries of the zone, e.g., red flags on trees and on posts driven into the mud.
- Patrolling the "conflict zone" to communicate and enforce the rules preventing access.
- Dispatching a team to spread awareness among local people so that they know (a) that a conflict zone level 1 has been set up, (b) the whereabouts of the conflict zone, and (c) the rules restricting entry to that zone.

Box 3. Conflict zones

A conflict zone is defined as an area in which people are at risk of tiger attack both in forests and villages. The smallest administrative unit of the Sundarbans (compartment) can be declared as a conflict zone for in forest cases. For village cases the adjacent area of the village can be declared a conflict zone. Conflict zones are delineated in terms of compartments, with the number and location of compartments being determined by the distribution of conflict incidents. Compartments are chosen to delineate conflict zones because compartments are large enough to contain one or more tiger territories and are an already established administrative unit.

It is recommended that the conflict zone level 1 is maintained as such until the tiger has been captured or zero conflict incidents have occurred in the area for at least a month. The roles and responsibilities for this management option are listed in Table 3. See Appendix 2 for guidance about how to define a conflict zone.

Table 3. Roles and responsibilities for establishing conflict zone level 1

Designation	Responsibilities	Responsible actor
Conflict zone designator	Define conflict zone area on map with input from HTC monitoring team	Concerned Range Officer (ACF) of BFD
Conflict zone managers	Place physical markers along boundary of conflict zone. Patrol conflict zone and enforce conflict zone rules. Communicate zone area and rules to community and local Forest Department staff.	BFD staff, FTRT, CPG

C 1.1 Monitor the tiger's movements

This action will involve camera trapping to track the tiger's movements and collect ancillary information on the tiger's body condition. Information obtained from this step will help support future actions involving capture and immobilization of the tiger.

The roles and responsibilities for this management option are listed in Table 4.

Table 4. Roles and responsibilities for monitoring the tiger's movement

Designation	Responsibilities	Responsible actor
Tiger monitoring team	Track the tiger's movements and behaviour	BFD officers and staff, Experienced NGO (if any), VTRT, CPG, experts (if any)

C2. Capture and immobilize tiger

For technical guidance on how to capture and immobilize a tiger see the associated *Wild tiger capture and immobilization* manual (Lewis *et al*. 2012). The roles and responsibilities for this management option are listed in Table 5.

Table 5. Roles and responsibilities for tiger immobilisation and relocation

Designation	Responsibilities	Responsible actor
Tiger capture team	Immobilise and capture the tiger	Emergency Tiger Response Team (ETRT)

C3. Does the tiger pass health check?

This step involves a thorough examination of the tiger in order to ascertain the best course of action e.g., if the tiger is fit enough for immediate release, requires rehabilitation or permanent removal from the wild. The examination should be carried out by experienced wildlife veterinarians and/or trained wildlife biologists (Goodrich 2010).

If the tiger meets any of the following criteria, then it should be considered unfit for release:

- **Has impaired physical condition:** The tiger is badly injured, lost its eyes, emaciated, dehydrated, diseased, or otherwise too old to survive (catch prey) on its own.
- **Is showing dangerous behaviour:** The tiger is continuously coming back to villages or attacking people inside the forest despite all attempts to prevent it from doing so.

If the tiger is found to be unfit for release, then it cannot be immediately released back into the forest because the tiger:

- Will suffer (be in considerable pain) due to its bad physical condition
- Will suffer (through starvation) due to an inability to hunt
- May re-enter a village and be killed by a crowd of villagers, or attack villagers and livestock
- May be killed covertly by villagers e.g., by poisoning
- May spread any disease to other tigers in the population (CITES 1997, IUCN 2000)

Box 4. Implications of a lactating tigress

A lactating tigress implies that she has dependent cubs living in the forest somewhere. Cubs are reliant on their mother's milk from birth until the cubs are about 6 months of age (Sunquist and Sunquis 2002). During the lactation period, cubs are unable to source their own food and will die without their mother's milk. Therefore, any decision regarding what to do with the tigress must take into account the presence of her cubs and their inability to survive in the forest on their own without her.

If a tiger is lactating (and therefore has dependent cubs living somewhere in the forest) (Box 4) and fails a health-check, then it will still not be released because the tiger will in any case not be fit enough to provide food for itself or its cubs. However, in this situation (or if a lactating tigress has otherwise been killed) then an attempt should be made to capture the cubs (Box 5), but only if there are rehabilitation or safari/zoo facilities available that meet international standards for animal welfare.

Box 5. Locating cubs

Locating cubs is a difficult and potentially dangerous exercise. However, locating cubs can be attempted by either:

- Tracking the female tiger's secondary signs (pugmarks) back into the forest to see if that leads to the cubs.
- Searching for cub tracks by boat or on foot within the area close to where the tigress was captured.

Any efforts to locate cubs should be stopped after 5 days, because after that time the cubs are likely to have died. It is also very important to ensure that cubs not associated with the captured tigress are captured by mistake.

The roles and responsibilities for this management option are listed in Table 6.

Table 6. Roles and responsibilities for checking the health of tiger

Designation	Responsibilities	Responsible actor
Tiger health assessor	Conduct health check to determine if the tiger is fit or not for release	Wildlife vet or experienced wildlife biologist from the BFD or Experienced NGO and experts (if any)
Tiger release authority	Provide authorisation to release or not release a tiger based on the assessment of the tiger health assessor	BFD

C4. Radio or satellite collar and release the tiger

Collar the tiger if it is not already collared. If the tiger is already collared, then take the opportunity to check the condition of the collar and make any adjustments/replace the battery if needed. See Appendix 5 to understand the considerations regarding fitting tigers with radio or satellite collars.

There are two options for release:

- **For tigers which are believed to be territory holders:** Release the tiger within or as near as possible to the area believed to be its territory. This is because tigers are territorial and there are tigers all over the SRF. This means that there is likely to be little or no available/empty territories in the forest. Therefore, if a tiger is released at location far away from where it was captured, then it will likely meet with the territory holder of that other area and be injured or killed through fighting or leave that area to return to its own territory.

If at some point in the future, a tiger population survey indicates areas that are empty of tigers or have a skewed sex ratio, this will likely be due to a threat such as tiger poaching, prey poaching, or habitat destruction. Therefore, a tiger should not be released in an empty area because it will likely meet with the same threats and therefore the same fate as the previous occupant (IUCN 1987). This has happened with tigers in other countries e.g., Russia (Goodrich and Miquelle 2005).

- **For tigers which are believed to be transient animals:** Release in another area of the forest far away from human habitation.
- **For tigers which are believed to be cubs or juveniles:** Release these tigers very close to the capture site as they are dependent on their mother providing them with food to survive.

The roles and responsibilities for this management option are listed in Table 7.

Table 7. Roles and responsibilities for collaring and releasing the tiger

Designation	Responsibilities	Responsible actor
Tiger collar fitter	Fit collar	Wildlife vet or experienced wildlife biologist from BFD or experienced NGO and experts
Tiger collaring authority	Provide authorisation to collar the tiger	BFD

C5. Continuous monitoring of the collared tiger including aversive conditioning

A team should track the tiger's movements for 24-hours per day. If the team observes that the tiger is approaching people/a village area, then the team will then use hazing techniques to scare the tiger back to the forest to ensure human and tiger safety. Also, this monitoring will help enable the forest resource users to avoid the tiger's location. See Appendix 3 for more on hazing techniques.

It is important to note that 24-hour monitoring of the collared tiger does not remove the risk of further attacks. There are factors out of the control of managers including: the high human population adjacent to the forest, the ease of access to the forest, the high number of forest users, and that individual tiger might be unresponsive to aversive conditioning. The roles and responsibilities for this management option are listed in Table 8.

Table 8. Roles and responsibilities for 24-hour monitoring of the collared tiger

Designation	Responsibilities	Responsible actor
Tiger monitoring team	Monitor tiger's movements. Warn forest users of tiger's location. Haze tiger if it threatens to enter a village or attack a forest user.	Experienced wildlife biologist and field staff from the BFD or experienced NGO and ETRT/VTRT/CPG

C6.Establish Conflict Zone Level 2

This activity happens when the conflict tiger has been collared and released back into the area. The tiger is now being monitored 24-hours per day, so the risk of attack is reduced, but the tiger is still present in the area, so people must remain alert. Within a conflict zone level 2 the following rules apply:

- People can only enter in their boats and are not allowed to set foot on land
- People must not enter the conflict zone unless absolutely necessary
- Entry is only allowed during daylight
- People can only enter as part of a group

Managing the conflict zone level 2 includes the following:

- Defining and delineating the conflict zone
- Patrolling the conflict zone to enforce the rules
- Communicating with the local villagers and authorities to ensure there is awareness of the conflict zone level 2 rules and activities

It is recommended that the conflict zone level 2 is maintained for the duration of the life of the collared tiger. The roles and responsibilities for this management option are listed in Table 9.

Table 9. Roles and responsibilities for establishing conflict zone 2

Designation	Responsibilities	Responsible actor
Conflict zone designator	Define conflict zone area on map with input from HTC monitoring team	Range Officer (ACF) of BFD
Conflict zone managers	Place physical markers along boundary of conflict zone Patrol conflict zone and enforce conflict zone rules Communicate zone area and rules to community and local Forest Department staff	Local BFD staff, CPG/ FTRT

C7. Rehabilitation and release are possible?

In order for rehabilitation to be possible, the following three factors must be met:

- **A tiger isolation and rehabilitation facility of international standards is available in the SRF:** The tiger isolation and rehabilitation facility must meet the criteria outlined in Appendix 4.
- **The tiger's condition is treatable:** Some animals which are in bad physical condition may be unlikely to survive in their present state if left untreated, but they might have a good chance of recovery to hunting fitness if they are treated at a tiger isolation and rehabilitation facility (Goodrich *et al*. 2001).
- **It is possible to collar and monitor the tiger after release:** The tiger can only be released if post-release monitoring is guaranteed (IUCN 1995). For tigers, this is done by fitting them with a collar and monitoring for 24-hours a day, 7 days a week. If there is insufficient manpower and equipment to collar and monitor the tiger, then the tiger cannot be released

as it will be a risk to people and to the tiger itself. In this case go to step *C9, permanently remove the tiger from the forest*. An injured tiger that is not identified as a conflict tiger can be released after successful rehabilitation without collaring.

The roles and responsibilities for this management option are listed in Table 10.

Table 10. Roles and responsibilities for rehabilitating and releasing tiger

Designation	Responsibilities	Responsible actor
Tiger rehabilitation authority	Provide authorisation to rehabilitate the tiger	BFD (including experienced wildlife vet)

C8. Rehabilitate in isolation facility

In this step, the tiger is rehabilitated in the tiger isolation and rehabilitation facility which meets the criteria outlined in Appendix 4. The tiger is deemed ready for release once it has been restored to hunting fitness. Hunting fitness can be defined as the capacity and behaviour to collect or hunt food or prey from nature. The roles and responsibilities for this management option are listed in Table 11.

Table 11. Roles and responsibilities for rehabilitating tiger in isolation facility

Designation	Responsibilities	Responsible actor
Tiger isolation and rehabilitation facility managers	Isolate, treat, and rehabilitate the tiger until it is fit for release	BFD (including experienced wildlife vet)
Tiger release authority	Provide authorisation to release the tiger	BFD (including experienced wildlife vet)

C9. Permanently remove tiger from forest

This step is reached if earlier steps have confirmed that the tiger cannot be released because there is a high risk that the tiger may:

- Attack humans
- Suffer due to its bad physical condition and inability to hunt
- Be killed by villagers
- Not be able to be rehabilitated

Therefore, there is no choice but to remove the tiger from the forest permanently. The options available for permanent removal are:

- **Keep the tiger in a safari park or zoo that meets international animal welfare standards.**
- **Mercy killing**: Also known as euthanasia, the options for euthanasia have been described in the *Wild tiger capture and immobilisation manual* (Lewis *et al*. 2012) and as per article 8(1) of Wildlife (Conservation and Security) Act, 2012. For details see Appendix 6.

The roles and responsibilities for this management option are listed in Table 12.

Table 12. Roles and responsibilities for permanently removing tiger from forest

Designation	Responsibilities	Responsible actor
Tiger removal to safari park or zoo authority	Provide authorisation for removing the tiger to a safari park or zoo	BFD
Tiger removal team	Removing the tiger to a safari park or zoo	BFD (including experienced wildlife vet), Experienced NGO, wildlife vet, VTRT
Tiger euthanasia authority	Provide authorisation for euthanizing the tiger	BFD
Tiger euthanasia specialist	Euthanize the tiger	BFD (including experienced wildlife vet)



A female tiger was successfully rescued from the village Angtihara of Khulna range of Sundarbans on January 14, 2012, by Bangladesh Forest Department, Village Tiger Response Team (VTRT) and Forest Tiger Response Team (FTRT).

5. KEY CHALLENGES AND RECOMMENDATIONS

Efficient management of human tiger conflict (HTC) situations requires effective and timely coordination among parties (Box 1) with varying roles in managing the situation. Bangladesh Forest Department (BFD), as the legal guardian managing the forest and its resources, should be leading the process in a HTC situation, together with other relevant parties. However, BFD is suffering from inadequate finance and lack of skilled manpower, or access to modern technologies and equipment for tackling current and future novel problems.

Novel problems due to climate change may have widespread impacts on wildlife, ecosystem functionality, and human livelihoods through changes in temperature and precipitation regimes, changes in seasonality, increased salinity, sedimentation, and sea-level rise (Ghimire & Vikas 2012). Disasters like cyclones and unusual tidal surges may cause injuries or death of tigers and their prey species. It is imperative to prepare our existing and next generation manpower with the advanced analytical skills for better management of our resources and to tackle novel problems.

To overcome the above key challenges, the following steps should be taken:

- Establish a specialised team under the Wildlife Management and Nature Conservation Division, Khulna. The team should consist of trained vets and compounders who can provide vital support during HTC situations.
- Develop a workflow within each field-based range team of the BFD and assign a key person to collaborate with other stakeholders to manage and respond to HTC situations.
- Training on how to mitigate the human-wildlife conflict be arranged for the four range-based teams.
- Acquire analytical capabilities to remove dependency on commercial software by using free open-source programming languages such as R and Python. Enhance skills for government staff, NGOs, community supporters, and future generations through quantitative training sessions from people who have received higher degrees from overseas and are experts in the field. The same approach can be taken to up-skill for climate change analyses.
- A wildlife rehabilitation centre be built for wildlife in the Sundarbans.
- Establish a framework of systematic documentation of HTC management for future use in computational analyses.
- Strengthen SMART Patrolling for law enforcement as well as monitoring wildlife species including tigers and their prey species.
- Promote co-management activities and conduct awareness programs.
- Involve and coordinate actions with community members, development partners, local NGOs, and relevant stakeholders.

The heavy dependence of local communities on forest resources has created a situation where human-tiger-conflict (HTC) continues to persist in the Sundarbans. As long as people rely on the forest for their livelihoods and essential needs, the risk of encountering tigers and conflicts between humans and wildlife remains. To address this issue, it is crucial to prioritise the creation of alternative livelihood opportunities for the communities living around the Sundarbans. By offering alternative sources of income and livelihood options, such as sustainable agriculture, eco-tourism, or skill development programs, pressure on the forest's resources can be reduced.

6. APPENDICES

Appendix 1. Guidelines to support managers in determining if incidents belong to the same tiger or more than one tiger

It is difficult to be 100% certain that multiple incidents (human or livestock attacks) belong to the same tiger without clear evidence, for example, photographic evidence confirming matching stripe patterns. However, for management purposes, in order to prevent loss of human, livestock, and tiger life, it is necessary to deduce if multiple incidents are attributable to one or multiple tigers. This deduction needs to consider the following:

For a territory holder, if the second incident happens within an area that matches the size of a territory, then a reasonable assumption would be that it is the same tiger carrying out the attacks. However, when a tiger attacks it is usually unclear as to whether the tiger is female or male, so to be conservative, the larger territory size of the male tiger instead of the female tiger can be used i.e., 32km^2 (Table 13). Likewise, territory holders can live for several years, and, because of the high numbers of forest resource users and livestock, these tigers will have multiple opportunities to attack humans or livestock. Therefore, if a second tiger attack incident occurs within a 32 km^2 area within a 6-month period it seems reasonable to assume that both incidents are attributable to the same tiger. If the incidents occur within the 32 km^2 area but more than 6 months apart, then it is reasonable to assume that the incidents are attributable to more than one tiger.

However, transient tigers may move over larger distances because they are not restricted to a territory that they are defending. If incidents are being carried out by a transient, therefore, it is more difficult to deduce that the incidents are attributable to the same tiger. An inspection of the pattern (location and time) of incidents is required to determine if there is a reasonable chance that the incidents are attributable to the same tiger. For example, multiple incidents may start to form a pattern which shows a possible transient tiger moving along the forest village boundary in a certain direction.

Finally, considering that tigers in the SRF probably move a maximum of about 11.3 km in 24 hrs (and probably a lot less) (Barlow 2009), then it may be possible to use the time and distance between incidents to deduce if it is possible or not that those incidents could have been carried out by the same tiger.

Table 13. Available tiger territory size and daily movement data for Sundarbans tigers

Type of tiger	Sundarbans data
Territorial female	The mean distance moved is 3.6 km/day within its territory, with a maximum of 11.3 km/day for one tiger and 10 km/day for a second tiger. A mean female territory size is 14.2 km^2 (Barlow 2009, Barlow *et al*. 2011).
Territorial male	There is no data available for male territory sizes in the SRF. So, for the time being, male: female ratio data available from Nepal (Smith and McDougal 1991) can be used to calculate a male territory size. In Nepal the ratio is 1 male: 2.25 females (Smith and McDougal 1991). Using the mean female territory size of 14.2 km^2 from the SRF (Barlow 2009, Barlow *et al*. 2011) and the Nepal ratio gives a male territory size of 32 km^2.
Young female transient	No data
Young male transient	No data
Old female transient	No data
Old male transient	No data

Appendix 2. Guidelines for definition of a conflict zone

The smallest administrative unit of the Sundarbans (compartment) can be declared as a conflict zone in forest cases and for village cases the adjacent compartment of the village can be declared a conflict zone.

A "conflict zone" is defined as an area in which people are at risk of tiger attack. We cannot be sure if a conflict tiger is a territory holder or a transient animal which makes it difficult to work out the area in which the tiger is operating i.e., the conflict zone. Nonetheless, managers still need to determine a conflict zone so that they know where to patrol.

- **For a tiger which is suspected to be a transient animal** - transient animals can move as many as 11km/day (Barlow 2009, Barlow *et al*. 2011) and in any direction.
- **For a tiger which is suspected to be a territory holder** - The territory size of a female Sundarbans tiger is between 12 and 40 km^2 (Barlow 2009). Therefore, it is estimated that the territory size of a male tiger is between 36 and 160 km^2 (Barlow *et al*. 2011) based on the knowledge that a male tiger includes three to four female tigers in his territory. We usually cannot usually be certain about the sex of the tiger, so we must be conservative and assume it is a male tiger in order to take the larger area.

Appendix 3. Hazing techniques

Hazing is a method of negative association that safely compels a tiger to move away from humans. These techniques can restore a tiger's natural avoidance of humans and minimise the interactions. The basic hazing techniques are:

- Stand tall, make yourself big, shout, move your hands
- Use air whistle, fire crackers
- Use water guns, color guns.

Do not run from the tiger as it may stimulate its hunt/chase mechanism.

Appendix 4. Guidelines for tiger isolation and rehabilitation

Creating isolation and rehabilitation facilities that meet best practice standards is necessary to increase the chance of achieving successful tiger re-introductions into the wild. Overall, the facilities need to provide for both the basic and higher needs of the tiger, including social, mental, physical, and emotional needs. The objective is, therefore, to create an interactive habitat that allows the tiger to live its life most closely aligned with a tiger's life in the wild (Forman *et al*. 2001) and that meets the 5 freedoms of animal welfare (Box 6). To achieve this objective the following minimum basic criteria should be met.

- The facility must meet international animal welfare standards.
- The facility should be located within the SRF and as far away as possible from human habitation or tourist spots to minimise the tiger's exposure to disturbances that may otherwise interfere with its rehabilitation and recovery.
- The rehabilitation enclosures will be as large as possible and contain natural wild habitat.
- The ratio of tiger to enclosure will be 1:1 to simulate the solitary existence of tigers in the wild.
- There will be solid concrete walls that are at least 4 m high so that the tigers are not disturbed by people or other tigers.
- There will be a one-metre internal wire mesh overhang extending at a 45-degrees angle from the boundary of the enclosure, along with at least one strand of electric wire.
- The facility will have large rehabilitation enclosures.
- Wildlife veterinarian(s) who are specially trained in wildlife veterinary medicine will be available at this facility to provide treatment as required for the duration of the tiger's stay.
- There will be a holding/treatment block placed separately from the rehabilitation enclosures. This will contain a room big enough for full anaesthesia and examination, and a small outside paddock.

In addition to the design of the facilities, best practice for care and handling of the tigers should be followed based on the below minimum criteria:

- The tiger should receive its initial check-up and treatment at the holding/treatment block.
- Once treated, the tiger should be shifted to the complete isolation of the rehabilitation enclosure for however long it takes for any wounds to heal and until the tiger is restored to hunting fitness and therefore ready for release.
- The tiger should not be kept for a long time in the facility. The tiger should be restored to hunting fitness by specialist veterinary treatment as quickly as possible and then released back into the wild.
- The only human contact should be from the wildlife veterinarian who will check on the tiger's condition and provide treatment as required.
- Food and water should be put in the enclosure discreetly, i.e., without direct human-tiger contact.
- No other contact between humans and the tiger should be permitted, because the more human contact the tiger experiences, the more likely it is to lose its fear of humans and reduce the chances of a successful release.

Box 6. The 5 freedoms of animal welfare:

1. Freedom from hunger or thirst by ready access to fresh water and a diet to maintain full health and vigour
2. Freedom from discomfort by providing an appropriate environment including shelter and a comfortable resting area
3. Freedom from pain, injury or disease by prevention or rapid diagnosis and treatment
4. Freedom to express (most) normal behaviour by providing sufficient space, proper facilities, and company of the animal's own kind
5. Freedom from fear and distress by ensuring conditions and treatment which avoid mental suffering

Not meeting all the above criteria is likely to result in:

- Mental and physical suffering to any tiger kept at the facility
- An increased chance of a tiger surviving after being released into the wild from the facility
- An increased chance of a tiger being involved in human tiger conflict incidents after its release

Information sources for the above guidelines include Forman *et al*. (2001), Goodrich *et al*. (2001), Goodrich and Miquelle (2005), and Sarah Christie, coordinator of managed conservation breeding programmes for tigers in European zoos & Manager of Tiger Zoo Programme in Russia (pers. comm.).

Appendix 5. Considerations regarding fitting tigers with radio or satellite collars

Fitting animals with radio or satellite collars to track the animal's movements is a common approach used by wildlife managers and scientists. Being able to follow a tiger's movements in real-time enables a monitoring team to anticipate and react to situations that may otherwise harm the tiger, humans, or livestock. Deciding to collar or not collar a tiger, however, requires consideration of the effects to both humans and the tigers.

Releasing a tiger without a satellite collar means that the tiger's location, movements, and behaviour cannot be monitored, which in turn may lead to:

- An increased chance of the tiger being poached
- An increased chance of the tiger straying into a village and being injured or killed by villagers
- An increased chance of the tiger attacking livestock or humans

Releasing a tiger with a satellite collar means that the tiger's location, movements, and behaviour can be monitored, which may lead to:

- A decreased chance of the tiger being poached
- If the tiger is poached, then there may be an increased chance of catching the poachers, which may result in saving tigers lives that would otherwise be lost should the poachers continue to be active
- A decreased chance of the tiger straying into a village and being injured or killed by villagers
- A decreased chance of the tiger attacking livestock or humans

Releasing a tiger with a satellite collar may also provide the following benefits:

- An improved understanding of conflict tiger behaviour/patterns, which may help to design more effective human tiger conflict management approaches
- Improved understanding of tiger resource needs
- Improved understanding of threats to tigers

To ensure the tiger's welfare needs are met and that it is able to fully express its natural behaviour in the wild, strict guidelines should be followed relating to the size and fitting of collars, and the related process for tiger immobilisation (Lewis *et al*. 2012). Likewise, the collaring should ensure adherence to the 5 freedoms of animal welfare (Box 6).

Appendix 6. Considerations regarding permanent removal of tigers

The two options for permanent removal of a tiger from the SRF are removal to a safari park/zoo and euthanasia. Selection of either option should ensure adherence to the 5 freedoms of animal welfare (Box 6), and the following considerations:

Permanent removal to a safari park/zoo:

- This should only be done if the facility in question meets international standards for animal care. Otherwise, the tiger is likely to be exposed to physical harm or mental stress.

Permanent removal by euthanasia:

- This option is always a last resort but may be necessary to ensure the tiger does not suffer undue physical or mental stress that it would otherwise be exposed to by being housed in facilities that do not meet international standards for animal care. Euthanasia can be done quickly and painlessly if best practice guidelines are followed (Lewis *et al*. 2012).

Appendix 7. Human tiger conflict data

Human Tiger Conflict Summary											
Year	Number of human incidents			Number of tiger incidents				Number of livestock incidents			Total incidents
	Dead	Injured	Total	Dead	Injured	Stray	Total	Dead	Injured	Total	
2008	28	9	37	1	0	0	1	31	0	31	69
2009	42	10	52	2	0	4	6	15	0	15	73
2010	36	18	54	2	0	14	16	16	0	16	86
2011	34	19	53	1	0	2	3	20	1	21	77
2012	36	11	47	2	0	73	75	136	8	144	266
2013	4	2	6	0	0	16	16	37	17	54	76
2014	2	4	6	0	1	3	4	21	2	23	33
2015	0	2	2	0	0	6	6	4	3	7	15
2016	0	0	0	0	0	7	7	4	0	4	11
2017	3	2	5	0	0	6	6	7	0	7	18
2018	0	0	0	1	0	2	3	5	2	7	10
2019	0	2	2	0	0	6	6	1	2	3	11
2020	0	0	0	0	0	3	3	2	2	4	7
2021	6	1	7	0	0	1	1	2	1	3	11
2022	1	3	4	0	0	0	0	6	4	10	14
Total incidents	192	83	275	9	1	143	153	307	42	349	777

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