# Technology Testing to Mitigate Human-Elephant Conflict and Promote Coexistence in West Bengal, India: Proof of Concept

## JICA WBFD PoC Final Report (February 2024)

Prepared by RESOLVE


## Executive Summary

Human-wildlife negative interactions are one of the most pressing issues in the context of Biodiversity Conservation globally. Such situations grow manifolds in areas with high human population densities with abundant wild animal species such as Bengal Tigers and Asian Elephants as is the case in India. Specifically, conflict with elephants in India is a major conservation issue wherein it becomes very difficult to move elephants out of crops or villages once crowds of people gather, thus requiring effective responses that need to be pre-emptive. These interfaces are more severe in multi-use landscapes outside the protected area boundaries which are inhabited by both humans and elephants. The negative interactions between humans and elephants lead to repercussions such as human injury, fatality, loss of agricultural produce and property and retaliatory killing of elephants. In case of West Bengal, in the 2021-2022 period, the tragic repercussions of the -elephant conflict (HEC) in West Bengal were starkly evident, with 77 lives lost, 190 individuals injured, and crop damage surpassing 40 million hectares in aggregate. -Managing such situations by the Forest Department often becomes difficult due to several unforeseen circumstances. This demands adopting a cautious approach in areas bordering adjacent states with several stakeholders involved as is the case of Jhargram forest division in Southern Bengal, India which has witnessed a steep rise in such human-elephant conflict events over the last three years. The proof-of-concept exercise to provide technological solutions to mitigate

human-elephant conflict in Jhargram was a collaborative project among the West Bengal Forest Department (WBFD), Japan International Cooperation Agency (JICA), and RESOLVE (NGO). RESOLVE served as the technological solution provider. The collaboration began on 21 August, 2023, starting with a kick-off project management meeting involving all stakeholders. This meeting was followed by a training workshop, a pilot deployment, and a full roll-out deployment of the TrailGuard AI system in the Jhargram forest division. Here, we present the detailed accounting of all major milestones of the PoC project. The TrailGuard AI systems installed across eight forest beats of Jhargram division detected and transmitted the first ever real-time alerts of Asian elephants. The camera alert system used AI models on the edge and on the server to detect and transmit only images of elephants, an important advance because the AI was required to filter out more than an estimated 25,000, images of humans (villagers) that would have been sent to West Bengal Forest Department officials without such screening. In all >170 elephant alerts were transmitted to the local forest staff and Rapid Response Teams (RRT) in Jhargram. Average time of response by the RRT was under 20 minutes. More than 60% of the detections occurred at night; this skew in activity patterns applied to matriarch herds and lone bulls, the latter of greater concern because of a higher level of potential conflict. Importantly, no human deaths and injuries were reported from villages around the sites being monitored by the TrailGuard AI systems. This is contrast to the previous year (late 2022-early 2023) when three people were killed by elephants in this area and three more injured. The high rate and high accuracy of the AI at night-time and real-time transmission (mean = 42 seconds) of alerts to designated parties demonstrates the effectiveness of TrailGuard AI as an early warning system. This technological solution, when integrated into the Standard Operating Procedures of RRTs, has the potential to become a key management tool in multi-use landscapes, thereby shifting from high human-elephant conflict to promoting coexistence across the range of the Asian elephant. Also, reduction in fatalities and injuries has the additional benefits of funds committed to compensation for human injuries, loss of life, or crop damage be spent on conservation.




## Activities in the PoC exercise

These can be categorised into four broad activities:

1. Project setup and planning

2. Training workshop for Jhargram forest staff
3. Pilot deployment of TrailGuard alert system
4. Roll-Out deployment in Jhargram forest division

## Initial project setup and planning

The initial stage of this PoC exercise included project timeline finalization, devising a deployment strategy based on discussions with WBFD officials and existing data, and anecdotal information on movements of elephants, shared with RESOLVE. We finalized Key Performance Indicators (KPIs) for the PoC exercise detailed in an Inception Report and shared with all stakeholders in September, 2023. In the next step, we initiated the site selection exercise through a reconnaissance survey with WBFD officials and local forest staff at Jhargram in mid-September, 2023. As part of this reconnaissance, extensive discussions were conducted with local forest staff and WBFD officials to gain a better understanding of human-elephant conflict in the multi-use landscape of Jhargram. Specific sites (and trails) at the forest-village boundaries exhibiting high frequency of elephant movement were selected conditional on availability of cell connectivity and suitable trees for deploying TrailGuard units. At this stage, the forest staff were also briefly introduced to the TrailGuard AI technology using RESOLVE's Legacy camera units (Annex A).

## Conducting a Training workshop in Jhargram Forest Division

Adopting an inclusive approach towards biodiversity conservation is an integral component to ensure long-term coexistence between local communities and wildlife. Putting this principle into action, RESOLVE, in collaboration with the WBFD, conducted a 1-day training workshop for disseminating information about the overall PoC exercise on 14th October, 2023 at Jhargram range conference hall. This included participation from WBFD officials, Jhargram forest staff (including Rapid Response Team), JFMC members and RESOLVE field biologists. The RESOLVE team provided information on the technological advances provided by TrailGuard AI, specifically highlighting the use-case of Human-elephant conflict (hereafter, HEC) pertinent to Jhargram. This step also included finalisation of a Rapid Response protocol with feedback from frontline forest staff along with inputs from JFMC members in devising effective mitigation strategies to prevent HEC events in the future. As part of the Rapid Response protocol, four RRTs were constituted across the four forest ranges, the members of which would receive the real-time alerts from the TrailGuard units deployed in their respective forest beats. The RRTs after receiving the elephant alerts pass this information to the local communities in the close proximity to the site with TrailGuard units where elephants are detected. In the final step, the RRTs fill the web-based form about their planned response on receiving the elephant alert and take decision to manage the situation as per their discretion.

## Pilot Deployment of the TrailGuard Alert System in Jhargram

After constructive discussions with WBFD officials and JICA, four TrailGuard units of the Legacy models (see Annex A) were deployed at high-priority sites in Jhargram forest division between 14-17 October, 2023. These sites were concentrated in the Kusumdanga area at the Jhargram-Lodhasuli range boundary (Figure 1). The sites were selected by Jhargram forest staff conditional on the elephant movement patterns in the last two-three weeks prior to the pilot deployment in the Jhargram and Manikpara forest ranges. The real-time alerts were transmitted to all relevant stakeholders from RESOLVE, WBFD, and specific Rapid Response Unit members as authorized by the Jhargram forest division officials. Over the course of the pilot deployment, elephant alerts were transmitted at four different occasions between 18.10.2023 - 13.11.2023 from two different locations within the Jhargram forest range. These alerts included small herds and lone bull elephants using the *sal* monoculture plantations-agriculture areas of Jhargram.

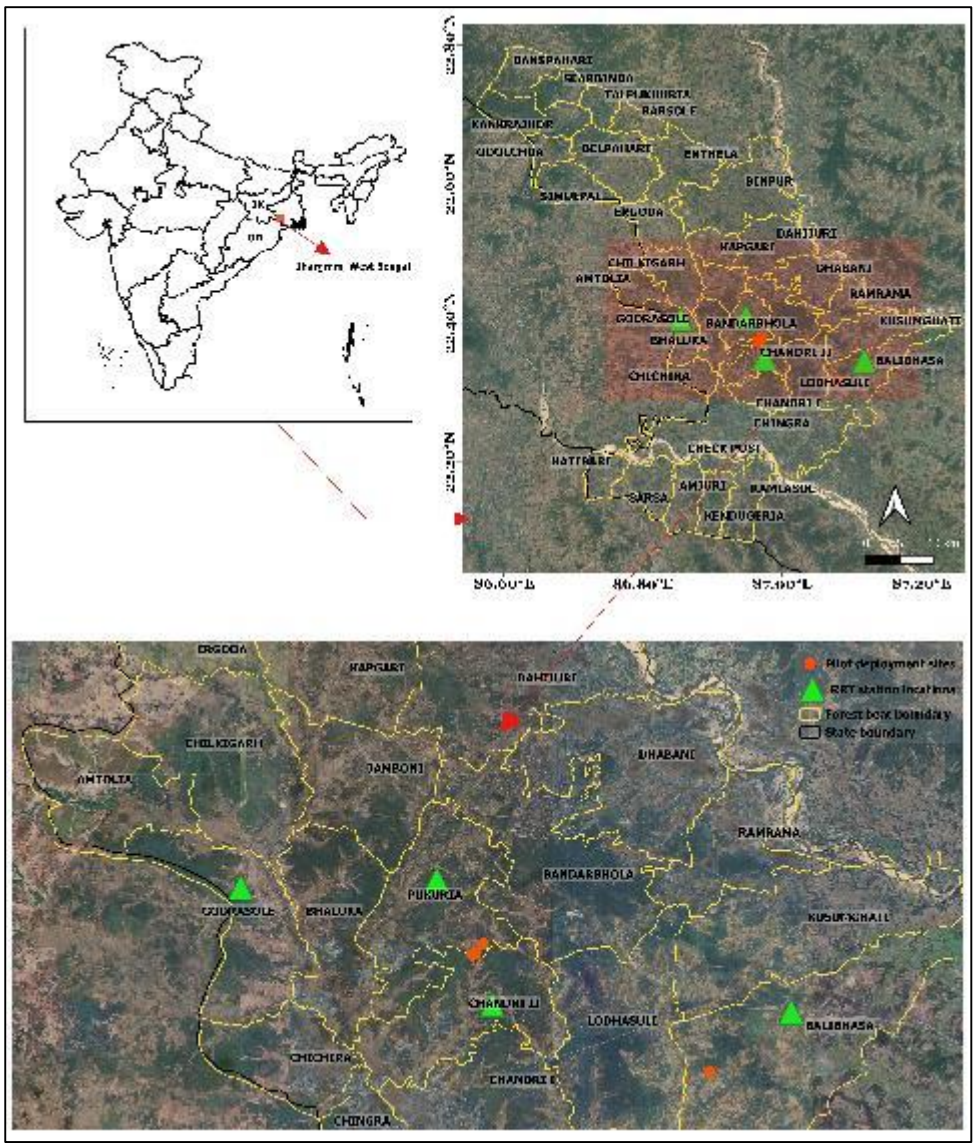



**Figure 1: Spatial locations of pilot sites with Legacy model of TrailGuard AI system installed in Jhargram division**

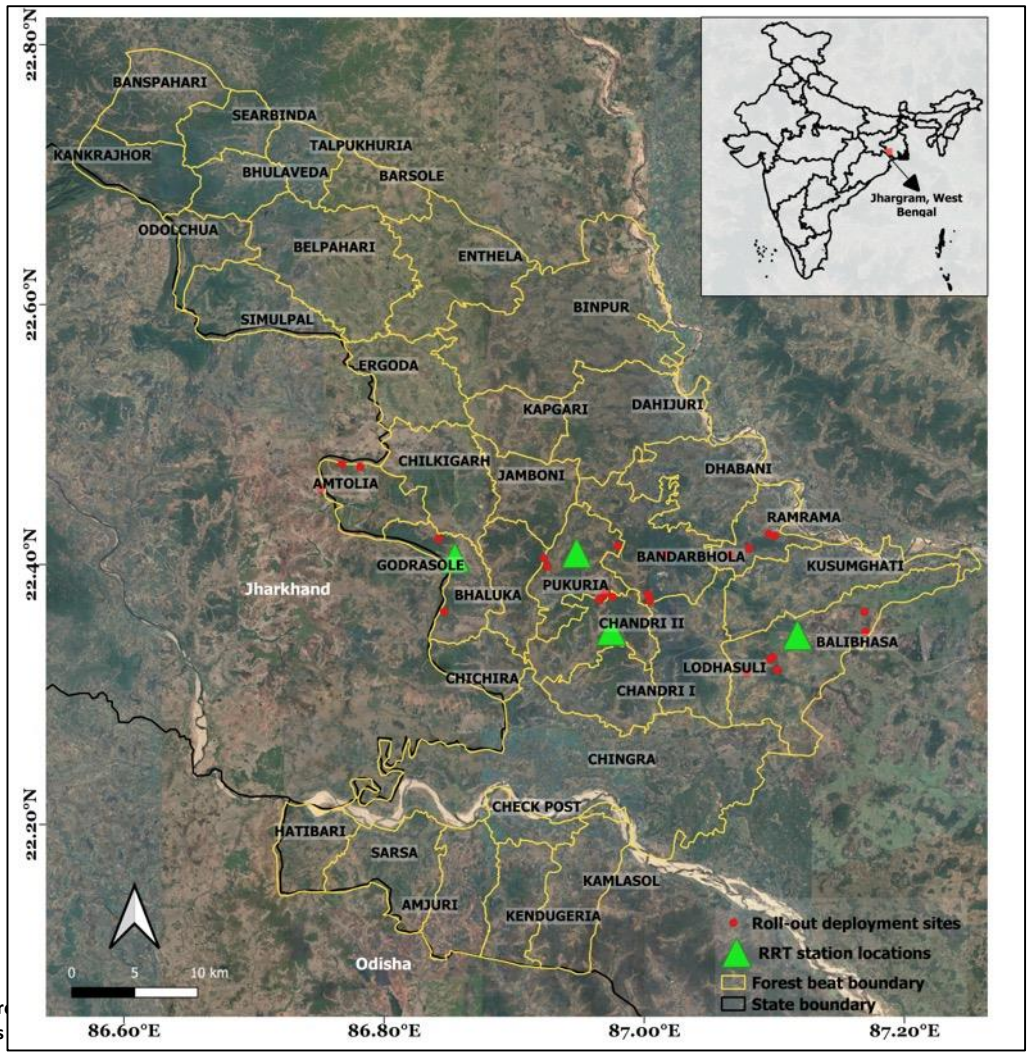
## Roll-out Deployment: A phased approach

After extensive discussions and several rounds of feedback from JICA and WBFD, we conducted the roll-out deployment in a phased manner. The phased roll-out consisted of three parts:

1. deployment of 8 units between 18-24 November, 2023;
2. deployment of 10 units between 8-11 December, 2023; and
3. deployment of the final 12 units in the field between 23-26 December, 2023.

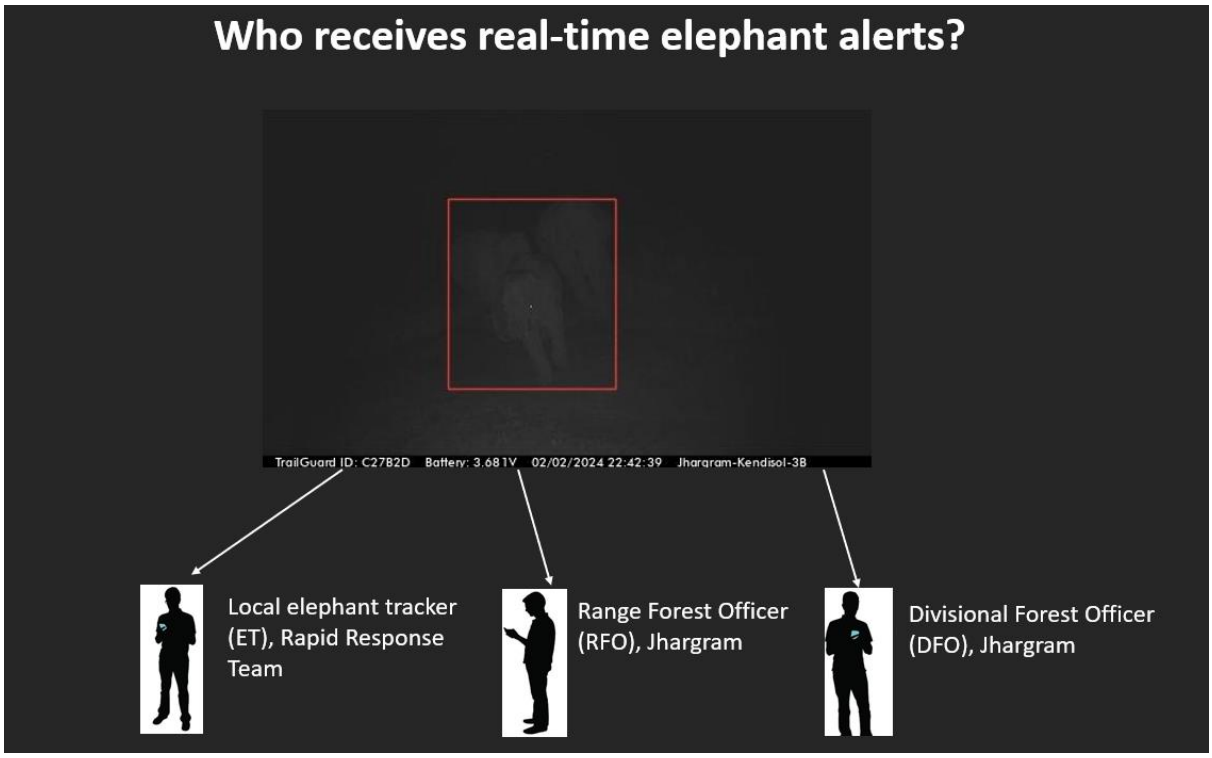
We worked in close coordination with frontline staff from the Jhargram forest division, especially concerning strategic site selection which was conditional on recent elephant movement along the forest-village interface. This effort also included close collaboration with JFMC members from local communities who helped throughout the TrailGuard deployment, particularly in placing the camera-alert systems high in trees (Annex B). We deployed new camera 3B model with improved night-vision, enhanced image quality and new version of the AI edge model for data processing in comparison to the Legacy model used during pilot deployment. In total, we deployed the TrailGuard system in four

forest ranges across the Jhargram division; Manikpara (10), Lodhasuli (3), Gidhni (8) and Jhargram (9) at sites where recent elephant movement was known from field knowledge of the frontline staff and those sites bordering adjoining districts within West Bengal and the states of Jharkhand and Odisha (Figure 2).




Figur
units

The SEAM detector in the TrailGuard units deployed at these 30 sites processes detections using AI on the edge and can detect eight output classes including humans, elephants, felids, canids, humans, bear, rhino and other_animals. Not all objects detected by the camera unit are transmitted to the end-user. In the case of Jhargram, the local forest department staff and WBFD officials are end-users and, as per their feedback, only elephant detections are sent to them in real-time. Other classes such as the human output class, is sent to the server but not transmitted to the forest department. The Jhargram forest department is governed by the Divisional Forest officer (DFO) assisted by the Assistant Divisional Forest officer (ADFO) and respective Range officers (RO) who head the Rapid Response Teams (RRTs) composed of forest guards, elephant trackers and local JFMC members. Therefore, the DFO and ADFO receive all the real-time alerts of elephants from each unit irrespective of their location within Jhargram. On the other hand, The ROs and their respective RRTs only receive the alerts from the TrailGuard units deployed within their respective forest range. This helps them in adopting a focused approach and planning the mitigation response efficiently.




**Schematic for real-time transmission of elephant alerts to Jhargram forest department aiding in managing HEC events**

## Results

## Real-time detection and transmission of elephant alerts

Over the last three and a half months, across all TrailGuard units installed in Jhargram, we have received **175 detections of elephants** using the AI technology and transmitted in real-time to the end users. The members of Rapid Response Teams (RRTs) and other frontline forest staff in Jhargram received the elephant alerts and planned their responses as per the Standard Operating Procedures (SOP) determined in consultation with WBFD officials. A large number of these real-time elephant detections were received from the new 3B models deployed during the roll-out deployment with Legacy models also functioning well mostly during the day-time hours. These real-time elephant detections included lone bulls, small groups, and herds moving along the forest-village boundaries, and at multiple occasions, crossing from one part of the forest to another in this multi-use landscape.

The breakdown of elephant detections conditional on various group type such as bulls (n=75), herds (n=52) and small groups (n=54) are shown in Figure 3.

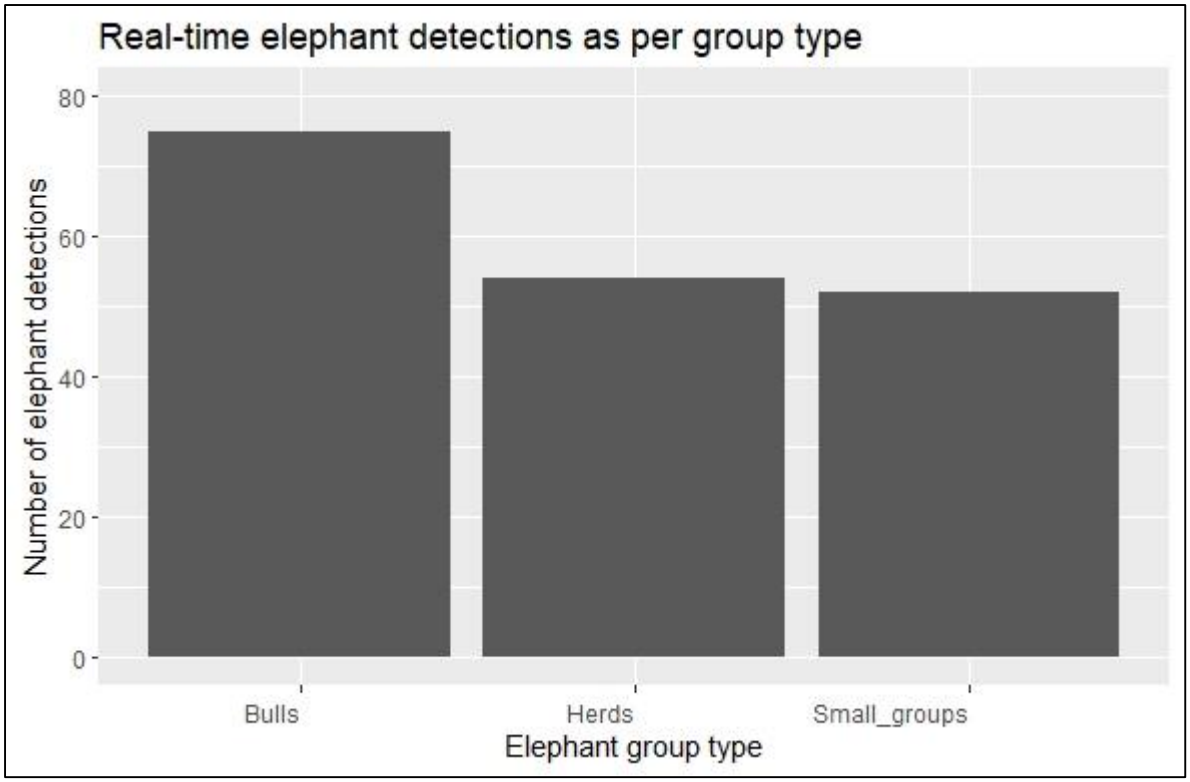



**Figure 3: Elephant detections from TrailGuard units classified as three group types, namely; lone bulls, small groups of 2-10 individuals and herds of >10 individuals**

Elephant detections varied by time-of-day across all sites. We recorded 38% (n=67) of the elephant detections during day-time hours (Figure 4a). in contrast about 62% (n=108) of the elephant detections and transmissions were from night-time (Figure 4b). This pattern demonstrated the capability and effectiveness of the TrailGuard AI system to operate even in total darkness with high accuracy (Figure 5). Nevertheless, there is room for improvement. Based on the data generated as part of this PoC, we are sharing feedback with our manufacturing partners at VVDN technologies to enhance the night-time detection of animal species of interest by increasing true exposure of the images taken at night-time and planning collaborations with other like-minded research labs in India and beyond to better our AI species models by providing them with additional data form this exercise.

**Figure 4a&b: The TrailGuard AI camera units installed in Jhargram forest division for 3.5 months detected and transmitted > 170 elephant alerts, including both herds and lone bulls with a greater proportion of detections during the late hours of the day post sunset.**

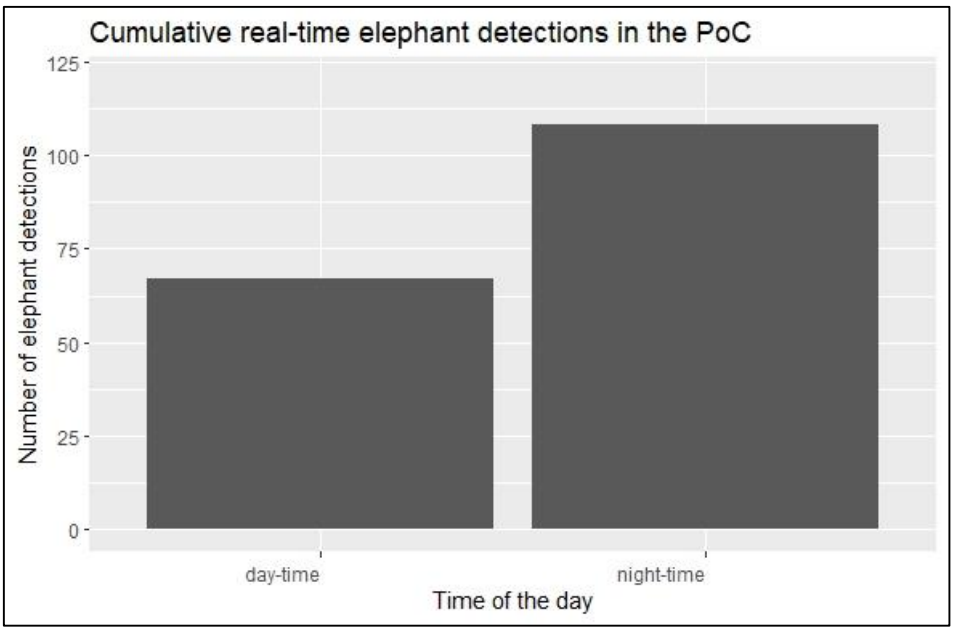



**Figure 5: Bar plot depicting the proportion of real-time elephant alerts partitioned by day and night with major proportion of transmissions from night-time when human movement along these trails decreases substantially (as seen from human detection data).**

We also analysed the data partitioned by detection of lone bulls vs herds by time of day. Small groups comprising 2-10 individuals and large herds of >10 individuals were predominantly detected post sunset 84% (n=85) and 16% (n=16) in the day-time across all the sites in Jhargram forest division. In contrast, the 59% (n=44) of the detections of lone bulls have been from day-time and the remaining 41% (n=30) from night-time (Figure 6).

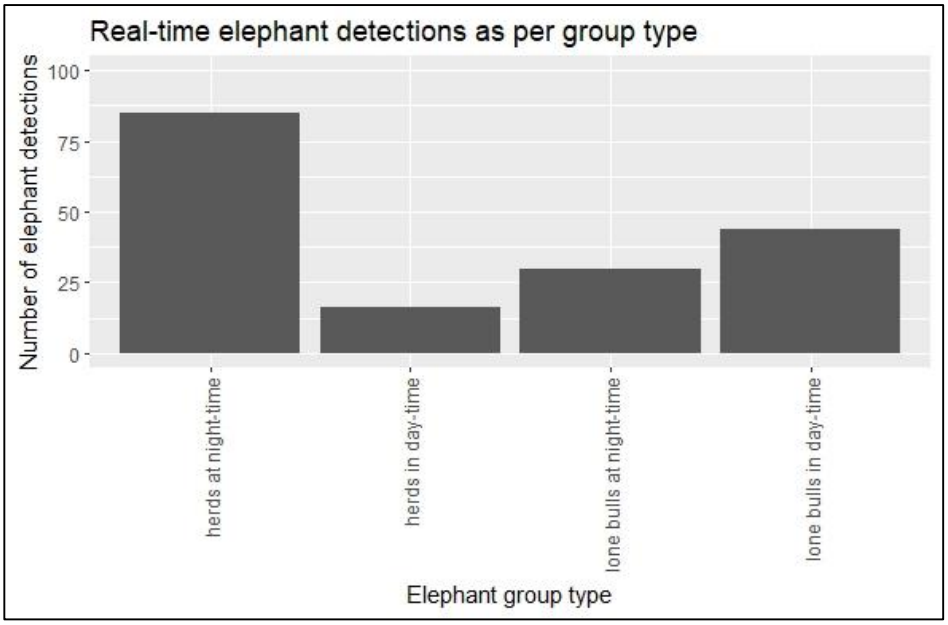



**Figure 6: Barplot with distribution of real-time elephant detections as per time of day and group type where the herds using the Jhargram landscape tend to move mostly at night hours than day-time while the lone bulls follow an opposite pattern by using the trails in day-time rather than during the night hours.**

The proportional human use of these sites where elephants were also detected revealed interesting patterns at different spatial scales:

1. Detections across the sites were skewed towards humans with low proportions of either bulls or herds detected at those sites.

2. At the scale of the forest beat—within Jhargram where TrailGuard AI units were installed—the real-time alerts of two output classes, (i.e. humans and elephants) detected from the edge and the server AI models indicated a very high mean proportion of human detections at four of the seven beats (Figure 7). This indicates the extent of human use of these fragmented forest blocks with interspersed farmlands and human settlements.

3. Overall, the real-time elephant detections were highest in forest beats containing the largest proportion of contiguous forest blocks (predominantly *sal* plantations), i.e. Pukuria and Chandri2 within Jhargram forest division (Figure 7).

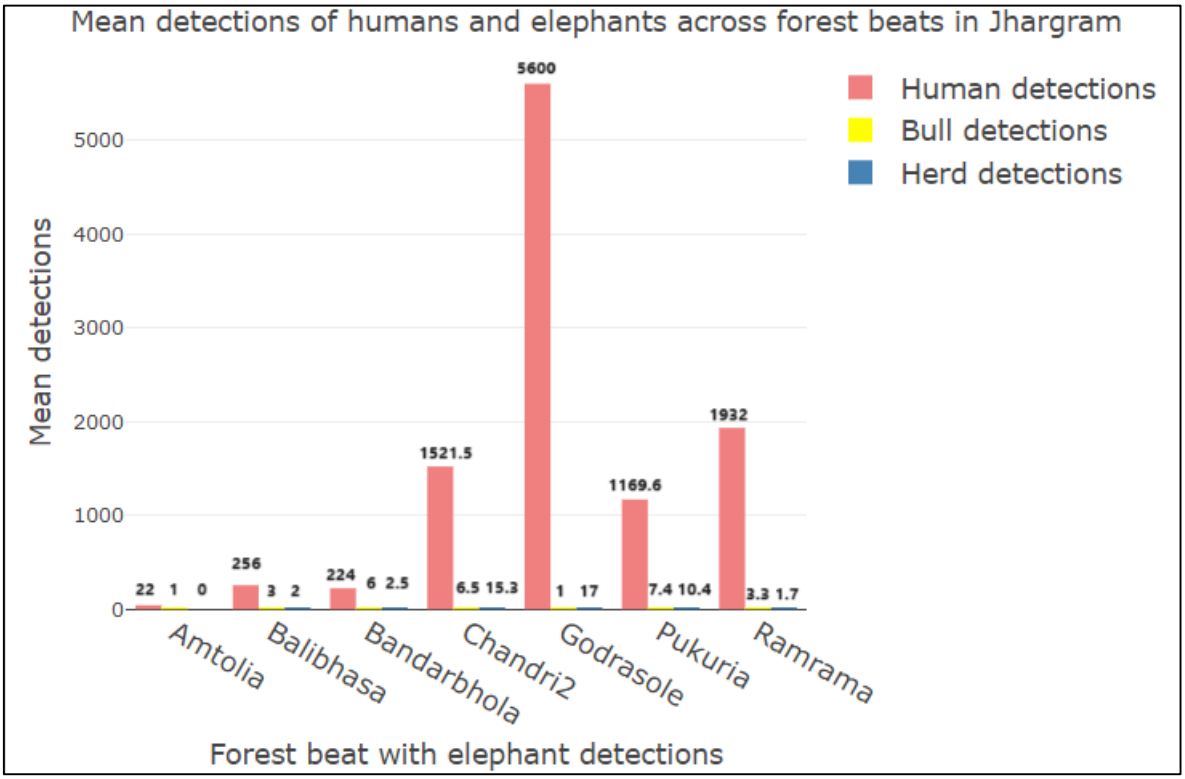



**Figure 7: Comparison of mean detections of humans with elephant group type (bull and herds) across forest beats in Jhargram forest division**

Across the four forest ranges within the Jhargram forest division, **~70%** of the real-time elephant detections have been generated from only **five sites** at the forest-village interface spread across Gidhni, Jhargram-Lodhasuli border forest ranges (Figure 8). These sites hold importance in terms of being hotspots of elephant occurrence. These hotspots represent the largest blocks of contiguous monoculture sal plantations within Jhargram. These results are also in agreement with the initial baseline data on elephant occurrence in Jhargram over last two years as shared by WBFD and Jhargram forest staff at start of the PoC.

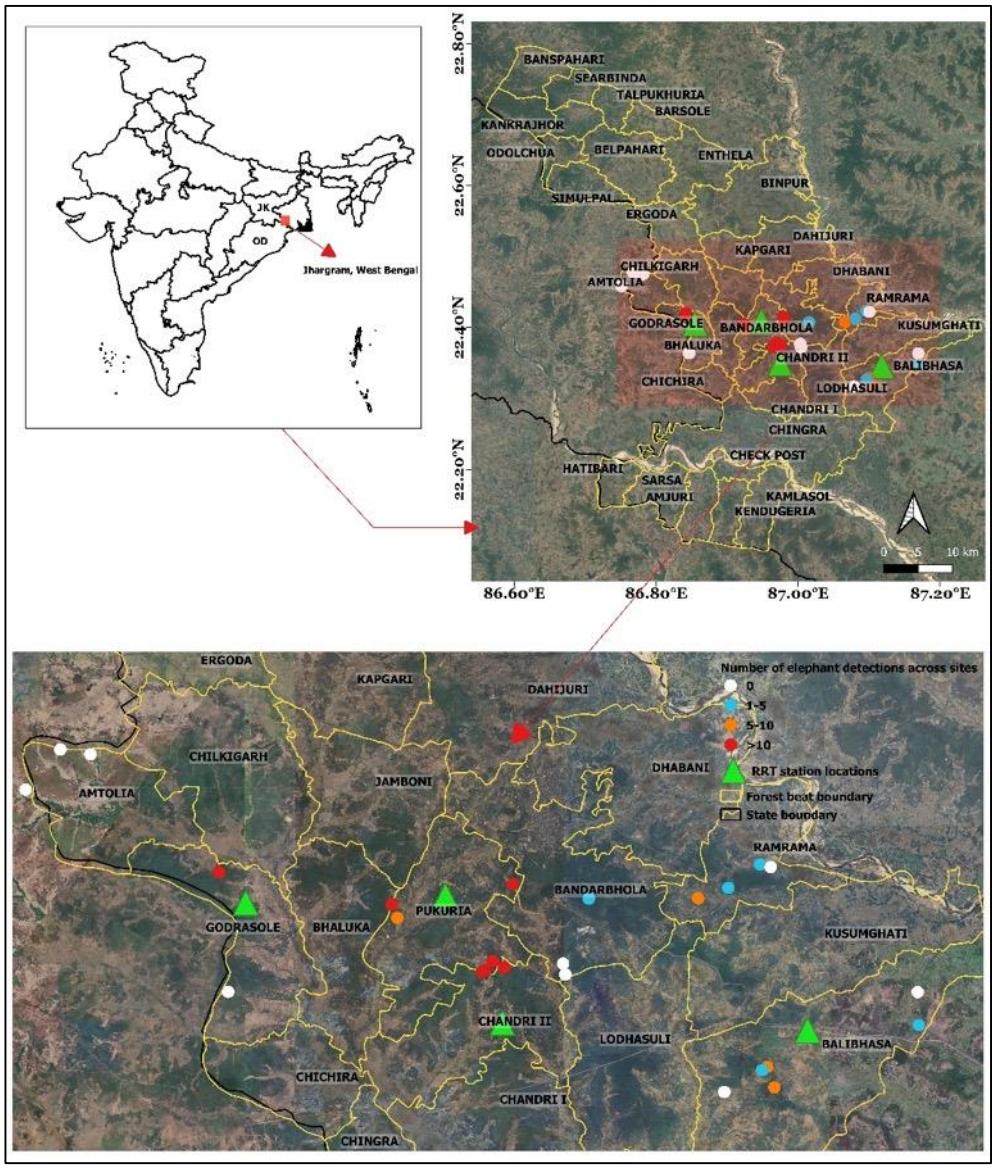



**Figure 8: Site-wise detection and transmission of number of elephant alerts across the 30 sites where TrailGuard AI systems were installed in Jhargram. The sites marked in red denote the hotspots of maximum elephant detections across this multi-use landscape.**

## Using Real-Time Elephant Alerts for Effective Mitigation Measures

After receiving the real-time elephant alerts, the respective RRTs relayed the information to JFMC members and the other local community members in the villages adjoining the sites of elephant detection. Throughout the course of the PoC, the data as collected from the web-based response form that RRTs filled out and data on human detection as received on the server end, indicate that RRTs respond to the elephant alerts as per their discretion. Our discussions with the local forest staff indicated that teams were sent out in most cases where elephants ranged near village boundaries. The response from the RRTs included: blocking of trails and forest roads from human use for the duration until elephants cross over to the forest; and using loud noises of human groups to scare them away. On all the occasions where RRTs responded to the real-time elephant alerts, the mean response time was **18.23 minutes** (Standard Deviation= 12.41 minutes, Range= 5.82-30.64 minutes). As indicated by the Jhargram forest staff in our feedback discussions, this response time before the TrailGuard

deployment previously took a longer duration, ranging somewhere between **1-5 hours.** Delays in the pre-TrailGuard situation was largely attributable to late transmission of information. These comparisons reinforce the effectiveness of the technology offered by TrailGuard AI to provide real-time alerts of target species to relevant stakeholders for better mitigation and prevention of Human-Elephant Conflict in Jhargram.

### Potential for re-identification of elephants in Jhargram

During the reconnaissance period, we learned that the primary management issues encountered by RRTs over the past two years were mostly in cases involving lone bull elephants. Thus, for this PoC exercise, the strategic placement of TrailGuard AI systems at sites of recent elephant movement of lone bulls was also essential. Across the 30 sites where camera units were deployed, about 44% (n=74 out of 170 total detections) of elephant alerts were of lone bulls detected at different times of the day, predominantly in day-time hours.

There is a pressing need for preparing a dossier of these "problem" elephants potentially involved in negative interactions with humans in Jhargram. In this regard, the TrailGuard system can act as an effective tool for monitoring the movement patterns of these lone bulls. During this PoC exercise, we identified around 7-12 unique lone bull individuals which were detected across different locations (Figure 9).

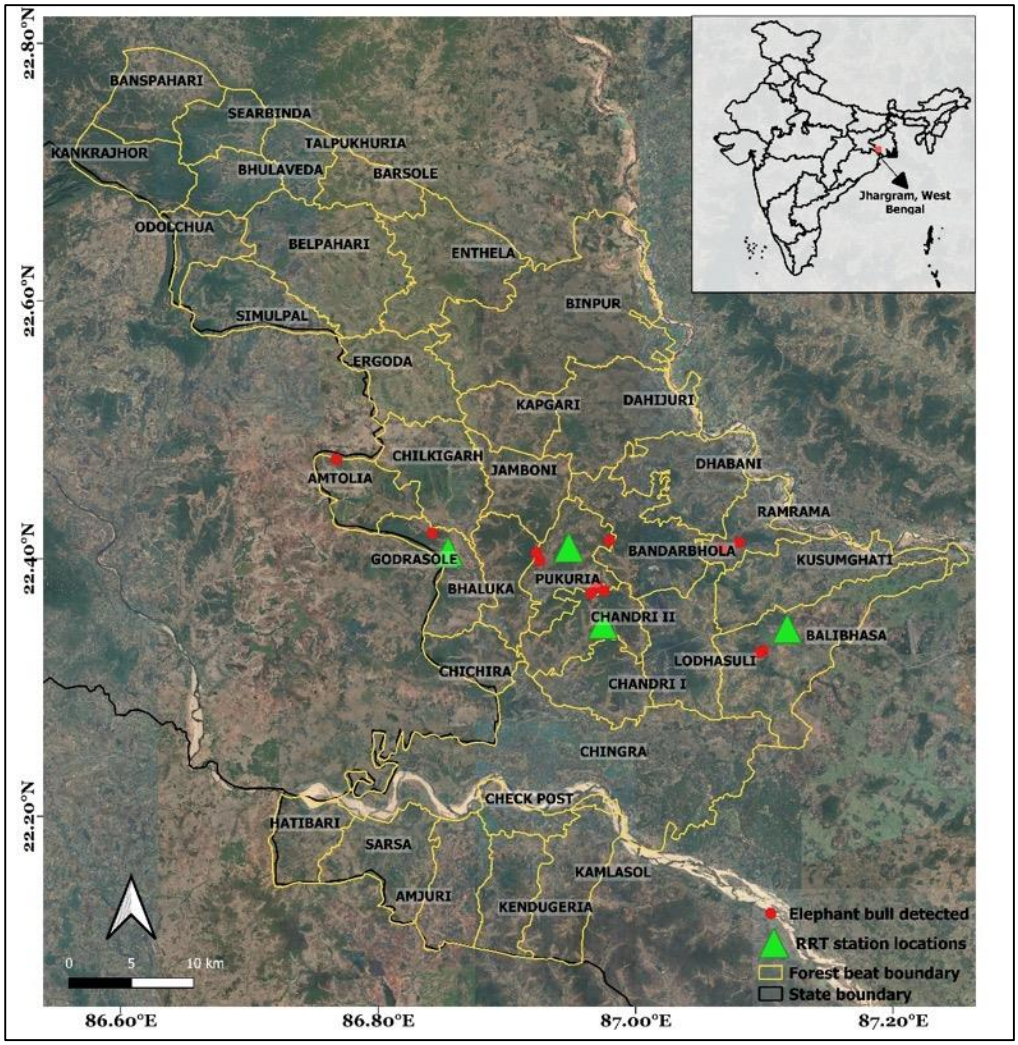


**Figure 9: Spatial location of the sites in Jhargram where the TrailGuard units detected lone bull elephants both in the pilot and roll-out deployment phases of the PoC exercise. Using human capabilities within the RESOLVE team, we could identify 7-12 unique individuals out of all the detections of such individuals**

Among detections of lone bulls, we obtained recaptures of three bull elephants across multiple sites where we were able to track their movement patterns across multiple sites. Bull-1 was detected at three different TrailGuard units deployed across a stretch of 1 km in the Kusumdanga area at Pukuria-Chandri2 beat boundary in the Jhargram-Lodhasuli range boundary (Figure 10a). Bull-2 was detected at two different TrailGuard units deployed in close proximity to border with adjoining district of Kharagpur within the Balibhasa beat in the Manikpara forest range (Figure 10b). Bull-3 was detected by two different TrailGuard units at a gap of one month across two forest ranges, first in Ramrama beat of Manikpara range, and, nearly a month after, at the Pukuria-Chandri2 beat boundary in the Jhargram-Lodhasuli range boundary (Figure 10c).

These data are critical for planning effective mitigation and preventive measures in cases of human-elephant conflict. This method can act as an important resource not only in Jhargram but adjoining districts (Kharagpur and West Midnapore) within West Bengal and potentially in the states of Jharkhand and Odisha, supporting larger landscapes where these elephants are more common. These results can thus be used in better planning for deployment of TrailGuard units potentially in the second phase of the project where additional units can be deployed to monitor trails for at least the adjoining districts of Kharagpur and Midnapore. This next step will involve setting up multiple TrailGuard units at sites with frequent detections of lone bulls to obtain pictures of these individuals from all directions. These pictures can then potentially be used as important data to retrain the AI models where alerts for specific individuals can be sent out in the future from Jhargram. This approach can be highly effective for managing human-elephant negative interactions in this larger yet important elephant landscape of Eastern India.

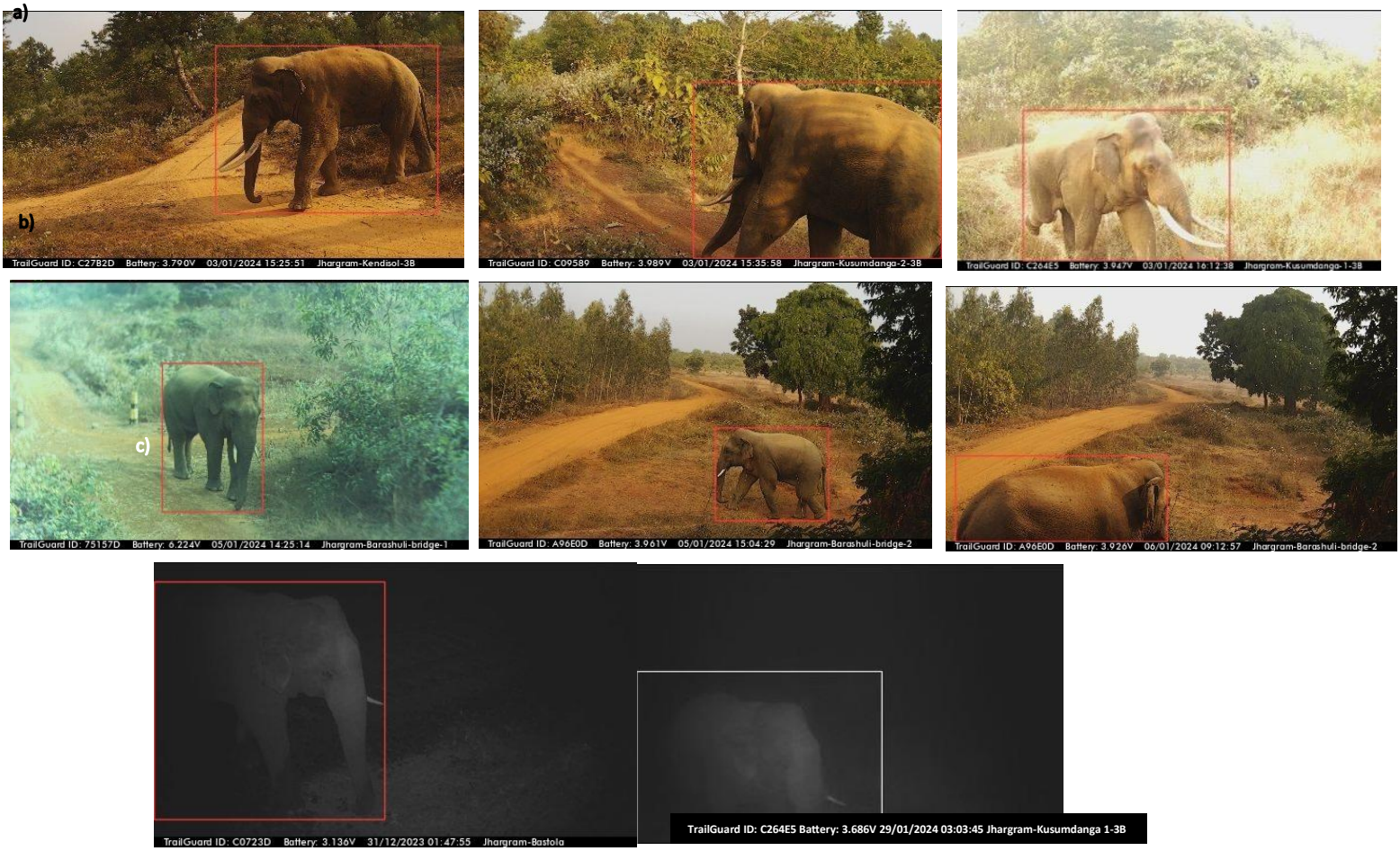


**Figure 10 a-c: Three lone bull elephants were re-identified at multiple sites by deployed TrailGuard units. The re-identification was aided by key distinguishing body features such as: a) very long tusks in case of Bull 1; b) forehead pattern for Bull 2; and c) Bull 3 with only a single tusk. Body features such as ear-folds, broken tusks, forehead shape, cuts due to infighting between individuals and others help in easy identification of elephants.**

The findings from this PoC exercise have helped all the stakeholders in realising the importance of species monitoring (here elephants) in multi-use landscapes. Taking this a step ahead, we should adopt an approach to identify important trails used by elephants and leading to villages. Prioritizing the trails over the number of cameras is critical to enhance our understanding of elephant movement in this landscape. The number of cameras needed to monitor such important trails can be very well derived from the trail identification exercise.

## Evaluating the KPIs for the PoC exercise

During the planning phase of the PoC project, certain important Key Performance Indicators (KPIs) were set that encompass critical aspects of this project. The category-wise evaluation of the KPIs are as below –

| **Key Results Area** | **Indicators** |
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| ***Performance of technology*** | |
| Durability and reliability | ● Number of problem units needing repair or replacement (major or minor problems)<br>Evaluation: **2 units, 1 each in Manikpara and Lodhasuli forest range were replaced with new units due to hardware related problems during the duration of this PoC; also a large proportion of 3B models (n=27) were installed and Legacy models were used at sites (n=3) where multiple units were required.**<br>● Number of units that remains operational<br>Evaluation: **23 TrailGuard units out of the total 30 units (77%) are currently functional and transmitting real-time alerts from designated sites in Jhargram; the other ~7 units need battery replacement**<br>● Number of successful alert transmission using cellular/GSM<br>Evaluation: **175 real-time alerts of elephants from across all the units from Jhargram where 70% of TrailGuard units detected and transmitted >=1 elephant alerts** |
| Accuracy | ● % of correct identification by AI<br>● % of true negatives filtered by AI<br>● % of false identifications by AI<br><br>**These results can only be evaluated after retrieving the data from SD cards in each of the TrailGuard units.** |
| Ease of use<br>● Training<br>● Implementation<br>● Monitoring and sustenance | ● Installation performed by WBFD staff, JFMCs in coordination with RESOLVE<br>Evaluation: **The deployment of 30 TrailGuard units spread across four phases was completed in close coordination with local forest staff from Jhargram, JFMC members (four of whom are now technically equipped and trained to install and move TrailGuard units as per need). These** |

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| | **installation of 30 units were completed in a mean time of 3.75 days across all phases.**<br>● Time (in days) required for localization/adaptation<br>Evaluation: **In a duration of one month (30 days). After initiation of pilot deployment and first phase of roll-out deployment, the local forest staff and RRT members were well-versed with the TrailGuard AI system in terms of planning response in case of elephant alerts and sending out respective teams as per their discretion.**<br>● Feedback on the ease of implementation and sustenance<br>Evaluation: **Summary of the feedback from field: As per the discussions with the local Jhargram forest officials, frontline forest staff and JFMC members who were the key stakeholders to use the real-time elephant alerts from TrailGuard systems and respond accordingly, the elephants being detected and alerts transmitted to them in a mean time of 42 seconds has considerably helped them to complement their efforts on field. As per the RRTs, earlier they did not have precise locations of the elephant movement in their respective area of jurisdiction and would receive information only when lone bulls (mostly) or even herds have moved near the village which translated into a delay of 2-4 hours in managing the situation. However, after the receiving the real-time alerts of elephants, particularly during the late-night hours, their management efforts have been streamlined with planning the response in a more organized manner.** |
| ***Rapid Response Protocol*** | |
| Time to respond in case of HEC incident | Average time to respond to the reports raised by TrailGuards and by villagers<br>Average time to deliver measures to drive elephants, etc.<br>Evaluation: **As per the data analysed from web-based forms filled out by RRTs and the data on RRTs movement gathered through server, the mean response time including the time to report of the elephant detection taken by frontline staff was estimated as 18.23 minutes. The measures undertaken included blocking of forest roads and using loud sounds to scare the elephants moving close to the villages.** |
| % Response | % of reports that received a response. Should give some indication of overall response effort.<br>Evaluation: **Out of all the real-time elephant alerts generated from TrailGuard units across Jhargram, 40% of the reports received a response from the RRT, especially in cases where the elephants were moving in the direction of the villages. For the rest of the detections, the elephant movement was a cross-over from one forest patch to another.** |
| Feedback and satisfaction from local communities | Feedback and ratings from stakeholders for reporting system<br>Evaluation: **Forty individuals representing villages from 80% of the forest beats where TrailGuard AI was deployed responded to questionnaires prepared by RESOLVE with data collection facilitated by the Jhargram local forest staff. As** |

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| | **is evident from the collected data shared by WBFD, all the respondents equivocally supported the deployment of TrailGuard AI as an early warning system for real-time elephant alerts at the border of forests and their villages. In addition, the respondents from all the villages across the forest ranges where TrailGuard units were deployed highlighted the importance of real-time information on elephant presence and movement in their localities to plan their work in a better way with minimal chances of negative interactions. Further, the community members also mentioned to initiate deployment of additional TrailGuard units in other remote parts of the forest-village boundaries used by elephants. Across the forest ranges where the households were surveyed, local communities also mentioned to be notified of all the elephant related real-time data in the future. Interestingly, even if informed of elephant movements in real time, only a minority of respondents (20%) supported an increase in elephant populations in Jhargram whereas the majority (60%) did not favor an increase in numbers.** |
| ***HEC Mitigation*** | |
| Prevention and reduction of HEC | # of deaths due to HEC compared to seasonally adjusted average:<br><br>Evaluation: **We compared the cumulative human deaths in the respective forest beats for the period between October-February for years 2021-22, and again in 2022-23, prior to when TrailGuard units were installed in Jhargram vs. the same time-period in 2023-24 when TrailGuard units were functional in the same landscape. For the same time-period, no human deaths were reported in 2021-22 while three human deaths in 2022-23, in comparison no human death was reported from the villages near the sites where TrailGuard units were deployed for the same period in 2023-24.**<br><br># of injuries due to HEC compared to seasonally adjusted average: **Under this KPI, we compared the human injuries in the respective forest beats for the period between October-February for years 2021-22, 2022-23 prior to when TrailGuard units were installed in Jhargram vs. the same time-period for 2023-24 when TrailGuard units were functional in the same landscape. For the same time-period, three human injuries were reported in 2021-22 while two human injuries in 2022-23. In comparison no human injuries were reported from the villages near the sites where TrailGuard units were deployed for the same period in 2023-24.**<br><br>Areas of crop raiding compared to seasonally adjusted average: **The data on crop loss was provided for January 2023 to provide a baseline and January 2024 after TrailGuard deployment. On comparing the crop depredation in the villages along the sites where TrailGuard alert system was installed, there seemed to be an elevated crop loss area. We also discovered that there were three times more elephant days (number of elephants*number of days) in January 2024 as compared to January 2023.**<br><br>**However, more data are needed to make an informative comparison. There are several trails at the forest-village boundary leading to these villages within a particular forest beat. TrailGuard units were deployed only on trails with the highest frequency of elephant movement at a particular site. Therefore, a** |

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| | **better metric for comparison would be to consider area under crop depredation only in those villages that received the information on real-time elephant movement relayed by the RRTs and are in the immediate proximity of the sites where TrailGuard units were deployed. This will help in actual comparison of the effectiveness of TrailGuard AI technology in preventing crop depredation since in the PoC exercise a single TrailGuard unit installed on just one trail was used to monitor > 50 km$^2$ area. This can be made more effective wherein it will be better to secure all trails with TrailGuard systems that open into villages at the forest-village edge to better assess this KPI.** |
| Promote awareness | # of focus group discussions/training participants targeted<br><br>Enhanced knowledge of all stakeholders on HEC prevention<br><br>Evaluation: **During the training workshop held in October, 2023; 44 participants participated including WBFD officials, Jhargram forest officials, frontline forest staff, RRT members and JFMC members. We held discussions with all stakeholders and disseminated information about the technological solutions provided by TrailGuard AI along with specifically highlighting the use-case of Human-elephant conflict (hereafter, HEC) pertinent to Jhargram. Over the course of the PoC during field deployment of TrailGuard system at designated sites in Jhargram, discussions on use of TrailGuard AI technology to mitigate and prevent human-elephant negative interactions were also conducted with ~35-40 individuals from the respective JFMCs and local communities who helped in deployment of units during different phases.** |
| Financial / Cost effectiveness | Actual project cost compared to budget; compare with (pre-TrailGuard) cost of HEC prevention/intervention without TrailGuard + actual damage/compensation<br><br>Evaluation: **The sanctioned budget for the project to RESOLVE was $70,000 out of which the actual cost incurred for the duration of the project is $65,257.56 inclusive of costs associated with technology setup, deployment logistics, travel etc. Since the TrailGuard units are currently deployed in Jhargram as per the request from WBFD, the remaining funds will be utilized to cover the costs of maintenance for these units along with planned trips to Jhargram in April, 2024 for retrieving the data from SD cards. The remaining funds will be utilized to As per the data shared by WBFD for January 2023, the total cost for HEC prevention without TrailGuard was estimated as $8,515. In January 2024, after TrailGuard deployment the costs incurred by Jhargram division towards HEC is estimated as $30,000. This is again correlated to the three times more elephant days (number of elephants*number of days) in January 2024 as compared to January 2023. We are working with WBFD to get more targeted cost estimates of compensation for villages that are in closest proximity to the TrailGuard units deployed at nearby sites and incurred crop loss after receiving the real-time alerts. There is also a need to collect more data on this aspect wherein compensation and monitoring costs during peak paddy harvest need to be considered, which can potentially be done as an extension in the future phase of this project. This will help in getting a better understanding of cost effectiveness after undertaking technological solution into account.** |

| | |
|---|---|
| Uptake and Scalability of solution | Feedback from stakeholders<br><br>Geographical spread of deployment aligned with elephant movement routes<br><br>Evaluation: **30 TrailGuard units were deployed across eight forest beats within the four forest ranges of Jhargram, namely; Lodhasuli, Manikpara, Jhargram and Gidhni with maximum elephant movement in the last one and a half years as per the baseline data provided by WBFD in the initial months of the PoC. After the initial site selection exercise, deployment sites were reselected considering the recent elephant movement collated from field knowledge of respective forest staff and cell connectivity in the landscape. During different deployment phases, the sites were pre-selected by Jhargram forest staff in advance aligned with elephant movement routes in their respective forest beats. Therefore, post the complete deployment, several real-time detections and transmissions of elephant alerts were generated for RRTs to manage HEC events more effectively.** |

## Overall recommendations to the West Bengal Forest Department

1. Understanding the ecological needs of elephant populations in Jhargram is a critical aspect for effectively reducing negative interactions between humans and elephants. A critical aspect could include initiating habitat restoration interventions where understory plants and trees preferred by elephants as palatable forage should be encouraged since Sal at any phenological stage is unpalatable for elephants and most other wild herbivores. Though Jhargram landscape, being a part of Chota Nagpur Plateau is a dry area, efforts to strengthen water source availability within forest patches is of much importance.

2. Jhargram is a multi-use landscape with juxtaposition of Sal monoculture plantations, dense human settlements, recreational resorts/hotels, farmlands and linear infrastructures such as a canal and metalled roads with elephants inhabiting this system. The movement patterns of these elephant populations are highly fluid, where they tend to migrate longer distances while exploring new routes. Based on this behavior, we recommend an adaptive approach using TrailGuard AI system to monitor these elephants. Given that TrailGuard systems are easy to move around, these units can be aligned with elephant movement and deployed at relevant sites in a short amount of time. To this end, it is essential to constitute a local field team from Jhargram forest staff trained in technical aspects of the TrailGuard AI system who can execute this need-based moving deployment going forward.

3. Cell connectivity in forested landscapes across India are highly variable with certain pockets within a particular landscape with sparse to no network. We encountered this in certain pre-decided sites within Jhargram as well where we managed to use local SIM cards of two cell network providers. However, it is essential to devise methods for systematic functioning of our system. To this end, RESOLVE is collaborating with partners in the realm of long-range WiFi and satellite transmission technology. We are planning to integrate these approaches with our TrailGuard system to aid real-time transmissions of targeted species from sites with extremely

weak cell connectivity. These approaches can be used for other use cases such as species monitoring within the core zones of the protected areas as well.

4. Nearly 40% of the TrailGuard units deployed in Jhargram were along the trails with very high human traffic where proportion of mean human detections to elephants were of the order 1,241 human alerts:12 elephant alerts. These data indicate extremely high human-use of these forest-village boundaries. This ratio in turn leads to steep dissipation of battery charge for the TrailGuard units which are otherwise in sleep mode until triggered by a species of interest. Repeated triggers due to frequent human movement at sites in Jhargram can be managed better where trails with high elephant movement and low human use can be strategically selected.

5. Another interesting result came from the quantitative data provided by Jhargram forest officials comparing crop losses in January 2023 with January 2024 with and without TrailGuard units, respectively. Given that the number of elephant days for January 2024 (number of elephants*number of days) are nearly five times higher when compared to the January 2023, the area under crop loss shows a strong correlation with this thus elevating the area under crop depredation across all forest beats. There is a need to infer this data in a more careful manner where the effectiveness of TrailGuard AI technology in preventing crop loss should be evaluated with the response rate of RRTs after receiving the real-time alerts. Of all the real-time elephant alerts transmitted to RRTs, nearly 40% of such detections received a response on field. Hence, a better metric would be to evaluate the area under crop loss in villages where the RRTs responded after receiving the alerts from TrailGuard units. In addition, it is also essential to understand that at most instances a single TrailGuard unit installed on a trail with highest frequency of elephant movement on a site near the forest-village boundary may encompass an area >50 $km^2$. However, there exist several trails that may lead to a particular village or where elephants may use a different trail where the TrailGuard unit was not installed during the PoC. Hence, it is recommended to deploy additional TrailGuard units and secure all such trails from forests leading into villages to provide a better understanding of the elephant movement and evaluation of effectiveness of TrailGuard system in a much quantitative manner with more data from field.

6. Data generated through TrailGuard AI as real-time alerts for elephants in Jhargram can be used for enhancing the alerts on elephant movements to stakeholders well in advance through network between forest department staff, JFMCs and local communities. Under this, as per the discretion of the Jhargram officials and WBFD officials, real-time information in the form of elephant pictures transmitted as alerts can be integrated with the existing alert messages on elephant occurrence/movement sent out to local communities. The photographic evidence can act as an effective tool to prevent negative interfaces between local communities and elephants. This will also provide local communities with advance preparation time to secure their resources.

7. In our new model, Camera 4B, which is under manufacturing currently at VVDN technologies, we have enhanced the charge capacity of the battery by two times to provide ~7,500-8,000 detections per single charge of the battery. This will help in increasing the battery life of a TrailGuard unit deployed on field. In addition, we are working with the software engineers at

VVDN to design a new software application where only the elephant output class (or targeted species) will be transmitted to the end-user. This will only transmit target species with other detections of such as humans, dogs, cattle, vehicles, etc. not transmitted and simply stored on the SD card after detection. This change will prolong battery life, increasing the endurance of the unit in the field.

8. Integrating data on real-time elephant occurrence and movement in the form of a live dashboard can also be adopted. We at RESOLVE are working on designing such a dashboard with our partners that should enable getting data summaries at all levels within a forest division such as range, beat and even site level. As per the need of the end-user the alerts for the target species can be sent as a pop-up notification on the live dashboard being monitored by a respective officer-in-charge designated by the head of the forest department.

## Scaling Deployment of TrailGuard AI system in Jhargram and Beyond

The results from the PoC project are encouraging wherein the TrailGuard AI systems installed could detect elephants accurately and transmit real-time alerts from the sites in Jhargram. The end-users, (i.e. the frontline staff in Jhargram, RRT members managing human-elephant interactions), received more than 170 real-time alerts of herds and lone bull elephants traversing the landscape during the three and a half month long PoC (October, 2023-February, 2024). These results help us infer that augmenting TrailGuard AI units in the field on strategic trails within sites raise the probability of detecting elephants in real-time which is key to understand movement patterns of these megaherbivores in multi-use landscape such as Jhargram. The data from this PoC, where the TrailGuard units installed across 30 sites detected ~7-12 lone bull elephants (which are of more concern from management perspective for Jhargram staff) with re-detections of at least four lone bulls reinforce the potential effectiveness of the system for monitoring individuals. Recent estimates of the costs incurred by state forest departments in India to monitor individual elephants involved in negative interactions with humans using radio-telemetry is exorbitant. In addition, several administration-related procedures to obtain permission are lengthy and delay addressing the immediate problem.

The results from this PoC support viewing the TrailGuard AI technology as a tool to complement existing efforts by the forest department to manage human-elephant conflict more effectively. Therefore, utilizing the data from this PoC, we recommend a convincing deployment strategy for Jhargram forest division, keeping in mind the below Venn diagram (Figure 11).

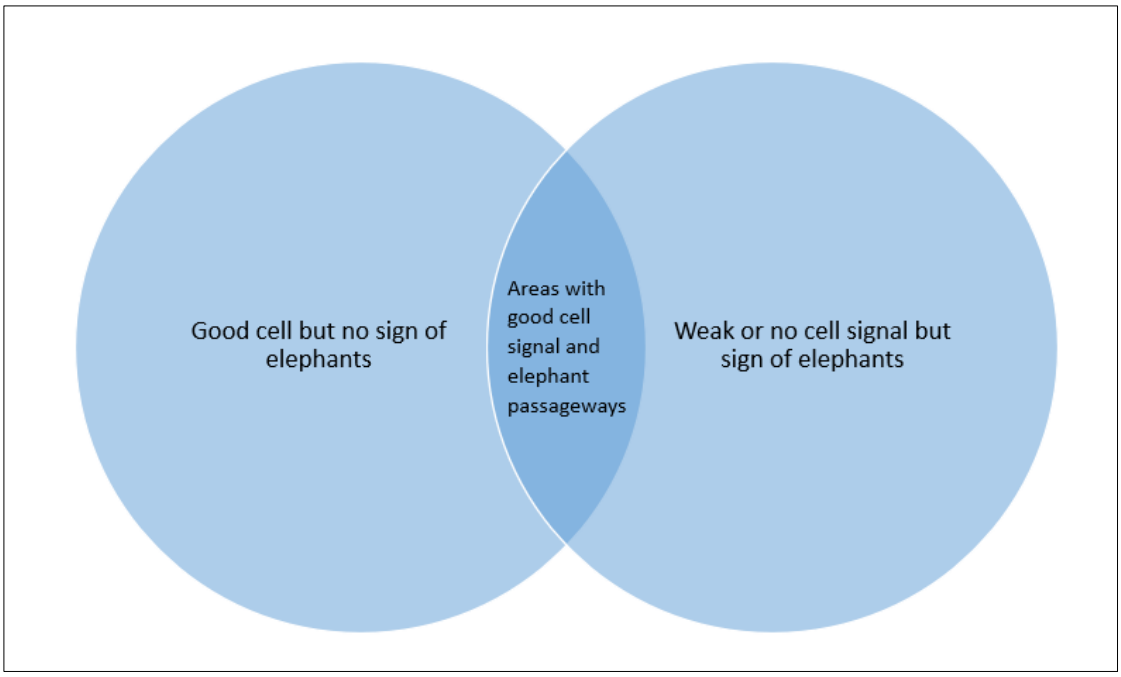


**Figure 11: Venn diagram for effective detection and transmission of real-time elephant alerts**

Under this scenario, at least 100 TrailGuard AI units should be installed across all the forest ranges in Jhargram aligned with elephant movement where the major proportion of units can be stationed in forest beats with maximum elephant use (Figure 12). This strategy can also help in monitoring the locations within Jhargram with adjoining districts of Midnapore and Kharagpur to the east within West Bengal and states of Jharkhand and Odisha on the west and south, respectively. Additionally, it will be useful to collate data on human injuries and deaths in Jhargram due to elephants for the peak time period of paddy harvest in the landscape over the last decade. This undertaking will help assess the effectiveness of mitigation measures in a more detailed manner.

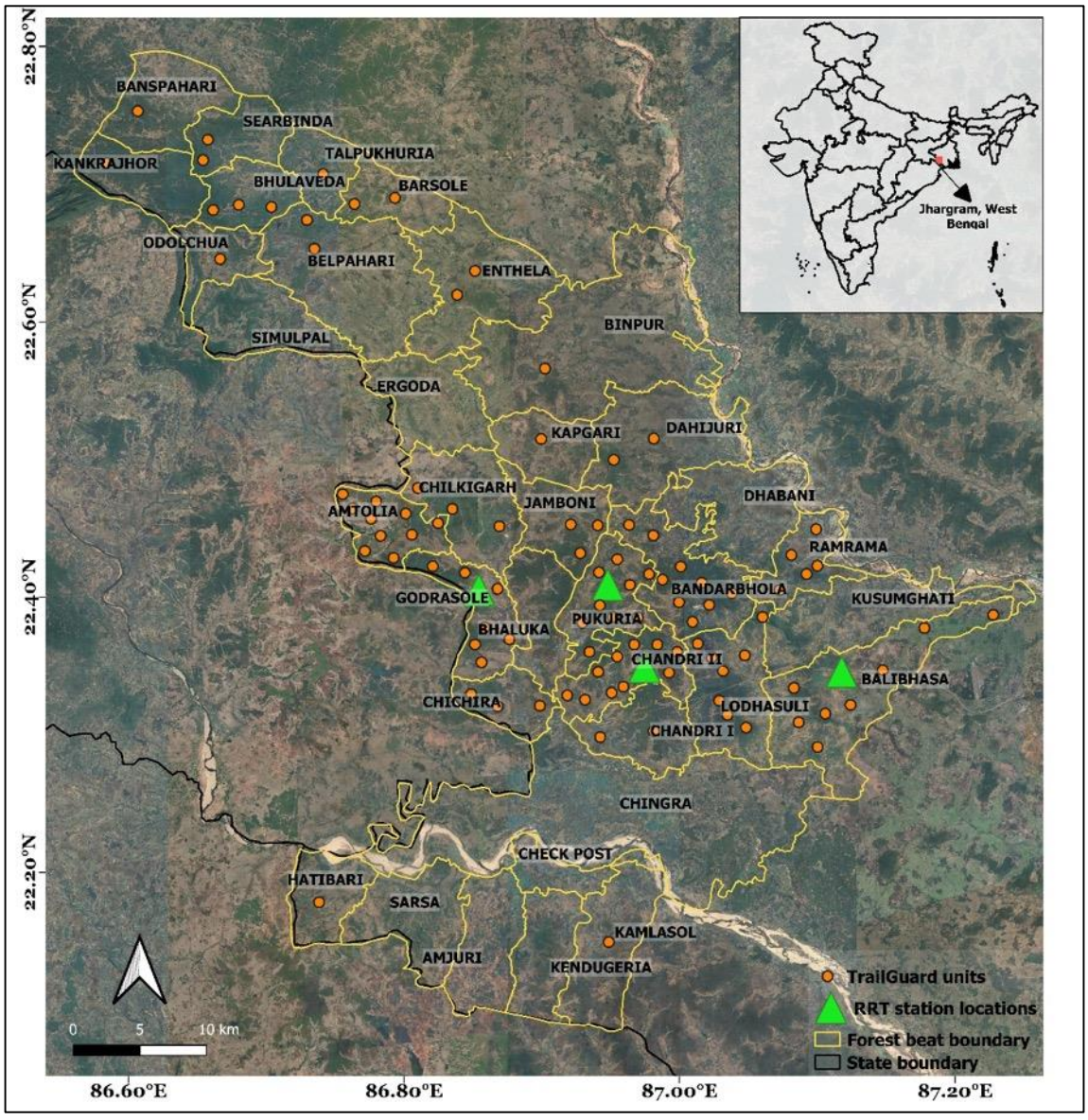


**Figure 12: Spatial locations of the recommended scaled deployment of TrailGuard AI units in Jhargram**

Extending the deployment of TrailGuard systems to these adjoining areas specifically Kharagpur and Midnapore which have functional corridors being used by elephants to migrate is essential. This expansion will help in monitoring the herds and lone bulls in this larger landscape of Eastern India being used by these elephant populations which is critical for effectively managing the human-elephant interface and promoting coexistence in multi-use landscapes in other parts of India.

## Annexure A

As part of the pilot deployment, we installed the legacy model of the TrailGuard units which date back four-five years and run the People-Vehicle-Animal AI detector mode. However, these units did perform satisfactorily on the field detecting elephants in real-time. Below is a picture of the legacy camera unit (Figure 1), TrailGuard version 3B (Figure 2), and the upcoming manufactured version 4B (available March 2024; Figure 3).



## Annexure B

The field deployment of TrailGuard AI system in Jhargram forest division was supported by local forest staff, JFMC members, and Elephant trackers who helped the RESOLVE team by deploying the camera units high on trees to maximize the detection and transmission of elephant alerts to all stakeholders (Figure 1a,1b & 1c). RESOLVE team members helped the local field teams by providing all necessary technical details and conducting hands-on training such as camera setup, battery installation and maintenance to the respective field teams from all forest beats thus aiding the deployment teams to operate independently (Figure 1d).

Figure 1a

Figure 1b

Figure 1c

Figure 1d