Mapping a Nature-Based Solution to Human-Elephant Conflict

MAHESH UNIYAL

Idea.

1. An African folktale tells of a wise elephant named Kibo who learns to respect honeybees' power after a painful encounter. While feasting on sugarcane, Kibo accidentally disturbs a beehive and endures a fierce bee attack.

2. He escapes and shares his lesson with other elephants, promoting peaceful coexistence with bees. This story highlights the wisdom of finding harmony in nature and solution to human elephant conflict.

Background.

3. Conflicts between humans and elephants result in significant monetary losses as well as human and animal deaths as well as property damage. These losses vary depending on the nature of the conflict, the area involved, and how well mitigation measures work. Given the persistent possibility of retaliatory murders, it is crucial to handle these conflicts for the safety and livelihood of humans as well as the preservation of elephants.

4. In West Bengal, a state with a large agricultural population in India, an investigation was done to look at the temporal and spatial patterns of human-elephant conflict (HEC) and the mitigation strategies used there. West Bengal has just 2% of India's elephant population, yet it has the most human casualties as a result of HEC. Between April 2010 and March 2019, West Bengal reported 726 human fatalities, 1233 injuries, 51,542.027 hectares of crop losses, 34,446 hut damages, and 136 unnatural elephant deaths directly attributable to HEC.

Concept.

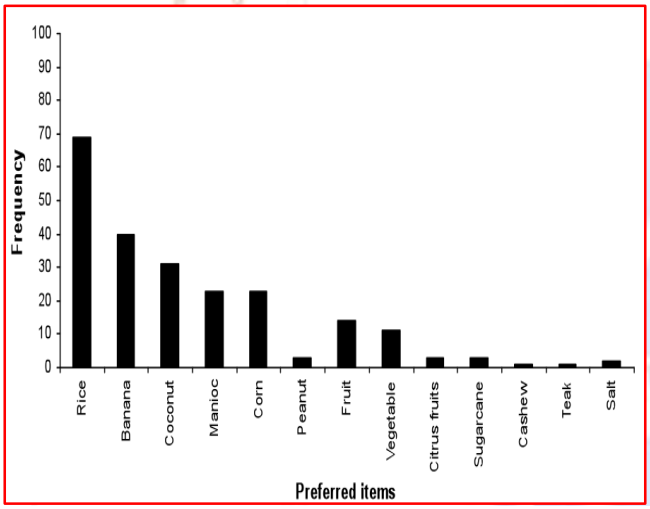
5. Various methods, including noise deterrents, repellents, trenches and more, have been employed for human-elephant conflict mitigation. ***However, bee fences and chili barriers offer a unique, sustainable, and cost-effective solution, leveraging elephants' aversion to bee stings and buzzing sound, protecting crops, and promoting honey production***.

6. This holistic approach encourages community involvement and contributes to wildlife conservation. The Concept was innovated by Dr Lucy King in 2019 and is being employed over 22 countries across the world. In India North Canara District, Karnataka, the Wildlife Research

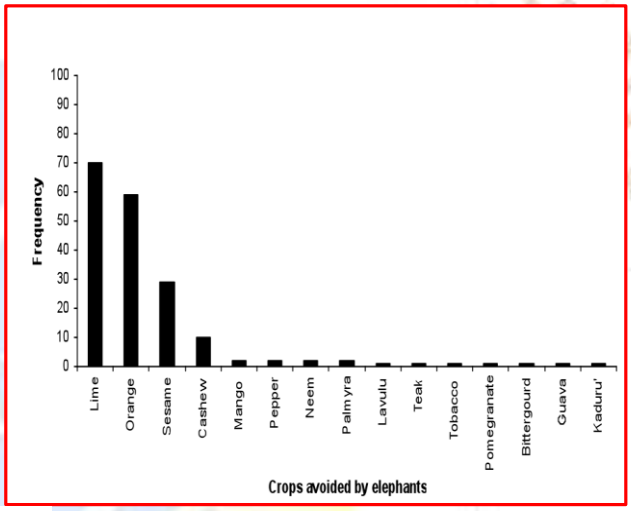
7. Conservation Society (WRCS) has introduced Community-Based Conflict Management (CBCM), empowering local communities to adopt bee-hive fences to reduce crop loss and conserve wild elephants, led by Program Officer Mr. Ravi Bandekar.

Literature Review

8. **Food Items Preferred by Elephants**. Wild elephants exhibit a broad dietary preference, consuming a wide range of crops grown by farmers. They are incredibly versatile herbivores, capable of transitioning between browsing on leaves of trees and shrubs and grazing on grasses. Unlike ruminants, elephants have a digestive system that allows them to consume a diverse array of food. In their natural habitat, ***elephants are documented to feed on over 60 plant species***, with a focus on specific plant groups like mallow family, legumes, palms, sedges, and grasses. Elephants typically graze in forests during the day and forage in agricultural areas at night, posing a particular threat to home gardens due to the high nutritional value of fruits. Crops like banana plantations, when left unprotected, face severe damage. This behavior highlights the significant role of cultivated crops in the diet of certain elephants known for chronic crop raiding. Additionally, elephants may consume bark to fulfill their calcium, trace metal, and possibly essential fatty acid (like linoleic acid) requirements. A study by Santiapillai et al. suggest fwg results as shown in graph



CULTIVATED CROPS AVOIDED BY WILD ELEPHANTS IN AGRICULTURAL AREAS.



FOOD ITEMS PREFERRED BY WILD ELEPHANTS

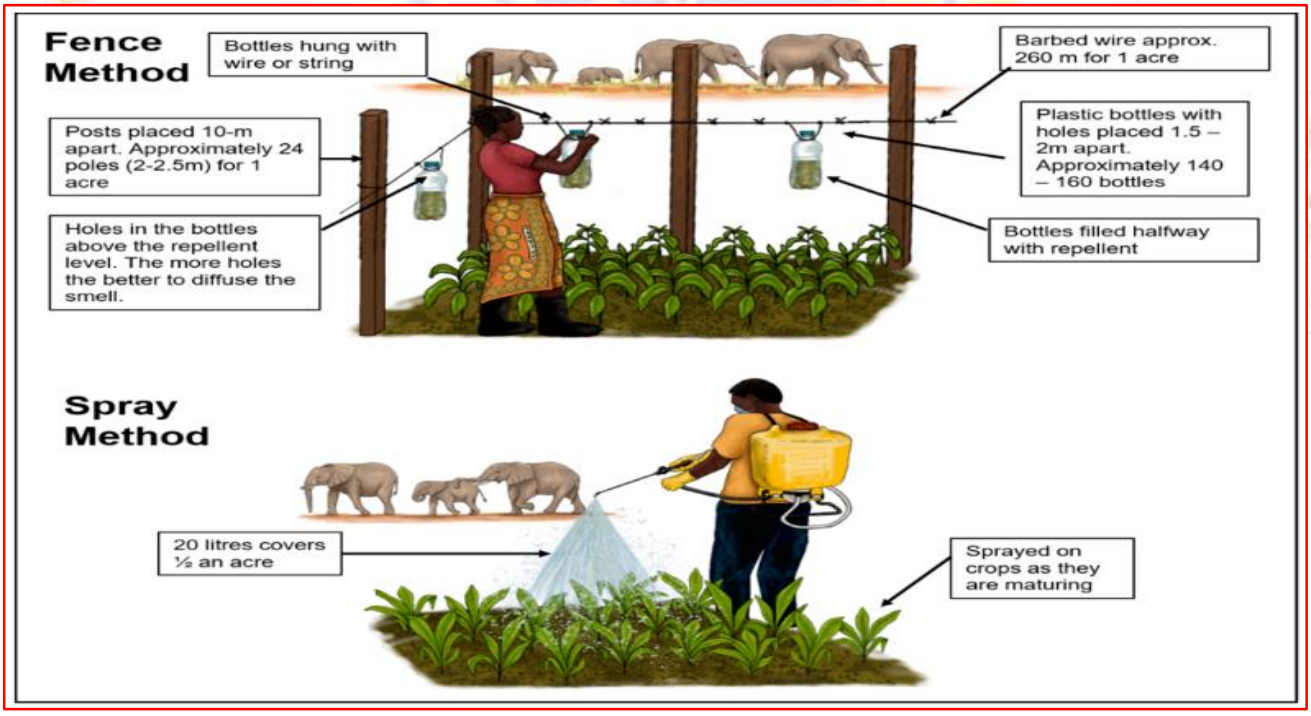
9. **Buzzing Sound Effect.** Researchers from Oxford University have demonstrated that the buzzing sound of disturbed bees unnerves both African and Asian elephants. In a study conducted in Sri Lanka, the team played the sounds of agitated Asian honey bees to Asian elephants, observing their reactions. The elephants noticeably withdrew to a greater distance and increased their vocalizations when exposed to the bee sounds, marking the first time such a response has been documented in Asian elephants. In a 2007 study conducted in Kenya's Samburu/Buffalo Springs National Reserves, researchers investigated African elephants' response to the sound of disturbed bees. They played bee buzzing sounds and natural white noise to elephant families resting under trees, capturing their reactions. The results showed that ***elephants displayed a rapid response to the bee sounds, with 94% of families leaving their resting spots within 80 seconds, while only s27% did so in response to the control sound.*** By the end of the 4-minute bee sound playback, just one elephant family (5.9%) remained stationary, contrasting with 53.3% of those exposed to the control sound. This suggests that elephants are highly sensitive to the sound of disturbed bees and react swiftly to it.

10. **Smelly Repellent Method**. The "smelly elephant repellent" has proven its effectiveness in deterring elephants from crop raiding in both Uganda and Kenya. In Uganda, it successfully deterred

82% of 309 recorded elephant crop raids, while in Kenya, it deterred 63% of 24 crop raiding incidents, showcasing its significant impact compared to control sites. The success of this olfactory-based deterrent can be attributed to multiple factors. ***Firstly, it incorporates chili peppers as a key ingredient, containing an active compound (8-methyl-N-vanillyl-6-nonenamide) known for its ability to irritate elephants' eyes and noses while stimulating their olfactory receptors***. Secondly, the repellent emits an extremely unpleasant Odor that elephants find aversive, independent of the chili factor. Anecdotal evidence from trial farmers even suggests elephants spitting out crops sprayed with the repellent that they had initially attempted to eat. ***Moreover, elephants have demonstrated aversion to other scents, including bee pheromones and predator scents***. Lastly, the repellent's potency is likely amplified for elephants, given their extensive genetic and neural capacity dedicated to olfaction. Additionally, the repellent's unpleasant smell can potentially mask the scent of ripening food crops, further discouraging elephants from approaching protected farms.

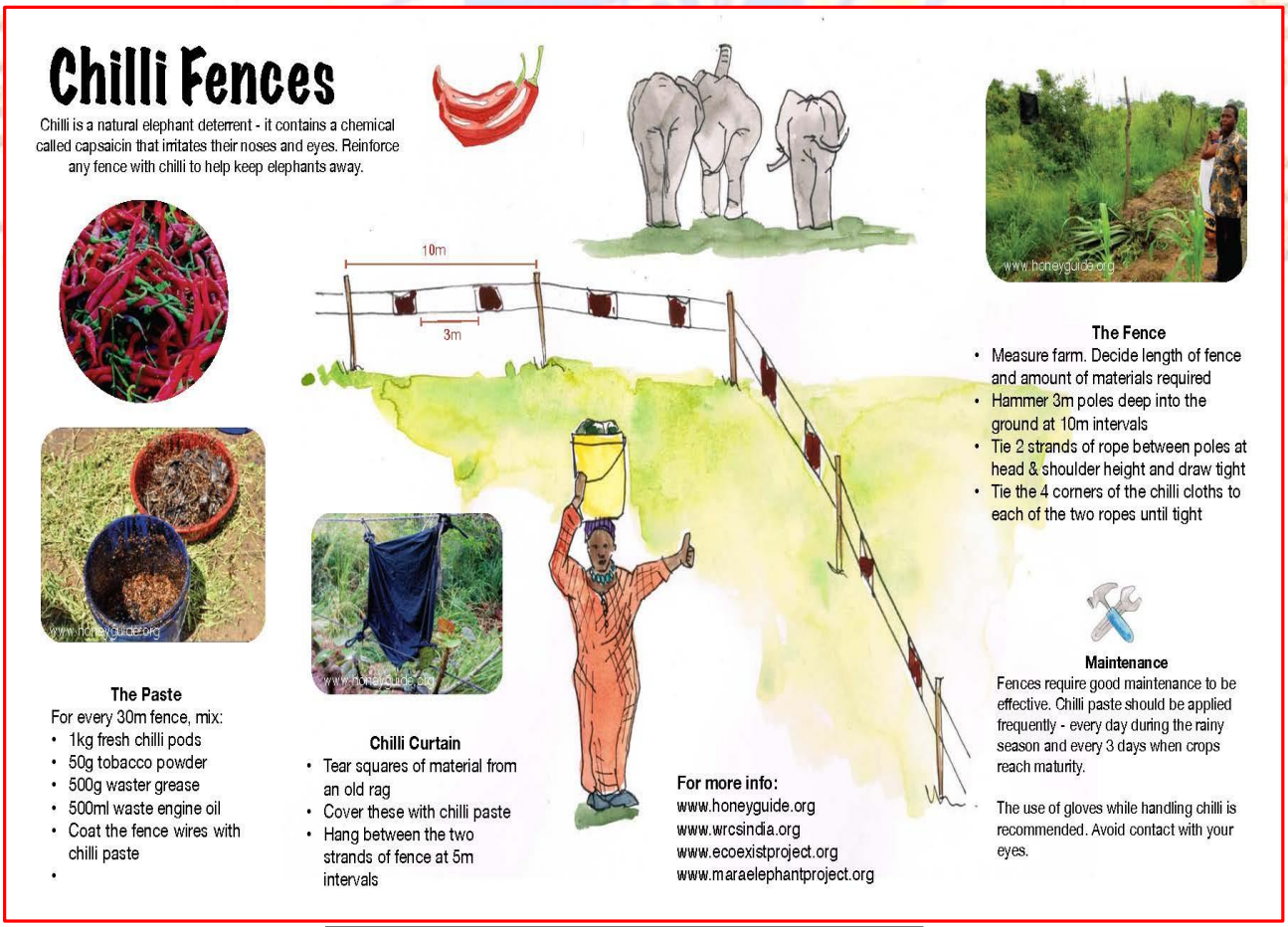
11. While effective, the repellent may lose effectiveness over time and require reapplication. Farmers view it positively for its versatility, serving as an organic pesticide and fertilizer. Its cost-effectiveness compared to alternatives like electric fencing and beehive fences makes it a promising choice for communities facing human-elephant conflict. Ongoing research is vital to assess its adaptability in diverse locations. Employing a range of approaches, including the repellent, is key to addressing human-elephant conflict, acknowledging that no single solution is all-encompassing. Conservation efforts should also target root causes like changes in land use and wildlife corridor loss

12. The smelly elephant repellent is notably more cost-effective than alternatives like electric fencing, trenches, or beehive fences, which often entail high setup and maintenance costs that can deter adoption, particularly among subsistence farmers who may lack the resources for such projects. Electric fencing, for instance, demands substantial material investments and ongoing maintenance expenses, rendering it unaffordable for many communities. In contrast, the smelly repellent holds promise as a cost-effective solution for numerous communities grappling with human-elephant conflict.



FENCE METHOD AND SMELLY SPRAY METHOD

13. **Farming Option**. This innovative use of chili plants and peppers, a non-lethal method of repelling elephants, not only mitigates human-wildlife conflict but also give manpower preservation employed for task. Elephants have an aversion to the scent of chili plants and will steer clear of them. By

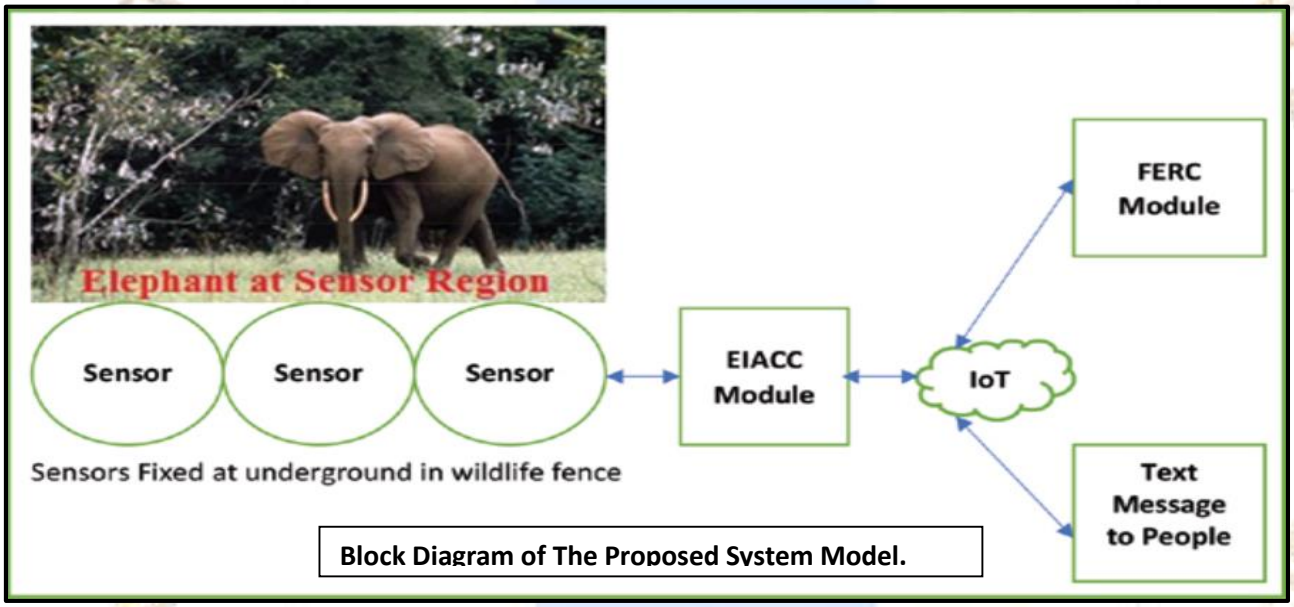


ELEPHANT AVERTED DUE TO SMELLY REPLLENT

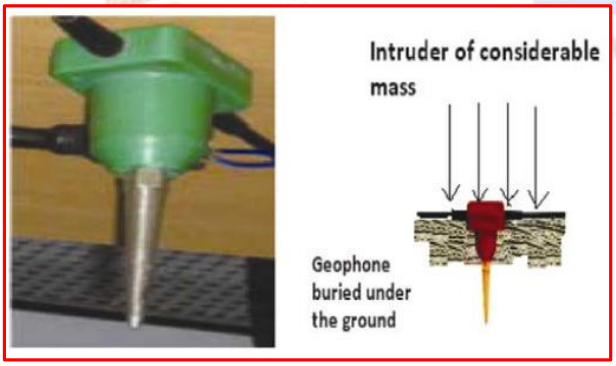
planting chili plants on the periphery of their fields, communities can avert herds of elephant. Chili peppers offer a straightforward and cost-effective solution. When compacted into blocks or combined with rice husks or cow dung and burned, the pungent aroma of chili deters most wildlife, including elephants. Chili also has a repellent effect when mixed with oil and applied to strings or rugs hung on garden edges. ***Capsaicin, the active molecule in chili*** responsible for its spiciness, reacts strongly to moisture. Elephants' trunks, rich in mucous membranes and sensory receptors, make them highly sensitive to capsaicin, causing them significant discomfort. This aversion can deter elephants from entering populated areas where they anticipate such irritation, effectively reducing HEC.

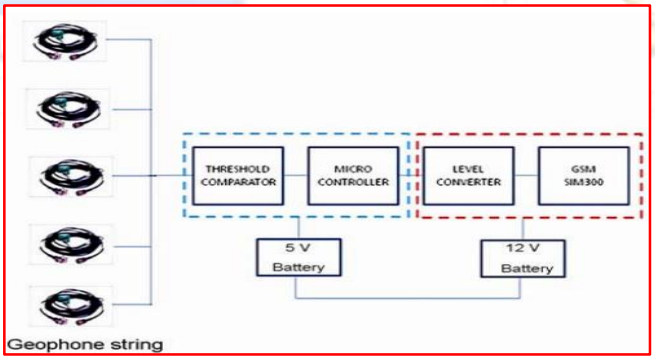
14. **Bio fences**. A number of thorny plant species such as agave, cacti and bougainvillea have been tried out as 'biological fences'. However, it is usually impractical to consistently grow such barriers to the length and depth required and without gaps to deter elephants from breaching the barrier. Additionally, because of their thick skin, the thorns prove an ineffective deterrent to elephants. In fact shrubs such as Acacia eburneum with 3-6 cm long thorns are preferred elephant food.

15. **Automated Early Warning System (AEWS)**. An automated elephant tracking device, based on infrared technology, was installed near fringe villages of Gorumara National Park, Jalpaiguri which could detect the presence of elephants within 200 m distance.



Block Diagram of The Proposed System Model.





16. Also an automatic IoT based elephant intrusion warning system specifically designed for detecting elephant intrusions into Krishnagiri villages that border wildlife reserves and alerting threatened communities of the location. It find the spectral energy magnitude of the elephant's vocal communication signal and the other to determine highest pitch frequency produced by elephants. The ultrasonic sensor detects the elephant's movements and alerts the distance from the sensor to the elephant and location of the intrusion. The sensor detects the elephant's intrusion in the wildlife fences and informs to the forest officials and people. In the Coimbatore Forest region, authorities have

devised a hardware solution designed for implementation in specific areas identified through analytical assessments along the forest borders, which serve as potential entry points for elephants into human settlements. This initiative seeks to address the ongoing challenge of elephant intrusions in the forest border regions, which occur as a result of animal migrations. The block diagram of the system is shown in Figure above.

17. The hardware setup includes geophones, a threshold comparator with amplification, an embedded controller, GSM transceiver, and power supply. Geophones detect ground vibrations caused by elephant footfalls within a 24-meter radius and trigger an interrupt when exceeding a preset threshold. The embedded controller sends SMS warnings to forest officials via GSM. Five geophones strung together cover approximately 120 square meters, allowing monitoring of elephant herds in critical areas along the forest border, improving human and elephant safety.

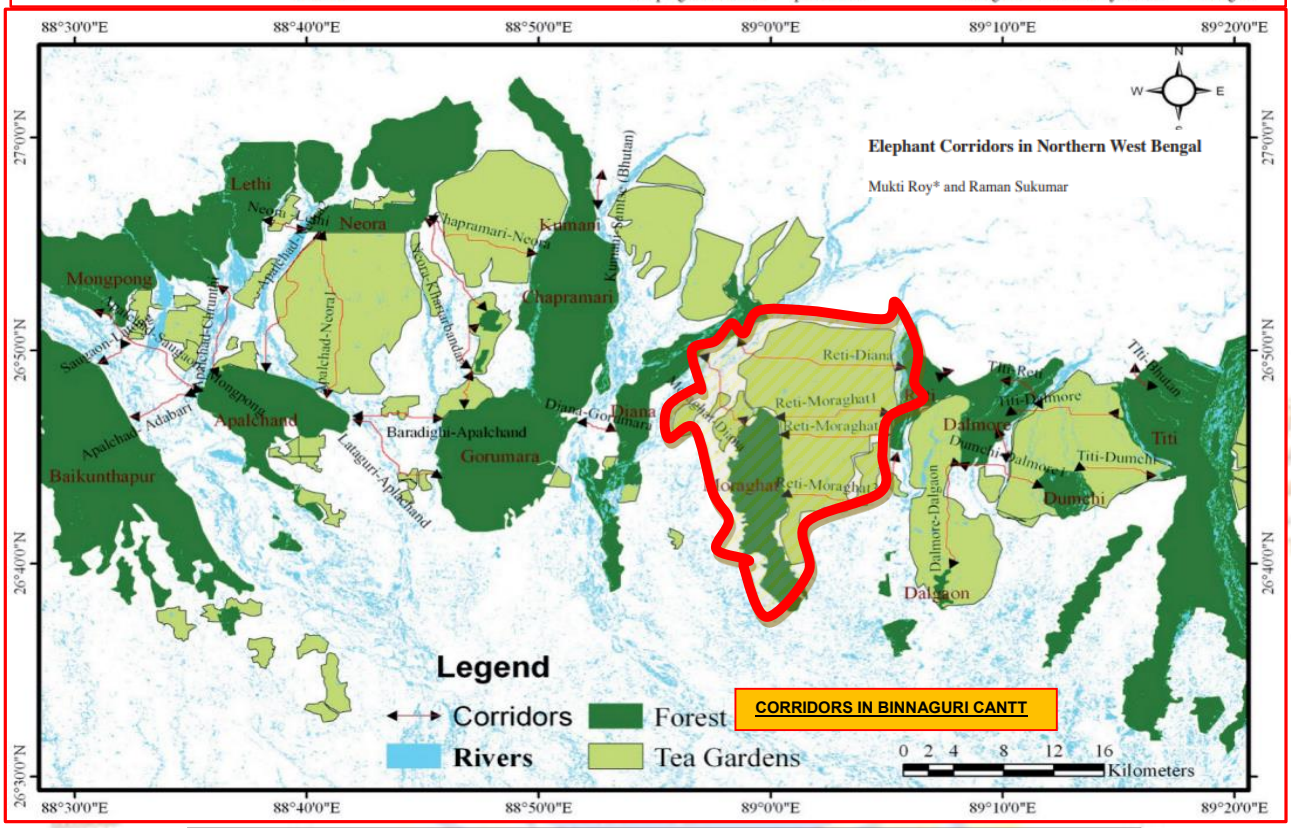
18. **Beehive Fence**. Beehive fences were first successfully trialled and implemented in Kenya by Lucy King of the Elephants and Bees Project, where it was found that the fences could exploit the African elephant's natural fear of bees. Its reported that ***human-elephant conflict there has fallen by as much as 80 percent*** and created new opportunities along the way. ***The paper focuses & discusses this method in detail in an attempt to address a decade-old problem in Binnaguri Cantonment***.

Topography of Binnaguri Cantt

19. Binnaguri cantt is a made of fragmented landscapes and enhance connectivity among forest patches, hence it is crucial to focus on preserving key corridors for elephant movement in Binnaguri cantt. The studies on the Jalpaiguri division which includes Binnaguri cant and falls in zone II of Torsa -Tista elephant corridor, many of these corridors pass through areas dominated by human activities, such as villages and tea garden labor lines, which are not ideal for facilitating unrestricted elephant movement. However, tea gardens, with their shade trees, offer a more suitable pathway compared to villages. As an initial step, efforts should be directed toward making the tea garden corridor areas free from human settlements and promoting the growth of more shade trees, enabling elephants to move between forest patches with reduced conflict. A more ambitious goal would involve transforming these corridor areas within tea gardens and human habitations into plantation forests. Such initiatives could potentially receive support in the form of carbon credits and the provision of ecosystem services.

Establishing a secure network of corridors should be a high-priority objective in conservation planning, not only for elephants but also for the benefit of other wildlife

No	Corridor	Length [km]	From Location	From Vegetation type	To Location	To Vegetation type	Corridor Via	Corridor Land-use
24	Reti - Moraghat [2]	9.0	Reti RF, Jalpaiguri FD, WB	open mixed, degraded	Moraghat RF, Jalpaiguri FD, WB	dense sal, mixed plantation	Binnaguri TG, Moraghat TG / Haldibari TG	TG, villages
25	Reti - Moraghat [3]	12.4	Reti RF, Jalpaiguri FD, WB	open mixed, degraded	Moraghat RF, Jalpaiguri FD, WB	dense sal, mixed plantation	Binnaguri Cantonment, Sarugaon basti, Shisujhumra,	TG, army, villages



ELEHANT CORRIDOR IN TISTA-TORSA INCULDING BINNAGURI CANTT

RE-HAB (Reducing Human Elephant Attacks using Bees)

20. Trenches, rail fencing, spiked pillars, electric fences, and electric wire curtains have proven ineffective and even caused tragic elephant deaths. In contrast, Project RE-HAB offers a cost-effective and non-harmful solution with numerous benefits. It reduces human-elephant conflicts, boosts farmers' income through beekeeping, combats climate change, promotes forest regeneration, and ensures food security for wildlife. Elephants share our instinctive fear of bees, and this fear is leveraged by using bee boxes as a barrier to deter them from entering human areas. Elephants are

ELEPHANT STUCK IN ELECTRIC FENCE

ELEPHANT STUCK IN TRENCH

apprehensive of honey bees potentially stinging their eyes and trunk's inner sides, and the buzzing sound further irritates them.

21. Project RE-HAB (Reducing Elephant-Human Attacks using Bees) was initiated in Karnataka in March 2021 to mitigate human-elephant conflicts. The project strategically places bee boxes connected by strings to create "bee-fences" that deter elephants from entering human-inhabited areas. This humane and cost-effective approach aims to reduce the loss of human and elephant lives and has been implemented as a sub-mission under the National Honey Mission.

22. **Key Points**. Project RE-HAB's main objective is to repel elephant attacks on human habitations using honey bees. Bee boxes are placed at locations prone to conflicts, with 15 to 20 bee boxes per location. The interconnected bee boxes release swarms of bees when triggered by elephants, deterring them from entering human areas without causing harm. The project was piloted in Kodagu district near Nagar hole National Park, known for human-wildlife conflicts. The project is initiated by the Khadi and Village Industries Commission (KVIC). Night vision cameras are installed to monitor events. Expansion plans include implementing the project in states facing similar conflicts, such as Chhattisgarh, West Bengal, Jharkhand, Assam, Kerala, Tamil Nadu, and Odisha.

23. **Significance and Benefits**: The project addresses the significant issue of human-elephant conflicts, which result in approximately human deaths and also elephant fatalities annually. It offers a cost-effective alternative to traditional methods like fences and trenches. Project RE-HAB is a humane approach, preventing elephants from entering villages without causing harm. The initiative promotes honey production and enhances farmers' incomes while reducing crop losses.

Methodology and Application.

24. **Creating Sys**. ArcGIS Survey123, a GIS app compatible with smartphones and tablets, to map elephant tracks, refine the analysis for identifying migration corridors, and create predictive models for pinpointing elephants' likely whereabouts during different seasons. Fwg methodology is involved: -

(a) **Collection**: Researchers gather data on elephant movement through various sources, such as GPS collars, satellite imagery, and field observations. This data includes information on elephant locations, migration routes, and behaviour.

(b) **Data Integration**: The collected data is integrated into the ArcGIS platform. This may involve converting data from different formats into GIS-compatible formats for analysis.

(c) **Mapping**: ArcGIS is used to create maps that display elephant movement patterns. Researchers can overlay elephant location data onto maps, allowing them to visualize the spatial distribution of elephants and their migration routes.

(d) **Spatial Analysis**: ArcGIS provides powerful spatial analysis tools that enable researchers to perform various analyses on elephant movement data. For example, they can calculate migration distances, identify key corridors, assess habitat suitability, and predict future movement based on historical data.

(e) **Modelling**: Researchers can develop predictive models within ArcGIS to forecast elephant movement patterns. These models may take into account environmental factors, seasonal changes, and historical movement data to predict where elephants are likely to be at specific times.

(f) **Data Visualization**: ArcGIS allows for the creation of interactive and informative data visualizations. These visualizations can be shared with conservation organizations, government agencies, and the public to raise awareness about elephant movement and conservation efforts.

(g) **Decision Support**: The insights gained from ArcGIS analysis and modelling can inform decision-making processes related to elephant conservation. Conservationists can use this

information to plan protected areas, implement mitigation strategies for human-elephant conflict, and prioritize conservation efforts.

(h) **Monitoring and Reporting**: ArcGIS provides real-time monitoring capabilities, allowing researchers to track elephants continuously. Any changes in movement patterns or unusual behaviour can be quickly identified and addressed.

25. **Understanding the Conflict**. Fwg points be adhered to for a holistic solution: -

(a) Engaging extensively with members of the surrounding areas and locals who are dealing with conflicts involving elephants and then determine the frequency and timing of these conflict events, whether they occur daily or seasonally, and if they happen during the day or night.

(b) Identifying the composition of elephant groups involved, whether single bulls or family herds, and inquire about the locals' expectations regarding assistance during these events.

(c) Assessing any underlying conflicts exist between the locals and the wildlife department, adding to the stress.

(d) Examining the reasons for elephants encroaching on farms or properties and investigating whether they are seeking food or water, if certain crops attract them, or if the property obstructs natural elephant migration routes. *Addressing the conflict's root causes may involve ensuring elephants have access to water sources*, *enabling free movement in natural bush areas for foraging, or relocating fences blocking migration paths*.

(e) External factors like livestock grazing inside a neighbouring national park can also influence elephant movement. Eliminating human-induced structures or triggers can lead to long-term conflict reduction. Encouraging the surrounding areas and locals to map elephant movements concerning the conflict. For instance, if elephants enter a school compound, have a teacher draw a plot map showing the elephants' typical entry points. Identifying weak spots in boundary defences that require focused investment in deterrents, optimizing limited resources. *These maps serve as records and facilitate before-and-after comparisons to assess the impact of protective measures*.

(f) **Terminology**. Understanding the conflict also entails understanding terminology associated with elephant behaviour. Few of them are listed below: -

(i) **Infrasonic rumbles**. Elephants emit low-frequency rumble vocalisations that can occur below the limit of the audible hearing range of humans (typically below 20Hz). Infrasonic rumbles allow elephants to communicate with each other over great distances.

(ii) **Migration corridors**. These are protected strips of natural habitat that allow animals to move safely between one protected area and another. They help to keep populations of the same species connected, which is essential for both genetic diversity and for seasonal dispersal for animals to access food and water supplies.

(iii) **Referential signalling**. Elephants produce an acoustically distinct alarm call that warns other elephants about the specific threat of honey bees. This alarm call (the signal) is so specific that the listener will learn quickly that there are bees (the reference) nearby. Once this information is communicated, these elephants can make an informed decision as to how to react and ultimately learn to avoid getting stung.

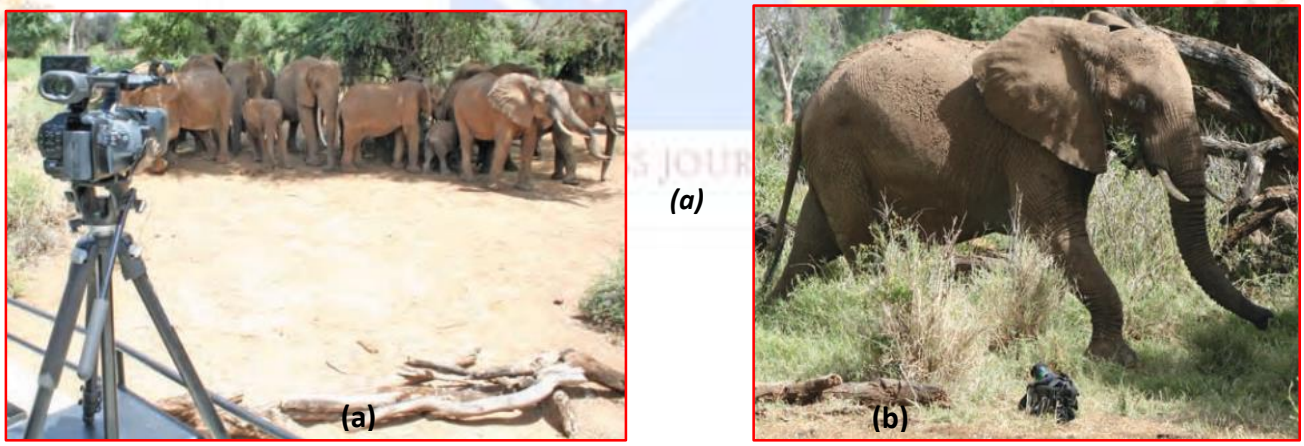
25. **Understanding Wild Elephant Behaviour**. ***Save the Elephants***, a research organization in Kenya, focused on studying natural elephant behaviour to find solutions for human-elephant conflicts. The research found fwg points

(a) They discovered that elephants avoid acacia trees with active beehives, prompting questions about elephants' fear of bee stings, their memory of hive locations, and the potential use of live beehives to deter elephants from farmland. The most innovative aspect of this study was the idea of using live beehives as an active deterrent to discourage elephants from entering farmlands. This approach could potentially provide a humane and effective solution to mitigate human-elephant conflicts and protect both the local communities and the elephants themselves.

Lucy with members of the local community finishing building a beehive fence at Tsavo, Kenya

(b) **Bee**

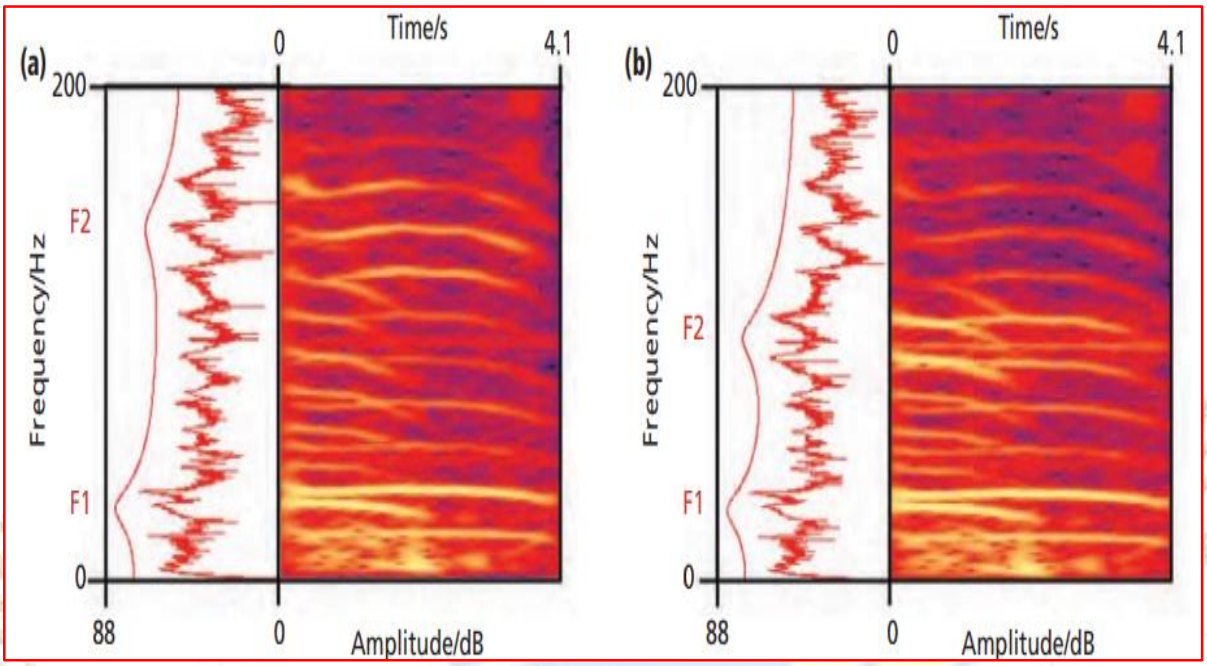
Playback Experiments. In same study on elephant reactions to bee sounds, researchers played high-quality recordings of disturbed bee sounds from a wild colony of African honeybees to different elephant families. They used a concealed wireless speaker system placed within bushes, positioned 10–20 meters away from resting elephants. The results were striking, as 16 out of 17 elephant families reacted by running away while shaking their heads, apparently to deter bees.



(a)

Camera set up to film the reaction to the sound of disturbed bees of an elephant family resting under a tree (b) Sensitive Earthworks microphones placed near the elephants during the experimental playback trials captured their infrasonic response to disturbed bees as they moved away.

(c) Notably, retreating elephants emitted as a warning to others about the bee threat. Using sensitive Earthworks microphones, capable of recording infrasound below the average lowest human hearing range of 20Hz, researchers found that these rumbles had elevated vocal structures compared to those emitted in response to control white noise. Additionally, when the sound of Samburu warrior voices was played, elephants produced a different structured alarm call, suggesting that elephants use different calls to signal various threats in their environment, a phenomenon known as ***referential signalling***. This discovery could have significant implications for conservation efforts and our understanding of how elephants perceive different threats in their environment. A recordable frequency spectrograph as below shows same thing



Frequency spectrograms of elephant rumbles in response to (a) the bee playback stimulus showing two formants (peaks, F1 and F2) that indicate where the stress in the vocal chords emphasises the communication information in the elephant rumble (b) Representative spectrogram of a typical elephant rumble from those recorded in response to control white noise playback. Note the different position of F2.

(a) an elephant closing its eyes when touching the fence, (b) an elephant spreading its ears, and (c) an elephant retreating with its tail in the air. Overall, 70.7% of behaviors suggested a heightened level of attentiveness or alarm

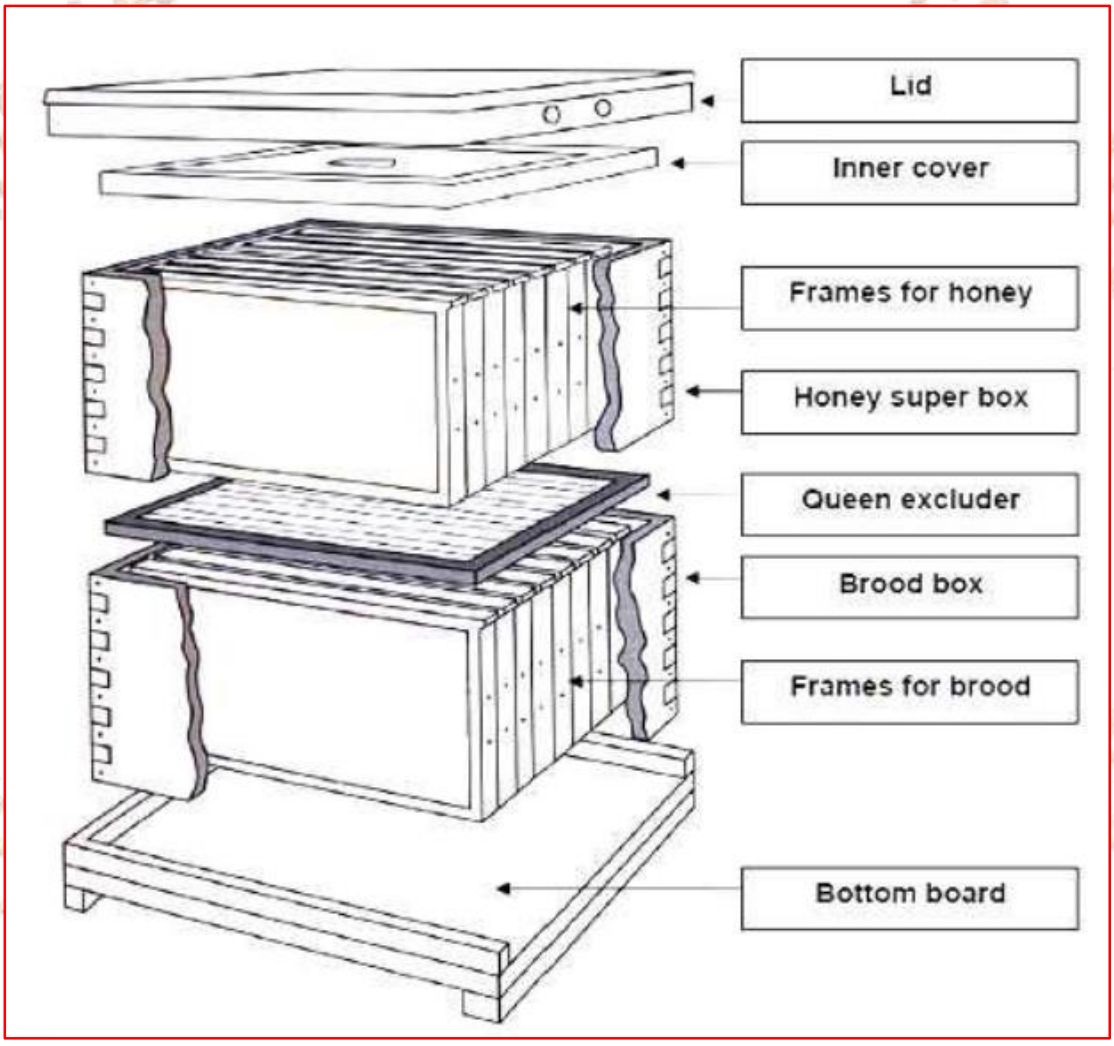
26. **Application**. Beehive fences are structures set up to prevent elephants from entering farmlands and causing damage. These fences can be constructed using different types of beehives, with the following three being the most commonly used:

(a) **The Langstroth Hive**. This is a popular beehive design that consists of rectangular boxes stacked on top of each other. It allows for the easy removal of honeycombs and is widely used in beekeeping operations methodology is adopted for application as follows: -

(j) Langstroth beehives are made of rectangular or square boxes that fit snuggly one on top of the other.

(ii) The larger brood chamber on the bottom contains a set of frames usually containing a thin foundation strip of beeswax that is held in place with fine strips of wire.

(iii) Once the bees have occupied the brood chamber and built up the foundation combs with beeswax and brood, a second 'super' box should be placed on top.



(iv) In between the two boxes lies a queen excluder wire mesh that lies as a horizontal sheet over the top of the brood chamber combs. This prevents the queen from traveling up into the super box which allows the worker bees to fill the super with a pure wax comb and honey stores. This is the section that you harvest for honey leaving the brood chamber alone.

(v) The posts between each bee hut should be 7m apart. The second post for hanging the beehive should be 3m apart.

(vi) The wooden posts should ideally be 8 or 9 foot long and need to be treated with an insecticide from top to bottom and left to dry thoroughly before embedding into the ground.

(vii) The iron sheet roof will keep the bees dry in the rain but if left in the sun the hive will overheat and the bees will become aggressive and leave.

(viii) Each beehive in the fence should be linked to each other with a strong piece of plain wire which should loop through the wire hanging the beehive and, crucially, must be on the inside of the farm so the beehives will swing should an elephant try to enter the farm.

(b) **The Top-bar Hive**. In this hive design, bars are laid horizontally across the top, and bees build their combs downward from these bars. It's a simpler and more natural beehive design often preferred by small-scale beekeepers. The methodology is as follows: -

(i) This beehive fence is comprised of two elements, the 'bee hut' and the connecting wire linking one beehive to the next with a gap of 7m between the post of one bee hut and the next

(ii) The bee hut houses an 80cm long Top Bar Hive constructed out of 9mm plywood and designed so that three beehives can be made from one large 2.4 x 1.8m industrial plywood sheet.

(iii) The rain-proof roof is made from a corrugated iron sheet and is protected from the sun by a flat thatched roof.

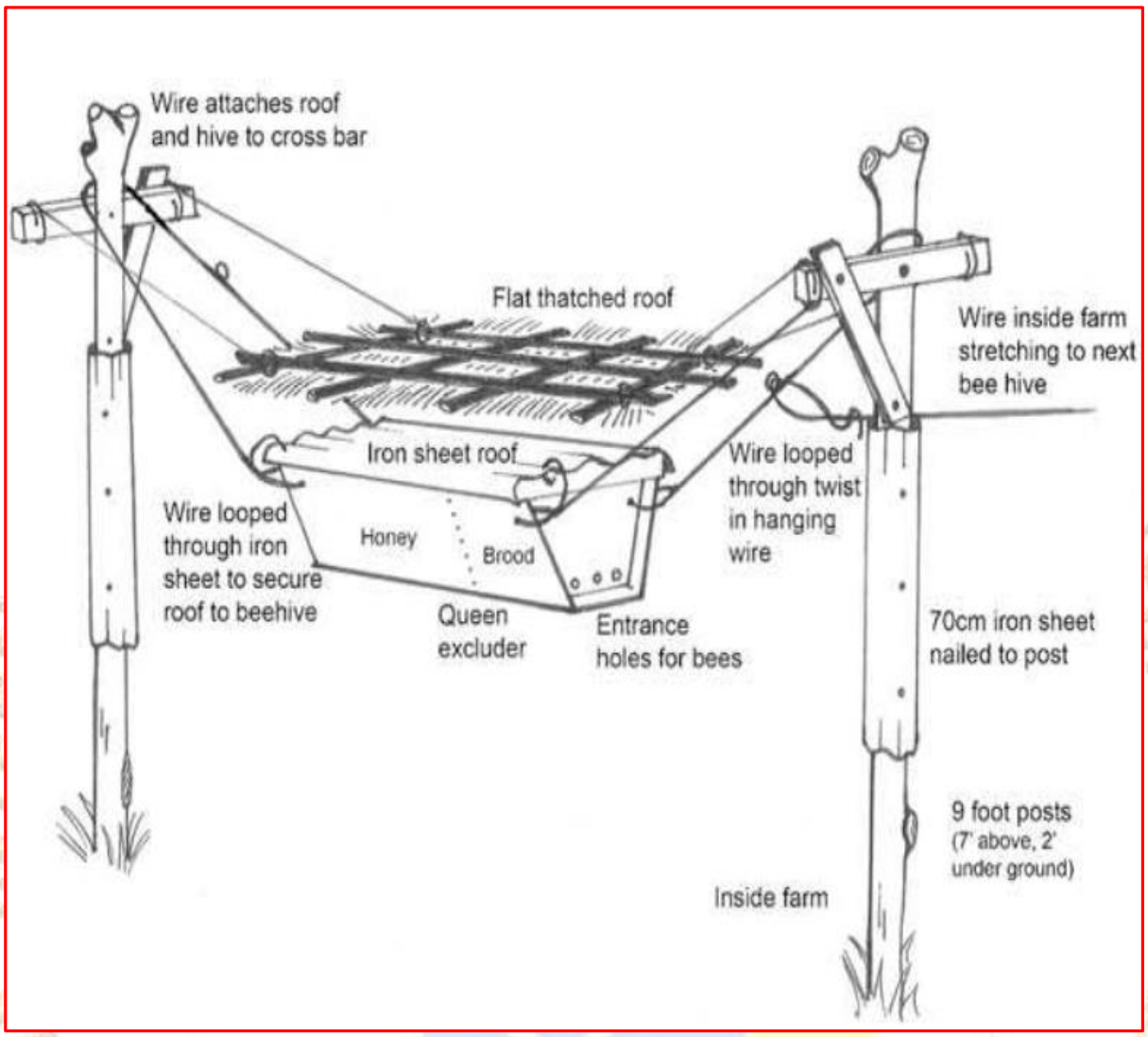
(iv) The roof is hung by thin binding wire, too thin for honey badgers to crawl down should they succeed in bridging the protective 70cm iron sheets nailed to the posts.

(v) The 9-foot posts must be coated in a cheap oil-based insecticide to prevent termites.

(vi) The hive is hung by drilling small holes in the side walls of the hive and feeding through a stronger plain wire. This is looped easily around the top of the upright posts and once through the hive the ends can be secured to the roof by drilling a small nail size hole.

(vii) A simple twist of the hive's hanging wire on the farm side of the bee hut enables a strong piece of plain wire to attach one beehive to the next beehive 10 meters away.

When an elephant attempt to enter the farm, he will instinctively try to pass between the bee huts and as the wire stretches the pressure on the beehives will cause them to swing erratically and, if occupied, release the bees. The wire is only looped through the hoop, not twisted tightly back onto itself, so that excessive pressure from an elephant will release the wire rather than pulling down the hive.



(c) **The Ware Hive**. This hive design is similar to the Langstroth hive but with standardized dimensions. It's widely used in commercial beekeeping due to its ease of management and honey extraction.

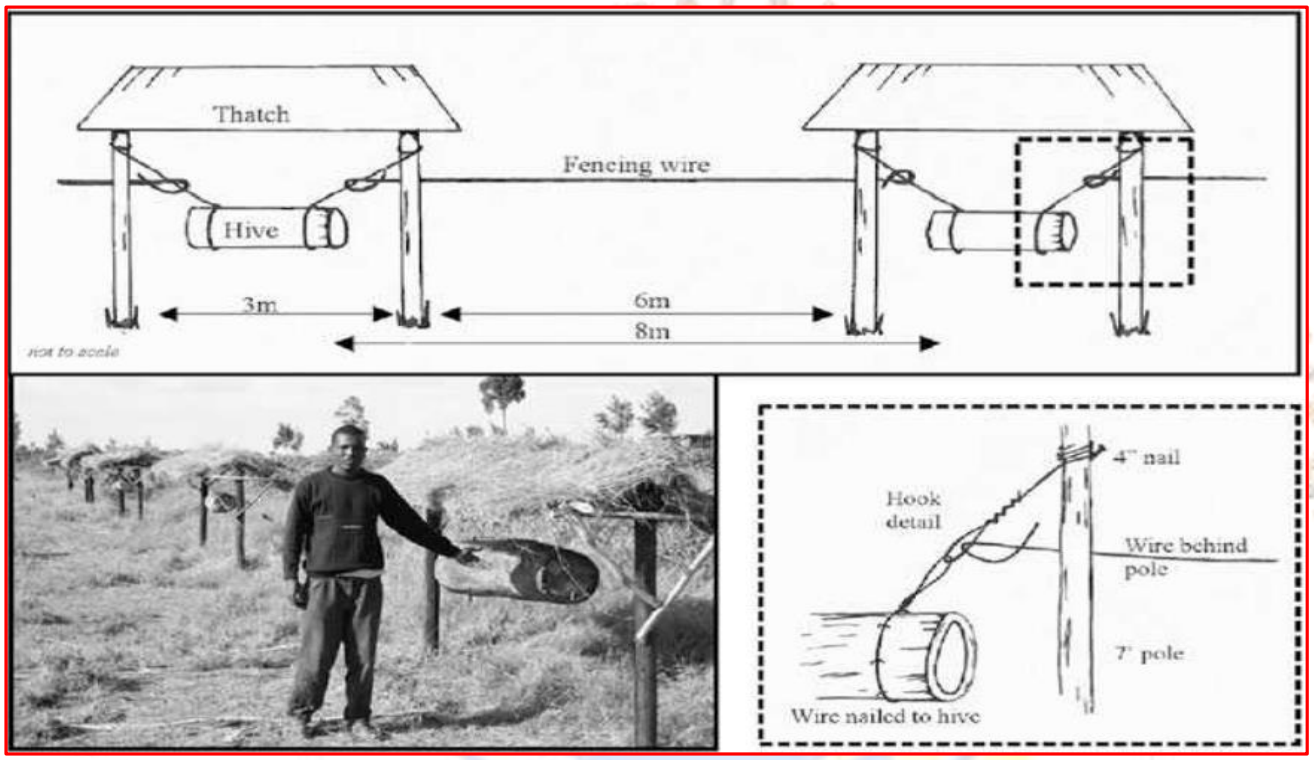
(d) **Beehive fences using Traditional Log Hives**. Fwg steps needs to be implemented to for this method: -

(i) The bee hut posts are spaced 6m. apart allowing the hives to be spaced 8m. apart.

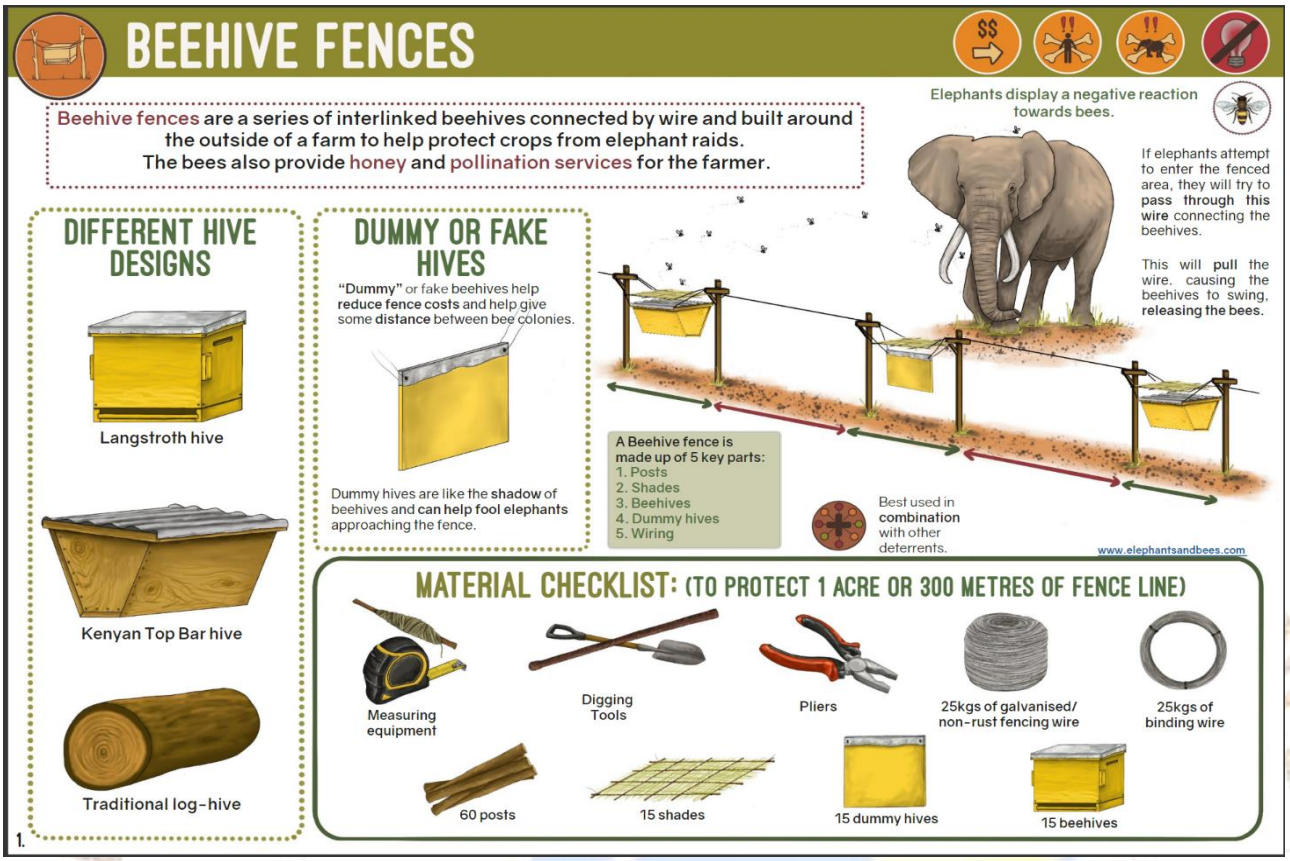
(ii) The beehives should be able to swing freely, suspended only by tightly secured fencing wire to the top of the posts.

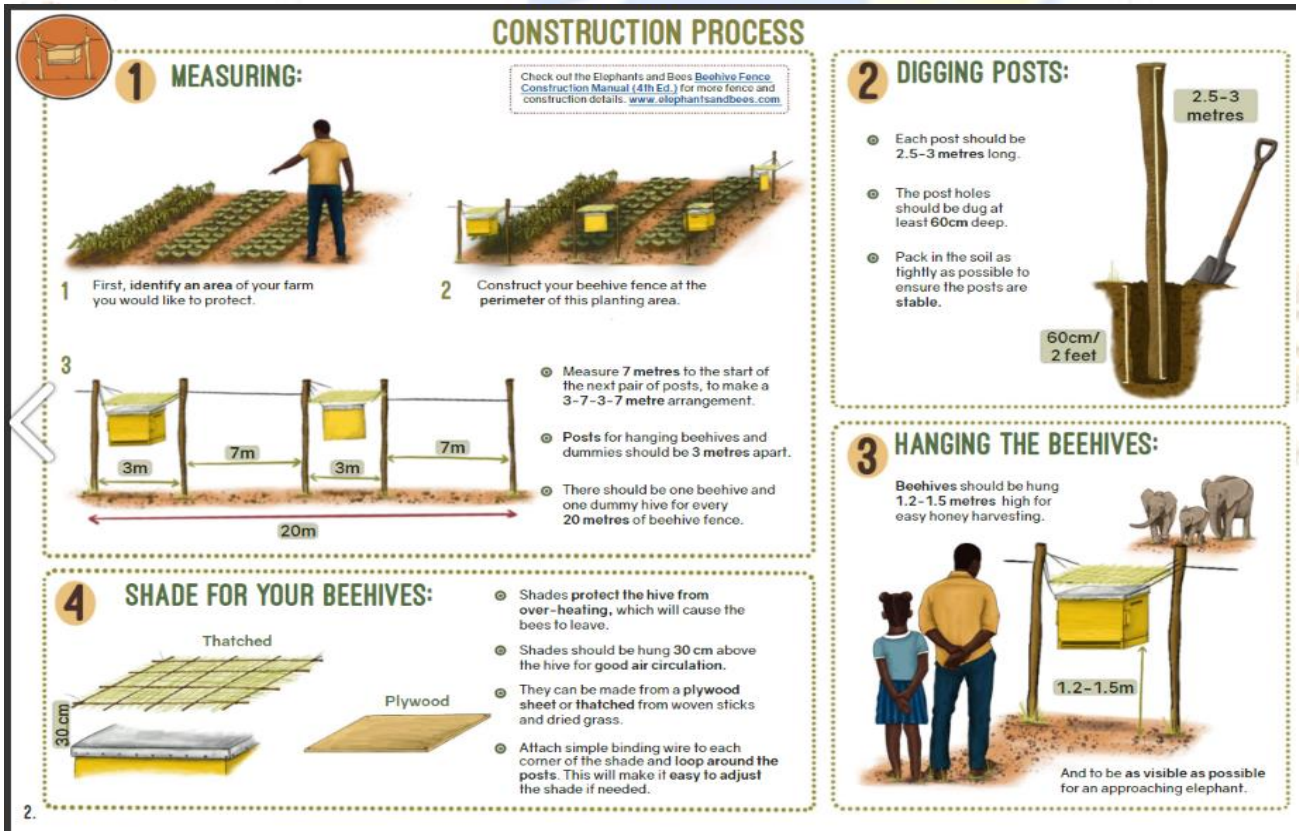
(iii) Each hive should be linked to each other with strong, taut, fencing wire that hooks to the centre of the permanent wire of each hive and must be, crucially, behind the upright posts on the crop side of the fence.

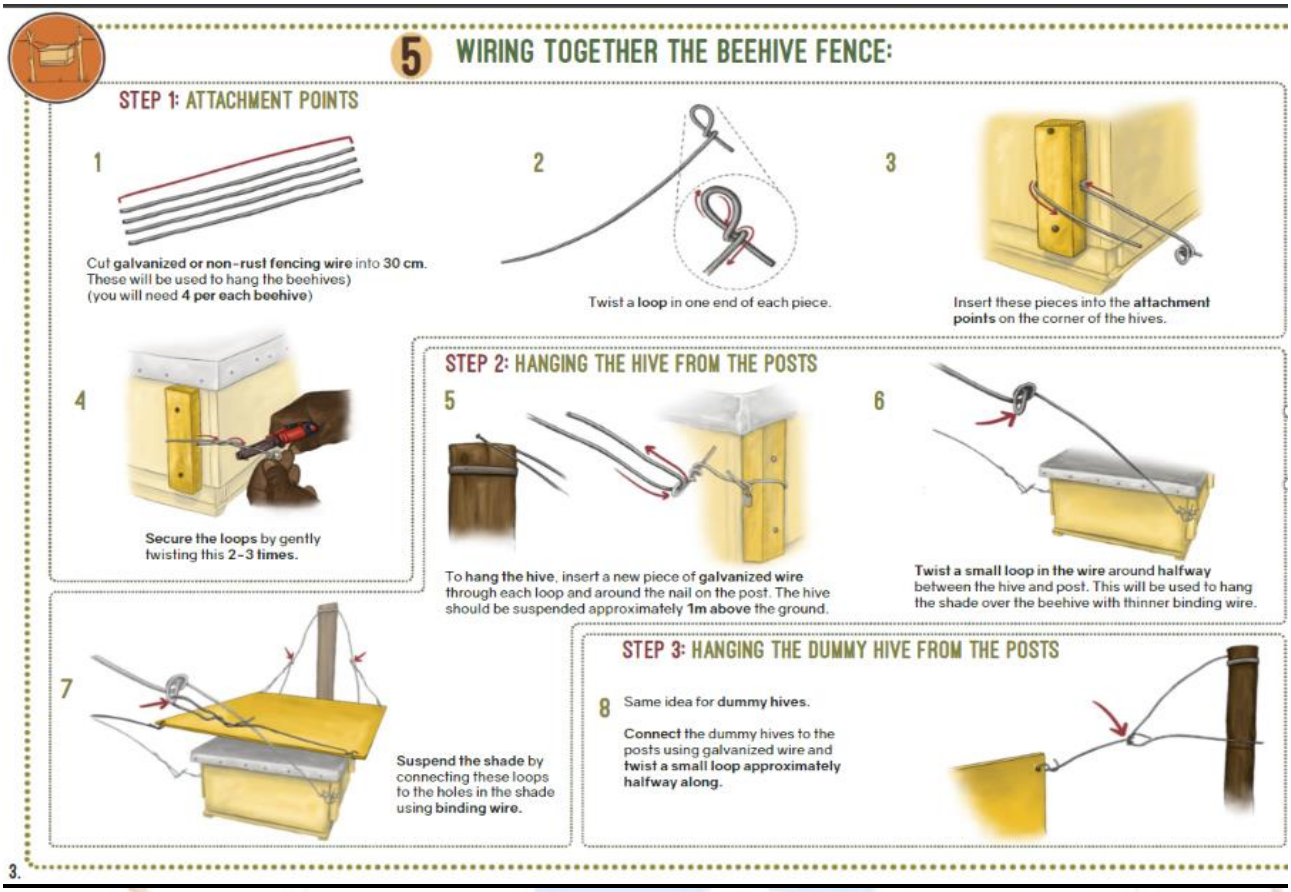
An intruding elephant trying to enter the field will avoid the complex solid structure of the bee huts and will be channelled between them. As the elephant tries to push through the thigh-high wire it causes the attached beehives to swing violently, thereby disturbing and releasing the bees to irritate or sting the elephant.

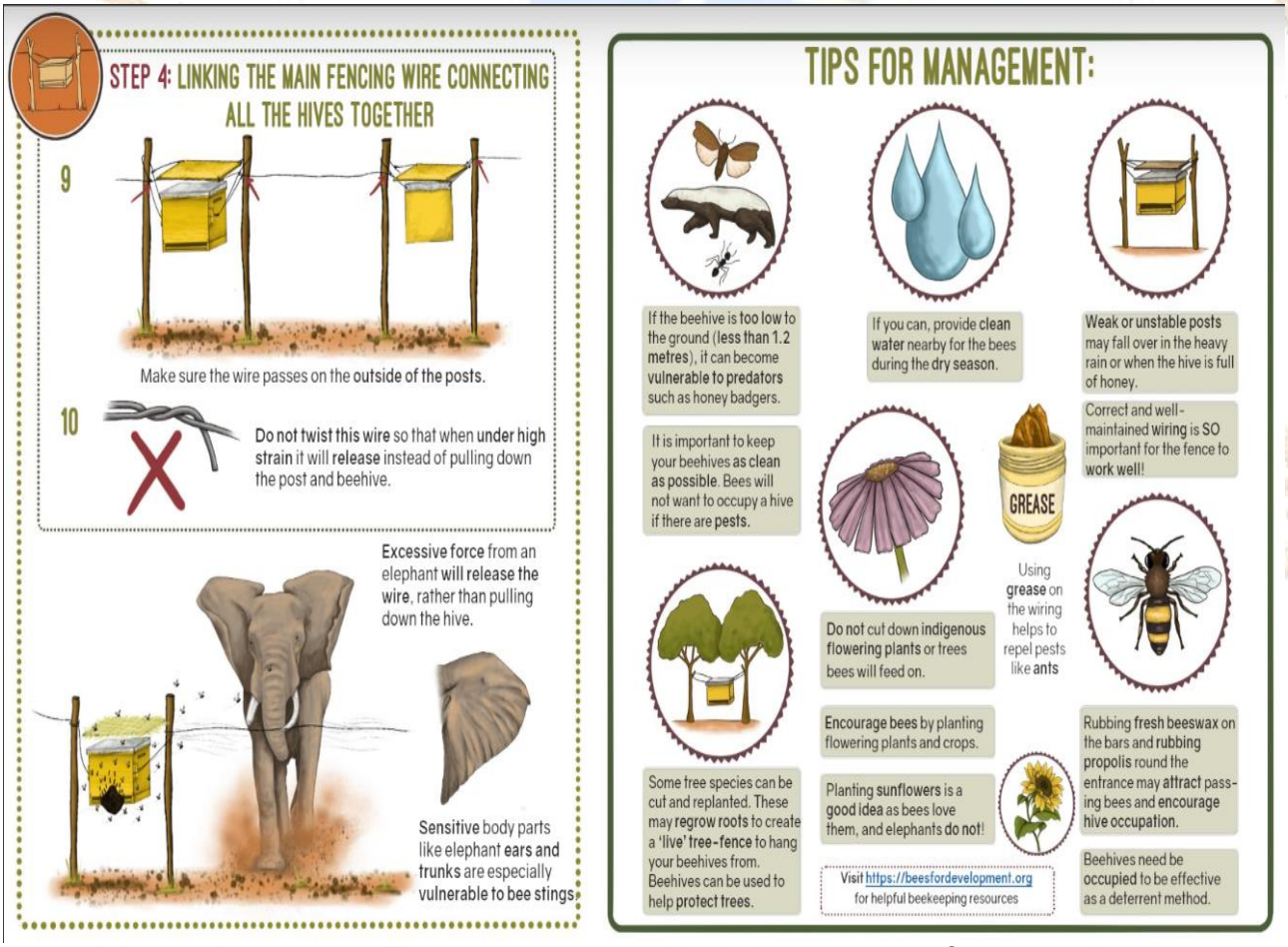


27. **Picture Guide for installation of Beehive Fence**. A toolbox pictures from *savetheelephants.org* explain the installation process simply as shown below:-









28. **Discussions**. The paper above highlights the significant challenges posed by the interaction between elephants and human populations, particularly in and around Binnaguri military cant area where elephant habitats overlap with agricultural lands and human settlements. It discusses various strategies and initiatives aimed at mitigating this conflict, with a focus on the use of beehive fences as a non-lethal deterrent. Few important discussion and keynotes which emerges are as below:-

(a) **Severity of the Conflict**. The paper emphasizes on the severity of human-elephant conflict, which often results in casualties and economic losses for both humans and elephants. The conflict arises from elephants entering military cantt in search of food, water, or due to blocked migration routes.

(b) **Alternative Solutions**. One of the key takeaways is the exploration of non-lethal, innovative approaches like beehive fences. These fences utilize the natural aversion elephants have to bees to deter them from entering crop fields, human community and thus reducing the conflict.

(c) **Environmental Impact**. The use of beehive fences and similar strategies highlights a growing awareness of the importance of conservation and coexistence between humans and wildlife. These approaches aim to protect elephants without harming them, contributing to biodiversity conservation.

(d) **Economic Benefits**. Implementing such solutions can have economic benefits for farmers by reducing crop losses and increasing honey production. Moreover, ***these approaches are often more cost-effective than traditional methods like electric fencing***.

29. **Conclusion**. The paper underscores the urgent need to address human-elephant conflict and highlights the potential of innovative, non-lethal solutions like beehive fences. By promoting coexistence and minimizing harm to both humans and elephants, these approaches offer a promising way forward. Additionally, these strategies align with broader conservation goals and contribute to sustainable practices in regions where such conflicts are prevalent. However, continued research and community involvement are essential to refine and adapt these methods for various contexts and ensure their long-term effectiveness. Ultimately, comprehensive solutions that consider the needs of both humans and elephants are crucial to reducing the impact of this conflict and fostering harmonious coexistence.

30. **Recommendation**. Based on above study, literature compiled and reviewed fwg recommendations are suggested to mitigate HEC:-

(a) **Mapping Elephant Corridors with GIS and Drone Surveys**. To Continue and expand the use of Geographic Information Systems (GIS) and drone surveys to map elephant corridors accurately. Utilize advanced technologies to monitor elephant movement patterns and identify key migration routes if any.

(b) **Earmarking External Entry and Exit Points for Elephants**: To Collaborate with wildlife experts and local communities to identify external entry and exit points that elephants use to access human habitats. Implement monitoring and early warning systems near these points to track elephant movement.

(c) **Implement a Multi-Layered Approach**: Combine various deterrent methods, such as beehive fences, chilli-based repellents, and noise-based devices, to create a multi-layered obstacle system. Ensure that these deterrents are strategically placed in areas prone to elephant intrusion.

(d) **Liaison with Government Agencies for Beehive Projects**: Collaborate with relevant government agencies like Khadi and Village Industries Commission (***KVIC***) responsible for wildlife conservation and rural development to launch elephant beehive projects. Seek government support and funding for the expansion of such projects in conflict-prone regions.

By implementing these recommendations, it is possible to reduce human-elephant conflict, protect both human and elephant lives, and contribute to the conservation of these magnificent creatures while fostering harmonious coexistence between humans and elephants.

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