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Elephant Mortality Cases in Peninsular Malaysia (2015-2024): Trends, Causes and Conservation Challenges

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Abstract

Elephant mortality in Peninsular Malaysia has become an increasing conservation concern due to human–elephant conflict (HEC), habitat encroachment, and anthropogenic threats. This study analyzed elephant mortality data from 2015 to 2024, categorizing 175 recorded deaths into illegal killings, management-related cases, natural mortality, and other unclassified causes. Illegal killings accounted for 37% of all cases, primarily due to poisoning (59%) and poaching (35%). Management-related deaths (19%) were associated with post-capture stress, self-defence shootings and suffocation. Natural causes and accidental human-induced deaths each comprised 19% and 14% of mortalities. Thirteen elephants were confirmed roadkill victims, with hotspot locations identified along the East–West Highway (Perak) and the Kota Tinggi–Mersing and Kluang–Mersing roads (Johor). An additional elephant mortality caused by a train collision was documented in 2024. These findings underscored the urgent need for enhanced anti-poaching measures, improved road safety interventions at identified hotspots, and refined management protocols to mitigate human-elephant conflict and reduce preventable deaths.

1. Introduction

The Asian elephant (*Elephas maximus*) is classified as Endangered on the IUCN Red List, with populations declining across its range due to habitat loss, fragmentation, and human-induced mortality [1]. In Southeast Asia, remaining elephant populations face unprecedented pressures from agricultural expansion, infrastructure development, and human-elephant conflict (HEC), which has emerged as a primary conservation challenge [2]. Peninsular Malaysia supports an estimated population of 1,223–1,677 wild elephants, primarily distributed across the states of Pahang, Perak, Johor, Kelantan, and Terengganu and Kedah and Negeri Sembilan [3]. These populations are increasingly isolated in fragmented forest patches surrounded by oil palm plantations, agricultural land, and human settlements [4]. The resulting spatial overlap between elephant ranging areas and human-dominated landscapes has intensified HEC incidents, leading to crop damage, property destruction, human injuries, and elephant mortalities [5]. Human-induced elephant mortality represents a critical threat to population viability, particularly given the species' slow reproductive rate and long generation time [6],[7].

Previous studies in Asia have documented various mortality causes including poaching for ivory and body parts, retaliatory killings following crop raids, electrocution from illegal electric fences, poisoning, vehicle collisions, and deaths resulting from capture and translocation operations [7],[8]. In Malaysia specifically, elephant mortality has been attributed to both intentional killings and accidental deaths associated with infrastructure development and HEC mitigation efforts [3],[6]. Despite the recognized importance of mortality monitoring for elephant conservation, comprehensive analyses of mortality patterns and causes in Peninsular Malaysia remain limited. Long-term mortality data are essential for identifying primary threats, assessing the effectiveness of conservation interventions, and informing evidence-based management strategies [9]. Road infrastructure expansion has been identified as an emerging threat to wildlife across Southeast Asia, with vehicle collisions increasingly documented for large mammals including elephants [6],[10].

Understanding the patterns, causes, and spatial distribution of elephant mortality is crucial for developing targeted conservation actions and mitigating preventable deaths. This study presents a comprehensive decade-long analysis of elephant mortality in Peninsular Malaysia from 2015 to 2024, examining temporal trends, mortality causes, and spatial patterns to inform conservation planning and management interventions. By systematically documenting mortality events over a decade, categorizing causes of death, and identifying high-risk areas, this research addresses critical knowledge gaps that have hindered effective conservation action. The findings are particularly timely given the escalating pressures on elephant populations from habitat fragmentation, infrastructure development, and human-wildlife conflict, and will directly inform the National Elephant Conservation Action Plan (NECAP 2.0), guide prioritization of conservation investments, and support the development of evidence-based policies for achieving human-elephant coexistence in increasingly human-dominated landscapes.

2. Methodology

2.1 Study Area

The study encompassed Peninsular Malaysia, focusing on the key elephant habitat in the states of Pahang, Perak, Johor, Kelantan, Kedah, Terengganu, and Negeri Sembilan. These states contain the majority of remaining elephant habitat, consisting primarily of lowland and hill dipterocarp forests, interspersed with oil palm and rubber plantations, agricultural areas, and human settlements [10].

2.2 Data Collection

Elephant mortality data were compiled from multiple sources including Department of Wildlife and National Parks (PERHILITAN) Peninsular Malaysia mortality records, post-mortem examination reports conducted by wildlife veterinarians, field investigation reports from wildlife officers and rangers, autopsy findings and forensic analyses, and media reports and verified public sightings. All recorded elephant deaths from 1st January 2015 to 31st December 2024, were included in the analysis. For each mortality case, the following information was extracted where available: date of discovery or incident, location (state and specific site), estimated age class (calf, juvenile, adult), sex, cause of death, and circumstances surrounding the mortality event.

2.3 Mortality Classification

Elephant deaths were categorized into five primary categories based on cause of death determined through post-mortem examination and field investigation. The illegally killed category comprised elephants whose death was due to voluntary human actions, with the intent to kill the animal, and where the killing was not legally permitted. These deaths resulted from deliberate shooting, deliberate poisoning, unintentional poisoning, trapping, snares, other traps, and electrocution. Management-related deaths encompassed mortalities associated with wildlife management operations, including post-capture stress and complications following translocation, self-defense shootings during authorized HEC response operations, deaths during capture or immobilization procedures, and suffocation or restraint-related mortality.

Natural death is defined as death due to natural occurrences or phenomena where no human interferences or obstacles cause death. This category includes old age, naturally occurring pathogens and diseases, intraspecific fighting, falling into a pit or trench, falling off a cliff or ravine, drowning in natural water bodies, and drowning in water wells or reservoirs. Accidental deaths caused by humans were defined as elephants that have been accidentally killed because of human actions. These circumstances are recorded under "Other" in the type of death classification in the CITES-MIKE Programme [37]. This category included falling into pits or trenches, accidental electrocution, collision with vehicles, and drowning in water wells or reservoirs. Cases with insufficient evidence or multiple contributing factors were classified as "Not Sure/Unclassified."

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2.4 Data Analysis

Geographic coordinates were recorded for all mortality cases where precise location data were available. Roadkill incidents were mapped using GIS software (ArcGIS 10.8) to identify mortality spatial distribution relative to major road networks, elephant habitat, and known elephant corridors. Descriptive statistics were calculated to summarize mortality frequencies, proportions, and temporal patterns. A chi-square test of independence was conducted to examine whether there is a significant association between the year of mortality and the cause of death among elephants from 2015 to 2024. The null hypothesis (H_0) assumes no association between year and cause of death, meaning the distribution of mortality causes remains independent of temporal factors. The alternative hypothesis (H_1) proposes that a significant relationship exists between these variables, suggesting that certain years are associated with specific patterns of mortality causes. Statistical significance was set at $p < 0.05$. All analyses were conducted using SPSS Statistics (Version 27).

3. Results

3.1 Temporal Mortality Trends

A total of 175 elephant deaths were recorded in Peninsular Malaysia during the ten-year study period (2015–2024), averaging 17.5 mortalities per year (range: 10–24 deaths annually) (Figure 1). The temporal distribution showed considerable annual variation, with peaks observed in 2024 (n=24) and 2016 (n=23), and the lowest mortality recorded in 2020 (n=10). The weak linear correlation (R^2 = 0.0611) indicates that elephant mortality does not follow a simple linear trend over time, but rather exhibits complex, year-specific fluctuations driven by multiple interacting factors including human-wildlife conflict intensity, enforcement effectiveness, and environmental conditions.

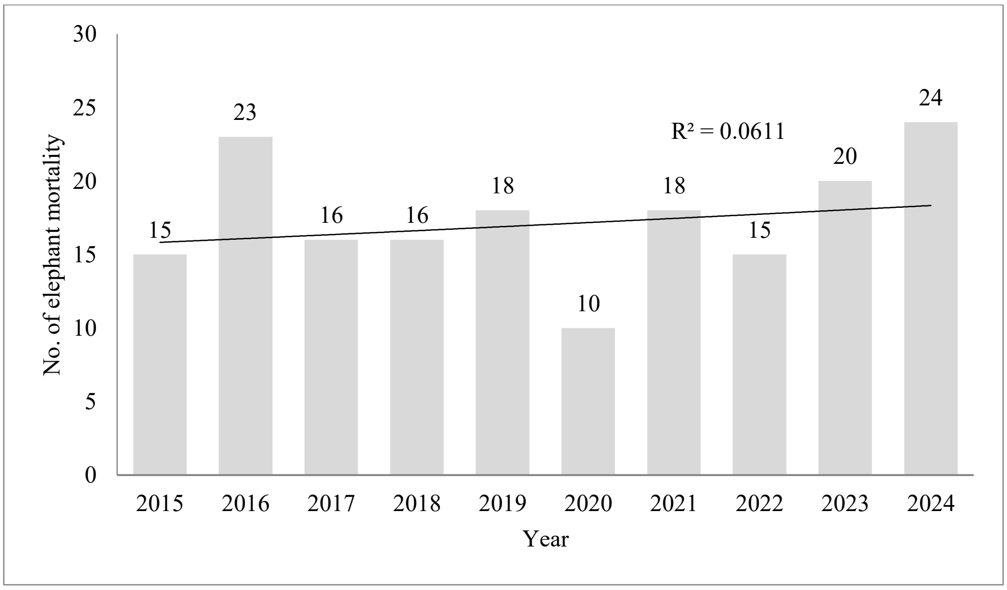

Fig. 1 *Elephant mortality from 2015 to 2024*

A notable low point occurred in 2020, with only 10 deaths recorded, marking the safest year in the entire observation period. This reduction could potentially reflect decreased human-wildlife interactions during global lockdowns associated with the COVID-19 pandemic. However, it is important to note that this low mortality record may also be partially attributable to reduced field surveillance and monitoring activities during movement restriction periods, which could have resulted in some elephant deaths going undetected or unreported. The combination of reduced human activity in forest and agricultural areas, alongside potential underreporting due to limited field access, makes it difficult to determine whether 2020 truly represented a year of lower elephant mortality or simply reduced detection capacity. Regardless, this positive trend was short-lived, as mortality rates have been rising steadily from 2020 onwards, climbing from 10 deaths to 18 in 2021, remaining relatively stable through 2022, then increasing to 20 in 2023, and finally reaching an alarming high of 24 deaths in 2024.

The 2024 figure is particularly concerning as it represents the highest mortality rate on record, constituting a 140% increase from the 2020 baseline. This sustained upward trajectory over the past four years suggests emerging or intensifying conservation challenges that require immediate attention and investigation. Possible factors contributing to this trend could include increased human-elephant conflict, habitat loss, disease outbreaks, poaching activities, or climate-related stressors. The consistent rise since 2020 indicates that whatever protective factors were present during that year have diminished, and more aggressive conservation strategies may be necessary to reverse this troubling pattern.

The stacked bar chart illustrates the annual distribution of elephant mortality by cause from 2015 to 2024 in Peninsular Malaysia (Figure 2). Illegal killing (red) consistently represents a substantial proportion of deaths throughout the decade, particularly prominent in 2015-2019 and maintaining significant presence in subsequent years. Management-related mortality (blue) occurs regularly across all years, with notable contributions in 2016, 2022, and 2024. The year 2020 recorded the lowest overall mortality with only 10 deaths, while 2016 and 2024 experienced the highest mortality at 23 and 24 deaths, respectively. Natural causes (green) show variable contributions, with marked increases in 2016, 2021, and 2024. The category "Others" (orange), which includes accidental human-induced deaths such as roadkill's and electrocution, demonstrates increasing prominence in recent years, particularly in 2024 with 7 deaths. Uncertain causes (purple) persist throughout the study period, highlighting ongoing challenges in mortality investigation and forensic capacity. The composition of mortality causes varies considerably across years, reflecting the dynamic and multifaceted nature of threats facing elephant populations.

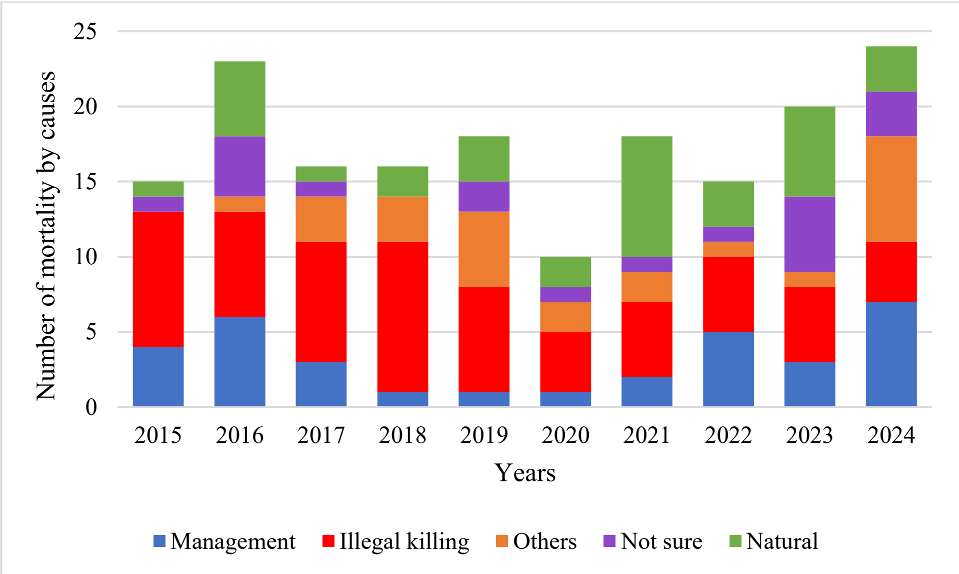

Fig. 2 *Elephant mortality by cause over time*

The analysis yielded a chi-square statistic of $\chi^2 = 49.145$ with 36 degrees of freedom, which does not exceed the critical value of 50.998 at the $\alpha = 0.05$ significance level ($p > 0.05$). Therefore, we fail to reject the null hypothesis, suggesting that year and cause of death are statistically independent. This indicates that while total mortality numbers may fluctuate across years, the proportional distribution of mortality causes remains relatively consistent throughout the decade, implying stable underlying factors affecting elephant populations regardless of temporal variations.

3.2 Mortality by Cause Category

The distribution of elephant mortality causes from 2015 to 2024 reveals that illegal killing represents the most significant threat to elephant populations, accounting for 37% of all recorded deaths (Figure 3). Management-related deaths and natural causes each contribute equally at 19% of total mortality, indicating that both human intervention activities and natural factors play substantial roles in elephant deaths. Natural causes encompass deaths from disease, old age, and other biological factors that occur without human influence. Additionally, 14% of elephant deaths are attributed to accidental human-induced deaths or other causes that fall outside the primary categories, while 11% of cases remain classified as "not sure/unclassified," reflecting instances where the exact cause of death could not be definitively determined through available evidence or investigation methods, due to advanced decomposition preventing definitive cause determination or insufficient investigation data. This uncertainty category highlights the challenges faced in post-mortem examinations and mortality investigations in wildlife conservation contexts.

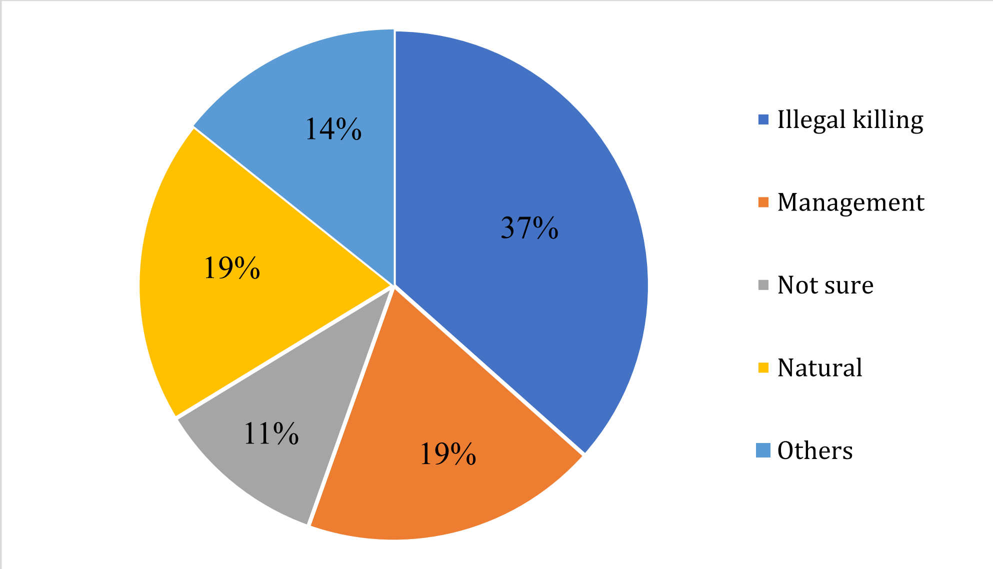

Fig. 3 *Elephant mortality by cause category from 2015 to 2024*

3.3 Spatial Distribution of Elephant Mortality and Roadkill Hotspots

Spatial analysis of the dataset (Table 1) reveals a total cumulative mortality of (N=175) elephant cases across six Malaysian states over the 10-year observational period from 2015 to 2024. The temporal distribution of these fatalities exhibits notable annual fluctuations.

Table 1 *Spatiotemporal distribution of elephant mortality records (2015–2024)*

Year	Johor	Kedah	Kelantan	Pahang	Perak	Terengganu	Total
2015	1	0	3	2	8	1	15
2016	4	1	9	3	4	2	23
2017	2	1	6	1	5	1	16
2018	3	6	1	2	3	1	16
2019	7	0	3	1	3	4	18
2020	3	1	2	0	3	1	10
2021	7	1	4	4	2	0	18
2022	3	1	3	5	2	1	15
2023	5	2	2	2	6	3	20
2024	8	0	3	4	9	0	24
Total	43	13	36	24	45	14	175
%	24.6	7.4	20.6	13.7	25.7	8.0	100.0

When disaggregated geographically, the data demonstrates a severe spatial concentration of elephant mortality, with three primary states accounting for more than 70% of the total recorded fatalities: Perak registered the highest cumulative mortality, accounting for 25.7% (n=45) of the total decade-long dataset. Notably, Perak experienced an acute escalation in fatalities toward the end of the study period, culminating in an annual peak of (n=9) cases in 2024. Following closely, Johor constitutes 24.6% (n=43) of the total baseline data. The mortality rate within this state remained persistently elevated throughout the decade, reaching its highest annual threshold (n=8) in 2024. Positioned as the third most critical jurisdiction, Kelantan contributed 20.6% (n=36) to the cumulative mortality count. In contrast to the progressive increases observed in Perak and Johor, Kelantan exhibited a distinct historical anomaly, characterized by a sharp, isolated spike in 2016 (n=9). Conversely, the remaining states exhibited substantially lower baseline mortality frequencies. Pahang occupied a moderate threshold, accounting for 13.7% (n=24) of the aggregate cases, with its maximum annual mortality recorded in 2022 (n=5). Terengganu (8.0%, n=14) and Kedah (7.4%, n=13) demonstrated the lowest overall mortality rates. While Kedah experienced an anomalous localized surge in 2018 (n=6), its annual mortality otherwise remained negligible, ranging consistently between 0 and 2 cases per annum. It is also highly noteworthy that despite hosting a documented wild elephant population, Negeri Sembilan recorded zero elephant mortalities throughout the entire 10-year observational matrix.

Spatial distribution of elephant mortality in Peninsular Malaysia from 2015 to 2024 were shown in Figure 4. Roadkill incidents were concentrated along three primary highways. The East–West Highway in Perak recorded five elephant roadkill cases, particularly in sections traversing forest reserves and known elephant corridors between Gerik and Jeli districts. The Kota Tinggi–Mersing Road in Johor documented four elephant deaths from vehicle collisions, bisecting important elephant habitat connecting Endau-Rompin and adjacent forest complexes. Additionally, the Kluang–Mersing Road in Johor recorded four roadkill incidents as it crosses through oil palm plantations interspersed with forest fragments utilized by elephant herds. In addition, the 2024 train collision involved an elephant struck by a passenger train traveling from Johor Bahru Sentral to Gemas at KM679.50, marked the first recorded elephant-train mortality in Peninsular Malaysia during the study period. Spatial distribution of elephant mortality revealed that roadkill incidents were clustered and occurred predominantly in areas where roads intersected known elephant movement corridors, forest edges adjacent to plantations, and zones with limited wildlife crossing infrastructure.

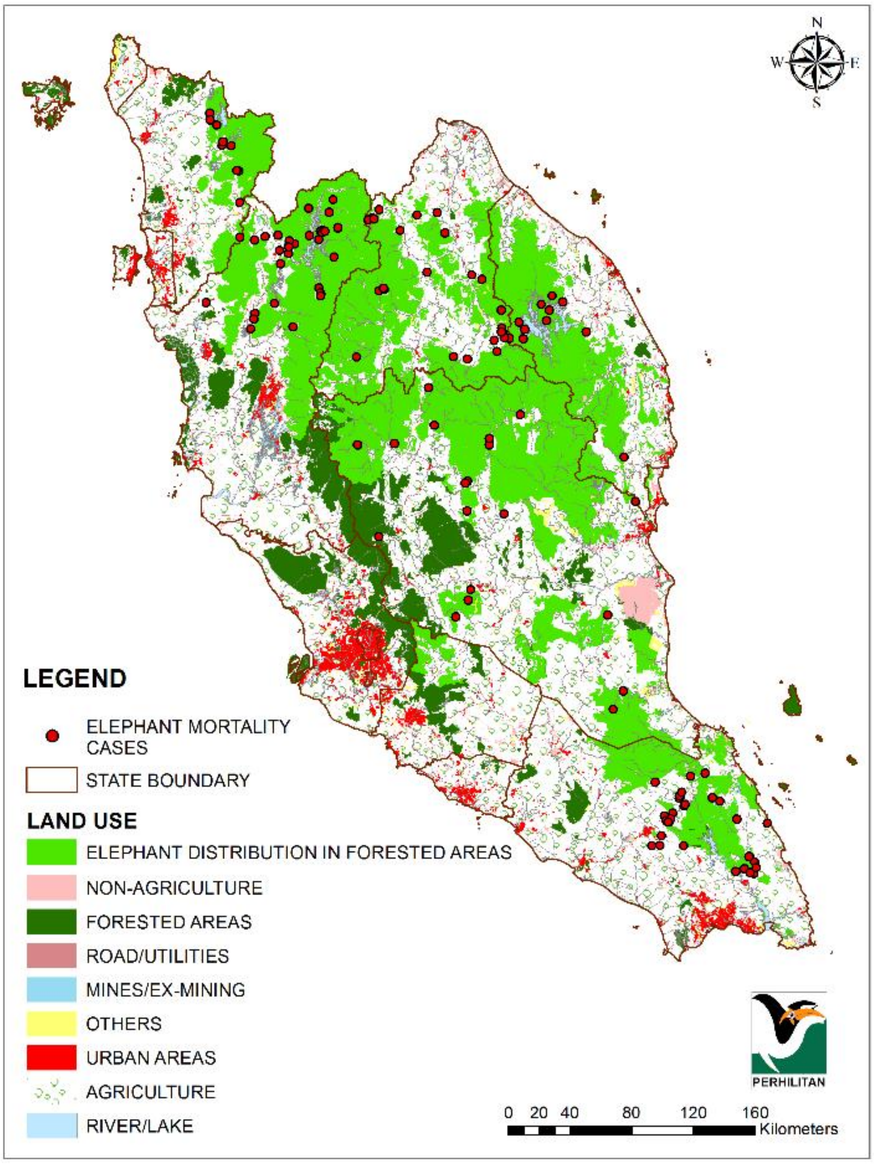

Fig. 4 *Spatial distribution of elephant mortality in Peninsular Malaysia from 2015 to 2024*

4. Discussion

4.1 Interpretation of Temporal Mortality Patterns

The observed fluctuations in elephant mortality over the study period reflect the complex and dynamic nature of threats facing Asian elephant populations. The variation in annual mortality rates is consistent with patterns documented in other elephant range states, where human-wildlife conflict, poaching pressure, and ecological stressors create temporally variable risk profiles [7],[11]. The dramatic reduction observed in 2020 presents a particularly intriguing pattern that may be linked to the global COVID-19 pandemic and associated restrictions on human movement and activities. Similar "anthropause" effects during pandemic lockdowns have been documented for various wildlife species, with reduced human disturbance leading to decreased wildlife mortality in several contexts [12]. The subsequent reversal of this trend and escalation to unprecedented levels by 2024 suggests that protective effects associated with reduced human activity were temporary, and that underlying threatening processes resumed and potentially intensified as restrictions lifted.

This escalating trajectory is particularly concerning when contextualized within broader conservation trends for Asian elephants. Across the species' range, elephant populations face mounting pressures from habitat fragmentation, agricultural expansion, and increasing human population density [6]. The doubling of mortality rates within a four-year period signals a potential tipping point where mortality may exceed reproduction, leading to population decline. This pattern warrants comparison with population viability analyses conducted for other Asian elephant populations, many of which have identified unsustainable mortality rates as a critical threat to long-term persistence [2].

4.2 Dominant Role of Illegal Killing in Elephant Mortality

The finding that illegal killing constitutes the primary mortality factor aligns with broader concerns about wildlife crime affecting elephant populations across Asia [13]. While African elephants have received considerable attention regarding ivory poaching [14], Asian elephants face similar pressures despite lower ivory value, as only male Asian elephants possess tusks. However, illegal killing of Asian elephants extends beyond ivory poaching to include retaliatory killings in response to crop raiding, capture for illegal trade, and killings for other body parts used in traditional medicine [15].

The proportion of deaths attributable to illegal activities in this study is higher than other categories. This finding is consistent with a study in Kenya, which reported that human activities accounted for most adult elephant deaths (67%, n = 100) [16]. This suggests that the population exists in a landscape where competition for resources between humans and elephants has intensified to levels that frequently result in lethal outcomes. The persistence of illegal killing as the dominant mortality cause throughout the decade, despite conservation efforts, indicates that current interventions have not adequately addressed the underlying drivers of human-elephant conflict and illegal activities [17].

Evidence suggested that effective reduction of elephant mortality from illegal activities requires integrated approaches that address both enforcement and community-level factors [18]. The continued prevalence of illegal killing in our dataset suggests that either enforcement capacity remains insufficient, or that socioeconomic conditions continue to motivate local communities toward lethal responses to elephant presence. Studies from India have demonstrated that compensation schemes alone are inadequate without accompanying measures to reduce actual crop losses and improve community tolerance [19].

4.3 Management-Related Mortality and Conservation Trade-Offs

The substantial contribution of management-related deaths raises important questions about the welfare implications and effectiveness of current intervention strategies. Management-related mortality in elephant populations often results from capture operations, translocation stress, drive operations to move elephants away from human settlements, and occasionally from euthanasia decisions. While some level of management intervention may be necessary in human-dominated landscapes, the proportion observed in this study suggests that current approaches may be contributing significantly to overall mortality.

Translocation of conflict elephants has been employed widely across Asia as a management tool, but evidence regarding its effectiveness and welfare implications remains mixed [20]. Studies have documented significant stress responses, elevated mortality risk during and after translocation, and in some cases, return movements of translocated individuals back to conflict areas [20]. The management-related mortality documented in our study may reflect risks inherent in such operations and suggests the need for critical evaluation of whether alternative, less invasive conflict mitigation strategies might achieve conservation goals with reduced mortality costs.

Emerging approaches emphasizing coexistence rather than separation of humans and elephants may offer pathways to reduce both conflict-related and management-related mortality [6]. These include community-based early warning systems, non-lethal deterrents such as spotlights, chili-based repellents, modified agricultural practices that reduce attractiveness to elephants, and land-use planning that maintains functional connectivity while minimizing conflict potential [21].

4.4 Natural Mortality in Context of Population Health

The contribution of natural causes to overall mortality provides important insights into population health and demographic structure. In stable, healthy elephant populations, natural mortality typically constitutes a significant proportion of deaths, with senescence, disease, and intraspecific competition being primary factors [16],[22]. The proportion observed in this study falls within ranges reported for other populations, suggesting that natural demographic processes continue to operate despite anthropogenic pressures [7].

However, distinguishing between natural and anthropogenically-influenced mortality is challenging in human-modified landscapes. Habitat degradation may cause nutritional stress that increases disease susceptibility, climate change-induced droughts may produce deaths that appear natural despite having anthropogenic origins, and injuries from human-elephant conflict may develop into fatal infections subsequently classified as disease mortality.

4.5 Statistical Significance and Conservation Planning

The statistical analysis examining associations between year and mortality cause provides crucial information for adaptive management. Evidence of temporal variation in mortality profiles would indicate that elephant conservation faces a dynamic threat landscape requiring flexible, responsive management strategies. Such variation might reflect changing enforcement effectiveness, shifting patterns of human land use, climate variability affecting resource availability, or demographic changes within the elephant population itself [23],[24].

If mortality cause distributions vary significantly across years, conservation planning must incorporate monitoring systems capable of detecting emerging threats and management frameworks that can rapidly reallocate resources to address changing risk profiles [25]. This might include enhanced field surveillance and patrol systems to detect carcasses and illegal activities earlier, rapid response capacity to address emerging human-elephant conflict situations before they escalate, and adaptive enforcement strategies that can be intensified and redirected to hotspot areas when monitoring data indicate increases in poaching or poisoning incidents.

Conversely, consistency in mortality profiles across years would suggest that elephant populations face stable, chronic threats requiring sustained, long-term interventions rather than reactive responses to episodic crises. In this scenario, conservation success would depend on addressing fundamental drivers of mortality through structural changes in land-use planning, enhanced permanent enforcement capacity, and long-term community engagement programs [26].

4.6 Addressing Uncertainty in Mortality Attribution

The proportion of deaths with uncertain causes highlights a critical challenge in wildlife mortality surveillance. Accurate cause-of-death determination is essential for evidence-based conservation planning, yet many elephant deaths occur in remote areas where carcasses may not be discovered until advanced decomposition makes forensic analysis difficult [7]. Additionally, resource limitations may constrain post-mortem examination capacity even when carcasses are discovered promptly.

Improving mortality surveillance infrastructure represents an important investment for conservation. Technologies such as GPS collaring can enable rapid detection of mortality events through automated mortality sensors [27], while enhanced training in wildlife forensics for field personnel can improve cause-of-death attribution even when decomposition is advanced [28]. Regional capacity building in wildlife forensic science, including access to laboratory facilities for toxicological and pathological analysis, would strengthen evidence collection and support prosecution of wildlife crimes [29].

4.7 Conservation Priorities and Recommendations

The findings from this study point to several clear priorities for elephant conservation. First, the dominance of illegal killing demands renewed commitment to both enforcement and community-based conservation approaches. This should include enhanced ranger capacity and equipment, improved legal frameworks and judicial support for wildlife crime prosecution, and comprehensive community engagement programs that address the socioeconomic drivers of human-elephant conflict [30],[31].

Second, the substantial management-related mortality warrants critical evaluation of current intervention protocols. Evidence from problem-elephant translocation programs demonstrates that such interventions can increase mortality rates, cause abnormal behavior, and subject individuals to extreme stress, ultimately defeating both conflict mitigation and conservation goals [20]. Conservation agencies should conduct rigorous assessments of translocation and drive operation outcomes using behavioral and physiological measures to evaluate animal welfare, explore alternative conflict mitigation strategies with lower mortality risks [18], and address the socioeconomic drivers—particularly poverty and resource scarcity—that reduce community adaptive capacity and engender animosity toward elephants [17]. Such approaches must integrate animal welfare considerations into management decision-making processes, recognizing that interventions which compromise individual welfare may undermine broader conservation objectives.

Third, the escalating mortality trend since 2020 requires urgent investigation to identify specific drivers of this increase. This should include spatial analysis to identify mortality hotspots, assessment of habitat quality changes, evaluation of climate impacts on resource availability, and examination of demographic factors that may influence vulnerability [32],[33].

Finally, the integration of mortality monitoring with broader population monitoring is essential for assessing whether current mortality rates are sustainable. Effective conservation strategies require evidence-based knowledge of rates of population change, levels of human-induced mortality, and the natural demographic processes that determine how populations will respond to severe size reductions [34]. Demographic modeling incorporating age-specific mortality rates, reproductive rates, and population structure derived from longitudinal monitoring and life table analyses can identify whether populations are in decline, stable, or growing, particularly when mortality fluctuates in relation to environmental variability and anthropogenic impacts [35]. Such age-specific demographic metrics help identify differential mortality risk and reproductive value across age classes, information critical for diagnosing and reversing population decline and projecting population status and trends under different management scenarios [34],[36].

4.8 Study Context and Future Directions

While this study provides valuable insights into temporal patterns of elephant mortality, several areas warrant further investigation. Spatial analysis examining geographic clustering of different mortality causes could identify priority areas for targeted interventions. Demographic analysis of mortality patterns by age and sex would reveal differential vulnerabilities and inform protective strategies. Integration with habitat assessment data could elucidate relationships between landscape characteristics and mortality risk. Finally, comparative analysis with mortality data from other elephant populations would provide broader context and help identify generalizable conservation principles applicable across different landscapes and management contexts.

Climate change represents an emerging threat that may increasingly influence elephant mortality patterns in coming decades. Projected increases in temperature, alterations to precipitation patterns, and increased frequency of extreme weather events may affect resource availability, modify human-elephant spatial overlap, and influence disease dynamics. Long-term monitoring programs that track mortality patterns alongside environmental variables will be essential for understanding and responding to climate-related impacts on elephant populations.

5. Conclusion

This analysis reveals a complex mortality landscape for elephants over the 2015-2024 period, with illegal killing emerging as the primary threat, substantial contributions from management activities and natural causes, and a concerning escalation in overall mortality in recent years. The patterns documented highlight the multidimensional nature of conservation challenges facing elephants in human-dominated landscapes and underscore the need for integrated approaches that address enforcement, community engagement, habitat management, and wildlife welfare. The trajectory observed since 2020 is particularly alarming and demands immediate, evidence-based responses to prevent further deterioration of conservation status. Success in reversing current trends will require sustained political commitment, adequate resource allocation, strong partnerships between government agencies and local communities, and adaptive management approaches responsive to evolving threat profiles. Only through such comprehensive efforts can we ensure the long-term persistence of elephant populations and the ecological and cultural values they represent.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Salman, Nur Fatin;* ***data collection:*** *Salman Saaban;* ***analysis and interpretation of results:*** *Salman Sabaan, Nur Fatin Khodri, Nazirah Mohamad Abdullah;* ***draft manuscript preparation:*** *Salman Sabaan, Nur Fatin Khodri, Nazirah Mohamad Abdullah. All authors reviewed the results and approved the final version of the manuscript.*

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