

Systematic Literature Review Of Conservation Experience Of The Greater One-Horned Rhinoceros In The Northeast Region Of India

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Abstract

The paper presents a systematic literature review on the conservation experience of the one-horned rhinoceros in the northeastern region of India. The study looks at various studies to identify seven key thematic areas: history of rhinoceros conservation, behavioural and habitat adjustments following translocation, food choices and nutritional issues, the impact of rapidly accelerating climate change on rhino behaviour, the use of spatial modelling for habitat expansion, and the crucial importance of involving local communities in conservation efforts. Additionally, the review highlights changes in rhino feeding habits according to the seasons, the health impact of grassland accessibility, and the success of predictive models in anticipating poaching trends. The review includes 18 selected studies from an initial pool of 91 records sourced from Scopus and Google Scholar, concentrating on terms such as "Greater one-horned," "Northeast," and "Conservation." A few research papers indicate that a translocation initiative in Manas National Park was successful, with the relocated animals acclimating to their new surroundings. GIS-based spatial modelling serves as a vital instrument for identifying and monitoring suitable habitats, while forecasting models have shown promise in predicting poaching trends and informing anti-poaching strategies. Local community engagement has also proven significant, as evidenced by initiatives in Nepal and parts of Assam, where it reduced poaching risks. Although conservation efforts like the Indian Rhino Vision 2020 have achieved commendable milestones, challenges driven by climate change, such as flooding and habitat destruction, continue to represent serious threats. The findings call for cohesive strategies incorporating scientific research, government actions, habitat modelling, community empowerment and anti-poaching schemes to ensure the species' long-term survival.

Key Words: Northeast India, Greater one-horned rhinoceros, *Rhinoceros unicornis*, GIS-based spatial modelling.

1. INTRODUCTION

The greater one-horned rhinoceros (*Rhinoceros unicornis*) is currently one of the endangered species in India. It is strongly found in the northeastern part of the country, which is in Assam, India, and is facing significant survival challenges (Vigne & Martin, 1991). No other category of animals has been as valued over such a long period while also enduring human aggression. Rhino horn has historically been esteemed in traditional Chinese medicine. It serves as a decorative item and an investment in several Middle Eastern and East Asian countries, with more recent applications emerging. The poaching of rhinoceroses to meet the demands of these markets continues to jeopardise the survival of most existing populations (Janssens & Trouwborst, 2018). Primarily reliant on grasses, which make up 24% of its diet (Dutta et al., 2016) It requires swampy habitats and abundant water sources, which is why it inhabits the northeast region. The species is vulnerable due to threats such as poaching, illegal trade, and climate change.

With climate change posing a growing threat to the environment in the northeastern region, it is increasingly difficult to conserve the greater one-horned rhinoceros in India. In 2017, intense monsoons caused many rhinos to be displaced from their protected habitats, leaving them vulnerable to poachers and underscoring the cross-

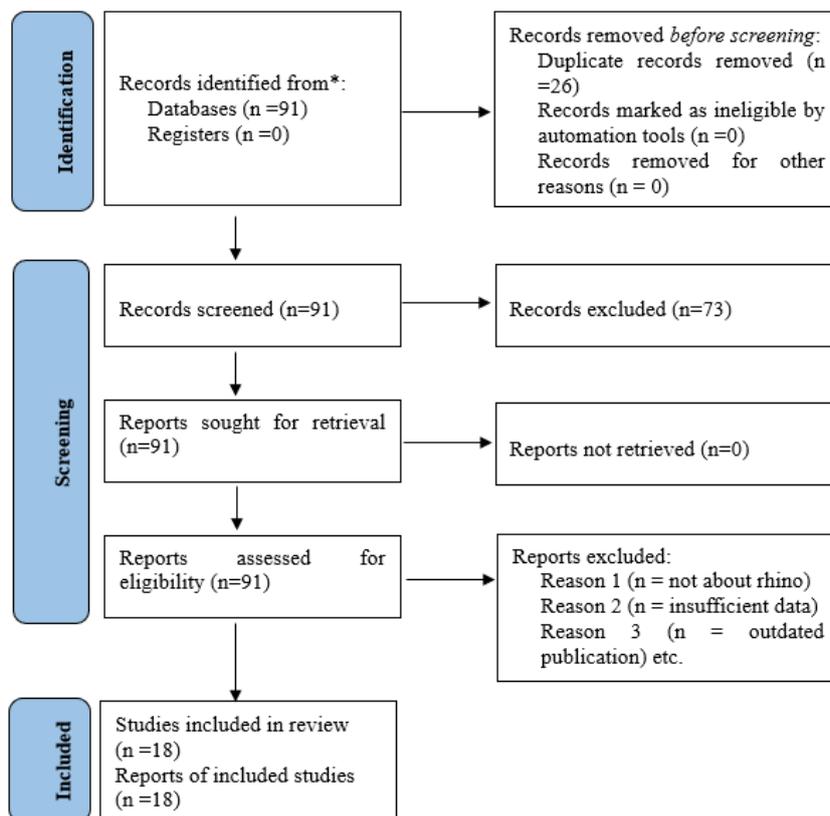
border challenges of rhino conservation when at least 15 animals were carried over the Indo-Nepalese border (Janssens & Trouwborst, 2018). In response, the government has implemented various measures to protect this species from the impacts of climate change. Additionally, several strategies have been put into practice to aid in the conservation of the rhinoceros.

The Government of India has also introduced policies like the Indian Rhino Vision Act 2020, which aims to improve basic infrastructure and facilitate the translocation of the species to different national parks to enhance its chances of survival. Furthermore, the government has launched anti-poaching initiatives and other management strategies to preserve the greater one-horned rhinoceros. These initiatives are backed by the cooperative roles of NGOs and government entities. One of the most encouraging factors is the crucial backing from the community, which is key to the conservation of the one-horned rhinoceros.

This systematic literature review examines the historical development of rhinos and the challenges they have faced due to both natural and human-induced factors. It discusses how human activities, particularly poaching, impact rhinos, including methods like electrocution and pitfall traps that lead to their deaths. It also highlights the role of Kaziranga National Park in implementing strategies to combat poaching. The review investigates the behaviour and habitat preferences of translocated rhinos to assess the success of the translocation method. Additionally, it looks into their behaviour in the context of climate change and identifies their most common food preferences. Lastly, it involves spatial modelling to identify potential habitat extensions and evaluate community support.

2. REVIEW METHODOLOGY

This review is conducted systematically using the PRISMA 2020 methodology, after analysing the literature while excluding irrelevant studies. The sources for the review were obtained from online platforms like Scopus and Google Scholar. The keywords utilised were ‘Greater one-horned rhinoceros’ AND ‘Northeast’ AND ‘Conservation’. The emphasis was placed on the conservation of greater one-horned rhinos located in the northeastern region of India. A total of 91 papers were identified, of which 26 were excluded due to duplication, and 18 studies were included in the review due to reasons such as insufficient data, outdated publications, and relevance to rhinos.



The selected studies explored various approaches to rhino conservation, including translocation, spatial modelling, community engagement, dietary preferences, historical evolution of rhinos, and community support. It also addresses the impact of climate change on rhino behaviour. This review provides fundamental insights into the conservation efforts for the Greater One-horned Rhinoceros and the conservation strategies that have been employed so far. In order to demonstrate identification, here listed all of the databases that were located and the records that were deleted prior to screening. The second point suggests screening, which includes the total number of records screened, reports that are sought for retrieval, and reports that are evaluated for eligibility. This results in the exclusion of records, reports that are not retrieved, and reports that are excluded. Studies included in the review and reports of included studies are suggested in the third point.

3. MAJOR AREAS OF RESEARCH

3.1. Historical Evolution of Rhino Conservation in India

The Rhinocerotidae family members were once among the most varied and widely spread terrestrial herbivores, boasting a complicated evolutionary background. The Greater One-horned Rhinoceros (*Rhinoceros unicornis*), part of the Eurasian rhino group alongside the Javan and Sumatran species, has been impacted by a mix of natural and human-induced factors during the transition from the Pleistocene to the Holocene, followed by events like industrialisation and poaching. As a result of these influences, its population has declined. During the period of British India, the Greater One-horned Rhinoceros (*Rhinoceros unicornis*) faced the threat of extinction as in the late 19th and early 20th centuries, a trend among royalty for sport hunting became popular, leading to the continuous and relentless pursuit of Greater one-horned rhinos.

Early records show that British individuals, especially military officers stationed in Assam, were responsible for the deaths of over 200 Indian rhinos due to sport hunting. As a result, by 1908, only around twelve of these wild animals remained in Kaziranga National Park (Mondal & Chauhan, 2024). In response, the Government of Assam established the Kaziranga Game Reserve in 1908, which is now recognised as Kaziranga National Park, to protect the dwindling rhino population. As the twentieth century advanced, conservation efforts for rhinos intensified, leading to new initiatives from the government, such as the Indian Rhino Act of 2020, and increased community participation in rhino conservation (Sarmah, 2024). Currently, the population of the Greater One-horned species is estimated at 3,700 according to the IUCN (Ghosh et al., 2022).

3.2. Poaching of Rhinoceros in Assam, India

Poaching poses the greatest danger and is the primary cause of the decline of the Greater One-horned Rhinoceros. Studies conducted in Manas National Park and Kaziranga National Park also reveal that poaching threatens these species. Techniques such as electrocution and pitfall traps are employed to capture and kill these animals for profit. This has rendered them highly vulnerable, pushing them to the brink of extinction. A notable example is Kaziranga National Park, recognised as the first area in Assam designated for Rhino protection in 1908 and awarded UNESCO World Heritage status in 1985 for being the largest sanctuary for the Greater one-horned Rhinoceros. The park is bordered by urban development on three sides, complicating its protection from unlawful encroachments by poachers and herders. The northern boundary is relatively secure due to the Brahmaputra River, which serves as a natural barrier; however, incidents of poachers using electrocution to kill animals prompted stringent measures. Consequently, fencing was enhanced, patrolling was intensified, and security was bolstered, resulting in a decrease in poaching. At present, India's Kaziranga National Park and Pobitora Wildlife Sanctuary, along with Nepal's Chitwan National Park and Bardia National Park, are the primary protected regions that sustain the majority of greater one-horned rhino populations (Bhandari et al., 2022). Various forecasting methods were utilised to analyse poaching trends, comparing three major approaches: Holt's method (HM), Holt-Winters's multiplicative method (HWMW), and Holt-Winters' additive method (HWAM). The methods were evaluated to identify the most effective one based on the observed outcomes. From the situation in Kaziranga National Park, it is evident how measures taken by the government have intermittently curbed poaching and highlight the significant threat it poses to these at-risk animals (Das & Bhardwaj, 2021).

3.3. Translocated Rhino's Behaviour and Habitat Preference

As mentioned earlier in the introduction, the government has reintroduced rhinos to Manas National Park in response to poaching concerns. The study examines their behaviour and habitat choices following their relocation from Kaziranga National Park, also located in Assam, India, to Manas National Park, which borders Bhutan internationally. Research indicates that during the 16th to 19th centuries, poaching rhinoceroses was popular among hunters, who believed that the animal's size and appearance reflected their hunting prowess, leading to a significant decline in rhino populations. Translocation refers to the release of wildlife for the purpose of re-establishing their populations, but the crucial aspect of translocation is the post-translocation phase, which involves monitoring and radio telemetry. Monitoring of the relocated rhinos shows that their grazing activity peaks during the monsoon season, which spans from June to September, while grazing declines during the dry winter months of December to February.

However, in the winter, browsing and resting activities tend to increase. The walking activity of adult females and their calves also rises during the monsoon, with females and calves typically walking more than males. The research further indicates that wallowing behaviour among rhinos often occurs in mud and water, and it has been observed that courtship and mating activities increase among the relocated individuals. Close observation of the translocated rhinos has shown that they adapt well to their new environment and do not create any problems. Nevertheless, for a successful translocation process, the government needs to implement well-structured translocation plans and ensure strong infrastructure (Dutta, 2023; Dutta et al., 2017; Rimal et al., 2018).

3.4. Behaviour of the Greater One-Horned Rhinoceros During Climate Change

Climate change presents a major risk not only to rhinoceroses but also to the populations living in northeastern areas. The effects of rapidly accelerating climate change on Rhinoceros populations are not only considerable but also diverse. Severe weather conditions, increasing temperatures, and habitat loss together heighten the susceptibility of these large herbivores. It is well understood that global warming is a central aspect of this climatic change, endangering both wildlife, such as rhinos and human populations. To address this problem and protect both ourselves and animals like rhinos, decisive actions are necessary. The annual flooding is a significant hazard for Kaziranga National Park, which is a crucial habitat in Assam, leading to the submergence of 70% of the area and causing distress to these animals.

While flooding plays a vital role in maintaining soil fertility, it adversely affects weaker species like rhinos. Studies have indicated that during times of climate-induced changes, particularly during intense flooding, rhinos often rest for longer periods, possibly as a behavioural strategy to cope with stress. In Kaziranga National Park, sub-adult rhinos usually focus on feeding, whereas in Burhachapori Wildlife Sanctuary, those same sub-adults tend to spend less time feeding. Furthermore, observations have shown that both sub-adult rhinos and calves in these parks navigate between higher ground during extreme flood events (Dutta et al., 2021; Pant et al., 2020).

3.5. Food Preference and Nutritional Profile of the Rhinoceros

Rhinos are primarily located in the northeastern part of India, particularly in Assam, where an abundance of grass and other vegetation is available. This area features grasslands that are crucial for the rhino's diet, as these animals mainly rely on grasses, which constitute 24% of their food intake. Numerous studies have been carried out, revealing that *Arundo donax* and *Cynodon dactylon* are among the notable grass species in their habitat. Additionally, herbs, trees, and aquatic plants are included in their diet. Research has shown that during winter, when young grasses are scarce, rhinos turn to the twigs of trees for sustenance, but the necessity for additional feeding strategies during months with limited resources is crucial to prevent health deterioration caused by stress. It has also been observed that in the winter months, the health of rhinos tends to decline due to the unavailability of grasslands, but once the monsoon arrives and fresh grass begins to sprout, their health improves again.

Table 1: Dietary classifications and their proportions in the diet of reintroduced Greater One-horned Rhinoceros at Manas National Park.

Food Category	Percentage in Rhino Diet (%)
Grasses	24%
Herbs	22.3%
Trees	18.7%
Aquatic plants	16.5%
Agricultural crops	8.6%
Shrubs	7.5%
Creepers	2.1%

Note: Data adapted from “Seasonal variations in food plant preferences of reintroduced Rhinos *Rhinoceros unicornis* (Mammalia: *Perrissodactyla*: *Rhinocerotidae*) in Manas National Park, Assam, India” by Dutta, D. K., Bora, P.J., Mahanta, R., Sharma, A., & Swargowari, A, published in *the Journal of Threatened Taxa* (2018). (Dutta et al., 2016; Islam et al., 2024)

3.6. Spatial Modelling for Extension of Potential Habitat

Spatial modelling plays a vital role in rhino conservation, as their survival becomes difficult without proper infrastructure. It acts as an essential instrument in this endeavour. Research indicates that observing rhino signs in the field and utilising camera traps are methods employed in spatial modelling efforts. Remote sensing and Geographic Information System (GIS) analysis are employed to prepare all necessary variables and create the model. The primary variables used to construct a spatial habitat suitability model include slope, flow accumulation, potential forage, normalisation of various vegetation indices, and distance to streams.

Furthermore, it's been noted that different species of rhinos have specific habitat preferences. In Manas National Park, where rhino translocation efforts are underway, such models can aid in minimising human-animal conflicts and prioritising areas for patrolling. Additionally, this can be utilised to forecast and identify suitable habitats for rhinos or regions that they prefer, where they spend considerable time, and thus facilitate their conservation (Latifiana et al., 2020).

3.7. Community Support in Protecting Rhinos

Community engagement is a key element in the protection of rhinoceroses. Without the involvement and cooperation of local communities, conservation efforts may face challenges or potentially fail. These communities can serve as the primary defence against poaching activities. Since conservation NGOs often support community development projects, such as schools and healthcare facilities, they also assist in the effort to protect rhinos from extinction. Informed communities are more likely to recognise the ecological importance of rhinos. While governments and NGOs may come and go, communities remain a steady presence. Their support is crucial for the sustainable success of conservation plans.

Local residents can help maintain and restore rhino habitats, which is essential for their reproduction and survival. A real-life instance can be observed in Nepal, where a reduction in rhino poaching occurred from 2008 to 2009 compared to the preceding seven years. A significant reason for this favourable change was the support from the community. This was accomplished by empowering individuals from lower castes, who have a better understanding of the needs of the underprivileged, to hold senior positions, thereby enabling them to effectively aid in rhino conservation. Surveys have confirmed this strategy, showing that poaching diminished as marginalised community members grew more supportive of rhino protection. The findings highlight the crucial role communities play in the conservation of the greater one-horned rhinoceros (Esmond & Martin, 2010; Sharma, 2022). However, the adverse effects of rhinos on nearby communities can be classified into crop destruction, loss of human life, and other types of physical damage. Of these negative consequences, crop destruction was identified as the most significant, accounting for 89%, compared to the other effects. These negative consequences represent a conflict between humans and wildlife (Sedhain & Adhikary, 2019).

4. DISCUSSION

The review outlines various successful strategies implemented in the conservation of the greater one-horned rhinoceros, such as translocation initiatives and community involvement. Some research examines the behaviour of translocated rhinos, while others focus on spatial modelling. Studies also discuss the dietary preferences of rhinos, the support from local communities, and the historical evolution of rhinos. Additionally, there is research on the behaviour of rhinos in relation to climate change, as this is a crucial aspect of their conservation. A considerable amount of literature addresses the behaviour of translocated rhinos and their habitat choices. It explains how the relocation of rhinos from Kaziranga National Park to Manas National Park successfully prevented the extinction of rhinos in the latter, highlighting the efficacy of translocation programs. Another prevalent theme in the literature is the effect of climate change on rhinos, which alters their behaviour patterns, feeding habits, and resting activities. The review also reveals the dietary inclinations of rhinos, identifying grasses like *Arundo donax* and *Cynodon dactylon* as fundamental components of their diet. Winter poses a challenge for their health due to the scarcity of grasses, indicating a need for seasonal habitat enhancement. A particularly intriguing finding is the support from local communities, which has led to a reduction in poaching activities, as seen in Nepal. There are numerous inspiring success stories, such as the effective translocation of rhinos in Manas National Park under the Indian Rhino Vision 2020 and the remarkable conservation achievements in Kaziranga National Park, as well as community support success stories from Nepal. Despite ongoing efforts, there are still challenges that must be addressed, including climate change, increased flooding, and habitat degradation, to ensure the successful conservation of rhinos in their fragmented yet vital habitats. The review has several limitations. From the 91 studies initially identified, only 18 were chosen for the review based on their relevance, recency, and the adequacy of their data. Studies that were outdated, lacked sufficient empirical evidence, or did not directly relate to the topic were excluded. Additionally, while issues such as poaching, climate change, and translocation were thoroughly examined, topics like disease ecology were not sufficiently addressed due to a lack of available papers. Future research could benefit from the use of real-time GIS monitoring, and broadening cross-border conservation initiatives involving Nepal and Bhutan could enhance the understanding of species migration and habitat sharing. The diverse themes discussed in this review underscore the complexity involved in planning for rhino conservation.

5. CONCLUSION

The conservation efforts for the Greater One-Horned Rhinoceros in Northeast India serve as a measure of India's dedication to wildlife protection. This review incorporates insights from academic studies and reports, providing a comprehensive understanding of the conservation journey. Significant findings emphasise government initiatives like the Indian Rhino Vision 2020, which facilitated the successful relocation of rhinos, their food preferences, behavioural responses to climate change, community support, and a rising population of rhinos. The adaptive behaviour of relocated rhinos contributes to the success of these translocations. Nevertheless, the increasing threats posed by climate change—such as flooding, habitat degradation, and unpredictable feeding behaviours—necessitate urgent adaptive management. Furthermore, nutritional stress during the winter months and the need for habitat quality evaluations during translocations are critical concerns. A particularly engaging aspect of this review underscores the vital role of local communities. Their active involvement, heightened awareness, and empowerment have notably diminished poaching incidents and aided in habitat restoration. Conservation extends beyond merely protecting a species; it involves maintaining and safeguarding the balance of the ecosystem. While significant challenges persist, strategies such as monitoring, infrastructure enhancement, and the use of spatial modelling tools can support conservation efforts. In summary, the future of the Greater One-Horned Rhinoceros hinges on approaches that integrate scientific research, community participation, infrastructure improvement, and innovative policy development. These approaches need to be regularly improved through ongoing field research, routine policy assessments, and community engagements to respond to changing environmental challenges and socio-economic developments in the area. Conservation should be regarded as an enduring commitment rather than a temporary measure, engaging multiple stakeholders such as local communities, academic researchers, forestry departments, and international organisations. Thriving in a dynamic and frequently challenging ecological environment can only be achieved through collaborative, well-funded, and consistently monitored strategies. Furthermore, conservation initiatives must be resilient to climate change, socially inclusive, and adaptable to new technologies in order to manage future ecological uncertainties.

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