Public Administration Research; Vol. 13, No. 2; 2024
ISSN 1927-517x E-ISSN 1927-5188
Published by Canadian Center of Science and Education

Controlling Wildlife Crime: The Positive Role of Workforce Capacity in Protected Areas

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Received: April 30, 2024 Accepted: July 1, 2024 Online Published: July 3, 2024

doi:10.5539/par.v13n2p1 URL: http://dx.doi.org/10.5539/par.v13n2p1

Abstract

Wildlife crime has been problematic in Assam, India, and Asian tigers, rhinos, and elephants are trafficked through illegal international networks mainly due to market demand. Against illicit poaching of wildlife, the Indian government has established protected areas that are managed by state forest departments in India. Despite this practice, little is known if workforce capacity can lead to effective wildlife management by controlling poaching threats. Using frontline staff numbers and salary as proxy variables, we conducted a novel empirical analysis for the relationship between workforce capacity and population size of endangered tigers, rhinos, and elephants in the Dibru Saikhowa, Kaziranga, Nemeri, and Orang national parks in Assam, India. The findings illustrate the need to enhance work capacity for tiger and rhino conservation and potential poaching control in protected areas of the Global South where conservation relies on human workforce capacity rather than sophisticated monitoring technologies.

Keywords: wildlife crime, wildlife poaching, workforce capacity, frontline staff, and protected areas

1. Introduction

Wildlife poaching causes a broader crisis in biodiversity loss (Redford, 1992; Seidensticker, 2010; Van Uhm & Moreto, 2018). Wildlife and their derivatives are trafficked through illegal international networks mainly due to market demand (United Nations Office of Drug and Crime, 2020). The greater one-horned rhino (*Rhinoceros unicornis*), Bengal tigers *(Panthera tigris tigris)*, and Asian elephants *(Elephas maximus)* are heavily poached because they yield lucrative gains to illegal poachers. For instance, illicit rhino horns may range from $97,000 to $400,000 USD per kg (Dang Vu & Nielsen, 2018; Haas & Ferreira, 2016), while tiger derivatives from dead tigers may range from $50,000 to $70,000 USD (Nowell, 2000; Criminal Nature the global security implications of the illegal wildlife trade, 2013). The Asian elephants are poached for their skin and tusks. Elephant tusks and skin may be sold on the black market on an average of $120 and $629 USD per kg, respectively (Gosling, 2018; United Nations Office of Drug and Crime, 2022).

Against illegal wildlife poaching, the Indian government has established protected areas that are managed by the Office of the Principal Chief Conservator of Forest (PCCF) and the Head of Forest Force (HoFF) in India. The state PCCF and HoFF are the primary authorities for managing all protected areas, as stated by the Wildlife Protection Act (1972) in India. Specific management practices are then determined by Field Directors (FDs), Division Field Officers (DFOs), and Conservators of Forests (CFs) in each protected area. The state PCCF and HoFF collaborate with local FDs, DFOs, and CFs to determine the workforce capacity in each protected area (Assam Project on Forest and Biodiversity Conservation, 2018).

Wildlife poaching has been particularly problematic in Assam and has caused reduced wildlife population sizes (Ellis & Talukdar, 2019; Gogoi & Gogoi, 2022; Talukdar, 2003). Workforce capacity is one of the most vital elements for effective wildlife management, including poaching control, thereby increasing wildlife protection and social security (Vasan, 2002). In India, the term ‘hunting’ and ‘poaching’ are synonymous according to the Wildlife Protection Act of 1972, and there is a blanket ban on hunting of all endangered species (e.g., tigers, rhinos, and elephants) (Sethi, 2022). The enforcement of the Wildlife Protection Act relies on the frontline forest staff, which can be a measure of workforce capacity (Vasan, 2002). Oftentimes, these personnel originate from local villages, making themselves an essential link between the Forest Department and local communities. Moreover, the perspectives of the frontline staff provide valuable insights into wildlife crime and conservation strategies (World

Wildlife Fund for Nature, 2018). It is known that India has about 60,000 frontline forest staff stationed in protected areas, and the average salary of those rangers is $259.24 USD per month, which is substantially low (World Wildlife Fund for Nature, 2018). Despite the significance of workforce capacity for illegal poaching control and wildlife protection, prior research has not examined if workforce capacity is related to poaching management, and to our knowledge, no empirical studies have been conducted. This research aims to fill the research void and investigate the relationship between workforce capacity and wildlife populations in Assam, India, where several national parks and UNESCO-designated conserved areas are located.

1.1 Study Sites

Assam is in northeastern India, south of the eastern Himalayas along the Brahmaputra and Barak River valleys. It is a biodiversity hotspot with a variety of plant, mammal, primate, avian, reptile, amphibian, fish, molluscan, butterfly, and moth diversity (Government of Assam--Environment and Forest, 2022). Assam shares porous international border with Myanmar and a state border with Nagaland, resulting in some opportunistic poaching (Talukdar, 2003). It is reported that poached rhino horns, tiger derivatives, and elephant skin from Assam have been traded in black markets in China (UNODC, 2010) and poachers from Myanmar often sell wildlife items for illegal firearms (Talukdar, 2003). Given Assam's rich biodiversity and its geopolitical location, wildlife poaching often occurs due to lucrative gains (Ellis & Talukdar, 2019; Gogoi & Gogoi, 2022; Talukdar, 2003). In response, Assam has developed an elaborate network of protected areas consisting of tiger/elephant reserves, national parks, and wildlife sanctuaries (Assam Project on Forest and Biodiversity Conservation, 2018).

Four national parks, Dibru-Saikhowa, Kaziranga, Nameri, and Orang National Parks, were selected as our study sites. Their area sizes varied from 78.81 sq. km to 430 sq. km. Kaziranga National Park is the largest site, about five times larger than Orang National Park. All four protected areas are home to many endangered mammals, birds, and reptiles (Government of Assam-Environment and Forest, 2022), but the species found in each park are slightly different. For instance, Kaziranga and Orang National Parks have tigers, elephants, and rhinos, while no rhinos are found in Nameri National Park. Two out of the four parks have global importance. The biological and cultural diversity of Dibru-Saikhowa National Park is recognized worldwide, and the park is designated as a UNESCO biosphere reserve. Kaziranga National Park, one of the world's last untouched natural areas, has been designated as a UNESCO World Heritage Site. Both national parks extend over large terrestrial ecosystems. Frontline staff are stationed in all four national parks for wildlife conservation and poaching control (Assam Project on Forest and Biodiversity Conservation, 2018). Table 1 summarizes the study sites and each park's designation as a conservation area, and Figure 1 shows the locations of national parks in Assam.

Table 1. Study sites in Assam, India

Protected Area	Special Designations	Size (sq. km)	Endangered Megafauna
Dibru-Saikhowa National Park	UNESCO Biosphere Reserve	340	Elephants
Kaziranga National Park	UNESCO World Heritage Site, Tiger Reserve	430	Tigers, elephants, rhinos
Nameri National Park	Tiger Reserve	200	Tigers, elephants
Rajiv Gandhi Orang National Park	Tiger Reserve	78.81	Tigers, elephants, rhinos

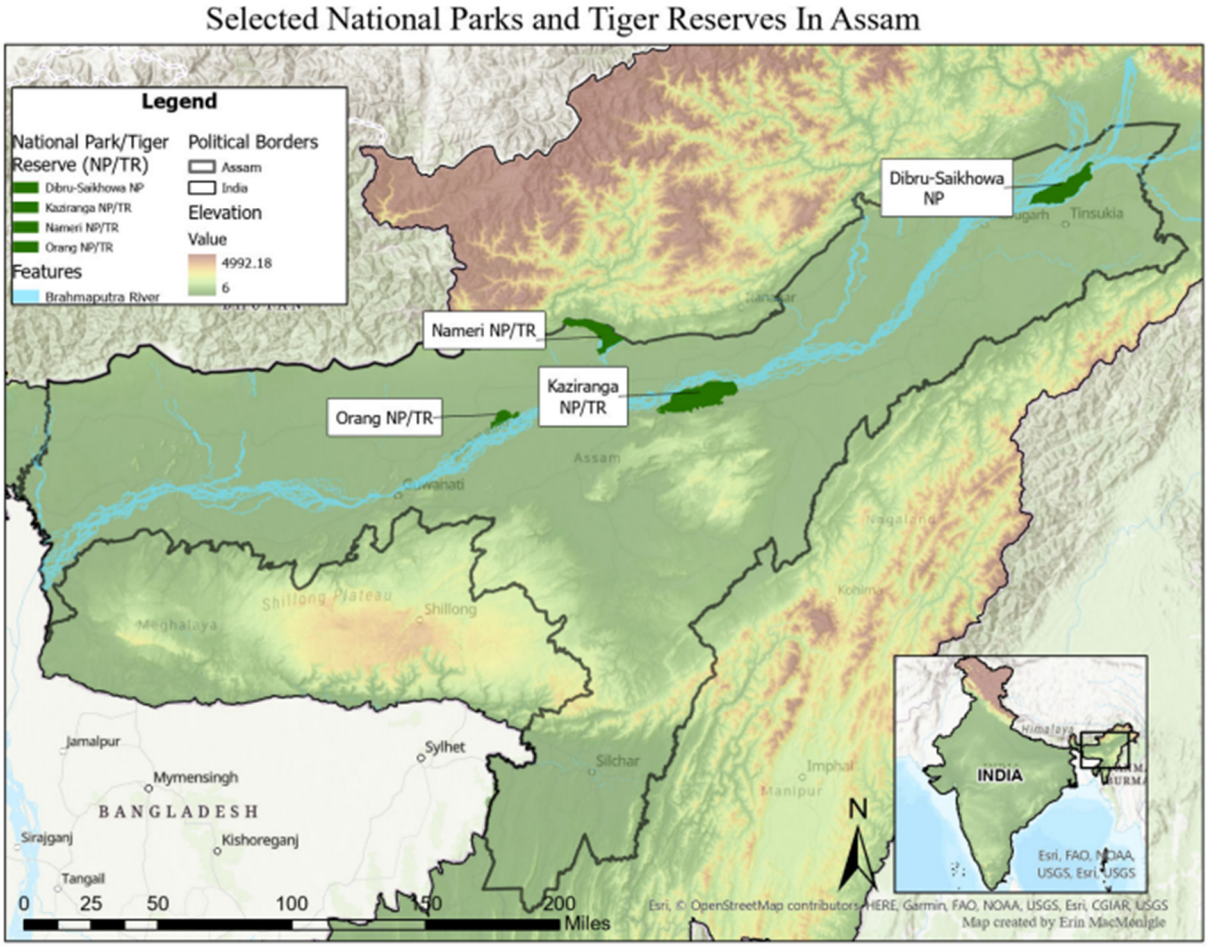

Figure 1. Map of study sites

2. Methods

To understand the relationship between workforce capacity and wildlife conservation, we developed a unique dataset including frontline staff numbers per year, frontline staff salary per year, and wildlife census data from Kaziranga, Orang, Nameri, and Dibru-Saikhowa National Parks. Frontline staff numbers and frontline salary were used as proxy variables for workforce capacity. The data were collected by Assam Forest Department between 1985 and 2020, and then integrated with the census data of endangered tigers, rhinos, and elephants in the four national parks. All variables were transformed to make them relative to a national park or tiger reserve, as stated below.

1) *Elephant Populations*: Population density was calculated by using the ratio of population numbers to a national park area (sq. km) and log-transformed using natural logarithm. This approach was taken to normalize the population numbers in the national park.

2) *Rhino Populations*: Population density was calculated by using the ratio of population numbers to a national park area (sq. km) and log-transformed using natural logarithm. This was done to normalize the population numbers in the national park.

3) *Tiger Populations*: Population density was calculated by using the ratio of population numbers to a core tiger reserve area (sq. km) and log-transformed using natural logarithm. This was done to normalize the population numbers in the tiger reserve.

4) *Frontline staff numbers per year*. In the analysis, the frontline staff included mainly the positions of Forest Guard, Game Watcher, Forester I and II, and Ranger Officer I and II job positions. The frontline staff number was calculated by using the ratio of the frontline staff to the area (sq. km) of a national park and log transformation using natural logarithms. This approach was taken to normalize the frontline staff numbers in the national park area.

5) *Frontline staff salary per year*. For the variable of frontline staff salary per year, the mid-range of the frontline staff income was first taken and converted from INR to USD using the observed year currency exchange rate. Then, the mid-range income in USD was multiplied by the number of frontline staff in each national park per year to compute the total frontline staff salary. We log-transformed frontline staff salaries using natural logarithms to normalize the data.

6) *Year*: The 'year' variable was added as a control variable, and the data is from 1985 to 2020.

The relationships of interest were analyzed by OLS regression method in R (R Core Team, 2022). It should be noted that outliers were not excluded to capture the changes or variations of species population size that could be driven from changes in the environment and market demands. We performed group mean imputation for missing data of rhino, tiger, and elephant population density (Tay, 2021). Each model was tested for multicollinearity using the variance inflation factor (VIF) criterion of four (4). This study used these specific criteria to ensure the results are as conservative as possible. Table 2 outlines descriptive statistics of dependent and independent variables in our regression models.

3. Results

Based on the statistical modeling, workforce capacity in terms of frontline staff numbers and frontline staff salary are predictive of endangered tiger, rhino, and elephant populations. Frontline staff numbers are positively correlated with endangered tigers and rhinos ($p < 0.001$), but interestingly, showed a negative correlation with endangered elephants ($p<0.001$). The direction of significance was observed the same way with the variable of frontline staff salary. Frontline staff salary is positively correlated with endangered tigers ($p<0.001$) but negatively correlated with endangered elephants ($p<0.001$). The variable of year has also shown a positive relationship with tiger population size, while it is negatively related to elephant population size. Table 2 provides the descriptive statistics of all the variables, and Table 3 provides the regression analysis outcomes.

Table 2. Descriptive statistics of frontline staff numbers, frontline staff salary, tiger, elephant, and rhino populations

	Number of Observations	Mean	SD	Max	Min
Dibru-Saikhowa National Park					
Elephant Population	36	-0.336	0.083	-0.021	-0.628
Frontline Staff Numbers	16	-0.926	0.074	-0.807	-1.084
Frontline Staff Salary	16	-5.176	0.210	-4.812	-5.501
Kaziranga National Park					
Elephant Population	36	0.416	0.019	0.478	0.342
Rhino Populations	36	0.608	0.073	0.749	0.400
Tiger Populations	36	-0.849	0.025	-0.771	-0.939
Frontline Staff Numbers	17	-0.021	0.054	0.075	-0.138
Frontline Staff Salary	17	-6.167	0.133	-5.913	-6.397
Nameri National Park					
Elephant Population	36	-0.116	0.046	0.063	-0.248
Tiger Populations	36	-1.718	0.065	-1.602	-2.028
Frontline Staff Numbers	22	-0.514	0.045	-0.469	-0.620
Frontline Staff Salary	22	-5.262	0.165	-5.011	-5.524
Orang National Park					
Elephant Population	36	-1.198	0.045	-1.053	-1.296
Rhino Populations	36	-0.025	0.054	0.107	-0.235
Tiger Populations	36	-0.594	0.113	-0.366	-0.898
Frontline Staff Numbers	30	-0.311	0.070	-0.134	-0.354
Frontline Staff Salary	30	-4.971	0.289	-4.611	-5.537

Table 3. Regression models of the relationships between workforce capacity and population size of tiger, rhino, and elephant in Dibru Saikhowa, Kaziranga, Nameri, and Orang National Parks

	Tiger population	Rhino Population	Elephant Population
Frontline staff numbers	3.385***(0.132)	1.948*** (0.094)	-0.760***(0.089)
Frontline staff salary	0.944*** (0.052)	NA[a]	-1.318***(0.061)
Year	0.008*** (0.002)	-0.000 (0.001)	-0.001***(0.002)
Adjusted R^2	0.861	0.858	0.777
Observations	108	72	144

Note: ***p<0.001, *p<0.05, **p<0.01

a: Multicollinearity violation

4. Discussion

Workforce capacity is essential for wildlife management and the protection of endangered species (Sethi, 2022). It is reasonable to assume that having forest staff in protected areas improves wildlife protection. This study builds on this assumption by quantifying the impact using empirical data from the Assam Forest Department. The findings show that increased workforce capacity positively affects wild tiger and rhino populations, which affirms the assumed significance of workforce capacity for wildlife protection.

The market demand for dead tigers is high (IFAW, 2013; Nowell, 2000), and poaching for illegal trade is a major threat to wild tiger populations. Habitat loss and fragmentation also contribute to poaching (Campbell et al., 2019; Dinerstein et al., 2007; Environmental Investigation Agency, 2017; Goodrich et al., 2022; Lapointe et al., 2007). Research shows that workforce capacity is crucial for maintaining healthy wild tiger and rhino populations. Frontline staff protect wild tigers primarily through their presence, being stationed in anti-poaching camps in Assam's tiger reserves. Their main responsibility is to monitor and protect the parks from intruders (World Wildlife Fund for Nature, 2018; WWF-India, 2021). This presence can deter poachers. Additionally, frontline staff typically come from local villages near protected areas, creating an important link between the Forest Department and the local community (World Wildlife Fund for Nature, 2018; WWF-India, 2021). Local communities are often the first to spot outsiders and can provide valuable intelligence to authorities. In this context, a trusted community member who is also part of the Forest Department facilitates collaborative ecosystem management. Interestingly, the salaries and benefits of these frontline staff are low by Western standards (Government of Assam, 2017). However, the job stability provided by government employment is valued by locals, motivating frontline staff to diligently perform their duties and protect wildlife.

Frontline staff are particularly important to maintaining wild rhino populations. The market demand for greater one-horned rhino horns is high (Dang Vu & Nielsen, 2018; Haas & Ferreira, 2016), making rhinos easy targets for poachers who exploit predictable defecation sites (Asian Rhino Specialist Group, 2009). Increasing the number of frontline staff is suggested to reduce rhino poaching (Archarya et al., 2020), with ranger patrols significantly decreasing the likelihood of poaching-related threats (Moore et al., 2018). In Assam, frontline staff patrol national parks and tiger reserves day and night, identifying poaching hotspots for focused protection (Hotte et al., 2016; Moreto & Matusiak, 2017). Consequently, frontline staff in anti-poaching camps are essential for safeguarding wild rhino populations and managing poaching threats (Gogoi & Gogoi, 2022).

On the contrary, the statistical analysis demonstrates a significant negative relationship between workforce capacity and wild elephant populations. A possible explanation for this might be that most of the elephant population is found in elephant reserves specifically designed for elephant conservation (Ministry of Environment and Forest, 2021). Elephants from the national park use the elephant migratory corridors to the elephant reserve. For example, elephants from Kaziranga National Park use the elephant corridor to Karbi Anglong Elephant Reserve. Likewise, Sonitpur Elephant Reserve is near Nameri National Park and Dining Patkai Elephant Reserve is near Dibru Saikhowa National Park. Only Orang National Park does not have an elephant reserve nearby or elephant corridor connectivity due to its location on the Brahmaputra River (Government of Assam--Environment and Forest, 2022). The possible movement of the elephant population from national parks to more preferred elephant reserves may produce the negative relationship observed in the elephant model. It is important to note that the statistical analysis only includes elephant population data from national parks and not elephant reserves because the Forest Department is not stationed in the elephant reserves. Further research is needed to fully understand the relationship between workforce capacity and wild elephant populations in Assam.

Furthermore, this research fills the knowledge gap left by wildlife management and conservation science. Previous studies on wildlife poaching were localized to a region in India (Bhatt & Pandit, 2019; Naro et al., 2015; Selvan et al., 2013) and offer perspectives through the lens of local communities (Velho et al., 2012). These studies did not consider the frontline forest staff who have the maximum impact on wildlife poaching. It is the frontline forest staff that interact with local communities, gather intelligence on potential wildlife poachers, patrol the protected area for wildlife poachers, and monitor wildlife populations (Sethi, 2022; WWF-India, 2021). Moreover, the prior conservation science literature has focused on increasing wildlife populations through increasing protected areas and developing corridors for better gene flow (Choudhury, 1999; Ellis & Talukdar, 2019; Walston et al., 2010). This study provides a novel approach that assesses relationships between conservation science and wildlife management to develop more effective conservation policies and strategies.

Our unique empirical approach could be expanded in future studies. While our focus is on workforce capacity, there may be other conservation management practices that could influence poaching controls and could be considered in future research. Additionally, since the census data for wild tigers, rhinos, and elephants was not collected annually, we used conditional-mean imputation. Despite these constraints, the novelty of this research lies in its reliance on archival data from the Assam Forest Department. To the best of our knowledge, no previous studies have attempted to understand and empirically test the relationships between workforce capacity and the conservation of three endangered megafauna species, tigers, rhinos, and elephants.

5. Conclusion

This research introduces a unique approach by quantifying the links between conservation biology and wildlife management, aiming to develop more effective conservation policies and strategies. The study outcomes suggest that enhancing workforce capacity, such as increasing the number of frontline staff and their salaries, can significantly improve wild tiger and rhino populations. It implies that forest departments struggling to conserve these endangered species can benefit from allocating more resources to their staff and increasing their salaries. Future research can apply this study design and analytical method to other regions or other endangered or threatened megafauna to enrich our understanding of the value of workforce capacity for wildlife protection and social security enhancement in marginalized communities around protected areas of the Global South where conservation relies on human workforce capacity rather than sophisticated monitoring technologies.

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Acknowledgments

We greatly appreciate the Principal Chief Conservator of Forest and Head of Forest Force in Assam for their support.

Authors contributions

Dr. Sudha Balajapalli was responsible for data collection and analysis, and Dr. Younsung Kim was responsible for study design and supervised data collection and analysis. Both authors contributed to the drafting and revising the manuscript and approved the final manuscript.

Funding

This research received no external funding.

Competing interests

The authors declare no conflict of interest.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.