Inventum Biologicum: *An International Journal of Biological Research*
2024, Vol. 4, Issue 1, pp. 1-6

Inventum Biologicum

Journal homepage: www.journals.worldbiologica.com/ib

Research paper

Assessment of Tree Diversity and Recruitment Patterns in the Kanha Tiger Reserve, Central India

Anthony Samy Mathalaimuthu [a], **Periyakaruppan Muthumanickam** [b], **Ganapathy Vanaraj** [c], **Subramanian Mutheeswaran** [c] *, **Bawa Mothilal Krishnakumar** [d], **Rathinavel Kanthasamy** [e], **Savarimuthu Ignacimuthu** [c]

[a] *Department of Botany, St Xavier's College, Palayamkottai, Tamil Nadu, India*
[b] *Department of Botany, Vivekananda College, Agasteeswaram, Kanyakumari, Tamil Nadu, India*
[c] *Xavier Research Foundation, St. Xaviers College, Palayamkottai, Tamil Nadu, India*
[d] *Chinmaya Vidyalaya Srimathi Lingammal Ramaraju Matriculation Higher Secondary School, Rajapalayam, Tamil Nadu, India*
[e] *Biologist, District Forest Office & Wildlife Warden, Tirunelveli, Tamil Nadu, India*

ARTICLE INFO

Article history

Received 22 February 2024
Revised 07 March 2024
Accepted 09 March 2024
Published 12 March 2024

Keywords

- Tree Diversity
- Regeneration
- Kanha Tiger Reserve
- Biodiversity
- Conservation
- Ecosystem resilience
- Species richness

ABSTRACT

Tree diversity and regeneration are vital indicators of forest health and resilience, particularly in biodiversity-rich areas like the Kanha Tiger Reserve in central India. This study assesses the diversity and recruitment patterns of tree populations across five distinct locations within the reserve: Chapari, Kisi, Manegaon, Patpara, and Soutiya. A total of 25 circular plots, each with a 10-meter radius, were systematically established to identify and measure all trees with a girth at breast height (GBH) greater than 30 cm. Additionally, a nested subplot approach was utilized to evaluate tree recruits with a GBH of 20 cm but less than 50 cm in height. Various diversity indices, including Taxa (S), Dominance (D), Simpson's Index (1-D), Shannon Index (H), and Evenness (e^H/S), were calculated to gauge species richness and distribution patterns.

The results demonstrate considerable spatial variation, with Chapari and Soutiya showing the highest species diversity and recruitment rates, while Kisi and Patpara exhibited lower diversity and higher dominance, possibly due to environmental or anthropogenic influences. A Kruskal-Wallis test identified significant differences among the locations for most of the ecological indices, and further Dunn's post-hoc tests highlighted specific pairwise differences between the locations. The findings of this study emphasize the need for targeted conservation strategies to enhance biodiversity and maintain ecological equilibrium within the Kanha Tiger Reserve.

1. Introduction

Biodiversity in forest ecosystems is crucial for maintaining ecological balance and providing essential ecosystem services. In tropical and subtropical regions, tree diversity serves as a key indicator of forest health and resilience (Skidmore et al., 2021; Jetz et al., 2019). High tree diversity contri-

DOI 10.5281/ib433024

*Corresponding author: Subramanian Mutheeswaran
Email: muthees2009@gmail.com

-butes to ecosystem stability, productivity, and resilience against environmental stresses, such as climate change and human activities (Cavender-Bares et al., 2022; Cristescu, 2019). The Kanha Tiger Reserve in central India is a notable biodiversity hotspot, home to a wide variety of flora and fauna. Assessing the diversity indices of tree populations across different areas within this reserve offers valuable insights into ecological dynamics and informs conservation planning (Sharma et al., 2020; Joshi et al., 2019; Kumar & Mishra, 2021).

This study examines five specific locations within the Kanha Tiger Reserve: Chapari, Kisi, Manegaon, Patpara, and Soutiya. These sites were selected due to their distinct environmental conditions and varying levels of human impact. By evaluating diversity indices, such as the number of taxa (S), individual counts, dominance (D), Simpson's Index (1-D), Shannon Index (H), and evenness (e^H/S), the study aims to analyze the distribution and diversity of tree species in these areas.

Previous studies have underscored the importance of using diversity indices to understand ecological patterns and processes. For example, recent research highlights the role of protected areas in sustaining high levels of biodiversity. Skidmore et al. (2021) and Cavender-Bares et al. (2022) emphasize the value of advanced technologies, like remote sensing, for effective biodiversity monitoring and conservation. Additionally, the impact of human activities on species distribution and ecosystem structure has been demonstrated by Pettorelli et al. (2016) and Reddy (2021). By integrating these insights, this study aims to contribute to the growing body of knowledge on forest biodiversity and conservation.

The role of tree diversity in supporting ecological functions and promoting forest resilience is well-established. A high level of species diversity and evenness can enhance ecosystem stability and productivity (Jetz et al., 2019; Anderson et al., 2017). Furthermore, technological advancements in remote sensing and environmental DNA (eDNA) techniques have significantly improved our capacity to monitor biodiversity and implement effective conservation strategies (Cristescu, 2019; Anderson et al., 2017). Recent studies by Funk et al. (2024) and Orme et al. (2024) underscore ongoing innovations in biodiversity monitoring and the pressing need for comprehensive conservation strategies. This paper provides a detailed analysis of tree diversity and recruitment across selected locations within the Kanha Tiger Reserve, offering a foundation for targeted conservation actions and highlighting the importance of maintaining diverse, balanced ecosystems for sustainable forest management.

2. Methodology

2.1 Study Area

The Kanha Tiger Reserve (KTR) is situated in the Mandla district of Madhya Pradesh, in central India. This area is known for its extensive forest cover and is predominantly inhabited by tribal communities who face considerable socio-economic challenges. The reserve is geographically located between latitudes 22°02'52.6" N to 22°25'48.8" N and longitudes 80°30'09.3" E to 81°02'48.4" E (Fig. 1). KTR is organized into two main zones: the core and buffer zones, each comprising six forest ranges. The buffer zone includes 35 forest villages and 126 revenue villages. The region experiences a tropical monsoonal climate, with temperatures varying from -2°C in winter to 45°C in summer, and an average annual rainfall of around 1300 mm, most of which falls during the monsoon season.

The forest landscape within the reserve is primarily dominated by teak (*Tectona grandis*) and sal (*Shorea robusta*), along with a variety of mixed species such as haldu (*Adina cardifolia*) and aonla (*Emblica officinalis*). Significant non-timber forest products (NTFPs) found in the area include tendu leaves (*Diospyros melanoxylon*), mahua flowers (*Madhuca indica*), and harra (*Terminalia chebula*).

The region is home to Primitive Tribal Groups (PTGs), mainly the Gond and Baiga communities, who are heavily dependent on forest resources for their subsistence. Due to their remote locations, these forest fringe villages face limited access to modern energy sources, inadequate infrastructure, and a high reliance on natural resources, which increases their vulnerability. Historically marginalized from mainstream development, these communities are further affected by the challenges posed by climate change (Devi et al., 2018).

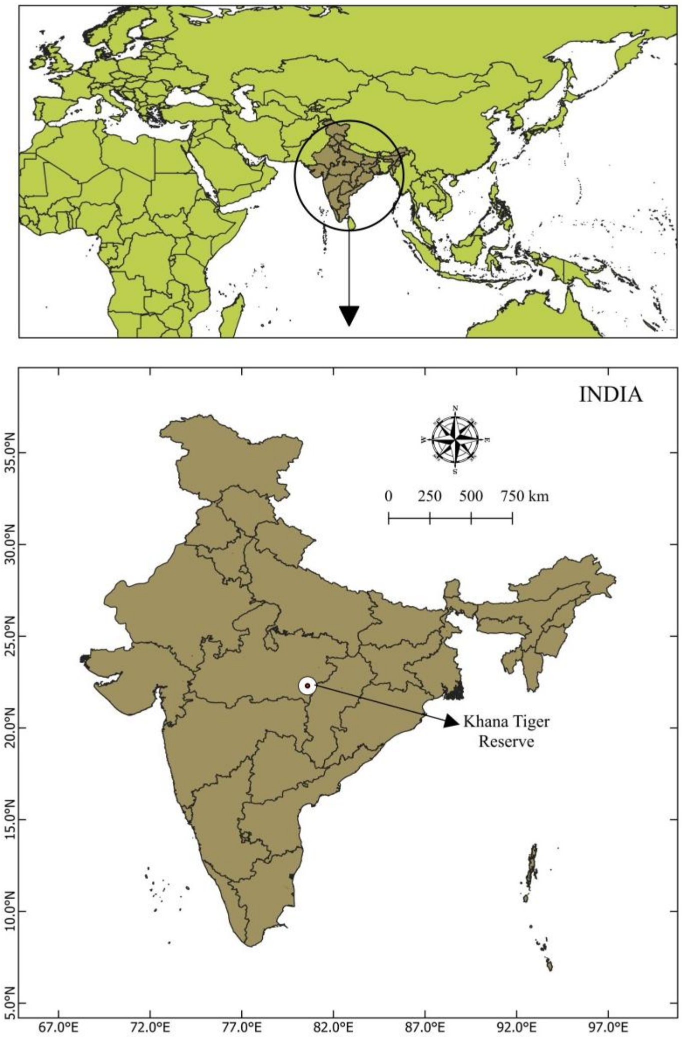

Fig. 1 Map of Kanha Tiger Reserve (KTR)

2.2 Data Collection

The study was carried out in a deciduous forest to assess tree diversity and regeneration. We established 25 circular plots, each with a 10-meter radius, systematically positioned from the forest edge inward. To ensure spatial independence, plots were spaced 100 meters apart. Within each plot, all trees with a girth at breast height (GBH) exceeding 30 cm were identified and measured. GBH was recorded at a standard height of 1.37 meters above ground using a tape measure. The species of each tree was documented to evaluate species composition and diversity.

To examine the regeneration of native tree species, we used a nested plot approach. Inside each 10-meter radius plot, a smaller circular subplot with an 8-meter radius was set aside for recruitment assessment. In these subplots, all tree recruits with a GBH between 20 cm and less than 50 cm in height were counted and identified. This allowed us to evaluate the forest's regeneration status. We calculated tree species diversity and recruitment using standard indices, including the Shannon-Wiener Index (H') and Simpson's Diversity Index (D). Additionally, we recorded human activities within each plot, noting indicators such as trails, litter, signs of logging, and other disturbances to understand their potential impact on tree diversity and regeneration.

3. Results

Analysis of the diversity indices across various locations in the Kanha Tiger Reserve revealed significant differences in tree diversity and abundance (Fig. 2). Chapari and Soutiya exhibited the highest species richness (Taxa_S), with median values around 14, whereas Kisi and Patpara showed lower values, around 12 and 10, respectively. Manegaon had intermediate values, suggesting moderate species diversity. The number of individuals also varied, with Chapari having the highest median count of approximately 75, indicating a robust tree population, while Kisi and Patpara had lower median counts of about 45 and 50, respectively, reflecting differences in tree density.

For the Dominance_D index, Kisi had a notably higher median value of around 0.25, indicating a less even distribution and dominance by a few species. In contrast, other locations, especially Chapari and Manegaon, had lower median dominance values, around 0.10. The Simpson_1-D index revealed high median values of about 0.85 in Chapari and Manegaon, indicating greater species diversity and evenness, while Kisi had a lower median value of approximately 0.75. Similarly, the Shannon_H index showed higher median values in Chapari and Manegaon, around 2.5, compared to lower values in Kisi and Patpara, around 1.8 and 2.0, respectively. The Evenness_e^H/S index also showed Chapari and Manegaon with the highest evenness (around 0.75), while Kisi had a lower value of about 0.55, suggesting notable ecological imbalances that may require targeted conservation measures.

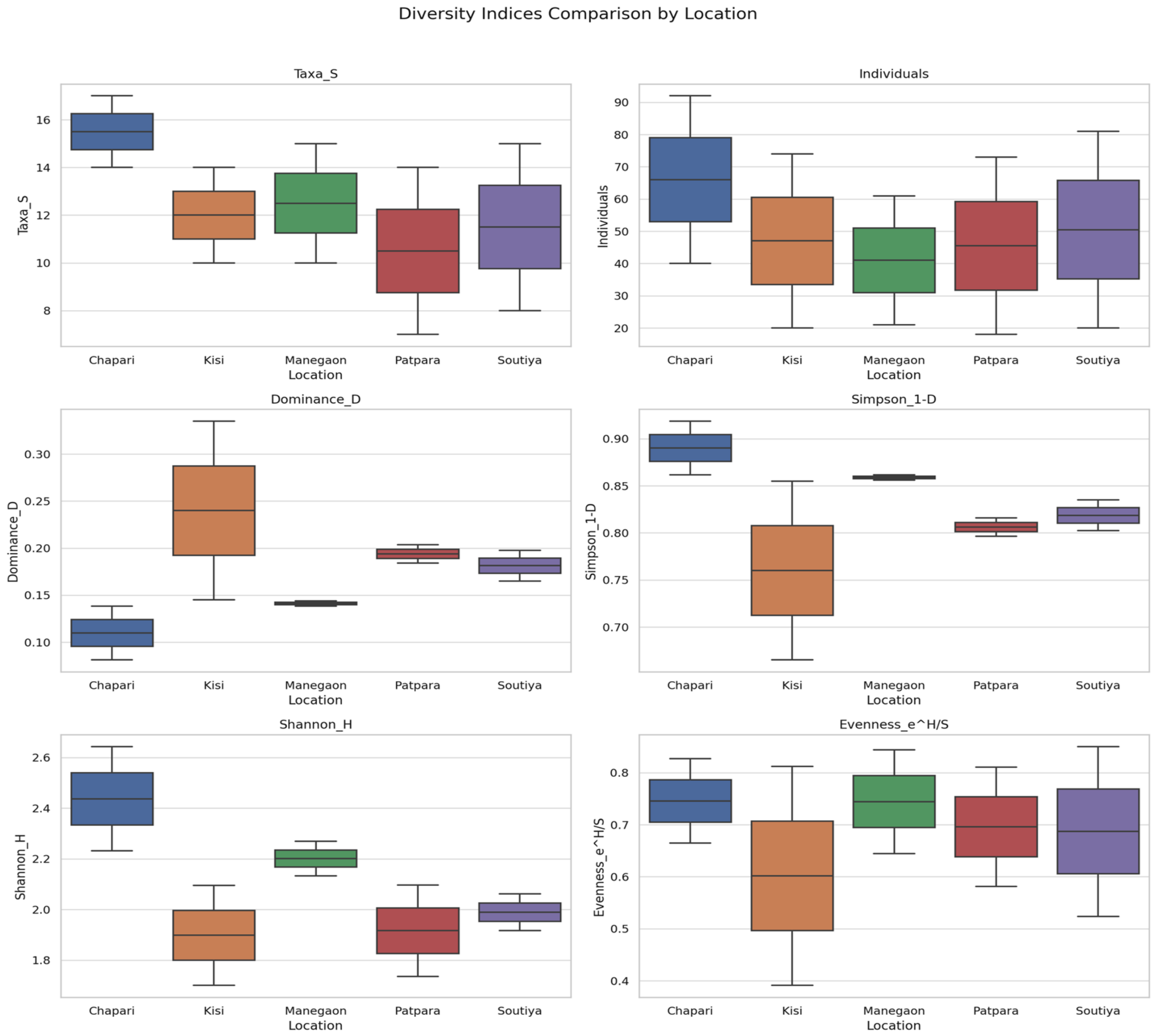

Fig. 2 Diversity Indices Comparison of Tree Populations across Different Locations

The Kruskal-Wallis test indicated significant differences among locations for most indices: Taxa_S ($H = 14.083$, $p = 0.007$), Dominance_D ($H = 11.632$, $p = 0.020$), Simpson_1-D ($H = 11.617$, $p = 0.020$), Shannon_H ($H = 11.625$, $p = 0.020$), and Evenness_e^H/S ($H = 11.726$, $p = 0.019$). However, there was no significant difference in the number of individuals ($H = 7.561$, $p = 0.109$; Fig. 2). Dunn's post-hoc tests identified specific pairwise differences: Dominance_D differed significantly between Chapari and Kisi ($p = 0.032$) and Chapari and Soutiya ($p = 0.032$). Simpson_1-D showed significant differences between Kisi and Patpara ($p = 0.032$). Shannon_H differed significantly between Chapari and Kisi ($p = 0.032$) and Chapari and Soutiya ($p = 0.032$). For Evenness_e^H/S, significant differences were found between Manegaon and Soutiya ($p = 0.032$). No significant pairwise differences were observed for Taxa_S, with all p-values exceeding 0.05 ($p > 0.05$; Fig. 2). These results highlight the distinct ecological variations among locations, underscoring the need for targeted conservation strategies to address the specific dynamics within each area.

4. Discussion

The results of this study indicate that Chapari consistently exhibited the highest values across most diversity indices, suggesting it hosts a diverse and well-balanced tree population. This includes both a rich variety of species and a balanced distribution among them. Soutiya also demonstrated high values, particularly in terms of tree diversity, making it another important area with notable biodiversity.

These observations align with previous research that highlights the role of protected areas in maintaining high levels of biodiversity (Skidmore et al., 2021; Cavender-Bares et al., 2022).

In contrast, Kisi showed lower diversity and higher dominance, reflecting a less even distribution of species. This pattern may be attributable to specific environmental or anthropogenic pressures that limit species diversity in this area. Such findings are consistent with research suggesting that human activities can significantly affect species distribution and ecosystem dynamics (Pettorelli et al., 2016; Reddy, 2021). This situation highlights the need for targeted conservation actions to mitigate these impacts and improve biodiversity in Kisi.

Manegaon and Patpara exhibited intermediate levels of diversity. Manegaon had relatively high values for Simpson's and Shannon indices, indicating good species diversity and evenness. Conversely, Patpara showed lower values for diversity and evenness, which may point to challenges related to species recruitment and survival. These results echo studies that underscore the influence of habitat quality and resource availability on species diversity and recruitment (Cristescu, 2019; Jetz et al., 2019). The findings stress the need for focused conservation efforts tailored to each location's specific conditions, incorporating modern tools such as remote sensing and environmental DNA (eDNA) for effective biodiversity monitoring and management (Anderson et al., 2017).

The Kruskal-Wallis test and Dunn's post-hoc tests revealed significant variations in ecological indices among the study locations, reflecting diverse ecological dynamics within the Kanha Tiger Reserve. Significant differences in Taxa_S, Dominance_D, Simpson_1-D, Shannon_H, and Evenness_e^H/S indicate that species diversity and distribution are not uniform across these areas. These variations might be due to differences in habitat quality, human disturbance, and microclimatic conditions (Sharma et al., 2020). For example, the notable differences in Dominance_D and Shannon_H between Chapari and Kisi suggest distinct species composition and diversity patterns in these regions. Such variations align with other studies documenting spatial heterogeneity in species diversity within forest reserves (Patil et al., 2018).

The lack of significant differences in the number of individuals ($p > 0.05$) suggests that while species composition and diversity vary, the overall tree abundance remained relatively stable across locations. This stability could be related to the carrying capacity of the forest ecosystem, which supports a consistent number of trees despite differences in species richness and dominance (Kumar & Mishra, 2021). The pairwise differences identified by Dunn's post-hoc tests underscore the importance of localized conservation strategies. For instance, the significant differences between Chapari and Soutiya in various indices indicate that these areas could benefit from customized management practices to enhance biodiversity and ecological balance. Addressing these spatial variations is crucial for effective conservation planning and the sustainability of forest ecosystems (Joshi et al., 2019).

5. Conclusion

This study highlights significant spatial variations in tree species diversity and composition across different areas within the Kanha Tiger Reserve. The findings underscore the need for targeted conservation strategies that consider the unique ecological characteristics of each location. Future research should aim to further investigate the factors driving these variations to develop more effective management practices. A comprehensive understanding of species diversity and the ecological processes that support it is essential for effective conservation planning and ensuring the long-term sustainability of forest ecosystems.

Funding information

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Conflict

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Anderson, K., Ryan, B., Sonntag, W., Kavvada, A., & Friedl, L. (2017). Earth observation in service of the 2030 agenda for Sustainable Development. Geo-spatial Information Science 20 (2), 77-96.
2. Cavender-Bares, J., Gamon, J. A., Hobbie, S. E., Madritch, M. D., Meireles, J. E., Schweiger, A. K. & Townsend, P. A. (2022). Integrating remote sensing with ecology and

evolution to advance biodiversity conservation. Nature Ecology & Evolution 6 (5), 506-519.
3. Clark, D. A., & Clark, D. B. (2000). Landscape-scale variation in forest structure and biomass in a tropical rain forest. Forest Ecology and Management 137(1-3), 185-198.
4. Condit, R. (1998). Tropical Forest Census Plots: Methods and Results from Barro Colorado Island, Panama and a Comparison with Other Plots. Springer-Verlag.
5. Cristescu, M. E., & Hebert, P. D. N. (2019). Can environmental RNA revolutionize biodiversity science? Trends in Ecology & Evolution 34 (8), 694-697.
6. Devi, R., Bhowmick, P. K., & Chhetri, P. (2018). Vulnerability of forest fringe tribal communities: A case study of the Baiga tribe in central India. Journal of Environmental Management, 223, 70-80. https://doi.org/10.1016/j.jenvman.2018.06.049
7. Funk, J. L., Cleland, E. E., Suding, K. N., & Zavaleta, E. S. (2024). Advancing biodiversity conservation through innovative monitoring techniques. Global Ecology and Biogeography 33(2), 235-249.
8. Jetz, W., McPherson, J. M., & Guralnick, R. P. (2019). Essential biodiversity variables for mapping and monitoring species populations. Nature Ecology & Evolution 3 (4), 539-551.
9. Joshi, V., Gupta, S., & Sinha, R. (2019). Spatial heterogeneity in species diversity in forest ecosystems. Forest Ecology and Management 437, 135-144.
10. Kumar, A., & Mishra, S. (2021). Ecological stability and species abundance in forest ecosystems. Journal of Tropical Ecology 37(2), 112-120.
11. Mueller-Dombois, D., & Ellenberg, H. (1974). Aims and Methods of Vegetation Ecology. Wiley.
12. Orme, C. D. L., Moritz, C., Ferrier, S., Huettman, F., & Peterson, A. T. (2024). Integrating eDNA and remote sensing for comprehensive biodiversity assessment. Conservation Biology 38 (1), 89-103.
13. Patil, R., Deshmukh, A., & Rao, K. (2018). Species diversity and its spatial patterns in tropical forests. Biodiversity and Conservation 27(7), 1987-2002.
14. Pettorelli, N., Safi, K., & Turner, W. (2016). Framing the concept of satellite remote sensing essential biodiversity variables: Challenges and future directions. Remote Sensing in Ecology and Conservation 2 (3), 122-131.
15. Reddy, C. S., Kumar, R., Jha, C. S., & Diwakar, P. G. (2021). Remote sensing of biodiversity: What to measure and monitor from space to species? Biodiversity and Conservation 30 (10), 2617-2631.
16. Sharma, P., Singh, R., & Kaur, J. (2020). Human disturbance and habitat quality: Impacts on species diversity in protected areas. Conservation Biology 34(3), 682-691.
17. Skidmore, A. K., Pettorelli, N., Coops, N. C., Geller, G. N., Hansen, M., Lucas, R., & Turner, W. (2021). Priority list of biodiversity metrics to observe from space. Nature Ecology & Evolution 5 (7), 896-906.