Journal of Advance Research in Science and Social Science (JARSSC) **ISSN:** 2582-2004
Publisher: Indian Mental Health & Research Centre Volume 09, Issue 01
DOI: 10.46523/jarssc.09.01.02
Multidisciplinary, Open Access
Impact Factor: 3.612
OPEN ACCESS
Crossref DOI Prefix 10.46523 Crossref

AI-Driven Ecological Insights into the Distribution and Habitat Selection of Smooth-Coated Otters (*Lutrogale perspicillata*) in Pilibhit Tiger Reserve, India

Arun Kumar[1], Arun Kumar[2], Ashok Kumar[1], Ujjwal Kumar[3]

[1]Department of Zoology, BSNV P.G. College, University of Lucknow, Lucknow
[2]Department of Zoology, Shia P.G. College, University of Lucknow, Lucknow
[3]Research Scientist, NTCA and Tiger Cell, Wildlife Institute of India, Dehradun
Corresponding author Email id: arunkumar02071997@gmail.com

ABSTRACT

The smooth-coated otter (*Lutrogale perspicillata*), a semi-aquatic carnivore of the Terai Arc Landscape, plays an important ecological role as an apex mesopredator in wetland ecosystems. Despite being classified as *Vulnerable* by the IUCN, its population ecology, habitat selection, and distribution remain poorly studied in India, particularly within protected areas of the Terai region. This study integrates field-based ecological surveys with statistical modeling and geospatial tools to assess otter population presence and habitat selection in Pilibhit Tiger Reserve (PTR), Uttar Pradesh. Standardized transects (n=80) were deployed across five forest ranges, with 144 ecological survey points assessed between June 2025. Habitat conditions such as water quality measures (salinity, TDS, turbidity, temp, pH), fish density, and habitat type were assessed with Mann–Whitney U tests and logistic regression. The model produced 84% classification accuracy and determined that fish density was the best predictor of otter presence (odds ratio = 57, p<0001). Habitat in riverine and wetland habitats had ~4× greater odds of otter presence compared to other aquatic habitats (p = 0002). High salinity had a negative impact on otter presence, whereas moderate total dissolved solids (TDS) levels had a positive relationship. pH, temperature, and turbidity had little impact on habitat use. These results highlight the significance of prey abundance, habitat structure, and water chemistry in determining otter distribution. Conservation priorities should focus on keeping freshwater flows, controlling livestock grazing, reducing salinization, and safeguarding fish populations in PTR. This study demonstrates the utility of combining AI-driven ecological insights, geospatial mapping, and statistical modeling for evidence-based otter conservation.

Keywords: Smooth-coated otter, habitat selection, logistic regression, fish abundance, Terai Arc Landscape, Pilibhit Tiger Reserve, AI ecology

Received: 14.12.2025 **Accepted:** 31.01.2026 **Published**: 01.02.2026

Journal of Advance Research in Science and Social Science (JARSSC) **ISSN:** 2582-2004
Publisher: Indian Mental Health & Research Centre Volume 09, Issue 01
DOI: 10.46523/jarssc.09.01.02
Multidisciplinary, Open Access
Impact Factor: 3.612

Introduction

The smooth-coated otter (Lutrogale perspicillata) is a semi-aquatic mustelid whose range covers South and Southeast Asia, from Iraq through the Indian subcontinent to southern China and Indochina (Pocock, 1941; Hussain, 1999). The only otter in most of northern India, it inhabits rivers, wetlands, and irrigation canals in the Terai Arc Landscape (Nawab & Hussain, 2012). The top-level piscivorous species is important in maintaining fish populations, wetland vigour, and acting as a freshwater ecosystem quality bioindicator (Foster-Turley, 1992; Hussain et al., 2011).

Ecologically significant, yet Vulnerable on the IUCN Red List due to a decline in populations from habitat destruction, water pollution, poaching, and retaliatory killing (Wright et al., 2021; de Silva et al., 2015). Major threats in India are wetland development, sand mining, overfishing, and crop cultivation into riparian zones (Khan et al., 2014).

Otters in the Terai Arc Landscape (TAL) encounter specific challenges in conservation. The TAL is a patchwork of forests, grasslands, rivers, and human-dominated agricultural fields covering India and Nepal (Johnsingh et al., 2004). In the TAL, irrigation canals, sugarcane cultivation, and cattle grazing often encroach on natural wetlands, and it results in habitat fragmentation as well as more human-otter conflicts. Pilibhit Tiger Reserve (PTR), a significant part of TAL, contains a rich diversity of river and land fauna and provides an important refuge for otters (Uttar Pradesh Forest Department, 2022).

While tigers and elephants dominate research and conservation attention in PTR, smooth-coated otters remain poorly studied, with limited ecological data on their population and habitat requirements. Given the species' vulnerability and its reliance on freshwater systems, understanding the drivers of habitat selection is vital for designing effective conservation strategies.

By integrating ecological field surveys, statistical modeling, and GIS mapping, this study contributes novel insights into otter ecology in the Terai region, where such research is scarce.

This study aims to comprehensively investigate the ecology of smooth-coated otters within Pilibhit Tiger Reserve (PTR) by assessing their occurrence and distribution across different ranges of the reserve. It further seeks to identify key ecological and water quality parameters

Received: 14.12.2025 **Accepted:** 31.01.2026 **Published**: 01.02.2026

Journal of Advance Research in Science and Social Science (JARSSC) **ISSN:** 2582-2004
Publisher: Indian Mental Health & Research Centre Volume 09, Issue 01
DOI: 10.46523/jarssc.09.01.02
Multidisciplinary, Open Access
Impact Factor: 3.612

that influence their habitat selection, with a particular emphasis on prey availability and the physicochemical characteristics of the water. Additionally, the study assesses the predictive capabilities of statistical models, such as logistic regression, to gain a deeper understanding of otter habitat use patterns. Finally, the research provides science-based conservation recommendations to ensure the long-term survival of smooth-coated otter populations in PTR.

Study Area

Pilibhit Tiger Reserve (PTR), located in Uttar Pradesh, India, spans approximately 730 km² along the Indo-Nepal border and forms part of the Terai Arc Landscape (Fig. 1). Established in 2014, PTR comprises moist deciduous forests, extensive wetlands, grasslands, and agricultural matrices (Jhala et al., 2020). The reserve contains five ranges, namely, Mahof, Mala, Deoria, Barahi, and Haripur.

PTR is also ecologically significant since it covers upper Gangetic plain river systems, i.e., Sharda, Ghaghara, and Gomti, maintaining rich fish diversity and wetland-associated species such as otters, turtles, and migratory birds. The region is a Tiger Reserve and home to over 65

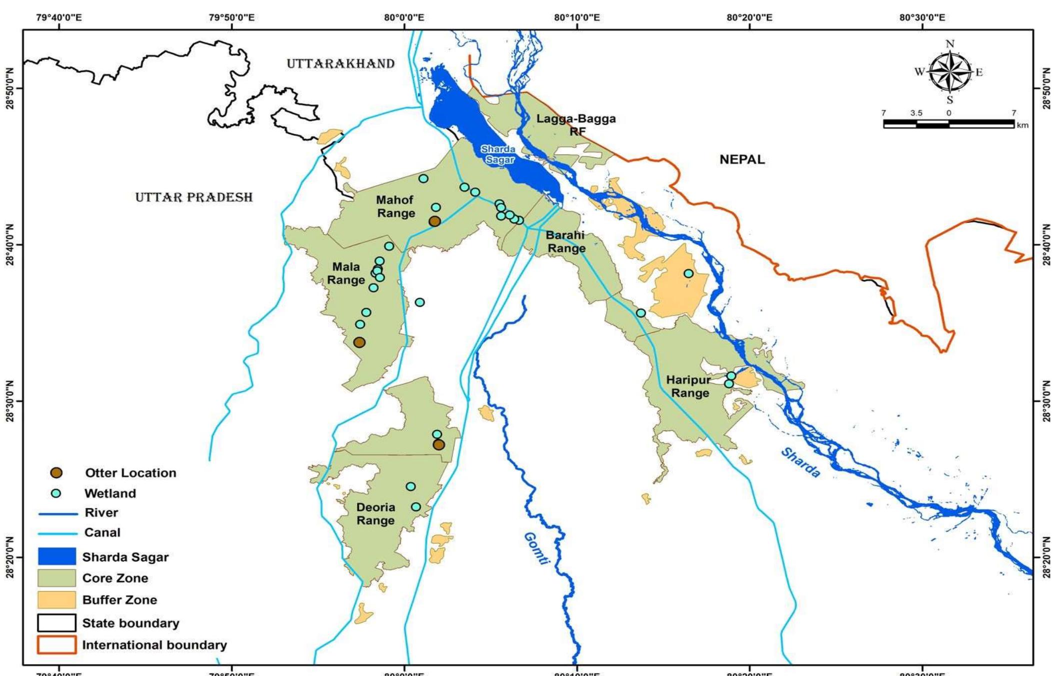

Fig 1: Map of Study Area

tigers (NTCA, 2023). The region lies within subtropical climate conditions, with 1,200 mm

Received: 14.12.2025 **Accepted:** 31.01.2026 **Published**: 01.02.2026

Journal of Advance Research in Science and Social Science (JARSSC) **ISSN:** 2582-2004
Publisher: Indian Mental Health & Research Centre Volume 09, Issue 01
DOI: 10.46523/jarssc.09.01.02
Multidisciplinary, Open Access
Impact Factor: 3.612

mean rainfall in a year, all of which occur during mainly during the monsoon months (June–September). Human activity pervades buffer zones, and in buffer zones, human activity is widespread, with agriculture (especially sugarcane cultivation), pastoral activities, and fishing significantly impacting riparian ecosystems. These anthropogenic activities and natural hydrological changes impact habitat quality and availability in smooth-coated otters.

Materials and Methods

Survey Design

Riverine and wetland habitats were systematically surveyed using 80 transects, each 1 km in length, across the five ranges. A total of 144 ecological survey points were sampled between 31st May to 30th June 2025. Each transect was assessed for otter presence (direct sightings, spraints, tracks) and co-occurrence of other fauna.

Water Quality Assessment

At each survey point, water samples were collected and analyzed for pH, temperature, turbidity, salinity, and total dissolved solids (TDS). Parameters were compared between otter presence and absence sites using the Mann–Whitney U test, as data were non-normally distributed.

Fish Abundance Assessment

Fish abundance was visually estimated using cast nets and catch-per-unit-effort (CPUE) surveys conducted with local fishers. Sites were categorized into high or low fish abundance.

Statistical Modeling

Binary logistic regression was applied to model otter presence (1) vs. absence (0) using predictor variables: fish abundance, habitat type (riverine/wetland vs. other), salinity, TDS, pH, turbidity, and temperature. Model performance was evaluated using classification accuracy and Akaike Information Criterion (AIC).

GIS and Remote Sensing

Wetlands were mapped using Google Earth Pro and ArcGIS. Riverine systems were divided into 1 km segments for standardized sampling. Presence data were plotted to visualize otter distribution across PTR.

Received: 14.12.2025 **Accepted:** 31.01.2026 **Published**: 01.02.2026

Journal of Advance Research in Science and Social Science (JARSSC)
Publisher: Indian Mental Health & Research Centre
DOI: 10.46523/jarssc.09.01.02
Multidisciplinary, Open Access
Impact Factor: 3.612
ISSN: 2582-2004
Volume 09, Issue 01
Crossref DOI Prefix 10.46523

Results

Systematic ecological surveys across the five ranges of Pilibhit Tiger Reserve (PTR) provided key insights into the habitat preferences and distribution of smooth-coated otters (*Lutrogale perspicillata*). Out of 144 ecological survey points, otter signs (direct sightings, spraints, and tracks) were confirmed at multiple riverine and wetland segments, particularly in Mala and Mahof ranges. Direct sightings were recorded at the Bifurcation Canal and Malasi Beat of the Mala Range, confirming active presence within flowing freshwater habitats

Comparison of water quality parameters between otter presence (n=71) and absence sites (n=73) revealed significant ecological patterns (Table 1). Total dissolved solids (TDS) were significantly higher at otter presence sites (128.2 ± 41.5 mg/L) than at absence sites (119.6 ± 35.2 mg/L; p = 0.048). This suggests that otters favor habitats with moderately elevated dissolved solids, which may reflect nutrient-rich conditions that support higher fish productivity. Conversely, salinity was significantly lower in otter presence sites (3.4 ± 1.8) compared to absence sites (4.1 ± 1.9; p = 0.012), highlighting their preference for freshwater

Parameter	Presence (n=71)	Absence (n=73)	p-value	Interpretation
pH	7.90 ± 0.29	7.85 ± 0.31	0.31	Not significant
Temperature	97.6°F ± 0.8	97.8°F ± 0.7	0.42	Not significant
TDS	128.2 ± 41.5	119.6 ± 35.2	**0.048**	Higher in presence sites
Salinity	3.4 ± 1.8	4.1 ± 1.9	**0.012**	Lower in presence sites
Turbidity	3.2 ± 2.1	2.8 ± 2.4	0.22	Not significant

Analysis of water Parameters in the presence and absence of a smooth-coated otter using the Mann-Whitney U Test for non-normal data

Variable	Odds Ratio	p-value	Interpretation
Fish Abundance	5.72	< 0.001	5.7× higher odds in high-fish sites
Salinity	0.45	0.008	55% lower odds per unit salinity increase
Riverine Habitat	3.91	0.002	4× higher odds in riverine/wetlands
TDS	1.02	0.039	Slight preference for higher TDS

Logistic regression in otter presence using Fish abundance, Salinity, riverine habitat, and TDS as predictors.

Received: 14.12.2025 **Accepted:** 31.01.2026 **Published**: 01.02.2026

habitats and avoidance of saline conditions. Other parameters—pH (7.90 vs. 7.85), water temperature (97.6°F vs. 97.8°F), and turbidity (3.2 vs. 2.8)—showed no statistically significant differences (p>0.05), indicating that otters are tolerant of a broad range of these environmental conditions.

Logistic regression modelling identified four key predictors of otter presence, yielding an overall classification accuracy of 84The most important predictor was fish abundance, and there was 5.72 greater likelihood of finding otters in areas having larger fish biomass ($p < 0.001$). Distribution was significantly affected by type of habitat, as there was 3.91 greater likelihood of observing otters in riverine and wetland systems in comparison with river mouths, fjords, and marine systems ($p = 0.002$). Salinity was a negative force on distribution, and there was a 55% decrease in the likelihood of occurrence in otters per unit increase ($p = 0.008$). TDS showed a weak, statistically significant positive association ($OR = 1.02$, $p = 0.039$), and it could be hypothesized that small increments in dissolved material provide a positive condition in habitats.

In general, availability of prey and habitat strongly influence the distribution of otters in PTR, and water chemistry plays secondary but significant roles. River/wetland habitat and high fish densities were the most important predictors in determining the presence of otters, and salinity was a limiting factor. Statistical robustness of the logistic regression model lends credibility to the ecological significance of the findings. The results highlight the importance of the preservation of freshwater river systems, the maintenance of fish stocks, and the prevention of salinization in preserving the sustainability of PTR's otter population.

Discussion

The paper sheds new lights on ecological determinants that govern the distribution of smooth-coated otters in PTR with the foremost significance of prey, environment, and chemical characteristics in water.

The close relationship of otters' occurrence with the presence of fish agrees with the prior study in India and Southeast Asia (Hussain, 1993; Nawab & Hussain, 2012). Since otters mainly rely on fish as food, they would be more centralized in the region with the high density of food. The decrease in the density of available fish as the result of overfishing or contamination could endanger otters directly (Khan et al., 2014).

Received: 14.12.2025 **Accepted:** 31.01.2026 **Published**: 01.02.2026

Journal of Advance Research in Science and Social Science (JARSSC) **ISSN:** 2582-2004
Publisher: Indian Mental Health & Research Centre Volume 09, Issue 01
DOI: 10.46523/jarssc.09.01.02
Multidisciplinary, Open Access
Impact Factor: 3.612

Otters' preference for riverine and wetland habitats is consistent with their ecological reliance on aquatic ecosystems offering both prey and denning opportunities (de Silva et al., 2015). Wetland locations are diverse in terms of fish, plants, and wildlife cover that are not available in canals as well as in agricultural fields. The same was realized in Koshi Tappu Wildlife Reserve in Nepal and the Chambal River in India (Shrestha, 2016; Sharma et al., 2020).

The negative effect of the salinity mirrors the role that otters play in freshwater environments. We see this in Bangladesh's and Goa's estuarine zones, where there are more otters in fresher waters (Hussain et al., 2011). Medium levels of TDS may reflect nutrient-rich waters with more fish. High TDS levels due to agricultural runoff can, in the long run, produce ecological problems.

The reason that pH, turbidity, and temperature don't significantly influence the data is that otters can survive in many kinds of waters if there is sufficient food. The ability to adjust to various habitats is also liable to have allowed the otters to coexist with man-made systems such as the canals and the irrigation system (Nawab & Hussain, 2012).

Conservation Implications

The results of this study emphasize the critical need to strengthen conservation strategies for smooth-coated otters (*Lutrogale perspicillata*) in Pilibhit Tiger Reserve (PTR), especially the increasing man-made pressures on freshwater ecosystems. The study concluded that the wetland and riverine areas were the primary predictors of otter presence and that there was an overriding imperative of their protection as part of the protection of otters. Ensuring the security and continuance of ecological integrity in the wetland and riverine habitats will benefit otters and other species that rely on aquatic and riparian ecosystems, therefore benefiting the overall safeguarding of the biodiversity in the Terai Arc Landscape.

The highest conservation priority is the protection of hydrological connectivity and freshwater flows. Otters largely rely on perennial streams, and alterations of streamflow through damming, diversion via irrigation drains, or groundwater extraction decrease the availability and quality of habitats and food for otters. Thus, the policy in the conservation effort should embrace policies related to the management of water resources that will yield ecological flows within the aquatic system such as rivers and wetlands.

Received: 14.12.2025 **Accepted:** 31.01.2026 **Published**: 01.02.2026

The other critical signal is the management of fishing activities to sustain fish stocks, the prime food source of otters. Over-fishing, destructive fishing gear, and poaching in closed sectors reduces prey biomass significantly, driving otters into abandoning otherwise suited habitats. Local fishing communities' participation in the form of co-management, banning fishing during certain seasons, and encouraging the use of a sustained fishery technique are essential in ensuring prey supply.

Livestock grazing and crop encroachment in riparian areas are also pressures that degrade vegetation cover, bank erosion, and denning opportunities in the area, respectively. The pressures can be abated by limiting livestock movement in buffer zones, encouraging substitute fodder sources, and conducting riparian restoration activities. Sugarcane, a prevailing land-use activity in the PTR buffer, draws prey, which in return attracts predators and mediates human-wildlife conflicts. Thus, land-use zoning is essential and requires careful consideration.

Another major concern was the salinization of freshwater ecosystems, which was exacerbated by climate conditions and caused by irrigation return flows. Otters were found to be negatively impacted by high salinity, which highlights the significance of monitoring and controlling agricultural runoff. Water quality can be guaranteed through management measures like regulated fertilizer application, effective irrigation techniques, and wetland restoration.

Finally, a possible path to adaptive management is the combination of AI and GIS-based monitoring systems. Early responses can be made possible by real-time habitat monitoring using satellite imaging, predictive modelling, and computerized detection of anthropogenic threats. Conservation managers can rank priority otter habitats, count threat dynamics, and implement timely conservation actions by combining field data and AI-based monitoring. Therefore, a multifaceted strategy combining ecological restoration, community-managed resource management, water governance, and technology-based monitoring is needed to conserve smooth-coated otters in PTR. Adopting conservation measures for otters, the flagship animals of rivers and freshwater systems, would benefit local human societies and biodiversity while also ensuring the ecological security of PTR's river and wetland systems.

Conclusion

Smooth-coated otters (*Lutrogale perspicillata*) in Pilibhit Tiger Reserve demonstrate habitat

Received: 14.12.2025 **Accepted:** 31.01.2026 **Published**: 01.02.2026

selection primarily influenced by prey availability, habitat structure, and water chemistry. Fish abundance was the best indicator of occurrence, and otters were approximately four times more likely to occur in river and wetland habitats than in other aquatic systems, underscoring the significance of intricate freshwater systems. Otters' occurrence was significantly suppressed by salinity, which is indicative of their dependence on freshwater systems. Additionally, moderate levels of total dissolved substances were significantly associated with occurrence, as a result of high aquatic productivity supporting fish populations. Temperature, turbidity, pH, and all other parameters did not significantly change, indicating that they were tolerant of wide ranges. The accuracy of 84% for logistic regression validates its dependability in ecological inference. Otter protection in the PTR should prioritize maintaining freshwater flows, adjusting fishing schedules to preserve prey biomass, and reducing human-caused stressors like fragmentation, overfishing, and salinization. The overall diversity of wetland habitats will be preserved through conservation as an umbrella species for otters.

Acknowledgements

The author gratefully acknowledges BSNV PG College, University of Lucknow, the Uttar Pradesh Forest Department, and field staff for logistical support and data collection. Appreciation is also extended to collaborators and local communities for facilitating surveys.

References

1. de Silva, P.K., Khan, W.A., Kanchanasaka, B., et al. (2015). *Lutrogale perspicillata*. The IUCN Red List of Threatened Species 2015.
2. Foster-Turley, P. (1992). Conservation ecology of otters: a review. *Rev. Ecol. (Terre Vie)*, 47, 63–79.
3. Hussain, S.A. (1993). Aspects of the ecology of smooth-coated otter (*Lutrogale perspicillata*) in National Chambal Sanctuary. *Mammalia*, 57(4), 533–542.
4. Hussain, S.A., Gupta, S.K., & de Silva, P.K. (2011). Biology and ecology of Asian small-clawed and smooth-coated otters: a review. *IUCN Otter Specialist Group Bulletin*, 28, 63–76.
5. Jhala, Y., Qureshi, Q., & Nayak, A.K. (2020). *Status of Tigers, Co-predators and Prey in India 2018*. National Tiger Conservation Authority, New Delhi.

Received: 14.12.2025 **Accepted:** 31.01.2026 **Published**: 01.02.2026

Journal of Advance Research in Science and Social Science (JARSSC) **ISSN:** 2582-2004
Publisher: Indian Mental Health & Research Centre Volume 09, Issue 01
DOI: 10.46523/jarssc.09.01.02
Multidisciplinary, Open Access
Impact Factor: 3.612
OPEN ACCESS
Crossref DOI Prefix 10.46523 Crossref

6. Johnsingh, A.J.T., Goyal, S.P., & Qureshi, Q. (2004). Conservation status of tiger and associated species in the Terai Arc Landscape. *RR-04/001*, Wildlife Institute of India.
7. Khan, W.A., Begum, S., & Sarker, S. (2014). Status and distribution of otters in the Sundarbans mangrove ecosystem. *IUCN Otter Specialist Group Bulletin*, 31(2), 26–37.
8. Nawab, A., & Hussain, S.A. (2012). Factors affecting the occurrence of smooth-coated otter (*Lutrogale perspicillata*) in agricultural landscapes of the Upper Gangetic Plains, India. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 22(5), 616–625.
9. NTCA (2023). *Tiger Population Estimates 2022*. National Tiger Conservation Authority, Ministry of Environment, Forests and Climate Change, Government of India.
10. Pocock, R.I. (1941). The fauna of British India, Mammalia. Vol. II. Taylor & Francis, London.
11. Sharma, R., Shrestha, T.K., & Bhatta, S.R. (2020). Otter status and conservation challenges in the Koshi River Basin, Nepal. *Journal of Threatened Taxa*, 12(14), 16923–16932.
12. Shrestha, T.K. (2016). *Otters of Nepal: status and conservation*. IUCN Nepal.
13. Uttar Pradesh Forest Department (2022). *Management Plan of Pilibhit Tiger Reserve*. Government of Uttar Pradesh.
14. Wright, L., de Silva, P.K., Chan, B., et al. (2021). Asian otters in decline: threats and conservation priorities. *Oryx*, 55(2), 163–172.

Received: 14.12.2025 **Accepted:** 31.01.2026 **Published**: 01.02.2026