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Snake Diversity, Habitat Distribution and Conservation Challenges in Uttar Pradesh, India: A Systematic Review

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ABSTRACT

Snakes represent an important ecological aspect in both the terrestrial and aquatic environment by being predators and also prey species, controlling the population of rodents, amphibians, reptiles, and other vertebrates. India has one of the richest snake faunas, with over 320 species of snakes recorded, among which one-fifth are venomous. Uttar Pradesh is the most populous state in India and has a variety of ecosystems like the Terai forests, Gangetic floodplains, wetlands, agricultural land, grasslands, ravines, and urban habitats. This diversity of ecosystems brings in many different snake species, but the available literature is very disorganized regarding the distribution of snakes in these ecosystems and other aspects. To address the research gap in this area, systematic review examines the collected literature on snake diversity and distribution from 2000-2025. It uses peer-reviewed journal articles, books, government data, and websites. The review discusses the species richness of the snakes in different ecological regions, habitat-specific distribution of snakes, various environmental changes, major threats, and the conservation works by the government. According to the recent literature, agriculture orientation, habitat degradation, wetland loss, urbanization, road kills, illegal trade, climate change, and human-snake interactions, are some of the prime causes responsible for the decline of snakes in the state. Although snakes in the protected areas such as Dudhwa National Park, Katarniaghat Wildlife Sanctuary, and Pilibhit Tiger Reserve are stable, knowledge regarding the snakes in central and western Uttar Pradesh is limited. The review gives various suggestions regarding future ecologic research.

Introduction

Snakes are among the most successful groups of reptiles in terms of evolution and can be found in a variety of natural habitats ranging from terrestrial to aquatic ecosystems. Snakes belong to the order of reptiles called Squamata and to the suborder known as Serpentes. They have developed various adaptations in terms of morphology, physiology as well as behavior. Currently, there are more than 4100 snake species that have been identified, and the countries continue to report new species thanks to various methods of taxonomy, which include using both morphology and molecular genetics (Uetz *et al.*, 2024). The importance of snakes in nature goes beyond being predators.

India is widely known as one of the most diverse countries in the world due to its climatic zones, variety of topography and wealth of plants, making it possible for India to have highest number of reptiles. Current estimates indicate that there are more than 320 species of snakes on the territory of India belonging to a number families, including Colubridae, Viperidae, Elapidae, Pythonidae, Natricidae, Typhlopidae, Boidae and Xenodermidae (Aengals *et al.*, 2022). Although only a few snake species can be considered really dangerous, snakes are generally described in a negative light as a result of snakebite reports and some incorrect beliefs about snakes making people think that all snakes are dangerous (Whitaker & Captain, 2018).

Geographically, Uttar Pradesh stands out among the provinces of India. The province occupies the territory of the fertile Indo-Gangetic Plain with the area of about 240,928 km². In the northern part of Uttar Pradesh, the Terai-Bhabar belt borders the Himalayan foothills, while the southern part contains the Vindhyas and the

Bundelkhand region with its rocky formation. Several important rivers such as the Ganga, Yamuna, Ghaghara, Gomti, Rapti, Betwa, Chambal, and Saryu have created vast floodplains, wetlands, marshes, oxbow lakes, and riparian forests, forming agricultural habitat conditions suitable for many reptiles (Rodgers *et al.*, 2002; Forest Survey of India, 2023).

Uttar Pradesh is conducive to both well-known snakes which can easily be found, and also to some of the lesser-known species which are highly restricted geographically. Forests provide habitat for snakes such as pythons, vine snakes, cat snakes, kukri snakes, wolf snakes, and cobras, while wetlands and floodplain areas host species such as keelback snakes, water snakes, and checkered keelbacks. Agricultural lands support snakes such as rat snakes, trinket snakes, bronzeback tree snakes, and kraits which are mostly found due to high populations of rodents in cultivated areas (Whitaker & Captain, 2018). Cities may provide habitats for many snake species as well even when their surroundings change.

Protected areas play a vital role in keeping reptilian biodiversity safe. The protected areas of Dudhwa National Park, Katarniaghat Wildlife Sanctuary, Kishanpur Wildlife Sanctuary, Pilibhit Tiger Reserve, Chambal Wildlife Sanctuary, Ranipur Tiger Reserve, Sohagibarwa Wildlife Sanctuary, and Sur Sarovar Bird Sanctuary offer protected ecosystems which can be used by diverse species of snakes (Wildlife Institute of India, 2022). However, in the most cases reptiles have gotten less attention compared to mammals and birds, which is why there is no crisis in the reptilian world even though researchers have no knowledge about biodiversity regarding species richness, habitat associations, or population changes. Recent biodiversity assessments undertaken throughout various regions of Uttar Pradesh indicate considerable differences between the

ecological regions of snakes. The Terai habitat has been observed to have the most variety of species due to the proper functioning of the forests, presence of several wetlands, and suitable climatic conditions. In comparison, western and middle regions with intensive farming and growing urban areas display lower and less diverse habitats often resulting in inbred characteristics of reptiles in that region. However, there are certain adaptable species that are able to thrive in the heavily altered anthropogenic environments which can reflect various levels of gradual ecological adaptation in those taxa (Chandra *et al.*, 2021). The snakes are among the most important species from ecological perspective; however, they are facing great difficulties regarding their conservation in Uttar Pradesh these days. Habitat destruction due to deforestation, intensification of agriculture, and building of infrastructure has caused major changes. Cities occupy the habitats, fragmenting them and hindering migration and bringing increased mortality caused by vehicles and human-initiated events and destruction (Böhm *et al.*, 2013). The fragmentation leads to inbreeding and less genetic variety in populations, threatening their existence at certain level.

Another significant issue regarding conservation in Uttar Pradesh is the conflict between human beings and snakes. Due to the large number of incidents with snake bites which happen in the region, the fear of snakes results in indiscriminate killing in that region. The "Big Four" venomous snake species in India, which comprises the Indian cobra (*Naja naja*), common krait (*Bungarus caeruleus*), Russell's viper (*Daboia russelii*), and saw-scaled viper (*Echis carinatus*), can be found in Uttar Pradesh and account for most of the major snakebites. However, there are several other harmless snake species of India that have suffered due to lack of proper identification of various species by the local people (WHO, 2023).

Climate change is yet another threat affecting the ecology of reptiles. Changes in temperature and rainfall patterns as well as seasonal floods and changes in vegetation may affect the suitability of a habitat, disrupt breeding patterns, change the availability of their prey type, and impact the geographical distribution of snakes. Climate niche modeling indicates that several species of reptiles will experience a sudden change in their geographic distribution, especially in isolated landscapes where their possibilities of moving around are limited (Araújo *et al.*, 2006; Roll *et al.*, 2017).

Moreover, the conservation of snakes is difficult because of the lack of ecological data. Unlike big mammals and birds, there are few long-term monitoring programs for reptiles. Most of what is known about them comes from opportunistic surveys, inventories of protected areas or any rescue operations that take place during the monitoring of the snakes. Hence, the available data does not provide a clear picture of the way snakes exist, their ecology, and the dangers facing them.

In the past 20 years, however, there has been increased interest in the study of reptiles and their diversity has been documented in protected areas, wetlands, agriculture, and urban areas. Some of the technologies that are being used for this purpose are molecular systematics, GIS, remote sensing, and citizen science approaches (Daniels *et al.*, 2023). These technologies have helped in identifying species, determining their habitat conditions, and identifying priority conservation areas.

Given the ecological significance of this species and the threats coming from rapid changes in the environment, it is necessary to conduct comprehensive research to ensure that snakes survive. Such research is needed to fill in the knowledge gaps, analyze distribution patterns, and assess conservation efforts. Moreover, having ecological knowledge integrated with conservation efforts can help reduce human much conflicts and support the preservation of biodiversity in one of the most densely populated states of India. Thus, the current paper will have the following goals: (i) to summarize the current information concerning reptiles in Uttar Pradesh, (ii) analyze the distribution of snakes across various habitats, (iii) explore the anthropogenic and environmental effects on snakes, (iv) compare and contrast different regional studies conducted recently, and (v) find directions for future research on conservation of snakes.

The evaluation was done in line with the PRISMA 2020 guidelines for transparency, reproducibility, and thorough literature coverage of the existing literature (Page *et al.*, 2021). The aim was to compile published evidence on the snake species, habitat distribution, and conservation problems in Uttar Pradesh, India.

Global Importance of Snake Diversity- Snakes are perhaps one of the most significant predators in the environment, as they can be found in nearly all terrestrial ecosystems except for Antarctica. The Reptile Database suggests that to date there are about 4,150 snake species identified and many more are discovered every year through various scientific approaches like molecular taxonomy (Uetz *et al.*, 2024). Snakes are known to regulate the populations of other groups of species including rodents, amphibians, birds, and insects and thus are crucial in keeping the ecosystem stable and even contributing to agricultural pest management (Greene, 1997; Shine, 2005).

The ecological role of snakes is not limited only to the predatory function. Snakes also become prey for many predators including raptors, mongooses and crocodiles, making them a vital part of the terrestrial food chain (Reading *et al.*, 2010). However, due to the fact that many snake species are among the top predators in food chains, they can be regarded as bioindicators of ecosystem changes. Snakes' abundance changes can show how the habitat quality, prey availability, pollution level, or climate change have changed (Todd *et al.*, 2010).

Recent assessments of reptiles on a global scale have demonstrated that large-scale declines in reptile populations can be observed today. Habitat destruction, climate changes, introduction of invasive species as well as illegal wildlife trade have made extinction risks huge for many snake species (Böhm *et al.*, 2013). Therefore, it can be argued that preserving snakes is also an important part of biodiversity conservation programs that are conducted by the Convention of Biological Diversity (CBD) and the IUCN.

Snake Diversity in India- Recognition of India as one of the megadiverse nations in the world is credited to having significant reptilian diversity. Indian climatic variations, different elevations, and many ecosystems contribute to this enormous diversity (Aengals *et al.*, 2022). Snakes of India belong to many families, such as Colubridae, Elapidae, Viperidae, Natricidae, Pythonidae, Boidae, Typhlopidae, Pareidae, Xenodermidae, and Uropeltidae, among which Colubridae is said to be the biggest family by contributing to more than 50% of recorded snake species in India (Whitaker & Captain, 2018).

Diversity in Indian ecosystems such as Himalayas, Western Ghats, Eastern Ghats, Thar Desert, Gangetic Plain, Deccan Plateau, mangroves, islands, and tropical forests lead to the emergence of region-specific snake species. Biodiversity hotspots in Western Ghats and northeast India exhibit extremely high levels of endemic species, while Indo-Gangetic Plain supports widespread generalist species adapted to agricultural wetland ecosystems (Ganesh *et al.*, 2021).

The medically necessary venomous snakes, also called "Big Four," Indian cobra (*Naja naja*), common krait (*Bungarus caeruleus*), Russell's viper (*Daboia russelii*), and the saw-scaled viper (*Echis carinatus*), occur in vast parts of the country and cause the most snakebite-related morbidity and mortality (WHO, 2023). However, 80% of snake species in India belong to different families that are non-venomous or have low venom.

Snake Diversity in Uttar Pradesh- Uttar Pradesh has a crucial biogeographical status within the northern region of India. The ecological regions of the state include the Terai vegetation located at the border of Nepal, vast alluvium of the Ganges, and a few more ecological regions like wetlands, agricultural lands, riverine forests, dry forests, grassy lands, the Bundelkhand plateau, etc., which contributes to a wide array of snake species that require different ecological conditions to survive (Rodgers *et al.*, 2002).

Surveys reveal that around 40–50 species of snakes have been confirmed from Uttar Pradesh, while some ongoing field studies reveal more localities and finer species distribution (Chandra *et al.*, 2021; Kushwaha *et al.*, 2025). The majority of the species belong to Colubridae, Natricidae, Elapidae, Viperidae, and Pythonidae. Frequently recorded species include:

- Indian Rat Snake (*Ptyas mucosa*)
- Spectacled Cobra (*Naja naja*)
- Common Krait (*Bungarus caeruleus*)
- Checkered Keelback (*Fowlea piscator*)
- Green Keelback (*Rhabdophis plumbicolor*)
- Indian Rock Python (*Python molurus*)
- Trinket Snake (*Coelognathus helena*)
- Common Wolf Snake (*Lycodon aulicus*)
- Buff-striped Keelback (*Amphiesma stolatum*)
- Common Cat Snake (*Boiga trigonata*)

Naja naja, *Bungarus caeruleus*, *Daboia russelii* and *Echis carinatus* are the leading venomous snake species of utmost ecological and health significance.

District-wise survey reports have shed light on species richness in the regions studied. However, research from areas such as Dudhwa National Park, Katarniaghat Wildlife Sanctuary, Pilibhit Tiger Reserve, Kushinagar, Bahraich, Lakhimpur Kheri, and some areas in eastern Uttar Pradesh has indicated the region's richness in terms of species diversity because the ecological conditions there are much better than in the densely populated areas (Chandra *et al.*, 2021; Kushwaha *et al.*, 2025). Nevertheless, complete statewide surveys are still absent and some districts, especially the western and central ones of Uttar Pradesh, remain underrepresented in the herpetological literature.

Taxonomic Composition of Snake Fauna in Uttar Pradesh- The snake population found in Uttar Pradesh displays an availability of species which indicate the transitional character between the Himalayan foothills and peninsular India. The composition of snakes depends on factors such as land use, elevation, amount of water, and type of vegetation found in the region.

Colubridae constitutes the most diverse family of snakes, as they exhibit various ecological adaptations. These snakes are found in a range of habitats such as forests, crops, wet areas, and urban settings. The most often recorded species in the region are *Ptyas mucosa*, *Coelognathus helena*, *Lycodon aulicus*, and *Boiga trigonata*.

Natricidae is the family that can be spotted in wetlands and rivers with species found in water being usually associated with waters and presence of amphibians and fishes.

The family Elapidae includes such poisonous snakes as cobras and kraits that are often seen in such habitats as forests, cropland, and urban settlements adding to their frequent interaction with humans.

While the number of individuals belonging to family Viperidae is low, the species is of significant ecological importance in terms of their medical importance. Russell's viper and saw-scaled viper are found in dry grass, scrubs, croplands, and rocky terrains.

Family Pythonidae has a representative of Indian Rock Python (*Python molurus*), which is one of the most massive reptiles in the country. This snake can mainly be found in protected areas such as forests, wetlands, and rivers where it can find sufficient food.

Summarizing the information, taxonomic diversity is a manifestation of ecological diversity of Uttar Pradesh. Nevertheless, ongoing changes of habitats, agricultural development, and climate change can significantly impact the species distribution in the region in the nearest future.

Habitat Distribution of Snake Species in Uttar Pradesh- The location of snake distribution in Uttar Pradesh is primarily controlled by certain environmental factors like climate variation, vegetation types, etc. The existence of different types of habitats combining the Indo-Gangetic regions with the northern Terai region and the Vindhyan belt in the south leads to the diversity of snake group members in these habitats. The way these species appear may vary from one aquatic ecosystem to another depending on the specific characteristics like hydrological status, amount of human interference (Whitaker & Captain, 2018; Chandra *et al.*, 2021).

Forest Ecosystems- Forest ecosystems play a critical role in preserving snake diversity in the state of Uttar Pradesh. The Terai forests, dry deciduous forests, moist mixed forests, riverine forests, and scrub forests have been known to maintain good microclimatic conditions alongside also being home to multiple snake species. The positive impact of protected forests on snake diversity can also be

noted in the examples of Dudhwa National Park, Katarniaghat Wildlife Sanctuary, Kishanpur Wildlife Sanctuary, Pilibhit Tiger Reserve, Ranipur Tiger Reserve, and Sohagibarwa Wildlife Sanctuary. In these forests, the number of reptiles observed tends to be comparatively high due to little disturbance in living conditions (Wildlife Institute of India, 2022). Bigger species, like the Indian Rock Python (*Python molurus*) tend to favor dense forests, tall grasslands, and woodlands before hunting for animals, birds, and reptiles. Snake species like *Boiga trigonata* and *Ahaetulla oxyrhyncha* favor trees while the Indian Cobra (*Naja naja*) and Common Wolf Snake (*Lycodon aulicus*) are examples of snakes that live on the ground (Whitaker & Captain, 2018).

The Terai system is of specific importance due to high rainfall and continuously operating water bodies, the combination of both factors providing perfect conditions for existence of snakes. Research shows that Dudhwa National Park has a larger number of snake species than other locations in Uttar Pradesh (Johnsingh *et al.*, 2004; Chandra *et al.*, 2021).

Though, according to some scientists, destruction of forests with the aid of roads, agriculture, and illegal logging creates obstacles for the continuity of snakes. As it has been shown, fragmented forests are often associated with a smaller number of snake species because of lesser vegetation and some negative factors coming from fragmentation (Böhm *et al.*, 2013).

Wetlands and Riverine Habitats- Wetlands are another important locality for snake diversity in Uttar Pradesh. The sheer number of both natural and artificial wetlands present in the region connected with the river systems like Ganga, Yamuna, Ghaghara, Rapti, Gomti, Betwa, Chambal, and other minor rivers is overwhelming. These wetlands host predominantly aquatic and semi-aquatic snake species. The Checkered Keelback (*Fowlea piscator*), Green Keelback (*Rhabdophis plumbicolor*), and Buff-striped Keelback (*Amphiesma stolatum*) are examples of the snakes present in marshes, ponds, oxbow lakes, canals, and floodplain wetlands having abundant amphibians and fishes as described by Whitaker and Captain in 2018.

Riverine habitats provide suitable nesting sites, basking sites, and dispersal corridors. Even the seasonal floods renew these habitats and increase the availability of prey despite the fact that during seasonal floods, snakes might undergo temporary displacement to the surrounding agricultural fields and human settlements.

Recent surveys of wetlands have highlighted the significance of Ramsar sites and specially protected wetlands in terms of conservation of reptilian biodiversity. Nevertheless, quite a number of wetlands are being affected by degradation like draining, pollution, encroachment, eutrophication, sand mining, and conversion into agricultural fields.

Additionally, water pollution due to industrial effluents, domestic effluents, pesticide runoff, and contamination with heavy metals impair aquatic food chains, thus affecting snake populations correlated to these wetlands.

Agricultural Landscapes

Approximately 75% of the territorial spread of Uttar Pradesh consists of agricultural systems that act as secondary habitats for various species of snakes. Agriculture may have replaced natural cover in some regions, but irrigated cropland can still accommodate a range of snakes.

Normally, crops such as wheat, rice, sugarcane, sorghum, and legumes attract predators such as *Ptyas mucosa*, *Bungarus caeruleus*, *Naja naja*, and *Coelognathus helena*. Because of that, snakes provide certain environmental services because they are capable of controlling rodent populations, thus preventing crop losses resulting in less utilization of chemicals.

Sugarcane plantations are often regarded as good habitats due to dense vegetation which retains moisture and provides concealment from predators. Also, irrigation ditches, bunds, and hedgerows assist in animal movements between disturbed habitats.

Almost everything hampers the process of agricultural intensification. Mostly, it is mechanization of agriculture, indiscriminate application of insecticides, herbicides, burning

residues, and destruction of hedges that lower habitat quality and negatively influence snake populations either directly or indirectly. Pesticides belonging to the organophosphate and pyrethroid classes accumulate in the bodies of prey and consequently result in secondary poisoning of snakes. The fact that reptiles are less sensitive to pesticides than amphibians implies that chronic exposure to pesticides may still affect reproduction, immunity, and survival of reptiles.

Urban and Peri-Urban Ecosystems- Urbanization is among the key sources of environmental transformation happening quickly in Uttar Pradesh. Growth of such cities as Lucknow, Kanpur, Agra, Prayagraj, Varanasi, Meerut, Noida, Ghaziabad, and Gorakhpur is transforming many natural areas.

Nonetheless, a good number of snake species have proved to be very adapted to urban areas, like Indian Rat Snake, Common Wolf Snake, Cobra, Krait, and Checkered Keelback which inhabit residential areas, gardens, parks, drainage facilities, empty constructions, and campuses (Whitaker and Captain, 2018).

Urban conditions offer a great amount of rodents as well as several artificial shelters and stabilized microhabitats. On the contrary, snakes living in urban areas face great mortality due to car traffic, killing, construction, pets, and pollution.

Thus, road mortality becomes one of the important conservation problems. Numerous studies show that roads passing through forests and wetlands greatly impact snake mortality, particularly regarding the rainy season when reptiles are more active in terms of breeding and spreading (Row et al., 2007).

Thus, fast urban development causes fragmentation of ecological corridors, leads to isolation of populations, and reduces the chance of gene flow.

3.5.5 Grasslands, Scrublands, and Bundelkhand Plateau- Although they have been relatively understudied, southern Uttar Pradesh's grasslands, scrub forests, ravines, and rocky habitats sustain specific assemblages of snakes. The Bundelkhand region with rocky outcrops, dry deciduous forest, and semi-arid climatic conditions is a suitable habitat for Russell's Viper (*Daboia russelii*), Saw-scaled Viper (*Echis carinatus*), Trinket Snake (*Coelognathus helena*), and many burrowing species. Some grassland ecosystems are home to fossorial snakes such as blind snakes (*Indotyphlops* spp.) as well, which play a role in soil ecology by burrowing through the soil. Most notably, grasslands are one of the least protected ecosystems in India. A significant portion has already been converted to agricultural land, mining sites, and infrastructure projects, allowing limited availability of habitat for reptiles associated with grasslands (Böhm et al., 2013).

3.6 Human-Snake Conflict in Uttar Pradesh- The issues related to human-snake conflict are among the most serious public health matters in the state of Uttar Pradesh. Since Uttar Pradesh is the most populated state of India there is a lot of interaction between people and snakes because of the vast area of farming and high density of population combined with nearness of villages to the forests and wetlands. Most of snake encounters take place in the rainy season when floods force snakes to leave their habitats to enter farmland and settlements. The probability of accidental encounters is heightened by agricultural harvesting, night farming, and storage of harvested agricultural produce (WHO, 2023). The medically important poisonous snake species responsible for the most serious cases of snakebite are:

- Indian Cobra (*Naja naja*)
- Common Krait (*Bungarus caeruleus*)
- Russell's Viper (*Daboia russelii*)
- Saw-scaled Viper (*Echis carinatus*)

While these four types of snakes are responsible for fast majority of severe snake bites that need to be treated, a variety of non-harmful snakes are also killed since the locals do not know the difference between poisonous and non-poisonous snakes.

It has been reported that there are over 58,000 cases of snakebite deaths every year in India. Uttar Pradesh is one of the states that contributes to this statistic because of the big rural population present in the area (Suraweera et al., 2020). This means that the

snake bite is considered to be a minor Tropical Disease by the World Health Organization (WHO, 2023).

A lot of programs that targeted snake safety and snakebites have shown that informing people about snakes, emergency services, and first aid helps in preventing the killing of snakes senselessly due to community fear.

Conservation Challenges

In spite of the affirmative from the Wildlife (Protection) Act, 1972, snake populations in Uttar Pradesh face several threats that continue to threaten its species.

Destruction of habitat- Deforestation for agriculture, urbanization, roadways, railways, and industrial setups have resulted in loss of habitat for many species.

Fragmentation of habitat- Due to fragmented landscape, populations may get cut off from each other and hence increase the chance of extinction for species that depend on habitat.

Degradation of wetlands- Wetlands providing habitat for aquatic snakes are dwindling due to drainage, pollution, introduction of exotic species and encroachment.

Intensification of agriculture- Excessive pesticide spraying affects food availability and causes adverse effects on reptilian physiology due to continuous exposure to toxic substances.

Road killing- Roads cutting through forests and wetlands contribute to the increasing number of snake deaths during periodic movements.

Illegal trafficking- Although snake collection is not as prevalent as in some other countries, it still has negative impact on some species through collection for selling as pets, snake charming performances, extraction of venom or for superstitious beliefs.

Effects of climate change- The predicted rising of temperatures, changing rainfall, prolonged droughts, and changes in flooding pattern might alter habitat suitability and species distribution in the whole northern India.

Knowledge gaps- Perhaps the biggest challenge preventing effective conservation efforts is a lack of scientific data. Vast areas of Uttar Pradesh remain unsurveyed leaving that complicating conservation planning.

Critical review- The analysis of the existing state of research on snakes in Uttar Pradesh shows that there is geographical bias evident. Most studies are conducted in protected areas like Dudhwa National Park, Katarniaghat Wildlife Sanctuary, and Pilibhit Tiger Reserve while the densely populated agricultural districts, urban areas, and Bundelkhand region are not studied accordingly. This leads to understanding of the occurrence of species across the state and a potential loss of species in modified habitats.

Another issue is the predominance of short observational studies among others. People prefer to carry out opportunistic studies and the number of standardized long-term monitoring studies is relatively small. As a result, there is a lack of information on population dynamics or functions of species.

Taxonomic confusion still exists among several groups of snakes, primarily among similar-looking colubrid snakes. Even though recent advances in phylogenetics have helped species identification in other parts of India, molecular-based confirmation is hardly used in Uttar Pradesh. Using the technique of molecular taxonomy in combination with methods of conventional morphology may help to increase efficiency of species identification and estimation of species diversity. Finally, although human-snake conflict and snakebite epidemiology are becoming increasingly interesting, studies in ecology dealing with questions such as coexistence, habitat connectivity, or landscape genetics are still lacking which is why future research should apply an interdisciplinary approach helping to combine ecology, remote sensing, molecular biology, citizen science, and socio-economics.

4. Comparative Analysis of Published Studies- The snakes of Uttar Pradesh are unevenly documented as per the literature published during 2000 to 2025. Most of the studies have concentrated in Pak protected areas and biodiversity-rich landscapes. Agricultural districts, urban ecosystems and Bundelkhand regions are comparatively under studied. Due to the variation in sampling intensity, duration of survey, extent of habitat

coverage and expertise of taxonomists, species richness of study varies extensively. Most of the studies carried out in the early 2000's were descriptive and based on species inventory and records of distribution. Most studies employed visual encounter surveys and used opportunistic encounters. Accordingly the data generated by these studies, at the time, were useful but lack of ecological interpretation. In recent years, the study has applied GIS, habitat characterisation, conservation assessments and statistics. Research conducted on the snake species in Dudhwa national park, Katarniaghat wildlife sanctuary and Pilibhit tiger reserve often records the highest diversity of snakes in the state. The large forest patches, wetlands, grasslands and riverine systems of the landscapes contribute to large heterogenous habitats for both terrestrial and aquatic snakes. In contrast, research from different districts densely cultivated, frequently highlights the prevalence of habit generalists like Indian Rat Snake (*Ptyas mucosa*), Spectacled Cobra (*Naja naja*), Common Krait (*Bungarus caeruleus*) and Checkered Keelback (*Fowlea piscator*), whereas. Recent literature reveals another key trend, i.e. wetlands being increasingly recognized as herpetofaunal habitats. The previous conservation programme focussed more on forests but current studies highlight that ponds, marshes, flood plains, irrigation canals and ox bow lakes are equally important for preserving aquatic and semi-aquatic snakes. Research on urban ecology shows that alien and native species have become established in the cities. They show surprising plasticity despite intense human activity. Over the last decade much has been modified, yet the same. Yet, western and central districts of UP neither have a detailed survey done till now. In addition, few studies use standardized sampling protocols or molecular taxonomic approaches, inhibiting comparability among studies. As a result, citizens should treat estimates of statewide snake diversity with caution.

Table 1. Representative Studies on Snake Diversity in Uttar Pradesh (2000–2025)

Author(s)	Study Area	Major Findings	Significance
Whitaker & Captain (2018)	India	Comprehensive guide to Indian snakes	Standard taxonomic reference
Chandra et al. (2021)	Uttar Pradesh	Documented regional snake diversity and distribution	Updated state checklist
Kushwaha et al. (2025)	Kushinagar	District-level inventory with habitat associations	Added new locality records
WII Reports (2022)	Dudhwa–Terai	High reptile diversity in protected forests	Conservation planning
ZSI Reports	Northern India	Distribution records of reptiles	Baseline biodiversity database
IUCN Assessments	Global	Conservation status evaluation	Species risk assessment

Table 2. Habitat-wise Distribution of Major Snake Species in Uttar Pradesh

Habitat	Representative Species	Ecological Importance
Terai Forest	Indian Rock Python, Indian Cobra	Apex predators, biodiversity indicators
Wetlands	Checkered Keelback, Green Keelback	Amphibian and fish population regulation
Agricultural Fields	Rat Snake, Common Krait	Rodent control
Riverine Forest	Trinket Snake, Cat Snake	Habitat connectivity
Grassland	Russell's Viper	Predator in dry ecosystems
Urban Areas	Wolf Snake, Rat Snake	Adaptation to anthropogenic habitats

Table 3. Major Threats to Snake Diversity in Uttar Pradesh

Threat	Impact
Deforestation	Habitat loss
Agricultural expansion	Habitat fragmentation
Wetland degradation	Decline of aquatic species
Urbanization	Population isolation
Road mortality	Direct mortality
Illegal killing	Population decline
Climate change	Habitat shifts
Pollution	Reduced prey availability

Pesticides	Physiological stress
Human fear	Indiscriminate killing

Table 4. Conservation Status of Important Snake Species in Uttar Pradesh

Species	Family	IUCN Status*	Primary Habitat
<i>Naja naja</i>	Elapidae	Least Concern	Forest, agriculture
<i>Bungarus caeruleus</i>	Elapidae	Least Concern	Agricultural fields
<i>Daboia russelii</i>	Viperidae	Least Concern	Grassland, cropland
<i>Echis carinatus</i>	Viperidae	Least Concern	Dry scrubland
<i>Python molurus</i>	Pythonidae	Near Threatened	Forests, wetlands
<i>Ptyas mucosa</i>	Colubridae	Least Concern	Forest, urban
<i>Fowlea piscator</i>	Natricidae	Least Concern	Wetlands

*According to current IUCN assessments (consult latest updates before submission).

There are research trends explaining how research activities evolve from 2000–2025 (2000-2025). 1st 05 Year's 2nd Phase 3rd Phase.

From 2000 to 2005, taxonomic inventories and descriptive biodiversity documentation were conducted. So localized were the surveys that only occurrence of species is available.

From 2006 to 2010, the management of protected areas was given greater emphasis. While discussing this, we also got to know about the surveys.

Between 2011 and 2015 researchers started to include habitat traits, indices of species richness and conservation assessments into ecological investigations. There was an increase in.

From 2016 to 2020, human-snake conflict, snakebite epidemiology, road mortality and conservation biology were studied more. Likewise, the citizen science platforms Naturalist and India.

As of now, there is a lot of survey work in progress for designing reference collections, handbooks, identification keys and new species descriptions. One of the most significant areas of investigation concerns the serial district-level surveys to add new distribution records. Researchers have added secondary distribution records by identifying specimens in reference collection. There was an ascending. Generally, research documentation has transitioned from just listing the species to identifying the ecological processes involved and using the information for evidence-based conservation planning.

6. Future Studies and Conservation Prospects.

According to research, Uttar Pradesh's snake variety will diminish in coming years. It is recommended to do the following actions.

Efforts should be made to protect snake species.

- Perform state-wide surveys with uniform sampling protocols.
- Prepare distribution maps for all snake species recorded using GIS.
- Utilize DNA barcoding to resolve taxonomic issues.
- Begin lasting surveillance programs in both saved and unsaved areas.
- Revive damaged wetlands and river habitats.
- Strengthening linkages between patches of forests.
- Minimise deaths of wildlife on road by using wildlife crossings and other mitigatory structures.
- Gather biodiversity data through citizen science projects.
- Raising awareness about identifying venomous and non-venomous snakes.
- Enhance district-based quick response snake rescue network.
- Include snake conservation in current agricultural biodiversity initiatives.
- Assess impact of climate change on species through distribution model.
- We need to foster greater links between ecologist, wildlife managers, public health managers and local communities.

Human-snake coexistence in one of India's most densely populated states will be promoted by a guideline for evidence-based conservation planning.

Conclusion

The snakes in Uttar Pradesh play a crucial role in the ecosystem of the area. Keeping the ecological balance intact, snakes help in controlling the population of rodents, amphibians and other prey. Our systematic review shows that the remarkable heterogeneity of

environments in the state accommodates many species of various taxonomic families. We see snakes demonstrating this behavior in Terai forests, Gangetic floodplains, wetland agricultural areas, grasslands, and urban ecosystems. Research shows that landscapes under strict protection i.e.... Despite the great ecological significance of snakes, most of the species occurring in UP are under increasing anthropogenic pressure. Human activities degrade habitats, destroy wetlands, fragment forests, intensify agriculture, use pesticides indiscriminately, develop urban areas rapidly, kill animals on the road, persecute illegally and change climate. Due to human development and expansion of agricultural activities, these threats threaten the long-term survival of several species. There is a significant problem with conflict between humans. Research concerning herpetofauna in Uttar Pradesh has been published over the last fifty years. Researchers have focused a lot on protected areas that are rich in biological diversity. Nonetheless, major parts of central, western and Bundelkhand zones of Uttar Pradesh remain largely unexplored. Ecological monitoring of herpetofauna has been rare. Molecular taxonomy, habitat suitability modelling and landscape-level conservation have suffered greatly from lack of research. A newly released study elaborates on the impact of climate change on snake distribution. The wide array of new technologies can be hugely beneficial to their use in biodiversity assessment and conservation planning. This involves the use of such tools as GIS, remote sensing, landscape genetics, environmental DNA (eDNA), citizen science and species distribution modelling in explaining species status and understanding conservation planning. Moving ahead, the efforts will be focused on restoration of habitat, protection of wetlands and ecological corridors, scientifically designed monitoring programmes, community campaigns, responsible snake rescue networks and smart inter-disciplinary collaborations of ecologists, wildlife managers, healthcare professionals and local communities.

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