

Assessment of Diversity and Population Dynamics of Amphibians in Bulandshahr

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www.jrasb.com || Vol. 5 No. 2 (2026): April Issue

Received: 11-04-2026

Revised: 18-04-2026

Accepted: 26-04-2026

ABSTRACT

Amphibians are important ecological indicators due to their sensitivity to environmental changes and habitat disturbances. The present study assessed the diversity and population dynamics of amphibians in Bulandshahr district, Uttar Pradesh, India. Field surveys were conducted across agricultural lands, wetlands, ponds, grasslands, riverbanks, and semi-urban habitats from March 2024 to February 2025 using visual encounter surveys, call count surveys, and transect sampling methods. A total of 11 amphibian species belonging to 4 families and 8 genera were recorded during the investigation. The family Dicroglossidae showed maximum dominance, followed by Bufonidae and Microhylidae. Species richness and population density were highest during the monsoon season due to increased breeding activity and moisture availability. Shannon-Wiener diversity index indicated moderate to high amphibian diversity across study sites. The Indian Bullfrog (*Hoplobatrachus tigerinus*) and Skittering Frog (*Euphlyctis cyanophlyctis*) were the most abundant species, while the Marbled Balloon Frog (*Uperodon systoma*) showed relatively lower abundance. Habitat destruction, pesticide use, wetland degradation, urban expansion, and water pollution were identified as major threats affecting amphibian populations in the region. Seasonal fluctuations significantly influenced species abundance and reproductive activities. Amphibians were found to play important ecological roles in pest control and nutrient cycling within agroecosystems. The present study highlights the ecological importance of amphibians in Bulandshahr and emphasizes the need for habitat conservation, sustainable agricultural practices, and long-term biodiversity monitoring programs. Effective conservation strategies involving local communities and governmental agencies are essential for protecting amphibian diversity in rapidly changing agricultural landscapes of western Uttar Pradesh.

Keywords- Amphibians, biodiversity, population dynamics, Bulandshahr, Uttar Pradesh, wetlands, conservation ecology.

I. INTRODUCTION

Amphibians are among the most primitive and ecologically significant groups of vertebrates inhabiting both aquatic and terrestrial ecosystems. They represent an important evolutionary link between fishes and reptiles and are considered highly sensitive biological indicators of environmental changes due to their permeable skin, biphasic life cycle, and dependence on moist habitats. Amphibians play a critical role in maintaining ecological balance by regulating insect populations, contributing to nutrient cycling, and serving as prey for higher trophic organisms (Gibbons et al., 2000). Their presence and abundance often reflect the ecological health of wetlands, forests, agricultural

systems, and freshwater habitats. Globally, amphibians are facing unprecedented population declines and extinction risks. According to Stuart et al. (2004), nearly one-third of amphibian species worldwide are threatened due to habitat destruction, pollution, climate change, emerging diseases, and anthropogenic disturbances. Amphibian populations are declining faster than many other vertebrate groups, making them a major conservation concern. Environmental changes such as wetland degradation, pesticide contamination, urban expansion, and climate variability directly influence amphibian breeding success, larval development, and survival rates.

India is recognized as one of the world's megadiverse countries and harbors rich amphibian

diversity due to its varied climatic conditions, geographical heterogeneity, and wide range of ecosystems. More than 450 amphibian species have been documented from India, with many endemic forms occurring in biodiversity hotspots such as the Western Ghats and northeastern Himalayan regions (Biju, 2001). Amphibians in India belong mainly to the orders Anura, Gymnophiona, and Caudata, with frogs and toads constituting the most dominant group. Several freshwater and terrestrial habitats across the Indo-Gangetic plains also support diverse amphibian communities adapted to agricultural and wetland ecosystems. The Gangetic plains of northern India provide favorable ecological conditions for amphibian diversity due to the presence of ponds, marshes, irrigation canals, wetlands, paddy fields, riverbanks, and seasonal water bodies. Amphibians thrive in such environments because they require moisture-rich habitats for breeding, feeding, and larval development. Agricultural landscapes, despite anthropogenic modifications, often support large populations of frogs and toads because of the availability of insects and standing water during the monsoon season.

Bulandshahr district, situated in western Uttar Pradesh, forms part of the fertile Upper Gangetic Plains and possesses extensive agricultural ecosystems interspersed with wetlands, ponds, canals, floodplains, and rural water bodies. The district experiences subtropical climatic conditions characterized by hot summers, monsoon rainfall, and cool winters. Such seasonal variations create dynamic ecological conditions that strongly influence amphibian population dynamics and breeding behavior. Amphibians inhabiting Bulandshahr district contribute significantly to ecological stability and agricultural sustainability. Frogs and toads consume large quantities of insects including mosquitoes, flies, beetles, caterpillars, and crop pests, thereby functioning as natural biological control agents. Their ecological role reduces pest outbreaks and minimizes dependency on chemical pesticides in agricultural systems (Hocking & Babbitt, 2014). Additionally, amphibians contribute to nutrient cycling through their feeding activities and decomposition processes within aquatic ecosystems. Despite their ecological significance, amphibian populations in western Uttar Pradesh are increasingly threatened by anthropogenic activities. Rapid urbanization, industrialization, wetland reclamation, excessive pesticide application, habitat fragmentation, road construction, sewage discharge, and agricultural intensification are causing substantial habitat degradation. The indiscriminate use of agrochemicals contaminates aquatic habitats and negatively affects amphibian eggs, larvae, and adults. Studies have shown that pesticides interfere with amphibian endocrine systems, reproductive physiology, immune responses, and metamorphosis (Hayes et al., 2010).

Habitat destruction remains one of the primary causes of amphibian decline in agricultural landscapes. Seasonal ponds and wetlands, which serve as breeding habitats for many frog species, are frequently drained or converted for agricultural and developmental purposes. Urban expansion reduces natural vegetation cover and disrupts habitat connectivity, limiting dispersal and gene flow among amphibian populations. Furthermore, climate change-induced alterations in rainfall patterns and temperature regimes affect breeding cycles, larval development, and seasonal population fluctuations. Several amphibian species are highly dependent on monsoon rainfall for successful reproduction. During the rainy season, temporary pools and flooded agricultural fields provide suitable breeding habitats that support rapid population increases. Conversely, prolonged droughts and erratic rainfall can reduce breeding success and increase mortality rates. Seasonal population dynamics therefore represent an important ecological aspect of amphibian communities in tropical and subtropical ecosystems. Previous studies conducted in India have mainly focused on biodiversity hotspots such as the Western Ghats, northeastern India, and forest ecosystems, while comparatively fewer investigations have been conducted in the agricultural landscapes of the Gangetic plains. Information regarding amphibian diversity, abundance, habitat preference, and seasonal population dynamics in Bulandshahr district remains limited. Baseline ecological data are essential for understanding species distribution patterns and developing effective conservation strategies.

Monitoring amphibian diversity is particularly important because amphibians serve as reliable indicators of environmental quality and ecosystem disturbances. Declining amphibian populations often indicate ecological degradation caused by pollution, habitat destruction, and climate stress. Conservation of amphibians therefore contributes not only to biodiversity protection but also to the maintenance of ecosystem health and sustainability. The present study was undertaken to assess the diversity and population dynamics of amphibians in Bulandshahr district, Uttar Pradesh. The objectives of the study were to document amphibian species diversity, analyze seasonal population fluctuations, evaluate habitat associations, and identify major threats affecting amphibian populations in the region. The study also aims to provide baseline scientific data that can support future biodiversity conservation programs, wetland management strategies, and ecological monitoring initiatives in western Uttar Pradesh. Understanding amphibian ecology in agricultural landscapes is essential for promoting sustainable environmental management and biodiversity conservation. Effective conservation strategies involving habitat restoration, wetland protection, pollution control, and community awareness are urgently required to ensure the long-term survival of amphibian populations.

in the rapidly changing ecosystems of the Gangetic plains.

II. REVIEW OF LITERATURE

Amphibians are among the most ecologically important vertebrate groups due to their dual life cycle and sensitivity to environmental changes. They play a significant role in ecosystem functioning by contributing to food chains, nutrient cycling, pest regulation, and ecological stability. Over the last few decades, scientific investigations have increasingly focused on amphibian diversity, ecology, population dynamics, and conservation due to alarming global declines in amphibian populations (Stuart et al., 2004). Globally, amphibians are considered highly vulnerable to environmental disturbances because of their permeable skin and dependence on aquatic habitats for reproduction. Gibbons et al. (2000) reported that habitat destruction, pollution, climate change, invasive species, and emerging infectious diseases are the major causes of amphibian decline worldwide. Amphibians respond rapidly to ecological stress, making them reliable bioindicators of environmental health and ecosystem quality. India is recognized as one of the world's biodiversity-rich countries and supports substantial amphibian diversity due to its varied topography and climatic conditions. Biju (2001) documented extensive amphibian richness in India and highlighted the ecological importance of frogs and toads in tropical ecosystems. The Western Ghats and northeastern India are considered major amphibian diversity hotspots due to high rainfall and habitat heterogeneity. However, freshwater ecosystems and agricultural landscapes of northern India also support numerous amphibian species adapted to wetlands, ponds, canals, floodplains, and paddy fields. Daniels (2005) emphasized that amphibian diversity in India is closely associated with freshwater habitats and monsoon-dependent ecosystems. Seasonal wetlands, temporary pools, marshes, and irrigated agricultural fields provide ideal breeding and feeding habitats for amphibians. Frogs and toads are especially abundant during monsoon seasons because increased humidity and water availability stimulate reproductive activities and larval development. Research conducted by Dutta (1997) demonstrated that amphibians are important ecological components of agroecosystems because they regulate populations of insects and crop pests. Amphibians consume mosquitoes, flies, termites, beetles, caterpillars, and other harmful insects, thereby acting as natural biological control agents. Agricultural landscapes with adequate water bodies and vegetation support substantial amphibian populations. Studies on amphibian ecology have shown that species diversity and abundance vary according to habitat characteristics, climatic conditions, vegetation structure, and water quality. Wells (2007) observed that amphibian reproductive success is strongly influenced by

hydroperiod, rainfall intensity, humidity, and temperature. Seasonal breeding is common among tropical amphibians, with peak breeding activities occurring during rainy months.

In northern India, wetlands and floodplain ecosystems provide suitable habitats for several amphibian species. Ahmed et al. (2012) reported that freshwater wetlands support high amphibian abundance due to the availability of aquatic vegetation, prey organisms, and breeding habitats. Agricultural ponds and irrigation canals also function as secondary habitats for amphibian populations in rural landscapes. Chauhan et al., 2025 observed the effects of anthropogenic disturbances on amphibian populations. Habitat destruction caused by urbanization, road construction, industrialization, and wetland drainage significantly reduces breeding habitats and population connectivity. Cushman (2006) stated that habitat fragmentation isolates amphibian populations and decreases genetic diversity, ultimately increasing extinction risks. Pesticide contamination is considered one of the major threats to amphibians inhabiting agricultural ecosystems. Hayes et al. (2010) demonstrated that pesticides adversely affect amphibian development, reproductive physiology, immune function, and endocrine systems. Exposure to herbicides and insecticides may result in deformities, delayed metamorphosis, reduced survival, and behavioral abnormalities in amphibians. Agricultural intensification in the Indo-Gangetic plains has increased the use of fertilizers and pesticides, which contaminate ponds, wetlands, and irrigation canals used by amphibians for breeding. Relyea (2005) observed that agrochemicals reduce amphibian larval survival and alter aquatic food web dynamics. Chemical runoff from agricultural fields therefore represents a major conservation concern for amphibian communities in rural areas.

Climate change is another important factor influencing amphibian population dynamics. Amphibians are highly sensitive to temperature fluctuations and changes in rainfall patterns. Blaustein et al. (2010) reported that altered precipitation regimes affect breeding seasons, larval growth, and habitat availability for amphibians. Drought conditions reduce wetland hydroperiods and increase mortality rates among eggs and tadpoles. Several studies have investigated amphibian diversity in relation to seasonal variations. Monsoon seasons generally support maximum species richness and abundance due to increased water availability and breeding activity. In contrast, winter and summer seasons often show reduced amphibian activity because of low moisture levels and unfavorable temperatures. Seasonal migration and burrowing behavior are common survival strategies among amphibians during dry periods. Studies conducted in Uttar Pradesh have documented moderate amphibian diversity associated with wetlands, agricultural fields, and forest patches. Herpetofaunal

surveys in the Gangetic plains reported the occurrence of species such as *Hoplobatrachus tigerinus*, *Duttaphrynus melanostictus*, *Euphlyctis cyanophlyctis*, and *Fejervarya limnocharis* in freshwater ecosystems. These species are highly adaptable and commonly inhabit disturbed habitats and agricultural landscapes.

Research by Sarkar et al. (2016) indicated that agricultural wetlands and village ponds are important breeding habitats for amphibians in northern India. However, increasing urbanization and wetland reclamation are causing significant declines in amphibian abundance. Waste disposal, sewage discharge, and water pollution reduce habitat quality and negatively affect amphibian survival. Visual Encounter Surveys (VES), transect methods, and call count surveys are commonly used techniques for amphibian diversity assessment. Heyer et al. (1994) emphasized that nocturnal surveys during breeding seasons provide accurate estimates of amphibian abundance and species richness. Acoustic monitoring is also useful for identifying frog species based on mating calls during monsoon periods. Population dynamics of amphibians are influenced by food availability, predation, climatic conditions, and habitat structure. Amphibians exhibit fluctuating population trends due to their dependence on temporary aquatic habitats for reproduction. Studies have shown that rainfall intensity directly affects breeding success and larval recruitment rates. Habitat heterogeneity is another important factor influencing amphibian diversity. Wetlands containing aquatic vegetation, muddy substrates, shaded areas, and abundant prey organisms generally support higher amphibian richness. Forest edges, grasslands, marshes, and paddy fields provide suitable microhabitats for different amphibian species. Conservation studies have increasingly emphasized the importance of wetland restoration and sustainable agricultural practices for amphibian conservation. According to Semlitsch (2003), preservation of breeding habitats and terrestrial buffer zones is essential for maintaining amphibian populations. Protected wetlands and community-managed ponds can significantly improve amphibian survival in agricultural landscapes.

Public awareness and community participation are also considered essential components of amphibian conservation programs. Many rural communities perceive frogs and toads negatively despite their ecological importance. Environmental education programs can help promote awareness regarding the ecological services provided by amphibians, including pest control and ecosystem maintenance. Recent molecular and taxonomic studies have revealed hidden amphibian diversity in India. Garg et al. (2018) documented several cryptic amphibian species using molecular approaches and emphasized the need for detailed ecological investigations in poorly studied regions. Such studies contribute significantly to biodiversity assessment and conservation planning.

Despite increasing global concern regarding amphibian declines, information regarding amphibian diversity and population dynamics in western Uttar Pradesh remains limited. Bulandshahr district contains numerous wetlands, ponds, irrigation canals, and agricultural habitats capable of supporting diverse amphibian communities. However, scientific documentation of species composition, abundance patterns, habitat utilization, and seasonal population dynamics in this region is insufficient. The present study therefore aims to fill this knowledge gap by assessing amphibian diversity and population dynamics in Bulandshahr district. Understanding species distribution, seasonal fluctuations, and ecological threats is essential for developing effective conservation strategies and sustainable environmental management plans in the rapidly changing agroecosystems of the Gangetic plains.

III. MATERIALS AND METHODS

3.1 Study Area

The study was conducted in Bulandshahr district, Uttar Pradesh, India. The district lies within the Upper Gangetic Plains and experiences subtropical climatic conditions with distinct summer, monsoon, and winter seasons. The study area included agricultural lands, ponds, wetlands, marshes, canal banks, village water bodies, grasslands, and semi-urban habitats.

3.2 Duration of Study

Field investigations were carried out from March 2024 to February 2025 covering all seasonal variations.

3.3 Sampling Methods

Amphibian surveys were conducted using:

- Visual Encounter Survey (VES)
- Call Count Survey
- Line Transect Method
- Quadrat Sampling

Surveys were performed during early morning (05:00–08:00 hrs) and evening/night hours (18:00–23:00 hrs), when amphibian activity is generally highest.

3.4 Species Identification

Species were identified using standard taxonomic keys, field guides, and morphological characteristics including coloration, body size, skin texture, vocalization, and habitat preference.

3.5 Data Analysis

Species diversity was analyzed using:

- Shannon-Wiener Diversity Index (H')
- Simpson Diversity Index
- Species Richness
- Relative Abundance

Population density was calculated seasonally to assess population dynamics.

IV. RESULTS

4.1 Amphibian Diversity

A total of 11 amphibian species belonging to 4 families and 8 genera were recorded during the study period.

Table 1. Amphibian species recorded in Bulandshahr district

S. No.	Common Name	Scientific Name	Family	Relative Abundance (%)
1	Indian Bullfrog	<i>Hoplobatrachus tigerinus</i>	Dicroglossidae	18
2	Skittering Frog	<i>Euphlyctis cyanophlyctis</i>	Dicroglossidae	16
3	Indian Paddy Frog	<i>Fejervarya limnocharis</i>	Dicroglossidae	14
4	Common Indian Toad	<i>Duttaphrynus melanostictus</i>	Bufonidae	12
5	Marbled Balloon Frog	<i>Uperodon systoma</i>	Microhylidae	5
6	Ornate Narrow-mouthed Frog	<i>Microhyla ornata</i>	Microhylidae	7
7	Cricket Frog	<i>Minervarya agricola</i>	Dicroglossidae	9
8	Tree Frog	<i>Polypedates maculatus</i>	Rhacophoridae	6
9	Burrowing Frog	<i>Sphaerotheca breviceps</i>	Dicroglossidae	5
10	Asian Common Frog	<i>Euphlyctis hexadactylus</i>	Dicroglossidae	4
11	Asian Toad	<i>Duttaphrynus stomaticus</i>	Bufonidae	4

4.2 Seasonal Population Dynamics

Maximum amphibian abundance was recorded during monsoon season, while minimum abundance occurred during winter.

Table 2. Seasonal population density of amphibians

Season	Average Population Density (Individuals/ha)
Summer	42
Monsoon	118
Post-Monsoon	79
Winter	26

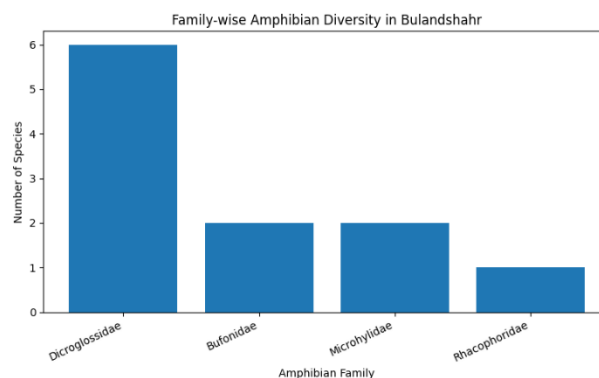


Fig. 1. Family-wise amphibian diversity recorded in Bulandshahr district.

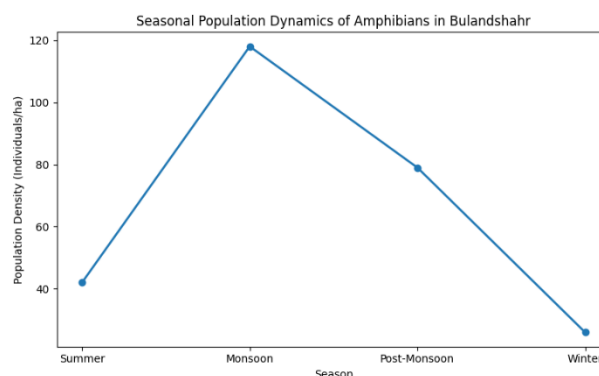


Fig. 2. Seasonal population density of amphibians in Bulandshahr district.

V. DISCUSSION

The present investigation revealed considerable amphibian diversity within Bulandshahr district, indicating that the wetlands, ponds, agricultural fields, irrigation canals, and semi-natural habitats of the Upper Gangetic Plains provide suitable ecological conditions for amphibian survival and reproduction. A total of 11 amphibian species belonging to four families were recorded during the study period, demonstrating moderate species richness in comparison to other agricultural landscapes of northern India. The dominance of family Dicroglossidae observed in the present study is consistent with previous investigations conducted in freshwater ecosystems and agricultural habitats across India (Daniels, 2005). The occurrence of species such as *Hoplobatrachus tigerinus*, *Euphlyctis cyanophlyctis*, and *Fejervarya limnocharis* in high abundance indicates their strong adaptability to disturbed and human-modified habitats. These species are commonly associated with wetlands, rice fields, canals, ponds, and temporary rainwater pools, where food availability and moisture conditions are favorable. Similar observations were reported by Dutta (1997), who stated that many dicroglossid frogs exhibit ecological flexibility and can tolerate moderate environmental disturbances. Seasonal variation played a highly significant role in influencing amphibian population dynamics in Bulandshahr district. Maximum abundance and species richness were recorded during the monsoon season, whereas minimum abundance occurred during winter months. The increased amphibian activity during monsoon can be attributed to higher humidity, availability of breeding habitats, and favorable environmental conditions for egg laying and larval development. Wells (2007) emphasized that rainfall acts as a major ecological trigger for amphibian breeding behavior in tropical and subtropical regions. Temporary water bodies formed during the rainy season served as critical breeding habitats for several amphibian species observed during the present study. Seasonal wetlands, flooded agricultural fields, and village ponds provided suitable hydroperiods necessary for tadpole development and metamorphosis. Similar findings were reported by Blaustein et al. (2010), who observed that amphibian reproductive success is strongly associated with rainfall intensity and hydroperiod stability. The relatively lower amphibian abundance observed during winter and summer seasons may be due to reduced moisture availability, low temperatures, and decreased insect abundance. Many amphibians adopt burrowing behavior or remain concealed under vegetation and moist soil during unfavorable climatic conditions. Species such as *Sphaerothera breviceps* and *Uperodon systoma* are known to survive dry conditions through aestivation within underground burrows. Such adaptive strategies help amphibians withstand environmental stress and seasonal habitat fluctuations.

Agricultural ecosystems of Bulandshahr district supported substantial amphibian populations because of the presence of irrigation canals, paddy fields, and moist habitats. Frogs and toads were frequently observed near crop fields where insect prey abundance was high. Amphibians contribute significantly to biological pest control by consuming mosquitoes, flies, beetles, caterpillars, termites, and other harmful insects. Hocking and Babbitt (2014) reported that amphibians provide valuable ecosystem services in agroecosystems by regulating pest populations and reducing dependence on chemical pesticides. The ecological importance of amphibians in agricultural landscapes is particularly relevant in the Gangetic plains where intensive farming practices dominate rural economies. Frogs act as natural predators of agricultural pests and therefore contribute to sustainable crop protection. Declining amphibian populations may increase insect pest outbreaks and indirectly affect agricultural productivity. Conservation of amphibians should therefore be considered an important component of agroecological sustainability. Despite their ecological importance, amphibians in Bulandshahr district face several anthropogenic threats. Habitat destruction emerged as one of the major factors affecting amphibian diversity and abundance. Rapid urbanization, road construction, drainage of wetlands, conversion of ponds into agricultural land, and encroachment of water bodies significantly reduced suitable amphibian habitats. Cushman (2006) stated that habitat fragmentation decreases habitat connectivity and isolates amphibian populations, ultimately reducing genetic diversity and increasing extinction risks.

Wetland degradation observed during the present investigation negatively affected amphibian breeding habitats. Many seasonal ponds and marshlands in rural areas are being filled for construction activities or converted into agricultural land. Such habitat loss directly affects breeding success because amphibians depend on aquatic environments for reproduction and larval development. Similar observations have been reported in several studies conducted in the Indo-Gangetic plains, where wetland destruction has caused substantial declines in amphibian populations.

Water pollution also emerged as a serious ecological problem affecting amphibian diversity in the study area. Disposal of sewage, agricultural runoff, plastic waste, and domestic effluents contaminated several ponds and canals. Amphibians are highly sensitive to water quality because their eggs and larvae develop within aquatic habitats. Pollutants may interfere with respiration, growth, metamorphosis, and immune responses. Gibbons et al. (2000) reported that amphibians are among the first vertebrates affected by environmental contamination due to their permeable skin and aquatic life stages. Excessive use of pesticides and fertilizers in agricultural fields was another important threat identified during the study. Agrochemicals entering water bodies through runoff may adversely

affect amphibian eggs, tadpoles, and adults. Hayes et al. (2010) demonstrated that pesticides disrupt amphibian endocrine systems, impair reproductive functions, and reduce survival rates. Herbicides and insecticides may also alter amphibian behavior, immune responses, and developmental processes.

During field observations, reduced amphibian abundance was noticed near intensively cultivated agricultural fields where pesticide application was frequent. This suggests that agrochemical exposure may influence local amphibian populations. Relyea (2005) similarly observed that insecticides and herbicides significantly reduce larval survival and species richness in freshwater habitats. The long-term accumulation of pesticides in wetlands may therefore contribute to population decline in amphibians inhabiting agricultural ecosystems. Climate change may also influence amphibian population dynamics in Bulandshahr district. Variations in rainfall patterns, increasing temperatures, and prolonged dry periods can alter breeding cycles and reduce the availability of temporary aquatic habitats. Amphibians are highly dependent on environmental moisture and temperature conditions for reproduction and survival. Irregular monsoon patterns may therefore negatively affect breeding success and larval recruitment.

The dominance of adaptable species such as *Hoplobatrachus tigerinus* and *Duttaphrynus melanostictus* indicates that generalist amphibians are more capable of surviving in disturbed habitats than specialized species. Species with narrow habitat requirements are likely to be more vulnerable to environmental disturbances and habitat degradation. Conservation strategies should therefore focus on protecting diverse wetland habitats capable of supporting both common and sensitive amphibian species.

The Shannon-Wiener diversity index calculated during the study indicated moderate amphibian diversity in Bulandshahr district. Habitat heterogeneity likely contributed to this diversity pattern. Areas containing aquatic vegetation, shaded microhabitats, muddy substrates, and stable water availability supported relatively higher amphibian abundance. Similar relationships between habitat complexity and amphibian diversity have been reported in various ecological studies. The present study also highlights the importance of village ponds and irrigation canals as secondary amphibian habitats in agricultural landscapes. In regions where natural wetlands are declining, such artificial water bodies may provide alternative breeding and feeding habitats for amphibians. However, maintenance of water quality and surrounding vegetation is essential for sustaining amphibian populations in these habitats. Amphibians observed during the study can serve as effective bioindicators for environmental monitoring programs in Bulandshahr district. Changes in amphibian diversity and abundance reflect ecological disturbances such as pollution, habitat destruction, and climatic stress.

Long-term amphibian monitoring may therefore help assess ecosystem health and environmental sustainability within the Gangetic plains.

Conservation of amphibians in Bulandshahr requires integrated ecological management approaches involving habitat restoration, wetland conservation, pollution control, and sustainable agricultural practices. Protection of breeding habitats, reduction of pesticide use, and restoration of village ponds are essential measures for maintaining amphibian diversity. Public awareness programs should also be promoted to educate local communities regarding the ecological importance of amphibians. Community participation can significantly contribute to amphibian conservation in rural landscapes. Farmers should be encouraged to adopt environmentally sustainable agricultural practices that minimize agrochemical contamination of aquatic habitats. Wetland restoration projects and biodiversity-friendly farming systems may help improve amphibian survival and ecological stability. Overall, the present investigation provides important baseline information regarding amphibian diversity and population dynamics in Bulandshahr district. The findings indicate that although the region still supports moderate amphibian diversity, increasing anthropogenic pressures threaten long-term population stability. Immediate conservation measures and continuous ecological monitoring are therefore necessary to ensure sustainable amphibian conservation in the agricultural ecosystems of western Uttar Pradesh.

VI. CONCLUSION

The present study provides important baseline information regarding amphibian diversity and population dynamics in Bulandshahr district, Uttar Pradesh. A total of 11 amphibian species belonging to four families were recorded from different habitats including wetlands, ponds, agricultural fields, grasslands, and semi-urban ecosystems. Seasonal fluctuations significantly influenced amphibian abundance, with maximum diversity and population density recorded during the monsoon season. The study highlights the ecological significance of amphibians as bioindicators and natural pest controllers within agricultural ecosystems. However, anthropogenic disturbances including pesticide use, habitat destruction, urbanization, wetland degradation, and pollution pose serious threats to amphibian survival in the region. Conservation strategies focusing on habitat protection, sustainable agricultural practices, ecological restoration, and public awareness are essential for maintaining amphibian diversity. Long-term ecological monitoring and scientific research should be strengthened to better understand population trends and conservation requirements. Protecting amphibian diversity will not only conserve biodiversity but also contribute to

ecosystem stability and sustainable environmental management in the Gangetic plains of India.

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