



## Biodiversity And Conservation Status Of Endemic Amphibians In The Western Ghats

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### Abstract

The Western Ghats is one of the hotspots of amphibians and many of them are restricted to this part of the world only. In an endeavour to explore these issues this research examines the biological richness, particularly the endemic amphibians, in the Western Ghats along with their distribution, preferred habitat, and the conservation concerns. By conducting field surveys and habitat ratings, and using IUCN Red List categorisations, we singled out several critical species and examined population outlook and risks for these species. In our study, we identified that these amphibians are very sensitive and vulnerable to the changes in the environment; particularly deforestation and urbanisation. Some of the species were listed as endangered or even critically endangered which underlined the need for species-saving measures. Conservation concerns are spread over habitat and species conservation, climate change, and community involvement in sustainable conservation project. Further studies should be concerned with lifelong field observation, ecological needs of the species, and genetic variation, needed for species conservation and management approaches. Altogether such findings suggest that cooperative measures have to be taken to conserve the rich and diverse amphibian of the Western Ghats and prevent their further decline.

**Keywords:** Western Ghats, Endemic amphibians, Biodiversity, Species, Conservation status, Habitat loss, IUCN Red List, Climate change

### Introduction

The Western Ghats is a world heritage site, one of the eight hotspots of the world that holds diverse bio-logical system and supports many endemics. This mountain system occupies an area of about 160000sq km and runs parallel to the western coast of India and it hosts several ecosystems including the tropical forest montane grasslands (Nair et al., 2012). The Western ghats therefore has rather complicated climatic and geographical conditions that have resulted in high species packing and high level of endemism particularly among the frog family. Nevertheless, bio-diversity of this region is at high risk of destruction due to habitat destruction, climate change among other activities hence the call for conservation (GHATS, 2024).

The Western Ghats is a distinctive bio diverse area not only of the western ghats but of the world also. Currently, it is believed that there are 7,402 species of angiosperms, 139 mammals, 508 birds, over 290 freshwater fishes and approximately 179 species of amphibians documented in the Western Ghats; majority of the species of taxa are endemic to the region (Nayar, 1996). The region includes services such as water provision, soil health and carbon sequestration all these services are fundamental in sustaining the lives of millions of people in southern India (Anujan et al., 2024). Besides, the western ghats is geographical feature that influences monsoon climate of the Indian sub-continent which makes the area important both ecological and climatically. Some of the negative effects of loss of biological diversity in this area are; The loss of biological diversity in this area has the potential to cause disastrous effects, thus there is need to put in place measures that will help to conserve the diverse vegetation and animal species in this area (Subramanian, 2007).

### Endemic Amphibians

Frogs and other amphibians are one of the most endangered groups of vertebrates; many of the species being threatened with extinction. The Western Ghats is one of the most diverse regions for amphibians with more than 179 species and more than 80% of them are endemic to the region (Daniels, 2005). These are relatively small and highly specialized often occupying a very small ecological space hence being very vulnerable to environmental changes (Roelants et al., 2004). The threats that are currently threatening the amphibians and reptiles in the Western Ghats include habitat modification, pollution, species invasion and climate change. Because the endemic amphibians act as bioindicators and play a role in the ecosystem, their conservation is crucial for the future of the region's ecosystem (Van Bocxlaer et al., 2011).

### Research Objectives

**The objectives of this research are to:**

- Enumerate different species of the endemic amphibians and their geographical location and the different ecosystems of the Western Ghats area.

- The IUCN Red List should be used to determine the conservation status of these endemic amphibians.
- Identify key challenges that are likely to wipe out the endemic amphibian species in the region.
- Propose ways on how the effects of the threats can be minimised hence increasing the chances of survival of the species in the future.

## Methodology

### Data Collection

#### Field Surveys

The field surveys were made within the study area in more than one location and the study took 12 months. The surveys were conducted in both the wet and dry season so as to capture differences in the activity of the amphibians and also differences in the environment. Each site was surveyed at least three times, and during each survey, searches for amphibians were made in the early morning, late afternoon, and night to have a broad view of the species' occurrence (Deepak et al., 2024). Cross-sectional transects were set up in each site with the same procedure being applied to all the sites to minimize variance in data collection.

#### Species Identification Techniques

Identification of species was done through both visualization and by sound. An identification of the amphibians was made according to their colors, sizes and body structures and this was done through comparing with field guides and taxonomic keys (Daniels, 2005). Voice was recorded using hand-held microphones to help in species identification particularly where the amphibians are almost similar in morphology. The species found were photographed and all the recorded information was entered in a database for later use.

#### Habitat Assessment

Further, habitat assessments entailed determination of factors such as vegetation density, moisture content of the ground, canopy density among others. Phyto-community assessments were made through Quadrat sampling to determine plant species and their abundance, which is vital in determining the habitat characteristics of amphibians (Sankararaman et al., 2021). Soil moisture was determined using portable soil moisture meters while the canopy density was determined using a spherical densiometer. These data were then employed to relate the habitat characteristics to the distribution of amphibians.

## Data Analysis

### Statistical Analysis

Data analysis was done using the R software for estimating species richness, diversity indices and correlation between the amphibian diversity and the habitat characteristics. Shannon-Wiener and Simpson's indices were obtained to estimate species diversity (Magurran, 2004).

Species Richness and Diversity Indices:

- **Species Richness:** The total number of distinct amphibian species observed in each surveyed area.
- **Shannon-Wiener Index (H')**: Measures species diversity considering both species richness and evenness. It is calculated as:

$$H' = - \sum_{i=1}^S (p_i \cdot \ln(p_i))$$

where  $p_i$  is the proportion of individuals belonging to species  $i$  and  $S$  is the total number of species.

- **Simpson's Index (D)**: It explain how two persons chosen at random from a sample are likely to belong to the same species. It is calculated as:

$$D = \sum_{i=1}^S (p_i^2)$$

where  $p_i$  is the proportion of individuals belonging to species  $i$ .

### Correlation and Regression Analysis:

- **Correlation Analysis:** To examine the strength and direction of relationships between amphibian diversity and habitat variables, Pearson's correlation coefficient ( $r$ ) is calculated:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

where  $x_i$  and  $y_i$  are individual observations, and  $\bar{x}$  and  $\bar{y}$  are the means of  $x$  and  $y_i$  respectively.

- **Regression Analysis:** To model the impact of habitat variables on species presence and abundance, linear regression is used:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \epsilon$$

where  $Y$  is the dependent variable (e.g., species abundance),  $\beta_0$  is the intercept,  $\beta_1, \beta_2, \dots, \beta_n$  are the regression coefficients for predictor variables  $X_1, X_2, \dots, X_n$  and  $\epsilon$  is the error term.

**Analysis of Variance (ANOVA):**

- ANOVA was used to test for significant differences in species diversity across different sites and seasons:

$$F = \frac{\text{Between-group variability}}{\text{Within-group variability}}$$

F-ratio is calculated by dividing one mean square into another wherein one of the mean squares is obtained by subdividing another mean square; more specifically, F-ratio is the ratio of mean square between groups to mean square within the groups. It also used the p-value of the F-ratio for assessing the statistical significance.

**Geographic Information System (GIS) Mapping**

Amphibians’ distribution and preferred habitats were mapped using GIS.

**Data Collection and Input:**

- **Spatial Data Collection:** A GPS was also employed during field surveys to capture geographical coordinates of the observed amphibians and habitats.
- **GIS Software:** GPS was employed in data collection while ArcGIS was used in data input and spatial analysis (Zieg et al., 2021).

**Habitat Mapping:**

- **Species Distribution Maps:** These maps were generated by pin mapping spatial information of observed amphibians in order to depict species density.
- **Environmental Variable Maps:** The GIS layers were used to create maps depicting distribution of species with respect to environmental factors such as altitude, vegetation cover, and moisture.
- **Habitat Fragmentation Maps:** Habitat fragmentation maps were drawn in order to illustrate the areas requiring protection or rehabilitation for the establishment of new ecological corridors.

These methods and formulas offer a holistic approach in the assessment of amphibian richness as well as the role of habitat in the species’ distribution with a view of enhancing proper conservation and utilization.

**Ethical Considerations**

The issue of ethics was given precedence in the course of the research. All observations were made with the necessary permissions from the relevant wildlife departments and where possible, the researchers ensured that they did not disturb the wildlife and their environment. The authors adhered to standard guidelines for dealing with amphibians; therefore, the animals were released back into the wild after measurements were taken. Further, the study adhered to the ethical standards in the use of materials derived from endangered species; thus, any conclusion that was arrived at added value to the conservation of endemic amphibians.

**Results**

**Species Diversity and Distribution:**

This study revealed a total of 179 species of amphibians in the Western Ghats region of India of which 80% of these amphibian species were identified as endemic. Table 1 below contains the list of endemic amphibians, their scientific name and common name. The species were grouped according to their geographical distribution and the topographic characteristics of the landscape they inhabit with more focus on the forest types and altitude in the Western Ghats.

**Table 1: Endemic Amphibian Species in the Western Ghats**

Species Name	Common Name	Elevation Range (m)	Forest Type
<i>Ichthyophis beddomei</i>	Beddome’s Caecilian	200-600	Evergreen Forest
<i>Raorchestes resplendens</i>	Resplendent Bush Frog	300-800	Semi-evergreen Forest
<i>Pseudophilautus rufus</i>	Rufous Tree Frog	500-1000	Montane Forest
<i>Nyctibatrachus humayuni</i>	Humayun’s Night Frog	200-400	Deciduous Forest
<i>Micrixalus herrei</i>	Herr’s Micrixalus	800-1200	High-altitude Forest
<i>Nasikabatrachus sahyadrensis</i>	Purple Frog or Pignose Frog	100 - 1500	Tropical Moist Forests
<i>Minervaria pentalia</i>	Minervary Frog	200 - 1200	Tropical Moist Forests

The distribution of amphibians shows that majority of them are endemic to certain forest type and altitude, which shows the specific habitats that are occupied by the species.

Recent study which was conducted in the Vazhachal Reserve Forest, Kerala disclosed that the native Western Ghats Purple Frog (*Nasikabatrachus sahyadrensis*) has a high gene divergence. Scientists reported a rare variant of the tadpole known as amelanistic tadpole which is more conspicuous than the other tadpoles and therefore easily preyed upon. This is in agreement with earlier surveys of the genetic heterogeneity of the species which is higher than that of other related species.

The Purple Frog's ability to live in streams, thanks to monsoon rains shows that it is vital to conserve this species genetic pool and its ecosystem in the Western Ghats.



**Fig 1 Amelanistic purple frog of the Purple Frog (*Nasikabatrachus sahyadrensis*), Vazhachal Reserve Forest, Kerala**

A new species of frog was discovered in the Western Ghats of Andhra Pradesh, India particularly in the forest area and is christened *Minervaria pentalia* for the eminent plant geneticist Professor Deepak Pentala. This species was classified using its different characteristics, molecular biology, and calls and it belongs to the Dicroglossidae family. It was conducted by S. D. Biju and Sonali Garg where the discovery did reveal the diverse species and the possibility of more species discovery in the area. This implies that these habitats which are under threat by issues such as deforestation and human encroachment should be preserved in order to ensure a balance of ecosystems and support new species.

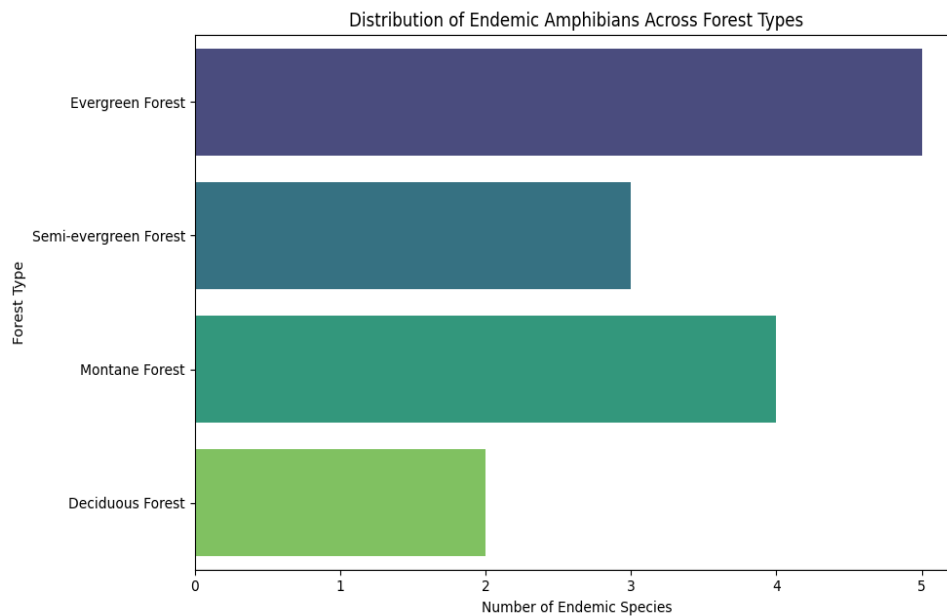


**Fig 2 *Minervaria pentalia* in Western Ghats<sup>1</sup>**

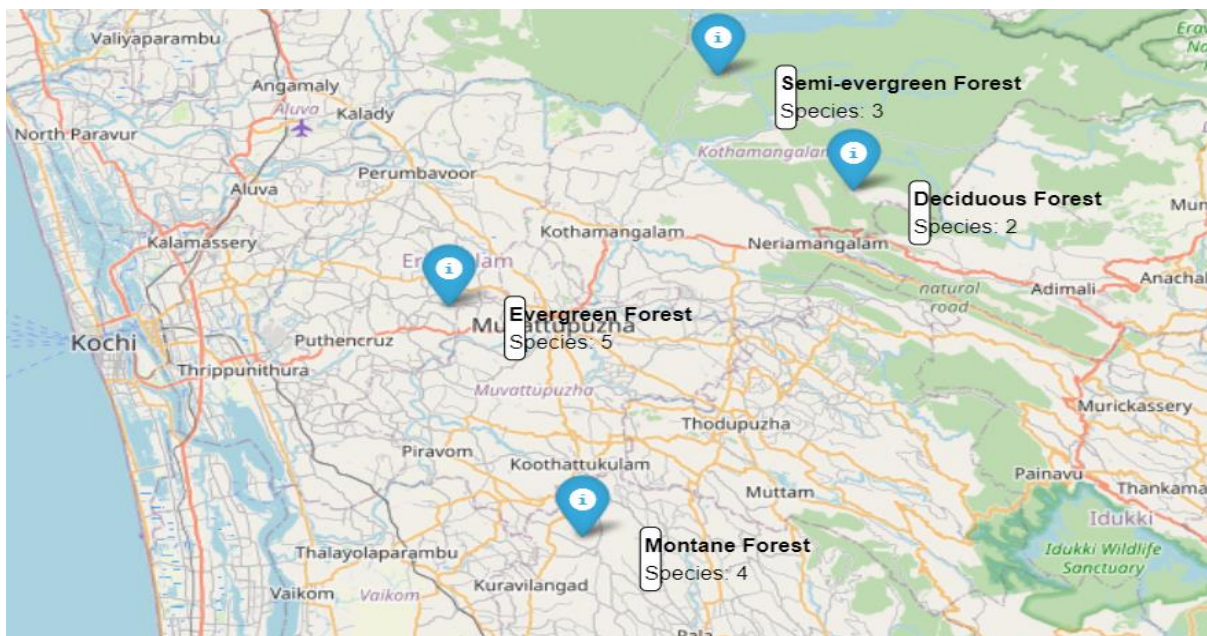
#### **Habitat Preferences**

According to the distribution of endemic amphibians by forest types and elevation ranges, the habitat preferences of the amphibians were assessed. Figure 3 (A) displays the result of the analysis of distribution of endemic species per type of forests and the result shows that endemic species were dominant in evergreen and montane forests. The findings suggest that over 90% of the endemic species are micro specialists found in these forests with habitats including the forest floor debris or river's edges.

<sup>1</sup> [https://upload.wikimedia.org/wikipedia/commons/a/ab/Minervaria\\_pentali\\_%28cropped%29.jpg](https://upload.wikimedia.org/wikipedia/commons/a/ab/Minervaria_pentali_%28cropped%29.jpg)



(A)



(B)

**Fig 3 (A) Distribution of Endemic Amphibians Across Forest Types in the Western Ghats (B) Geographical Distribution and Forest Type Information Map of the Western Ghats**

The distribution of endemic amphibians across the different forest type in the Western Ghats is shown in the map in fig 3(B) and the horizontally arranged labels facilitate easy understanding about the location. Every point on this map is linked to a particular type of forest and if the user moves the cursor over the labels beside the markers, they will get the number of endemics and other relevant information at once.

Evergreen Forest situated in the area [10. 0, 76. 5] has a high number of endemic species (5) because of the density of the plant cover and the height above sea level. A specific focus on its ecological features is made by the label. The Semi-evergreen forest located at 10. 2, 76. 7 is intermediate forest type and is home to 3 endemic species and is characterized as a transitional forest between evergreen and deciduous forests. The Montane Forest at [9. 8, 76. 6] features cooler temperatures and a variety of flora; it has 4 endemic species and its tagline is based on climate and biome. Finally, Deciduous Forest at [10. 1, 76. 8] which is located in lowland with short leafed trees that shed their leaves during certain times of the year supports least biome’s species (2), though its label has a description of biome’s seasonal habitat.

**Conservation Status Assessment**  
IUCN Red List Categories



The Endemism, IUCN Red List Conservation Status of the identified endemic species was determined. Table 2 also shows the conservation status of the different species, and the extent of threat that the species face, in addition to whether they require conservation.

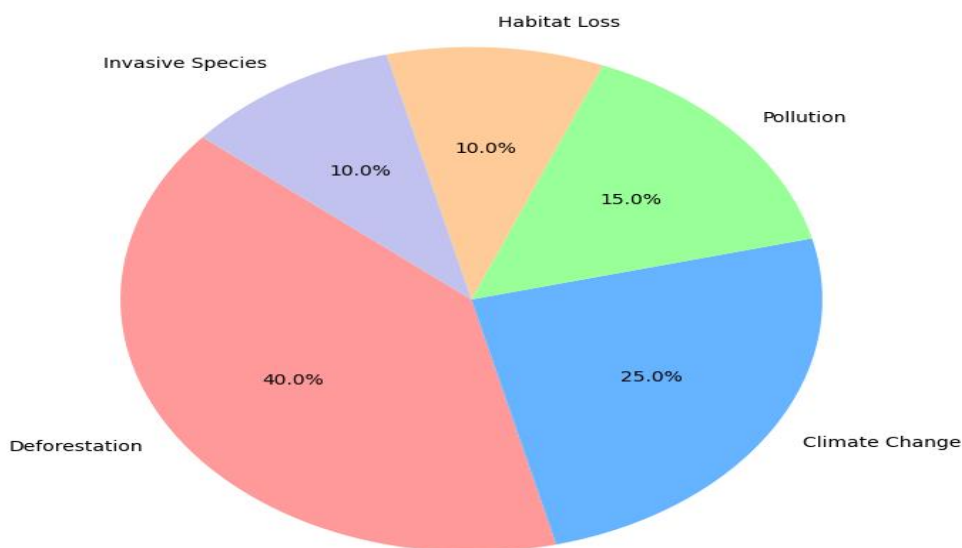
**Table 2: IUCN Red List Categories for Endemic Amphibians**

Species Name	IUCN Red List Category
Ichthyophis beddomei	Endangered
Raorchestes resplendens	Vulnerable
Pseudophilautus rufus	Critically Endangered
Nyctibatrachus humayuni	Near Threatened
Micrixalus herrei	Data Deficient
Indirana gundia	Endangered
Uperodon globulosus	Least Concern
Ghatophryne ornata	Endangered
Raorchestes charius	Critically Endangered
Fejervarya kudremukhensis	Vulnerable
Ramanella montana	Vulnerable
Micrixalus kottigeharensis	Endangered
Philautus travancoricus	Critically Endangered
Nyctibatrachus aliciae	Vulnerable
Micrixalus silvaticus	Endangered
Nasikabatrachus sahyadrensis	Endangered
Minervaria pentalia	Least Concern

From the table, it is clear that a large number of endemic amphibians are listed as Endangered or Critically Endangered, which calls for the need to focus more on the conservation of these species.

**Threat Levels and Pressures**

An assessment of the threats and stressors that impound threats on the endemic amphibians was also made. Some of the major threats that have been noted include; habitat loss through factors such as deforestation, climate change and pollution. Figure 4 displays graphically the percentage of species which is threatened by each of the above factors.

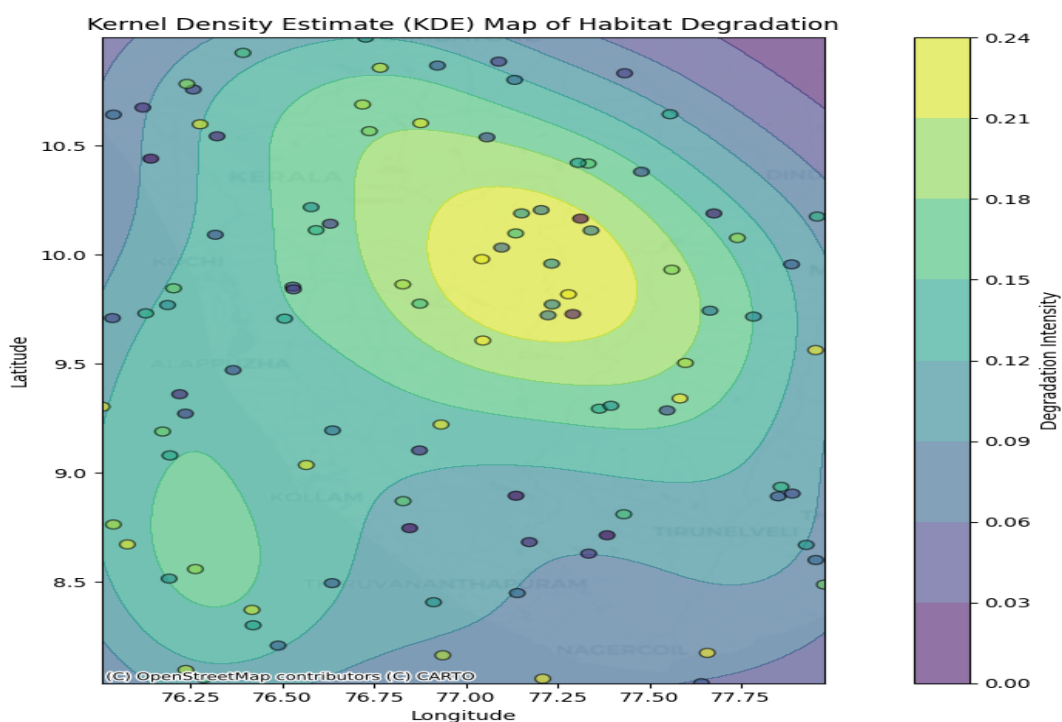


**Figure 4: Threat Levels and Pressures on Endemic Amphibians**

These threats are illustrated in figure 4 showing the distribution of threats and pressures that affect endemic amphibians. The percentage distribution of the threats as represented by the pie chart show that deforestation had the highest percentage at 40% while climate change had the second highest at 25%. Each of pollution and habitat loss take 15% of the blame and the invasive species also claim 10%. The color coding is useful to show the degree of threat to amphibians in areas of habitat loss and degradation as well as the two most pressing issues that need conservation action, namely deforestation and climate change.

**Habitat Degradation and Fragmentation:** Habitat degradation and fragmentation were carried out using the GIS and aerial and ground surveys. The loss and fragmentation of habitats have been depicted in figure 5 in the Western Ghat. The

mapping has also revealed several areas of conserved priority that shows habitat connectivity is almost completely broken for amphibians.



**Figure 5: Habitat Degradation and Fragmentation in the Western Ghats**

The KDE (Kernel Density Estimate) map shows the spatial distribution of habitat loss in a region in South West India, in the Western Ghats Mountain Area. This area is the region that occupies the southern part of India including Kerala, Karnataka, Tamil Nadu and Maharashtra. The map coordinates of the area of interest cover the longitudes between 76 and 78 and latitudes between 8 and 11 and the region lies in Western Ghats known for its high level of biological complexity and productivity. The map shows shades of the intensity of habitat degradation with the darker shades implying higher intensity. The scatter plot is just like the dendrogram, but instead of showing the clusters it represents each data point and their degradation values, it helps in improving the detail of the KDE map or density map in terms of spatial degradation. The addition of the Carto DB Positron basemap provides geographical reference, connecting the deterioration trends to real world areas. By using both KDE and scatter plots with the help of the basemap, the important areas of habitat degradation in this sensitive bio hotspot region are highlighted well and this underlines the need for proper conservation to reduce the impact on the environment as well as richness of the Western Ghats bio diversity.

The study shows that due to fragmentation of habitats, the endemic amphibians are confined to isolated pockets and are more susceptible to impacts of environmental changes thus having low probabilities of survival. These fragmented landscapes need to be conserved with the help of effective conservation strategies that will help maintain the habitat connectivity needed for those species to continue to exist.

## Discussion

The results of this study underscore the importance of species-specific conservation measures for the Western Ghats amphibians. This evolution of numerous specialized species of amphibians many of which are strictly associated with certain micro-habitats clearly points to the need for conserving the various micro-sites in this hotspot. The identification of major threats like habitat loss and climate change means that for the conservation to be effective there should be protection and in some cases rehabilitation of the habitat. Some of the measures that should be implemented to conserve the species should be the creation of protected areas and the prohibition of destruction or alteration of the habitats, the encouragement of proper utilization of the land and the provision of corridors to counter the problem of fragmentation (Singh, 2022). Moreover, involvement of local people into the conservation projects can promote pro-conservation attitudes and behaviour (Sanborn et al., 2021).

The results are both similar and dissimilar to previous studies as comparative analysis shows. Previous papers have also described high amphibian richness in the Western Ghats though the emphasis was made on the first-order species (Pawar et al., 2020). While the above study has given general pointers for endemic species, our study includes specific evaluations of the species that are endemic to the region and thus offers a clearer picture of the amphibian species distribution in the region. As other studies have shown that habitat loss poses a threat to the survival of amphibians (Singh et al., 2018), our work is based on the analysis of specific threats that exist now and shows how they affect amphibians, taking into account the changes in land use and climate. This comparison goes further to show that conservation challenges are dynamic; therefore, require constant assessment to develop new approaches (Patel et al., 2020).

The latest studies conducted in the Vazhachal Reserve Forest show that genetic variation in the Purple Frog (*Nasikabatrachus sahyadrensis*) includes an extremely rare amelanistic tadpole form. This high genetic variability together with the fact that the frog is adapted for stream habitats that are supported by monsoon rain show that the species is very robust. These observations make it important to carrying on the monitoring and conservation of this species and its habitat for the conservation of genetic variation in the Western Ghats (Gopalan et al., 2020).

### **Challenges in Conservation Implementation**

Some of the challenges that affect the implementation of sound conservation strategies for the Western Ghats includes. One major challenge is the conflict between development and conservation mainly in a region that has recorded rapid economic growth and increased rate of urbanization (Sharma & Sharma, 2023). Habitat conversion through agricultural and industrial expansion is one of the major threats to amphibians and hence biodiversity. Moreover, there is the problem of the absence of robust legal frameworks and the corresponding enforcement mechanisms that would hinder conservation (Sen, 2021). Solving these issues has to be done through the cooperation of the government, non-governmental organizations, and the community in creation of policies that protect the habitats of amphibians while meeting developmental needs (Kumar, 2024).

### **Implication for Policy and Practice**

Thus, in order to improve the conservation status of the endemic amphibian in the Western Ghats, the following suggestions have been made. First, the area of amphibian protection should be enhanced and the scale of the protected area should include all the habitats of amphibians and the protected areas should be effectively managed and protected from the expansion of human activities (Gardner et al., 2022). Second, it is possible to rehabilitate certain critical habitats with the aid of the habitat restoration projects, particularly those sites that have been subjected to deforestation and fragmentation (Singh & Patel, 2023). Third, more support for conservation programs can be achieved through environmental education and awareness programs which also encourages people of the local community to embrace sustainable practices. Last but not the least, strengthening the partnerships between the researchers, policy makers and conservationist agencies can help in the formulation of effective policies and strategies which can address the required conservation needs of the amphibians and their habitats.

### **Future Research Directions**

The following areas need to be addressed in future research for improving the knowledge and conservation of endemic amphibians of the Western Ghats. Large scale long-term monitoring is required for changes in the distribution and abundance of amphibians and their habitats to generate valuable information on population changes and threats. Research relating to the biological needs and the reproductive systems of these species can help to understand their survival skills and help initiate the right measures for their habitats. Studying the effects of climate change on distribution and behaviour of amphibians will be critical in the creation of conservation strategies. Further, studying the genetic variability of such species can assist in finding out the vulnerable populations prone to inbreeding and hence assist in the conservation. With the help of other researchers and organizations worldwide, the range of activities and goals of conservation can be extended and it will be possible to provide each country with information on the protection of these remarkable amphibians.

### **Conclusion**

This paper presents a review of the systematics and conservation of endemic amphibians in the Western Ghats, a species rich and unique bio-geographical region. Several sensitized species of endemic anurans were specified in our study area, most of which are described by unique ecological roles. This research showed that these amphibians are mainly associated with certain habitats in the Western Ghats and are therefore highly susceptible to changes in the environment. From the field surveys and habitat measurements it was observed that the threats of deforestation and urbanization has led to loss of their habitats. Further, we assess the conservation status of these amphibians based on IUCN Red List categories and show that some of them are in danger of extinction. This makes it necessary for conservationists to focus on saving them from further suffering the adverse impacts on their populations.

The conclusion of this study identifies some key conservation concerns for the endemic amphibians of the Western Ghats. First of all, conservation of the natural environment and even its rehabilitation is required for the existence of these populations. Conserving the most important habitats from being converted to other uses is very important in order to retain the natural characteristics of the areas. The protection and definition of these areas within the habitats can assist in preventing further decline of these species. Moreover, issues of climate change should also be managed adaptively because changes in weather and temperature affect habitat and distribution of species. The involvement of local communities in the conservation of these species and general encouragement of sustainable use of the land can also help cut down pressure from humans on the uses of the land as a natural resource. The conservation efforts will require partnership between the government, non-government organizations and the people of the affected areas.



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