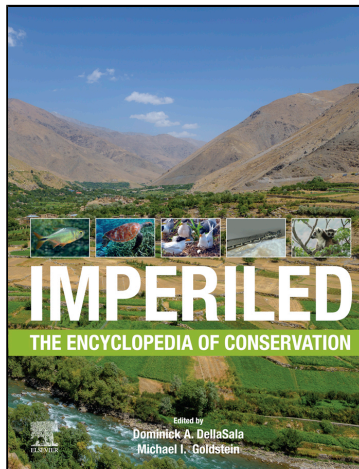


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## Riparian Forest of Western Ghats, an Endangered Ecosystem

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### Abstract

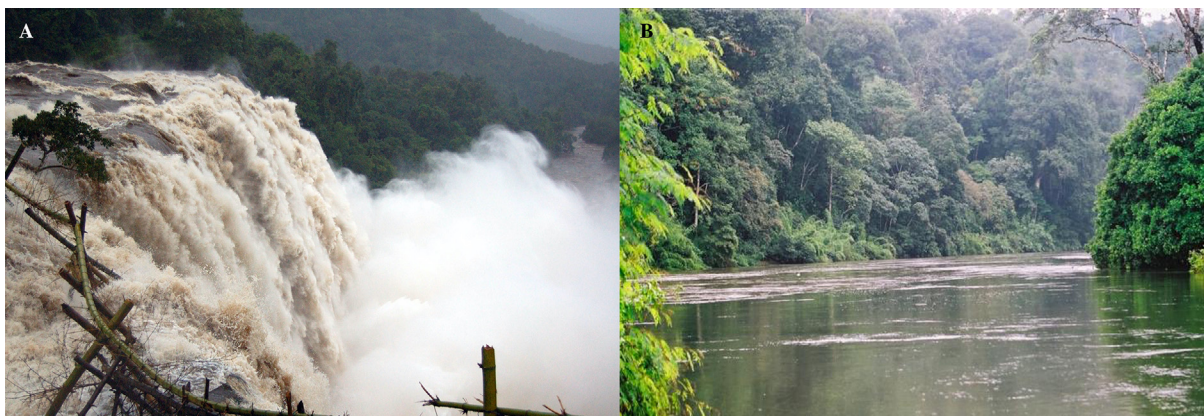
The tropical riparian evergreen forests in the Southern Western Ghats were mapped and described based on biodiversity and spatial distribution. The ecosystem was assessed against multiple criteria, IUCN Red List of ecosystem (Ver. 1.1.) for the first time in India. The periodic reduction of riparian vegetation revealed a loss of 83% in the past 100 years due to factors such as dams, forest plantations, reservoir operation coupled with climate change induced flood. At minimum degradation rate, the collapse of the ecosystem is projected within 20–40 years, indicating it as Critically Endangered (CR). Prediction of potential areas based on Niche modelling and terrain suitability provided three priority areas and policy suggestions for conservation and restoration.

### Introduction

The tropical evergreen forest formation in the Western Ghats, an important biodiversity hotspot in the Indian Subcontinent, is unique with its diverse flora and fauna. The Western Ghats has more than 30% of plant, fish, herpetofauna, bird, and mammal species found in India (Bawa et al., 2007). It harbors more than 5000 species of flowering plants including more than 1800 endemics. The Western slopes of Western Ghats, especially in the part of Southern Western Ghats of Kerala, has a wide range of wet forest formations including tropical moist deciduous to tropical wet evergreen and montane shola forests due to the high monsoonal rainfall in the region. Apart from the low elevation to medium elevation evergreen and wet evergreen types, different kinds of moist forest types; such as the endangered Myristica swamp forest, Dry evergreen forest, Shola grassland ecosystem and vegetation of the lateritic plateaus, are considered to be unique. The riparian forest in the rainfed region of the Western Ghats remained unnoticed until 2000, even though Champion and Seth (1968), in the revised forest classification of India, mentioned the riparian forest in the dry part of the country as an independent forest type. A study on the riparian vegetation in the Chalakudy River (Amitha Bachan, 2003) pioneered detailed documentation of the floral faunal wealth and its importance as a unique vegetation.

The Athirappilly Vazhachal (waterfall), popularly known as 'Indian Niagara' in the Chalakudy River (Fig. 1A) is always a fascination to everyone who visits the section of Ghats in Kerala. Regular visits to the falls in the lower elevations (100 m from mean sea level MSL), and meanders alongside the Anamalai road or the trail along the banks of the river up to a 6 km upstream from the beautiful Vazhachal rapid is a unique evergreen forest formation. The narrow belt of low elevation evergreen riparian forest is verdant even in extreme summer months and easily distinguishable from the surrounding deciduous teak plantations (Fig. 1B). The presence of tall evergreen forest trees such as *Dipterocarpus indicus*, *Vateria indica*, *Prioria pinnata* along with obligate riparian elements, *Barringtonia acutangula*, *Humboldtia vahliana*, *Homonoia riparia*, accommodate many endemic and threatened plants and fauna including the Great hornbill (*Buceros bicornis*), Malabar pied hornbill (*Anthracoseros coronatus*), Malabar grey hornbill (*Ocy-ceros griseus*) and Lion tailed macaque (*Macaca silenus*).

The available literature hardly supported the presence of the riparian evergreen vegetation since the revised classification of vegetation in India by Champion and Seth (1968), that mentions only the riparian fringing forest type in the dry areas of Central India. However, the richness of the rainfed sections of the Ghats in Kerala as catchments of 41 west and three east-flowing rivers, support the hypothesis of riparian forest types in the moist Western Ghats. The Chalakudy River is the fifth longest river amongst these catchments. A comprehensive assessment of the 1704 km<sup>2</sup> area of the river basin, spread over four different bioclimatic regimes revealed the existence of several riparian forest types (Amitha Bachan, 2010).



**Fig. 1** (A) Athirappilly falls in Chalakudy River, Western Ghats, Kerala, India. (B) Riparian forests at Orukombankutty, the confluence point of all the tributaries.

A detailed investigation of the different riparian forest types in the Southern Western Ghats revealed the Tropical low elevation evergreen riparian forest (T1.1.iii. Rp.) as a unique forest type with very limited distribution. Only 2.60 km<sup>2</sup> of such riparian forest in the region remains and it's limited to just a few locations (Amitha Bachan, 2010). The available 2.60 km<sup>2</sup> of low elevation riparian forest is confined to 30 km (50–350 m MSL) and is already fragmented by a reservoir and facing the threat of submergence with a proposed dam. In the Chalakudy River alone, 60 km of the valley was submerged in the reservoir and 29 km dried up downstream to the dam. The adjacent forest in the valley was converted to a monoculture forest plantation that imposed a serious threat to the unique low elevation riparian forest (Amitha Bachan and Devika, 2020).

The profile of different rivers in the Western Ghats (CWRDM, 1995) indicate such low elevation river stretches are limited to the Chalakudy, Chaliyar, Thutha and a small portion of the Periyar River. Research spanning two decades has revealed the distribution, importance and necessity of serious conservation measures to preserve this ecosystem. The scope of this study is to provide a scientific elucidation of the distribution, modelling of potential areas, and systematic assessment of the threatened status of riparian forests in this region using IUCN criteria while bringing together different bioclimatic and ecological parameters, including key threats.

## Methodology

All landscapes composed of mosaics of heterogenous ecosystems are characterized by heterogeneity in vegetation. These differences have evolved over time in response to bioclimate, biotic and abiotic interference. The riparian vegetation connects the landscape mosaic. Attempts have been made here to differentiate the riparian forests from other wetlands based on criteria provided by Newson (1994) and the works of Stancioff et al. (1985), Keith et al. (2013), Champion and Seth (1968), Amitha Bachan (2003, 2005, 2010), Sunil et al. (2009) and Amitha Bachan and Pooja et al. (2020). The riparian vegetation in the Southern Western Ghats region were mapped using QGIS, Landsat images, Google Earth and field level mapping. The satellite imagery based classification alone did not suffice since the composition of riparian vegetation merges with the evergreen forests in the surrounding landscape. The field level cadastral mapping was done in the Chalakudy River during three periods documented in Amitha Bachan (2003), Amitha Bachan (2010) and Amitha Bachan et al. (2019). These field level maps were updated here with Landsat classification. This was further refined using the Goggle hybrid in QGIS. The species composition corresponding to different riparian forest types (Amitha Bachan, 2010; Amitha Bachan and Pooja, 2020) were identified from 178 sampling plots, including 106 from Amitha Bachan (2010), four from Amitha Bachan et al. (2019) and 68 plots during this study period. Species similarity clustering was done for the heterogeneous clusters with each cluster analyzed for phytosociological parameters including Importance Value Index (IVI). We scrutinized the available literature on riparian vegetation from the region (Amitha Bachan, 2003, 2005, 2010; Sunil et al., 2009, 2011; Paul, 2014; Jisha and Maya, 2018; Amitha Bachan et al., 2019; Amitha Bachan and Pooja, 2020; Amitha Bachan and Devika, 2020), the working and management plans of the forest department and data collected for three river basins in collaboration with Kerala State Landuse Board in ecorestoration planning to understand the distribution of the riparian forest composition. Field verifications were done during 2019–2021 to fine tune and finalize the mapping.

Estimates of riparian forest decline were obtained by comparing the maps for 2000–2003 (Amitha Bachan, 2003), 2007–2010 (Amitha Bachan, 2010), the post-flood 2018 period (Amitha Bachan et al. (2019) and with the current status. Mapping shows that only 2.77 km<sup>2</sup> of the low elevation riparian forest remains in the four zones of the Chalakudy River and the field observations in heavily degraded zones constitute 2.44 km<sup>2</sup> in total. The rate of degradation since 1920 was estimated based on information obtained from forest working plans and also from the above studies. Periodic riparian forest degradation rate, mean (0.24 km<sup>2</sup>) and minimum (1.8 km<sup>2</sup>) in percentage per year were projected to estimate the degree of collapse in the future, upto 50 years.

ecosystem. The Riparian Forest (T1.1.iii. Rp.) is classified as Critically Endangered ecosystem as per multiple criteria of the IUCN. These are restricted to two locations in the Southern Western Ghats and its best sample (95%) is within the low elevations (50–350 m MSL) of the Vazhachal forests of the Chalakudy River. The indicator flora and fauna within are also of endemic and threatened category. The estimated loss of the ecosystem is 83.7% in the last 100 years. The major factors of degradation are dams and reservoirs (21%), forest plantations (12.3%), reservoir operations coupled with intensive rain in the unusual cyclonic events in the Arabian sea (7.2%). Other factors such as agriculture expansion, roads, tourism and forest fires contributed to the loss of 36.4%. The projection of a future decline indicates a complete collapse within next 50 years with minimum estimated degradation rate. Out of the seven predicted potential areas, based on bioclimatic suitability, Niche modelling was employed to identify four regions with terrain suitability, and these were further narrowed down to two regions based on present land use. The remaining are chiefly in the Chalakudy River, distributed in four micro zones. The continued existence of factors of degradation necessitates immediate conservation action through policy intervention, monitoring and ecorestoration. Changes in the reservoir operation parameters, restoration of encroached riparian areas by the state and private agencies for plantations and continuous monitoring are recommended to save the Critically Endangered forest ecosystem from extinction.

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