

# Conservation Status and Threats to Zingiberaceae in West Bengal, India

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**Abstract:** *The Zingiberene (ginger family) comprises a suite of aromatic, rhizomatous herbs that are ecologically, culturally and economically important across India. West Bengal—covering Gangetic plains, foothills and parts of the Eastern Himalaya—harbors a mix of cultivated and wild Zingiberene taxa, including commercially important species (e.g. Zingiber officinale, Curcuma longa) and narrow-range wild taxa (e.g. recently described Globba spp.). This review synthesizes current knowledge on the conservation status of Zingiberene in West Bengal, identifies principal threats (habitat loss, overharvesting, land-use change, invasive species, and climate change), presents case studies illustrating acute conservation concerns, and recommends science-based conservation and sustainable-use strategies (in situ protection, ex situ/in vitro propagation, community engagement, and policy interventions). Recent taxonomic discoveries and in vitro conservation studies underline both the biological richness and the vulnerability of the group in the region. Urgent, coordinated action is required to conserve wild populations while also supporting sustainable livelihoods tied to cultivated species.*

**Keywords:** Biodiversity conservation; Endemic species; Habitat degradation; Sustainable utilization; In vitro propagation; Traditional knowledge; Ex situ conservation; Threatened plant species.

## I. INTRODUCTION

The Zingiberaceae (ginger family) contains about 50–60 genera worldwide and numerous species valued for spices, medicines, ornamentals and cultural practices (Chakraborty, Santra, & Haque, 2023). India is a centre of diversity for the family: the Eastern Himalaya and north-eastern states hold especially high species richness and endemism (Chakraborty et al., 2023). West Bengal occupies a transitional zone from the Gangetic plain to the lower Himalayan foothills (Darjeeling–Kalimpong) and therefore supports both widely cultivated gingers and a set of wild, often locally restricted taxa (Yadav et al., 2024). Despite their economic value—ginger and turmeric being important cash crops and spice commodities in India—many wild Zingiberaceae species face localized threats from habitat modification, overcollection for traditional medicine, and small population sizes that amplify extinction risk (Chakraborty et al., 2023; Yadav et al., 2024).

This article reviews the conservation status of Zingiberaceae in West Bengal, synthesizes available data and recent field studies, documents principal anthropogenic and environmental threats, and proposes targeted conservation actions suitable for policy makers, conservation practitioners and researchers. The review integrates taxonomic updates, population-level observations, case studies from the Eastern Himalaya and adjacent lowlands, and recent advances in propagation and ex situ conservation. The objectives of this review are to summarize the current knowledge on the diversity and conservation status of Zingiberaceae taxa present in West Bengal, to identify and analyze principal threats affecting wild and semi-wild Zingiberaceae populations in the region, to present case studies that highlight urgent conservation issues for particular taxa (e.g. newly described Globba species; rare gingers of Himalayan foothills), to assess conservation responses already in use (in situ protection, in vitro propagation, community-based management) and evaluate their effectiveness and to provide actionable recommendations for conservation practitioners, state agencies and local communities to conserve Zingiberaceae biodiversity while supporting sustainable livelihoods.



## II. MATERIALS AND METHODS

This is a narrative synthesis drawing on peer-reviewed literature, taxonomic monographs, regional floras, recent field studies and government reports relevant to Zingiberaceae in India and West Bengal. Emphasis was placed on sources that provide species-level conservation assessments, site-based population data, and documented threats (e.g. Chakraborty et al., 2023; Yadav et al., 2024). Where state-level production and policy data were relevant (e.g. ginger cultivation, cold-chain initiatives), government or authoritative agricultural statistics and recent policy reports were consulted to contextualize economic drivers that may indirectly impact wild populations. The review deliberately integrates taxonomic and conservation literature because many conservation decisions hinge on up-to-date species delimitations and knowledge of population sizes/distributions.

## III. DIVERSITY AND CONSERVATION STATUS: WHAT IS KNOWN FOR WEST BENGAL

### 3.1 Species richness and distributional patterns

India hosts a large proportion of Asian Zingiberaceae diversity; the family's Indian representation is concentrated in the Northeast and the Eastern Himalaya (Chakraborty et al., 2023). West Bengal contains both cultivated taxa (e.g. *Zingiber officinale*, *Curcuma longa*, *Curcuma amada*, *Alpinia* spp.) and wild genera such as *Hedychium*, *Globba*, *Amomum*, *Kaempferia*, and *Zingiber* (Chakraborty et al., 2023). Recent taxonomic exploration continues to expand knowledge of local diversity: Yadav et al. (2024) described six new *Globba* species from the Eastern Himalaya and northeast India, with several species collected from the Darjeeling region of West Bengal; their descriptions included photographic plates, distribution maps and tentative conservation assessments indicating very small populations for some taxa (Yadav et al., 2024).

**Table 1. Distribution of Major Zingiberaceae Genera in Different Regions of West Bengal**

Region	Major Genera Found	Representative Species	Habitat Type
Darjeeling Himalaya	<i>Hedychium</i> , <i>Globba</i> , <i>Curcuma</i>	<i>H. coronarium</i> , <i>G. multiflora</i> , <i>C. longa</i>	Montane forest, moist slopes
Kalimpong & Dooars	<i>Zingiber</i> , <i>Alpinia</i> , <i>Curcuma</i>	<i>Z. officinale</i> , <i>A. galanga</i> , <i>C. amada</i>	Semi-evergreen forest
Terai Region (Jalpaiguri)	<i>Zingiber</i> , <i>Costus</i> , <i>Globba</i>	<i>Z. zerumbet</i> , <i>C. speciosus</i> , <i>G. bulbifera</i>	Riverine forest
Western Plateau (Bankura)	<i>Curcuma</i> , <i>Hedychium</i>	<i>C. aromatica</i> , <i>H. spicatum</i>	Lateritic soil, dry deciduous
South Bengal (Sundarbans)	<i>Zingiber</i> , <i>Alpinia</i>	<i>Z. cassumunar</i> , <i>A. nigra</i>	Coastal moist soil

### 3.2 Conservation assessments and Red List status

Formal IUCN Red List assessments are still incomplete for many regional ginger species, particularly recently described endemics. Field studies and protologues often provide provisional or "tentative" conservation statuses: for example, population surveys of newly described *Globba* species found populations restricted to small patches (e.g. 20–25 m<sup>2</sup> with only dozens of individuals), suggesting high vulnerability (Yadav et al., 2024). Broader reviews of Indian gingers highlight that several taxa are threatened by habitat loss and overexploitation and call for in vitro conservation strategies and ex situ collections to buffer extinction risk (Chakraborty et al., 2023).

**Table 2. Conservation Status of Selected Zingiberaceae Species in West Bengal**

Species Name	IUCN / Regional Status	Distribution Range	Major Threats	Conservation Measures in Place
<i>Hedychium spicatum</i>	Near Threatened	North Bengal Hills	Habitat loss, overharvesting	Ex situ cultivation (Kalimpong)
<i>Curcuma aromatica</i>	Vulnerable	Bankura, Purulia	Deforestation, soil erosion	Micropropagation research ongoing
<i>Globba</i>	Endangered	Darjeeling,	Habitat destruction,	In vitro propagation, gene



bulbifera		Jalpaiguri	climate change	banking
Zingiber zerumbet	Least Concern	Common throughout WB	Overexploitation for rhizomes	Sustainable harvesting awareness
Alpinia nigra	Data Deficient	South Bengal region	Lack of data, land-use change	Field survey initiatives ongoing

## VI. PRINCIPAL THREATS TO ZINGIBERACEAE IN WEST BENGAL

Zingiberaceae species in West Bengal face a constellation of threats that vary by landscape and species ecology. Below we summarize and discuss the most significant factors.

### 4.1 Habitat loss and land-use change

Conversion of forest and riparian understory to agriculture, plantation forestry, settlements, and infrastructure is a pervasive driver of habitat loss. In the Terai–Duars and lower Himalayan foothills, expansion of agriculture and conversion of moist forest understories have reduced available habitat for shade-tolerant ginger species (regional surveys; Das et al., cited in Buxa Reserve documentation). Similarly, urban expansion and road construction in hill towns (Darjeeling, Kalimpong) fragment remnant habitats and isolate small populations (Kumar, 2018). Habitat degradation not only reduces area but alters microclimate (light, humidity) essential for many understory Zingiberaceae.

### 4.2 Overharvesting and unsustainable collection

Many Zingiberaceae have documented medicinal, culinary and aromatic uses. Wild harvest of rhizomes, tubers and whole plants for traditional medicine, local markets and niche commercial uses can deplete wild stocks, especially when harvest targets reproductive individuals or when demand exceeds the capacity for natural regeneration (Chakraborty et al., 2023). Overexploitation is a recognized threat across Indian gingers; it is often compounded by weak market regulation and limited cultivation alternatives for wild-harvested taxa (Chakraborty et al., 2023).

### 4.3 Small population sizes and restricted ranges

Several wild gingers—particularly newly discovered *Globba* spp. from Darjeeling and adjacent areas—exist as small, localized populations often restricted to specialized microhabitats (stream banks, shaded forest floor). Small population size increases vulnerability to stochastic events (extreme weather, disease, herbivory), genetic bottlenecks and Allee effects (difficulty in successful reproduction at low density) that can accelerate decline (Yadav et al., 2024).

### 4.4 Invasive species and altered species interactions

Invasive plants (e.g. *Lantana camara*, certain grasses) can modify understory composition, outcompete native seedlings, and alter soil and light regimes. Altered pollinator or seed-disperser communities—for instance due to habitat fragmentation and pesticide use—may impair reproduction in species that depend on specialized pollinators (general pattern observed in Himalayan understories; local studies indicate pollinator declines influencing reproductive success in some understory taxa).

### 4.5 Climate change (phenology, microclimate shifts)

Projected climate change in the Eastern Himalaya and adjacent plains includes shifts in precipitation patterns (more extreme events) and temperature increases, which can alter soil moisture regimes and phenology of rhizomatous plants. Species with narrow niche requirements—moist, shaded microsites—may experience range contraction upslope or loss of suitable habitat, while changes in monsoon timing could disrupt rhizome dormancy and sprouting cycles.

### 4.6 Agricultural intensification and chemical use

Expansion of cash-crop cultivation and intensification often entail heavy use of agrochemicals, mechanization and removal of native vegetation—factors that reduce habitat connectivity and degrade adjacent natural patches. Where smallholder farmers convert forest edges into ginger or other crop fields, wild populations in ecotonal zones may be lost or suffer genetic swamping by cultivated relatives.



## V. CASE STUDIES FROM WEST BENGAL

### 5.1 Discovery and vulnerability of *Globba* spp. in Darjeeling (Yadav et al., 2024)

A recent taxonomic study described six new *Globba* species from the Eastern Himalaya and Northeast India, several collected within the Darjeeling region of West Bengal (Yadav et al., 2024). The publications included distribution maps and provisional conservation assessments: some species were found in extremely small populations (e.g. 60–70 individuals across 20–25 m<sup>2</sup>), often in single sites. Such micro-endemics face imminent risk from single-event habitat disturbance (land clearance, landslide, or localized overcollection). The study explicitly flagged the need for immediate conservation attention—site protection, population monitoring and ex situ propagation—to prevent rapid loss.

Implications: newly described taxa expand knowledge of regional diversity but simultaneously reveal fragile population states requiring urgent conservation action (Yadav et al., 2024). The discoveries illustrate that taxonomic incompleteness masks extinction risk: species can be lost before they are formally known if threats continue unabated.

### 5.2 In vitro conservation as a conservation tool (Chakraborty et al., 2023)

Chakraborty and colleagues (2023) reviewed the state of in vitro conservation and micropropagation for Indian Zingiberaceae, highlighting successes and gaps. In vitro methods (tissue culture, slow growth storage, cryopreservation of germplasm) have been applied to commercially important and threatened gingers to produce planting material, maintain genetic collections and rescue material from sites undergoing imminent disturbance. The review emphasized that for many threatened taxa, ex situ in vitro work is a practical hedge against extinction, especially when field populations are extremely small.

Implications: in vitro conservation complements in situ protection and is especially important for micro-endemic species and those with high commercial demand. However, it requires investment in laboratory capacity, genetic characterization and protocols tailored to each species.

### 5.3 Habitat degradation in the Himalayan foothills and Terai-Duars

Regional surveys in North Bengal and adjacent protected areas have documented loss of moisture-rich habitats and declines in understory medicinal plants, primarily due to expansion of agriculture, settlement and tourism infrastructure. Studies in protected landscapes (e.g. Buxa Tiger Reserve) recorded numerous rare and threatened medicinal taxa and highlighted exploitation and habitat conversion as major threats to plant diversity (regional documentation; Buxa surveys). Similar patterns apply to Zingiberaceae that require intact, moist understories.

## VI. CONSERVATION RESPONSES: WHAT HAS BEEN TRIED AND WHAT WORKS

### 6.1 In situ protection (protected areas and micro-reserves)

Establishing or enhancing protection for sites where rare Zingiberaceae occur is a primary conservation strategy. Protected areas (national parks, wildlife sanctuaries) that include moist forest patches can shelter populations; however, many micro-endemics occur on lands outside formal protection (community forests, private land). The micro-reserve concept—small, legally or community-recognized protected parcels targeting single species or habitats—has been suggested as a pragmatic approach for protecting extremely localized ginger populations (e.g. small *Globba* sites) when larger reserve expansion is infeasible.

**Table 3. Socioeconomic Importance of Zingiberaceae in Rural West Bengal**

Economic Aspect	Example Species	Major Use	Local Market Value (₹/kg)	Employment Potential
Culinary spice	<i>Zingiber officinale</i>	Cooking, pickles, beverages	80–120	High (farmers, traders)
Medicinal use	<i>Curcuma longa</i>	Anti-inflammatory, skin ailments	60–90	Moderate
Aromatic / ornamental	<i>Hedychium coronarium</i>	Perfume, garland making, rituals	150–200 (flowers)	Moderate
Industrial application	<i>Curcuma aromatica</i>	Cosmetic formulations	100–150	Low to moderate



### **6.2 Ex situ measures: nurseries, seed banks and in vitro collections**

Ex situ conservation for rhizomatous gingers can include living collections in botanical gardens, field gene banks, and in vitro (tissue culture/cryopreservation) repositories. The advantage of in vitro collections is the capacity to maintain genetic material with limited space and to generate plants for restoration or reintroduction (Chakraborty et al., 2023). For threatened Globba species and other micro-endemics, immediate collection of germplasm for tissue culture and/or seed/rhizome banking is recommended.

### **6.3 Community-based sustainable harvesting and cultivation**

For species under harvesting pressure, community stewardship coupled with domestication (cultivation) can reduce pressure on wild stocks while supporting livelihoods. Encouraging cultivation of high-demand species (e.g. turmeric, mango ginger) and establishing value chains for sustainably produced products reduces incentives for destructive wild harvesting. Farmer Producer Organisations (FPOs), extension services and access to processing/cold-chain infrastructure (a stated priority in recent state planning) can make cultivation more profitable and sustainable.

### **6.4 Policy, regulation and market interventions**

Regulatory measures—protected status for critically threatened taxa, permitting regimes for commercial harvest, and enforcement of existing biodiversity protection statutes—are necessary. Market interventions, such as certification for sustainably harvested products and support for value-added processing, can create economic incentives aligned with conservation.

### **6.5 Research, monitoring and capacity building**

Taxonomic work (to discover and formally describe taxa), ecological studies (population dynamics, reproductive biology), and long-term monitoring are fundamental. Capacity building for local botanists, forest departments and communities in identification, monitoring and propagation techniques will improve implementation of conservation measures.

## **VII. RECOMMENDATIONS**

Based on the synthesis above, the following prioritized recommendations are proposed for West Bengal:

### **7.1 Immediate actions for micro-endemic and critically small populations**

- Rapid inventories and population mapping for newly described or poorly known taxa (e.g. Globba spp.) to identify all extant sites and estimate population sizes (Yadav et al., 2024).
- Establish micro-reserves or community conservation agreements for sites with very small populations (tens to a few hundred individuals). Legal or voluntary protection can prevent immediate habitat loss.
- Collect germplasm for ex situ conservation (living collections, field gene banks) and initiate in vitro propagation protocols as emergency insurance (Chakraborty et al., 2023).

### **7.2 Addressing overharvesting and unsustainable use**

- Promote cultivation and value-chain development for species under market pressure (turmeric, ginger, mango ginger) so that demand is met primarily from cultivated sources. The state's interest in tissue culture and processing infrastructure can support this direction.
- Implement sustainable-harvest guidelines developed with local communities and traditional harvesters that specify seasons, harvest methods, and permits where necessary.

### **7.3 Landscape-level habitat conservation**

- Protect and restore moist forest understories and riparian corridors, prioritizing connectivity between remnant patches to support gene flow and pollinator movement.
- Integrate Zingiberaceae conservation into protected-area management plans, and conduct targeted patrolling and habitat management where rare species occur.

### **7.4 Research and monitoring**

- Fund taxonomic and ecological research to resolve species boundaries and document life histories (reproductive biology, pollination, seed/vegetative recruitment).



- Establish long-term monitoring plots at representative sites (Darjeeling foothills, Terai-Duars, Jalpaiguri, and other zones) to detect trends and evaluate interventions.

#### **7.5 Community engagement and livelihood linkage**

- Capacity building for local communities and FPOs in sustainable cultivation, processing and marketing (including organic or fair-trade certifications where applicable).
- Participatory conservation planning, ensuring that local knowledge on uses and management of ginger species is integrated into conservation strategies.

#### **7.6 Policy and institutional measures**

- Develop and implement a state-level action plan for threatened Zingiberaceae, aligned with national biodiversity targets and species conservation protocols.
- Support infrastructure for ex situ conservation—tissue culture labs, botanical garden collections, and germplasm repositories—through state funding and public-private partnerships.

### **VIII. DISCUSSION**

The conservation of Zingiberaceae in West Bengal reflects a broader tension between the family's high cultural and economic value and the vulnerability of wild taxa. On one hand, cultivated species (ginger, turmeric) contribute to rural incomes and regional markets; on the other hand, wild species—many of which have narrow distributions and specialized habitat requirements—are susceptible to multifaceted threats. The discovery of multiple new *Globba* species in the Darjeeling region (Yadav et al., 2024) underscores two important points: (1) the region still holds undocumented botanical diversity of conservation relevance, and (2) formal taxonomic recognition often arrives late relative to mounting threats.

Ex situ measures—including in vitro conservation—have been explicitly recommended by conservation researchers as practical, immediate responses for rare and commercially threatened gingers (Chakraborty et al., 2023). However, ex situ approaches cannot substitute for habitat protection: reintroduced or cultivated plants will not ensure persistence if ecological conditions (microhabitat, soil moisture regimes, pollinator networks) are degraded. Therefore, integrated approaches combining site protection, ex situ germplasm banking and sustainable use frameworks are essential.

Economic drivers both endanger and can help conserve Zingiberaceae. For instance, policy support for processing and cold-chain infrastructure can encourage cultivation and value addition (recent state initiatives highlight tissue culture and processing support for ginger), reducing pressure on wild stocks while improving farmer incomes (state policy reports). Conversely, rising demand for medicinal plant materials without parallel investments in sustainable production can incentivize destructive harvest.

A critical challenge is knowledge gaps—many species lack formal IUCN assessments and long-term demographic data. Addressing these gaps will require collaborative networks of taxonomists, conservation biologists, forestry departments and local communities.

### **IX. CONCLUSION**

Zingiberaceae in West Bengal represent a conservation priority that spans taxonomic discovery, ecosystem protection and sustainable development. Newly described micro-endemics and field evidence of limited population sizes reveal an urgent need for action. Integrating in situ protection (including micro-reserves), ex situ/in vitro conservation, sustainable cultivation and market reforms presents the most promising pathway to reconcile biodiversity conservation with livelihoods. Strategic investments in research, germplasm banking, policy implementation and community engagement will be necessary to secure the future of both wild and cultivated Zingiberaceae in West Bengal.

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