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A review on: Biodiversity and Ecological Significance of Wild Legumes in the Western Ghats

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Abstract

This review summarizes the diversity, ecological roles, ethnobotanical relevance, conservation status, and microbiological associations of wild legume (Fabaceae) species in the Western Ghats, one of the world's most important biodiversity hotspots. Wild legumes contribute significantly to ecosystem functioning through nitrogen fixation, soil fertility enhancement, carbon sequestration, and habitat stabilization. Many species hold traditional medicinal, nutritional, and cultural value among local and Indigenous communities, reflecting their ethnobotanical importance. The review also highlights the symbiotic interactions of these legumes with rhizobia and non-rhizobial endophytes, emphasizing their potential in sustainable agriculture, biofertilizer development, and ecosystem restoration. Emerging biotechnological approaches including microbial inoculant formulation, phytochemical exploration, and genetic characterization offer new opportunities to harness the functional diversity of these species. Despite their ecological and economic importance, numerous wild legumes face threats from habitat loss, overharvesting, and climate change, underscoring the need for targeted conservation strategies. This review integrates current research to provide a comprehensive understanding of wild legume resources in the Western Ghats and proposes future directions for conservation, sustainable utilization, and biotechnological innovation.

Introduction

The Western Ghats (Sahyadri Range) is recognized as one of the world's foremost biodiversity hotspots, characterized by exceptional species richness, high levels of endemism, and a variety of ecosystems spanning from lowland plains to montane shola-grasslands (Binoy, 2022). The family Fabaceae (Leguminosae) is particularly well represented in this region, with wild legume species distributed across diverse forest types, including evergreen forests, riparian zones, scrublands, and higher-elevation montane habitats (Jabeena et al., 2023). Wild legumes in the Western Ghats play vital ecological roles. Through symbiotic or associative relationships with nitrogen-fixing bacteria, they contribute significantly to biological nitrogen fixation, thereby improving soil fertility and supporting nutrient cycling in otherwise nutrient-poor tropical soils (Thamizhseran & Shendye, 2023). Wild legumes in the Western Ghats play vital ecological roles. Through symbiotic relationships with nitrogen-fixing bacteria, they contribute significantly to biological nitrogen fixation, thereby improving soil fertility, supporting nutrient cycling, and enhancing carbon sequestration, while also being embedded in the ethnobotanical knowledge of local communities (Aswani et al., 2024). In addition to their ecological importance, these wild legumes harbor rich microbiological associations. Studies have shown that plants in the Western Ghats host diverse endophytic bacteria, including rhizobia and non-rhizobial endophytes, many of which have specialized metabolic capabilities. For example, a culture-based survey isolated 75 bacterial endophytes from 24 plant species in the Western Ghats, revealing potential for antimicrobial metabolite production (Gossain et al., 2020). These microbial populations are promising for biotechnological exploitation, such as the development of biofertilizers, plant-growth promoters, and novel bioactive compounds (Webster *et al.*, 2020). Despite their functional versatility, wild legume species in the Western Ghats face increasing threats. Habitat fragmentation, overharvesting for traditional uses, and climate change pose serious risks to their populations. Ethnobotanical studies continue to document traditional uses among local communities (Karthik et al., 2025).

Conservation of these species is further underscored by recent taxonomic work, such as the reinstatement of *Alysicarpus monilifer* var. *venosa* (Fabaceae), which includes an updated IUCN Red List assessment (Purohit & Meena, 2025).

Given their ecological, cultural, and biotechnological importance, wild legumes of the Western Ghats warrant a comprehensive review. This article synthesizes current literature on their diversity, microbiological associations, traditional uses, and conservation status, and proposes future directions for research, sustainable use, and preservation.

2. Study Area

The Western Ghats, a UNESCO World Heritage Site along India’s western coast, are a global biodiversity hotspot. With varied topography and a tropical monsoon climate, the region supports diverse ecosystems that harbor numerous wild legume species. These legumes contribute to soil fertility through nitrogen fixation and play key ecological roles in vegetation recovery and habitat support.

Map showing green patch of wild legumes Plant from Western ghats

3. Biodiversity of Wild Legumes in the Western Ghats

The Western Ghats support an exceptionally rich diversity of wild legumes, with hundreds of taxa distributed across diverse ecological zones. Major genera represented in the region include *Desmodium*, *Crotalaria*, *Indigofera*, *Vigna*, *Dalbergia*, *Mucuna*, and *Pongamia*, many of which display ecological specialization and high levels of local endemism (Wagh & Patil, 2023; Aitawade & Yadav, 2022; Balan, 2021). Several species of *Crotalaria, Indigofera,* and *Desmodium* are known only from narrow altitudinal belts and unique microhabitats, such as lateritic plateaus, shola-grassland mosaics, and riparian forest edges (Lekhak, M. M. & Yadav, S. R. 2012)

State-level floristic accounts, particularly for Kerala and Karnataka, have highlighted the exceptional richness of the Fabaceae family in the southern Western Ghats. The "Checklist of Legumes of Kerala" provides one of the most comprehensive regional inventories, documenting numerous endemics, rare, and threatened species and emphasizing the conservation significance of these taxa (Balan, 2021). Additional regional floras and botanical surveys across Maharashtra, Goa, and Tamil Nadu also report a high number of Fabaceae members, illustrating the widespread distribution of legumes from lowland deciduous forests to montane evergreen formations (Rather et al., 2018; Flora of Goa, Botanical Survey of India 2013; Kottaimuthu, 2019). The genus *Crotalaria* alone exhibits remarkable diversification in the Western Ghats, with new species still being described, indicating that the legume flora remains incompletely explored. For instance, two new *Crotalaria* species were recently reported from the central Western Ghats, and later another new species *C. shrirangiana* was described from the northern Western Ghats (Rather et al., 2018; Rokade et al., 2020).Similarly, wild *Vigna* species including *Vigna vexillata, Vigna trilobata,* and several wild relatives of cultivated pulses are frequent in forest margins, grasslands, and open scrublands, and serve as valuable genetic resources for crop improvement (Gita Kumari et al., 2022).

"Legume diversity in the Western Ghats is also strongly linked to ecological function. Species such as *Pongamia pinnata*, *Mucuna pruriens*, and *Dalbergia latifolia* are keystone components of forest ecosystems, contributing to soil fertility, stabilizing slopes, and forming critical habitat for wildlife. Endemic tree legumes such as *Humboldtia bourdillonii* and *Humboldtia vahliana* are restricted to the southern Western Ghats and are listed as threatened due to habitat fragmentation and limited distribution ranges (Balan, Predeep & Udayan, 2016)." "Overall, the floristic richness and high endemism of Fabaceae in the Western Ghats underscore the need for updated taxonomic assessments, molecular phylogenetic studies, and long-term ecological monitoring to better understand the distribution, evolution, and conservation requirements of these important plant groups (Rather et al., 2024)."The Western Ghats are recognized as one of the world's eight "hottest" biodiversity hotspots and harbor exceptionally rich legume diversity. The family Fabaceae is represented by over 350 wild species distributed across diverse habitats ranging from montane forests and semi-evergreen tracts to lateritic plateaus and scrublands (Sreekumari et al., 2025).

"A significant proportion of these taxa are endemic or narrowly distributed, especially *Crotalaria*, *Indigofera*, *Vigna*, and *Mucuna*, which display strong habitat specialization on lateritic outcrops and shola–grassland mosaics (Lekhak & Yadav, 2012)." "Several species, such as *Vigna vexillata* var. *dalzelliana*, *Indigofera barberi*, and *Mucuna pruriens* var. *hirsuta*, are considered rare or threatened due to habitat fragmentation and anthropogenic pressures (Chadburn, 2012; Koza et al., 2025)." "Ecologically, wild legumes contribute to soil fertility through nitrogen fixation, support pollinator networks, and act as keystone species in forest ecosystems. Several taxa also exhibit remarkable adaptive traits, such as drought tolerance in *Mucuna pruriens* (Saleem et al., 2018), shade tolerance in *Desmodium heterocarpon* (Jia et al., 2022), and salinity resistance in salt-tolerant legumes including *Alysicarpus* (Bouzroud et al., 2023). From an ethnobotanical perspective, wild legumes serve as sources of traditional medicine, fodder, fiber, gums, dyes, and minor food crops, highlighting their socio-economic value (Abdussalam., 2021)

Overall, the wild Fabaceae of the Western Ghats represent a genetically rich reservoir for crop improvement, especially for traits such as stress resistance, high protein content, and enhanced symbiotic efficiency making them crucial for future legume breeding programs and ecological restoration efforts (Jha, Nayyar & Siddique, 2024).

4. Ecological Role of wild legume plants

Wild legumes play a fundamental ecological role in Western Ghats ecosystems. Their ability to perform biological nitrogen fixation (BNF) through symbiotic associations with rhizobia significantly enhances soil nitrogen pools, improves nutrient cycling, and supports long-term soil fertility in nutrient-poor tropical environments (Kawaka, 2022). Many herbaceous legumes (*Desmodium, Indigofera, Crotalaria)* act as pioneer species during early successional stages, colonizing disturbed sites, stabilizing soil, and promoting vegetation recovery (Hernández, et al., 2020). Legume flowers also support a wide array of pollinators, including bees, butterflies, and beetles, while their seeds and foliage serve as food for herbivores and frugivores (Camurça, et al., 2020). Their capacity to increase soil organic matter and nitrogen levels makes them crucial components of forest regeneration and restoration programs across the Western Ghats (Sardar, M. F. et al., 2023).

5. Ethnobotanical and Medicinal Importance of wild legume plants

Wild legumes have deep ethnobotanical relevance among tribal and rural communities in the Western Ghats. Numerous species are integral to traditional medicine, food systems, and cultural practices. *Abrus precatorius* is widely used for treating fevers, skin ailments, and inflammation (Dhole and Surwase., 2024). *Mucuna pruriens*, a species native to the region, is a natural source of L-DOPA, used in Parkinson's disease treatment (Hammoud, et al., 2025). *Canavalia* species, such as *C.gladiata* and *C.ensiformis,* have historically served as famine foods, green manure, and livestock fodder (Indriani et al., 2024; Heuzé and Tran 2025). Ethnobotanical surveys across the North-Central and Southern Western Ghats consistently document diverse medicinal preparations, dietary uses, and cultural significance associated with Fabaceae species. Such knowledge also highlights the need for conservation of traditional medicinal flora (Hurkadale & Bidikar, 2023; Kullampady & Nekrakalaya, 2025).

6. Conservation Status and Threats of wild legume plants

"Despite their importance, many wild legume species in the Western Ghats face significant conservation challenges. Habitat loss due to agricultural expansion, road construction, and urbanization remains a primary threat (Karnataka State Western Ghats Conservation Task-Force, 2024; Alex, 2024)."Overharvesting of medicinal species like *Abrus precatorius* and *Mucuna pruriens* further reduces natural populations (Raghavendra, et al., 2011; Ahmad, et al., 2011). Forest fragmentation, invasive species encroachment (e.g., *Lantana camara, Senna spectabilis),* and climate change contribute to declining distribution and genetic erosion in several endemic taxa (NR Anoop, et al., 2022; Bhattacharya, 2025). Regional assessments categorize many Fabaceae members as Endangered, Vulnerable, or Near Threatened, including endemic tree legumes such as *Humboldtia bourdillonii* and *H. vahliana* (Ramachandran, et al., 2014;Jose, 2025). Conservation strategies recommended include in situ protection through reserve forests and wildlife sanctuaries, ex situ seed banking, and habitat restoration programs involving native legume species. (Katwal, et al., 2004)

7. Root Nodule Microbiome and Non-Rhizobial Endophytes of wild legume plants

Root nodules of wild legumes in the Western Ghats host highly diverse bacterial microbiomes composed of both classical rhizobia (e.g., *Rhizobium, Bradyrhizobium, Mesorhizobium)* and a wide range of non-rhizobial endophytes (NREs) (Hnini, et al., 2025). Studies isolating nodule-associated bacteria from genera such as *Desmodium, Vigna,* and *Crotalaria* have identified beneficial NREs including *Bacillus, Pseudomonas, Enterobacter, Serratia*, and *Klebsiella* (Raja et al., 2019).These microorganisms contribute to plant growth promotion, phosphate solubilization, indole acetic acid (IAA) production, siderophore release, and enhanced tolerance to drought and metal stress (Youseif, et al., 2025). Comparative microbiome profiling of wild legumes indicates significant variation in community composition between species and across altitudinal gradients (Pang et al., 2021).

8. Biotechnological Applications of wild legume plants

The functional diversity of wild legumes and their microbial symbionts hold considerable promise for biotechnological exploitation. Region-specific rhizobial and endophytic isolates are increasingly being evaluated for biofertilizer development, particularly for enhancing nutrient-use efficiency in sustainable agriculture systems (Ben Gaied, et al., 2024). Several legumes (*Mucuna, Desmodium, Crotalaria)* exhibit traits suitable for phytoremediation, including tolerance to heavy metals and the ability to accumulate or stabilize contaminants in degraded soils (Silva et al., 2021). Wild relatives of food legumes, including *Vigna* and *Canavalia* species, are valuable reservoirs of genetic traits such as drought tolerance, pest resistance, and high nutritional content, which can be harnessed through breeding and molecular approaches for crop improvement programs (Henry, 2023). Exploring phytochemicals from species like *Mucuna pruriens* and *Abrus precatorius* also opens pathways for drug discovery and therapeutic applications(BM, et al.,2024). Collectively, these attributes position wild legumes as ideal candidates for ecological restoration, climate-resilient agriculture, and industrial bioproducts.

Table No. 1 Wild legume From Western ghats

Sr. No.	Scientific Name	Genus	Habit	Typical Habitat	Distribution Status	Importance
1	*Crotalaria shrirangiana*	Crotalaria	Herb	Lateritic plateaus	Endemic	Newly described (NW Ghats)
2	*Crotalaria concanensis*	Crotalaria	Herb	Grasslands	Regional	Pollinator plant
3	*Crotalaria lawii*	Crotalaria	Shrub	Shola–grassland	Endemic	Rare
4	*Crotalaria montana*	Crotalaria	Herb	Hill slopes	Endemic	High elevation species
5	*Crotalaria retusa*	Crotalaria	Herb	Open scrub	Widespread	Medicinal
6	*Crotalaria verrucosa*	Crotalaria	Herb	Coastal plains	Widespread	Ornamental
7	*Indigofera barberi*	Indigofera	Shrub	Rocky slopes	Rare	Threatened
8	*Indigofera tinctoria*	Indigofera	Shrub	Forest edges	Widespread	Dye (indigo)
9	*Indigofera trifoliata*	Indigofera	Herb	Woodland margins	Widespread	Useful fodder
10	*Indigofera cassioides*	Indigofera	Shrub	Montane forests	Regional	Nitrogen-fixing
11	*Indigofera*	Indigofera	Herb	Scrubland	Regional	Medicinal

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12	*Vigna trilobata*	Vigna	Herb	Grasslands	Widespread	Drought-tolerant
13	*Vigna vexillata var. dalzelliana*	Vigna	Climber	Forest margins	Rare	Wild relative
14	*Vigna radiata var. sublobata*	Vigna	Herb	Open scrub	Regional	Progenitor of mungbean
15	*Vigna angustifolia*	Vigna	Herb	Sandy soils	Regional	Stress-tolerant
16	*Vigna unguiculata ssp. stenophylla*	Vigna	Herb	Dry areas	Wild relative	Heat tolerance
17	*Mucuna pruriens var. hirsuta*	Mucuna	Climber	Moist forests	Rare	L-DOPA source
18	*Mucuna monosperma*	Mucuna	Climber	Evergreen forests	Regional	Ethnobotanical
19	*Mucuna gigantea*	Mucuna	Climber	Coast, evergreen	Regional	Nitrogen-fixer
20	*Desmodium heterocarpon*	Desmodium	Herb	Forest shade	Widespread	Shade-tolerant
21	*Desmodium triflorum*	Desmodium	Herb	Grasslands	Widespread	Fodder
22	*Desmodium gangeticum*	Desmodium	Shrub	Deciduous forests	Widespread	Ayurvedic drug
23	*Desmodium pulchellum*	Desmodium	Herb	Moist forests	Regional	Soil enrichment
24	*Alysicarpus vaginalis*	Alysicarpus	Herb	Grasslands	Widespread	Salinity-tolerant
25	*Alysicarpus monilifer*	Alysicarpus	Herb	Lateritic soils	Regional	Fodder
26	*Dalbergia latifolia*	Dalbergia	Tree	Moist deciduous	Regional	Timber; keystone
27	*Dalbergia lanceolaria*	Dalbergia	Tree	Dry deciduous	Regional	Soil binder
28	*Pongamia pinnata*	Pongamia	Tree	Riparian zones	Widespread	Biodiesel tree
29	*Humboldtia bourdillonii*	Humboldtia	Tree	Evergreen forests	Endemic	Threatened
30	*Humboldtia vahliana*	Humboldtia	Tree	Evergreen forests	Endemic	Conservation priority
31	*Abrus precatorius*	Abrus	Climber	Forest edges	Common	Medicinal; toxic seeds

32	*Canavalia cathartica*	Canavalia	Climber	Coastal forests	Regional	Salt-tolerant
33	*Canavalia ensiformis*	Canavalia	Climber	Scrublands	Widespread	Green manure
34	*Canavalia rosea*	Canavalia	Climber	Sand dunes	Coastal	Stabilizes dunes
35	*Atylosia scarabaeoides (Vigna scarabaeoide)*	Vigna	Herb	Lateritic soils	Regional	Wild Cajanus relative
36	*Clitoria ternatea*	Clitoria	Climber	Open woodlands	Widespread	Medicinal; ornamental
37	*Clitoria laurifolia*	Clitoria	Climber	Moist forests	Regional	Rare
38	*Flemingia strobilifera*	Flemingia	Shrub	Evergreen margins	Regional	Agroforestry species
39	*Flemingia macrophylla*	Flemingia	Shrub	Moist forests	Regional	Soil improvement
40	*Smithia sensitiva*	Smithia	Herb	Lateritic plateaus	Endemic	Seasonal wetland indicator
41	*Smithia hirsuta*	Smithia	Herb	Grasslands	Regional	Monsoon herb
42	*Pueraria tuberosa*	Pueraria	Climber	Deciduous forests	Regional	Edible tubers
43	*Pueraria montana*	Pueraria	Climber	Moist deciduous	Regional	Erosion control
44	*Tephrosia purpurea*	Tephrosia	Herb	Dry scrub	Widespread	Medicinal
45	*Tephrosia tinctoria*	Tephrosia	Herb	Lateritic soil	Regional	Dye plant
46	*Tephrosia villosa*	Tephrosia	Herb	Open grasslands	Widespread	Fodder
47	*Butea monosperma*	Butea	Tree	Dry deciduous	Regional	“Flame of forest”
48	*Peltophorum pterocarpum*	Peltophorum	Tree	Coastal & plains	Regional	Avenue tree
49	*Sesbania bispinosa*	Sesbania	Herb/Shrub	Wetlands	Widespread	Green manure
50	*Sesbania grandiflora*	Sesbania	Tree	Village groves	Widespread	Edible flowers
51	*Cassia fistula*	Senna	Tree	Dry deciduous	Widespread	Medicinal
52	*Senna tora*	Senna	Herb	Scrublands	Widespread	Seeds used medicinally

53	*Senna occidentalis*	Senna	Herb	Wastelands	Common	Common weed
54	*Bauhinia racemosa*	Bauhinia	Tree	Dry forests	Regional	Leaf used as plate material
55	*Bauhinia purpurea*	Bauhinia	Tree	Forest margins	Regional	Ornamental
56	*Bauhinia phoenicea*	Bauhinia	Climber	Evergreen forests	Rare	High conservation value
57	*Millettia peguensis*	Millettia	Tree	Evergreen margins	Regional	Ornamental
58	*Millettia extensa*	Millettia	Climber	Montane forests	Regional	Fodder
59	*Adenanthera pavonina*	Adenanthera	Tree	Evergreen forests	Regional	Red seeds; medicinal
60	*Acacia auriculiformis*	Acacia	Tree	Moist deciduous	Introduced/ Naturalized	Plantation species
61	*Acacia catechu*	Acacia	Tree	Dry deciduous	Regional	Catechu extraction
62	*Acacia sinuata*	Acacia	Climber	Evergreen forests	Endemic	Soap pod
63	*Albizia lebbeck*	Albizia	Tree	Plains, dry forests	Widespread	Timber, shade
64	*Albizia amara*	Albizia	Tree	Dry rocky hills	Regional	Soil binder
65	*Derris trifoliata*	Derris	Climber	Mangroves	Regional	Fish poison plant
66	*Erythrina variegata*	Erythrina	Tree	Coastal & plains	Regional	Coral tree
67	*Erythrina stricta*	Erythrina	Tree	Moist forests	Regional	Ornamental
68	*Oxyrhynchus oxyphyllus*	Oxyrhynchus	Climber	Evergreen forests	Rare	Little studied
69	*Uraria picta*	Uraria	Herb	Deciduous forests	Widespread	Ayurvedic (Dasha Moola)
70	*Uraria lagopoides*	Uraria	Herb	Grasslands	Regional	Soil improving

9.Conclusion

Wild legumes of the Western Ghats represent an invaluable ecological, genetic, and socio-economic resource. Their remarkable diversity, high levels of endemism, and specialized adaptations play a crucial role in maintaining soil fertility, stabilizing ecosystems, and supporting pollinator and herbivore communities. Beyond their ecological significance, these wild species and their associated root nodule microbiomes including nitrogen-fixing *Rhizobium* and diverse non-rhizobial endophytes hold immense potential for sustainable agriculture, particularly in the development of biofertilizers, stress-resilient crop varieties, and low-input farming systems.

Moreover, wild legume genetic resources offer novel traits such as drought tolerance, disease resistance, high nitrogen-use efficiency, and unique secondary metabolites that can be harnessed through advanced breeding, genomics, and biotechnological interventions. Their role in restoration ecology is equally significant, as many species are pioneer colonizers capable of rehabilitating degraded landscapes, improving soil organic matter, and facilitating succession. However, increasing habitat loss, climate change, land-use transformation, and limited taxonomic exploration pose serious threats to these valuable resources. Thus, concerted and multidisciplinary efforts integrating taxonomy, ecology, microbiome research, conservation biology, and local community participation are urgently required. Strengthening in situ and ex situ conservation strategies, developing region-specific germplasm repositories, and promoting awareness about the ecological services of wild legumes are essential steps toward sustainable utilization.

In summary, the wild legumes of the Western Ghats together with their diverse microbial symbionts constitute a strategic biodiversity asset. Protecting and effectively harnessing this resource will contribute significantly to climate-resilient agriculture, environmental sustainability, and future biotechnological innovations.

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