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Biodiversity Assessment of Trees and Shrubs at Tirunelveli's Science Centre in Southern India: A Conservation Perspective

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A comprehensive taxonomical floristic survey conducted at the District Science Centre in Tirunelveli identified 84 species of trees and shrubs, documenting each plant species with detailed information on medicinal uses, family classification, commercial importance, and population count of individual

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plants. The survey identified 33 families and 68 genera, with Fabaceae being the most dominant family, followed by Rubiaceae, Arecaceae, and Malvaceae. Additionally, the survey highlighted a list of vulnerable, threatened, and endangered tree species such as *Cycas beddomei Dyer., Santalum album L*., emphasizing the need for conservation efforts based on their spatial reach and anthropogenic pressures. These species face various threats, including loss of habitat, agriculture, pollution load, and recreational disturbances, and were assessed according to the IUCN Red List criteria. This study provides valuable insights for botanists, conservationists, and policymakers, promoting sustainable management and protection of plant biodiversity in the region.

Keywords: Tirunelveli science centre; medicinal plants; conservation of plants; flora diversity.

1. INTRODUCTION

The District Science Centre in Tirunelveli serves as a significant repository of plant biodiversity, encompassing a wide array of tree and shrub species. As an edutainment centre, it combines education and entertainment, attracting tourists and operating under the NCSM network of India. With the support of the local community, the Centre aims to make science and technology more accessible and appealing to the general public, complementing formal science education. This study undertakes a meticulous taxonomical survey of the flora within the Centre, identifying distinct varieties of trees and shrubs to conserve species biodiversity.

Conservation efforts focused on indigenous plants are pivotal for maintaining biodiversity and ensuring the sustainability of ecosystems. Indigenous plants like Neem, Peepul, Coconut, teak and Indian gooseberry naturally adapted to specific regions, fulfil critical roles in local ecosystems by providing habitats and food for wildlife, contributing to soil fertility, and supporting cultural practice. This approach not only aids in preserving diverse tree species but also fosters a thriving community of organisms [1], Gao and Weibang, 2013 [2]. Cultivating a variety of tree species within a single location enhances ecosystem resilience against environmental changes and creates habitats for a wide range of wildlife, from insects to birds [3].

Botanical gardens play a crucial role in conservation approaches that involves preserving plants within their native habitats, ensuring their continued survival and their ability to contribute to local ecosystems [4]. Botanical gardens serve not only as living showcases of plant diversity but also actively engage in research, conservation breeding programs, and public education, making significant contributions to global conservation initiatives [5,6,7]. These efforts are crucial for preserving ecosystem services like clean air, water, and climate regulation, thereby mitigating the threats posed by habitat destruction, climate change, and other environmental challenges.

2. MATERIALS AND METHODS

2.1 Study Area

The data collection encompassed the regions within the District Science Centre, situated near the Collector Office in Kokkirakulam, Tirunelveli Corporation, adjacent to the banks of the sacred river Tamiraparani (Fig. 1). The study area spans a latitudinal range of 8.7268° N and a longitudinal range of 77.7165° E.

2.2 Methodology

In the present study, field trips were conducted to explore the tree species within the selected area. Standard procedure was employed and recorded on index cards for each species. Collected plant specimens were processed at the Botany laboratory of St. Xavier's College (Autonomous), Palayamkottai. The plant identification was conducted using references such as "Flora of the Presidency of Madras" by Gamble JS [8], and "The Flora of the Palani Hills, South India" (3 volumes) by Matthew KM [9].

3. RESULTS AND DISCUSSION

The District Science Centre in Tirunelveli not only serves as an educational and scientific hub but also as a vibrant botanical sanctuary. It is home to an impressive array of flora, with 84 distinct species of trees and shrubs classified, representing 33 different plant families. This rich biodiversity offers visitors a unique opportunity to explore and learn about various plant species in their natural habitat [10]. The detailed mapping of trees and shrubs within the campus enhances the educational experience, allowing for a better

understanding of plant ecology and the importance of biodiversity conservation (Fig. 2). The comprehensive list of trees and shrubs provides a valuable resource for researchers, students, and nature enthusiasts interested in studying the region's flora (Table 1).

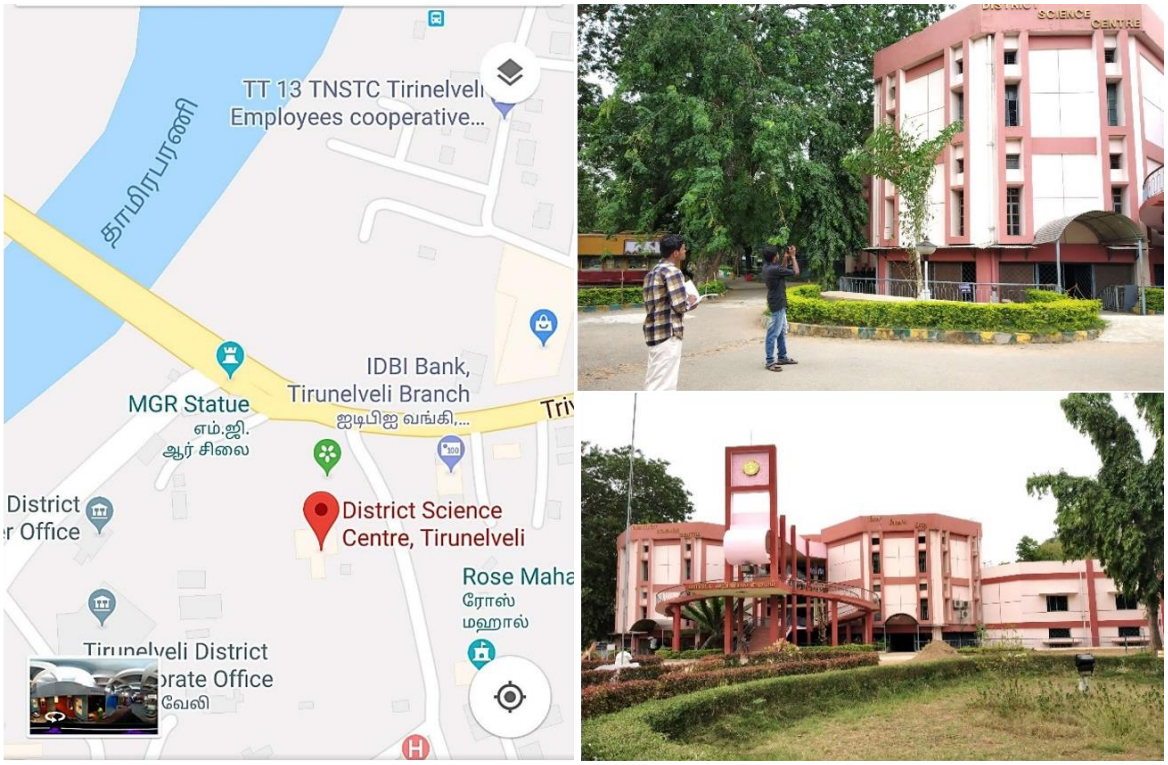

Fig. 1. Geographic Location and site area of the study

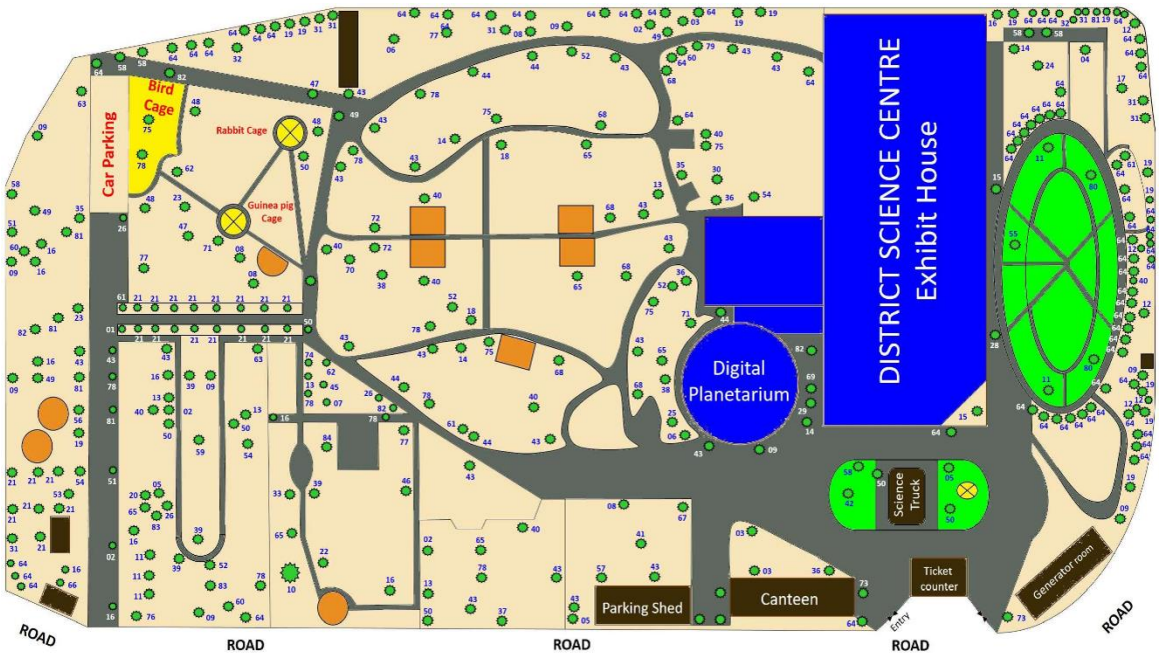

Fig. 2. Mapping of Trees and Shrubs showing within the campus of District Science Centre, Tirunelveli

Table 1. List of Trees and Shrubs in District Science Centre, Tirunelveli

Code No.	Botanical Name	Family	Vernacular Name
DSCTEN001	*Acacia auriculiformis A. Cunn. ex Benth.*	Fabaceae	Earleafacasia
DSCTEN002	*Adenanthera pavonina L.*	Fabaceae	Red bead tree
DSCTEN003	*Aegle marmelos (L.) Corrêa*	Rutaceae	Indian bael
DSCTEN004	*Ailanthus excels Roxb.*	Simaroubaceae	Tree of heaven
DSCTEN005	*Albizia lebbeck (L.) Benth.*	Fabaceae	Siris
DSCTEN006	*Alstonia scholaris (L.) R.Br.*	Apocynaceae	Devil
DSCTEN007	*Artocarpus heterophyllus Lam.*	Moraceae	Jack fruit
DSCTEN008	*Averrhoa carambola L.*	Oxalidaceae	Star pickle
DSCTEN009	*Azadirachta indica A.Juss.*	Meliaceae	Neem
DSCTEN010	*Bambusa arundinacea (Retz.) Willd.*	Poaceae	Indian thorny
DSCTEN011	*Bauhinia purpurea L.*	Fabaceae	Purple butterfly tree
DSCTEN012	*Borassus flabellifer L.*	Arecaceae	Palmyra palm
DSCTEN013	*Caesalpinia pulcherrima (L.) Sw.*	Fabaceae	Peacock flower
DSCTEN014	*Callistemon lanceolatus (Sm.) Sweet*	Myrtaceae	Crimson bottlebrush
DSCTEN015	*Caryota urensL.*	Arecaceae	Fishtail palm
DSCTEN016	*Cassia fistula L.*	Fabaceae	Golden rain
DSCTEN017	*Cassia javanica L.*	Fabaceae	Pink shower
DSCTEN018	*Cassia siamea Lam.*	Fabaceae	Iron wood tree
DSCTEN019	*Casuarina equisetifolia L.*	Casuarinaceae	Whistling pine
DSCTEN020	*Ceiba pentandra (L.) Gaertn.*	Malvaceae	Silk cotton tree
DSCTEN021	*Cocus nucifera L.*	Arecaceae	Coconut tree
DSCTEN022	*Cordia dichotoma G.Forst.*	Boraginaceae	Assyrian plum
DSCTEN023	*Couroupita guianensis Aubl.*	Lecythidaceae	Cannon ball tree
DSCTEN024	*Cycas beddomei Dyer*	Cycadaceae	-
DSCTEN025	*Cycas revolute Thunb.*	Cycadaceae	Japanese sago palm
DSCTEN026	*Delonix regia (Boj. Ex Hook.) Raf.*	Fabaceae	Flame
DSCTEN027	*Duranta erecta L.*	Verbenaceae	Sky flower
DSCTEN028	*Ensete superbum (Roxb.) Cheesman*	Musaceae	Wild plantain
DSCTEN029	*Ervatamia divaricata (L.) Burkill*	Apocynaceae	Crape jasmine
DSCTEN030	*Erythrina variegata L.*	Fabaceae	Indian coral tree
DSCTEN031	*Eucalyptus globulus Labill.*	Myrtaceae	Tasmanian blue gum
DSCTEN032	*Ficus benghalensis L.*	Moraceae	Banyan fig
DSCTEN033	*Ficus racemosa L.*	Moraceae	Cluster fig
DSCTEN034	*Ficus religiosa L.*	Moraceae	Peepul
DSCTEN035	*Gardenia jasminoides J.Ellis.*	Rubiaceae	Cape jasmine
DSCTEN036	*Grewia asiatica L.*	Malvaceae	Phalsa
DSCTEN037	*Guazuma ulmifolia Lam.*	Sterculiaceae	Bastard cedar
DSCTEN038	*Hamelia patens Jacq.*	Rubiaceae	Firebush
DSCTEN039	*Holarrhena pubescens Wall. Ex G.Don*	Apocynaceae	Fever pod
DSCTEN040	*Ixora coccinea L.*	Rubiaceae	Jungle jeranium
DSCTEN041	*Ixora parviflora Lam.*	Rubiaceae	Small flower ixora
DSCTEN042	*Juniperus sp.*	Cupressaceae	-
DSCTEN044	*Lagerstroemia indica x fauriei 'Natchez'*	Lythraceae	Queen of shrubs
DSCTEN043	*Lagerstroemia indicia (L.) Pers.*	Lythraceae	Queen of shrubs
DSCTEN045	*Lawsonia inermis L.*	Lythraceae	Henna
DSCTEN046	*Madhuca longifolia (J.Koenig ex L.) J.F.Macbr.*	Sapotaceae	Indian butter tree

Code No.	Botanical Name	Family	Vernacular Name
DSCTEN047	*Malphigia emarginata DC.*	Malphigiaceae	Barbados cherry
DSCTEN048	*Mangifera indica L.*	Anacardiaceae	Mango
DSCTEN049	*Manilkara zapota (L.) P.Royen*	Sapotaceae	Sapota
DSCTEN050	*Millingtonia hortensis L.f.*	Bignoniaceae	Tree jasmine
DSCTEN051	*Mimusops elengi L.*	Sapotaceae	Spanish cherry
DSCTEN052	*Morinda tinctoria Roxb.*	Rubiaceae	Indian mulberry
DSCTEN053	*Moringa oleifera Lam.*	Moringaceae	Horseradish
DSCTEN054	*Murraya koenigii (L.) Sprengel.*	Rutaceae	Curry leaf
DSCTEN055	*Mussaenda hirsutissima (Hook.f.) Hutch.ex.Gamble.*	Rubiaceae	-
DSCTEN056	*Neolamarckia cadamba (Roxb.) Bosser*	Rubiaceae	Bur flower tree
DSCTEN057	*Parkia biglandulosa R.Br.*	Fabaceae	Kiboko
DSCTEN058	*Peltophorum pterocarpum (DC.) K.Heyne.*	Fabaceae	Yellow flame
DSCTEN059	*Phoenix dactylifera L.*	Arecaceae	Wild dates tree
DSCTEN060	*Phyllanthus acidus (L.) Skeels.*	Phyllanthaceae	Star gooseberry
DSCTEN061	*Phyllanthus emblica L.*	Phyllanthaceae	Indian gooseberry
DSCTEN063	*Pithecellobium dulce (Roxb.) Benth.*	Fabaceae	Madras thorn
DSCTEN064	*Polyalthialongifolia (Sonn.) var.pendula*	Annonaceae	False ashoka
DSCTEN065	*Pongamia pinnata (L.) Panigrahi*	Fabaceae	Pongam oil tree
DSCTEN066	*Pritchardia pacifica Seem.*	Arecaceae	Fiji fan palm
DSCTEN062	*Psidium guajava L.*	Myrtaceae	Guava tree
DSCTEN067	*Pterocarpus santalinus L.f.*	Fabaceae	Red sandal wood
DSCTEN068	*Pterospermum acerifolium (L.) Willd.*	Malvaceae	Bayur tree
DSCTEN069	*Ravenala madagascarensis Sonn.*	Strelitziaceae	Traveller's tree
DSCTEN070	*Russelia equisetiformis Schlecht& Cham.*	Plantaginaceae	Fire cracker plant
DSCTEN071	*Santalum album L.*	Santalaceae	Sandal wood
DSCTEN072	*Saraca asoca (Roxb.) Willd.*	Fabaceae	Ashoka
DSCTEN073	*Spathodea campanulata Beauv.*	Bignoniaceae	African tulip tree
DSCTEN074	*Sterculia foetida L.*	Malvaceae	Hazel sterculia
DSCTEN075	*Stereospermum chelonoides DC.*	Bignoniaceae	Fragrant padri tree
DSCTEN076	*Swietenia mahagoni (L.) Jacq.*	Meliaceae	Mahogany
DSCTEN077	*Syzygium cumini (L.) Skeels.*	Myrtaceae	Java plum
DSCTEN078	*Tabebuia rosea DC.*	Bignoniaceae	Pink poui
DSCTEN079	*Tamarindus indica L.*	Fabaceae	Indian dates
DSCTEN080	*Tecoma stans (L.) Juss. ex Kunth*	Bignoniaceae	Yellow elder
DSCTEN081	*Tectona grandis L.f.*	Lamiaceae	Teak
DSCTEN082	*Terminalia catappaL.*	Combretaceae	Indian almond
DSCTEN083	*Thespesia populnea (L.) Sol. ex Corrêa.*	Malvaceae	Head ache
DSCTEN084	*Vitex altissima L.f.*	Lamiaceae	Peacock chaste

Among the notable families are Fabaceae, with the maximum representation of 15 species that follow Moraceae and Malvaceae (Fig. 3). The flora includes the root of *Acacia auriculiformis A. Cunn. ex Benth.* which is utilized for alleviating aches and pains, at the same time Neem is known for its applications in treating eczema. Species such as *Aegle marmelos (L.) Corrêa* and *Ailanthus excels Roxb.* serve medicinal purposes such as treating Diarrhoea and acting as a fever tonic, respectively. Each species in the collection offers unique medicinal properties, contributing to the biodiversity and therapeutic resources of the region (Table 2).

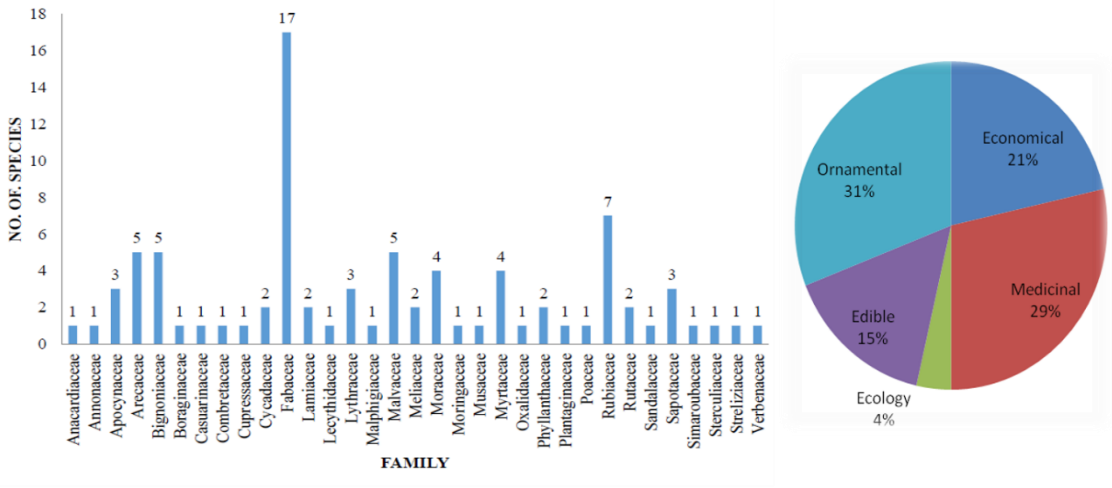

Fig. 3. Family-wise screening of species diversity and its commercial importance

Table 2. Medicinal Uses of Trees and Shrubs in District Science Centre, Tirunelveli

Code No.	Botanical Name	Useful part	Medicinal uses
DSCTEN001	*Acacia auriculiformis A. Cunn. ex Benth.*	Root	Aches and pains
DSCTEN002	*Adenanthera pavonina L.*	Seed	Anti-inflammatory
DSCTEN003	*Aegle marmelos (L.) Corrêa*	Fruit	Chronic diarrhea
DSCTEN004	*Ailanthus excels Roxb.*	Bark	Fever and tonic
DSCTEN005	*Albizia lebbeck (L.) Benth.*	Bark	Anti-allergic activity
DSCTEN006	*Alstonia scholaris (L.) R.Br.*	Bark	Diarrhea and Indigestion remedy
DSCTEN007	*Artocarpus heterophyllus Lam.*	Leaves	Reduce high blood sugar
DSCTEN008	*Averrhoa carambola L.*	Leaves	Leprosy; skin ulcers and fever
DSCTEN009	*Azadirachta indica A.Juss.*	Root	Eczema
DSCTEN010	*Bambusa arundinacea (Retz.) Willd.*	Bark	Diarrhea
DSCTEN011	*Bauhinia purpurea L.*	Leaf stalk	Hiccough and gastric reflux
DSCTEN012	*Borassus flabellifer L.*	Leaves	Malaria and Menstrual flow
DSCTEN013	*Caesalpinia pulcherrima (L.) Sw.*	Flower and fruit	Anti-bacterial & fungalactivity
DSCTEN014	*Callistemon lanceolatus (Sm.) Sweet*	Flower	Gastric ulcer
DSCTEN015	*Caryota urensL.*	Leaves	Skin disorders
DSCTEN016	*Cassia fistula L.*	Root	Fever
DSCTEN017	*Cassia javanica L.*	Bark	Relieve aliments
DSCTEN018	*Cassia siamea Lam.*	Twigs; root	Anti-bacterial agent
DSCTEN019	*Casuarina equisetifolia L.*	Bark	Diuretic
DSCTEN020	*Ceiba pentandra (L.) Gaertn.*	Fruit	Hypoglycemic;Antidermatophytic
DSCTEN021	*Cocus nucifera L.*	Leaves	Anthelmintic; astringent
DSCTEN022	*Cordia dichotoma G.Forst.*	Leaves	Skin infections
DSCTEN023	*Couroupita guianensis Aubl.*	Flowers	Rheumatoid arthritis
DSCTEN024	*Cycas beddomei Dyer*	Leaves	Cancer and hepatoma
DSCTEN025	*Cycas revolute Thunb.*	Leaves	Diabetes
DSCTEN026	*Delonix regia (Boj. Ex Hook.) Raf.*	Fruit	Insecticide
DSCTEN027	*Duranta erecta L.*	Fruit	Diabetes and Leucorrhea
DSCTEN028	*Ensete superbum (Roxb.)*	Leaves	Anti-inflammatory action

Code No.	Botanical Name	Useful part	Medicinal uses
	Cheesman		
DSCTEN029	*Ervatamia divaricata (L.) Burkill*	Bark and Root	Fever and Liver aliment
DSCTEN030	*Erythrina variegata L.*	Leaves	Sore throat; Sinusitis and colds
DSCTEN031	*Eucalyptus globulus Labill.*	Leaves and bark	Diarrhea and Polyuria
DSCTEN032	*Ficus benghalensis L.*	Fruit	Constipation
DSCTEN033	*Ficus racemosa L.*	Leaves	Inflammatory disorders
DSCTEN034	*Ficus religiosa L.*	Leaves	Fever and Kidney problems
DSCTEN035	*Gardenia jasminoides J.Ellis.*	Fruit juice	Anti-inflammatory agent
DSCTEN036	*Grewia asiatica L.*	Seeds	Dysentery; colds
DSCTEN037	*Guazuma ulmifolia Lam.*	Leaves	Sores; rashes; Anti-inflammatory
DSCTEN038	*Hamelia patens Jacq.*	Bark	Diarrhea; piles
DSCTEN039	*Holarrhena pubescens Wall. Ex G.Don*	Bark	Anthelmintic
DSCTEN040	*Ixora coccinea L.*	Root	Astringent; Antiseptics
DSCTEN041	*Ixora parviflora Lam.*	Leaves	Diabetes
DSCTEN042	*Juniperus sp.*	Fruit	Urinary tract infections (UTI)
DSCTEN043	*Lagerstroemia indicia (L.) Pers.*	Flower	Common colds
DSCTEN044	*Lagerstroemia indica x fauriei 'Natchez'*	Flower	Ornamental value
DSCTEN045	*Lawsonia inermis L.*	Leaves	Dandruff; Scabies;Eczema
DSCTEN046	*Madhuca longifolia (J.Koenig ex L.) J.F.Macbr.*	Flower; oil	Skin disease and body pain
DSCTEN047	*Malphigia emarginata DC.*	Fruits	Liver Aliments and Diarrhea
DSCTEN048	*Mangifera indica L.*	Leaves	Diabetes
DSCTEN049	*Manilkara zapota (L.) P.Royen*	Fruit	Anti-oxidant
DSCTEN050	*Millingtonia hortensis L.f.*	Leaves	Anti-pyretic ;Asthma
DSCTEN051	*Mimusops elengi L.*	Seeds	Astringent
DSCTEN052	*Morinda tinctoria Roxb.*	Leaves	Scabies; itching and hip pain
DSCTEN053	*Moringa oleifera Lam.*	Leaves and Fruit	Antioxidant
DSCTEN054	*Murraya koenigii (L.) Sprengel.*	Leaves	Cures liver dysfunctions
DSCTEN055	*Mussaenda hirsutissima (Hook.f.) Hutch.ex.Gamble.*	Leaves	Anti-inflammatory
DSCTEN056	*Neolamarckia cadamba (Roxb.) Bosser*	Dry leaves	Buboes and Hydrocele
DSCTEN057	*Parkia biglandulosa R.Br.*	Leaves	Parasitic infections
DSCTEN058	*Peltophorum pterocarpum (DC.) K.Heyne.*	Leaves	Intestinal problems
DSCTEN059	*Phoenix dactylifera L.*	Gum	Diarrhea
DSCTEN060	*Phyllanthus acidus (L.) Skeels.*	Leaves	Sciatica and Rheumatism
DSCTEN061	*Phyllanthus emblica L.*	Fruits	Controls Hair loss
DSCTEN062	*Psidium guajava L.*	Fruits & Leaves	Immune booster
DSCTEN063	*Pithecellobium dulce (Roxb.) Benth.*	Bark	Chronic diarrhea
DSCTEN064	*Polyalthialongifolia (Sonn.) var.pendula*	Leaves	Skin diseases and Fever
DSCTEN065	*Pongamia pinnata (L.) Panigrahi*	Oil & Leaves	Rheumatism& Colds-Coughs.
DSCTEN066	*Pritchardia pacifica Seem.*	Leaves	Aches and pains
DSCTEN067	*Pterocarpus santalinus L.f.*	Wood	Economic value- Timber

Code No.	Botanical Name	Useful part	Medicinal uses
DSCTEN068	*Pterospermum acerifolium (L.) Willd.*	Flowers&Leaves	Anti inflammatory
DSCTEN069	*Ravenala madagascarensis Sonn.*	Leaves	Ornamental
DSCTEN070	*Russelia equisetiformis Schlecht& Cham.*	Leaves	Treats Malarial; Cancer
DSCTEN071	*Santalum album L.*	Wood	Common colds
DSCTEN072	*Saraca asoca (Roxb.) Willd.*	Bark	Uterine fibroids
DSCTEN073	*Spathodea campanulata Beauv.*	Bark	Ulcer ; Skin disease
DSCTEN074	*Sterculia foetida L.*	Bark	Diaphoeretic and diuretic
DSCTEN075	*Stereospermum chelonoides DC.*	Root & Bark	Diuretic and Cardiac tonic
DSCTEN076	*Swietenia mahagoni (L.) Jacq.*	Bark	Amoebiasis and Anemia
DSCTEN077	*Syzygium cumini (L.) Skeels.*	Fruit	Hyperglycemia
DSCTEN078	*Tabebuia rosea DC.*	Leaves	Fever and Pains
DSCTEN079	*Tamarindus indica L.*	Fruit	Gallbladder problems
DSCTEN080	*Tecoma stans (L.) Juss. ex Kunth*	Flower &Leaves	Diabetes and Diuretic
DSCTEN081	*Tectona grandis L.f.*	laxative	Gravid uterus
DSCTEN082	*Terminalia catappa L.*	Leaves	Liver diseases
DSCTEN083	*Thespesia populnea (L.) Sol. ex Corrêa.*	Bark	Anti-bacterial –Fungal agent
DSCTEN084	*Vitex altissima L.f.*	Leaves	Ulcer and allergic

Table 3. List of Vulnerable, Threatened and Endangered Trees in District Science Centre, Tirunelveli

Code	Botanical name	Family	IUCN Status
DSCTEN024	*Cycas beddomei Dyer.*	Cycadaceae	Endangered
DSCTEN067	*Pterocarpus santalinus L.f.*	Fabaceae	Near Threatened
DSCTEN071	*Santalum album L.*	Santalaceae	Vulnerable
DSCTEN072	*Saraca asoca (Roxb.)Willd.*	Fabaceae	Vulnerable
DSCTEN076	*Swietenia mahagoni (L.) Jacq.*	Meliaceae	Endangered

This extensive collection not only supports the ecological balance but also serves educational and medicinal purposes [11]. The presence of diverse species like the Peacock chaste tree (*Vitex altissima L.f.*), Indian almond (*Terminalia catappa L*) and Sandalwood (*Santalum album L.)* underlines the Centre's role in preserving both common, rare and vulnerable botanical varieties [12] (Table 3). The medicinal uses range from anti-inflammatory and antibacterial agents to treatments for diabetes and skin disorders, highlighting the practical applications of these plants in traditional medicine. Additionally, trees like *Albizia lebbeck (L.) Benth.* effective against allergies, and *Alstonia scholaris (L.) R.Br.* used for diarrhea and indigestion remedies, contribute significantly to the Centre's collection. Other species like *Casuarina equisetifolia L.* (Whistling pine) and *Azadirachta indica A.Juss.* also show significant presence. Economically valuable species such as *Cocos nucifera* (Coconut tree) being the most abundant at 23 individuals and other ornamental plants like *Delonix regia (Boj. Ex Hook.) Raf.* ensure that the Centre is not only a repository of medicinal plants but also a vital green space that supports ecological balance and educational opportunities [13].

4. CONCLUSION

In conclusion, our comprehensive floristic survey at the District Science Centre in Tirunelveli has meticulously documented and catalogued 84 distinct species of trees and shrubs, representing 33 different families. This significant finding underscores the Centre's unique role as both an educational institution and a crucial botanical repository, where the rich diversity of plant life is both studied and preserved. The

survey has deepened our understanding of the local flora, providing critical insights into the ecological roles and medicinal uses of these species, many of which are integral to the region's natural heritage. By systematically inventorying these species, our research serves as a valuable resource for ongoing and future conservation efforts, offering a scientific basis for protecting and managing these important plant populations. Moreover, this study emphasizes the urgent need for biodiversity preservation, which is essential not only for maintaining ecological stability but also for supporting the health and well-being of the local community. The findings highlight the interconnectedness of education, conservation, and community well-being, making a strong case for continued efforts to safeguard the botanical diversity of the District Science Centre for generations.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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