

RIPARIAN PROFILE
OF
DUBARE RESERVED FOREST



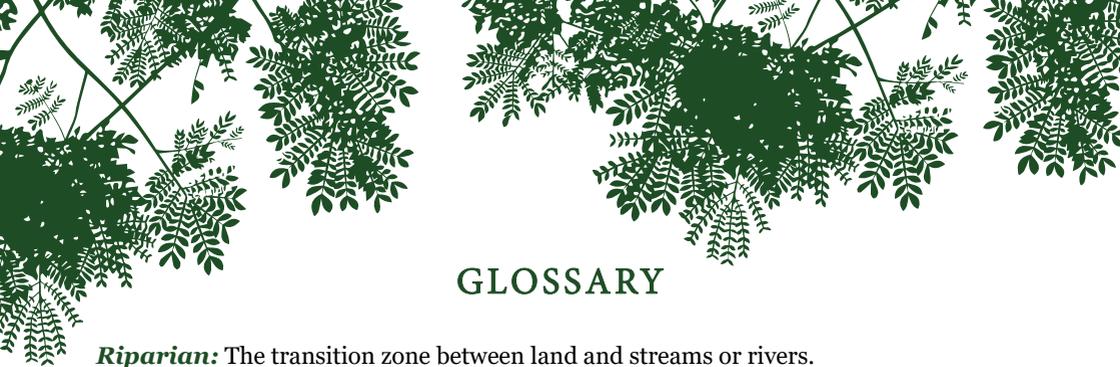
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GLOSSARY

Riparian: The transition zone between land and streams or rivers.

Flora: All the plants from a particular place or time in history.

Evergreen Forest: Evergreen forest is a category containing multi-storey forests, where more than 80% of tree species keep their leaves during the entire year. They are found in areas which receive heavy rainfall up to 6000mm, with the humidity level ranging between 90- 100%.

Semi- Evergreen: Considered the transitional stage between evergreen and moist deciduous forests. They are characteristic of seasonal tropical forest species, a distinct formation type, dominated by both evergreen and deciduous broad-leaved trees, flanking the rain forest in areas that have a marked dry season. They are found in areas which receive rainfall between 2000- 3000mm with the humidity level ranging between 75- 80%.

Moist deciduous Forest: They encompass a mixture of trees and grasses. The trees shed their leaves in early spring and summer when sufficient moisture is not available. The general appearance is bare during summers and forests are prone to forest fires which spread rapidly due to the leaf litter. They are found in areas which receive moderate rainfall, averaging to 2000mm per year with the humidity level ranging between 60-75%.

Density: In plant ecology is defined as the number of individuals of a given species that occurs within a given sample unit or study area.

Abundance: Is the relative representation of a species in a particular ecosystem. It is usually measured as the number of individuals found in the ecosystem.

Canopy: In forest ecology, canopy refers to the upper layer or emergent layer, formed by mature tree crowns. The term canopy is also used to refer to the extent of the outer



layer of leaves of an individual tree or group of trees.

Mid- Storey: Middle layer of the forest strata or canopy, with small trees.

Under- Storey: Lowest layer of the forest, which comprises of herbaceous plants, leafy shrubs and other small plants.

Ecosystem services: The many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems. United Nations 2004 Millennium Ecosystem Assessment (MA), a four-year study involving more than 1,300 scientists worldwide, grouped ecosystem services into four broad categories: provisioning, such as the production of food and water; regulating, such as the control of climate and disease; supporting, such as nutrient cycles and crop pollination; and cultural, such as spiritual and recreational benefits.

Biome: A major ecological community type (such as tropical rain forest, grassland, or desert).

Floristic communities: Plant communities.

Hydrophilic: Special affinity for water.

International Union for Conservation of Nature, Red List: Established in 1964, the International Union for Conservation of Nature's Red List of Threatened Species has evolved to become the world's most comprehensive information source on the global conservation status of animal, fungi and plant species.

Watershed Development: Refers to the conservation; regeneration and the judicious use of all the natural resources particularly land, water, vegetation and animals and human development within the watershed.

Propagation: The breeding of species of a plant or animal by natural processes from the parent stock.



*A land bridge connecting the riparian zone to a river island.
The Cauvery has a myriad of Island scapes which can be accessed post monsoon.*



INTRODUCTION

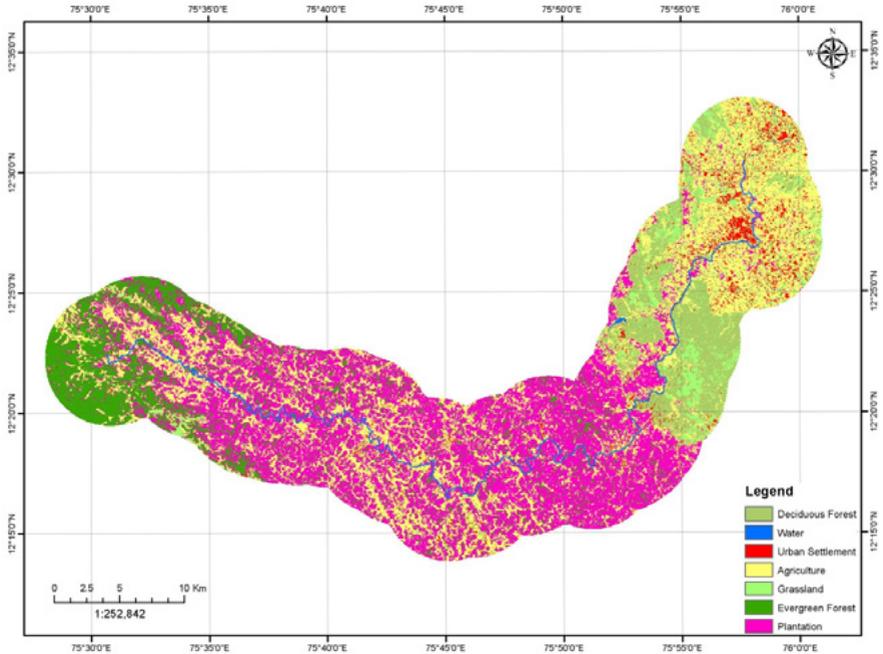
The riparian flora guide is an effort to provide a primer, for protecting, restoring and enhancing riparian buffer zones in Kodagu District. The Cauvery River in Kodagu District has two important riparian forest stretches falling under the protected area framework, which provide baseline reference on native species of trees for riparian buffer zones, with their intact riparian corridors. Therefore, this serves as an attempt to highlight a case study which can be replicated along different altitudinal gradients, from high elevation to low elevation, covering different forest and vegetation types.

The headwaters of the river which arise from the Brahmagiri Wildlife Sanctuary, has 70% of the headwater- forest cover in pristine conditions, due to its status as a protected area. The Talacauvery Devarakadu or community protected sacred grove comprising of evergreen- semi evergreen forests, is one prime example of a pristine riparian corridor, approximately 3 kilometres long, at the headwaters. The river as it flows eastwards is then subject to alteration of riparian corridors due to the presence and expansion of cultivated land. This guide is an insight into the structure of a contiguous riparian corridor, extending up to 12 km, along the Moist Deciduous Forest of Maldare and Dubare Reserved Forests.

When you walk along a riparian corridor in the forest, it is simply hard to miss the sprawling beauty of layered canopies and the network of roots grasping and holding onto the river bank like giant forest, fortresses. When you look beyond the demeanour, there's a story behind each species of tree and the mutual relationship it has formed with the river and other organisms, intrinsic to their environment. The tree species here are few as compared to the forest zone, as it takes a special kind to forge a bond with the river. In the monsoon, the fortresses hold strong with water gushing through every nook, corner and rooted pathway forged with the river bank, and they readily welcome the rush of water, with their entirety, standing submerged up to the canopy, at times. Trees in the riparian zone, in this sense are different and distinct from trees in the adjacent forest zone, in moist deciduous forests, with their ability to embrace or withstand flooding and water logging.



MAP SHOWING LAND USE LAND COVER IN 5 KM RADIUS OF CAUVERY RIVER



Landuse map created for the year 2018, delineating forest cover along the river from evergreen forests in Talacauvery, to deciduous forests along the Dubare stretch, with the map extending up to Kushalnagar.



Riparian flora, survey area spanning over Dubare and Maldare Reserved Forest, along the river Cauvery.



The riparian corridor can go up to 100 meters in width in certain areas with connectivity to river islands, but its expanse is between 30- 50m from the river's edge depending on variables such as the incline of slopes, where steep inclines harbour a higher density and abundance of emergent canopy species. Riparian corridors, also indicate natural flood levels for this landscape through the distribution of riparian trees up to the extent of the documented corridor width. This serves as an additional indicator as to why monoculture or selective species are not recommended, as each tree has its own role and function, contributing to ecosystem services.

The presence of evergreen- semi evergreen species in a moist deciduous corridor, is mainly due to the availability of water and moisture content in the soil which has created conditions favourable for the documented species to establish themselves. This simplified version of a guide, shows the number of evergreen- semi evergreen species, some of which can be found in higher altitudes in protected areas, and deciduous species present in the moist deciduous corridor, pictorially, with relevant information on phenology, or the natural cycle of flowering and fruiting, through different seasons. The guide also provides information on dispersal, natural regeneration and propagation with planting guidelines, to elevate riparian corridors to healthy functioning systems, as embodied in protected areas.

GEOGRAPHICAL LOCATION

The riparian corridor was surveyed from 12°20'3.79"N, 75°52'53.81"E with an elevation of 860m a.s.l. near Karadigod to 12°23'14.12"N, 75°54'49.76"E with an elevation of 855m a.s.l. downstream, under the jurisdiction of Kushalnagar Range, Madikeri Territorial Division, up to the Doddaharve Reserved Forest, Hunsur Territorial Division.

This moist deciduous landscape receives less than 2000mm of rain during the South West Monsoon, with an extended dry period compared to the rest of Kodagu District. The forest comprises of over 150 species of flora, with examples of species such as Red Silk Cotton Tree (*Bombax ceiba*), Malabar Neem (*Melia dubia*), Dhaman (*Grewia tiliifolia*). Teak (*Tectona Grandis*) plantations are found interspersed with the natural forest and support a high density of *Curcuma* in the under- storey. The riparian corridor here is the longest, contiguous stretch of forest, providing refuge for wildlife during times of drought and forest fires and provides an additional refuge for elephants during conflict situations from across the river bank.



Small Clawed Otter (*Aonyx cinereus*) are found higher up in mountain streams and are very difficult to sight. They have been declared **Vulnerable**, due to loss of habitat leading to a decline in populations. *Photo ~ Dilan Mandanna*



Smooth Coated Otter (*Lutrogale perspicillata*) are found in the main river and are very difficult to sight. They have been declared **Vulnerable**, due to competition for food with declining fish stocks and habitat loss, leading to a decline in populations. *Photo ~ Mike Prince*



Hump-Backed Mahseer (*Tor remadevii*) are protected by Coorg Wildlife Society in Valnoor, where the river also flows along Dubare Reserved Forest, located on the opposite bank. They have been declared **Critically Endangered**, due to threats such as overfishing, dynamiting, habitat destruction and competitive species. *Photo ~ Wildlife Association of South India*



Blue Finned Mahseer (*Tor khudree*) are protected by Coorg Wildlife Society in Valnoor, where the river also flows along Dubare Reserved Forest, located on the opposite bank. They have been declared **Endangered**, due to threats such as overfishing, dynamiting and habitat destruction. *Photo ~ Jibran Shariff*

RIPARIAN ECOSYSTEMS

Riparian gallery forests are bio-geographic regions where land interfaces with rivers or streams. It operates primarily as a transition zone between land and water. The term 'Riparian' is reflected in the nomenclature of biomes of the earth, being one of the fifteen terrestrial biomes. Floristic communities along the river edges and banks are therefore called riparian vegetation, characterized by hydrophilic vegetation.

Many 'Ecosystem Services' or the various benefits we gain from rivers, directly or indirectly which contribute to our overall well being, are enumerated in the context of riparian ecosystems.

The important among them are:

HARBOURING BIODIVERSITY

In Kodagu district, the riparian corridors support aquatic, semi- aquatic and terrestrial fauna, with important species of mammals, reptiles, amphibians, fish, birds, crustaceans and insects. Riparian trees play host to numerous pollinators through the year, vital to the health of the agro- forest zone. Highlighted below are some important species present in the riverscape, with their conservation status accorded by the International Union for Conservation of Nature (IUCN), red list.



Indian Narrow Headed Softshell Turtle (*Chitra indica*) not commonly found anymore, because of hunting and habitat disturbance. They have been declared **Endangered**, due to the rapid decline in populations due to hunting and habitat disturbance. Photo ~ Krishna Kumar Mishra



Indian Black Turtle (*Melanochelys trijuga*) are commonly found in streams and rivers. They have been declared **Near Threatened**, as they face threats from hunting and habitat disturbance. Photo ~ Sandeep Gangadharan



Painted Stork (*Mycteria leucocephala*) are commonly found in huge gatherings during summer, when the water level is low. They have been declared **Near Threatened**, due to pollution, habitat disturbance and habitat modification. *Photo ~ John Harrison*



Malabar Pied Hornbill (*Anthracoceros coronatus*) are seasonal visitors, less commonly sighted. They have been declared **Near Threatened**, due to threats such as landscape modification, forest fires and decrease in forest species of trees in human dominated landscapes. *Photo ~ Vikas Patil*



Indian Honey Bee (*Apis cerana indica*) is an important crop pollinator species, which are increasingly being reared due to the regional decline in population attributed to landscape modification, leading to decline of native species of trees. *Photo ~ Grossman's hives*



Dwarf Honey Bee (*Apis cerana florea*) is an important crop pollinator species, with a decline in population attributed to landscape modification, leading to decline of native species of trees. *Photo ~ Alchetron.com*



WATERSHED DEVELOPMENT VALUE

Riparian forest buffers act as a sponge for absorbing rain water and runoff water, enriching and enabling ground water recharge. It is this ground water stock which feeds the rivers in the downstream region, which make them perennial. Therefore, the watershed development functions of these riparian zones are vital in terms of ground water recharge and water security in times of drought when irrigation directly from the river is intensive and extensive in the riparian agro- forest zones.

REGULATING FLOW

Riparian forest buffers also help regulate water flow. During a flood, trees reduce the velocity of the water, allowing more water to infiltrate into the ground and recharge groundwater supplies. This enables water to be released more slowly and over longer periods of time. The reduced velocity of water and increased infiltration also helps minimize the magnitude of flooding.



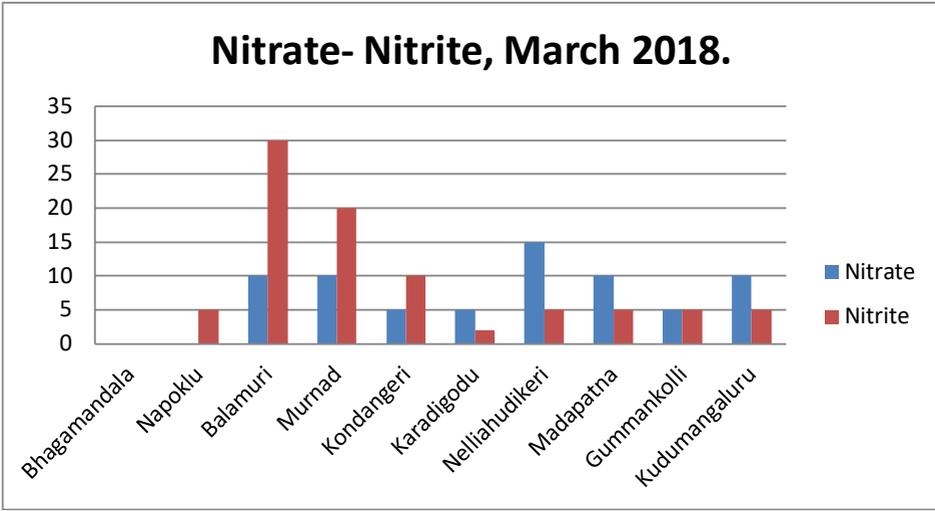
Mugger Crocodile (*Crocodylus palustris*) are few in the river, living amidst humans and highly sensitive to human disturbance, along the river bank. They have been declared **Vulnerable**, due to declining populations.
Photo ~ Naren Sreenivasan



WATER QUALITY

Riparian forest buffers help maintain water quality. They reduce the amount of pollutants in runoff — such as sediments, nutrients, pesticides, and fecal Coliform bacteria — from entering streams and rivers. Riparian forest buffers provide shade maintaining cooler water temperatures and healthy levels of dissolved oxygen, which is important for aquatic habitats. They attenuate nitrate or cause the de-nitrification of the nitrates brought from surface runoff, which takes place in these buffer zones. Riparian zones can thus play a significant role in lowering nitrate contamination in surface runoff from agricultural fields, which would otherwise damage ecosystems and affect human health.

The threshold or maximum contamination level for Nitrate- Nitrite is 10mg/ litre. As part of an ongoing citizen science initiative for river monitoring, data for 10 different water quality parameters, along with observations of human activity by the river, was collected by government high schools, situated close to the river.





WILDLIFE HABITAT

Riparian forest buffers are critical for the survival of many wildlife species. They serve as safe travel corridors between land and water, provide a reliable food source, and serve as areas of cover. Many fish and bird species depend on the insects that live in forested riparian areas for food. Many threatened and endangered species require the presence of forested areas along rivers to survive. Trees also act as a source of nutrients and woody debris that are important as a source of food and shelter for aquatic invertebrates, fish, reptiles, and amphibians.

STABILITY OF RIVER BANKS

Riparian forest buffers are important for the stability of river banks. In addition to smaller roots found mainly in the upper 8 inches of the soil, trees send larger roots into the ground vertically and laterally and use those roots as anchors to hold them in place. These larger roots help hold the soil and reduce the amount of erosion. After a flood, non-forested stream banks have been found to have significantly more erosion than forested banks. Forested stream banks have even shown overall deposition of sediment and accumulation of sand. With high water flows, as the trees slow the velocity of the water, sediment has more time to settle down, allowing soil to accumulate in the forested areas. Trees also stop large debris carried by the floodwaters from entering fields and other land, along with the new alien toxic introduction of plastics which get washed down with the flood.

RIPARIAN VEGETATION PROFILE



Lower and mid section riparian zone filtering sediment water flow from adjacent paddy fields in the Agro- Forest zone. The buffer zones play a crucial role in slowing down flood waters during the monsoon and filtering sediments and pollutants before they enter the river, from adjacent human settlements.



Aerial view of the agro-forest zone and riparian forest corridor. Photo ~ Arati Kumar Rao

GUIDELINES FOR PLANTING IN THE AGRO- FOREST ZONE

The guidelines are for a list of riparian flora listed below in order to establish adapted and compatible native species, as found in the forest zone that provide numerous ecosystem services, including providing for aquatic habitats and increased carbon storage.



Upper Section

Consists of deep rooted trees which stabilize the bank against slope erosion or surface runoff, and bind the soil and nutrients together.

Middle Section

The landward buffer zone is subject to flooding during the monsoon period and consists of trees, shrubs and other vegetation needed to filter runoff and provide uptake of nutrients and pollutants.

Lower Section

This buffer zone begins at the water level and contains trees and shrubs needed to provide aquatic shade, bank stability, detritus, large woody debris, and retain nutrients bound to soils. Large woody debris and tree roots in the water create habitat complexity and niches for invertebrates and aquatic organisms. Detritus such as leaves, twigs and fruit seeds entering the water and held by woody debris provide a base to the aquatic food chain with important species such as freshwater fish.



PROPAGATION TABLE

| TREES | SECTION | DISTANCE (from wetted zone) | PROPAGATION MATERIAL | COLLECTION OF SEEDS, CUTTINGS AND BULBS. | COLLECTION OF SEEDS, CUTTINGS AND BULBS. | SOWING AND PLANTING |
|--|----------------------------------|--------------------------------|----------------------|--|--|--|
| <i>Mangifera indica</i> Wild mango <i>Kaadu manu</i> | Upper section/ Middle section | 0-50m | Seeds | July- August | <p>Dispersal: -Mammals and fish. - Water.</p> <p>Natural Regeneration: The seeds germinate immediately under favourable conditions.</p> | <p>Sowing: Mature fruits can be pulped and sowed directly or can be dried in the shade and transferred to nursery bags.</p> <p>Germination: 1-2 weeks after sowing</p> <p>Planting: Saplings can be transplanted after 3-6 weeks.</p> |
| <i>Hopea parviflora</i> Malabar Iron-wood <i>Irp</i> | Upper section/ Middle section | 0-50m | Seeds | May- June | <p>Dispersal: -Wind -Water. -Fish, birds and other animals.</p> <p>Natural Regeneration: The seeds are dispersed mainly by wind. The seeds begin germinating with the pre- monsoon showers and the rate of germination is higher along the flooded zone.</p> | <p>Sowing: Seeds are sown immediately into nursery beds with wings placed flat on the ground.</p> <p>Germination: 2-3 weeks after sowing.</p> <p>Planting: Seedlings can be transplanted after 6-12 months.</p> |

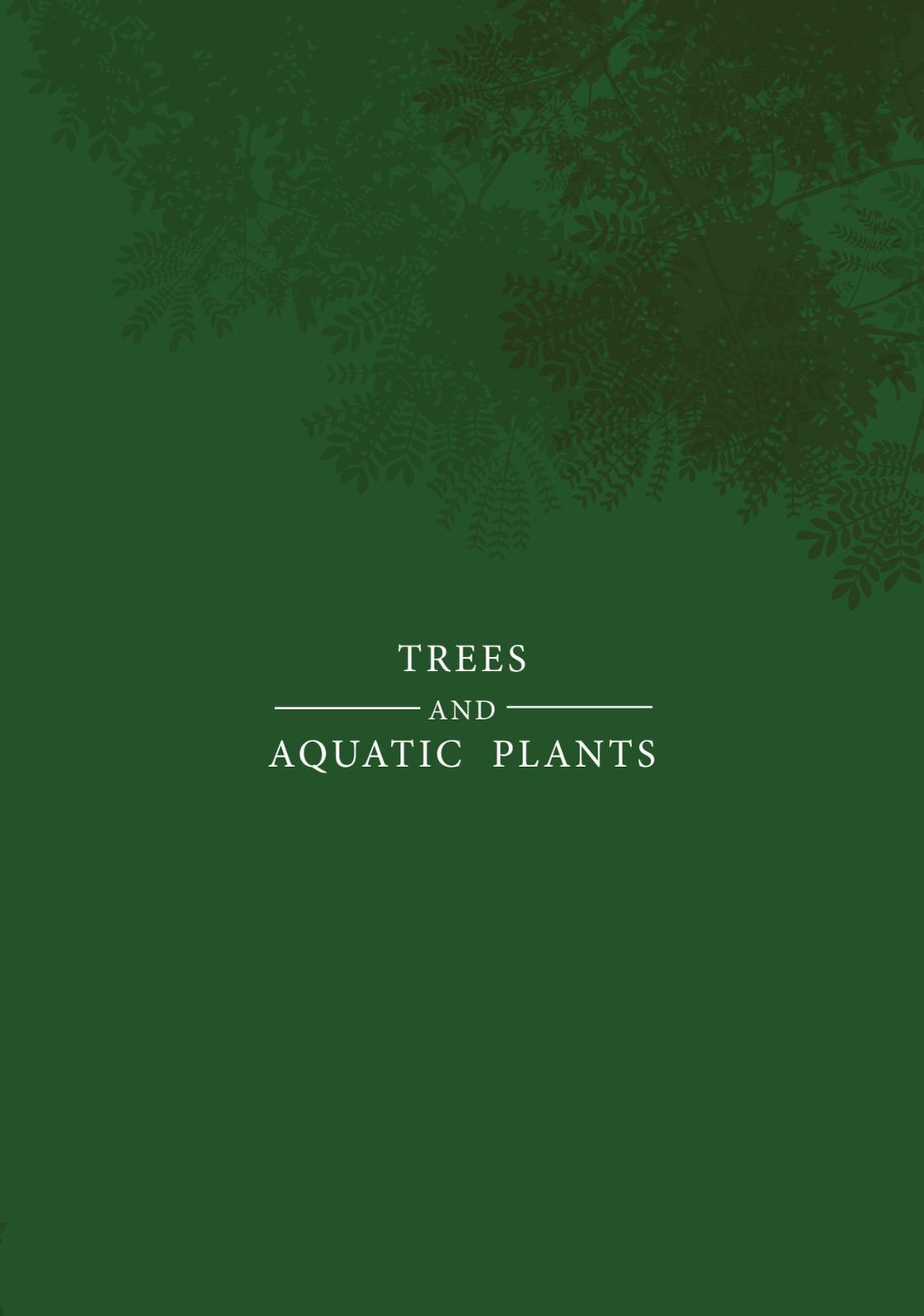
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|---|-------------------------------------|--------------------------------|------------------------------|--|--|---|
| Madhuca nerifolia Hole Alae mara | Middle section/ Lower section | 0-30m | Seeds | April- May | Dispersal: -Mammals, birds and fish. Natural Regeneration: The seeds begin germi- nating around the moth- er tree in abundance with the pre-monsoon showers. | Sowing: Fresh seeds should be sown directly into nursery beds, under shade. Germination: 2 weeks after sowing, after which they can be trans- planted into nursery bags or containers. Planting: Seedlings can be transplanted after 6-12 months. |
| Syzygium heyneanum River Jamun Hole Nerale | Middle section/ Lower section | 0-30m | Stem cut- tings | April- May | Dispersal: -Monsoon flood. -Fish and birds. Natural Regeneration: The seeds germinate immediately under favourable conditions, when the flood water recedes. | *Collection of seeds is challenging as the trees fruit when the river is flooded and the trees are partially sub- merged in the flooded zone. Planting: Stem cuttings can be planted in sand or humus rich nursery beds. Alternat- ively, they can be planted in containers or directly along the river's edge. |
| Salix tetrasperma Indian Willow Pongshae mara | Middle section/ Lower section | 0-30m | Stem Cut- tings | April- May | Dispersal: -Water. -Birds. Natural Regeneration: The seeds germinate immediately under favourable conditions, in sandy- loamy soil. | Cuttings are the most effec- tive method for propagation of this species. They how- ever, require well aerated sandy or loamy soil with high moisture content. |

| TREES | SECTION | DISTANCE (from wetted zone) | PROPA- GATION MATERIAL | COLLECTION OF SEEDS, CUTTINGS AND BULBS. | COLLECTION OF SEEDS, CUTTINGS AND BULBS. | SOWING AND PLANTING |
|---|----------------------------------|-----------------------------------|------------------------------|--|--|--|
| Diospyros malabarica Malabar Ebony Hole Thupuru | Upper section/ Middle section | 10- 50m | Seeds | February- June | Dispersal: -Water. -Birds. Natural Regeneration: Not very abundant, slow to establish itself. | Sowing: Seeds have a very short viability and should be sown immediately, in a nursery bed under shade. Germination: The seeds germinate any- where between 15 days to 6 weeks. Planting: Seedlings can be transplant- ed after 6-12 months. |
| Scleropyrum pentandrum Hard Pear Tree Hole Bappa | Upper section | 20- 50m | Seeds | February and No- vember | Dispersal: -Water. -Birds Natural Regeneration: Not very abundant, slow to establish itself. | Seed propagation has been tried and tested with less than 90% chance of germi- nation. Propagation of the species takes up to 10 months using cuttings, with the survival rate being very low. |
| Vitex leucoxylon White- Wood Chaste Tree Myladi | Upper section/ Middle section | 10- 30m | Seeds and cuttings | April- June | Dispersal: -Water. -Fish, birds and mam- mals. Natural Regeneration: Seeds germinate imme- diately under favourable conditions. | Sowing: Seeds or stem cuttings can be laid in sand and humus rich nursery bed or contain- ers/ nursery bags. Germination: 6-8 weeks Planting: Saplings can be transplanted after 6 months. |

| TREES | SECTION | DISTANCE (from wetted zone) | PROPAGATION MATERIAL | COLLECTION OF SEEDS, CUTTINGS AND BULBS. | COLLECTION OF SEEDS, CUTTINGS AND BULBS. | SOWING AND PLANTING |
|--|----------------------------------|--------------------------------|----------------------|--|--|---|
| Shorea roxburghii Lac Tree Irupu | Upper section/ Middle section | 10- 30m | Seeds | May- June | <p>Dispersal: -Wind -Water -Fish, birds and other animals. Natural Regeneration: The seeds begin germinating with the pre-monsoon showers.</p> | <p>Sowing: Seeds are sown immediately into nursery beds with wings placed flat on the ground. The nursery bed required a mixture of sand and humus for the seeds to germinate, with shade provided. Germination: 2-3 weeks after sowing. Planting: Seedlings require adequate light and can be transplanted after 6-12 months.</p> |
| Vitex altissima Peacock Chaste Tree Navuladi | Upper section/ Middle section | 10- 30m | Seeds and cuttings | September - October | <p>Dispersal: -Water. -Fish, birds and mammals. Natural Regeneration: Seeds germinate immediately under favourable conditions.</p> | <p>Sowing: Seeds or stem cuttings can be laid in sand and humus rich nursery bed or containers/ nursery bags. Germination: 6-8 weeks Planting: Saplings can be transplanted after 6 months.</p> |

| TREES | SECTION | DISTANCE (from wetted zone) | PROPAGATION MATERIAL | COLLECTION OF SEEDS, CUTTINGS AND BULBS. | COLLECTION OF SEEDS, CUTTINGS AND BULBS. | SOWING AND PLANTING |
|--|--|--------------------------------|-----------------------|--|---|--|
| Crateva religiosa Garlic Pear Tree Aane Paada | Upper section/ Middle section | 10- 30m | Seeds and Cuttings | April- May | Dispersal: -Birds. -Water. Natural Regeneration: Extremely slow to establish itself compared to Vitex altissima and Vitex leucoxylon. | Sowing: The seeds can be transferred to a nursery bed, under shade. Cuttings can be planted in a nursery bag container with sandy- loamy mixture. Germination: 2-3 weeks after sowing. Planting: They can be transplanted after 6- 12 months. |
| Calophyllum inophyllum Alexandrian Laurel Arshina Ipu | Middle- section to Lower section | 0m- 30m | Seeds | January- March | Dispersal: -Mammals, birds and fish. -Water. Natural Regeneration: The seeds germinate immediately under favourable conditions, but the growth is extremely slow. | Sowing: Fruits can be picked when they are pale yellow, to harvest the seeds and transferred into nursery beds, under shade. Germination: 60 days after sowing. Planting: Seedlings can be transplanted after 3 months. |
| Pongamia pinnata Indian Beech Tree Hongae | Upper section/ Mid- dle section | 10- 30m | Seeds | April- May | Dispersal: -Water. Natural Regeneration: Seeds can be found scattered around the mother tree and the rate of regeneration is rapid, coinciding with the pre-monsoon rains. | Sowing: The seeds can be transferred to a nursery bed, under shade. Germination: 1- 2 weeks after sowing. Planting: Seedlings can be transplanted after 6- 12 months. |

| TREES | SECTION | DISTANCE (from wetted zone) | PROPA- GATION MATERIAL | COLLECTION OF SEEDS, CUTTINGS AND BULBS. | COLLECTION OF SEEDS, CUTTINGS AND BULBS. | SOWING AND PLANTING |
|---|---------------------------------------|--------------------------------|------------------------------|--|---|--|
| Semi Aquatic Shrub | | | | | | |
| Homonoia riparia Willow- leaved Water Croton Hole Nigge | Lower section- Middle section | 0-5m | Seeds and cuttings | January- March | Dispersal: -Water. Natural Regeneration: The seeds germinate be- tween rocks and crevices, where the conditions are favourable. | Sowing: The seeds can be collected and placed on wet filter paper OR cuttings of young tender twigs can be planted directly in the river. Germination: 24 hours after sowing. + Planting: They can be transplanted after two weeks. |
| Phyllanthus Lawii Law's Goose- berry Mulli Nelli | Lower Sec- tion- Middle Section | 0-5m | Seeds and Cuttings | October- January | Dispersal: -Water. Natural Regeneration: The seeds germinate be- tween rocks and crevices, where the conditions are favourable. | Sowing: The seeds can be placed on filter paper or directly in a nursery bed. Cuttings of young tender twigs can be planted directly in the river. Germination: 24- 40 hours after sowing. Planting: They can be planted after two weeks. |
| Emergent Aquatic plant | | | | | | |
| Crinum viviparum River Crinum Lily Hole Sebu | Lower section | 0 m | Bulbs | December - March | Dispersal: -Water. Natural Regeneration: The Bulbs are dispersed by water and propagate in crevices and shallow waters. | Bulbs can be planted directly in the river bed in rocky areas and shallow waters with a sandy and humus rich substrate. |



TREES
— AND —
AQUATIC PLANTS



RIPARIAN WILD MANGO

SCIENTIFIC NAME 🌿 *Mangifera indica*

LOCAL NAMES 🌿 *Kaadu maavu, mangae*

HABIT 🌿 Evergreen tree

HEIGHT 🌿 15- 30m

IUCN CONSERVATION STATUS 🌿 Data deficient

FLOWERING PERIOD 🌿 February to march

FRUITING 🌿 March to May, with fruits ripening up to the month of June. The riparian wild mango is discernible from other wild mangoes, with its large fruit which is highly fibrous when ripe. The fruit is extremely sour and is only harvested for its juice, used as a sour base for cooking purposes.

POLLINATORS 🌿 Beetles, bees, butterflies, fruit flies.

RIPARIAN ASSOCIATION 🌿 Canopy species with deep vertical and lateral roots which stabilize the river banks and provide shade for mid-storey riparian species of trees. Commonly found only on the banks of the river on slopes and the edge of the river, in the middle section and upper section, with branches leaning towards to the river.



MALABAR IRONWOOD

SCIENTIFIC NAME 🌿 *Hopea parviflora*

LOCAL NAME 🌿 Irpu, Hole Jaalu

HABIT 🌿 Evergreen tree.

HEIGHT 🌿 35- 40m

IUCN CONSERVATION STATUS 🌿 Least concern

FLOWERING PERIOD 🌿 January to March

FRUITING 🌿 April to May

POLLINATORS 🌿 Beetles, bees, butterflies, ants.

RIPARIAN ASSOCIATION 🌿 Canopy species with deep vertical and lateral roots which stabilize the river banks and provide shade for mid-storey riparian species of trees. Commonly found only on the banks of the river on slopes and the edge of the river in the middle section and upper section. Food tree for many species of mammals, birds and fish.



Regeneration of Malabar Iron Wood in the flooded riparian zone. The saplings withstand flooding and submersion during the monsoon, due to their deep tap root system.



INDIAN LAUREL

SCIENTIFIC NAME 🌿 *Calophyllum inophyllum*

LOCAL NAME 🌿 Arshina Irpu

HABIT 🌿 Evergreen tree.

HEIGHT 🌿 10- 20m

IUCN CONSERVATION STATUS 🌿 Least concern

FLOWERING PERIOD 🌿 December- February

FRUITING 🌿 February- March

POLLINATORS 🌿 Beetles, bees, butterflies, fruit bats, ants.

RIPARIAN ASSOCIATION 🌿 Canopy species with deep vertical and lateral roots which stabilize the river banks and provide shade for mid-storey riparian species of trees. Commonly found only on the banks of the river on slopes and the edge of the river, in the middle section, with branches leaning towards to the river.





Regeneration of Madhuca neriifolia under the mother tree, along the river's edge.

ILLIPE BUTTER TREE

SCIENTIFIC NAME 🌿 *Madhuca neriiifolia*

LOCAL NAME 🌿 Aale

HABIT 🌿 Evergreen tree

HEIGHT 🌿 10- 15m

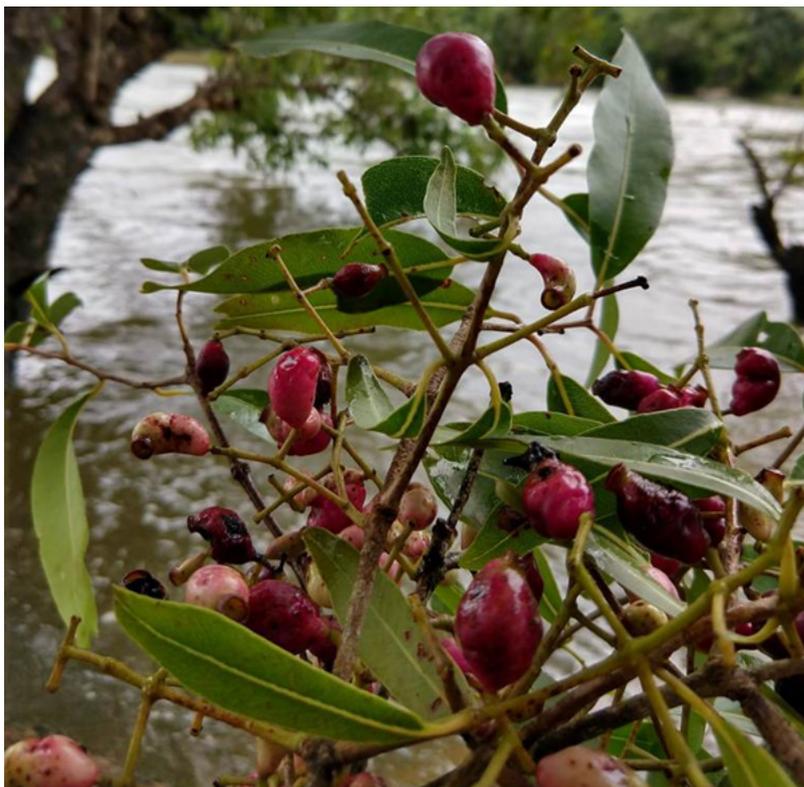
IUCN CONSERVATION STATUS 🌿 Least concern

FLOWERING PERIOD 🌿 February- March

FRUITING 🌿 March- April

POLLINATORS 🌿 Beetles, bees, butterflies, fruit bats, ants.

RIPARIAN ASSOCIATION 🌿 Strictly riparian species with deep vertical and lateral roots which stabilize the river banks. Commonly found only on the edge of the river bank, in the middle section with branches leaning towards the river. The species require a lot of sunlight. Food tree for many species of birds and mammals, including elephants.



RIVER JAMUN

SCIENTIFIC NAME 🌿 *Syzygium heyneanum*

LOCAL NAME 🌿 Hole Nerale

HABIT 🌿 Evergreen tree

HEIGHT 🌿 5- 10m

IUCN CONSERVATION STATUS 🌿 Not evaluated

FLOWERING PERIOD 🌿 March- April

FRUITING 🌿 May- July

POLLINATORS 🌿 Beetles, bees, butterflies.

RIPARIAN ASSOCIATION 🌿 Strictly riparian species with deep vertical and lateral roots which stabilize the river bank and river bed. Commonly found only on the edge of the river bank, in the middle and lower section- in the river bed and on islands, with branches leaning towards to the river. The species require a lot of sunlight. Food tree for many species of birds and fish. Elephants are known to eat the bark of the tree, when suffering from stomach ailments.



Syzygium heyneanum are typically found in the flooding or wetted zone of the riparian buffer zone. They are also found on river islands which get submerged during the monsoon.



INDIAN WILLOW

SCIENTIFIC NAME 🌿 *Salix tetrasperma*

LOCAL NAME 🌿 Pongshe, Bhaiyya

HABIT 🌿 Deciduous tree

HEIGHT 🌿 10- 20m

IUCN CONSERVATION STATUS 🌿 Not evaluated

FLOWERING PERIOD 🌿 January to February

FRUITING 🌿 March

POLLINATORS 🌿 Beetles, bees, butterflies, ants.

RIPARIAN ASSOCIATION 🌿 Strictly riparian species, it is a large deciduous tree commonly found only on the edge of the river bank in the middle section, with branches leaning towards to the river. The species require a lot of sunlight. The flowering event draws many species of fish below the trees, which attract otters.







INDIAN PERSIMMON MALABAR EBONY

SCIENTIFIC NAME 🌿 *Diospyros malabarica*

LOCAL NAME 🌿 Hole Thupuru

HABIT 🌿 Evergreen tree.

HEIGHT 🌿 15- 20m

IUCN CONSERVATION STATUS 🌿 Not evaluated

FLOWERING PERIOD 🌿 May- June

FRUITING 🌿 August- November

POLLINATORS 🌿 Beetles, bees, butterflies, ants.

RIPARIAN ASSOCIATION 🌿 Large evergreen trees, found scattered along the river bank and on the edge of the river, in the middle section. The fruits contain toxins which affect freshwater fish and is traditionally used by the tribals to catch fish.



Semi-parasitic tree with spiny trunk and branches, and fruits in drupes.

HARD PEAR

SCIENTIFIC NAME 🌿 *Scleropyrum pentandrum*

LOCAL NAME 🌿 Hole Bappa

HABIT 🌿 Evergreen species. Present in semi-evergreen and evergreen forests, including sacred groves. Also present in the riparian corridor of the moist deciduous stretch.

HEIGHT 🌿 10m

IUCN CONSERVATION STATUS 🌿 Not evaluated

FLOWERING PERIOD 🌿 January to March (Also observed to be flowering in the month of October).

FRUITING 🌿 August- November

POLLINATORS 🌿 Beetles, bees, butterflies, ants.

RIPARIAN ASSOCIATION 🌿 Small evergreen trees, scattered along the river bank on slopes.





WHITEWOOD CHASTE TREE

SCIENTIFIC NAME 🌿 *Vitex leucoxylon*

LOCAL NAME 🌿 Myladi

HABIT 🌿 Deciduous tree

HEIGHT 🌿 15- 20m

IUCN CONSERVATION STATUS 🌿 Not evaluated

FLOWERING PERIOD 🌿 April to May

FRUITING 🌿 June- August

POLLINATORS 🌿 Beetles, bees, butterflies, ants.

RIPARIAN ASSOCIATION 🌿 Commonly found only along the river bank, in the middle section. Food tree for birds and fish.





PEACOCK CHASTE TREE

SCIENTIFIC NAME 🌿 *Vitex altissima*

LOCAL NAME 🌿 Navilaadi

HABIT 🌿 Deciduous tree, also found in the moist deciduous forest.

HEIGHT 🌿 15- 20m

IUCN CONSERVATION STATUS 🌿 Not evaluated

FLOWERING PERIOD 🌿 May- June

FRUITING 🌿 July to August

POLLINATORS 🌿 Beetles, bees, ants.

RIPARIAN ASSOCIATION 🌿 Large deciduous trees, found commonly along the banks of the river, away from the edge of the river bank in the middle section and upper section.



LAC TREE

SCIENTIFIC NAME 🌿 *Shorea roxburghii*

LOCAL NAME 🌿 Irpu

HABIT 🌿 Deciduous tree

HEIGHT 🌿 20- 25m

IUCN CONSERVATION STATUS 🌿 Endangered

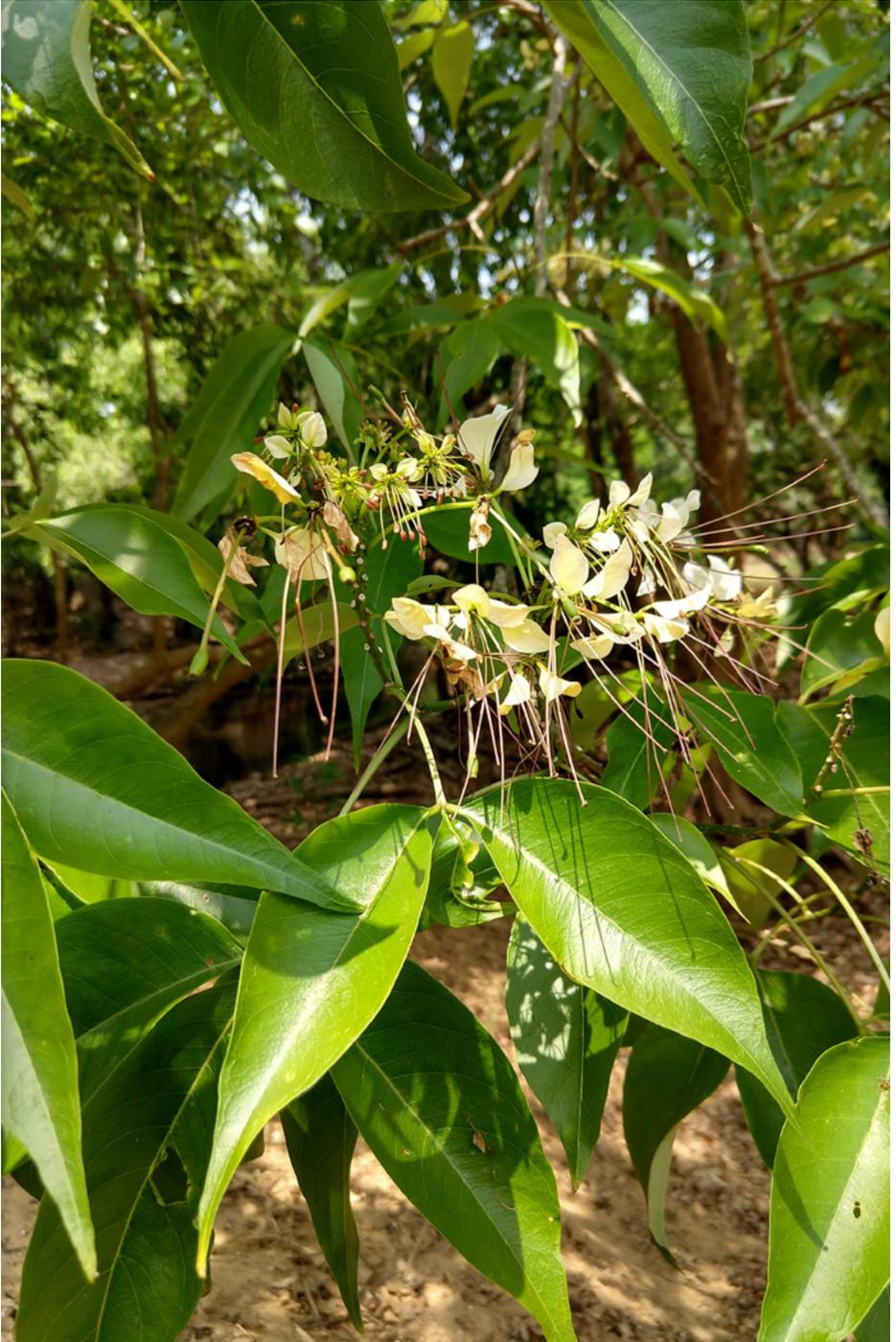
FLOWERING PERIOD 🌿 February to March

FRUITING 🌿 March to May

POLLINATORS 🌿 Beetles, bees, butterflies, ants.

RIPARIAN ASSOCIATION 🌿 Large deciduous tree found only on the river banks, in the moist deciduous stretch.





GARLIC PEAR TREE

SCIENTIFIC NAME 🌿 *Crateva religiosa*

LOCAL NAME 🌿 Aane paada

HABIT 🌿 Deciduous tree

HEIGHT 🌿 15m

IUCN CONSERVATION STATUS 🌿 Not evaluated

FLOWERING PERIOD 🌿 April- May

FRUITING 🌿 June- July

POLLINATORS 🌿 Beetles, bees, butterflies, ants.

RIPARIAN ASSOCIATION 🌿 A mid- sized deciduous tree, found scattered away from the river's edge in the middle section- upper section.



INDIAN BEECH TREE

SCIENTIFIC NAME 🌿 *Pongamia pinnata*

CONSERVATION STATUS 🌿 *Hongae*

HABIT 🌿 Deciduous tree, found commonly along riparian areas.

HEIGHT 🌿 15- 20m

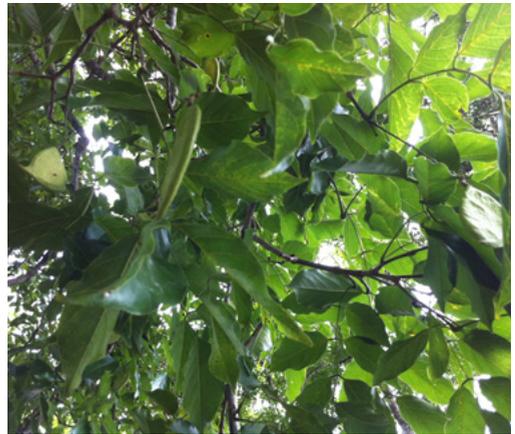
IUCN CONSERVATION STATUS 🌿 Least Concern

FLOWERING PERIOD 🌿 March to April

FRUITING 🌿 April to May

POLLINATORS 🌿 Beetles, bees, butterflies.

RIPARIAN ASSOCIATION 🌿 Mid- storey species, with deep vertical and lateral roots which stabilize the river banks. Commonly found on the banks of the river on slopes and the edge of the river, in the middle section and upper section.





WILLOW- LEAVED WATER CROTON

SCIENTIFIC NAME 🌿 *Homonoia riparia*

LOCAL NAME 🌿 Hole Nugge

HABIT 🌿 Large evergreen shrub

HEIGHT 🌿 3m

IUCN CONSERVATION STATUS 🌿 Least concern

FLOWERING PERIOD 🌿 March- April

FRUITING 🌿 May

POLLINATORS 🌿 Bees, butterflies, ants.

RIPARIAN ASSOCIATION 🌿 A well established shrub growing in the river bed and along the edge of the river bank in the lower section. It provides firm stabilization to the river bed due its extensive root system.



LAW'S GOOSEBERRY

SCIENTIFIC NAME 🌿 *Phyllanthus lawii*

LOCAL NAME 🌿 Tirneli, Mullu Nelli

HABIT 🌿 Straggling shrub, commonly found in the Western Ghats along streams and rivers.

HEIGHT 🌿 1-2m

IUCN CONSERVATION STATUS 🌿 Not evaluated

FLOWERING PERIOD 🌿 September- November

FRUITING 🌿 October- December

POLLINATORS 🌿 Bees, butterflies.

RIPARIAN ASSOCIATION 🌿 Lateral roots which stabilize the edge of river banks. Commonly found at the edge of the river, in the lower section. Fish are commonly found feeding on the fruits.





RIVER CRINUM LILY

SCIENTIFIC NAME 🌿 *Crinum viviparum*

LOCAL NAME 🌿 Hole Sebu

HABIT 🌿 Aquatic emergent plant

HEIGHT 🌿 0.5- 1m

IUCN CONSERVATION STATUS 🌿 Not evaluated

FLOWERING PERIOD 🌿 September- November

FRUITING 🌿 December- April

POLLINATORS 🌿 Bees, butterflies, beetles.

RIPARIAN ASSOCIATION 🌿 A well established aquatic plant found in the river bed and around rocky areas in rapids.

PLANNING THE PLANTING

GEOGRAPHICAL LOCATION

Restoration planning can cover areas that fall within an elevation of 800m down to an elevation of 700m. Further surveys and studies, done locally or with expertise of Tribals and the Forestry College, are required to assess location specific guidelines which depend on the distribution of native tree species.

SITE PREPARATION

The first step in riparian buffer establishment is site preparation. Preparation of a site requires removal of all invasive vegetation- with examples such as *Lantana camara* and *Eupatorium* species to reduce competition to new native species and shrubs.

BUFFER WIDTH

There is no one size fits all buffer width in the riparian corridor. The buffer width is largely dependent on the terrain and incline of the slope. The recommendations given are based on gradual slopes and steep inclined slopes.

Planting in the field:

| Gradual slopes and even terrain (up to 50m) | |
|---|--|
| Lower Section | Species |
| Spacing (feet) 9×9 | <i>Homonia riparia</i> <i>Syzygium heyneanum</i> |
| Middle Section | Species |
| Spacing (feet) 9×9 | <i>Syzygium heyneanum</i> <i>Salix tetrasperma</i> <i>Madhuca neriifolia</i> <i>Mangifera indica</i> <i>Hopea parviflora</i> <i>Calophyllum inophyllum</i> <i>Vitex leucoxydon</i> <i>Diospyros malabarica</i> <i>Pongamia pinnata</i> <i>Shorea roxburghii</i> |



| Gradual slopes and even terrain (up to 50m) | |
|---|---|
| Upper Section | Species |
| Spacing (feet) 9×9 | <i>Hopea parviflora</i> <i>Mangifera indica</i> <i>Vitex leucoxyllon</i> <i>Vitex altissima</i> <i>Scleropyrum pentandrum</i> <i>Diospyros malabarica</i> <i>Pongamia pinnata</i> <i>Shorea roxburghii</i> |
| Steep Slopes (up to 30m) | |
| Middle Section | Species |
| Spacing (feet) 9×9 | <i>Syzygium heyneanum</i> <i>Salix tetrasperma</i> <i>Madhuca neriifolia</i> <i>Mangifera indica</i> <i>Hopea parviflora</i> <i>Calophyllum inophyllum</i> <i>Vitex leucoxyllon</i> <i>Diospyros malabarica</i> <i>Pongamia pinnata</i> <i>Shorea roxburghii</i> |
| Upper Section | Species |
| Spacing (feet) 9×9 | <i>Hopea parviflora</i> <i>Mangifera indica</i> <i>Vitex leucoxyllon</i> <i>Vitex altissima</i> <i>Scleropyrum pentandrum</i> <i>Diospyros malabarica</i> <i>Pongamia pinnata</i> <i>Shorea roxburghii</i> |

Special note: The conservation status “**least concern**” does not necessarily indicate that the species is not endangered or under threat in the Cauvery. The species *Hopea parviflora*, *Calophyllum inophyllum* and *Madhuca neriifolia*, require robust conservation measures in Coorg District.

REFERENCES AND ACKNOWLEDGMENTS

INDIGENOUS KNOWLEDGE

The riparian flora guide has been derived from indigenous expertise of Jenu Kuruba, forest dwellers from Dubare Reserved Forest. The tribe play an integral role, having lived in the forest for generations, for their lives are closely interconnected with the forest making them the sole proprietors of a wealth of knowledge on native flora and fauna. The assessment was carried out using local names to ensure thorough and detailed mapping of trees along the river bank, documenting density and abundance, along with samples collected for scientific verification. The Jenu Kuruba tribe in Dubare Reserved Forest, are predominantly Mahouts employed by the Forest Department and the older generation of men, have in the past, been involved with Forest Department nurseries and possess expertise in nursery care for this reason. Work with Jenu Kurubas, has progressed to raising a riparian nursery for restoration and it recognizes not only the need for riparian restoration in agro- forest zones, but also the importance of preserving indigenous knowledge and facilitating restoration work with indigenous communities to enable conservation of riparian habitats, as a conservation measure for the river Cauvery, in Kodagu District.

Key personnel from the Jenu Kuruba tribe in Dubare Reserved Forest.



Appane



Darshan



Ramanna



Bunda

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Western Ghats Tree Id- Biotik retrieved from an app based identification guide and CD guide.

The IUCN Redlist of Threatened Species retrieved from <https://iucnredlist.org/>

ACKNOWLEDGMENTS

There are many people who have been instrumental in making this work happen. The Karnataka Forest Department for recognizing the importance of the work and providing resources. The field staff of Dubare and Maldare Reserved forest. Siddharth Machado and Navendu Page were of enormous help with identification of species. Aanemane Foundation for support throughout the field assessment. Romulus Whitaker for his sustained support. Dr. A.J.T. Johnsingh for his guidance which led to the field assessment. Dr. Todd Steiner for inspiration in riparian habitat conservation. Government Schools in Kodagu District. Siddharth Baruah for GIS support. Dr. C.G. Kushalappa and the Forestry College in Kodagu District. Dr. B.C. Nagaraj, from Bangalore University. Akhila Machaiah, C.T. Ponappa, C.K. Pooviah, Rishwin Devaya, M.G. Devaiah, Sheetal Devaiah, Sandeep Charkarabarti, Riya Sequeira Shetty, Thangamma Cariappa, Diya Nanjapa, Nithya Reddy (book design), Smriti Chanchani, Baneen Karachiwala, Sandhya Satyamurthy, Naren Sreenivasan, Miriam John, Meena Subramanian, Aravind Madhyastha, Gowri Varanashi, Paul Rosolie and Suprabha Seshan for providing invaluable support through the endeavour and last but not the least, my parents R.E. Prameela and B.N. Mahesh. Primary grant providers include WWF- India Small Grants Programme, Rufford Foundation and The Habitats Trust.



AFTERWORD

It was a pleasant and cool day walking along the riparian forest on the banks of the Tambiraparani River in Mundanthurai Wildlife Sanctuary, Tamil Nadu. It was a day in 1984 and my companion on the walk was Justus Joshua, a gifted naturalist. As we walked and quantified the vegetation, what emerged was that the dominant tree species along the riparian tract was *Hopea parviflora* and the most abundant understorey species was *Glycosmis cochinchinensis*.



Dasia haliana photographed in the riverine forests of Tambiraparani

cirrhatus) and a pair of grey-headed fishing eagles (*Ichthyophaga ichthyaetus*). The latter had come to catch their meal from the much decimated and depleted fish population of the river. Malabar grey hornbills (*Tockus griseus*) and great hornbills (*Buceros bicornis*) were also heard calling.

Another day Ajay Desai, who was to evolve into one of the foremost elephant biologists in Asia, accompanied us and Justus with his keen eyes could see a *Dasia haliana*, an attractive arboreal skink hitherto thought to occur only in Sri Lanka, in the leafy branch of a mango tree. Sankaran, our field assistant of exceptional fitness climbed the tree, the skink fell on the ground and in lightning speed, buried itself in the river sand. We took it out gently, photographed and released it back in the canopy of the mango tree. Years later Karthik Vasudevan, a renowned herpetologist, was kind enough to name this different and newly described species, species *Dasia johnsinghi*.

The riparian forests on the Mundanthurai Plateau are found along two rivers, Tambiraparani and Servalar. In the past, the forests on the banks of these rivers

were contiguous with the evergreen forests in the upper reaches so that species of high-altitude evergreen forests such as *Mesua ferrea* and *Entada scandens* could colonize the lower areas of the river stretch, which is at an altitude of 180 m. Continuity along the Tambiraparani River was broken when the Upper or Karaiyar dam was built in 1941 and the continuity of the Servalar River was broken with the



Riparian forests of Moyar River. Lack of regeneration is clearly visible.

construction of the Servalar dam in 1986. The total length of the remaining riparian forests on the Plateau is about 15 km and the area covered by them, as the average width of the forests is about 25 m, is c. 0.5 sq.km.

Yet, this is the only patch in the entire Western Ghats where the Nilgiri langur, Vulnerable according to the IUCN, is found at such a low altitude. Now the wood-cutting pressure on the riparian forests has reduced drastically, except around the Sorimuthayyanar temple on the right bank of the Tambiraparani River, as a result of the ecodevelopment programs initiated by the Reserve management after the 895-sq. km Kalakad-Mundanthurai area was declared a Tiger Reserve in 1988.

Providentially, I got a job as a faculty member in the Wildlife Institute of India (WII) in 1985, and I worked there for 20 years. I have a great love for the golden mahseer (*Tor putitora*), one of the most beautiful freshwater fish species of the country. While surveying the Ganges River for golden mahseer, between Haridwar and Rishikesh a distance of 16km, I came across nearly 1.5–km-long fairly intact riparian patch, the only fragment along the entire 2500-km-long Ganges River, which was still being used by the Indian pied and great hornbills, sambar, elephant bulls and tiger. Elephant cow groups were deterred by a canal but the bulls were bold enough to walk either over a bridge and through an aqueduct below the canal to reach the riparian forest.

The under-storey contained species such as *Clerodendron infortunatum*, *Glycosmis pentaphylla* and *Murraya koenigii*. Highly medicinal and valuable *Rauwolfia serpentina* occurred in marshy areas. There were tree species such as *Mallotus philippinensis*, *Terminalia belerica*, *T. tomentosa*, *Trewia nudiflora* and *Putranjiva roxburghii*. My colleague, GS Rawat, an eminent plant ecologist, showed me the only

T. chebula tree in that patch, a very large one. The biotic pressures on that rare and irreplaceable riparian forest from the nearby Gangabagpur thalla village, which in the late 1980s had about 25 households, were enormous. There were talks of resettling the village, but today the village has grown big and prosperous, with an ashram, resorts, hospital and boarding school. I am not sure about the damage that this developed village is causing to that patch of riparian forest.



In summer the heated hills force the tigers to seek asylum in the riparian forests and in the cool waters of the Moyar River. During one trip in the summer we saw three different tigers along the river.

After retiring from WII, I returned to the South in 2006. With my colleague Raghunath from Nature Conservation Foundation (NCF) and colleagues from the Wildlife Association of South India (WASI), I have walked several times along the riparian forests of the Moyar River. While on foot, we encountered tigers twice, and a tigress with two jungle-cat sized cubs. We were lucky to photograph them. The Moyar riparian forest with stately tree species such as *Diospyros malabarica*, *Madhuca longifolia* and *Terminalia arjuna* looked ancient and impressive. Although there was no human habitation nearby, the forest lacked regeneration.



The tiger which was coming to the Moyar River

This was also the case with the riparian forest along the Bhavani River in the Coimbatore Forest Division, where I had gone looking for the orange-finned mahseer with colleagues from Wildlife Association of South India. There were tree species such as *Aglaia roxburghii*, *Hopea parviflora*, *Mangifera indica* and *Strychnos nuxvomica*.

The riparian forests along Cauvery Wildlife Sanctuary, which has a small population of endangered grizzled giant squirrel (*Ratufa macroura*), are also not safe. Pilgrims to places like Muthathi collect firewood and cook anywhere along the riparian forest. They should bring cooked food, take a bath in the river, eat the food sitting in the cool shade of the forest and go home, leaving only their footprints on the river bank.



The riparian forests of the Bhavani River.

All of the above observations prompted some questions: Why is there less regeneration in the riparian forests downstream, that are reported to be vital to the landscape and rivers, as they serve several vital ecological functions? Why are managers and conservationists not interested in the regeneration of the gallery forests? What can be done to revive the floral richness of the riparian forests in the country? Is it even possible?

In this context it is extremely pleasing to see the efforts initiated by Neethi Mahesh, an independent researcher, to rejuvenate agro- forest riparian forests of the Cauvery River in Coorg. The world's mahseer conservation community is aware that the Cauvery River, till recently, was supporting a population of hump-backed mahseer, which is now for various reasons on the verge of extinction. Neethi's attempt to rejuvenate the Cauvery riparian forests is one of the many steps needed to bring the iconic fish of the Cauvery basin back to its former abundance, as the fruit and flowers of several riparian species are eaten by the mahseer. Insects falling from the canopy also contribute to the protein requirements of the mahseer.

What is appreciable is that Neethi is undertaking the restoration work by involving the Jenu kurubas of the area as they still retain a link with nature and the traditional knowledge related to forests and wildlife, which needs to be nurtured and made use of. As the first step, she has brought out an informative field guide, along with efforts in raising a nursery to support restoration work by local communities. Restoration efforts are going to be challenging as they can go on for years. I hope earnestly that this endeavour receives necessary support from the Karnataka Government, and conservation and funding agencies to create a model in Coorg for riparian forest restoration, which can be emulated all over the country.

Dr. A.J.T. Johnsingh,
*Nature Conservation Foundation,
WWF-India and Corbett Foundation*

