The study area comes along the Cauvery river stretch in Karnataka, covering five districts namely Chamarajanagar, Mysore, Mandya, Hassan and Kodagu (Coorg). Based on the landuse patterns, the study area can be categorized into two different landscapes

### 2.1. Forest Landscapes

Forest landscapes are observed along the Cauvery stretch at peripheral ends with legal status under Wildlife Protection Act 1972 and Karnataka Forest Rules, 1969.

- **Mekedatu to Kootale (~47 km)** located in the Cauvery wildlife sanctuary in the lower reaches of river Cauvery in Chamarajanagar district.

- **Kaveriammana sacred groove (~3 km)**, located at river origin region in the upper reaches of river Cauvery in Kodagu district. The sacred grove is termed as “Kaveri Devarakadu” locally and is located at the point of river origin, Talacauvery. The sacred landscapes extend to an area of 379.85 acres along the main stream of the river from its origin point to a village downstream (Cherangala). The Sacred grove is shaped like a parallelogram with the river Cauvery forming its diagonal with the Talacauvery Wildlife Sanctuary on right side from river origin point and Bhagamandala Range Forest on the left side.

### 2.2. Agro ecosystem Landscapes

The Agro ecosystem landscapes are found in the middle stretch of River cauvery, where intense farming activities are seen. It extends from Kollegala at Chamagajnagar District to Cherangala at Kodagu District covering ~268 km along the study area.

Along these Agro ecosystem landscapes, few pockets of riparian tourist spot namely, Ranganathittu Bird Sanctuary in Mandya district, Kaveri Nisarga Dhama and Dubare Nature camp at Kushalanagara, Kodagu district are located. The Riparian vegetation found in these places is retained to preserve the natural beauty of the river.
2.3 Description of River Cauvery

The Kaveri River, also spelled Cauvery in English, a major river in India is one of the seven most sacred rivers of the country. The river originates at Talakaveri (12° 25' N, 75° 34' E) in Kodagu district, in the Western Ghats at an altitude of 1341m. It is the 8th largest river in the subcontinent and ranks as a medium river on a global scale. The river flows generally towards south and east through Karnataka and Tamil Nadu and across the southern Deccan plateau through the southeastern lowlands, emptying into the Bay of Bengal through two principal mouths.

The Cauvery River basin is estimated to occupy 81155 km\(^2\) area with many tributaries including the Shimsha, Hemavati, Arkavathy, Honnuhole, Lakshmana Tirtha, Kabini, Bhavani, Lokapavani, Noyyal and Amaravati. It occupies nearly 2.5% of the total geographical area of the country. The catchments of the river basin lie in the states of Karnataka, Tamil Nadu, Kerala and Union Territory of Pondicherry. Of the total area of the basin 41.2% is in the state of Karnataka, 55.5% in the state of Tamil Nadu and 3.3 % in Kerala. The width of the basin ranges from 65 to 250 km. The total length of the river from its source to outfall in Bay of Bengal is around 800 km, of which 318 km is in Karnataka and 416 km in Tamil Nadu.
In Kodagu, the river flows for 89 km through plantations, agricultural land and villages. From Kushalanagar town up to Shivanasamudram falls (193 km), the river flows through towns, villages and agricultural land. From there on, the last 36 km of the river is through forested land, with little human settlements along the course (Shenoy, 2005).

Table 1. Catchment area of Cauvery river basin

<table>
<thead>
<tr>
<th>State wise catchments area of Cauvery river Basin (Km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karnataka</td>
</tr>
<tr>
<td>34273</td>
</tr>
</tbody>
</table>

From Krishna Raja Sagar (KRS) to Srirangapatnam the River occupies a wide zone and is characterized by broad meanders between KRS and Srirangapatnam. The Krishnarajasagar dam is the first manmade barrier built on Cauvery at Kannambadi. At Srirangapatnam the river bifurcates into two branches because of the structural peculiarities of the bed rock and the two branches reunite again at a place called Sangam about 5 Km from the Srirangapatnam town. Below this dam and above its confluence with Shimsha, the river crosses 610 contour at Shivanasamudram island (12° 16’ N 77° 13’ E) on either side of which it branches off as Gaganachukki (Western branch) and Bharachukki (Eastern branch). Below Shivanasamudram Island the Shimsha joins, the shimsha falls (94m) at Shimshapura where hydroelectric plant exists.

At Wadepati, the plateau course of the river ends and culminates in Hogenekkal falls where it cut across the state west-east. Chinnar, a small tributary, joins the river below Hogenekkal and the river flows through a narrow steep sided valley at Mettur.

Table 2. Major tributaries and their features of Cauvery basin in Karnataka

<table>
<thead>
<tr>
<th>Tributary Name</th>
<th>Catchments area (Km²)</th>
<th>Origin, altitude, length</th>
<th>Sub-tributaries</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkavathy</td>
<td>4351</td>
<td>Nandidurga, 1480 m, 161 km.</td>
<td>Kumudavathi, Manihalla, Kuttehole, Vrishabhavatry.</td>
<td>Karnataka and Tamil nadu.</td>
</tr>
<tr>
<td>Harangi</td>
<td>717</td>
<td>Pushpagiri hills of Western Ghats, 1067 m,</td>
<td></td>
<td>Karnataka</td>
</tr>
<tr>
<td>Tributary Name</td>
<td>Catchments area (Km²)</td>
<td>Origin, altitude, length</td>
<td>Sub-tributaries</td>
<td>State</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------------</td>
<td>--------------------------</td>
<td>-----------------</td>
<td>-------</td>
</tr>
<tr>
<td>Hemavathy</td>
<td>5410</td>
<td>Ballarayana durga in Western Ghats, 1219 m, 245 km.</td>
<td>—</td>
<td>Karnataka</td>
</tr>
<tr>
<td>Kabini</td>
<td>7040</td>
<td>Western Ghats in Kerala, 2140 m, 230 km.</td>
<td>Taraka, Hebballa, Nugu, Gundal.</td>
<td>Karnataka, Kerala and Tamil Nadu</td>
</tr>
<tr>
<td>Lakshmanathirtha</td>
<td>1950</td>
<td>Western Ghats 1950 m, 131km.</td>
<td>Ramathirtha</td>
<td>Karnataka</td>
</tr>
<tr>
<td>Shimsha</td>
<td>8469</td>
<td>Tumkur, 14m, 221 km.</td>
<td>Veeravaishnav, Kanihalla, Chikkhole, Habbahalla, Mullahalla, Kanya.</td>
<td>Karnataka</td>
</tr>
<tr>
<td>Suvarnavathy</td>
<td>1787</td>
<td>Nasrur Ghat range, 88 km.</td>
<td>—</td>
<td>Karnataka and Tamil Nadu</td>
</tr>
</tbody>
</table>

*Source: [http://waterresources.kar.nic.in/river_systems.htm](http://waterresources.kar.nic.in/river_systems.htm)*

### 2.4. Elevation

The origin of Cauvery in the Brahmagiri hills is at a place called Talakaveri located at an elevation of 1340 above mean sea level (amsl). The upper reach of the basin is covered with hill ranges of the Western Ghats and the sub basin area is broad and open with gently undulating terrain.

Hassan and Coorg districts are in the upper catchment area at an elevation of 1000 to 2000m amsl, whereas going eastwards the average elevation of the rest of the Mandya Plateau is around 545 m to 620 m amsl. In the Chamarajanagar district the average elevation is around 370-660m. The slope is towards east and the delta regions in the east in Tamil Nadu have an elevation of 300 to 600 m amsl. Further eastwards, land slopes merge very gently into the sea with an average elevation < 300m amsl.

### 2.5. Soil

Soil types vary across the basin but the red soils are the predominant category followed by black soils. The highland areas which fall in Karnataka have lateritic soils, reddish brown in colour. These soils are shallow, acidic to neutral and are fertile, good for agricultural practices. Red Loamy soils are found in the eastern slope of Western Ghats.
Study area

and upper reaches of the Karnataka basin area around Krishna Raja Sagar and also entire Vrishabhavathi valley. Low lands and plains of Karnataka have reddish brown soils which are neutral to acidic and are well drained. In some lowlands though, the soils are neutral to weakly alkaline, have higher water holding capacity.

2.6. Biodiversity

The Cauvery river basin area have a large floristic wealth enough to constitute as a separate phyto geographic unit. The vegetation of entire peninsular India excluding Western Ghats is adequately represented in this tract alone. Infact, the basin includes nearly every type of vegetation of Deccan, east of Western Ghats. The known flora of the basin comprises 2037 species from 990 genera belonging to 180 families. The Cauvery river system harbors 1050 species belonging 128 families. 504 herbs (48%), 270 shrubs (25.7%), 170 trees (16.2%) other plant forms like climber, twinners etc constitutes 10% (Jayaram, 2000).

The Cauvery river basin from headwater reaches to outlet exhibits remarkable habitat heterogeneity. The river is reserved by guilds of fish species. Headwater support more endangered fish which is confined to rock stream types having high gradients and predominantly bedrock substrates (Smakhtin et al., 2007; Lakra et al., 2010). The riparian zone in the sacred landscape provides habitat for wildlife such as Asian elephants (*Elephas maximus*), Otter species (*Amblonyx cinereus*) (near threatened) (Shenoy, 2005), Endangered Nilgiri languar (*Trachypithecus johnii*) (Sunderraj and Johnsingh 2001), Indian civet (*Viverricula indica*), Lion-tailed Macaque (*Macaca silenus*) and so on. The forest landscapes here act as corridors for wildlife, as they are in contiguous with large protected areas such as Nagarabhole National Park, Talacauvery, Brahmagiri and Pushpagiri Wildlife Sanctuaries.

The river bordering the Cauvery Wildlife Sanctuary has a population of otters, crocodiles and many varieties of fishes along with the famous Masheer. This area is the breeding ground for a number of reptilian species like crocodiles, turtles, python, cobra, russell’s viper, banded krait and masheer fish besides wild boar, barking deer, four-horned antelope, green-billed malkoha, white-browed bulbul, pigmy woodpecker. Around 1000 elephants (*Elepha maximus*) graze through this division from Muthathi to Hogenekkal falls. It also provides connectivity to Biligiri Rangan Hills Temple (BRT)
Sanctuary and Mudumalai Tiger Reserve, which are in conjunction with Mysore–Nilgiri corridor (largest population of Asian elephants is found here) (Sukumar 1989).

2.7. Climate

A part of the river basin receives rain from the South-West monsoon, and a part from the North-East monsoon. Bhagamandala (Kodagu district), in the Cauvery basin receives an annual rainfall of 603cm. Most rainfall of the Kodagu (Coorg) district is due to the South-West monsoon that occurs between June and September. The river basin in Mysore and Mandya districts located in the rain shadow area receive relatively a less rainfall of 60 to 100cm. The retreating monsoons bring rain to the western part of the basin between October and December. The day temperatures in the Cauvery basin vary roughly around 30°C except for some parts in Kodagu district where the temperatures are below 20°C at higher elevations.

Twice in a year the wind direction reverses with the alteration of seasons which is a major feature. From June to September the wind blows from the southwest over most of the stations in the basin, while during October through December the direction turns northeast and east.

With the rise in temperature, very deep low southeast trade winds develop and these on crossing the equator, become monsoon winds. They flow from Southwest and West and hitting against Western Ghats, shed copious rains of 200 to 400 cm, and in some places more than 400 cm. The upper reaches of Cauvery have 3 places (Bhagamandala, Makut and Pulingoth) out of the 14 heavy rainfall stations of India. This area contributes a large quantity of water to the Cauvery river system and its tributaries Amaravati, Bhavani, Kabini, Harangi, Hemavathy and Lakshmanatheertha. Maximum relative humidity recorded is in July (Jayaram, 2000).

2.8. Land use

Population density in Cauvery is more than the world average (350 people/km² against world’s average of 42 people/km²). The population growth is also 2.5 times the rate of the world’s population growth as a whole which could be visualized as a major threat to the vast native forests in the basin and their disappearance in the nearest decades (Smakhtin, 2006).
Land use in the basin can be divided into four categories; arable, non arable, forest land and land for habitation. More than 50% of the land area in the basin is arable that implies that it can be cultivated. About 21.6% of the land is non arable. Total forest cover in the basin comes is 19.53% and the rest of the area is inhabited.

**i) Agriculture**

More than 60% of the total population in the basin lives in rural areas and their major occupation is agriculture. The land under cultivation in the basin is 48%. Around 24% of the cultivable area has some means of irrigation or other.

**ii) Forest cover**

Out of the total area of the basin, the area under forest is just 19.53% representing roughly 18% of total basin area in Karnataka. The minimal forest cover is in Kodagu and Mandya districts. Forests have been and are under great stress because of the ever increasing demand for the forest products. About 526.955 Sq.mt of reserve forest was found in the lower part of Cauvery basin covering three districts Chamarajnagar, Bangalore rural and Mandya. Totally, 9 reserve forests (Table 3) exist in the riparian forest of river.

**Table 3. State Forests of the study area.**

<table>
<thead>
<tr>
<th>Name of the Forest</th>
<th>District</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basavana betta</td>
<td>Chamarajanagar</td>
</tr>
<tr>
<td>Chilandavadi</td>
<td>Chamarajanagar</td>
</tr>
<tr>
<td>Muggur</td>
<td>Chamarajanagar</td>
</tr>
<tr>
<td>Chikkayellur</td>
<td>Chamarajanagar</td>
</tr>
<tr>
<td>Madheshwara</td>
<td>Chamarajanagar</td>
</tr>
<tr>
<td>Dubare</td>
<td>Chamarajanagar</td>
</tr>
<tr>
<td>Ayyengeri State Forest</td>
<td>Chamarajanagar</td>
</tr>
<tr>
<td>Doddapulikote State Forest</td>
<td>Chamarajanagar</td>
</tr>
<tr>
<td>Kaveriammana sacred groove</td>
<td>Chamarajanagar</td>
</tr>
</tbody>
</table>

Champion and Seth (1968) classified the forests in the study area as

1. The Southern Moist Deciduous forests found in the areas receiving less than 200 cm of rainfall.

2. The Southern Tropical Dry Deciduous forest type occurring in Mysore and Mandya districts at an altitude varying from 650 m to 1200 m.
3. Southern Thorn Scrub forests found in the low lying areas of the hills especially in the Kollegala plateau.

4. Evergreen, semi evergreen and moist deciduous forests in Kodagu belt of Western Ghats.

2.9. River usage

Krishna Raja Sagara Dam and Mettur Dam, and those on its tributaries such as Banasura sagar Dam on a Kabini River tributary etc., store water from monsoon and the same are used. The primary uses of Cauvery are providing water for irrigation, household consumption, industries and the generation of electricity (Varunprasath and Daniel, 2010).

2.9.1 Irrigation

Over 90% of the river water is abstracted for irrigation. Water for irrigation is also abstracted through wells, bore wells, canals, tanks and lifts.

More than 12,000 ha of the land are irrigated in Mysore, Chamrajnagar and Tumkur districts. In Mandya and Mysore districts cultivable land is irrigated by canals. Lift irrigation is used mostly in Chamrajnagar and Bangalore rural area district.

2.9.2 Urban Consumption

Domestic uses, both urban and rural make around 6% of the total water use in the basin. Urban centers like Bangalore and Mysore have highest demand for domestic water and, some demand from commercial sector as well. The Torekadanahalli pump station sends 540 mld is located at around 100 km to Bangalore.

2.10. Nature of disturbance to riparian ecosystem in the study area

An intense biotic pressure on riparian forest can be observed through out the study area. The Riparian areas of lower stretch come under the protected area of Cauvery Wildlife Sanctuary (CWS) occupies an area of 526.96 km² and is set amidst the valleys with the river Cauvery flowing from Shivanasamudra to Hogenakkal falls. The CWS is listed as a protected area under section 18 of the Indian Wildlife Protection Act 1973. The large stretch of trees growing along the riverbanks offering various ecosystem services for wildlife (Manjunath 2001). The major portion of the sanctuary is surrounded by dry deciduous patches, and riparian forests during dry season assume a
very significant place for wildlife (Natta et al., 2003) particularly to otters and elephant herds. In the past few years, the sanctuary was distressed with various kinds of anthropogenic pressures due to the presence of touristic spots, pilgrimage centres, cultivation of crops and human-inhabited places (Shenoy et al., 2006).

The tourism potential is immense in this protected area due to its proximity to Bangalore city besides its natural scenery, mountain hillocks, fishing camp, river rafting and recreational features. Riparian forest in this area has been an integral part of the cultural and traditional parts of landscape. Pilgrims and tourists often camp on the riverbank and use the riparian areas for cooking and other ritual purposes thus increasing the pressure on the riparian forest. Shenoy et al., (2006) studied on smooth-coated otter (Lutra perspicillata) categorized as vulnerable’ by 2004 IUCN Red List, stating that thinning of bank vegetation has a detrimental effect on these populations.

Around fourteen villages in the sanctuary are totally dependent on river for their livelihoods. Human population is estimated to be around 8000 and cattle population is 6500. In addition there are a few shepherd camp grounds also. Tourism is the major factor affecting the Riparian habitats all along the fringes. The peripheral villages having substantial livestock population also influence the disturbances in riparian zone. Lantana sp., and Eupatorium sp., have invaded the Riparian areas and suppressed the natural regenerating of species and substantially reduced the growth of fodders for herbivores (Manjunath, 2001). Forest fire is common in this zone due to the accumulation of dry biomass. Mekedatu, Barachukki and Gaganachukki, have become popular forest and river-related tourism spots.

In the Agro ecosystem landscape the nature and quantity of disturbance to Riparian zone is severe. Most of the Riparian areas are converted in to agricultural fields, not more than 10m of riparian forest buffer are found in this area. Native vegetation has been replaced by plantations like Eucalyptus sp., Acacia sp., Coconut, Areca nut etc. The Riparian area has been encroached to give the impression that river bank has become part of agricultural land. This could be worse situation for the Riparian vegetation.

Also, numerous temples exist on the river bank. The ethnical tourism is also affecting the riparian zone. Various activities by the pilgrims in riparian areas like cooking food, washing and bathing etc., have spoiled the vegetation and environment.
Sand mining can be seen in several locations. Machineries are used in some places to lift sand from the river. This is affecting the riparian areas via mass destruction of river bank, creating infrastructures like roads and for constructing bunds on river banks.

The riparian areas in the upper stretch of River Cauvery in Kodagu District, a mountainous region located in the central part of the Western Ghats, has diverse vegetation with 80% of the geographical area under tree cover (Garcia et al., 2007). The Kodagu district is lauded under the IMFN (International Model Forest Network) due to its unique approach to forest conservation through community participation and management known as “Sacred Groves”, incorporating a broad range of forest values including social, cultural, economic and environmental concerns (Chandrakanth et al., 2010). For the past 30 years, the district has been the focus of a variety of farming activities, including crop plantations that has lead to a loss of 30% of species rich forest cover (Garcia et al., 2007), creating a more vulnerable and fragile ecosystem.

The district is the largest coffee producer in the country dates back to 18th century and has an international reputation as a prominent coffee-producing center (Farooqui, 2007). This anthropogenic pressure has led to forest cover dropping to 45% (Rameshaiah et al., 2002; Ambinakudige and Sathish, 2009) which is far lower than the 60% minimum required to be preserved in mountain regions according to the National Forest Policy, 1988. The river valley in this region also degraded in the past by shifting cultivation (Ramakrishnan et al., 2000), affecting biodiversity (Begum et al., 2009; Nikhil et al., 2010; Garcia et al., 2007). Smathkin et al., (2006), in their studies on Indian rivers, present a clear indication of the threat experienced by the riparian forest in this region due to expansion of crop plantation. Even under such extreme anthropogenic pressure, 70% of the habitats in the headwater streams of river Cauvery are still in intact (Mittemeier et al., 2003) as they enjoy legal protection.