INTRODUCTION

Conservation of biodiversity has become a major issue in the biosphere. Increase in population growth and development activities have put aside the biodiversity which at present day is getting less attention. Aquatic ecosystem has been an integral part of human development throughout history (WWAP, 2003). The association of man and aquatic ecosystem is ancient (Gopal, 2004). Past civilizations came up on river banks; the generations used rivers as a source of water and food (Tockner and Stanford, 2002; Dudgeon, 1992). The flood plains of the Indus, the Nile delta, and the fertile crescent of the Tigris and Euphrates rivers provided man with all his basic necessities (Ramachandra et al., 2002). They can be considered the pillars of human civilization as they have formed the nuclei for human settlements from the very origins of mankind (Welcomme, 1985).

Rivers from their source (head water) to the end point support a wide variety of unique habitats and represent the major array for biodiversity (Tockner and Stanford, 2002). Riverine flood plains and its corridors are among the Earth’s most distinctive landscape features, characterized by high biodiversity and productivity (Ward et al., 2002). As riverine corridors are related with seasonal flood disturbance, high productivity (Mitsch and Gosselink, 2000) and geomorphic heterogeneity (Wittmann et al., 2008), it preserves naturally high degree of floristic and structural diversity (NRC, 2002; Kewu et al., 2007). The vegetation in riverine corridors plays a considerable role in the ecological functioning of floodplain ecosystems (Zeug et al., 2008; Dudgeon, 1992). Flood plains are considered as centers of biocomplexity and bioproduction (Tockner and Stanford, 2002).

Despite their vital importance and our total dependence in the natural systems, indeed it is likely that rivers have suffered the single most intense destructive onslaught particularly during the past one century of human history (Dudgeon, 2008; Revenga and Kura, 2003; Burby, 2005). As years passed out this precious commodity has been used as a means of transport, as a defensive barrier, as a source of power, as a recreational source
and as a means of disposing of waste (Gopal, 2000). The human activity keeps affecting the aquatic ecosystem continuously up to its final dissipation into the sea from their origin in the mountains (Jyothi et al., 2003). Presence of irrigated agriculture, towns, cities and industrial sites along the river bank shows the dependence of human on river ecosystem. Such increasing developmental activities are dramatically affecting the floodplain habitat by alteration of hydrologic regime and degradation of natural landscape (Tockner and Stanford, 2002). Consequently, rivers are turned to one of the most threatened (Tockner and Stanford, 2002) and degraded ecosystems in the world (Biervliet, 2009; Petts, 1984). Globally, riverine flood plains covering > 2 x 10^6 km^2 are now facing increasing in human impact and continuing to disappear at an alarming rate (Tockner and Stanford, 2002; Ravenga et al., 2000) which strongly affect organisms that live in the river and riparian zone (Nilsson and Jansson, 1995).

1.1 Riparian zone

Riparius is a Latin word meaning "of or belonging to the bank of a river". The riparian zone is the place where aquatic systems merge with the terrestrial Environment. The anglicized term riparian refers to biotic communities on the shores of streams and lakes. The “United States Department of Agriculture Natural Resources Conservation Service” (USDA NRCS) defines riparian areas as ecosystems that occur along watercourses or water bodies.

They are distinctly different from the surrounding lands because of unique soil and vegetation characteristics that are strongly influenced by free or unbound water in the soil (NRC, 2002). Riparian zones have been reported as some of the most species rich and most productive systems (Naiman et al., 2005). Globally, riparian zones had become some of the most sensitive to human influence and potentially threatened ecosystems (Malanson, 1993). They are habitats of critical conservation concern worldwide, as they are known to filter agricultural contaminants, buffer landscapes against erosion (Kiley and Schneider, 2005) and provide habitat for high numbers of species (USDA-NRCS 2003; Schultz et al., 2004; Sabo et al., 2005) than adjacent up-land habitats within the same geographic location (NRC, 2002). This ecological site has certain habitats which are highly influenced
by water and considered as “hotspots” of diversity, often superseding that of the surrounding landscape (Goebel et al., 2003).

Only during the past two decades, riparian areas begun to receive legal recognition as places requiring special attention (NAC, 2002). The year ‘1985’ logically called “The Year of the Riparian” because of the great amount of agency and public attention that came into focus on riparian areas (William Anderson, 1987).

1.2 Plants life in riparian zone

The vegetation in riparian zone ranges from emergent aquatic and semi-aquatic plants through to terrestrial understorey and canopy species (Parsons, 1991). The vegetation in the riparian area commonly has characteristics of both aquatic and upland habitats. Many of the plants in the riparian area require plenty of water and are adapted to shallow water table conditions. Plants of the riparian forest have numerous morphological, physiological, and adaptations which suit them for life in high-energy and wet environments (Barker et al., 2002; Merritt et al., 2009). Adaptations by riparian plants include tree species growing upon large woody debris, species establishing upon mineral soils of the floodplain surface, and obligate hydrophytes growing in saturated or flooded soils. Morphological adaptations such as adventitious roots, stem buttressing, root and stem flexibility in riparian plants are response to either soil anoxia or unstable substrate conditions, or reproductive requirements (Parolin et al., 2009). The number of tree species adapted to long-term soil water logging along the streams is higher in the tropics than temperate regions (Dudgeon, 2008).

Water level patterns are critical for the successful establishment of new plants (both exotic and native species) following dispersal of seeds or other propagules by water, wind, animal vectors or other dispersal agents. Flow has been determined as primary factors for determining plant community composition and structure along the riparian zone (Blom et al., 1990; Ferreira, 1997). Flood disturbance is one process that can maintain high levels of biodiversity in riparian ecosystems, by creating spatial and temporal heterogeneity and allowing for co-existence of plants with a variety of life history strategies (Richter and Stromberg, 2005; Kewu, 2007). Many plant species depend particularly on the flow for dispersal of their propagules, a process referred to as 'hydrochory' (Nilsson et al., 1991).
Types of propagules include sexually derived seeds as well as vegetative fragments (mechanically sheared or physiologically abscised branch or root segments) that can re-sprout to result in asexual propagation. Propagative dispersals typically occur in a downstream direction along streams. Such dispersal by water is an effective adaptation of native plants but also provides a major mechanism for invasion by exotic weeds, of which noxious species can have severe ecological and economic impacts (Braatne et al., 2002).

Riparian habitats support diverse plant communities - for example, 78 species of Cyperaceae have been found along the banks of the River Ganges and its tributaries (Guha Bakshi et al., 1977) and are also sites of unusually high herpetofaunal abundance (Dudgeon 1992). Though some studies on vegetation had been carried out in riparian zone, demarcation of riverine forests from terrestrial forests is less clear, and floristic analyses of strictly riparian vegetation in the tropical forest regions are rare (Dudgeon, 2008).

1.3 Importance of riparian vegetation

Riparian vegetation provides a valuable service to the environment. The riparian zone is a good indicator of ecological condition of aquatic bodies because of their role or function in a river bank. Some important roles of riparian vegetations are

- Rivers combined with stream vegetation and root systems in conjunction with other herbaceous vegetation dissipate stream energy, resulting in less erosion and a reduction in flood damage (Eric, 1998). A 5 cm deep root system resists erosion up to 20,000 times better than bare soil stream banks. A woody rootmat is the "re-bat' of stream banks.

- Riparian forests act as a buffer between the upland and the river in the lower reaches. It avoids a sediment input to stream water by trapping the sediments in the bank, there by replenishing the soils and building a stream banks.

- It filters pollutants from surface run off coming from agricultural fields and enhances water quality (Kileyand Schneider, 2005).

- The riparian canopy provides organic matter via litter fall; surfaces of submerged leaves are sites of primary and secondary production by micro algae and bacteria,
which can rival that of phytoplankton and bacteriofili in water column (Amitha, 2003).

- The vegetation of the riparian zone is of fundamental importance in maintaining the low Eh (soils should be anaerobic or low oxidation-reduction potential (Eh) at least part of the year, for maintaining a characteristic of riparian zones such as species composition of vegetation and processes such as denitrification.
- Riparian vegetation reduces solar heating of stream water by shading, especially in low order streams (Nancy et al., 2004).
- The Logs of riparian vegetation play an important role in the dynamics of stream morphology and serve as substrates for biological activity by microbial and invertebrate organisms (Nancy et al., 2004; Gloss et al., 2004).
- On land the riparian stream ecosystem is the single most productive type of wildlife habitat (Robert et al., 1997). The Riparian areas act as a corridor for big game migratory animals between summer and winter range.
- Due to the availability of water, shade, thermal cover, and the quality and variety of forage in the riparian areas cattle’s use to prefer these areas (Hannah, 1997).
- Agronomists prefer riparian areas for the development of agriculture because of the presence of fertile soil as a result of the occasional deposition of nutrient rich sediments from flooding rivers.
- Additional values of riparian areas includes hunting and trapping, fishing, wildlife observation and study, tourism, picnicking, and camping, fuel wood and lumber, water purification and honey production.

1.4 Threats to riparian vegetation

As human use more than half of the geographically accessible river runoff, their significant impact on the structure and functioning of riparian areas is not surprising (NRC, 2002). Explosive population growth in and around river basins has caused deforestation which in turn increased the sediment rich surface runoff and stream-flood flow (Subramanian, 2006). Construction of large and small dams and reservoirs for
irrigation and electricity generation has destroyed extensive areas of forest and riparian habitats in the catchments of major rivers of India. Many of the river banks have been turned into a holy pilgrimage centers affecting the continuity of riparian corridor. River bed is a reservoir for sand having a more economic value at present day. Over utilization of this resource results in the changes in the water regime where the flows are converted into stagnation. This avoids the cleansing and replenishing activity in the riparian zone caused by floods, as a consequence of which normal water regime changes and riparian areas get affected (Amitha, 2003).

Management of riparian sites and knotty problems associated with it is highly difficult especially in the developing nations where there is weak enforcement of laws. As such river flood plains are considered to be some of the most degraded and threatened ecosystems on the planet (Tockner and Stanford, 2002).

The following threats are most peril to the riparian forest

1.4.1 Invasion of alien species

Owing to frequent disturbances, riparian areas are particularly vulnerable to invasion by non-native plants (Miyawaki and Washitani, 2004; Pysek 1994; Planty-Tabacchi et al., 1995). The nutrient rich sediments of riparian zones induce the spread of non-native plants all along the corridor. The invasion of exotic species in the riparian zone is one of the most serious threats to biodiversity which alters the structure and composition of riparian vegetation where natural communities are further disturbed (Nilsson and Berggren, 2000) and leads to the displacement of native species (Miyawaki and Washitani, 2004).

1.4.2 Grazing

The primary effects of livestock grazing include the removal and trampling of vegetation, compaction of underlying soils, and dispersal of exotic plant species and pathogens (NRC, 2002). Heavy grazing or uncontrolled activities of livestock possess a serious threat to this fragile zone. It affects the species richness of vegetation (Suominen and Olofsson, 2000) by reducing the dominance of few plant species and thus increases the number of coexisting species (Pajunen et al., 2008; Suominen and Olofsson, 2000). Intensive grazing may hinder seedling establishment and reduces the regeneration power of trees thereby
affecting the productivity of a riparian zone (Austrheim and Eriksson 2001; Kauffman and Krueger, 1984). Without vegetation the area can become eroded to the point where it provides no benefit to the land, water or livestock.

1.4.3 Agricultural expansion

Human utilization of river flood plain for agricultural and farming activities is a long history. As flood plains regions are easy access resources of water and nutrient rich sediment, farmers to prefer these regions for agricultural and farming activities by removing the riparian forest. Conversion of riparian land to agriculture activities has the potential to decrease infiltration and increase overland flow volumes and peak runoff rates (NRC, 2002). Rice farming is a wetland-dependent activity commonly seen in riparian zones, river deltas and savannah. Of the estimated 58.2 million ha of wetlands in India, 40.9 million ha are under rice cultivation (MoEF, 1993).

1.4.4 Hydrologic alterations

Riparian areas are particularly sensitive to variation in the hydrological cycle and serve as good indicators of the environmental change caused by dam operations. Manipulation of the hydrologic regime via., the construction of dams and other structures, interbasin diversion and irrigation has served to disconnect rivers from their riparian areas. Variation in flow changes caused by dam operations will significantly changes the species composition of riparian forests (Nilsson and Berggren, 2000) including loss of native species (Cronk and Fennessy, 2000), shifts in vegetation structure (Bren, 1992) and mass invasion by exotic species (Glenn et al., 1998).

1.5 Status of riparian vegetation

The many deleterious consequences of changes to flow on the ecological diversity and functioning of river floodplain systems are now well documented and include declining biodiversity, water quality and floodplain area (Bayley, 1995; Tockner and Stanford, 2002). In Europe and North America, up to 90% of flood plains are already ‘cultivated’ and therefore functionally extinct. The Amazon River basin covering more than 6,100,000 km² or 44% of the land area of the South American continent facing constant pressure on
the region’s natural resources and in particular on residual native forests due to increase in percentage of population growth.

In Australia, poor management practices have fostered the substantial and ongoing degradation of riparian lands. Removal, fragmentation and alternation of vegetation cover, combined with changed flow regimes, have increased the incidence of riverbank erosion. Poorly managed riparian zones have also led to increased movement of sediments, nutrients and other contaminants from surrounding lands into river systems (Abernethy and Rutherfurd, 1999). Murray-Darling basin region in Australia is under pressure from high water demand, limited water availability, rising population and land use changes. Two-third of its 700,000 km² of woodlands have been converted to crop and pasturelands. Salinization of heavily irrigated soils and changes in the water table has reduced agricultural output by 20% besides decline of ecological health of the river basin.

In United States, riparian areas constitute a small fraction of total land area probably less than 5 percent. Loss of natural riparian vegetation is as much as 95 percent in United States indicating that riparian areas are some of the most severely altered landscapes in the country. A majority of riparian areas in the United States have been converted or degraded (NRC, 2002).

In the developing world, the now remaining natural flood plains are disappearing at an accelerating rate, primarily as a result of changing hydrology (Tockner and Stanford, 2002). Tropical Asian rivers are drastically transformed by human activities and are now considered as threatened ecosystems (Dudgeon, 1992). Data from Global Environmental Monitoring System (GEMS) water project initiated in 1996 by WHO, UNESCO, WMO and UNEP shows that Asia’s rivers are among the most degraded in the world. Riparian vegetation and gallery forest along tropical Asian rivers are also under threat (Johnsingh and Joshua, 1989; Dudgeon, 1995) affecting terrestrial animals which depend upon the riverine habitat during the dry season (Dudgeon, 1995) and would cause the demise of plant species associated with it. The floodplain habitats in India are threatened by overgrazing, deforestation, and land reclamation (Gopal, 1988). River Ganga has lost 80% of its original forest cover in its basin (Smakhtin et al., 2006). Riparian forests adjoining
stream and river banks have been almost entirely eliminated outside the protected areas (Madhav, 2004).

Several rivers in Karnataka had also lost their perenniality because of the damages done to catchments and riparian areas. Each and every first and second order streams have vanished and the rest have become seasonal. The net outcome is drinking water scarcity, erosion of river banks and lack of basic life supporting resources.

1.6 Legislations to protect riparian vegetation

1.6.1 Global legislations

The Land Act, 1994 is the principal legislation for the management of State-owned (Crown) lands, including leases, reserves etc., The QDNRM (Queensland Natural resource Management) administers this Act. Over 70% of the land in Queensland is State-owned. The Act places constraints on the clearing of trees in ‘critical areas’ on leasehold and other State-owned lands. Importantly, this includes riparian lands. A permit is required from the local QDNRM office to undertake clearing within a critical area, unless the clearing is for isolated trees as part of routine property maintenance, for example, replacement of fence posts, etc. Local Tree Clearing Guidelines are available to assist in determining whether or not the proposed clearing will be authorized.

Water Act, 2000 is the principal legislation for the protection of the ‘physical integrity’ of non-tidal rivers, lakes, springs and their riparian environments. ‘Physical integrity’ relates to bed and bank stability, and associated water quality. The Act applies to all lands (Crown and private) defined as being within the high banks of a stream or lake, as well as imposing limited controls on lands outside of these features and provides for protection against disturbances that may adversely affect the stability of bed and banks of streams and lakes like the clearing of native vegetation, excavation, and placement of fill.

Riparian Areas Regulation (RAR) in the province of British Columbia is a Provincial policy directive approved and ordered on July 27, 2004 under the Provincial Fish Protection Act (FPA). On March 31, 2006 a Provincial policy of Riparian Areas Regulation (RAR) came into the effect with the objective to provide protection for the features, functions and conditions that are vital for healthy water resource systems.
The government of the Republic of Benin, West Africa decreed a new forest law (no. 93-009) in July 1993 with the aim to prohibit the clearance of wood and shrubs within 25 m at both sides of any waterway.

1.6.2 Legislations in India


National Forest Policy 1988 enacted by Ministry of Environment and Forests in 1988. This is the principal legislation for the conservation of state and natural forests of the country. The act includes the Checking soil erosion and denudation in the catchments areas of rivers, lakes and reservoirs in the interest of soil and water conservation, for mitigating floods and droughts and for the retardation of siltation of reservoirs. The national goal of this policy should be to have a minimum of one-third of the total land area of the country under forest or tree cover. In the hills and in mountainous regions, the aim should be to maintain two-third of the area under such cover in order to prevent erosion and land degradation and to ensure the stability of the fragile eco-system. The policy includes the strategy of afforestation, social forestry and farm forestry like planting of trees alongside of roads, railway lines, rivers and streams and canals, and on other unutilized lands understate or corporate, institutional or private ownership. Schemes and projects which interfere with forests steep slopes, catchments of rivers, lakes, and reservoirs, geologically unstable terrain and such other ecologically sensitive areas should be severely restricted.

The laws on wetlands had given protective initiatives for riparian forest. Under the Ramsar Convention, riverine flood plains includes river flats, flooded river basins, fresh water swamp forest, seasonally flooded forest etc., are considered as a good representative example of wetland and identified for its conservation and management. India is also a signatory to the Ramsar Convention on Wetlands.
1.7 Scope of study

The Cauvery river basin area harbors a large floristic wealth enough to constitute as a separate phyto-geographic unit. The vegetation of the entire peninsular India excluding Western Ghats is adequately represented in this tract alone (Jayaram, 2000). The river basin is in human use since the beginning of the human civilization. Human activities within the river basin and surrounding landscapes have persistently stressed the riparian ecosystems in the Cauvery river basin. Population density in Cauvery is perhaps among the highest in the world (350 people per square kilometer; Smakhtin et al., 2006) indicating that potential for human disturbance is inevitable along the basin.

The increase in the rate of population growth and agricultural practices are the major threats to the vast native forests in the basin and their disappearance in the nearest decades (Cincotta and Engelman, 2000). As increase in population growth intensified demands keep putting pressure on these riparian areas for agricultural development, recreational uses, commercial development, housing development and others. Expansion of agricultural lands along the river banks has lead to encroachment of riparian forests particularly in the lower stretch of Cauvery river in Karnataka (Shenoy, 2005).

The riparian vegetation in Cauvery Wildlife Sanctuary (CWS) at lower reaches of river is very significant for wildlife during dry season, as major portion of the sanctuary is surrounded by dry deciduous patches. In the past few years, the sanctuary was distressed with several 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 peripheral villagers with substantial livestock population and no adjoining grazing land drive their cattle to the riparian areas for grazing. 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.

A study on the Algal flora (Somashekar, 1983), Mycoflora (Somashekar, 1983a), Phytoplankton (Chetana Suverna and Somashekar, 2000), riverine vegetation (Jayaram, 2000) and macro-invertebrates (Narayana and Somashekar, 2002) have been carried out in the Cauvery river basin. Nonetheless riparian tree vegetation studies along the Cauvery river basin in Karnataka stretch has not been fully understood, where evergreen belt of western Ghats has not been appraised so far (Chandran and Mesta, 2001; Amitha Bachan, 2001; Korse and Sunil, 2006). Smathkin et al., (2007), in their studies on Indian rivers, give a clear indication of the threat experienced by the riparian forest in the Western Ghats region by expanding of crop plantations. The river valley in this mountainous region is degraded in the past by shifting cultivation (Ramakrishnan et al., 2000), affecting biodiversity (Begum et al., 2009). 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. However, increasing life standard of the population around the basin has greatly modified the values and knowledge pertaining to Riparian forests.

Insignificant efforts have been to explore the riparian vegetation dynamics within and between the forest and agro ecosystem landscapes of the River Cauvery. Hence, the present study aimed to analyze the changes in structure, diversity and composition of riparian vegetation in different type of landscapes viz., forest and agro ecosystem.
1.8 OBJECTIVES

1. Assessment of species diversity, endemism and rarity of riparian forests along the River Cauvery stretch in Karnataka.

2. Assessing the regeneration status of tree species in riparian zone with respect to endemic species.

3. Study the vegetation structure of riparian forest through vertical profile diagram.


5. Document the anthropogenic disturbances along the Cauvery River. Evolve a management plan to protect residual pockets of riparian vegetation, towards their conservation.