INTRODUCTION
The tourism carrying capacity assessment (TCCA) has recently become an important prerequisite for sustainable tourism development. The tourism industry is a powerful economic system, commercially driven with adverse impact on many of the world’s protected areas. These impacts are related to resource consumption, pollution, unbridled development, and environmental degradation of natural areas and deterioration of the cultural heritage of the local population. Unless tourism is properly managed and regulated, it will literally consume the environments, which sustain tourism. The representative samples selected for carrying capacity study consists of Varkala – a coastal town, Vagamon – a hill station and Kumarakom – a back water tourism area in Kerala.

STUDY AREA
The areas selected for the present study include Kumarakom, Varkala and Vagamon in Kerala, India. Each of these has its own unique ecological and physiological characteristics. Kumarakom is a back water tourism destination; Varkala is a beach tourism destination whereas Vagamon is a hill station. Thus each has its own unique tourist attractions.

Varkala, a coastal town in Thiruvananthapuram district is a fast developing tourism destination, which is increasingly attracting many Indian and foreign tourists. The areal extent of the study area falls within 8° 71’ to 8° 78’ N latitude 76° 67’ to 76° 72’ E longitude. The main tourist attraction of Varkala is the 1.5 km long Papanasam beach backed by laterite cliffs, which attract many local and foreign tourists. There are a few mineral springs at the foot of the cliffs, which are known, for their medicinal properties.

Vagamon is located on the western fringes of Idukki district, bordering with Kottayam district. Vagamon, a relatively remote area in a sparsely populated region comprising mostly of pristine, unspoilt and natural landscape of a diverse nature and rich in endemic flora and fauna, falls within the Western Ghats, and has been identified as a biodiversity ‘hotspot’. Vagamon lies 1100 metres above sea level. It is an ideal tourist spot surrounded by the greenery of tea gardens, beautiful meadows, deep valleys and dales is enchanting hill station dotted with tea gardens will soon be the venue of one of Kerala's foremost eco-tourism projects. Hill areas are fragile eco-systems. Kerala Tourism in association with Adventure Sports and Sustainable Tourism Academy (ASSTA) organises international paragliding festivals at Vagamon, which brings international and national glider pilots to Vagamon and some of the heaviest turnout of visitors.

Kumarakom, located on the eastern bank of Vembanad Lake in central Kerala is a fast developing tourist centre. The area falls within 9° 33’ & 9° 40’ N latitudes and 76° 22’ & 76° 30’ E longitudes. Kumarakom, located 16 km west of Kottayam town, lies on the shore of the Vembanad Lake. The village of Kumarakom is a cluster of little islands on the Vembanad Lake, and is part of the
Kuttanad region - the rice bowl of Kerala. House boating is the main attraction of Vembanad Lake. Vembanad lake was identified as one of India’s Important Bird Areas (Islam & Rahmani, 2004).

PRESENT WORK
The present study focussed mainly on the tourism carrying capacity of Varkala, Vagamon and Kumarakom. The seasonal variation of physico-chemical factors and bacteriological count in water were assessed. The flora and fauna of the respective study areas has been documented. Various impacts of tourism on the study areas were also assessed.

SCOPE OF THE STUDY
Kerala has emerged as the most acclaimed and ‘must see’ tourist destination not only just in the country but also in the world, in the recent years. Kerala has bagged the award for best performance in tourism for three consecutive years (2000-2002). To quote from the Tourism Vision-2025 of the Dept. of Tourism, Kerala (2001) ‘The strength of Kerala tourism is its excellent natural resources in the form of backwaters, hill stations and beaches. Having understood the need for looking into the sustainable development of these destinations, Kerala tourism focuses on the conservation of ecology to reduce the negative impact of tourism on the environment and intend to promote development of tourism based on the carrying capacities of the destination’. This Ph. D. study on Carrying Capacity could indicate the limit or the threshold for the tourism development and will also indicate methods to be followed for the development of sustainable tourism in select Tourism areas. This might be the first piece of Ph. D. work on Tourism Carrying Capacity reported from Kerala. It is hoped that the Dept of Tourism and the Government of Kerala would implement the recommendations that emerge from the study.

OBJECTIVES
1. To assess the carrying capacity of Varkala, Vagamon and Kumarakom.
2. To analyze the environmental, socio-cultural and economic impacts of tourism with special reference to the area under investigation.
3. To evolve a ‘sustainable developmental strategy’ of tourism, focusing on the Kerala scenario.

METHODOLOGY
Carrying capacity is ‘the maximum level of visitor use an area can accommodate with high levels of satisfaction for visitors and few negative impacts on resources’ (McNeely and Thorsell, 1987). WTO recommended a formula (Boullon, 1985) for estimating tourist carrying capacity. Estimation of boat carrying capacity was carried out based on the methodology formulated by Holly E. Bosley (2005).

For assessing the carrying capacity, the ecological, economic and socio-cultural characteristics of the area should be analyzed. The floral components were collected and identified with the help of regional floras and taxonomic experts. The vegetation data were quantitatively analyzed for abundance, density and frequency (Curtis and McIntosh, 1950). The importance value index (IVI) for the tree species was determined as the sum of the relative frequency, relative density
and relative dominance (Curtis, 1959; Muller-Dombois and Ellenberg, 1978). Relative frequency, relative density and relative dominance were determined (Philips, 1959). Similarity between two vegetation types was determined (Sorenson’s index of similarity) (Sorenson, 1948). Data were analyzed for species richness (SR) (Kershaw, 1973), density (D) (Odum, 1971; Whittaker, 1965), species diversity index (H) (Philips, 1959; Shannon and Wiener, 1963), concentration of dominance (Cd) (Shannon and Wiener, 1963), Hill diversity (Hill, 1973), evenness (J) (Simpson, 1949) and abundance/frequency (A/F) ratio (Pielou, 1966; Curtis and McIntosh, 1950a). Alpha (α) biodiversity (or phytodiversity) and Beta diversity (β) was computed. The identification of endemic plants of the study area was done with standard books such as Endemic Plants of the Indian Region (Ahmedulla & Nair, 1987), Red Data Book of Indian Plants (Nayar & Sastry, 1987, 1988, 1990), Hot Spots of Endemic Plants of India, Nepal and Bhutan (Nayar, 1996) and Flowering Plants of Kerala (Sasidharan, 2004). The list of threatened and endangered species was complied according to the IUCN checklist 2006. The faunal diversity was assessed during the period 2008-2010. Secondary data was also collected for the above mentioned categories.

Physico-chemical and bacteriological parameters of water samples were analyzed as per standard methods prescribed in APHA. Statistical analysis was carried out using Statistical Package for Social Sciences (SPSS 11.0 Version). The Landuse/Land Cover (LULC) map for 2010 was prepared using IRS-P6-LISS-III data. The change in the extent of different landuse categories during the period 1969 and 2010 was also detected. Socio-economic survey was conducted among tourists, local residents, resort owners, auto and taxi drivers and shopkeepers to document their perception about tourism. SWOT analysis has been incorporated into the strategic planning model.

RESULTS

Varkala is a developing coastal tourism destination with a total area of 29.62 sq. km. (total land area - 25.3 sq. km. and kayal area - 4.32 sq. km). 64 plant species identified belonged to 34 families and wild terrestrial fauna comprising of amphibians, reptiles, aves and mammals. The aquatic fauna consists of some edible fishes with economic importance in foreign trade, and also some molluscs. Total 123 resorts and other accommodation facilities exist in and around the tourism sector of Varkala with total bed capacity estimated as 1969. Available beach area in peak tourism season is found to be 29,300 sq. m. and the carrying capacity of tourists in peak tourism season is 2930. The available beach area in offseason is only 8000 sq. m. and the carrying capacity in off season is around 800. The negative impacts of tourism in Varkala include increase in the cost of living, rate of pollution, traffic congestion and decline in tourism affects the repayment of loans whereas uncontrolled tourism affects the natural beauty of the area and affects local culture.

The total land area of the Vagamon comes around 104.3 sq. km, majority of the land area consists of open scrub. 286 floral species from 85 families were identified, of which 86 are endemic species. 112 species of butterflies belonging to five families, 22 species of mammals and 20 species of
reptiles were recorded during the study period. The lodging facilities in Vagamon consist of resorts, home stays and small lodges; the total bed capacity of all categories includes 102. The total recreational area available in Vagamon area is estimated as 72.88 sq. km. and the carrying capacity of the area is estimated as 365 tourists at a time. The impacts of tourism indicate threats to biodiversity including endemic species, increase in price levels, rental costs and property values.

The total study area of Kumarakom consists of 234.60 sq. km. The Vembanad wetland - associated with Kumarakom, supports 20,000 residential/migratory water birds and a good number of prawns, fishes and mangroves. The carrying capacity of Kumarakom refers to lake carrying capacity of boats because recreational boating is the major tourism activity in Kumarakom. The total lake area is 77.06 sq. km. from Kumarakom south to Thannermukkam barrage and canal area is 13.76 sq. km. But the usable lake area for sustainable tourism is only 64.82 sq. km. The optimum boat density for sustainable boat tourism comes around 10 – 50 acres per boats. Optimum number of boats at a time in the study area of the lake is 130 and the total carrying capacity of lake is between 780 and 1040. The total number of resorts surveyed in Kumarakom tourism area is 28 and the total number of home stays is 12, the maximum bed capacity in the Kumarakom tourism area is 1850. The major impacts of tourism in Kumarakom are increase in the cost of living, pollution rate, traffic congestion, wetland removal by land filling for tourism facilities and threats to biodiversity including migratory birds.

Based on the study major strategies for sustainable development of tourism destinations was developed.