2.1. Introduction

The Kochi city lies near the western coast of Kerala, the south-western state of India. It is the commercial capital of the state and is one among the five major ports of the country. Kochi port was formed in 1341, as a result of deposition of silt on the mouth of the harbor due to heavy floods (Benjamin, 1998). It is situated on the bank of Cochin estuary, (known as Kochi Kayal in local parlance), a part of Vembanad - Kol wetland system - the longest wetlands of South-India. Kochi is linked to the entire coastal stretch of Kerala through inland waterways. From 16th century, Kochi was colonized by various European powers. Portuguese was the first to arrive, followed by the Dutch and British. The population of the city is increasing at a fast rate due to local immigration stimulated by the commercial and industrial growth. Major developmental activities, in recent times include International Container
Trans-shipment Terminal (ICTT) at Vallarpadam, Liquified Natural Gas (LNG) terminal at Puthuvype and Metrorail having a stretch of 25.612 km. in length. The city is interspersed with backwater system and has dense mangrove vegetation on its fringes.

This profile traces the city’s metamorphosis as a European colony to a highly urbanized regional center and discusses its major environmental problems and concerns and a viable strategy to attain sustainable development.

### 2.2. Geographical Location

The Kochi City and the surrounding urbanizing area comprises about 330 Sq. km extending from 9° 49’ to 10°14’N latitudes and 76° 10’ E to 76° 31’E longitudes. Tourism has always been a major contributor to the prosperity of Cochin. Year by year, the number of tourists to this ‘Queen of the Arabian Sea’ keeps increasing. Kochi is geographically linked with the wetlands of Vembanad estuary. The Vembanad Lake and the surrounding geological formation are the fruit of all the major rivers of central Kerala, namely Chalakkudypuzha, Periyar, Muvattupuzha River, Meenachilar, Manimalayar, Pampa River and Achancoil River and lesser rivers like Keecheri, Karuvannur and Puzhackal. The silt and sand washed down by these rivers from the Eastern highlands originally sculptured the landscape of the coastal belt on either side of Cochin. The wetland system with its drainage basins cover an area of about 16,200 sq, kms, which is about 40% of the area of Kerala (James et al, 1996).
Map.2.1. Location map of Kochi
Map 2.2. Map showing the local governing bodies in the study area
2.3. Early History

Kochi Port was formed in 1341, when the heavy floods of that year silted up the mouths of the Musiris harbor and the surging waters forced a channel past the present inlet into the sea. The old merchants of Musiris shifted to Kochi as soon as the new outlet became more or less stable. As the harbour gained prominence, the then ruler of the region shifted his capital also to Kochi, giving further impetus to the growth of the town. The early settlement of Kochi was at Mattanchery, facing the protected lagoons in the east, which provided safe anchorage to country crafts in all seasons. Mattanchery was linked to the entire coastal stretch of Kerala through these inland waters. Thus gradually it grew into a busy settlement. Nicolo Conti recorded that, by 1440, Kochi was a city 5 miles in circumference and that Chinese and Arabs carried on brisk trade with the natives of this town.
Kochi finds its way into modern history with the arrival of Vasco da Gama in 1498 and the advent of European colonialism. In early 16th century, Mattanchery and Kochi regions had grown as important trading posts where merchants and sailors of various nationalities jostled. In 1663, the Dutch overthrew the Portuguese. The Dutch East India Company tried to persuade the local rulers into giving them monopoly in pepper trade. In this attempt, they came across varied interests of other forces viz. English and the French. For about hundred years Kochi thus became the center of political and commercial battle. In 1795, The British took over Kochi from the Dutch. Fort Kochi thus became British Kochi and it became a Municipality in 1866.

Kochi emerged as a major port city on the west coast in 1939 through the zeal and vision of Sir Robert Bristow. Under the direction of Sir Robert Bristo, the sand bar at sea mouth was cut open and a deep shipping channel was dredged to the backwaters. The spoil of the dredging was used to reclaim Wellington Island from the backwaters. Road connection to the main land on the west and road-rail connection to the east from the island was completed in 1940 when the Government of India declared Kochi as a major port. Wellington Island developed with its wharfs, quays and other infrastructure as terminal complex of transportation. Centered around the port facility grew several business and commercial establishments providing the economic base to the city. In order to streamline the municipal administration, the Kochi Corporation was formed in 1967, incorporating the three Municipalities (Fort Kochi, Mattanchery and Ernakulam), Wellington Island and few surrounding areas in the suburbs.

2.4. Demography

A unique demographical feature of Kerala State is that it is more or less a uniformly continuous, scattered city or town from north to south unlike other
dwelling concentrations interspersed with vast agricultural or barren lands found elsewhere in India. Various cities in the Kerala State accommodate only 2.90% of the urban population of India. A remarkable feature of urbanization in Kerala is that though the urban content of the state’s population is only 25.97%, Ernakulam is the most urbanized district in the state in terms of absolute number of urban population (14.77 lakhs) and the percentage of urban to total district population (47.56%) as per 2001 census (City Development Plan, Kochi, 2007). The population of Kochi goes on increasing at a fast rate due to immigration stimulated by the developmental activities. The population of Ernakulum town at the end of 19th century was below 20,000. From the beginning of 20th century, an explosive growth in population was observed. By the end of 20th century the population in the corporation area was 5,95,000 with a density of 5950/ sq.km. Human resource indicators such as education levels and literacy are unusually high throughout Kerala; the literacy rate is reported to be virtually 100%.

2.5. Physiographical Significance and Climate

Being a coastal district, majority of the Kochi region is within the low land regions of the state. The average altitude of the land is less than 1 meter above MSL. The whole of the land slopes gradually from east to west. The soil of the planning region can be broadly classified into two categories viz. alluvial and lateritic. The flat terrain of the central city with the low altitude interspersed with a network of canals provide link to the backwaters. The secondary canals in the city used to serve as natural drainage for flood waters, but today they are in an advanced stage of deterioration through silting and waste dumping and fail to serve their purpose. The wetlands are formed by the gradual leaching of dry land into the flood basins of the watercourse, canals and estuaries. They remain covered by water during rainy seasons, but
in summer they partially dry up and become suitable for paddy cultivation and aquaculture.

Tidal canals play a vital role in the surface water hydrology of Kochi. The vegetation is found to reveal remarkable zonation even within few tens of meters from the backwater system (Benjamin, 1998). In the waterward and landward edges of intertidal areas, vegetation is found to be exclusively mangrove species, whereas in the areas above the high tide level, remnants of mangrove species along with mesophytic vegetation are found to co-exist. Vegetation of the backwater shores (Mangrove and associated vegetation) exists in patches in the shorelines of the backwater system, particularly, in the intertidal areas. These plants, that once relentlessly protected the shores, are now being destroyed to residual remnant stands. The city hosts a bird sanctuary at its center. Mangalavanam Bird Sanctuary is a small mangrove area comprising of a shallow tidal lake in the centre with its edges covered with thick mangrove vegetation. It is considered as the ‘green lung’ of Ernakulam City, which is now polluted by many industries and motor vehicles (Jayson, 2001).

Kochi has a tropical climate with intense solar radiation and abundant precipitation. Like the rest of coastal Kerala, Kochi experiences warm climate with gentle prevailing winds and daily temperatures varying in the range 23 - 34° C. Annual temperature ranges between 20°C and 35°C (68–95°F). Coastal location along with its proximity to the equator results in a very low seasonal temperature variation with moderate to high levels of humidity. Humidity ranges from 65% and 95% with diurnal and seasonal variations and the average annual rainfall is 3,359.2 mm (Groundwater Board, Government of India, 2007). There are two distinct periods of higher than average rainfall from June to August and October to November.
2.6. Economic Growth and Landuse

The economy of the region emphasizes trade, including major exports of fish, prawns, coconut-derived fibers, tea, cashew kernels, and rubber. In addition, although the state of Kerala is not one of the heavily industrialized regions of India, the Cochin area is the site of the state's largest concentration of industrial activity. The special economic zone of Kochi zone includes 55 facilities producing food and agricultural products, chemicals, textiles, ceramics, latex products, wood processing, electronic hardware and software, biotechnology, and engineering. Eloor, situated 17 km north of the city, is the largest industrial belt in Kerala, with more than 250 industries manufacturing a range of products including chemicals and petrochemical products, pesticides, rare earth elements, rubber processing chemicals, fertilisers, zinc and chromium compounds, and leather products. *Ambalamukal industrial area is also within the city premises.* The per capita income of Cochin is about 25000 rupees/year (roughly $500 per year), which is above the state average. Land use in Kochi is diversified. According to the estimates of Greater Cochin Development Authority (GCDA), 78% of the land area of the Cochin Corporation is residential, followed by 9% for transport and communication, 3% for commercial establishments, 3% for industry, 6% for public and semi-public institutions, and 1% for open space (Development Plan For Kochi City Region, 2031). The percentage of residential land to the net dry land is 69.39% in the Kochi City Region. Considering the existing population (11,64,225 as per 2001 census) the gross residential density is 32 persons per hectare in the Kochi City Region. The gross residential density of Kochi City is 63 persons per hectare.
2.7. Major Developmental Activities

Major developmental activities of Kochi are ICTT, Metro Rail, Liquefied Natural Gas (LNG) Terminal, Kochi International Airport, Smart City, Info Park etc. ICTT is the first container trans-shipment hub in India. For close to two decades, the proposed development of a world class container transshipment terminal was under consideration of government of India. Several studies have clearly demonstrated the geographic advantage that Kochi enjoyed being strategically positioned in close proximity to the major global east-west trade routes. Creating a trans-shipment hub at Kochi is beneficial to both importers and exporters as an alternative solution to move their cargo at lower costs. The LNG terminal has been constructed and commissioned in August, 2013 and is currently operating at 8 percent capacity. Present transport facilities and infrastructure of Kochi are grossly inadequate for a developing city, resulting in wastage of time resources, fuel
and increased pollution level as per the traffic survey conducted by the corporation in 2011; peak cover peak direction traffic (PCPDT) in Kochi is 13,861. Annual growth in vehicles is around 12-13%. As a solution for the problem due to increased vehicular traffic, a Mass Rapid Transport System (MRTS), Metro rail started its construction in 2012. It is expected to be complete by 2016.

Smart city is a planned industry township for information technology and enabled services, media and bio-technology. It is a joint venture between the government of Kerala and Dubai, Technology Electronic Commerce & Media Free Zone Authority (TECOM). Info Park is an IT park promoted by the Government of Kerala, located at Kakkanad, Kochi. Kochi International Airport, situated at Nedumbassery on the outskirts of the city, has recorded the highest number of flights and passengers (international and domestic) in Kerala. Cochin port, one of India’s twelve major ports, is located in Wellington Island. It is an ISO 9001-2000 certified port administered by a Board of Trustees under the Major Port Trust Act 1963. As per Asian Development Bank (ADB) projection for G.D.P growth, traffic through Cochin Port could be over two million Twenty Foot Equivalent Units (TEUs) by 2012 and by 2022, it is projected to go up to 3.3 million TEUs.

2.8. Major Problems and Concerns

The most decisive problem faced by the city is the poor state of transport due to increased vehicular traffic and the lack of wide roads to accommodate the increased number of vehicles. In order to curb this problem a Mass Rapid Transport System (MRTS) - Metro Rail - will be commissioned in 2016. Solid Waste Management (SWM), which is an obligatory function of the Urban Local Body (ULB), is in a pathetic state resulting in problems of flood, water logging,
mosquito menace, sanitation and environmental and health related problems. Management of solid wastes and Sewerage system are critical environmental issues associated with high rise buildings and apartments. A solid waste management plant was commissioned at Brahmapuram, but was only a partial success. Air and water of the city are polluted significantly. Percolation of septic tank effluents and dispersion trenches pollute the ground water. Commercial wastes are mostly directed to open surface drains. Coastal aquifers in this area experience severe degradation of water quality due to various anthropogenic activities. The main driving forces of coastal pollution are pollution owing to population followed by discharge of industrial effluents, oil pollution, indiscriminate use of agricultural chemicals which damages the quality of river water and ending up as marine pollution.

Some of the problems faced by the city are geographic in origin. Kochi is crisscrossed by a network of canals that were earlier used for navigation. Today, these canals have been turned into wastewater drains. The canals show high levels of pollution, clogging due to weeds, disposal of plastics and other wastes, encroachment and filling of many portions of these networks, finally resulting in floods during the monsoon season. Development of the slums around narrow streets and sides of canals combined with the lack of awareness on hygiene create large scale environmental problems for the Corporation to deal with. Most of the low lands in the Corporation area were earlier used for paddy cultivation. These low lands have undergone large-scale reclamation, both legal as well as illegal encroachments and land filling.

2.8.1. Impacts of Global Warming and Climate Change

It is reported that there is already an increase of 2.2 mm annual rise in sea level in the coast of Kochi which will amount to 22 cms in the next 100 years. If it happens, millions of people would be forced to relocate; human
stress, anxiety and discomfort would be the result. International Panel for Climatic change (IPCC) in 1990, has predicted a 31 cm rise (lower scenario) in sea level induced by greenhouse warming, by the year 2100. Such a rise in ocean levels would cause the sea to move several meters farther inland thus permanently inundating a large area of the highly urbanised western flatland region of the study area (Benjamin, 1998).

2.9. Rationale for Selecting Kochi as the Study Area

Greater Cochin area, for one, falls in the grey area between land and ocean and the thick of the city is chronically plagued by water logging. Cochin is endowed with a fairly large estuary and an elaborate network of tidal canals. Such a complex and highly productive ecosystem is, at present, not effectively managed but subjected to severe exploitation. Increasing population and urbanization have far reaching impacts on the environment. At the same time ground water resources are heavily taxed to cope up with the burgeoning demand for fresh water. The municipal water supply fails miserably to meet the ever increasing demand of this fast growing city. Canals have already become a dumpsite of urban waste as well as drainage and untreated sewage. At present, the city of Kochi is subjected to serious anthropogenic interventions due to development activities in the mainland like urbanization, industrialization (both in the Corporation and adjoining areas), activities in the port, shipyard etc. Due to unplanned land use, impervious cover of the city is increasing which creates ground water shortage, water pollution and drainage problems. Major issues faced by the city are uncontrolled vehicular traffic, solid waste management, lack of developable land and problems due to pollution. Kochi is ardently trying for a planned sustainable development by framing policies that can curb the problems faced by the city. During the past decades, large areas of land have been reclaimed from backwaters and other wetlands to supplement the
developed land (P.T. Dipson et al, 2013). Deliberate steps and policies were taken to retain a part of agricultural land within the city to cater to the open space requirement of future population. Most of the problems faced by Kochi are due to unplanned development. Planned development of water fronts and canal system will make the city beautiful and good to dwell.

References

1. Alex, P.M., (2005), Salinity Intrusion and Seasonal Water Quality Variation in the Tidal Canals of Cochin, Ph. D Thesis, submitted to Cochin University of Science & Technology, p 65-71


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