CHAPTER - I

INTRODUCTION
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1.1 General

India is the second largest nation in the world, with a population of 1.21 billion, accounting for nearly 18% of the world’s human population. Its urban population grew at a rate of 31.8% during the last decade to 377 million, which is greater than the entire population of the US, the third largest country in the world according to population. India is facing a sharp contrast between its increasing urban population and available services and resources. It does not have enough resources or adequate systems in place to treat its solid wastes. Solid Waste Management (SWM) is one such service where India has an enormous gap to fill.

In recent years, the urban environment has become a major subject of concern. The process of rapid urbanization poses serious challenges to metropolitan cities, which are struggling to provide and maintain the already inadequate level of urban services. The major environmental problems faced by urban areas are air, water and soil pollution and growing volume of solid waste.

Until 1950 the solid waste disposal had not posed any problem. However during the period 1953-55, the spread of viral disease to hogs attracted the attention of several sanitary engineers and farmers. Since that time feeding garbage to hogs was banned in the USA, however in India feeding to cattle is still continued unabatedly. It is probably for the first time that scientific studies on refuse management were started and published in Chicago by the Public Administration Department (APHA, 1980). The EPA of the US published its
fourth report on the resource recovery from solid waste in 1977. After 1970, several people started working on this topic.

The volume of garbage in Indian cities is increasing. Indian cities and towns are estimated to generate about 80,000 metric tonnes of solid waste every day. Per capita solid waste generated is about 350-400 gm and in large cities it exceeds 500 gm. Only 60 per cent of this volume is collected, even less is transported and disposed off. Sanitary landfill or composting as methods of garbage disposal is limited to very few cities. In industrial areas of many cities, the municipal solid waste is getting mixed up with hazardous waste creating a serious problem, while the accumulation of garbage has become a common sight in most of the cities.

Till date segregation at source, collection, transportation, treatment and scientific disposal of municipal solid waste is largely insufficient leading to degradation of the environment and the aesthetic quality of urban habitats. In many cities nearly half of solid waste generated remains unclear, giving rise to insanitary conditions especially in densely populated slums which in turn results in an increase in morbidity especially due to microbial and parasitic infections and infestations in all segments of the population. The waste handlers and the urban slum dwellers are the worst affected.

Improper disposal of solid waste pollutes all the vital components of the living environment (i.e., air, land and water). The problem is more acute in developing nations than in developed nations, as their economic growth as well as urbanization is more rapid. There has been a significant rise in MSW (Municipal Solid Waste) generation in India in the last few decades with respect to rapid population growth and economic development in the
country. Due to rapid urbanization, the management of solid waste poses a difficult and complex problem for the society and its improper management gravely affects the public health and degrades environment. This trend can be ascribed to our changing lifestyles and change in living standards. Solid waste management has been one of the neglected areas of urban management activities in India. In cities and towns hardly 50 per cent of the solid waste generated are collected, transported and disposed off, giving rise to insanitary conditions and diseases, especially amongst the urban poor who constitute about 35 per cent of the urban population.

Improper solid waste management causes environmental pollution, accelerates natural resources degradation, causes climate change and greatly impacts the quality of life of citizens.

1.2 Significance of the Study

The more civilized we get, the more waste we generate. Ever since the rapid growth in civilization has been witnessed, the complexity of waste generation and its management have been increasing. However, countries all over the world have developed their own strategies to combat their waste management issues and have been successful. Population, infrastructure and regulation are the three main factors that play a significant role in achieving an Integrated Waste Management (IWM) are interrelated. In India, though the waste management policies and regulations are in place, their effective implementation fails due to the growth in population at an alarming rate and ineffective implementation plans.
Municipal solid waste management is limited to the collection, transportation and disposal of un-segregated waste. The dumps are filling up faster than we can even find newer sites for them. There is a need to have an Integrated Waste Management System (IWMS) that would provide sustainable solutions in our country. Garbage disposal has been a long-standing problem and will continue to be a future problem. It is therefore important to seek out the ways that can best be employed to minimize the amount of garbage. Shortage of land for waste disposal and inappropriate landfill site is one of the biggest problems in most large urban areas. Therefore more efforts are needed to overcome this problem. An inappropriate landfill site may have negative environmental, economic and ecological impacts. This is not a problem of the future but a problem of today.

The developing city, Kakinada still depends on the age-old mode of garbage collection and waste disposal methods. At present, 260 tonnes of garbage a day is being collected from the Kakinada city. It is being dumped in the unauthorized dumping yard at cheedelapora near saradamba temple - located amidst residential areas. Construction of a permanent dumping yard in the city is one of the long pending projects. The 150-year-old civic body failed to find a permanent solution to the garbage problem, as it is about the practice of identifying open lands to dump the litter.
1.3 **Aim**

Aim of the study is environment friendly site selection for municipal solid waste dumping in Kakinada city using remote sensing and Geographical Information System (GIS) techniques and to analyze the information of solid waste management with the view to protect the environment and public health.

1.3.1 **Objectives of the Study**

- To study the existing scenario of solid waste management in Kakinada city and to analyze the information on municipal solid waste, industrial solid waste and biomedical waste to evolve a strategic plan for future years.
- To create spatial digital database comprising base map, soil, slope, drainage pattern, land use / land cover, geology, geomorphology, ground water infiltration rate, watershed and transport network map with the help of LANDSAT satellite data and Survey of India toposheets along with limited ground truth, analysis of ArcGIS software.
- To evaluate multi overlay analysis for different digital thematic layers and to integrate them into a GIS environment for evaluating risk suitability and to find probable solid waste disposal sites in and around Kakinada based on the integrated study.
- To carry out route optimization – Shortest path analysis from collection point to the dumping site using Network analyst module using ArcGIS software.
- To suggest the alternate measures for solid waste disposal.
1.4. Thesis Outline

A brief description of the chapter's content is presented below.

**Chapter One** highlights the need for research in the field of SWM. The aim and objectives of the research are described. This chapter describes the study area and its demographics and meteorological characteristics.

**Chapter Two** reviews the main related topics of SWM such that definitions, land filling and other disposal methods and the Indian scenario and international scenario of SWM.

In **Chapter Three** the existing literature on selection of appropriate sites for developing a landfill, criteria to be considered and the role of remote sensing and Geographical Information System (GIS) in selecting a disposal facility in different areas of India and in different countries with different environmental settings is reviewed.

**Chapter Four** introduces and outlines the approaches and methodologies implemented to achieve the specific objectives of the study and the overall goal of the research.

**Chapter Five** presents the results. It describes the existing scenario of solid waste management in the study area. It describes the design and implementation of an expert system for facilitating the multi-disciplinary approach of identifying solid waste landfills using GIS and multicriteria decision analysis techniques. Shortest pathway analysis from collection point to the dump site using network analyst module was carried out using ArcGIS software.

**Chapter Six** describes the summary and conclusions of the research with recommendations.
1.5 Description of the Study Area

1.5.1 Introduction

India, officially the Republic of India, is a country in South Asia. It is the seventh largest country by area, the second-most populous country with over 1.2 billion people and the most populous democracy in the world. The population of India, in the beginning of the twentieth century, was only around 238.4 million. This has increased by fourfold in a period of one hundred and ten years to reach 1210 million in 2011.

Andhra Pradesh (A.P) is situated on the country's southeastern coast. It is India's fourth largest state by area and fifth largest by population. Hyderabad is the capital city and the largest one. On 1st November 1956, the States Reorganization Act formed Andhra Pradesh by merging Telugu-speaking areas of Andhra State. The state is organized into three united regions: Telangana, Coastal Andhra and Rayalaseema. Andhra Pradesh lies between 12°41' and 22°N latitude and 77° and 84°40'E longitude and is bordered by Chattisgarh, Maharashtra and Orissa in the north, the Bay of Bengal in the east, Tamil Nadu to the south and Karnataka to the west.

The state accounts for 7.0 per cent of the total population in the country (Census, 2011). The population of Andhra Pradesh more than quadrupled in the last century from 19.1 million in 1901 to 84.7 million in 2011.

Andhra Pradesh is referred to as the Rice Bowl of India. Agriculture is the main occupation of about 62 per cent of the people in Andhra Pradesh. Rice is a major food crop and staple food of the state contributing about 77 per cent of the food grain production. Other important crops are Ragi, Jowar, Bajra, Maize, small millets, pulses, Castor, Cotton,
Sugarcane and Tobacco (Ministry of Agriculture, 2004). Forests cover 23 per cent of the state's area. Important forest products are teak, eucalyptus, cashew, casuarinas, bamboo, softwood, etc. The production of food grains in the state for the first time since the formation of the state is recorded at 20.40 million tonnes in 2008-09 as against 19.82 million tonnes in 2007-08. Andhra Pradesh has promoted 102 Special Economic Zones (SEZs) of which 64 have been notified by the Government of India.

1.5.2 Location and Extent

1.5.2.1 Introduction

Kakinada is a city and a municipal corporation in the Indian state of Andhra Pradesh. It is located 465 kilometers east of the state capital, Hyderabad. It is also the headquarters of East Godavari district. It is nicknamed "Fertilizer City", "Pensioner's Paradise" and “Second Madras”. The city had an urban population of 312,275 in 2011, making it the sixth largest city by area and the ninth largest city by population in Andhra Pradesh. It is spread over an area of 190 km². Kakinada is part of a Special Economic Zone (SEZ) and a proposed "Petroleum, Chemical and Petrochemical Investment Region (PCPIR)". It is a hub for all the deep sea exploratory activity in the region due to its deep-water seaport and its proximity to the gas fields.

To cater the recreational activities of the people in this coastal town, the Andhra Pradesh state government has taken up an interactive to develop the beaches between the Fishing Harbour and the Uppada village for the recreational and coastal development activities. Kakinada is one of the intermediate ports in Andhra Pradesh. The state government is interested to develop the port in order to increase its export/import
capability round the year. For the purpose, construction of deepwater port, establishment of fishing harbour and construction of the breakwater are some of the events that have taken place in the recent years. Nagarjuna fertilizers Ltd., Bharat Petroleum Corporation Ltd., Godavari Fertilizers, Southern Power Generation Ltd., etc., are some of the other major industries established in this region.

The Kakinada Bay is about 11 km wide and shallow. The Coringa and the Gaderu estuaries join in the south of the study area, originate from Godavari river, drain a huge quantity of fresh water during July and October. Kakinada town is situated on the western side of this bay. An irrigation canal joins the bay on the western side of Kakinada town. The continental shelf of Kakinada is dominantly silted till 1.8 m depth of 9.4 m. The seafloor up to a distance of 3 km sand, from 3-20 km it is covered with clay and up to 20-30 km it is covered with shells. The outermost zone consists of clay, fine sand and shell fragments (Reddy and Mohan Rao, 1996). The region of interest for site selection includes all areas, which falls within the buffer distance of 30 km from the center of the Kakinada city. It is covered by toposheets No’s 65L1, 65L5, 65K4, 65K8 & K12 on 1:50000 scale. The location map of the study area is given in fig 1.1.

1.5.2.2 Geography

Kakinada is located at 16.93°N 82.22°E. The 82½ degrees East Longitude passes through Kakinada. It has an average elevation of 2 meters (6 ft) and many areas of the city are below sea level. The city has roughly a north-south orientation and is confined to a long narrow strip parallel to the sea coast. The length is around 15 km of the city but its average
width is around 6 km. It can be divided into two broad regions. The city in the South called Jagannathapuram is separated from the rest of the city by Buckingham canal.

The northern part consists of the more modern part of the city and its recent outgrowth. The eastern part is separated from coastline by an industrial belt, running north-south through the entire length of the city. The city is bordered in the south east by Kakinada bay and a marshy wetland, home to India's second largest mangrove forest and Coringa wildlife sanctuary. Gouthami, one of the branches of the mighty river Godavari, flows into the Bay of Bengal at this point.

1.5.2.3 Climate and Weather

Kakinada has a tropical savannah climate. The climate here remains hot and humid almost throughout the year with the weather becoming a little comfortable during the winter months. Summer season in Kakinada sets in by early March and continues till mid-July. During this time the temperature rises quite a bit. The average minimum temperature is around 35°C and the average maximum temperature is about 40°C, which is quite high. Humidity is around 80 percent, making the weather quite uncomfortable. End of May to early June is usually the hottest time here and during this time the maximum temperatures are around 38°C-42°C Celsius (Hand book of statistics, 2009).

Kakinada receives substantial rainfall during the monsoons and the place experiences both the southwest monsoon and the northeast monsoon. Although the place gets a fair share of seasonal rainfall from the south-west monsoon winds, the major part of its rainfall is brought on by the northeast monsoon which arrives between mid-October and mid-December. Kakinada gets an average annual rainfall of 1100-1150 mm. The months of
October and November get the maximum amount of rainfall and cyclones originating in the Bay of Bengal frequently hit the city.

Winter season in Kakinada is from December to February. During this season the weather is quite cool and temperatures range from a minimum of 20\(^0\)Celsius to a maximum of 30\(^0\) Celsius. January is usually the coolest month during which time the minimum temperatures are around 18\(^0\)-20\(^0\) Celsius. The best time to visit Kakinada is during the months of November to March when the weather is pleasant and humidity is relatively less.

Based on the Kakinada port information, most of the time, an average wind speed for this region does not exceed 19 km/hr. The average wind speed during the summer is 5 to 10 km/hr and in winter it is greater than 15 km/hr. Based on climatic table compiled for 30 years observations (1931 to 1960), 8 m above MSL at Kakinada, the wind speed is 9.125 km per hour in May in the SE-W and during June it is 10 km per hour in SE-W direction

**1.5.2.4 Demography**

As per provisional reports of Census India, a population of Kakinada in 2011 is 312,275; of which male and female are 152,606 and 159,669 respectively. The sex ratio of Kakinada city is 1046 per 1000 males (Census of India, 2011). The details of the population of the Kakinada municipal corporation are given in table 1.1 and the demography map of the study area was shown in Fig 1.2.
Table 1.1: Population Trends - Kakinada Municipal Corporation

<table>
<thead>
<tr>
<th></th>
<th>City</th>
<th>Kakinada</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>District</td>
<td>East Godavari</td>
</tr>
<tr>
<td>3</td>
<td>State</td>
<td>Andhra Pradesh</td>
</tr>
<tr>
<td>4</td>
<td>Country</td>
<td>India</td>
</tr>
<tr>
<td>5</td>
<td>Population as per 1991 census</td>
<td>2,79,980</td>
</tr>
<tr>
<td>6</td>
<td>Population as per 2001 census</td>
<td>2,96,329</td>
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<td>7</td>
<td>Population as per 2011 census</td>
<td>3,12,275</td>
</tr>
<tr>
<td>8</td>
<td>No. of households</td>
<td>82,588</td>
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<tr>
<td>9</td>
<td>Area (Sq.km)</td>
<td>30.51</td>
</tr>
<tr>
<td>10</td>
<td>Density of population (per sq.km)</td>
<td>10787</td>
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<tr>
<td>11</td>
<td>No. of Wards / Zones</td>
<td>50</td>
</tr>
<tr>
<td>12</td>
<td>Percentage of increase from 1991-2001</td>
<td>5.84</td>
</tr>
<tr>
<td>13</td>
<td>Percentage of increase from 2001-2011</td>
<td>5.11</td>
</tr>
</tbody>
</table>

Source: Kakinada Municipal Corporation

1.5.2.5 Geology and Hydrogeology

The Kakinada city is on the deltaic and flood – plain alluvium. No hard rocks are exposed and thus no sediment is from cliff erosion. The mud flats of the mangrove swamp on the eastern side of the city consist of muddy sediments having higher percentages of silt over clay. Extensive tidal flats are developed on the eastern side of the Kakinada city, which is a part of the western side of the Kakinada Bay along the gently, dipping sea coasts with significant tidal rhythms, where enough sediment is available under low wave energy
Fig. 1.2: DEMOGRAPHY MAP OF THE STUDY AREA
conditions (SubbaRao, 1967; Kalesha, 1980; Reddy and Rao, 1996). Beaches are attached to the land and aligned parallel to the shoreline on the east.

1.5.2.6 Flora and Fauna

Coringa sanctuary is located near Kakinada port around 20 km from Kakinada. The Coringa wildlife sanctuary is rich in flora and fauna. Dynamic ecosystem of this sanctuary constitutes of dense mangroves and lush vegetation makes this place evergreen forest. This is an excellent place for fishing and bird watching. One can get to see saltwater crocodiles, Pelicans, seagulls and other several species of animals.

The mangrove plants have been categorized into thirty-five species that belong to a group of 24 families. The mangrove plants have adapted themselves to the environment in which it grows. The sanctuary also has a heavy growth of shrubs and herbs. Numerous species of salt tolerant plant species constitutes its flora, which include tropical and subtropical floral species such as Rhizophora, Avincinia, Sonneratia aegiceros and others.

Mangroves normally occur between high water levels and near about mean sea level along the sheltered shores, estuaries, tidal creeks, backwaters, lagoons, marshes and mud-flats. Wherever conditions favour, the mangroves may form extensive and productive forests in the sheltered coastal lines. The mangroves contain a highly specialized community of plants associated with animal species which are not capable of surviving in any other situations. Mangroves occur in Andhra Pradesh in estuaries of Krishna and Godavari rivers.

The Coringa wildlife sanctuary also a collection of 125 species of birds that include the Crested Serpent Eagle, Scarlet Minivet, Indian Roller and Black capped Kingfisher,
Oriental Dwarf Kingfisher and White bellied Woodpecker. The Coringa wildlife sanctuary provides habitat for numerous endangered and protected species of animals and plants. The dynamic mangrove ecosystem of the Coringa wildlife sanctuary supports biodiversities such as Fishing Cats, Otters, Jackals, Estuarine Crocodiles, Sea Turtles, Sea Gulls, Pelicans, Storks, Herons, Snipes, Flamingos, to name only a few. However, the Coringa wildlife sanctuary is renowned for its salt water crocodiles.

1.5.2.7 Road Network

Good roads connect Kakinada with all the places within the state and the rest of the country. NH 214 from Kathipudi to Ongole (both on NH-5) passes through Kakinada. A couple of state highways connect Kakinada to Rajahmundry and other places within the district. There is a proposal to develop the road between Kakinada and Suryapet via Rajahmundry into a national highway which will reduce the distance between Kakinada and Hyderabad.