INVESTIGATION ON-OPTIMUM ROUTE COLLECTION FOR MUNICIPAL SOLID WASTE FROM COIMBATORE USING GPS AND GIS

PROJECT REPORT

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BONAFIDE CERTIFICATE

Certificate that this project report **"INVESTIGATION ON-OPTIMUM ROUTE COLLECTION FOR MUNICIPAL SOLID WASTE FROM COIMBATORE USING GPS AND GIS"** is the bonafide work of .... who carried out the project work under my supervision.

27/4/09

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EXTERNAL EXAMINER **INTERNAL EXAMINER**

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SYNOPSIS

The population outburst, coupled with rapidly changing lifestyle in urban and rural areas, has resulted in a substantial increase in the generation of Municipal Solid Waste (MSW) in our country over the last few years. The Municipal Corporation and council authorities are challenged with this problem of effectively managing the Municipal Solid Waste. Hence this project work focused on optimizing the collection routes of municipal solid waste treatment in coimbatore city using GIS and GPS.

The Geographic Information System (GIS) has been used to analyze existing maps and data, to digitize the existing sanitary ward boundaries and its to enter the data about the wards and disposal sites. The generated ArcGIS maps give the efficient information concerning static and dynamic parameters of the municipal solid waste management (MSWM) problem such as the collection point locations, MSW transport means and their routes, the number of disposal sites and their attributes

CHAPTER - 1
INTRODUCTION

1.1. GENERAL

The issue of poor solid waste management (SWM) is a challenge throughout the world, in both developed and developing countries. People always generate solid waste through their daily activities. This solid waste needs to be properly managed in a way that minimizes risk to the environment and human health, which means storage, collection and proper disposal. At the same time solid waste creates livelihoods for the urban poor in terms of employment and business.

Waste generally means 'something unwanted'. Its precise definition and scope however, differs from one country to another. Solid waste is all the waste arising from human and animal activities that are normally solid and that are discarded as useless or unwanted. The overall objective of SWM is to minimize the adverse environmental effects caused by indiscriminate disposal of solid wastes.

Important factors in the relationship between SWM and environmental pollution are reflected in the deterioration effect of waste management on the quality of environment and on human health, which are brought about through environmental media, i.e. air, water and soil. Similarly, in the waste management functional elements, namely discharge, collection, transport, treatment and final disposal, and illegal dumping may result in the pollution of air, soils and water bodies.

Since the early 1990s, many governments in developing countries have been showing a great deal of concern in improving urban SWM

This is because urbanizations and rapid economic growth in these countries have resulted in large increases in refuse output resulting in rapid depletion of landfill and poor performance of waste disposal systems that are used in these countries. Similarly, in the course of achieving proper SWM, a lot of efforts in many developing countries have focused more on collection and disposal and ignored waste recycling which can result in reduction of the waste quantities that will finally require disposal. With future trends of further economic growth, increase in population, higher standard of living and changing lifestyles, refuse output is expected to rise if no effort is made to minimize solid waste generation rates.

It is reported that in most cities, municipalities and towns in developing countries, SWM costs consume between 20% and 50% of municipal revenues. However, the waste collection service levels remain low with only between 50% and 70% of the residents receiving services and most of the disposal being unsafe. Further it is observed that the efficiency of collection of waste in urban areas of developing countries vary from 59% to 82% suggesting that a substantial amount of solid waste remains uncollected. Poor solid waste collection and disposal is a threat to public health and reduces the quality of life for urban residents.

Several approaches have been suggested in order to improve SWM in developing countries. Municipal solid waste (MSW) management is a global problem. Discovering how to utilize waste reduction and resource recycling programs effectively has become a priority in recent years. The increasing production of MSW has reached the point at which changes must be made, including the implementation of waste minimization programs. MSW minimization has been placed at the top of the solid waste management hierarchy. MSW minimization consists of two basic operations: sources reduction and recycling. To assess MSW management systems, a simple indicator to simulate the effects of MSW management systems across different regions was adopted. Assessment of an optimal waste disposal system should utilize a number of standard indicators.

1.2. WASTE COLLECTION SYSTEM IN INDIA

1.2.1. General

Until recently, environment was not an issue in a third world country like India and solid waste management was definitely not the prime concern of environmentalists and the government, when the awakening to the issue finally did happen. It is only in very recent times, when certain NGO'S started working and highlighting the pathetic state of municipal waste services provision in country, that the Indian decision makers realized the importance of this particular aspect of environmental management.

In India, the collection, transportation and disposal of MSW are unscientific and chaotic. Uncontrolled dumping of wastes on outskirts of towns and cities has created overflowing landfills, which are not only impossible to reclaim because of the haphazard manner of dumping, but also have serious environmental implications in terms of ground water pollution and contribution to global warming. Burning of waste leads to air pollution, which is equivalent to vehicular emissions at times.

In the absence of waste segregation practices, recycling has remained to be an informal sector working on outdated technology, but nevertheless thriving owing to waste material availability and market demand of cheaper recycled products. Paper and plastic recycling have been especially growing due to continuously increasing consumption levels of both the commodities. Composting-aerobic and anaerobic, both the options are available to the country for scientific disposal of waste in future.

However, India lacks well formulated guidelines and policy structure regarding waste management services, in the absence of which the municipal agencies have not been performing their duties in this aspect satisfactorily. Though, few rules are there within the various municipal acts, which govern the day-to-day running of these agencies, the same however due to lack of enforcement, have not served much purpose.

1.2.2. Waste collection services

In the absence of modernization and automization of waste management services, its various components, i.e. collection, transportation and disposal, continue to be labour-intensive activities in India. About 80% of the total budget of all municipal corporations is accounted for by the salaries of sanitation workers engaged in road sweeping and related activities. A survey of 159 cities conducted by the National Institute of Urban Affairs (NIUA) in 1989 [4] revealed that the waste collection efficiency in these cities varied from 66% to 77% and the national average was a poor 72.5%, as compared to the developed countries where the waste collection is almost complete except for the most rural areas.

Waste collection efficiency is a function of two major factors; manpower availability and transport capacity. Less than 10% of the 157 cities surveyed in 1989 had more than 2800 workers : million population which is an accepted benchmark of optimum workforce requirement, by most of the municipal corporations in India.

1.2.3. Waste characteristics

The composition of waste depends on a wide range of factors such as food habits, cultural traditions, lifestyles, climate and income etc. The variations due to such factors are found across different countries as well as across different regions within one country. The inter-regional variations are, however, not as marked as those across the countries. Variation also occurs within a region over the years as a consequence of economic and social changes.

India is no exception to this, and the data given in Table clearly shows the changes in the composition of Indian MSW over a time period of about 25 years.

Table: Physico-chemical characteristics of Indian MSW

Component	Percentage on wet weight basis	
	1971-73	1995
Paper	4.1	5.8
Plastics	0.7	3.9
Metals	0.5	1.9
Glass	0.4	2.1
rags	3.8	3.5
Ash and fine earth	49.2	40.3
Total compost-able matter	41.3	42.5

The most remarkable change is in the percentage of recyclables (plastic, metals etc.) which increased from 9.6% in 1971-73 to 17.2% in 1995 owing to changing lifestyles and the increasingly consummeristic attitude of the common man in the country. This increase has given rise to the phenomenon of rag-picking activity especially in the metro cities of the country

Where in the recycling units have mushroomed on the peripheral areas providing employment to thousands of unskilled labour. The organic matter has more or less remained the same, whereas ash and fine the organic matter has more or less remained the same, whereas ash and fine earth has decreased corresponding to the increase in recyclables. A shift in energy resources consumption from coal and wood to petrochemical-based products could be a plausible explanation for the ash and fine earth percentage decrease.

1.2.4. Waste disposal practices

In majority of urban centers in India, MSW is disposed by depositing the same in low-lying areas outside the city. Compaction and leveling of waste and a final covering by earth are rarely observed practices at most of these disposal sites. These low-lying disposal sites, being devoid of a leachate collection system, landfill gas monitoring and collection equipment, can hardly be called sanitary landfills and are more in the nature of dumping sites. Nearly all the Indian cities dispose of their waste by simple dumping and only about 9% practice the environment friendly way of disposal, namely composting.

Table: Waste disposal trends in India

Waste disposal method	1971(40 cities)	1991(23 cities)
Land dumping	Almost all	89.8
Composting	-	8.6
Others(pelletization, vermin-composting)	-	1.6

The Indian municipal waste can be broadly categorized into organic waste, recyclables and ash and fine earth. Of these three, the organic waste component has remained constant over the past many years at approximately 40% and is not expected to change much in absolute terms in the near future. However, the ratio between the other two components has changed in past years and is expected to change further, with the shift occurring in favour of recyclables. At the moment, the country has no policy on segregation of recyclables and hence these too, are dumped along with the organic waste.

1.3. WASTE COLLECTION SYSTEM IN COIMBATORE

Coimbatore city is divided into 72 wards and these wards are grouped in to 4 zonal committees. The municipal waste is collected from each ward and transported to the composting yard at Vellalore by municipal vehicles at regular intervals.

1.4. ABOUT THE PROJECT

In our project we have developed the shortest network for the collection of solid waste using GIS. Waste is an unavoidable by product of human activities. Economic development, urbanization and improving living standards in cities, have led to an increase in the quantity and complexity of generated waste. Rapid growth of population and industrialization degrades the urban environment and places serious stress on natural resources, which undermines equitable and sustainable development. Inefficient management and disposal of solid waste is an obvious cause of degradation of the environment in most cities of the developing world. Municipal corporations of the developing countries are not able to handle increasing quantities of waste, which results in uncollected waste on roads and in other public places. There is a need to work towards a sustainable waste management system, which requires environmental, institutional, financial, economic and social sustainability. There is no regularity in the collection and disposal of the solid waste in the corporation which leads to excessive fuel consumption.

The solid waste generated from domestic and commercial activities cause severe environmental problems and is threatening human health and life. It is in this view that the Ministry of Environment and Forest, Government of India, has enacted Municipal Solid Waste (Management &Handling) Rules in the year 2000, under the Environment protection Act, 1986. As per these Rules, all the municipal solid waste has to be managed scientifically and disposed off in an environmentally secured manner.

This project is proceeded by using the software ARCVIEW 9.3 and its subsidiary tool network analyst is used to find the shortest route between bins and the transfer station. This tool help us to generate the shortest network which ultimately helps in reducing fuel consumption and there improves the existing solid waste management practices in the

1.5 OBJECTIVES OF THE PROJECT

- To get base map (street map, toposheet, google maps)
- To get GPS data of bins and bench marks (latitude and longitude)
- To get the existing route map
- To digitize the base map using ArcView 9.3
- To optimize the existing route using network analyst

CHAPTER - 2

NEED FOR THE STUDY

The objectives of the study are to develop the shortest network for the collection of solid waste using GIS. The Geographic Information System (GIS) has been used to analyze existing maps and data, to digitize the existing sanitary ward boundaries and to enter the data about the wards and disposal sites. The generated Arc GIS maps give efficient information such as collection point locations, MSW transport means and their routes, and the number of disposal sites and their attributes.

The population outburst, coupled with rapidly changing lifestyle in urban and rural areas, has resulted in a substantial increase in the generation of Municipal Solid Waste (MSW) generated in our country over the last few years. The municipal corporation and council authorities are challenged with this problem of effectively managing the Municipal Solid Waste. At present, the municipality generates nearly 601 T of MSW every day.

Open dumping is the method followed by the local bodies for disposal of wastes. Wastes are dumped where lands are available. Open dumping is the method followed by the local bodies for disposal of wastes. Wastes are dumped where lands are available. There is a heavy paucity of land for the local bodies to build an individual treatment facility for their respective Municipalities. It is also desirable to have common waste collection and disposal systems and considering the above aspects, it has been planned to improve the existing solid waste management practices in Coimbatore.

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Hence in this work an attempt has been made for the engineered design of solid waste disposal using GIS.Network analysis in GIS is often used to find solutions to transportation problems by using either vector or raster models to represent the real world. There have been numerous studies done on which model is more effective for network analysis. The vector- based model appears to be more suited to analysis of precisely defined paths such as roads and rivers. The raster based model seems best suited for analysis of problems where paths are not pre-defined.People everywhere need to get somewhere else and are dependent on automobiles, buses, trains, subways, or airplanes to arrive at a final destination. Most people would like to arrive at a destination in the least amount of time, least number of stops, and lowest cost. Not only do these transportation issues concern individuals, but businesses and governments as well. Routes and networks are the interconnected features that are used for transportation and include highways, railways, city streets, rivers, transportation routes (transit, school buses, garbage collection), and utility systems (electricity, telephone, water, sewage). Networks are an important part of our everyday lives and analysis of these networks improves the movement of people, goods, services and the flow of resources.

CHAPTER – 3

REVIEW OF LITERATURE

A GIS based transportation model for solid waste disposal – A case study on Asansol municipality

M.K. Ghose –et-al() - Optimisation of the routing system for collection and transport of solid waste constitutes an important component of an effective solid waste management system. This paper describes an attempt to design and develop an appropriate storage, collection and disposal plan for the Asansol Municipality Corporation (AMC) of West Bengal State (India).A GIS optimal routing model is proposed to determine the minimum cost/distance efficient collection paths for transporting the solid wastes to the landfill. The model uses information on population density, waste generation capacity, road network and the types of road, storage bins and collection vehicles, etc. The proposed model can be used as a decision support tool by municipal authorities for efficient management of the daily operations for transporting solid wastes, load balancing within vehicles, managing fuel consumption and generating work schedules for the workers and vehicles.The total cost of the proposed collection systems is estimated to be around 80 million rupees for the fixed cost of storage bins, collection vehicles and a sanitary landfill and around 8.4 million rupees for the annual operating cost of crews, vehicles and landfill maintenance.A substantial amount (25 million rupees/yr) is currently being spent by AMC on waste collection alone without any proper storage/collection system and sanitary landfill. Over a projected period of 15 yr, the overall

Solid waste management in India: options and Opportunities

Krishna Mohan-et-al (May 1998) -In India, the collection, transportation and disposal of MSW are unscientific and chaotic. Uncontrolled dumping of wastes on outskirts of towns and cities has created overflowing landfills, which are not only impossible to reclaim because of the haphazard manner of dumping, but also have serious environmental implications in terms of ground water pollution and contribution to global warming. Burning of waste leads to air pollution in terms of increased TSP and PM10 emissions, which is equivalent to vehicular emissions at times. In the absence of waste segregation practices, recycling has remained to be an informal sector working on outdated technology, but nevertheless thriving owing to waste material availability and market demand of cheaper recycled products. Paper and plastic recycling have been especially growing due to continuously increasing consumption levels of both the commodities.

Composting-aerobic and anaerobic, both the options are available to the country for scientific disposal of waste in future. However, country also needs something in terms of policy and guidelines to enable the municipal corporations to run the waste services efficiently.

Life cycle assesment of municipal solid waste management methods:Ankara case study

O¨zeler D-et-al (oct 2005) -Different solid waste management system scenarios were developed and compared for the Municipal Solid Waste Management System of Ankara by using the life cycle assessment (LCA) methodology. The solid waste management methods considered in the scenarios were collection and transportation of wastes, source reduction, Material Recovery Facility (MRF)/Transfer Stations (TS), incineration, anaerobic digestion and landfilling. The goal of the study was to determine the most environmentally friendly option of MSWM system for Ankara. The functional unit of the study was the amount of solid waste generated in the system area of concern, which are the districts of Ankara. The life cycle inventory analysis was carried out by IWM Model-1. The inputs and outputs of each management stage were defined and the inventory emissions calculated by the model were classified in to impact categories; non-renewable energy sources exhausting potential, final solid waste as hazardous and non-hazardous, global warming, acidification, eutrophication and human toxicity. The impacts were quantified with the weighing factors of each category to develop the environmental profiles of each scenario. In most of the categories, Source Reduction Scenario was found to be the most feasible management method, except the global warming category. The lowest contribution to GWP was calculated for the anaerobic digestion process. In the interpretation and improvement assessment stage, the results were further evaluated and recommendations were made to improve the current solid waste management system of Ankara.

Household solid waste characteristics and management

Mohammad Sujauddin-et-al (June 2007) - Solid waste management (SWM) is a multidimensional challenge faced by urban authorities, especially in developing countries like Bangladesh. We investigated per capita waste generation by residents, its composition, and the households' attitudes towards waste management at Rahman Nagar Residential Area, Chittagong, Bangladesh. The study involved a structured questionnaire and encompassed 75 households from five different socioeconomic groups (SEGs): low (LSEG), lower middle (LMSEG), middle (MSEG), upper middle (UMSEG) and high (HSEG). Wastes, collected from all of the groups of households, were segregated and weighed. Waste generation was 1.3 kg/household/day and 0.25 kg/person/day. Household solid waste (HSW) was comprised of nine categories of wastes with vegetable/ food waste being the largest component (62%). Vegetable/food waste generation increased from the HSEG (47%) to the LSEG(88%). By weight, 66% of the waste was compostable in nature. The generation of HSW was positively correlated with family size($r_{xy} = 0.236$, $p < 0.05$), education level ($r_{xy} = 0.244$, $p < 0.05$) and monthly income ($r_{xy} = 0.671$, $p < 0.01$) of the households. Municipal authorities are usually the responsible agencies for solid waste collection and disposal, but the magnitude of the problem is well beyond the ability of any municipal government to tackle. Hence dwellers were found to take the service from the local waste management initiative.

Of the respondents, an impressive 44% were willing to pay US$0.3 to US$0.4 per month to waste collectors and it is recommended that service charge be based on the volume of waste generated by households. Almost a quarter (22.7%) of the respondents preferred 12–1 pm as the time period for their waste to be collected. This study adequately shows that household solid waste can be converted from burden to resource through segregation at the source, since people are aware of their role in this direction provided a mechanism to assist them in this pursuit exists and the burden is distributed according to the amount of waste generated.

Resident's concerns and attitudes towards Solid Waste Management facilities

B. Rahardyan-et-al (Nov 2003) -Because of limited space, the siting and construction of a new SWM facility is a big challenge in Japan. An SWM facility should be socially accepted as well as environmentally and economically sound. This study aimed to investigate people's concerns about SWM facilities and their attitudes towards such facilities. A questionnaire was designed based on literature reviews and was sent to residents in three municipalities with different backgrounds. The questions covered concerns on the impact of an SWM facility, management aspects, unfairness of facility siting, and attitudes to facility construction. Of the many concerns, "pollution and health effect" had the highest rating, followed by "reliability", "damage to nature" and "cost". The rating was different between municipalities, reflecting their geographic and social backgrounds. Using factor analysis, correlations among concerns were analyzed, and five principal components were extracted, namely "pollution", "nuisance", "facility management", "planning of facility", and "merit/demerit". Although obvious correlations were not found between individual items of concern and attitudes to construction of a facility, the discriminant analysis indicated dominant concerns of attitudes, but the disagreement between actual impact and citizens were found. As for attributes, the "opposed" attitude decreased for residents who had visited an SWM facility, even if they had only seen it from outside.

Collection and transportation cost of household solid waste in Kuwait

P.A. Koushki-et-al (March 2004) -The specific aim of this funded research project was to examine and evaluate the efficiency and the effectiveness of the municipal solid waste collection and transportation system in the State of Kuwait. The contract resources of the seven contracting firms, the annual contract budgets, and the district area and population of each service contract are presented. Service efficiency and effectiveness indicators for each collection/disposal contract are also computed and discussed. The cost of collection and transportation of household waste in Kuwait is also compared with those of a number of urban areas in other nations. The low energy and manpower costs are mainly responsible for the favorable cost of management, collection and transportation of residential waste in Kuwait.

Appraisal of solid waste collection following private sector involvement in Dar es Salaam city, Tanzania

Mengiseny E. Kaseva-et-al (Dec 2003) -This paper presents findings of a study, which was carried out in Dar es Salaam city to assess post privatization of solid waste collection and disposal. Prior to the assessment, fieldwork studies indicated that current solid waste generation rate in the city is 0.4 kg/cap/day and total waste generation is within the range of 2425 tons/day. This study also indicated that out of the total waste generated, a total of 957 tons/day is collected by the three city municipalities (231 tons/day or equivalent to 10% of the total generation), private solid waste collection contractors (592 tons/day or equivalent of 24.4%) and through recycling (134 tons/day or equivalent of 5.5%). These findings suggest that as a result of privatisation of solid waste collection activities in Dar es Salaam city, solid waste collection has improved from 10% in 1994 to 40% of the total waste generated in the city daily in 2001. The paper recommends that waste recycling and composting activities be encouraged since this approach is considered to

Assessing the demand of solid waste disposal in urban region by urban dynamics modelling in a GIS environment

Simone Leao-et-al (June 2001) -The twentieth century saw a dramatic increase in the production of urban solid waste, reflecting unprecedented global levels of economic activity. Despite some efforts to reduce and recover the waste, disposal in landfills is still the most usual destination. However, landfill has become more difficult to implement because of its increasing cost, community opposition to landfill siting, and more restrictive environmental regulations regarding the siting and operation of landfills. Moreover, disposal in landfill is the waste destination method with the largest demand for land, while land is a resource whose availability has been decreasing in urban systems. Shortage of land for landfills is a problem frequently cited in the literature as a physical constraint. Nonetheless, the shortage of land for waste disposal has not been fully studied and, in particular, quantified. This paper presents a method to quantify the relationship between the demand and supply of suitable land for waste disposal over time using a geographic information system and modelling techniques. Based on projections of population growth, urban sprawl and waste generation the method can allow policy and decision-makers to measure the dimension of the problem of shortage of land into the future. The procedure can provide information to guide the design and schedule of programs to reduce and recover waste, and can potentially lead to a better use of the land resource. Porto Alegre City, Brazil was used as the case study to illustrate and analyse the approach. By testing different waste management scenarios, the results indicated that the demand for land for waste disposal overcomes the supply of suitable land for this use in the study area before the year 2050.

Optimization of municipal solid waste management in Port Said – Egypt

M.F. Badran-et-al (Aug 2005) - Optimization of solid waste management systems using operational research methodologies has not yet been applied in any Egyptian governorate. In this paper, a proposed model for a municipal solid waste management system in Port Said, Egypt is presented. It includes the use of the concept of collection stations, which have not yet been used in Egypt. Mixed integer programming is used to model the proposed system and its solution is performed using MPL software V4.2. The results show that the best model would include 27 collection stations of 15-ton daily capacity and 2 collection stations of 10 ton daily capacity. Any transfer of waste between the collection station and the landfill should not occur. Moreover, the flow of the district waste should not be confined to the district collection stations. The cost of the objective function for this solution is 10,122 LE/day (equivalent to US$1716). After further calculations, the profit generated by the proposed model is 49,655.8 LE/day.

AN OPTIMIZATION PROCEDURE FOR MUNICIPAL SOLID WASTE DISPOSAL IN A SELECTED AREA

A. MAIORANO-et-al (June 2000) - In recent years, instead of the simple, often unsupervised landfill disposal, there has been a growing interest in waste management. The waste management includes several activities with the following priority: reduction, re-use, separate collection of recyclable materials, recycling at the plant level (collection of recyclable materials by pre-selection technologies), energy recovery and residue disposal in controlled landfill. In the field of energy recovery, waste to energy (WE) power plants is an unavoidable disposal measure at present and will continue, in the future, to be optimised with respect to emission and energy utilisation. Among the WE power plants, the combustion processes widely considered are the "grate" technology which could burn untreated refuses, or the "fluidised bed" technology which required an appropriate pre-selection of refuses and burns refuse derived fuel (RDF). In this paper a systematic procedure is developed to solve the municipal solid waste (MSW) disposal problem for a large territorial area with several municipal communities. For the specific area, the proposed procedure optimised the location and the capacity of the pre-selective plants and the WE power plant. The suggested approach is applied to provide a solution for the waste disposal problem in a large area of the Puglia region in Southern Italy.

Salha M. Kassim-et-al (May 2006) - The issue of poor solid waste management (SWM) is a challenge throughout the world, in both developed and developing countries. People always generate solid waste through their daily activities. This solid waste needs to be properly managed in a way that minimises risk to the environment and human health, which means storage, collection and proper disposal. At the same time solid waste creates livelihoods for the urban poor in terms of employment and business. This paper looks into one aspect of SWM, namely collection service. The importance of SWM is now recognised at international, national and community level. The Agenda 21 declaration of the United Nations [UN. (1993). The global partnership for environment and development: A guide to agenda 21 (pp. 88–94). New York: United Nations] addresses the issue of environmentally sound management of solid waste, with emphasis on the extension of solid waste service coverage to all urban and rural areas worldwide.

Contracting out of solid waste collection services to the private sector has emerged to fill the gap in service delivery. In 1991 the city was generating 1400 tonnes of solid waste per day out of which only 5% was being collected. Currently daily solid waste generation is estimated at about 2500 tonnes and approximately 48% of the total waste generated is collected. At present, privatisation covers 44 out of 73 city wards, and 451 active registered private companies are involved [Chinamo, E. B. M. (2003). An overview of solid waste management and how solid waste collection benefits the poor in the city of Dar es Salaam. Solid waste collection that benefits the poor, Dar es Salaam, Tanzania, Collaborating Working Group on Solid Waste Management in Low and Middle - Income Countries (CWG)].This paper presents the findings of a study that explored the households' perspective on solid waste collection services provided by the private sector. The study showed that the solid waste collection service by the private sector is greatly influenced by households' attitudes and behaviour. Their participation, demand for service, awareness, satisfaction level and views on cost recovery are important in the sector. The study concludes that the above factors would be superior if customers (households) were more involved in the planning and decision-making.

Trends and problems of solid waste management in developing countries:

A case study in seven Palestinian districts Issam A. Al-Khatib-et-al (Nov 2006) - There is a great interest in solving problems related to municipal solid waste (MSW) management in the Palestinian territory. However, few studies have been done to assess the extent of these problems and suggest the best alternative solutions. This study aims at assessing MSW conditions in the seven major districts in northern West Bank, Palestinian territory. The study focuses on comparing several MSW management elements (such as collection, budget, and disposal) in municipalities, village councils, and refugee camps in the studied districts and the problems faced by these institutions in handling the waste. It also provides information on MSW collection service availability and waste disposal practices in the districts studied. It was found that, although MSW collection service was available for 98% of the residents in the areas surveyed, no proper treatment or landfill procedure was followed for the collected waste in most of these areas. Instead, waste burning in open dumpsites was the most common practice. Moreover, due to inefficient collection of waste disposal fees from the residents, municipalities were forced to sometimes cut the collection service and reduce its labor force, especially in villages. The budget for MSW management was between 2% and 8% of the total budget of the municipalities studied, indicating a low priority for this issue.

Solid wastes generation in India and their recycling potential in building materials

Asokan Pappu-et-al (Sep 2005) - Presently in India, about 960 million tonnes of solid waste is being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Of this _350 million tonnes are organic wastes from agricultural sources; _290 million tonnes are inorganic waste of industrial and mining sectors and _4.5 million tonnes are hazardous in nature. Advances in solid waste management resulted in alternative construction materials as a substitute to traditional materials like bricks, blocks, tiles, aggregates, ceramics, cement, lime, soil, timber and paint. To safeguard the environment, efforts are being made for recycling different wastes and utilise them in value added applications. In this paper, present status on generation and utilization of both non-hazardous and hazardous solid wastes in India, their recycling potentials and environmental implication are reported and discussed in details.

CHAPTER – 4
ABOUT THE TOOL

4.1. THREE VIEWS OF GIS

Many have characterized GIS as one of the most powerful of all information technologies because it focuses on integrating knowledge from multiple sources and creates a crosscutting environment for collaboration. In addition, GIS is attractive to most people who encounter it because it is both intuitive and cognitive. It combines a powerful visualization environment with a strong analytic and modeling framework that is rooted in the science of geography. This combination has resulted in a technology that is science-based, trusted, and easily communicated across cultures, social classes, languages, and disciplines. To support this vision, GIS combines three fundamental aspects or views:

4.1. 1. The geo database view:

A GIS manages geographic information. One way to think of a GIS is as a spatial database containing datasets that represent geographic information in terms of a generic GIS data model— features, rasters, attributes, topologies, networks, and so forth.

GIS datasets are like map layers; they are geographically referenced so that they overlay onto the earth's surface. In many cases, the features (points, lines, and polygons) share spatial relationships with one another. For example, adjacent features share a common boundary. Many linear features connect at their endpoints. Many point locations fall along linear features (e.g., address locations along roads).

4.1.2.The map view

A GIS is a set of intelligent maps and other views that show features and feature relationships on the earth's surface. Various map views of the underlying geographic information can be constructed and used as "windows into the geographic database" to support query, analysis, and editing of geographic information. Each GIS has a series of two-dimensional (2D) and three-dimensional (3D) map applications that provide rich tools for working with geographic information through these views.

4.1.3.The geo-processing view:

A GIS is a set of information transformation tools that derive new information from existing datasets. These geoprocessing functions take information from existing datasets, apply analytic functions, and write results into new derived datasets. Geoprocessing involves the ability to string together a series of operations so that users can perform spatial analysis and automate data processing -- all by assembling an ordered sequence of operations.

There are numerous spatial operators that can be applied to GIS data. The ability to derive new information within a GIS analysis process is one of the fundamental capabilities in GIS.

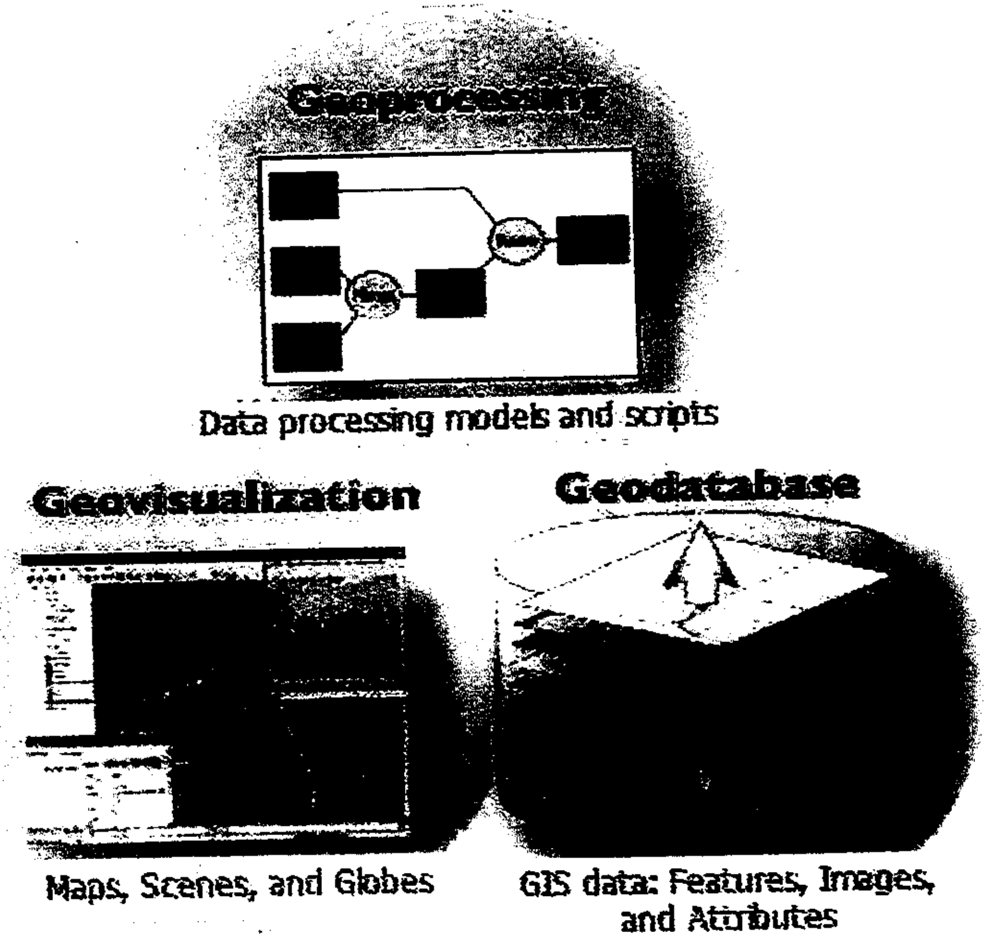


Figure 4.1.Three views of a GIS

These three GIS views are represented in ArcGIS by the catalog and the geodatabase (a GIS is a collection of geographic datasets), the map (a GIS is an intelligent map view), and the toolbox (a GIS is a set of geoprocessing tools). Together, all three are critical parts of a complete GIS and are used at varying levels in all GIS applications

4.2.COMPONENTS OF GIS

Software

- MapInfo Professional V 9.0
- ArcView GIS
- Network Analyst

Data

- Data Creation and Representation
- Data transfer
- Projections, coordinate systems and registration
- Spatial analysis with GIS

4.2.1. ArcGIS

ArcGIS is a complete system for authoring, serving, and using geographic information. It is an integrated collection of GIS software products for building and deploying a complete GIS wherever it is needed—on desktops, servers, or custom applications; over the Web; or in the field. .ArcGIS provides a complete set of tools for modeling geographic information to support smarter, faster decisions. It is used for

- Discover and characterize geographic patterns
- Model and analyze against all sources of geographic information
- Optimize network and resource allocation
- Automate workflows through a visual modeling environment

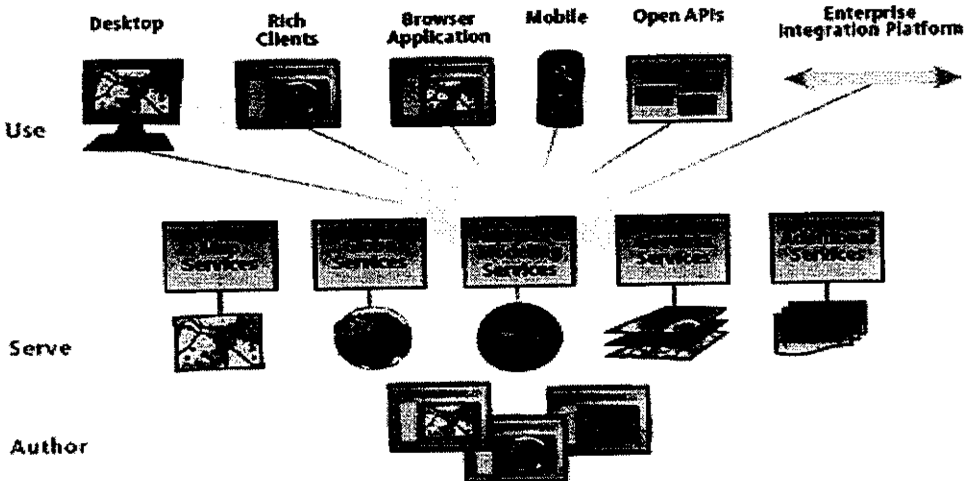
ArcGIS organizes and manages geographic information to support fast and efficient visualization and analytics applications, regardless of the amount of data held within your organization. Vast amounts of spatial information could be securely stored, managed and propagate data changes between multiple data sources. The geodatabase is the common data storage and management framework for ArcGIS. The geodatabase is the common data storage and management framework for ArcGIS and can be utilized wherever it is needed—on desktops, in servers (including the Web), or in mobile devices. It supports all the different types of data that can be used by ArcGIS such as:

- Attribute tables
- Geographic features
- Satellite and aerial imagery
- Surface modeling data
- Survey measurements

ArcGIS provides a complete suite of conversion tools to easily migrate existing geospatial data into the geodatabase. The geodatabase not only defines how data is stored, accessed, and managed, but it can also implement complex business logic such as

- Modeling of spatial relationships between data (e.g., topologies, networks, and terrains)
- Data validation (e.g., subtypes and domains)
- Long transactions (e.g., versioning

Figure 4.2 Enhanced features of Arc GIS



4.3.DATA CAPTURE

It is entering information into the system and there are a variety of methods used to enter data into a GIS where it is stored in a digital format. A digitizer produces vector data as an operator traces points, lines, and polygon boundaries from a map. Survey data could be directly entered into a GIS from digital data collection systems from a Global Positioning System (GPS). Global Positioning System (GPS), Megellan Explorer 2000 series model had been used to locate the Dumper Placer Bins Municipal authorities along with the study team identified the location of Dumper Placer Bins in each ward. How ever in this work, collection of waste in to Dumper placers had been designed and provided in suitable locations based on the quantity of waste collected, road width and availability of open spaces not creating nuisance to public and traffic. .Based on these data the requirements of bins was designed.

4.3.1.Working with GPS

- POWER button was pressed to turn the GPS unit on and the Status Page would appear
- GPS acquires satellites and Sky view will be displayed with Signal Strength Indicators.
- Once sufficient satellite signals have been acquired, the Position Page will appear.
- The graphic heading display indicates the direction heading (track)
- Next Trip odometer and the Altitude are indicated
- Next, Latitude and Longitude are displayed.
- Once the coordinates are determined, present position was marked by pressing the MARK button and the Mark Position page will

appear. The Coordinate of that location was saved by pressing the Enter button.

4.4. GEO-REFERENCING AND COORDINATE SYSTEMS

4.4.1. Georeferencing: Assigning map coordinates and spatial location

All the elements in a map layer have a specific geographic location and extent that enables them to be located on or near the earth's surface. The ability to accurately describe geographic locations is critical in both mapping and GIS. This process is called georeferencing.

Describing the correct location and shape of features requires a framework for defining real-world locations. A geographic coordinate system is used to assign geographic locations to objects. A global coordinate system of latitude-longitude is one such framework. Another is a planar or Cartesian coordinate system derived from the global framework.

Maps represent locations on the earth's surface using grids, graticules, and tic marks labeled with various ground locations (both in measures of latitude-longitude and in projected coordinate systems (such as UTM meters). The geographic elements contained in various map layers are drawn in a specific order (on top of one another) for the given map extent. GIS datasets contain coordinate locations within a global or Cartesian coordinate system to record geographic locations and shapes.

4.4.2.Latitude and longitude

One method for describing the position of a geographic location on the earth's surface is using spherical measures of latitude and longitude. They are measures of the angles (in degrees) from the center of the earth to a point on the earth's surface. This reference system is often referred to as a geographic coordinate system

Latitude angles are measured in a north-south direction. The equator is at an angle of 0. Often, the northern hemisphere has positive measures of latitude and the southern hemisphere has negative measures of latitude. Longitude measures angles in an east-west direction. Longitude measures are traditionally based on the Prime Meridian, which is an imaginary line running from the North Pole through Greenwich, England to the South Pole. This angle is Longitude 0. West of the Prime Meridian is often recorded as negative Longitude and east is recorded as positive. Although longitude and latitude can locate exact positions on the surface of the globe, they are not uniform units of measure. Only along the equator does the distance represented by one degree of longitude approximate the distance represented by one degree of latitude. This is because the equator is the only parallel as large as a meridian. (Circles with the same radius as the spherical earth are called great circles. The equator and all meridians are great circles.)

Above and below the equator, the circles defining the parallels of latitude get gradually smaller until they become a single point at the North and South Poles where the meridians converge. As the meridians converge toward the poles, the distance represented by one degree of longitude decreases to zero. On the Clarke 1866 spheroid, one degree of longitude at the equator equals 111.321 km, while at 60° latitude, it is only 55.802 km. Since degrees of latitude and longitude don't have a standard length, you can't measure distances or areas accurately or display the data easily on a flat map or computer screen. Performing GIS analysis and mapping applications requires a more stable coordinate framework, which is provided by projected coordinate systems.

4.5. ELEMENTS OF GEOGRAPHIC INFORMATION

There are some universal principles that provide the foundation for how GIS systems represent, operate on, manage, and share geographic information. The purpose of this topic is to provide you with a solid foundation for understanding these key concepts and how ArcGIS employs them.

Like a map, a GIS is layer-based. And like the layers in a map, GIS datasets represent collections of individual features with their geographic locations and shapes as well as with descriptive information stored as attributes.

There are four fundamental types of geographic representations:

- Features (collections or points, lines, and polygons)
- Attributes
- Imagery
- Continuous surfaces (such as elevation)

All of the rich GIS behavior for representing and managing geographic information is based on these fundamental types.

4.5.1. Features - Points, lines, and polygons

Geographic features are representations of things located on or near the surface of the earth. Geographic features can occur naturally (such as rivers and vegetation), can be constructions (such as roads, pipelines, wells, and buildings), and can be subdivisions of land (such as counties, political divisions, and land parcels).

Although there are a number of additional types, geographic features are most commonly represented as points, lines, and polygons.

Points define discrete locations of geographic features too small to be depicted as lines or areas, such as well locations, telephone poles, and stream gauges. Points can also represent locations such as address locations, GPS coordinates, or mountain peaks.

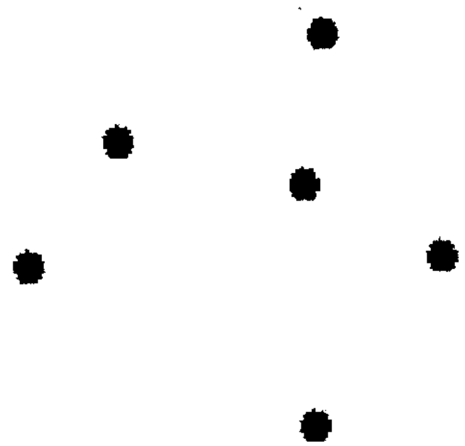


Figure.4.5

Lines represent the shape and location of geographic objects too narrow to depict as areas (such as street centerlines and streams). Lines are also used to represent features that have length but no area such as contour lines and administrative boundaries. (Contours are interesting, as you'll read later on, because they provide one of a number of alternatives for representing continuous surfaces.)

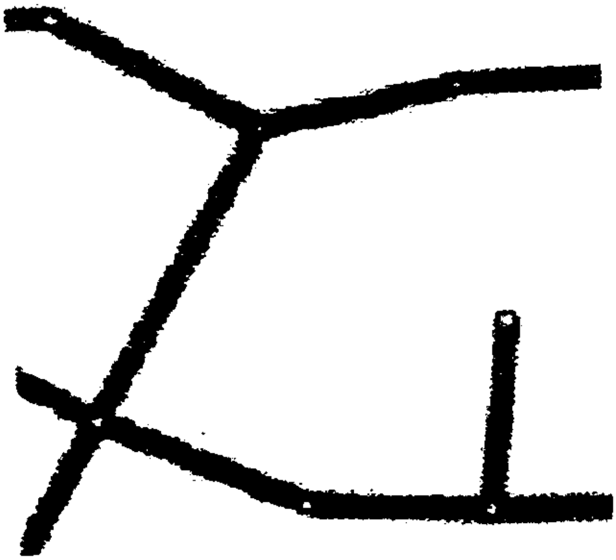


Figure 4.6

Polygons are enclosed areas (many-sided figures) that represent the shape and location of homogeneous features such as states, counties, parcels, soil types, and land use zones. In the example below, the polygons represent Parcels.

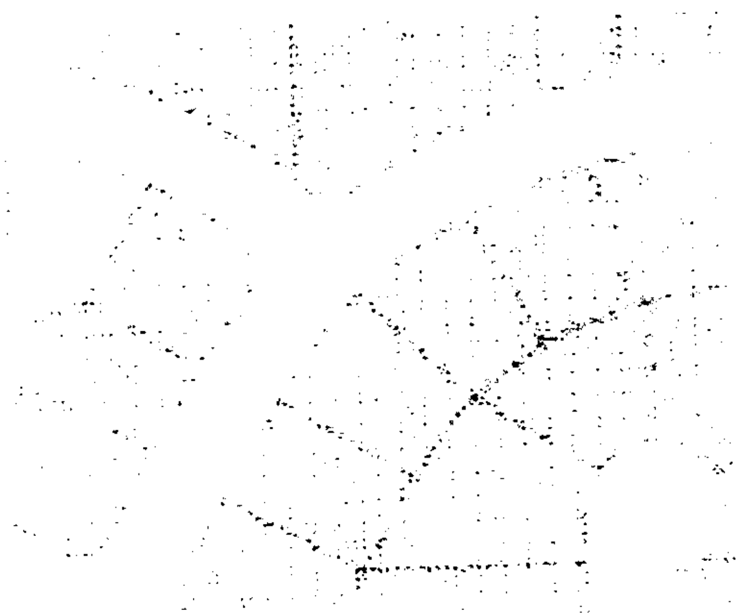


Figure 5.7

4.5.2. Attributes

Maps convey descriptive information through map symbols, colors, and labels. Here are some typical examples:

- Roads are displayed based on their road class (for example, line symbols representing divided highways, main streets, residential streets, unpaved roads, and trails).
- Streams and water bodies are drawn in blue to indicate water.
- City streets are labeled with their name and often some address range information.
- Special point and line symbols denote specific features such as rail lines, airports, schools, hospitals, and special facilities.

4.5.3.Imagery

Aerial imagery is a raster data structure obtained from various sensors carried in satellites and aircraft. Imagery is managed as a raster data type composed of cells organized in a grid of rows and columns. In addition to the map projection, the coordinate system for a raster dataset includes its cell size and a reference coordinate (usually the upper left or lower left corner of the grid).

These properties enable a raster dataset to be described by a series of cell values starting in the upper left row. Each cell location can be automatically located using the reference coordinate, the cell size, and the number of rows and columns.

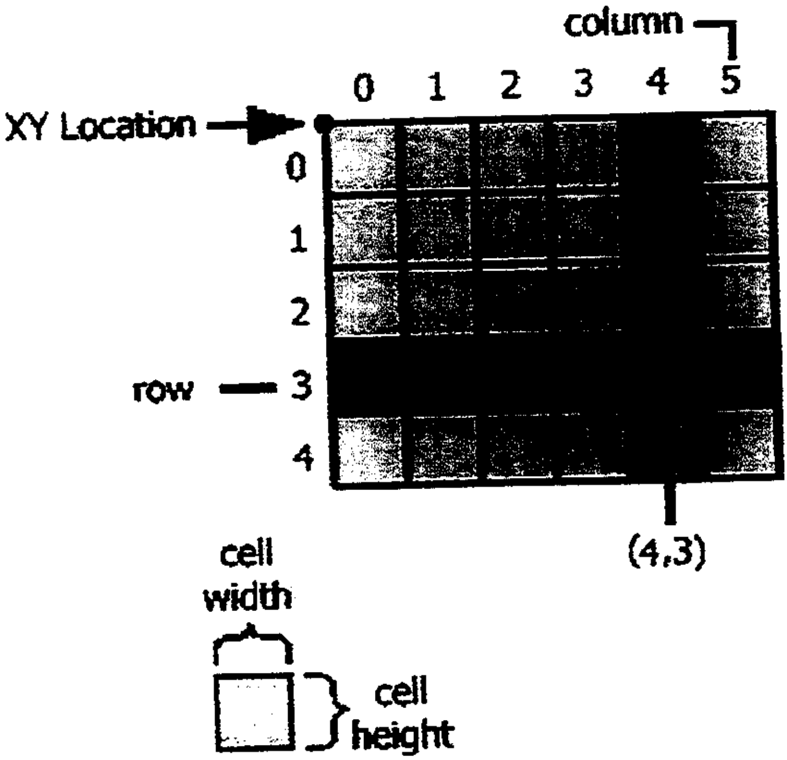


Figure 4.8.

4.5.4.Surfaces

A surface describes an occurrence that has a value for every point on the earth. For example, surface elevation is a continuous layer of values for ground elevation above mean sea level for the entire extent of the dataset. Other surface type examples include rainfall, pollution concentration, and sub-surface representations of geological formations.

Surface representation is somewhat challenging. With continuous datasets, it is impossible to represent all values for all locations. Various alternatives exist for representing surfaces using either features or rasters. Here are some example alternatives for surface representation:

Contour lines—Isolines represent locations having an equal value, such as elevation contours.

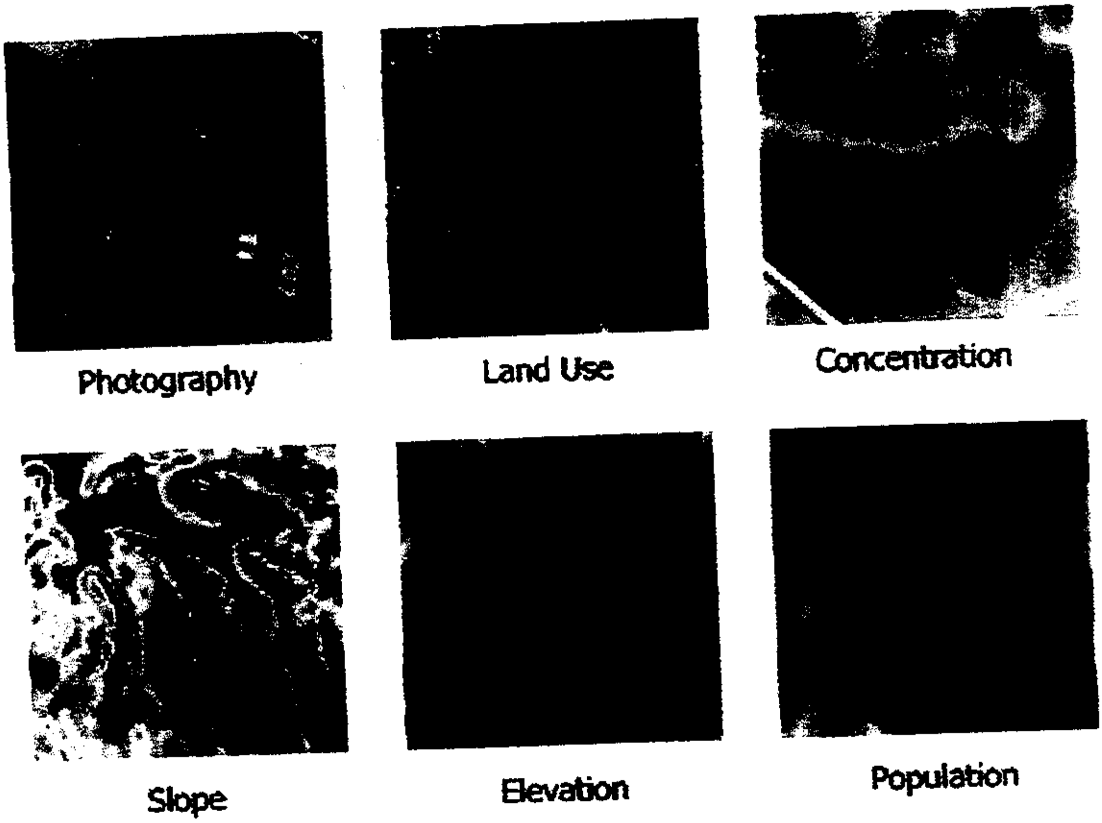


Figure 4.9.

Contour bands—The areas where the surface value is within a specified range, such as bands of average annual rainfall between 25 CM and 50 CM per year.

Figure4.10.

Raster datasets—A matrix of cells where each cell value represents a measure of the continuous variable. For example, Digital Elevation Models (DEMs) are frequently used to represent surface elevation.

Figure 4.11.

TIN layers—A Triangulated Irregular Network (TIN) is a data structure for representing surfaces as a connected network of triangles. Each triangle node has an XY coordinate and a Z or surface value.

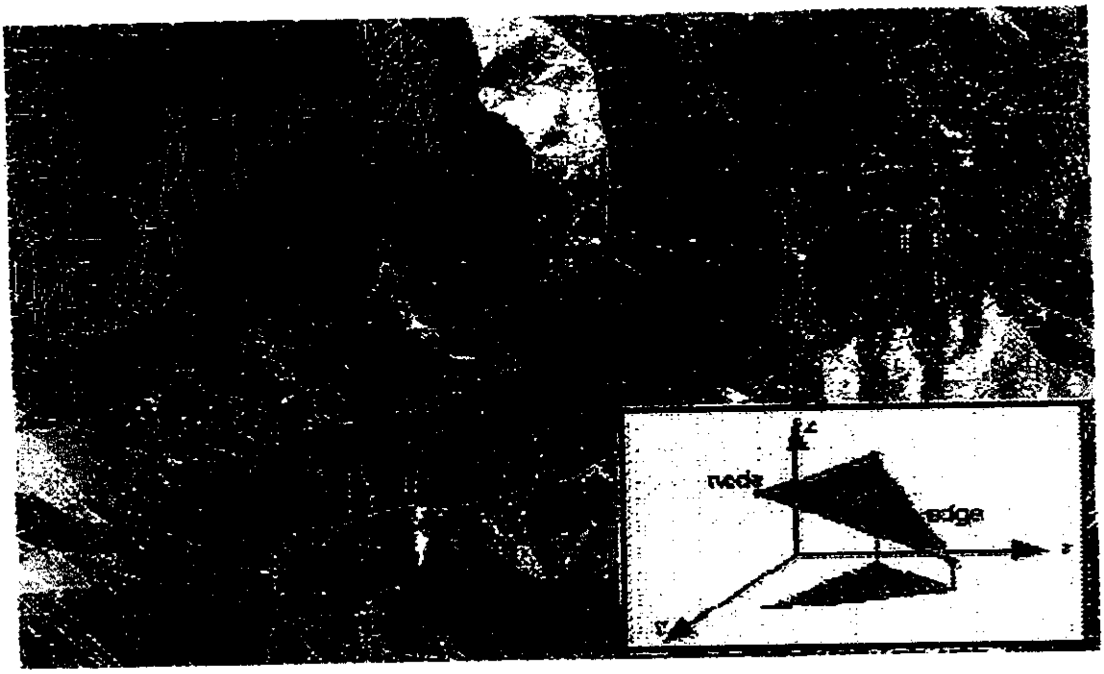


Figure 4.12.

The raster and TIN representations can be used to estimate the surface value for any location using interpolation.

4.6.MAPPING AND VISUALIZATION IN ARCMAP

The main application in ArcGIS is Arc Map, which is used for all mapping and editing tasks as well as for map-based query and analysis. A map is the most common view for users to work with geographic information. It's the primary application in any GIS to work with geographic information.

ArcMap represents geographic information as a collection of layers and other elements in a map view. Common map elements include the data frame containing map layers for a given extent plus a scale bar, north arrow, title, descriptive text, and a symbol legend.

There are two primary map display panels in ArcMap: the data frame and the layout view. The data frame provides a geographic "window", or map frame, in which you can display and work with geographic information as a series of map layers. The layout view provides a page view where map elements (such as the data frame, a scale bar, and a map title) are arranged on a page. You can learn more about data frames and map layouts below.

When you save a map you have created in ArcMap, it will automatically append a file extension (.mxd) to your map document name. All the maps you compose in ArcMap are saved to an ArcMap document file named with a .mxd extension. Map document files are managed in file system folders. You can work with an existing .mxd by opening it in Windows. This will start an ArcMap session for that .mxd.

You can also save a map layer definition as a .lyr file in ArcMap. This enables you to share layer definitions and display properties with others.

Working with toolbars—ArcMap includes a set of toolbars that organize a broad set of tools for working with maps and their contents. Tools can be used to navigate around maps (for example, pan and zoom, and select features), edit features, and compose map layouts for printing.

Map printing and graphics export—ArcMap also has a printing engine for printing maps from small to very large formats.

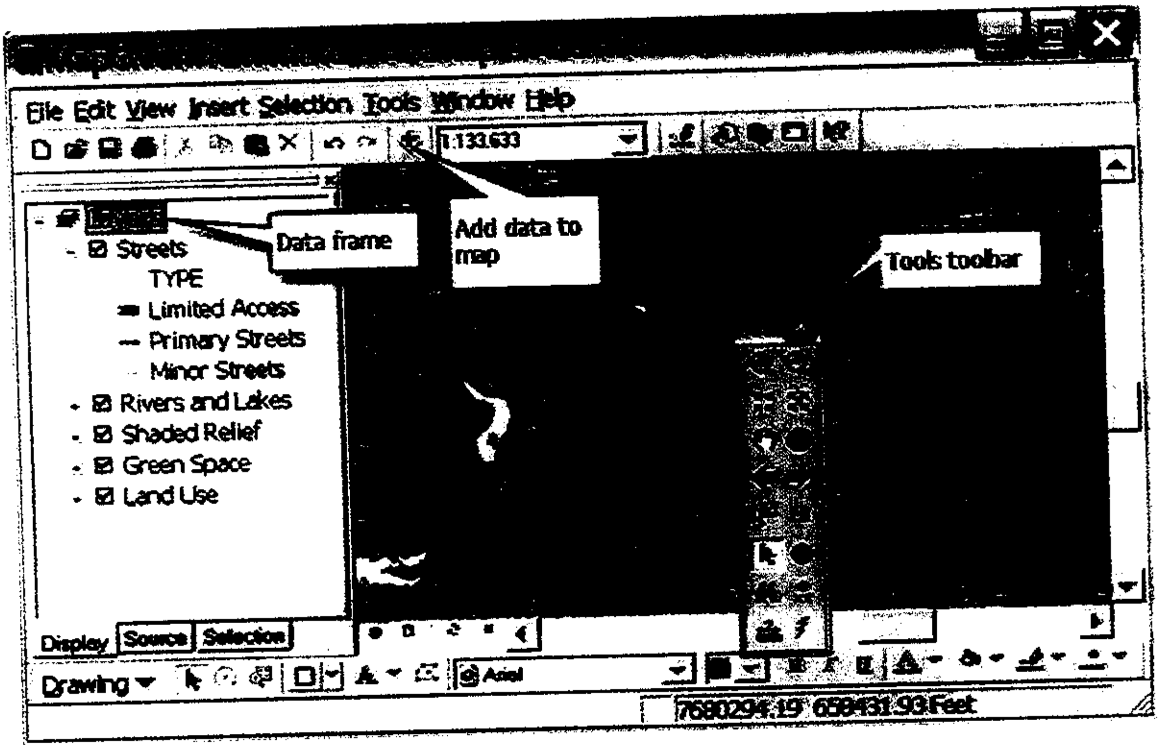


Fig 4.13.Data frame view

ArcMap includes a number of toolbars that are used to interact with the map and its elements. For example, you can choose a tool to zoom in on the map or another tool to pan the map. Logical sets of interactive tools are organized onto toolbars in ArcMap.

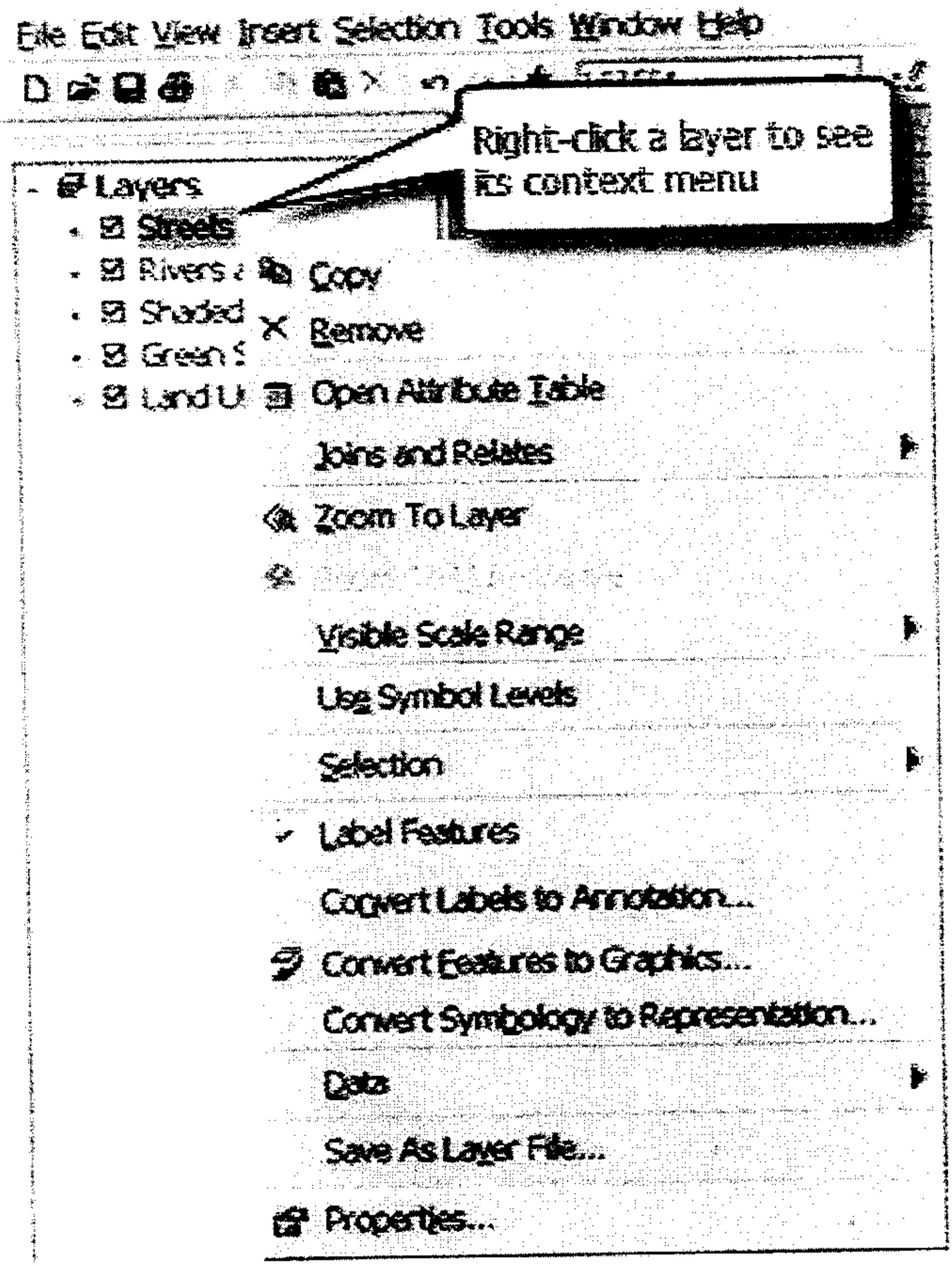


Figure 4.14

4.6.1. Working with toolbars

Here are some commonly used toolbars in ArcMap:

- Standard toolbar—map printing, saving a map, starting related ArcGIS applications, and so on
- Tools toolbar—map navigation and query
- Layout toolbar—editing and managing map layouts

- Editor toolbar—editing map features
- Draw toolbar—adding and editing map graphics, text, and layout elements
- Standard toolbar— Typically appears at the top of the ArcCatalog application window and is used to navigate between workspaces, to set the viewing properties of your folder and dataset contents, for starting related ArcGIS applications, and more.
- Metadata toolbar—Used to edit, share, and import standards-based metadata documents.
- Geography toolbar—Used with the Preview panel for navigating within a map view of a selected dataset, to identify features, and to create a thumbnail picture for metadata in ArcCatalog
- ArcGIS Server Administrator toolbar—Used by ArcGIS Server administrators to start, stop, and pause server objects.

4.7. ARC-CATALOG

In ArcGIS applications, you work with multiple data sources—datasets, relational databases, and file types and schemas. ArcGIS allows you to work with geographic information in many forms including relational databases, files, ArcGIS documents, and remote GIS Web services.

ArcCatalog helps you by providing an integrated and unified view of these various sources of information. The ArcCatalog application helps you organize and manage all your geographic information, such as maps, globes, datasets, models, metadata, and services. It includes tools to:

- Browse and find geographic information
- Record, view, and manage metadata
- Define, export, and import geodatabase data models
- Search for and discover GIS data on local networks and the Web

- Administer an ArcGIS server

You can employ ArcCatalog to find, organize, and use GIS data as well as to document data holdings using standards-based metadata. A GIS database administrator uses ArcCatalog to define and build geodatabases. A GIS server administrator uses ArcCatalog to administer his ArcGIS server framework.

4.7.1.Workspaces and geodatabases

Workspaces and geodatabases provide the primary containers to store and manage geographic information for ArcGIS. Workspaces are directories (file folders on disk) that hold numerous GIS datasets and a series of ArcGIS documents. Workspaces can contain external datasets in many file formats as well as references to geodatabases. For example, you can work with file geodatabases, connect to ArcSDE geodatabases, and work with folders containing numerous data files—such as ESRI shapefiles and coverages, JPEG images, DXF CAD files, dBase tables, Excel spreadsheets, and GML data files.

You organize your datasets and ArcGIS documents into a series of file system folders (often referred to as ArcGIS workspaces) and in geodatabases.

Organizing datasets by workspaces and in geodatabases is useful because it provides a mechanism to:

- Control access to datasets Provide a transaction framework for updating and sharing datasets
- Organize, document, and catalog numerous geographic datasets.

Typical contents in a workspace can include:

- .ArcGIS documents, such as ArcMap documents (.mxd), layer files (.lyr), ArcGlobe documents (.3dd), and Python scripts (.py)
- Any number of external datasets
- Subfolders containing file geodatabases
- Microsoft Access files (.mdb) containing personal geodatabases

A geodatabase is a collection of geographic datasets of various types used for representing features, images, tabular data, and other data types managed in either a file structure or a multiuser relational database. It is the native data source for ArcGIS and is used for editing and data automation in ArcGIS.

ArcCatalog provides an integrated and unified view of all the data files, databases, and ArcGIS documents available to you. ArcCatalog is also used to document and manage metadata and to define the schemas of geodatabases.

4.7.2.The Catalog tree

A key step in ArcGIS is to establish a connection to file folders and geodatabases that you plan to use.

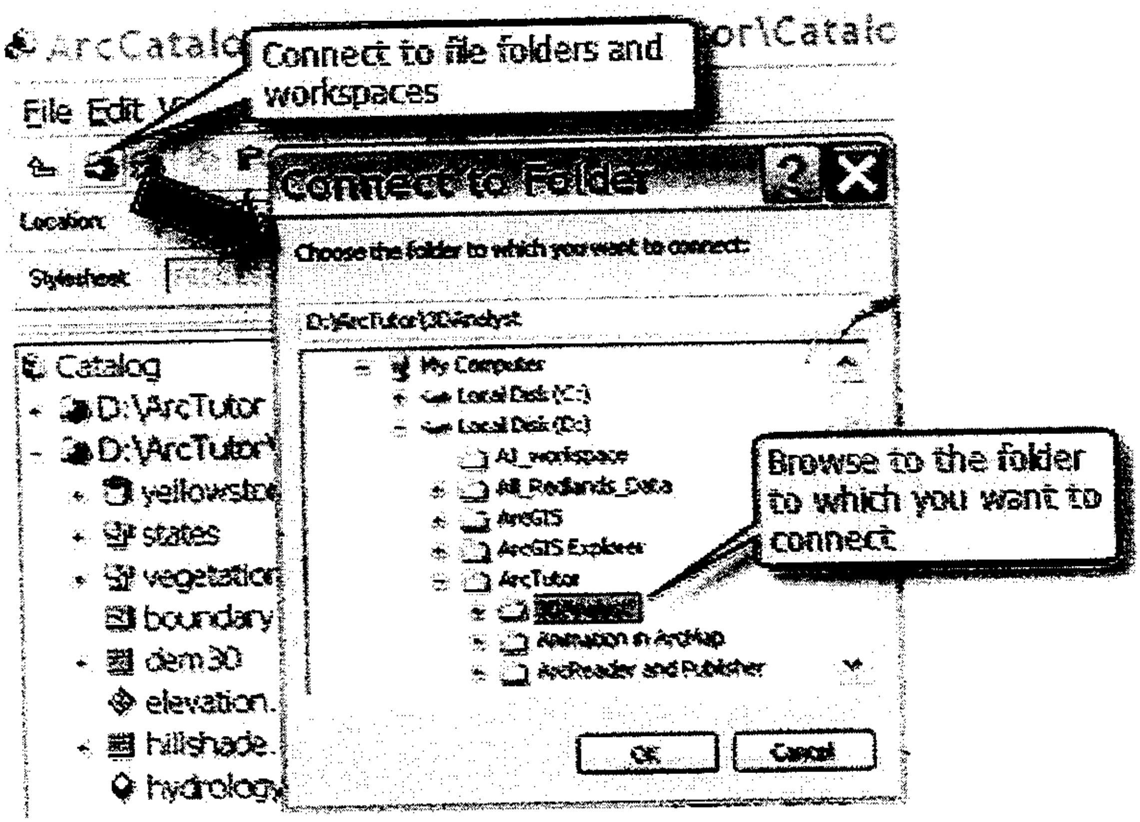


Figure 4.16.

Once connected, ArcCatalog helps you manage all your geographic information sets using the Catalog tree to view your disk files and database connections. The ArcCatalog user interface presents the Catalog tree in the left-hand panel. By selecting an element in the Catalog tree, you can read its various properties and views in the right-hand panel. You can edit the Catalog tree, make new connections, add new elements (such as datasets), and remove elements.

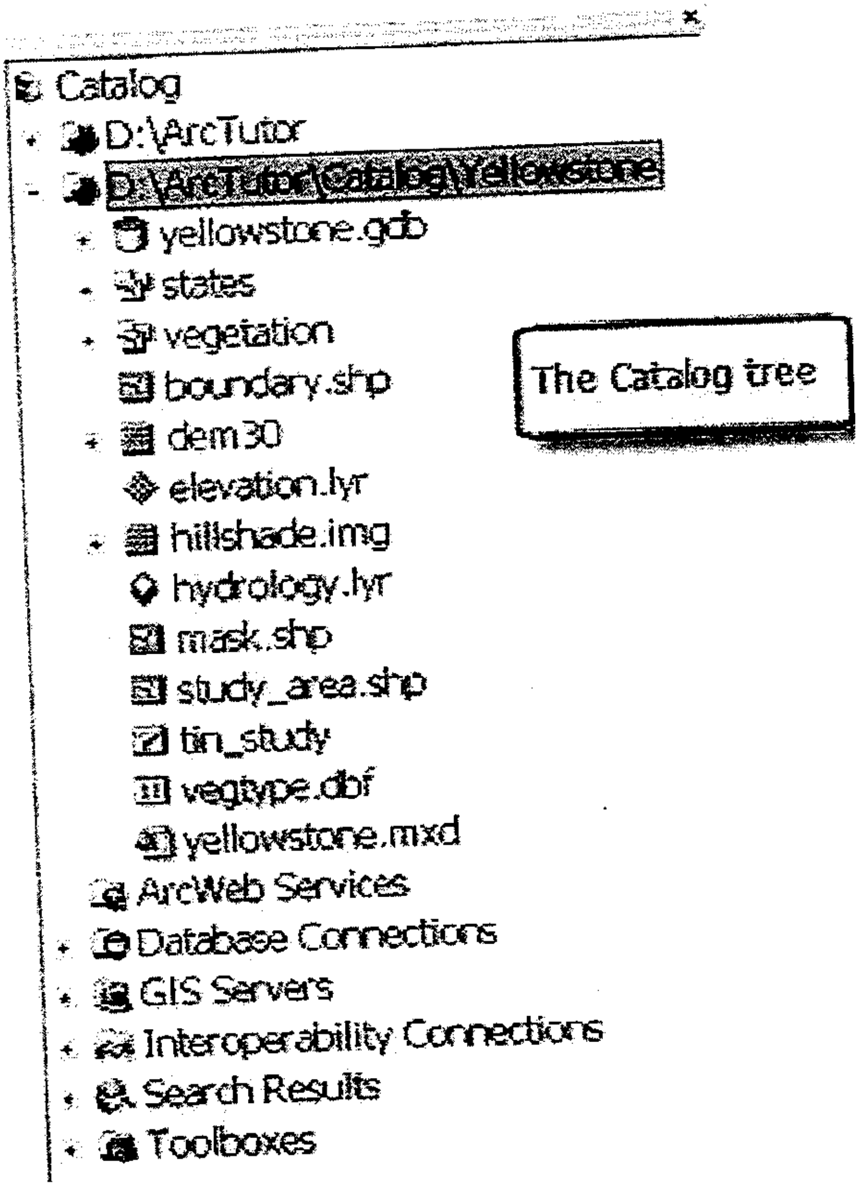


Figure 4.17.

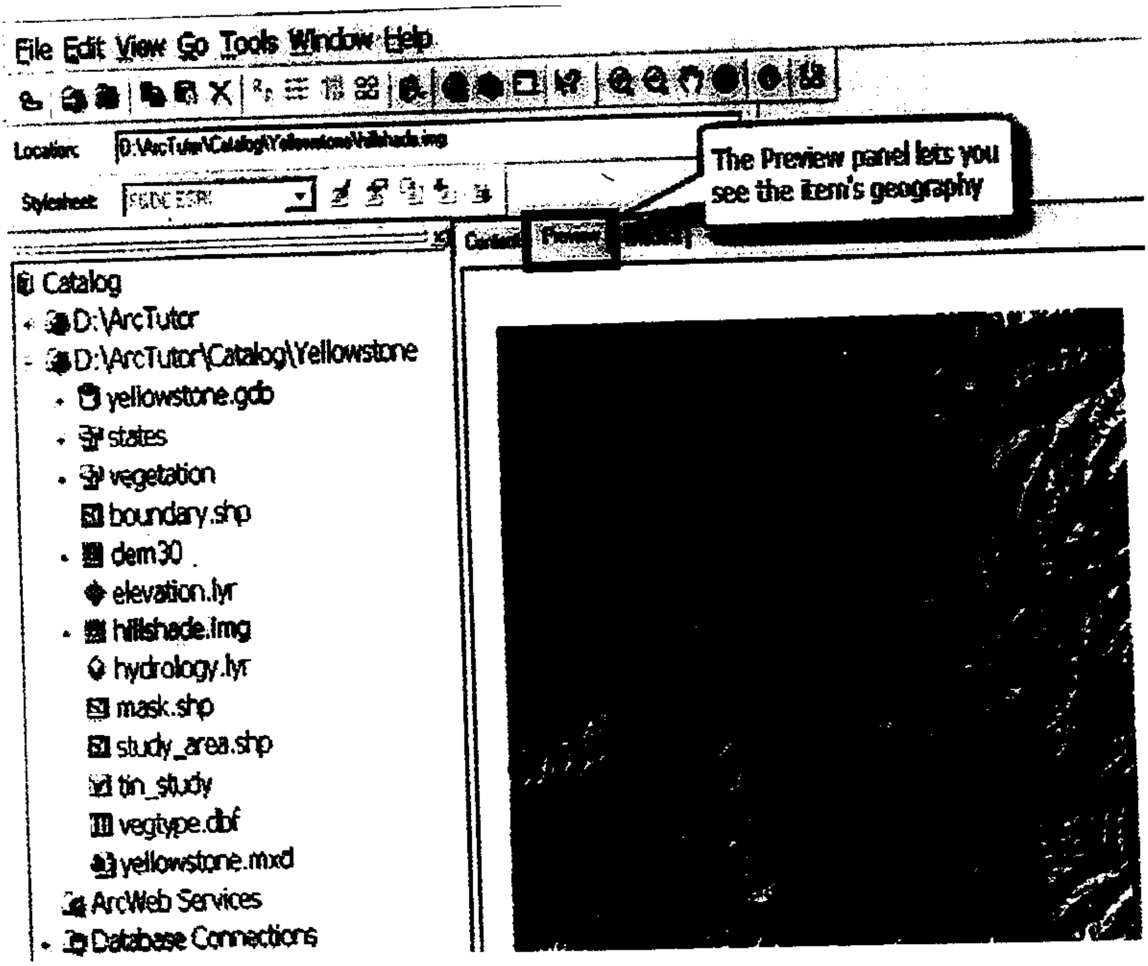
Some of the elements commonly shown in the Catalog tree include:

- Folders—Connections to workspaces holding datasets and ArcGIS documents .
- Database connections—ArcSDE geodatabase connections
- Address locators—Address geocoding files used in ArcGIS
- Coordinate systems—Map projection and coordinate system definitions used to georeference datasets

- GIS Servers—A list of the ArcGIS servers that can be managed with ArcCatalog
- Toolboxes—Geoprocessing tools used in ArcGIS
- Styles—Contains map symbols such as Marker (point) symbols, Line symbols, Pattern fill symbols (for polygons), and Text symbols used for map labels.
- Map Templates—Map styles that you can use as a staring point in ArcMap

4.7.3.The Preview panel

You can see the geographic content of an item that is selected (and highlighted) in the Catalog tree using the Preview panel.



Metadata in ArcCatalog

Metadata documents can be created, edited, and viewed in ArcCatalog.

4.7.5.Creating and managing geodatabase schemas in ArcCatalog

Database administrators can create and manage the schemas of their geodatabases using ArcCatalog.

4.8. DATA COMPILATION AND EDITING

One of the most significant investments you are likely to make in your GIS involves data compilation and editing. Nearly all users get some of their data from outside of their organizations, but all users must build significant portions of their GIS datasets.

There are five primary mechanisms used to add GIS data to ArcGIS

- Digitizing and editing geographic features
- Importing and processing data from other sources
- Using geocoding and linear referencing to assign locations to other information sets (for example, a set of customer records holding addresses).
- Using mobile clients to collect important information in the field.
- Accessing data and software functions through a series of GIS Web services.

The following sections present information on the editing process.

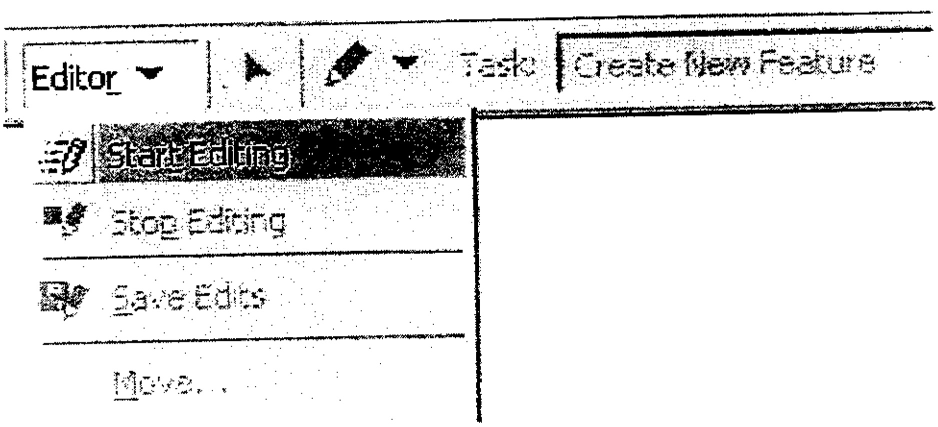
4.8.1.The process of editing in ArcMap

You use ArcMap to create new datasets using digitizing as well as to edit and update existing data sources in a geodatabase. You can also edit shapefiles in ArcMap, but geodatabases provide rich data types and behavior that improve the integrity of your data, simplify editing, and help ensure valid geometry for use in a range of GIS applications.

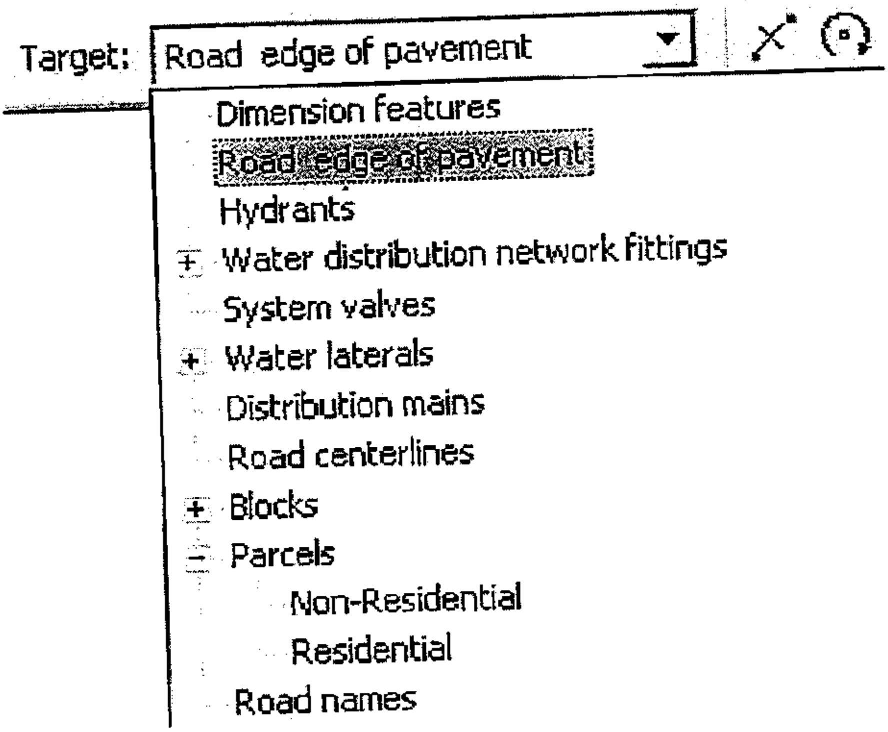
Editing in ArcMap is done within the framework of a map document and its map layers. Each map layer references a dataset. During editing, you set a target map layer whose data source will be edited. During the editing process, you can change your target layer as needed so you can edit many data sources in one session.

Here is an overview of the process used when editing in ArcMap.

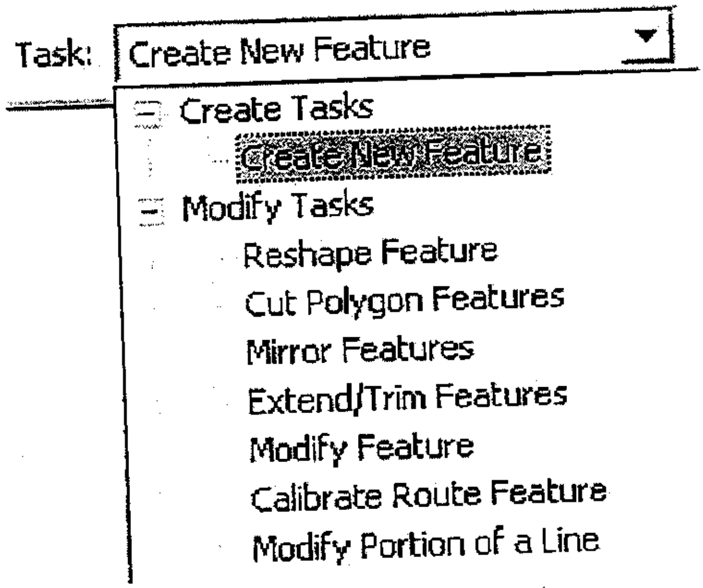
- Create a map in ArcMap that contains map layers for each feature class you want to edit. When you edit, all the data needs to be in the same workspace (a geodatabase or folder of shapefiles) and added to the same data frame.
- Add the Editor toolbar to your ArcMap application window by clicking the Editor toolbar button on the Standard toolbar. View the Editor toolbar and its tools
- Start an edit session (start editing). Click the Editor menu and click Start Editing.



4.Choose which layer within your workspace you want to be the target of your actions (the target layer). You can also set a subtype to be edited, such as Parcels: Non-residential or Parcels: Residential.

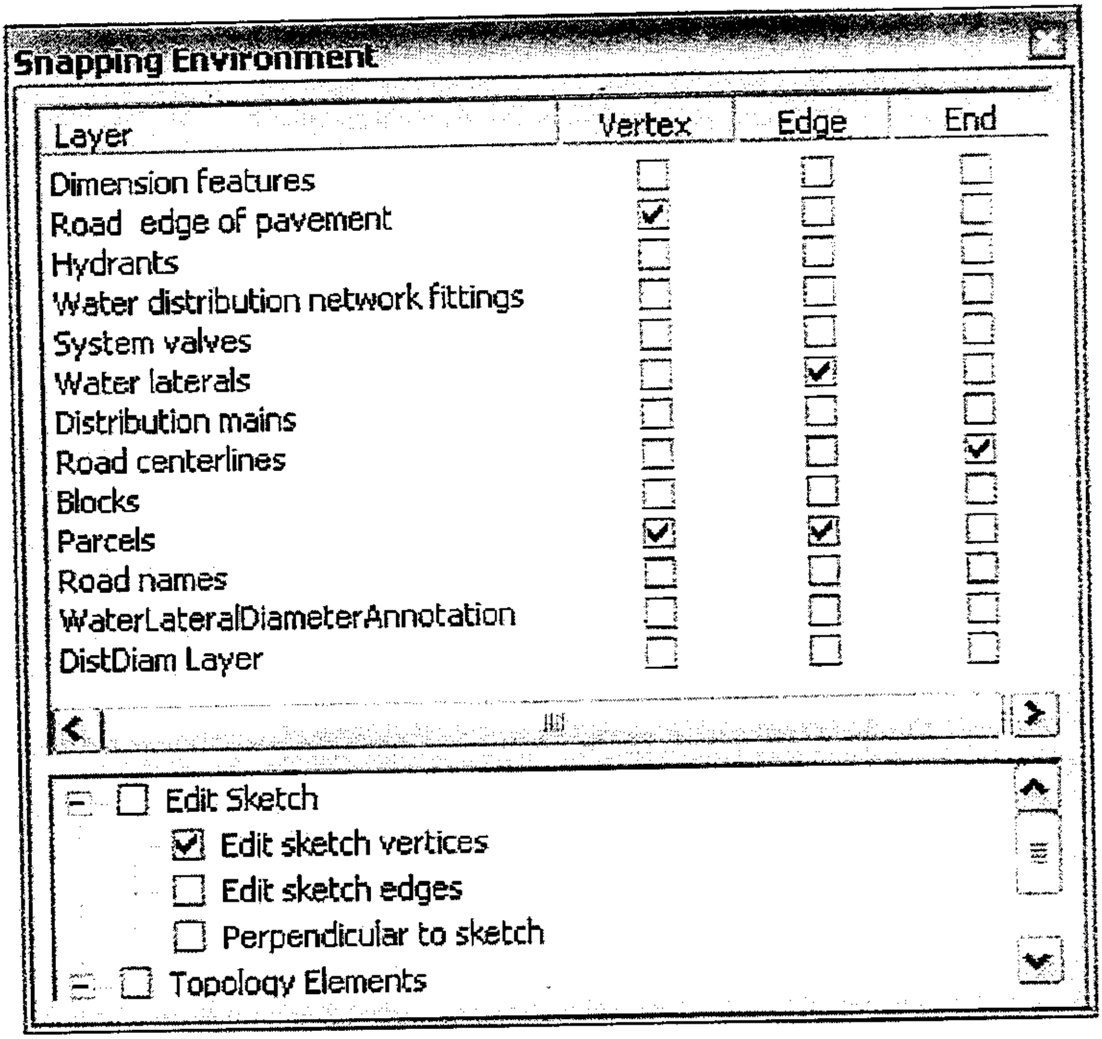


5.Use the Task drop-down list to choose whether you want to create new features or edit existing ones.



6.Set up additional properties or options, such as turning on snapping, setting which layers are selectable, and specifying input units.

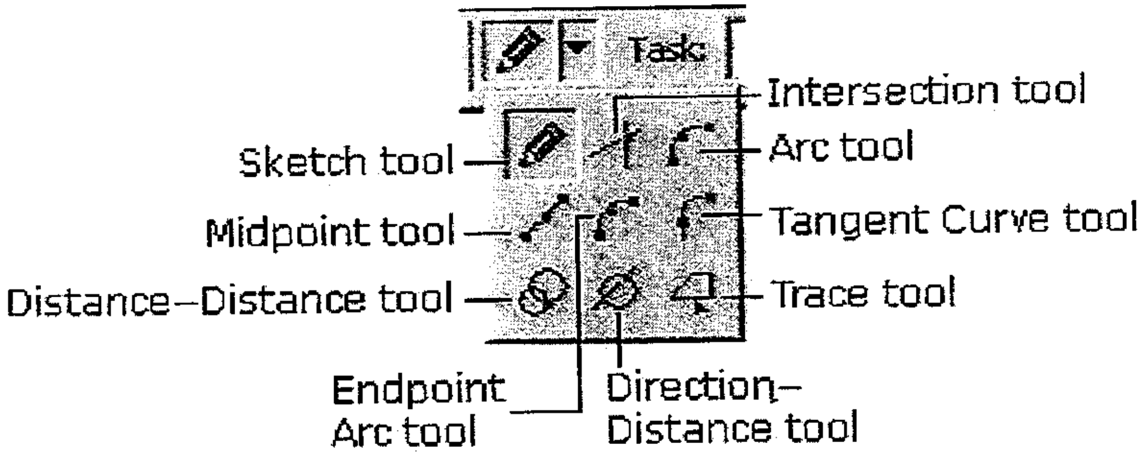
You can turn on snapping by clicking the Editor menu and clicking Snapping. Snapping is one of the easiest ways to more accurately position new vertices and segments. Snapping can help you with many editing operations; for example, creating polygons that do not overlap or have gaps between them or placing a point exactly along an existing line.



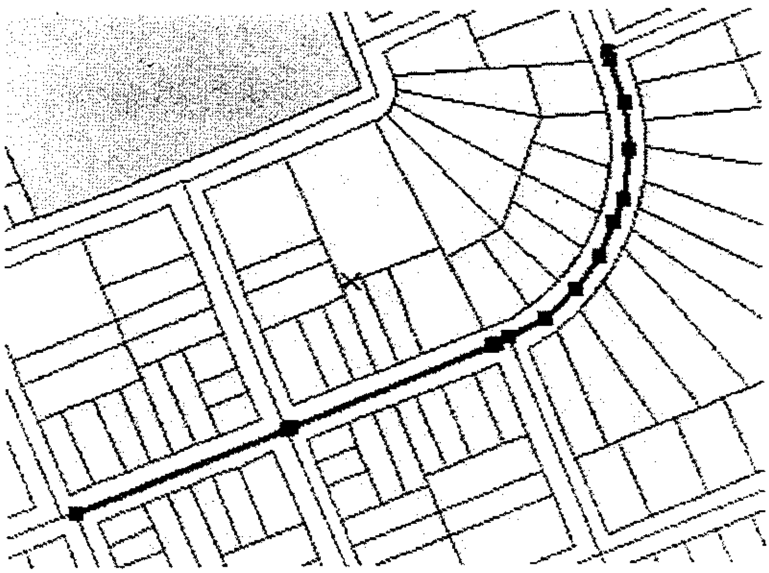
Other editing properties, such as units, direction measuring systems, and tolerances, can be set using the Editing Options dialog box. (Click Editor, then click Options).

7.Choose a tool and create an edit sketch.

The Editor toolbar contains the most frequently used simple-feature editing tools. Additional toolbars contain tools for editing topologies, geometric networks, routes, annotation features, and so on. When you want to create new features, you'll likely use the Sketch tool and the tools on the Editor toolbar tool palette. With those tools, for example, you can create lines, arcs, and tangent curves, vertices at intersections or midpoints, vertices based on distances and directions from other features, or new segments by tracing along existing ones.

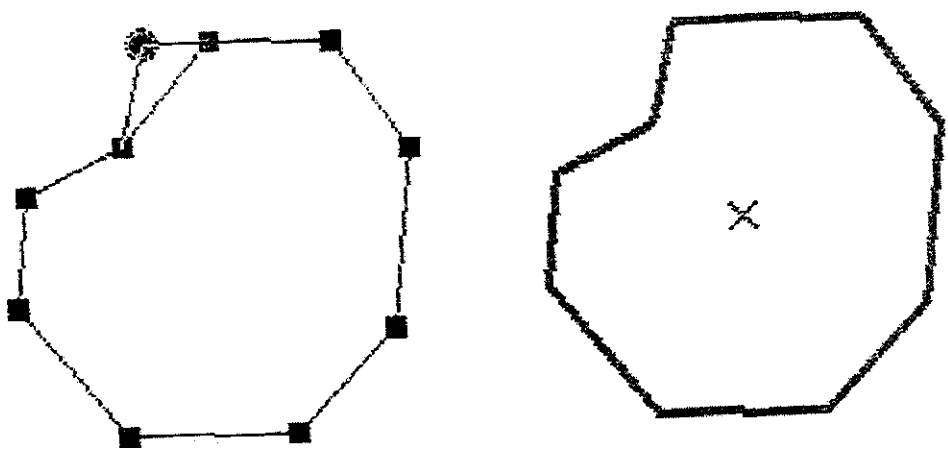


In ArcMap, you use an edit sketch to create or modify the shape of features. A sketch is composed of all the vertices and segments of the feature. Vertices are the points at which the sketch changes direction, such as corners; segments are the lines that connect vertices.



The Sketch tool has an accompanying context menu (accessed by right-clicking the map) that helps you place vertices and segments more accurately. For example, you can add a vertex at a specific x,y location, draw a segment at an exact length and direction, or make a segment parallel or perpendicular to another segment. You can also set up any additional options for editing, such as turning to specific features.

When you create the vertices in a sketch (typically, by clicking with your mouse), the segments between vertices are added automatically. Once you're satisfied with the shape of the sketch, you need to finish the sketch to complete the feature's geometry and actually create the feature. There are several ways that you can finish a sketch, including double-clicking with your mouse, choosing the command from a context menu, or using a keyboard shortcut (F2).

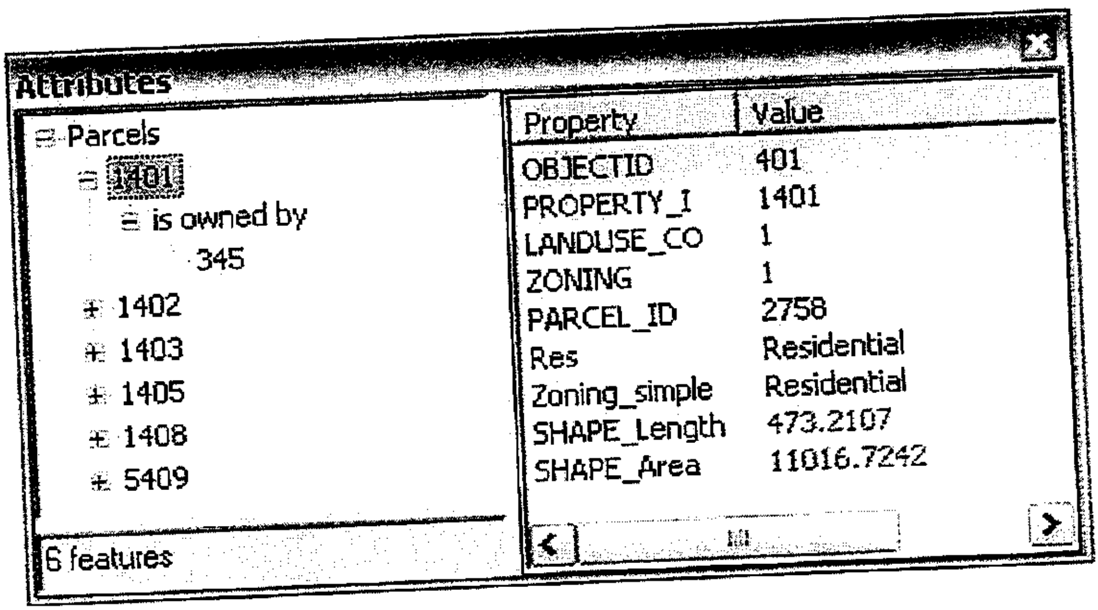


8.Add or edit attributes of the feature. Attributes are descriptions of a geographic feature in a GIS, usually stored as a row in a table. For example, attributes of a river might include its name, length, and average depth. You can enter new attribute values when you create features, and you can edit existing values. When you create a new feature, it starts with only the default attribute values. You input attributes after you create a feature.

You add and modify the attributes of features within an edit session. You can edit attribute values manually by typing in new values or by copying and pasting existing values. Some features are designed with subtypes, default values, and attribute domains. These can make it easier to edit values and can help prevent data entry errors.

The Attributes dialog box displays attributes of selected features and shows you the raw data and fields as they are stored in your geodatabase. The Attributes dialog box is the primary way of adding and modifying attribute values when you are editing. To open the Attributes dialog box, click the Attributes button on the Editor toolbar.

The left side of the dialog box shows the name of the layer to which the selected feature or features belong, while the right side shows the attribute values.



9.Once you are done creating and editing features and attributes, save your edits and stop editing.

4.8.2.Editing toolbars in ArcMap

Here are some of the toolbars commonly used during editing in ArcMap:

- Advanced editing tools
- Annotation editing tools
- COGO tools
- Dimensioning tools
- Geometric network editing tools
- Representation editing tools
- Route editing tools
- Spatial adjustment tools
- Topology editing tools

4.9. ARC/INFO COVERAGES

ARC/INFO coverage format is one of the most popular and widely available spatial data formats found in digital mapping and GIS applications. ARC/INFO coverages are a topological data structure for geographic features. The coverage format is suitable for spatial analysis and large geographic data management applications. Defining spatial features topologically in coverage can optimize data storage by reducing coordinate redundancy, and facilitate a number of key spatial operations such as polygon overlay, path finding through connectivity of arcs and contiguity analysis that can be performed in ARC/INFO.

4.10. ARC/INFO COVERAGE FEATURE CLASSES

In ARC/INFO coverages, features are stored as vector data and their attributes are stored in tables known as attribute tables. Each class of features stored in a coverage has its own attribute table. Attribute tables contain one record for each feature of that class in the coverage.

4.11.NETWORK ANALYSIS

ArcGIS Network Analyst is a powerful extension that provides network-based spatial analysis including routing, travel directions, closest facility, and service area analysis. ArcGIS Network Analyst enables users to dynamically model realistic network conditions, including turn restrictions, speed limits, height restrictions, and traffic conditions, at different times of the day.

With ArcGIS Network Analyst, the following applications were available.

- Drive-time analysis
- Point-to-point routing
- Route directions
- Service area definition
- Shortest path
- Optimum route
- Closest facility and Origin-destination analysis

ArcGIS Network Analyst provides a rich environment with easy-to-use menus and tools as well as the robust functionality available in the geoprocessing environment for modeling and scripting. Routes and networks are the interconnected features that are used for transportation and include highways, railways, city streets, rivers, transportation routes (transit, school buses,Jgarbage collection), and utility systems (electricity, telephone, water, sewage). Networks are an important part of our everyday lives and analysis of these networks improves the movement of people, goods, services and the flow of resources (Lo and Yeung, 2002). Network analysis in GIS is often used to find solutions to transportation problems by using either vector or raster models to represent the real world. There have been numerous studies done on which model is more effective for network analysis. The vector-based model appears to be more suited to analysis of precisely defined paths such as roads and rivers. The raster based model seems best suited for analysis of problems where paths are not pre-defined (Husdal, 2003).

4.11.1.What is a geometric network?

Geometric networks offer a way to model common networks and infrastructures found in the real world. Water distribution, electrical lines, gas pipelines, telephone services, and water flow in a stream are all examples of resource flows that can be modeled and analyzed using a geometric network.

A geometric network is a set of connected edges and junctions, along with connectivity rules that are used to represent and model the behavior of a common network infrastructure in the real world. Geodatabase feature classes are used as the data sources to define the geometric network. You define the roles that various features will play in the geometric network and rules for how resources flow through the geometric network.

A geometric network is built within a feature dataset in the geodatabase. The feature classes in the feature dataset are used as the data sources for network junctions and edges. The network connectivity is based upon the geometric coincidence of the feature classes used as data sources.

Geometric networks are comprised of two main elements: Edges and Junctions

Edges - An edge is a feature which has a length through which some commodity flows. Edges are created from line feature classes in a feature dataset and correspond to edge elements in a logical network.
Examples of edges: water mains, electrical transmission lines, gas pipelines, telephone lines, etc...

Junctions - A junction is a feature that allows two or more edges to connect and facilitates the transfer of flow between edges. Junctions are created from point feature classes in a feature dataset and correspond to junction elements in the logical network.
Examples of junctions: fuses, switches, service taps, valves, etc...
Edges and junctions in a network are topologically connected to each other—edges must connect to other edges at junctions; the flow from edges in the network is transferred to other edges through junctions.

There are two types of edges in a geometric network:

- **Simple Edges** - Simple edges are always connected to exactly two junctions, one at each end.

An example of a simple edge would be a water lateral in a water network. The water lateral connects at one end to a junction along the main distribution line and, at the other end, to a service point junction (such as a tap or pump).

Simple edges have no mid-span connectivity. If a new junction is snapped mid-span on a simple edge, thereby establishing connectivity, then that simple edge is physically split into two features.

A simple edge corresponds to a single edge element in the logical network.

- **Complex Edges** - Complex edges are always connected to at least two junctions at their endpoints but can be connected to additional junctions along their length.

An example of a complex edge would be a water main in a water network. The main water distribution line is a single complex edge with multiple lateral lines connected to junctions along its length. The water main is not split at the junction where each lateral connects to the main. Complex edges have mid-span connectivity. If a new junction is snapped mid-span on a complex edge, that complex edge remains a single feature. Snapping the junction does cause the complex edge to be split logically—for example, if it corresponded to one edge element in the logical network before the junction was connected, it now corresponds to two edge elements.

Complex edges correspond to one or more edge elements in the logical network.

There are two types of junctions in a geometric network:

- **User defined junctions** - Junctions that are created based upon a users source data (point feature classes) when the geometric network is first established. Junctions correspond to a single junction element in the logical network.

- **Orphan junctions** - When the first edge feature class is added to the geometric network, a simple junction feature class is created, called the orphan junction feature class. The name of the orphan junction feature class corresponds to the name of the geometric network appended with '_Junctions'. For example, a geometric network named 'Electric_Net' would have a corresponding orphan junction feature class named 'Electric_Net_Junctions'. The orphan junction feature class is used by the geometric network to maintain network integrity.

During the creation of the geometric network, an orphan junction is inserted at the endpoint of any edge at which a geometrically coincident junction does not already exist in your source data. Orphan junction features can be removed from the geometric network by subsuming them with other junction features. To subsume an orphan junction is to incorporate it into the network by deleting it and replacing it with a user defined junction while still maintaining network connectivity

The orphan junction feature class is deleted when its geometric network is deleted. For this reason, the schema of the orphan junction feature class should not be modified.

The image below shows an example of a network as it would appear in ArcMap.

4.11.2.Creating a new, empty network

Geometric networks are created inside feature datasets. Once a geometric network has been created, you must add feature classes to the feature dataset for that geometric network and assign them roles in the network.

ArcCatalog lets you create a new geometric network from nothing, then design and build up the network from scratch. You can then use editing tools in ArcMap, custom Visual Basic (VB), Visual Basic for Applications (VBA), or C++ code to add features to the geometric network. New feature classes can be added to a geometric network at any time.

The process of creating a network can be summarized in the following steps:

- Use ArcCatalog to create the feature dataset that will contain the geometric network and its feature classes.
- Use ArcCatalog to create an empty geometric network in the feature dataset (Shown below, see How to create a new geometric network).
- Use ArcCatalog to create new feature classes in the feature dataset and assign each a role in the geometric network.
- Use ArcCatalog to establish connectivity rules for elements of the geometric network.
- Use custom scripts or editing in ArcMap to add features to the network.

4.11.3.Building a geometric network from existing data

You may already have data from which you want to create a geometric network in your geodatabase. ArcCatalog and ArcToolbox contain tools to create a geometric network from that data.

The process of building a geometric network from existing data can be summarized in the following steps, all performed in ArcCatalog:

- Import data into new or existing feature classes.
- Build a geometric network from the feature classes.
- Establish connectivity rules for the geometric network.

4.11.4.How geometric networks are built?

You may already have data from which you want to create a geometric network in your geodatabase. ArcCatalog and ArcToolbox contain tools to create a geometric network from that data.

The process of building a geometric network from existing data can be summarized in the following steps, all performed in ArcCatalog:

- Import data into new or existing feature classes.
- Build a geometric network from the feature classes.
- Establish connectivity rules for the geometric network.

4.11.5.Geometric network snapping models

Ideally, your data should be clean before you build a network. Clean data means that all features that should be connected in the network are geometrically coincident—that is, no overshoots or undershoots. However, if this is not the case, the data may be snapped during the network building process.

It is important to understand how connectivity is established based on snapping during the network building process and how feature geometries are adjusted to establish that connectivity. The following is a series of examples of how connectivity is established in given scenarios.

4.11.6.Simple edges connectivity model

Simple edges: Connectivity against simple edges is established only at the ends of edge features. Mid-span connectivity will not be established, even if there is a vertex along the simple edge feature.

4.11.7.Complex edges connectivity model

Complex edges: Connectivity against complex edges is established both at the ends of features and mid-span. If there is no vertex along the complex edge where connectivity is established, a new vertex is created. When snapping complex edges, connectivity must be at the endpoint of at least one of the edges. Connectivity will not be established between the mid-span of one edge and the mid-span of another edge.

4.11.8.Vertex clustering connectivity model

Vertex clustering: When snapping two features, if there is more than one vertex within the snapping tolerance, then those vertices are treated as a cluster. Snapping will occur to one of the vertices in the cluster but not necessarily the closest.

4.11.9.Coincident junctions connectivity model

Coincident junctions: When the network building process encounters coincident junctions or when the snapping process results in coincident junctions, the resulting connectivity will be nondeterministic.

In other words, connectivity will only be established to one of the coincident junctions.

4.11.10.Adjusting features

When snapping features during network building, it is important to understand how the geometry of features is adjusted when snapping. All or part of any feature in a feature class that was specified as being adjustable in the Build Geometric Network wizard can potentially be moved. Those features in feature classes that are not adjustable will remain fixed throughout the network building process.

All features in all feature classes have equal weights when being adjusted during snapping. This means that if the endpoints for two edges need to be snapped and both features can be adjusted, then they will move an equal distance to snap together. If one of the features is not adjustable, then only the adjustable feature will move to snap to the static feature.

4.11.11. Network build errors

When building a geometric network from existing simple feature classes, illegal network geometries may be encountered in some of the input feature classes. Instead of failing when an illegal geometry is encountered, the network builder creates an instance of the feature as a network feature but will not create any network connectivity for that particular feature. If this occurs, a warning message is displayed at the end of the network building process, and a table is created in the database to record these errors.

The warning message will report the total number of illegal features in each network feature class. The error table's name will be <geometricnetwork_name>_BUILDERR.

ArcMap has tools that allow you to use the network build error table to identify these illegal features. Once you have identified the features and repaired their geometries to be legal geometries, you can use the

The network build error table will only show those features that have illegal network geometry at the time the network was built. If you repair these features, or other features are created in the network with illegal geometries, the network build error is required on all the input feature classes when building a geometric network. If any of the input feature classes has a shared lock, the network will not be built.

If any of the feature classes in a network has a shared or exclusive lock, that lock is propagated table will not be updated. Once you have fixed the geometry of the features reported in this table, it is no longer needed and can be deleted using ArcCatalog.

There are a number of tools and commands in ArcMap to help you identify and repair network features with illegal geometries and with inconsistent network connectivity.

CHAPTER - 5

DATA COLLECTION

As the first step of the project, we collected the details of the city (coimbatore). The city coimbatore was constituted as municipality in the year 1866 and was subsequently constituted as a city municipal corporation from 1.5.1981. It has a population of 11 lakhs (2001 census) and has an extent of 105.50sq km.Coimbatore city generates an average amount of 601 T of waste per day. The city is divided in to 72 wards and these wards are grouped in to 4 zonal committees.

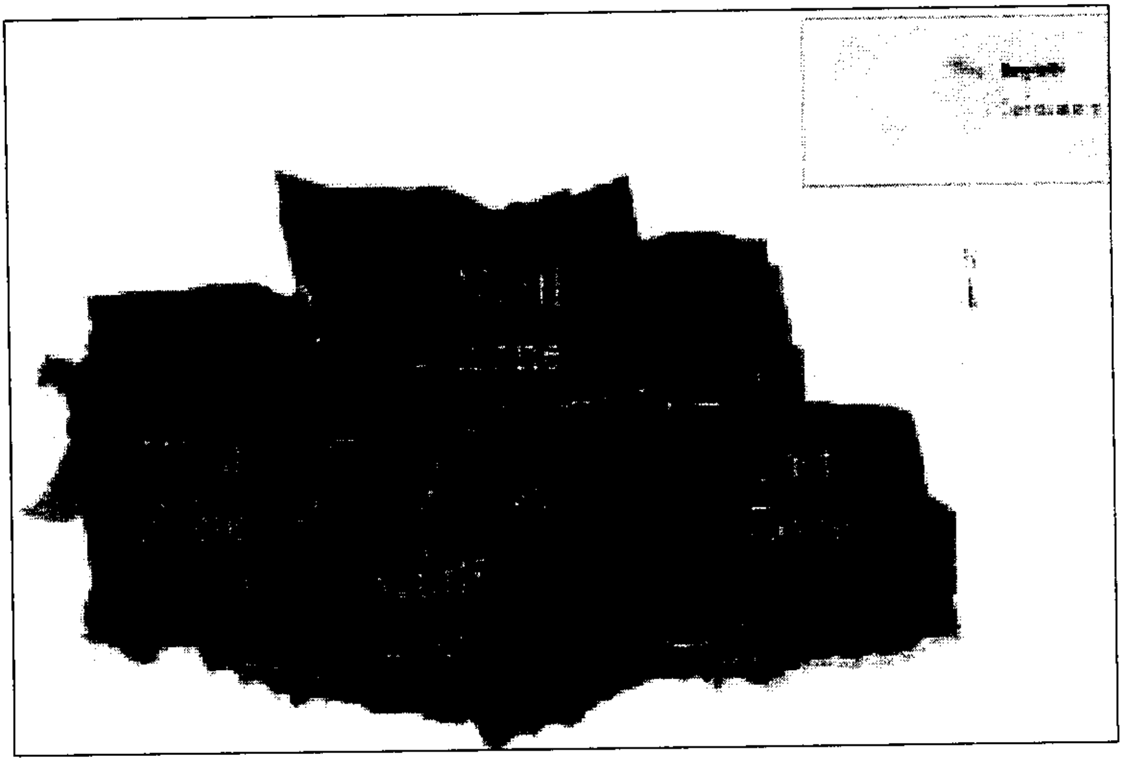
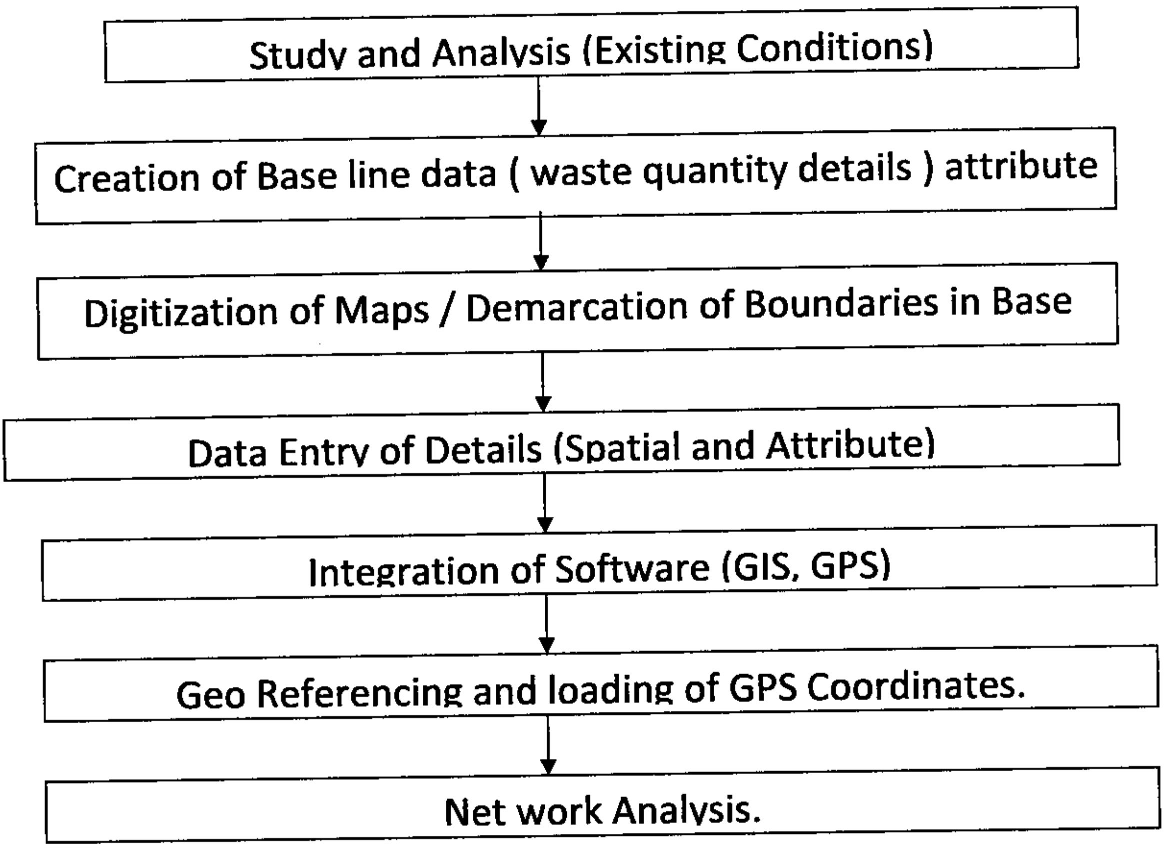


Figure 5.1: zonal map

Among these wards we have selected peelamedu (ward no:16) .This ward belong to north zone.We have met major officials of unicipal corporation council like town planning officer, ACHO, Deputy commissioner, commissioner etc for getting the ward maps and route maps of the selected wards. After receiving the map we proceeded further with the collection of data's using GPS by which the latitude, longitude and elevation of each community bins and various benchmarks of respective wards were taken.

Conceptual flow diagram of the GIS work

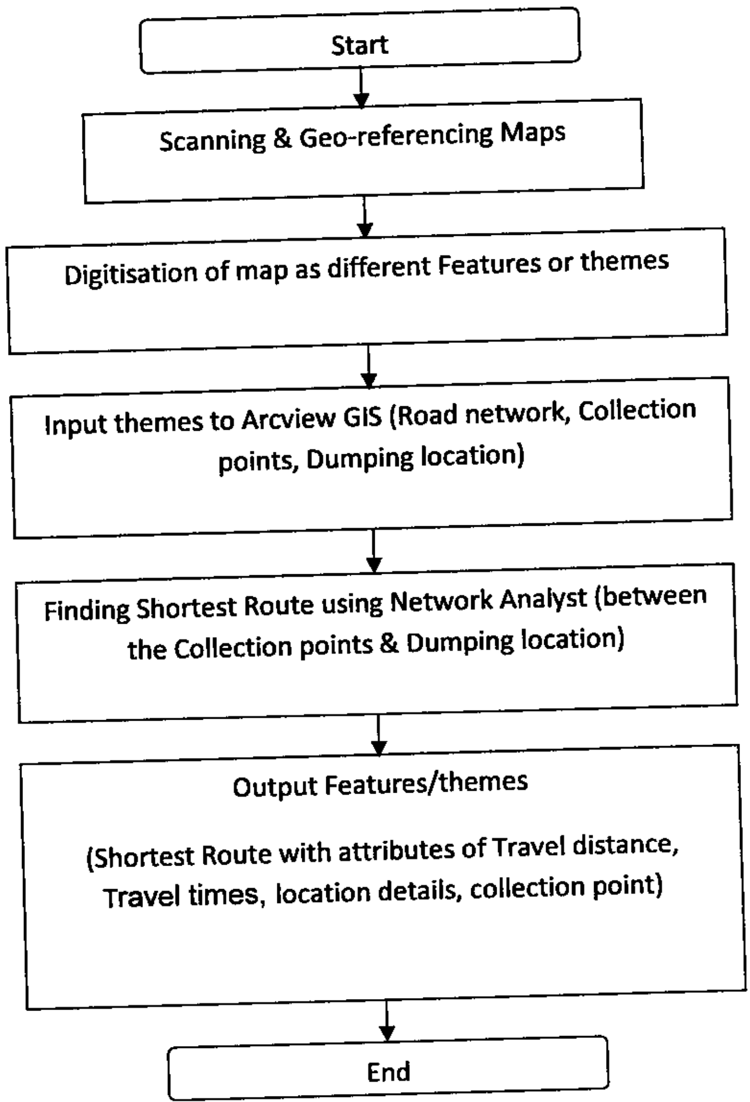


We went to Survey of India(Chennai) and got the toposheet for coimbatore. We tried to georeference the toposheet, autocadd map, scanned autocadd map, hand drawn scanned map and finally the google earth map but we succeeded only with the google earth map which came out to be more accurate than other maps. And the values obtained using GPS was for used georeferencing. Using the software we then proceeded further with the digitization and using ARC GIS 9.3 extension , Network Analyst we came out with the shortest collection route. Now its up to the corporation to select the collection route depending on its current

CHAPTER 6

METHODOLOGY

As suggested by the municipal corporation coimbatore a model ward (peelamedu -ward 16) was taken to find the Shortest Route from the collection points to the transfer stations. Solid waste from these three transfer stations is again transferred to another site location at vellallur composting yard Proceedings of vellallur yard was observed and various snaps were taken. Details of respective wards were collected and the following methodology proceeded.



Detailed methodology for finding shortest route are:

- Collection of the data from corporation such as map, size and capacity of the bin.
- Getting the location of bins and the benchmarks using GPS.
- Geo-referencing and digitising .
- Optimisation of the existing waste collection route.

1. Collection of the data from corporation

The details of wards like ward map, size of the bin, capacity of the bin , location of bin etc was calculated. There are two types of bins of which the former is used for carrying biodegradable waste and the latter is used for collection of non-biodegradable waste. And these bins can have capacity of 0.5T or 1T.

2. Getting the location of bins and the benchmarks using GPS

We went to the spot and took the respective latitude and longitude of the bin location using GPS. The data was entered in the excel sheet and stored. And this data was later used for geo-referencing.

3. Geo-referencing and Digitising

Geo-referencing :

The process of delimiting a given object, either physical (eg. a lake) or conceptual (eg. an administrative region), in terms of its spatial relationship to the land; the geographic reference thus established consists of points, lines, areas or volumes defined in terms of some coordinate system (usually latitude and longitude).

Digitisation :

Digitising is the transformation of information from analog format, such as a paper map, to digital format, so that it can be stored and displayed within a computer .

4. Optimization of the existing waste collection route

Using an extension tool network analyst in Arc GIS software, the digitized map's road network is optimized and the shortest route for collecting the waste is determined.

Network analysis in GIS is often used to find solutions to transportation problems by using either vector or raster models to represent the real world. The Network Analyst extension for ArcView solves problems of network traffic on streets, rivers, railroads, pipes, or any interconnected set of lines. It can find the shortest or fastest route between your origin and your destination, including all the stops along the way. It can tell whether one place is or is not linked to another hundreds of miles away. It finds the closest facilities to a location, such as the closest hospital to a vehicle accident and it identifies service areas, such as areas serviced by a bank. Network Analyst can also build spatial models of traffic flow.

Procedure for finding the closest facility and the shortest route

Both the closest facility and the best way can be determined at the same time with the Network Analyst. Number of locations and number of facilities are to be specified.

- Open a view with a point theme representing facilities.
- Make a line theme in the Table of Contents active.

- From the Network menu choose Find Closest Facility. This opens the problem definition dialog and adds a theme called Fac1 to the Table of Contents.
- Click the Properties button in the problem definition dialog. In the Properties dialog, choose the cost field in your network theme's feature table. The Network Analyst will use the cost field to find the closest facility.
- Specify the working units. These are the units that will be used in reporting the total cost of travel to or from each facility. Press OK to dismiss the Properties dialog.
- In the problem definition dialog, choose a facility theme. The drop down box lists all available point themes in the view. If you select a group of facilties using ArcView's selection tools, only that group will be considered in the problem. If no facilties are selected, all facilities will be considered.
- Specify the number of facilities you want to find.
- Specify a cutoff distance if you want to limit how far away a facility can be. Make sure they are in the same units as the working units you specified in step 5.
- Specify the event from which you want to find the closest facilities. You can specify an event by using the Add Location tool to point to a place on the line theme, by using the Add Location by Address button to enter an address, or by using the Load Events button to load a point theme.
- Specify the direction of travel. If travel is from the event to the closest facilities, check the Travel from event option. If travel is from the closest facilities to the event, check the Travel to event option.

- Click the Solve button. The Network Analyst finds the specified number of closest facilities and displays the best route to or from each facility in the view.

The Geographic Information System (GIS) has been used to analyze existing maps and data, to digitize the existing sanitary ward boundaries and to enter the data about the wards and disposal sites. The generated ArcGIS maps give efficient information such as collection point locations, MSW transport means and their routes, and the number of disposal sites and their attributes.

The methodology includes the collection of information about the waste management situations in these municipalities and preparing a database about the waste situations of the project area. Analysis of the present waste situation and recognize the problems faced in the system. On the basis of the present situation analysis, the data availability of the Project area and the study analysis, the framing of guidelines for the work to be proposed in dealing with waste management planning for the Project area was carried out. In the proposed model the waste management issues are considered to solve some of the present situation problems like proper allocation of Dumper bins and check for unsuitability and proximity convenience by Primary collection. Finally collection route is optimized based on analysis of bin locations which thereby results in the reduction of fuel consumption and proper waste management.

CHAPTER – 7

RESULTS AND DISCUSSIONS

7.1.GENERAL

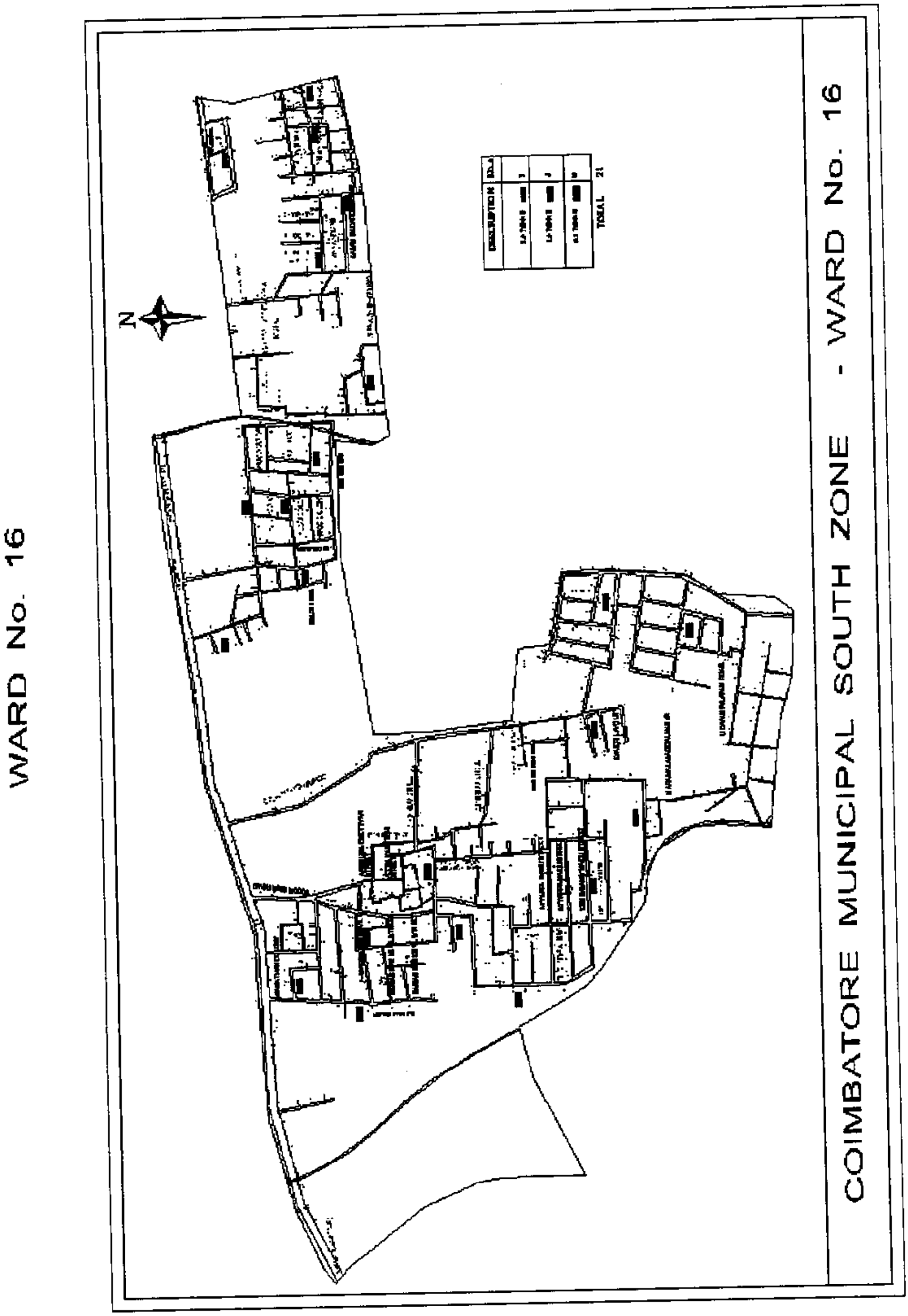
From the information provided by corporation about the population density and the waste generated in the ward , we determined the :

- No of bins , bin capacity , and the bin position.
- Latitude and longitude of bin locations using gps.
- Bin locations which were geo referenced and digitized using arc GIS software.
- Shortest collection route using Network Analyst which ultimately results in less fuel consumption and fuel emission.
- Finally we have recommended the corporation about the various collection frequencies that can be implemented in the ward for the collection of waste.

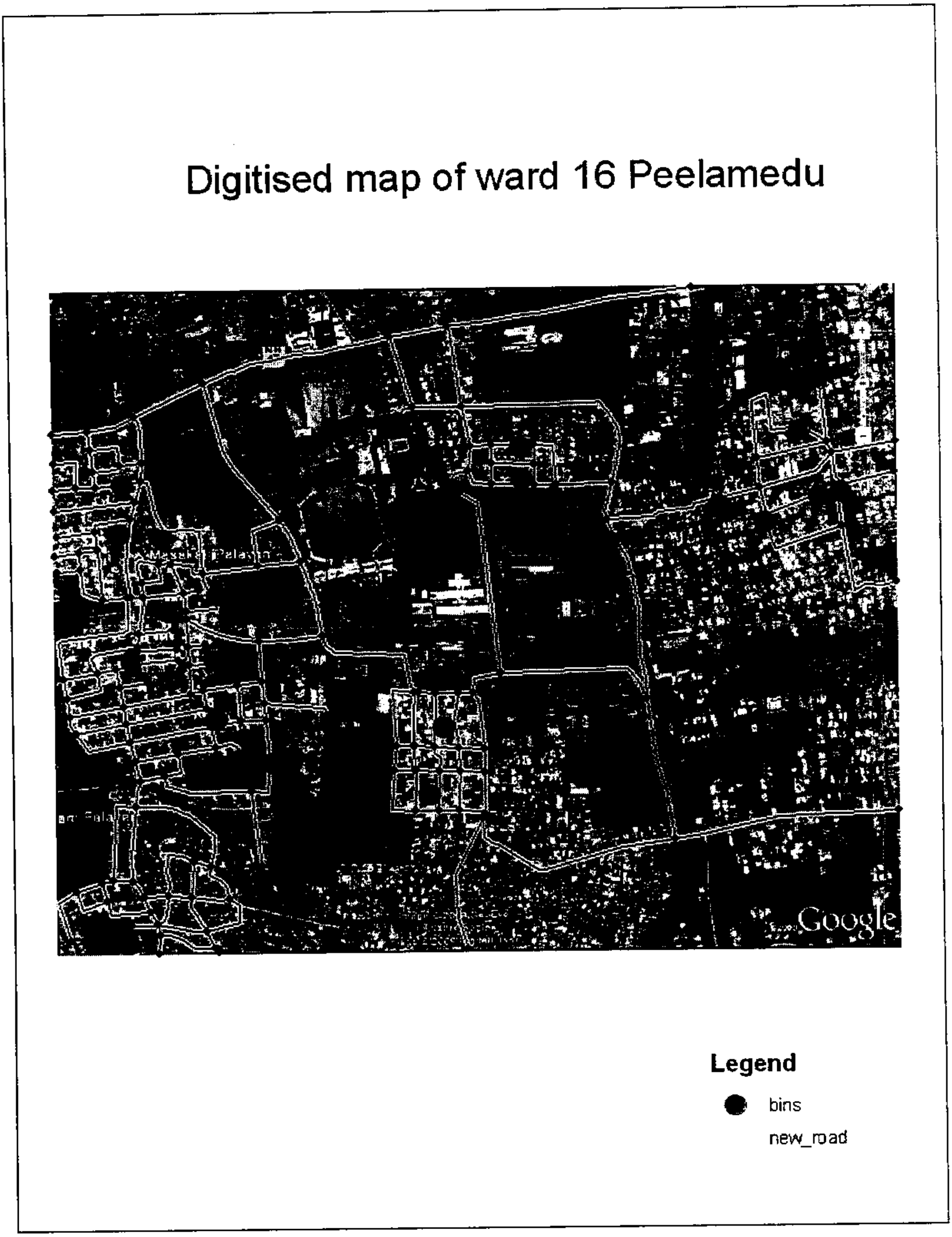
Basic map is a primary requirement for working with ARC GIS software. As part of our project we have taken google map of peelamedu as basic map. The google map itself is a georeferenced map. And this map is further digitized. Using the network analyst an extension of ARCGIS software the optimised route between the collection route is determined. All these maps has been shown in the following pages.

7.2. BASIC MAP

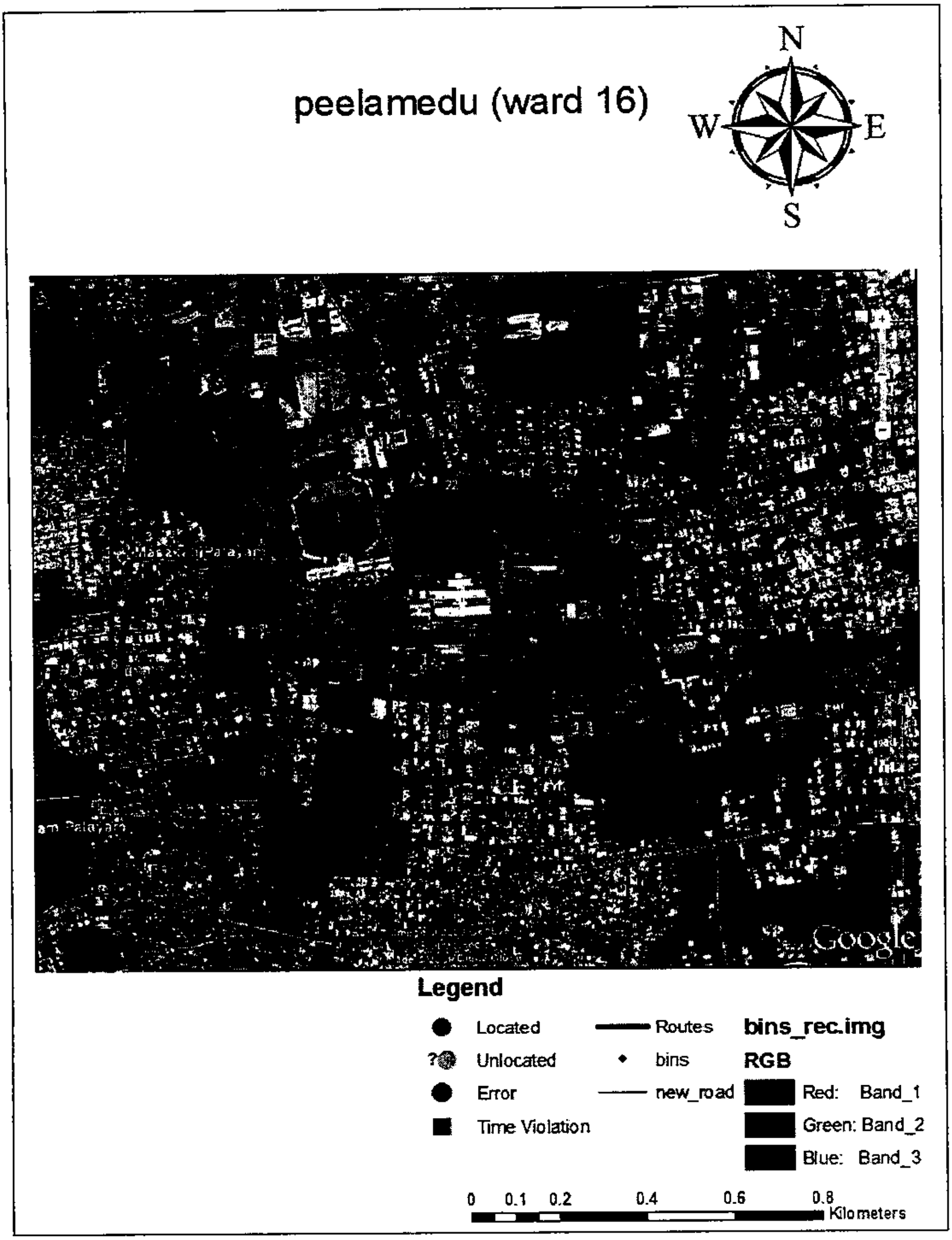
BASIC MAP FIG



7.3. DIGITISED MAP



7.4.MAP SHOWING THE OPTIMISED ROUTE



7.5.COMPLETE DIRECTION FOR PEELAMEDU

Begin route Location 1 - Location 22

1: Start at Location 1

2: Go east

Drive < 0.1 km

3: Make sharp right

Drive 0.1 km

4: Arrive at Location 2, on the right

5: Depart Location 2

6: Go back north

Drive 0.1 km

7: Turn right

Drive 0.1 km

8: Arrive at Location 3, on the right

9: Depart Location 3

10: Go southeast

Drive 0.3 km

11: Arrive at Location 4, on the left

12: Depart Location 4

13: Continue southwest
Drive 0.1 km

14: Turn right
Drive < 0.1 km

15: Arrive at Location 5, on the left

16: Depart Location 5

17: Go north
Drive < 0.1 km

18: Turn left
Drive < 0.1 km

19: Turn left
Drive 0.2 km

20: Turn right
Drive < 0.1 km

21: Arrive at Location 6, on the right

22: Depart Location 6

23: Continue west

Drive < 0.1 km

24: Turn left

Drive < 0.1 km

25: Turn left

Drive 0.2 km

26: Turn right

Drive < 0.1 km

27: Turn left

Drive < 0.1 km

28: Arrive at Location 7, on the left

29: Depart Location 7

30: Continue east

Drive 0.1 km

31: Turn right

Drive 0.1 km

32: Arrive at Location 8, on the left

33: Depart Location 8

34: Go back north
Drive 0.1 km

35: Turn right
Drive 0.2 km

36: Arrive at Location 9, on the right

37: Depart Location 9

38: Go back west
Drive 0.2 km

39: Turn right
Drive 0.1 km

40: Turn right
Drive 0.2 km

41: Turn right
Drive 0.4 km

42: Turn right
Drive < 0.1 km

43: Arrive at Location 10, on the left

44: Depart Location 10

45: Continue south

Drive 0.2 km

46: Arrive at Location 11, on the right

47: Depart Location 11

48: Go back north

Drive < 0.1 km

49: Turn right

Drive < 0.1 km

50: Turn left

Drive 0.2 km

51: Turn right

Drive < 0.1 km

52: Turn left

Drive 0.5 km

Drive 0.4 km

54: Arrive at Location 12, on the left

55: Depart Location 12

56: Continue north
Drive 0.1 km

57: Turn left
Drive 0.1 km

58: Arrive at Location 13, on the left

59: Depart Location 13

60: Continue west
Drive < 0.1 km

61: Arrive at Location 14, on the right

62: Depart Location 14

63: Go back east
Drive < 0.1 km

64: Turn left
Drive < 0.1 km

65: Turn left

Drive < 0.1 km

66: Arrive at Location 15, on the left

67: Depart Location 15

68: Go back southeast

Drive 0.2 km

69: Turn left

Drive 0.1 km

70: Turn right

Drive < 0.1 km

71: Turn left

Drive 0.3 km

72: Arrive at Location 16, on the right

73: Depart Location 16

74: Continue east

Drive 0.1 km

75: Turn right

Drive < 0.1 km

76: Turn left

Drive 0.1 km

77: Arrive at Location 17, on the right

78: Depart Location 17

79: Go back west

Drive 0.1 km

80: Turn left

Drive < 0.1 km

81: Arrive at Location 18, on the right

82: Depart Location 18

83: Go back north

Drive < 0.1 km

84: Turn right

Drive 0.2 km

85: Make sharp right

Drive < 0.1 km

86: Arrive at Location 19, on the left

87: Depart Location 19

88: Go back north
Drive < 0.1 km

89: Turn left
Drive < 0.1 km

90: Bear left
Drive < 0.1 km

91: Bear left
Drive 0.1 km

92: Arrive at Location 20, on the left

93: Depart Location 20

94: Go back southeast
Drive 0.1 km

95: Turn right
Drive 0.6 km

96: Turn right
Drive < 0.1 km

97: Turn left

Drive 0.5 km

98: Turn left

Drive 0.2 km

99: Arrive at Location 21, on the right

100: Depart Location 21

101: Go back east

Drive 0.2 km

102: Turn right

Drive 0.2 km

103: Turn right

Drive < 0.1 km

104: Finish at Location 22, on the right

Total distance: 8.4 km

CONCLUSION

Economic development, urbanization and improving living standards in cities, have led to an increase in the quantity and complexity of generated waste.

There is a need to work towards a sustainable waste management system, which requires environmental, institutional, financial, economic and social sustainability.

So it is our duty to find some solution for this problem. Thus we had used one of the recent devolping field ie Geographic Information System to find the optimized route.Using Geographic Information System, we had analysed existing maps and datas and digitized the sanitary boundaries.

By using Network analysis,we had found the optimized route for collecting Municipal Solid Waste from one model ward to the composting yard.This will be a useful one for the Corporation and an good example.

In future they can experiment our project for all other wards in Coimbatore city and find some solution for problems in Municipal Solid Waste Management(MSWM).

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