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1. INTRODUCTION

Geographic information system is an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. Geographic information systems (GIS) have been widely spread into many disciplines that utilize spatial referenced data in the last two decades. It is not surprised to see that GIS and Urban planning applications becomes one of the fastest growing fields in GIS applications. Unique and sophisticated functions and capabilities provided by GIS technologies draw attention from academic scholars as well as practitioners, although there is less rapid development in the area of spatial analysis within GIS.

People use geographic information system (GIS) software because they understand that better information leads to better decisions. A GIS helps create better information by storing data about real-world objects in a database and dynamically linking the database to an onscreen map. Linking the database to the map allows you to quickly see geographic features and display them using different information from the database.

A geographic information system (GIS) integrates information about the real world to help people find solutions to problems. Data about real-world objects is stored in a database and dynamically linked to an onscreen map, which displays the real-world objects. A GIS is used for three main purposes: data display, analysis, and output.

1.1 Different aspects of GIS

Components of a GIS: GIS has five components. They are: people, data, hardware, software, and procedures.

- People—people are the most important component of a GIS. People must develop the procedures and define the tasks the GIS will perform.
- Data—the availability and accuracy of data affect the results of queries and analysis.
- Hardware—hardware capabilities affect processing speed, ease of use, and the types of available output.
- Software—this includes not only GIS software, but also various database, drawing, statistical, imaging, and other software programs.
- Procedures—GIS analysis requires well-defined, consistent methods to produce correct and reproducible results.

Functions of GIS: Any geographic information system should be capable of six fundamental operations in order to be useful for finding solutions to real-world problems. A GIS should be able to:

- Capture data
- Store data
- Query data
- Analyze data
- Display data and Output data

Geographic phenomena can be represented using raster or vector models. The raster data model represents geographic features using cells, while the vector data model represents features using points, lines, and polygons. Geographic vector data has three components: geometry, attributes, and behavior.

Components of geographic data: There are three main components to geographic data:

- Geometry represents the geographic features associated with real-world locations. Geographic features are abstracted into (drawn as) points, lines, or polygons (areas).
- Attributes are descriptive characteristics of the geographic features.
- Behavior means that geographic features can be made to allow certain types of editing, display, or analysis, depending on circumstances that the user defines. Feature behavior is most easily implemented in the Geodatabase.

Feature spatial relationships: Feature spatial relationships, or where they are located in space relative to one another, communicate important information. Topology is a mathematical procedure used to determine feature spatial relationships and properties. Topology makes most types of geographic analysis possible.

On a map, feature spatial relationships, or where they are located in space relative to one another, communicate important information. The spatial relationships implicit on a map determine what the map conveys to the reader. For example, connectivity and adjacency are two types of spatial relationships.

Topology is a mathematical procedure used to determine feature spatial relationships and properties, including:

- Connectivity of lines
- Direction of lines
- Length of lines
- Adjacency of areas
- Area definition

A GIS organizes and stores information about the world as a collection of thematic layers that can be linked by geography. Each layer contains features having similar attributes, like streets or cities, which are located within the same geographic extent. This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems—from tracking delivery vehicles to recording details of planning applications to modeling global atmospheric circulation.

1.2 Case Study

The case study for this project is City of AUSTIN at Texas, USA. The geographic data for land use, transportation, services is obtained from the website of city of AUSTIN (ftp://issweb.ci.austin.tx.us/pub/coa_gis.html). The obtained is in the form of shape files, the data is completely raw with no description and differentiation.

2. LITERATURE REVIEW

In the section of the literature review the different applications of GIS in the urban planning field is discussed. With the ability of GIS to deal with different forms of data it makes it easier for the planners and decision maker to deal with complex problems pertaining to urban planning application such as infrastructure planning, transportation planning, site selection, planning for services, land use planning etc. Some of which are discussed below in the following section.

2.1 GIS and transportation planning.

GIS can assist in spatial analysis through his unique spatial data structure (Goodchild, 1992). Spatial and attribute data are integrated in GIS databases so that many sophisticated spatial operations, such as overlay and buffer, can be conducted. These spatial operations may generate information that are of importance and vital in the planning and decision-making process. The GIS functions employed in this study include:

- Spatial data representation makes it easy to maintain and update network data and related attribute data such as capacity, speed restriction, and direction for links and turn penalty for nodes. Besides, thoroughly coding network links make it possible to select different network configuration onto which trip flows will be loaded.
- Data integration capability provides transportation analysts tools to access and use various data sets which are unavailable before. Transportation analysts employ not only linear data but also polygon and point data.
- Spatial measurement along with locational data enables us to directly calculate various indexes of compactness for polygons.
- Topological relationships represented in GIS database are among the most useful data for transportation planning and management. Connectivity is needed to prepare the input files for transportation models (particularly trip assignment models).
- Finally visual display functions provide great assistance, not only in comparing and contrasting generated alternatives. It is also very useful to interpret and evaluate the outcomes of transportation models.

2.2 GIS - Land Use Planning and Urban Infrastructure Planning

Land use is a key input to water distribution, wastewater collection, storm water, traffic, and other urban and rural infrastructure master plans. It is the driving force for service expansions or existing system upgrades and it dictates the need as well as the scheduling of improvement projects.

If GIS data sources are available for the land use development, a GIS interface can be used to extract land use directly from these data sources to build this land use plan. Linking the land use to GIS data sources has several benefits:

- Existing land use estimates can be extracted from data sources maintained by different disciplines (e.g., the tax assessor's office or the agency's planning department).
- Land use zoning and General Plan information can be merged to provide a comprehensive estimate of future land use development.
- Interfacing the land use plan with its GIS data sources enables updating of the model's input with changes to the land use data sources.
- The extracted land use plan can be shared by multiple facility master plans, which could result in a coordinated planning effort for all services managed by the agency.

3. PROBLEM STATEMENT

We understand that successful urban design is that, which not only integrate public and private, but focus on the positive relationship between whole and parts, big picture ideas and detail and realistic implementation. The problems pertaining to the urban design and planning applications deals with a different types of spatial data, and they are to be analyzed simultaneously.

With out the help of GIS it is very hard to deals with different spatially references entities. In complex problems; such as to identify the best suitable site for development of a residential neighborhood - this requires to study different spatially referenced features, such as the type of land; nature of soil; whether there is proper drainage and water facility; whether there are schools and hospitals near by available, and parks. For these things to be analyzed at a time to get the results it is very difficult or mere impossible to do with out any GIS applications.

Problem defined – *"It is very difficult to analyze problems of urban applications which involves multiple spatial entities; which are to be analyzed simultaneously"*

4. OBJECTIVES

There are different urban applications that require the analysis of spatial data. Such as the transportation network analysis; site suitability analysis for a particular land use; land use planning; overlaying of multiple layers of different geographical features and many more. Based on this following are objectives of this study.

- ✓ To locate the residential/ commercial areas those are more susceptible to crime on the basis of its distance from the police neighborhood.
- ✓ A company of certain product is interested to find out its consumers of certain product which are used by a particular set of people; to find out the location of all the Single family and double family houses in the vicinity of the commercial center.
- ✓ Site selection for railway station based upon the areas around which it serves. The details of the selection criterion are mentioned in the analysis part.

5. METHODOLOGY

This section discusses the methodology that has been involved in achieving the objectives of the project. The tasked explained would be acquiring data, arranging them in proper order, classification of each and every layer, symbolizing, editing, and others. The software used is Arc GIS INFO 8.3, in that the most of the operations are dealt in Arc MAP. The following section describes the various set of operations performed.

Acquiring and arranging data: The whole data for the project is obtained from the website of the city of AUSTIN; the data obtained is in the form of shape files as

Zoning - It represents the various land uses for the area such as residential, commercial, recreational, industrial, down town mixed use, agricultural etc. This layer acts as the base map for the whole analysis part, so it is placed at the bottom most in the table of contents.

Facilities – This layer shows the different facilities that are available for the area like hospitals, medical centers, colleges, recreational centers, post office, library, museum, electric generating plant, waste water treatment plant etc,.

Security Services – this layer shows the security services such as fire stations, and police stations.

Main roads – this layer shows the alignment of roads depending upon its priority and classified as Major, minor and rural roads.

The other layers are **parks, streets, railway tracks, airports, water bodies.**

Symbolizing the data

Symbolizing is one of the important functions of GIS; it helps in proper representation of data for the users and others. The data obtained was in raw format, there was no symbolization for any of the layer. The symbolization may be variation in color representation for polygon feature, and line feature; for point feature it could be symbols depending upon the service such as hospital, post office or a museum. Let us see some cases of symbolizing the data. Initially let us consider the layer for zoning, the figure shows the snap shot for the layer properties and in symbology tab where the different color is assigned depending upon the type of land use.

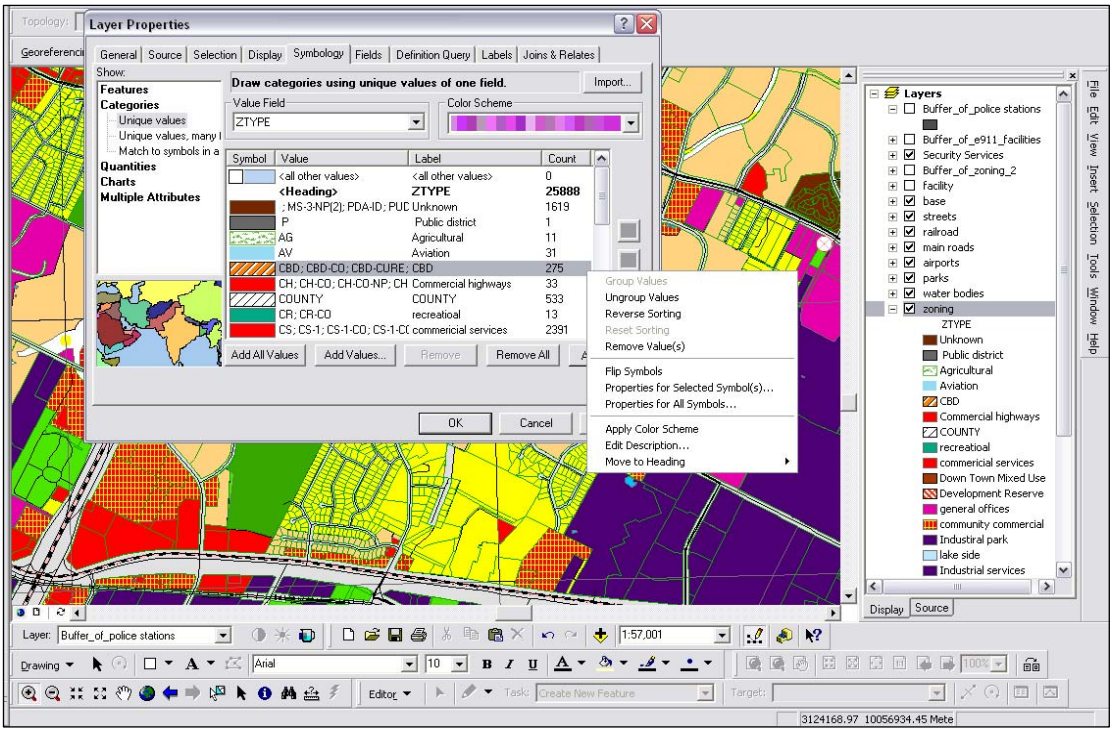

Fig showing the symbolizing tab of the *zoning* layer

The data in the layer zoning is symbolized according to type of land use. To avoid complexions the similar zoning categories are grouped under a major group. For example, the residential group was subdivided into single family and multi family housing groups. And again the single and multi family housing groups were classified based on the number of bedrooms and the size of lot. So in order to simplify the color coding all these types were grouped under single category, Residential. In the same way other land uses were also grouped such as commercial, industrial, etc.

It is to be noted that upon group these different sub categories into single one, the actual zoning type remains unchanged. These are grouped under one section to represent them under one single unit. For example, SF-1, SF-2, SF-3, SF-4, SF-5, MF-1 TO 6 were grouped under on tree, “Residential” and represented with a single color. But the zoning type of the each individual type remains unchanged. This makes easier to understand and study different color coding, more ever human can differentiate at a time only 12 to 14 colors.

Another major symbolization was done on the same basis for the layer for main roads. It is classified into three main types' namely major roads, minor roads, and rural roads.

The second type of symbology was the symbol specification for facilities layer. This is a point feature class. It represents the various facilities like libraries, museums, post offices, nursing homes, hospitals, and various other facilities. For this the symbols are chosen based on the type of service, such that it resembles the service it provides. For example the symbology for hospital or a nursing home would be a *"plus"* sign. Arc GIS provides certain standard set of symbology for different services, in addition to that there is also facility that we could create our own symbol or customize the existing ones. The snap shot below shows the symbology done for the facilities layer.

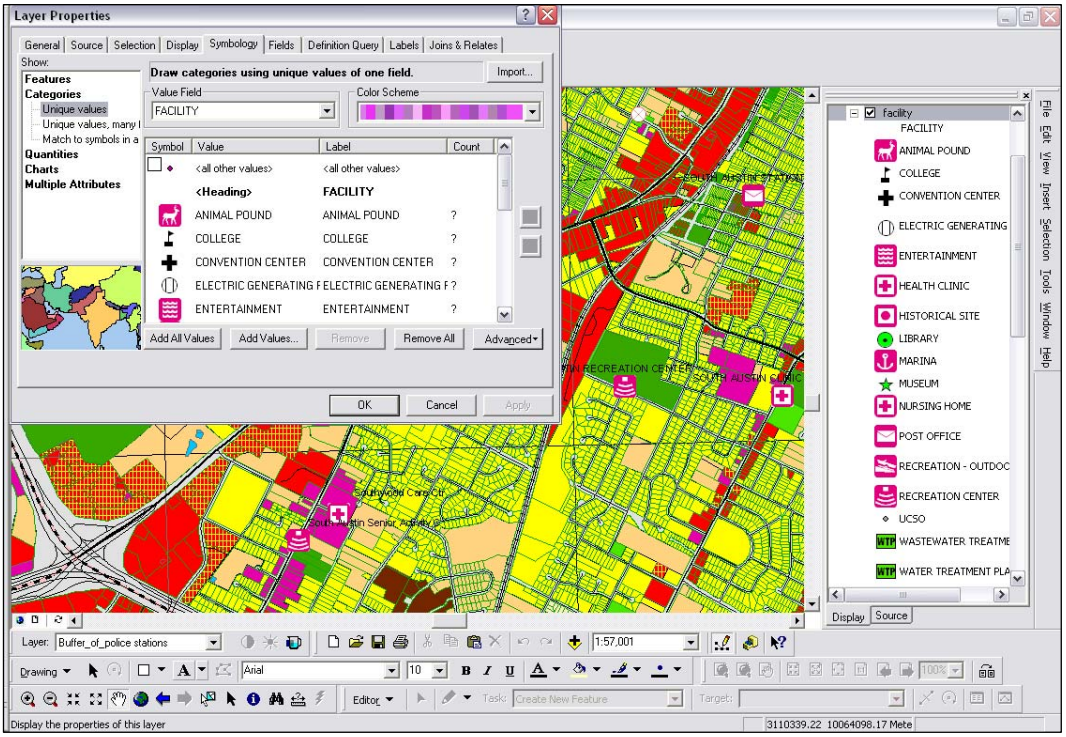

Fig showing the symbology for *facilities* layer

The next part of this section is the operations that are performed for the analysis. The main operations are selection by attribute, selection by location, buffering and geo processing wizards. The application of each and every operation is discussed in details in the following section when the analysis is done.

6. ANALYSIS AND RESULTS

In this project we are dealing with four tasks, we will discuss every task in details and discuss the results.

Task 1: To locate the residential/ commercial areas those are more susceptible for theft and crime on the basis of its distance from the police neighborhood. For this analysis a hypothetical assumption is made that the effective area of any police neighborhood is about 5 miles from the center of it. So let us see how it is done.

Initially from the layer of facilities the police neighborhoods are selected. This is done by selection by attribute criterion. The police neighborhoods are selected, in which there are police neighbor hood, police stations, and police substations these all serving the same purpose.

The snap shot of the Arc GIS analysis shown in Fig 3 gives the picture of the buffering of the police neighborhood. The center of the circles is the actual location of the police stations and the circle around it is the area of influence. It can be seen that there are two concentric circles for each police stations. The radius of each circle is 2.5 miles. It shows the variation in the influence of the police station for that area. It means that the areas which are under the inner circle are lot safer when compared to the areas in the outer circles. Having seen the overlay of the buffer on the base map the following comments could be made.

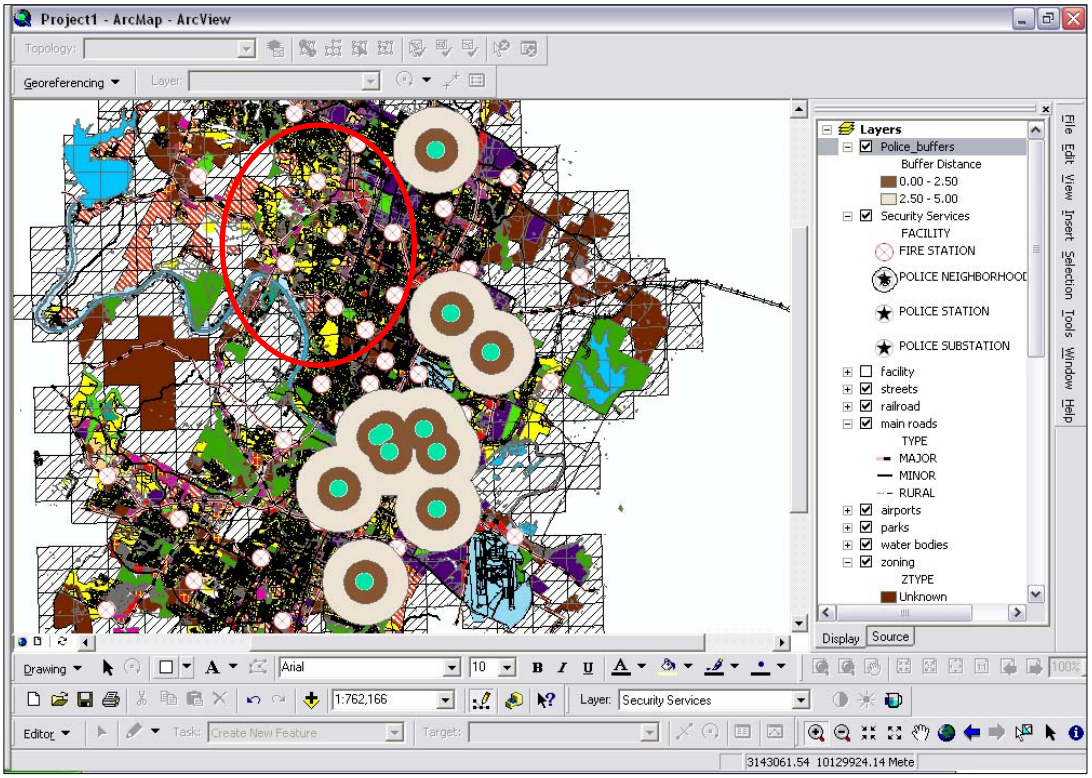

Fig 3 Showing the Buffering of the police neighborhood

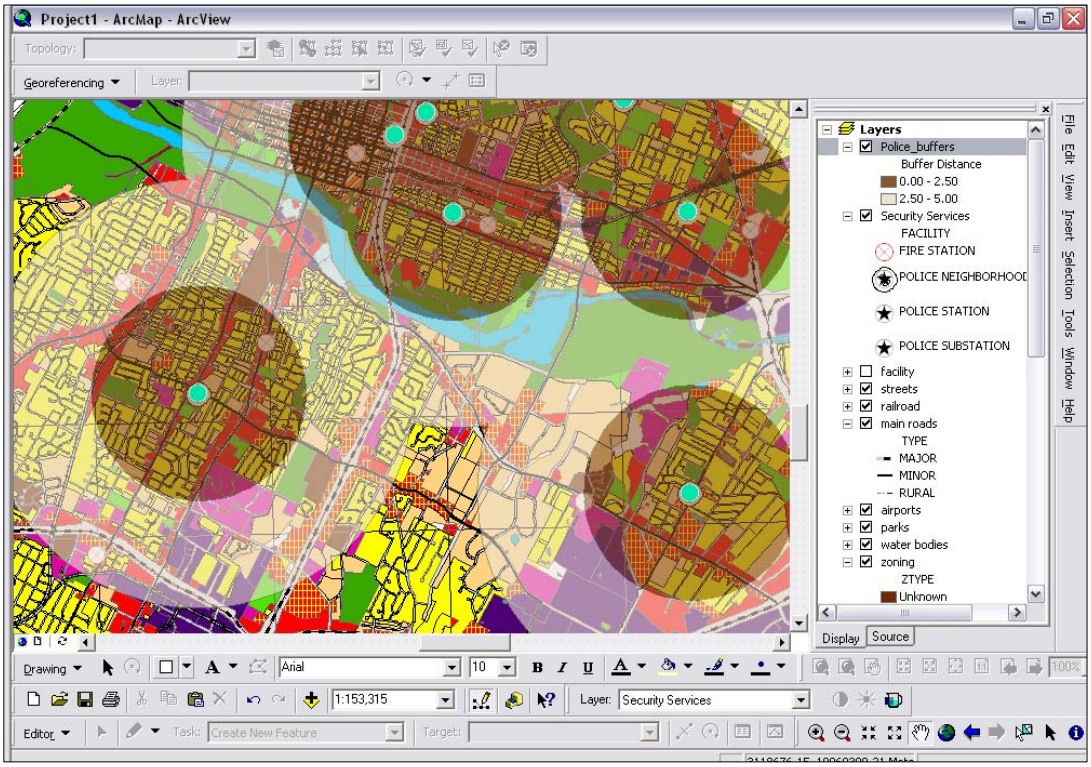

Fig 3a Showing the over lay of buffering with zoning of different land uses

- There is concentration of police services in the center of city.
- Location of the police services are mostly in the commercial areas, this could be seen from the fig 3a. This could help the planning authority to find out optimum site selection which requires more security like financial institutions like bank.
- From the figure 3 it is observed that the area encircled red is far outside the reach of any police station, this states that it is more susceptible for crimes and thefts. This analysis really helps to find out the best possible location for establishing new police stations.

Task 2:

The second task is regarding the commercial services. The problem defined is as follows; A certain company produces some goods that are consumed by some specific group of communities and are been sold in only certain commercial centers. And the company wants to either increase its supply for the areas where there are more consumers. Or trace down where has its least costumers so that it can cut down its supply for that particular area. Here in our hypothetical problem let us consider the single family and double family residents that use certain commodity for their daily life. Another assumption is made that a certain commercial center serves around 2 miles of its area. The task is to exactly find out the location and number of house holds of the specified characteristics.

To carry out this three main GIS tools are used initially buffering is done, then the selection by location query is done, and finally selection by attribute is done. The following figures and comments explains in details.

The first step would be to select the required commercial centers that sell the goods of this product. Then it to create a buffer zones around each commercial center with a radius of 2 miles. The locations for commercial centers are named as Areas 1, 2, 3, 4, 5, 6, and 7.

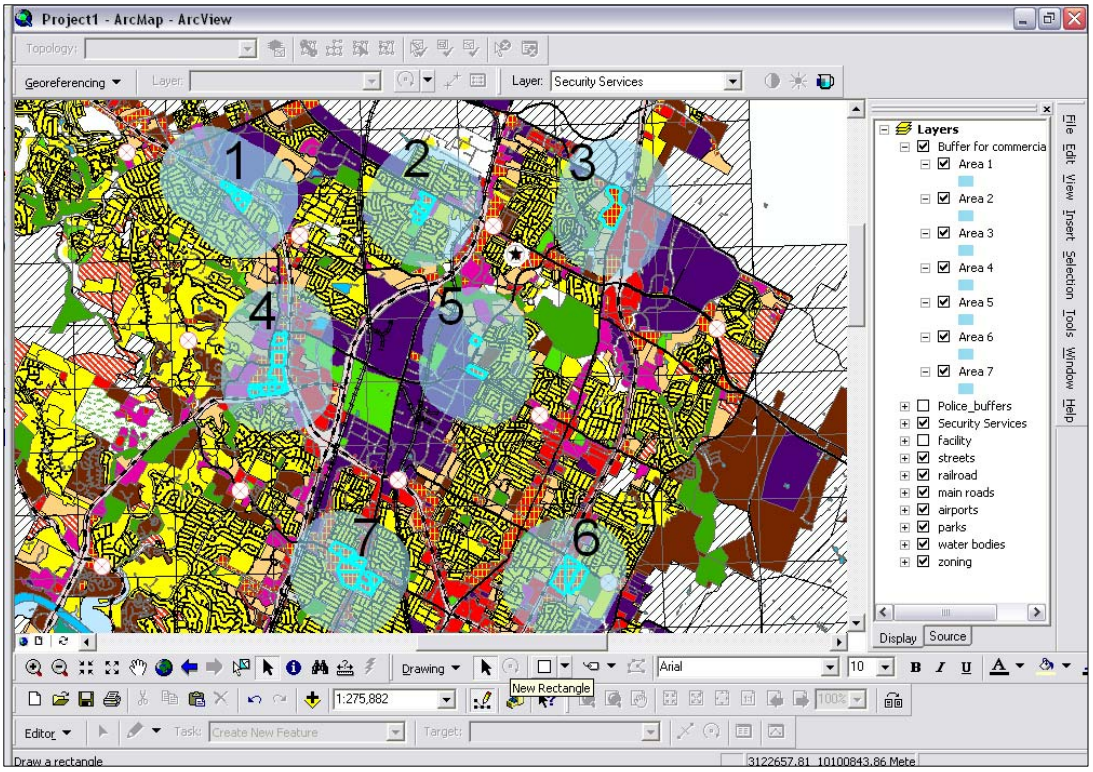

Fig 4 showing the location of commercial centers with buffer of 2 miles

Now by selection of location dialog, all the residential area that are completely with in the buffers are selected as shown below in the figure 4a.

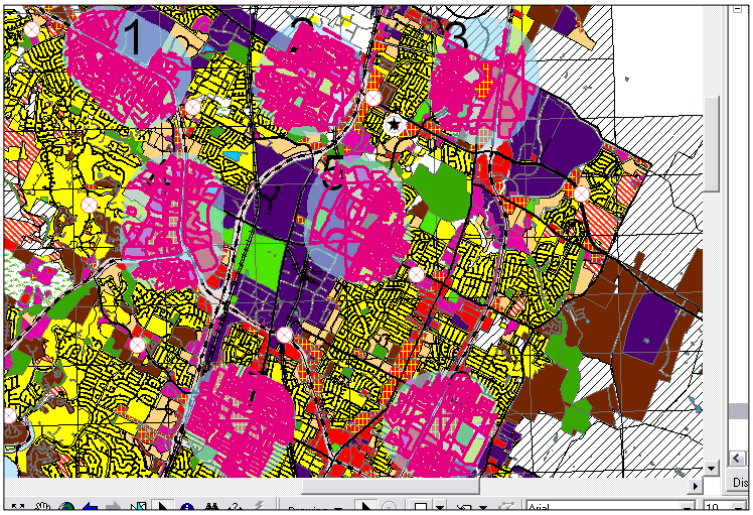

Fig 4a

The final task would be to from the selected residential areas sort out ones which are single family and double family residences. For this selection by attribute for already selected features is done, by specifying in the attribute of zoning type as single and double family the required areas are selected as shown below in the Fig 4c. Based upon this the following points could be concluded.

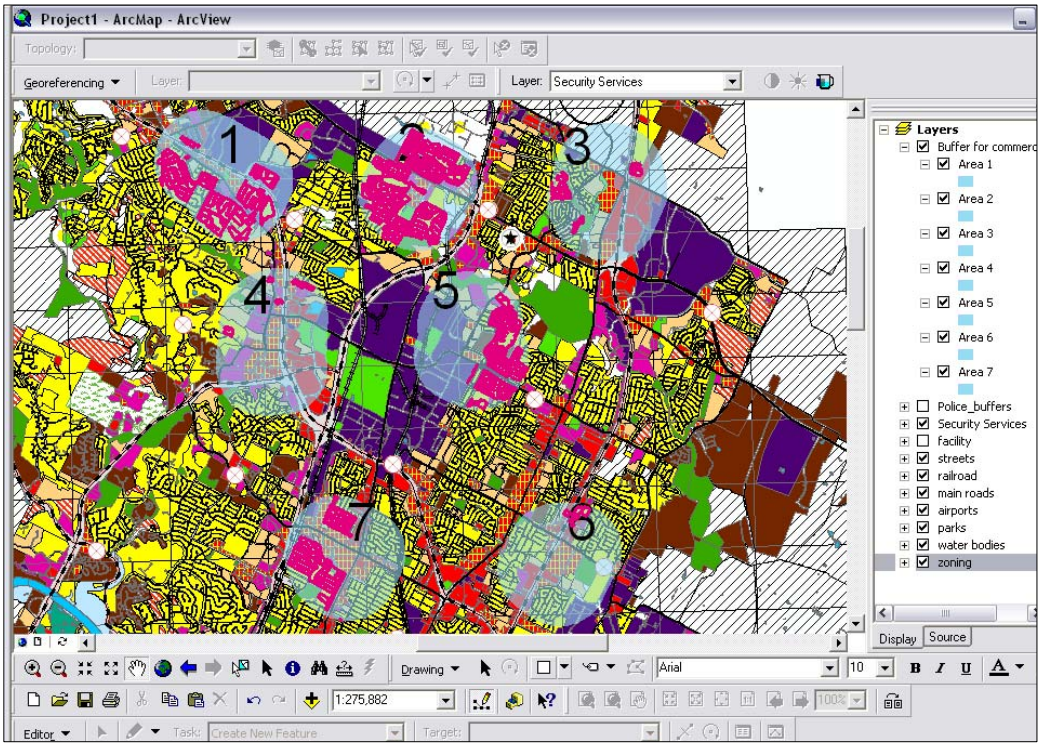

Fig 4c showing the single & double family residents in the selected areas

- The final figure 4c shows that the areas 3, 4 and 6 are having almost negligible or very little number of the costumers. It refers that the company which produces this product has to cut down its supply for that particular area, so that company may decrease the operating costs.
- Second observation is that the areas 1, 2, 5 and 7 have a good demand for the product. As the consumption of this commodity is more in these areas, the company should increase the supply in these areas so as to get more benefits.

Task 3:

The third task is to justify for the site selection for the railway station along the existing track. For this let us see the context of problem. The railway line lines runs through the length of the city, it connects the suburbs to the CBD. There are few stations from where the people going towards CBD are supposed to catch the train, people need to travel a longer distances to take a train. So the task would be the location of a railway station between so that it facilitates the people to get the train for CBD for their daily work

The selection criteria are

- People staying in multi family neighborhood use more frequently the railway services.
- Another criterion is that the railway station should be about 5 miles in reach of the houses.

This is done in the following steps. Initially the residential areas that with in the 5 KM distance of the railway track; this done by using selection by location tool. From these the multiple family houses are selected by selection by attribute tool. From the figure 5a it could be seen that are certain places where there is a larger concentration of multiple family residents. About four locations are selected and applied a buffer of 5 km of applied to it. From fig 5b it could be seen that all the four newly established stations almost cover all the multi family residents.

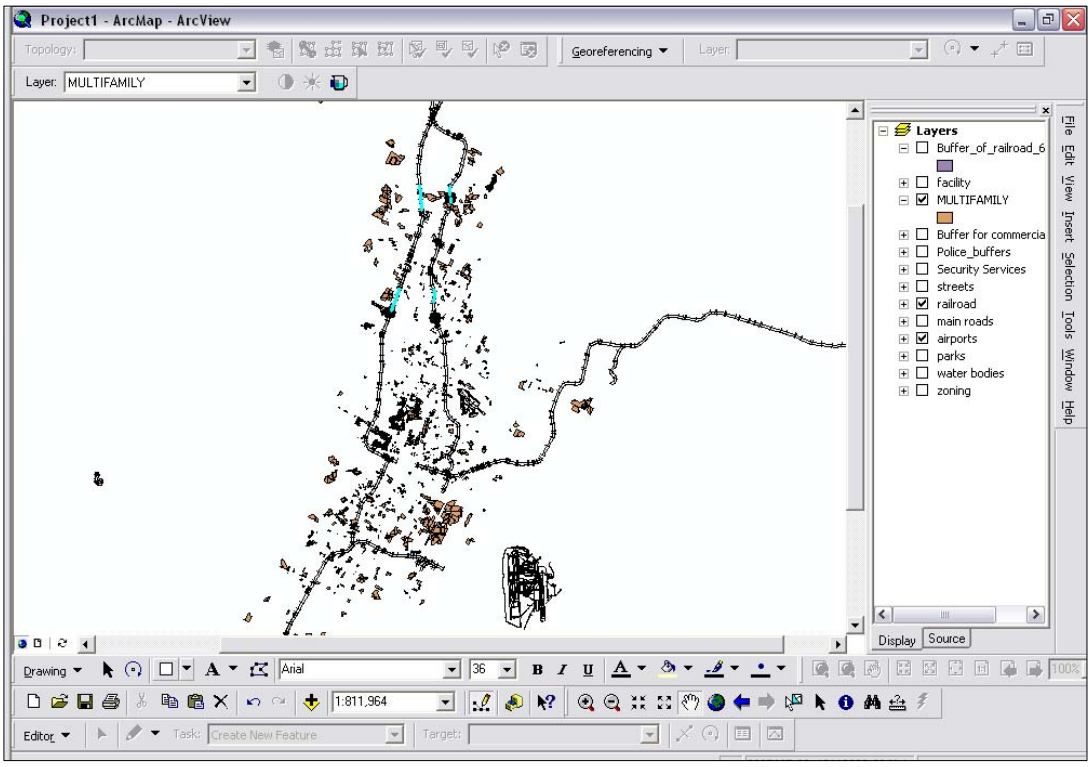

Fig 5a showing the concentration of multi family residents along the railway track

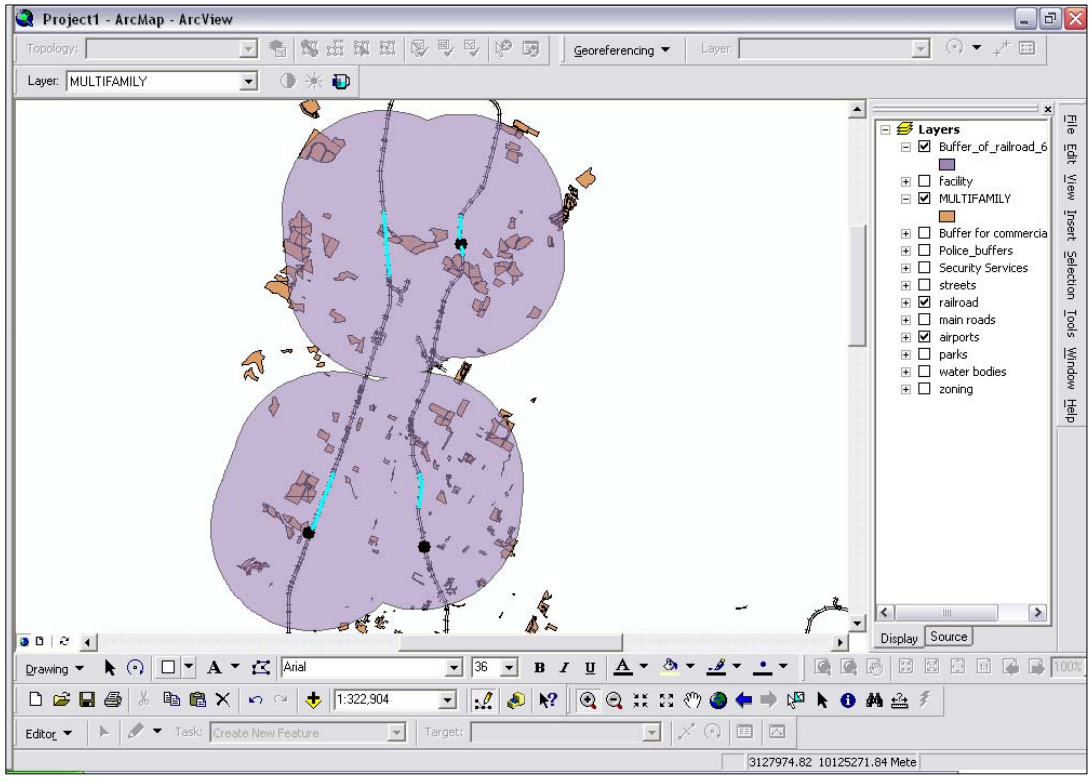

Fig 5b showing the buffering of the four newly established railway stations

7. CONCLUSIONS

Having seen the capabilities of GIS solving various complex problems the following point could be concluded.

1. GIS can solve many complex problems that require the analysis of different geographic features at a single instant of time.

2. Having seeing the vast applications of GIS in urban planning applications it can be concluded that GIS is a very powerful tool that can deal with any complex problem.

3. It is very easier for any city's authority like municipality to solve different instantaneous problems such as find out the location of houses with infants for the vaccination program; or it could be the determination of most crowded streets.

4. GIS helps in any governing authority either on federal, state or local level in finding out the working conditions of various facilities available for the society.

5. There are numerous multi operational tools in GIS that deals with multi layer problems such as; site selection – which depends on many different criteria for selecting an appropriate site.

6. Finally the most important component of GIS is the data. If there is no proper data available even with the availability of best resources i.e., hardware and software nothing can be done.

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