King Fahd University of Petroleum and Minerals

COLLEGE OF ENVIRONMENTAL DESIGN

Department of City & Regional Planning

INTRODUCTION TO GIS

(CRP 514)
Fall Semester 031

TERM PROJECT

IDENTIFYING & PLANNING PUBLIC SCHOOL FACILITY IN CALIFORNIA USING GIS

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1.0 INTRODUCTION

Geographic Information System (GIS) is defined as an information system that is used to input, store, retrieve, manipulate, analyze and output geographically referenced data or geospatial data, in order to support decision making for planning and management of land use, natural resources, environment, transportation, urban facilities, and other administrative records.

GIS can also be defined as A system of hardware, software, data, people, organization and institutional arrangements for collecting, storing, analyzing, and disseminating information about areas of the earth.

A GIS can be seen as a system of hardware, software and procedures (tools) designed to capture, manage, manipulate, analyze, modelling, and display spatial or geo-referenced data for solving complex planning and management problems. The key phrase is ``spatially-referenced data." A database system that combines data sets of different types from different sources about different features/objects is likely to find that converting data sets into a common form dominates the processing efforts, when it is possible at all. They contain both geometry data (topological information) and attribute data, i.e. information describing the properties of geometrical spatial objects such as points, lines and areas. The spatial analysis includes techniques such as spatial querying, point-in-polygon operation, buffering, overlaying, intersection, dissolving, proximity analysis, etc.

GIS – An extensive Technology, unfortunately very few knows the true GIS Generally, a geographic information system (GIS) must consist of at least two models, the raster data and the vector data. The raster data come in various forms. And one of these is the orthophoto. Orthophoto can be utilized to study the true image of an area and extract all visible objects. It can also be used as the main basis for the creation or orientation of vector data. Vector data, on the other hand, are sets of points, lines and polygons that could be linked to any database system. Unlike raster data, what you see is what you get, vector data can carry unlimited number of information and can even be linked to different relational database management systems. This means that a single line representing a road can have various details such as the name of that

specific road, its length, its current status, and more. There is actually no limitation in extracting or linking information to vector.

A GIS is more than just layering of maps. The principal component is the ability to give attributes to the features on the map. This capability means that dots on the map are more than just households, but a wealth of information about each household. For instance, the household layer could contain information on the number of people in the household, their ages, genders, etc. This wealth of information, which is available in the layers allow for quite sophisticated analysis. A GIS is generally a tool that enables information that has an earth-based reference to be stored in a logical fashion. It will allow a user to accurately map areas and to store information that is pertinent to that map to be linked to the digital map. A GIS also must know the spatial relationship of one object in relation to all of those other objects surrounding it. A Geographic Information System must not only enable users to analyse the data that is stored in the system, but it must allow additional data to be introduced and therefore new relationships to be created. One of the major benefits of any GIS is that it enables users to visualise information and as the visualisation of information is one of the most powerful learning and understanding methods available, a GIS becomes one of the most potent methods of analysing, understanding and presenting data.

GIS is not only one of the fastest growing areas in applied computing, but is an integrating technology bringing together information, systems, applications and people from many diverse fields. GIS are important to a wide range of disciplines and applications including mining and exploration, environmental and natural resources management, urban and regional planning, land administration, asset management and utilisation, health monitoring and management, demographic marketing, etc. The use of GIS is rapidly growing in governments, utility companies, and related private organizations. Many cities, countries, regional agencies, and private organizations are adopting this technology to improve their services, assist in managing resources, and provide support for better decision making and policy planning activities. The intent of this process followed in both government and business is to place policy issues in a planning perspective so that today's solutions do not become tomorrow's problems.

Generally, the GIS applications shall contain at least five (5) components, the hardware, software, data, people and method. And among these components, the data is the most important component that needs to be considered. Proper creation of the data shall be observed or the whole GIS application will fail. It means that especially designed applications shall be utilized in creating the data. It is not true that there is a sole application out there in the market that can handle all processes in the creation of GIS data. GIS is a special-purpose digital database in which a common spatial coordinate system is the primary means of reference. Comprehensive GIS require a means of:

1. Data input, from maps, aerial photos, satellites, surveys, and other sources
2. Data storage, retrieval, and query
3. Data transformation, analysis, and modeling, including spatial statistics
4. Reporting, such as maps, reports, and plans

These are some of basic requirements called as Elements of a GIS (Chan and Williamson 1995).

Elements of a GIS	**Scope of Each Element**
Data	all accessible data, both geographical and attribute, required to meet the geographical information needs, identified or latent.
Information Technology	all computer hardware, software (including applications) and the associated communication technology required to meet the geographical information needs, identified or latent.
Standards	all agreed practices required to facilitate the sharing of the other four components of a GIS.
People with GIS Expertise	all knowledge, skills, procedures, and systems, technical or otherwise, acquired by the stakeholders, that are required for the smooth functioning of the GIS to meet the information needs, both identified or latent.
Organisational Setting	all the operating environments, technical, political, or financial, created by the interaction among stakeholders, in which the GIS is to function.

GIS has always been a tool that crosses the boundaries of disciplines and application areas. As GIS users we are all familiar with science and technology, and engineering applications. The power of GIS lies not only in the ability to visualize spatial relationships, but also beyond the space to a holistic view of the world with its many interconnected components and complex relationships. The ability to develop higher-level thinking and problem solving through the use of GIS definitely gives a better understanding for decision-based systems. Before finding the best site on a particular area, the owner had to do a lot of preparations like finding the number of people living in a given county or city, and if he is going to do that manually it is going to take a long time and still will not be able to find exactly all the details regarding the things that needed for his business and in the process wont find the best location as well. GIS provides ready to use data which helps in knowing all the details and much more than required and he can go in small details in finding the best possible location.

These are the following reasons why a GIS is needed.
- geospatial data are poorly maintained
- maps and statistics are out of date
- data and information are inaccurate
- there is no data retrieval service
- there is no data sharing

Once a GIS is implemented, the following benefits are expected.
- geospatial data are better maintained in a standard format
- revision and updating are easier
- geospatial data and information are easier to search, analyze and represent
- more value added product
- geospatial data can be shared and exchanged freely
- productivity of the staff is improved and more efficient
- time and money are saved
- better decisions can be made

Thus, Geographic Information System is very powerful and the only limitation in this application is the users' imagination. However, there are a lot of things that are to be considered. First is the software that will be utilized in the GIS application and

another is the creation of the data for the said application. With these things in mind, the implementation may come very smoothly and the users will be able to grab the technology quickly. And, with the phasing of GIS technology now a days, it is not really very practical to purchase a large and very expensive software that will surely be obsolete in a few years or perhaps just a couple of months. It is recommended to acquire small-scale GIS software and simply upgrade it as need arises. It this way, new and latest technology can surely be acquired in the future.

2.0 PROBLEM STATEMENT

The location of public facilities in urban landscapes is a multi-faceted process in which numerous social and physical criteria must be taken into account. In doing so, planners are responsible to ensure that each new individual facility can be utilized and accessible to the optimal proportions of the population. The relatively recent integration of geographical information systems (GIS) into the area of facility siting has enabled urban planners to make more effective location decisions, with the aid of spatial data and a wider range of spatial analysis tools. Issues of competitive distances, physical constraints, and accessibility can all be incorporated into the GIS-based modeling methodology, in order to provide sound decision making criteria (Pettit and Pullar, 1999).

Government schools are among such facilities which can be more efficiently sited with the aid of GIS tools. Most of the schools are located in the urban areas in United States and Community schools are neglected in many areas of United States. This project reviews the existing facility available in California State and identifies the areas which are rich in population of age group 5 to 17 and do not have school facility near by which is the main concern of this project in order to study those areas and find some solution for them and recommend few new sites where schools has to be established.

3.0 OBJECTIVES

In order to provide a best solution for the above discussed problem, the following objectives are derived.

1. To identify the existing school facility in the area.
2. To recognize the areas which are rich in facilities and population and do not have school facility.
3. Make recommendations for development of new facility in the identified areas.
4. To assess the strengths and limitations of this study.

4.0 STUDY AREA

The study area of this project is California in USA. In order perform a detail study on the subject a small place called El Dorado was selected from California State. The reason behind this selection was the number of schools in this area after browsing through California map was found to be less when compared to other areas. The selection of California was just because data was available for this state. This project can be applied to any area on the globe but the condition is that you have to have necessary input data of that area.

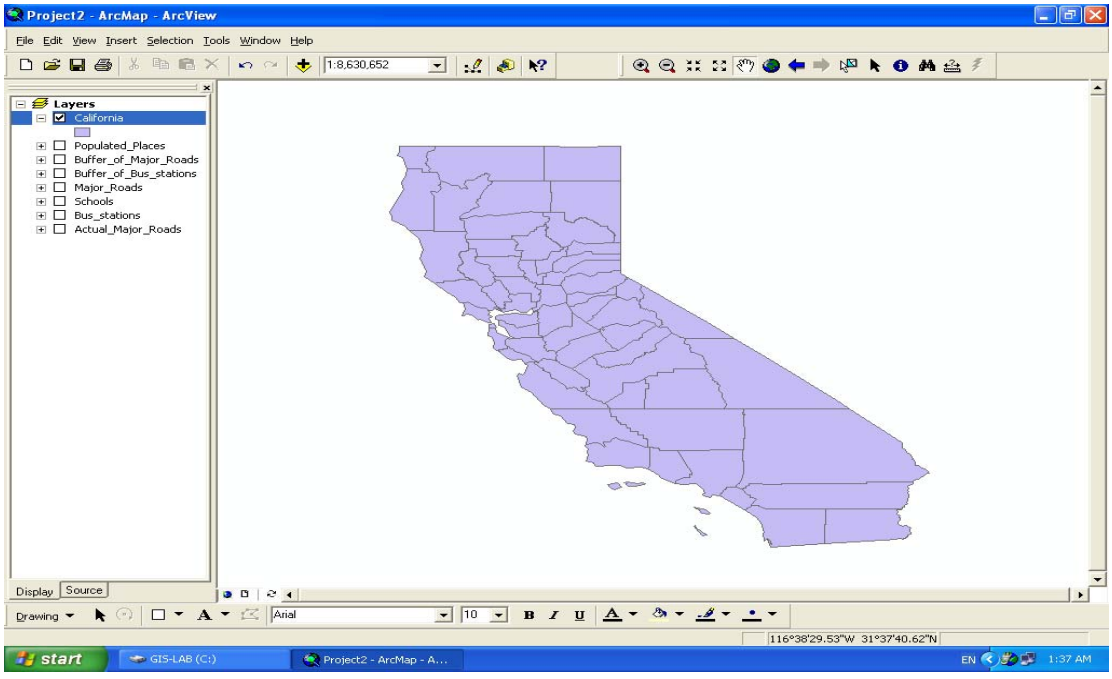


Figure 1. Map of California

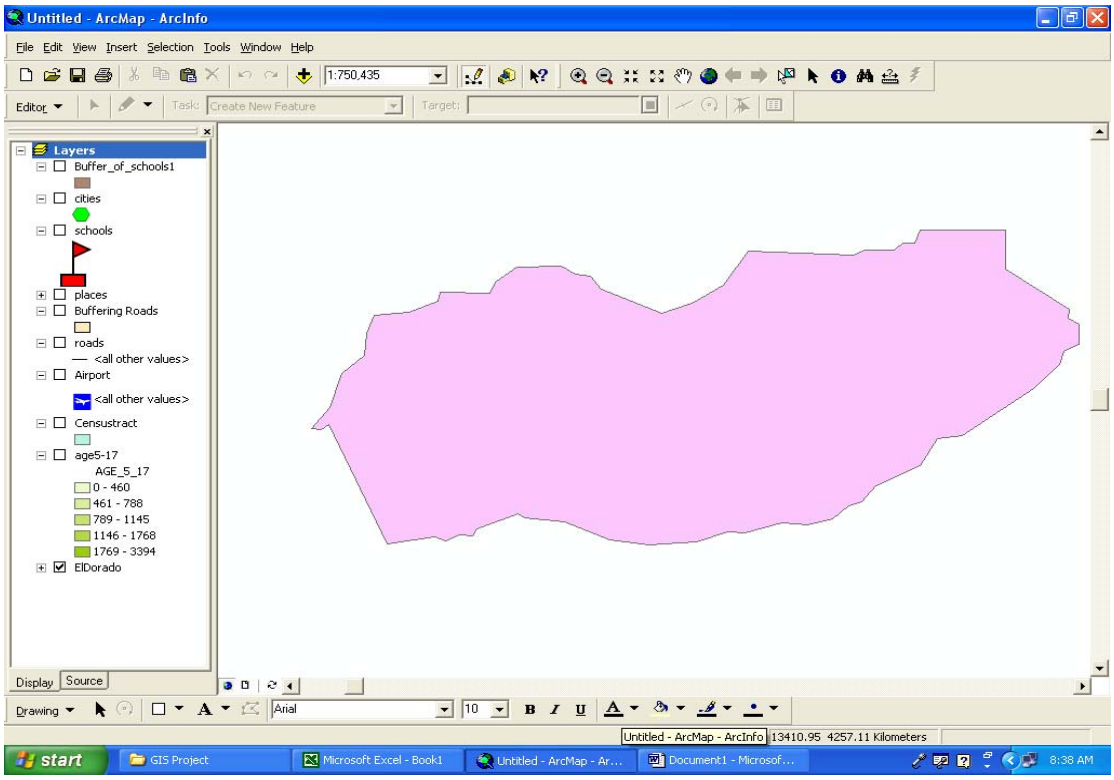


Figure 2. Map of El Dorado Extracted from California map

5.0 DATA SOURCE

This project has utilized the available data in GIS resources folder provided by ESRI which is present in GIS lab unit of City and Regional Planning Department of K.F.U.P.M. The software used in this project is ArcGIS.

6.0 PROJECT APPROACH

The above listed objectives are achieved by following this methodology which is listed below:

- At first the map of California is extracted from the maps data provided by ESRI as a layer in the data frame and then a separate layer of the schools is laid on it in order to see the availability of existing school facility in that area. Figure 3 shows you the actual map along with schools laid on it. Here you see some areas are rich in school facility and some other areas are poor and even some areas do not have school facility.

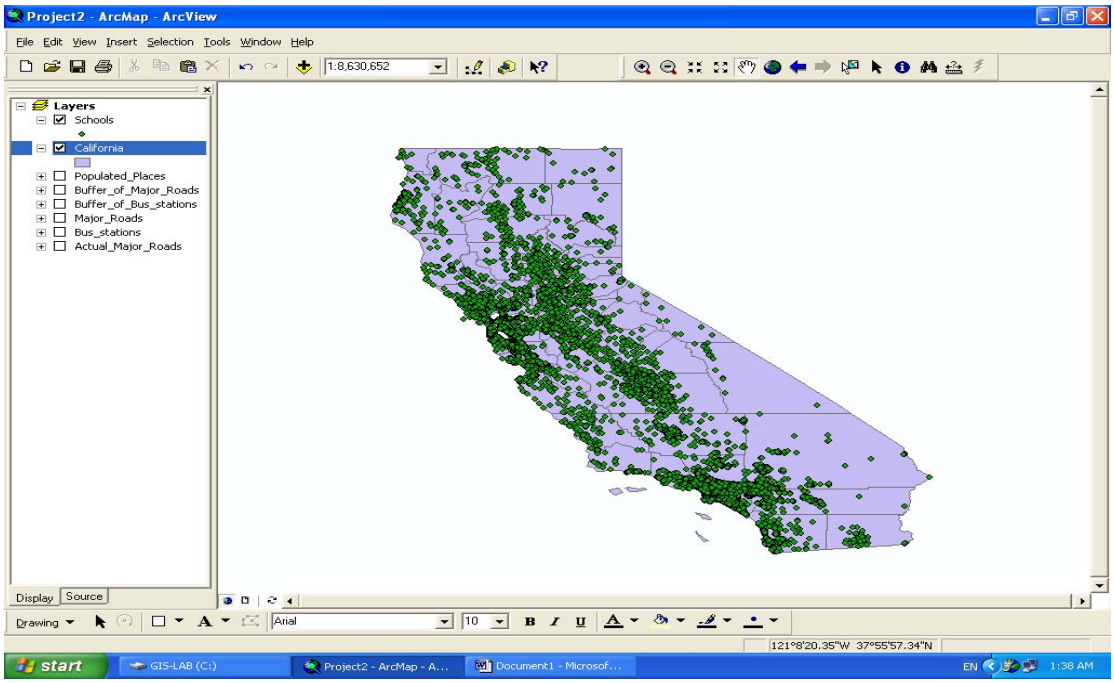


Figure 3. Map of California along with existing school facility

- A Bus Stations layer is laid upon the previous map in order to see the accessibility to the schools and more over for the analysis of these discrepancies in a state i.e., why some areas have good facility while the other or poor. This is made clear in the figure 4 which is below.

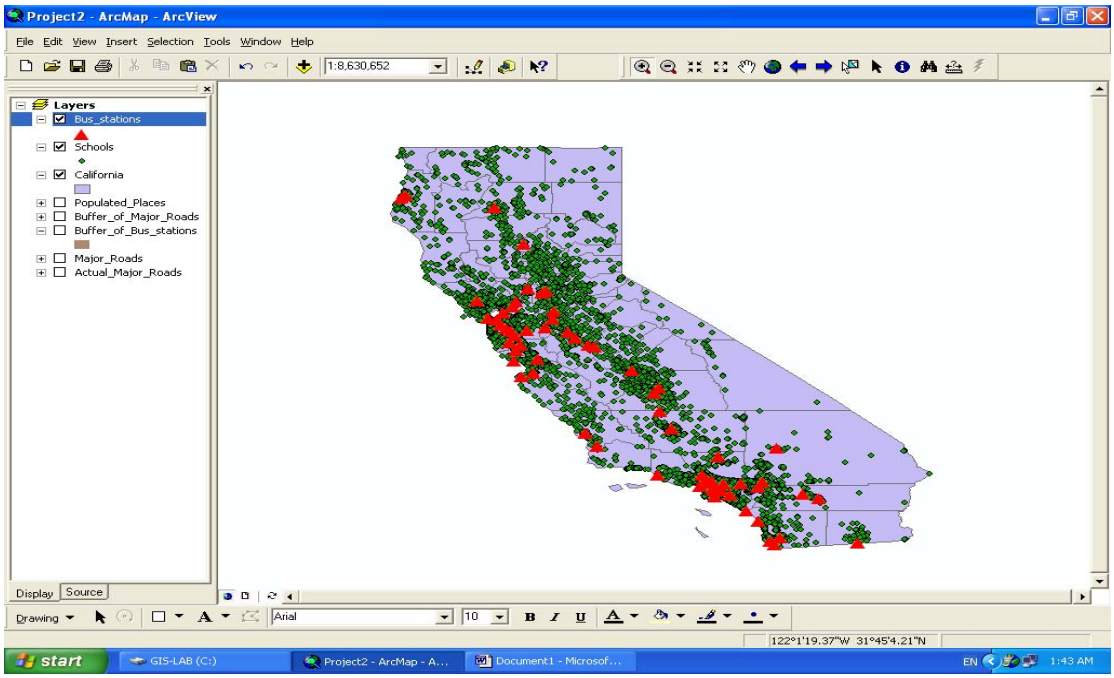


Figure 4 Map of California along with the existing schools and Bus stations

❖ In order to see the accessibility of the schools a separate layer of the major roads has be overlapped with the map of California which is clearly depicted in the figure below.

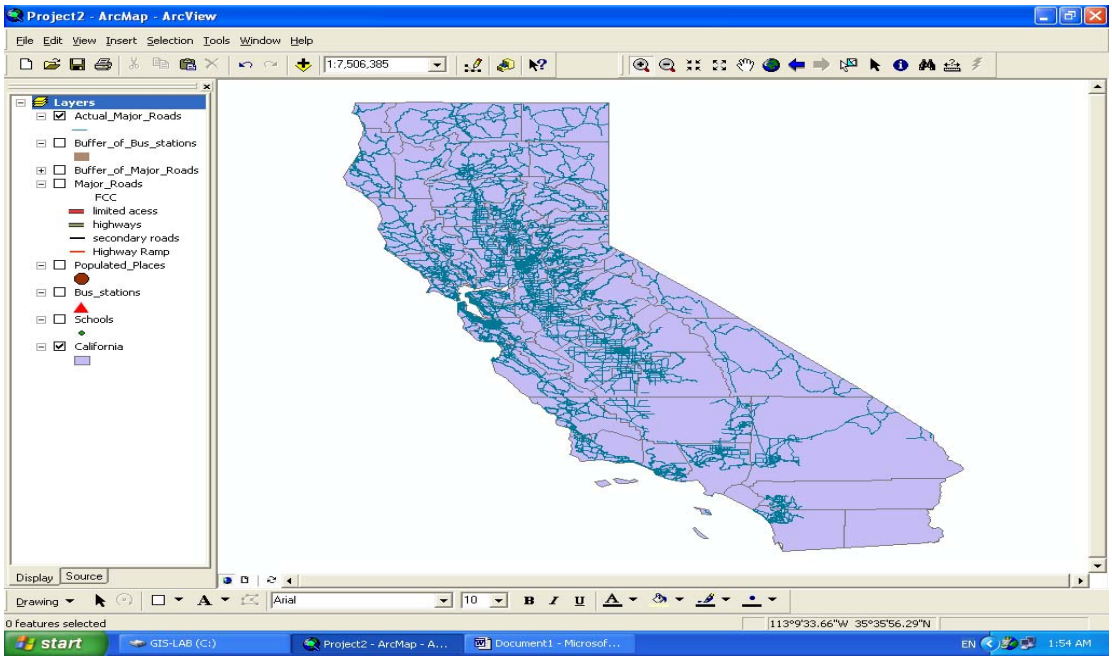


Figure 5 Map of California along with Major Road network

❖ As the major road network was not clear it was subdivided based on the categorization from actual source in to Highways, internal access, Secondary roads and highway ramps. Then the data is again exported with this new categorization in order to show the difference. This is depicted in the figure below.

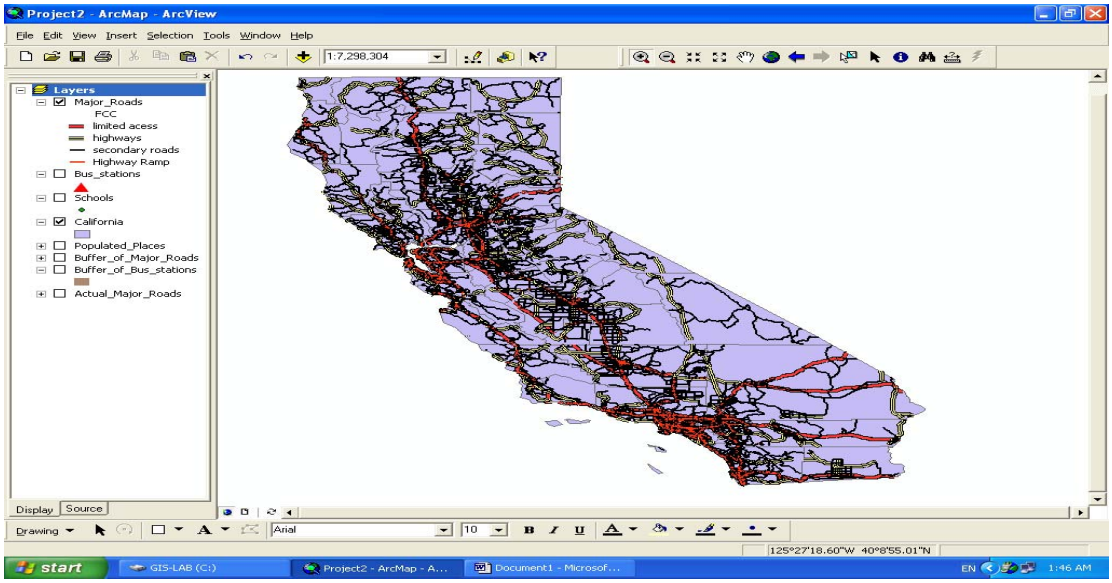


Figure 6 Map of California along with road classification

❖ Now the accessibility of the school is checked by laying the school layer and bus station layer along with California map. But the map has become messy to do further analysis that is why a place called El Dorado from the map has been selected for further detail analysis. Still an example of how to select the school site is given in the following section. The figure below shows how messy the map is to deal with.

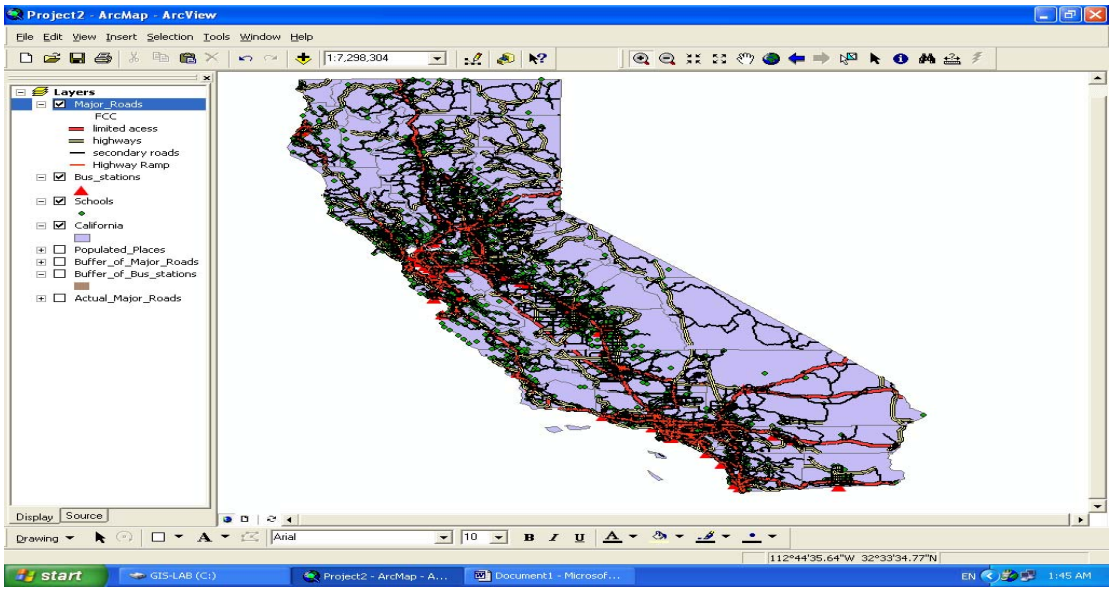


Figure 7 Map of California along with Schools, Bus stations and Major roads

❖ A buffer of 1 kilometer around the bus station is laid in order to select the areas which are near to it and having no school facility this is taken as a criterion in selecting the new sites. The map of California along with Bus stations layers and buffer of bus stations is laid to show the actual situation there.

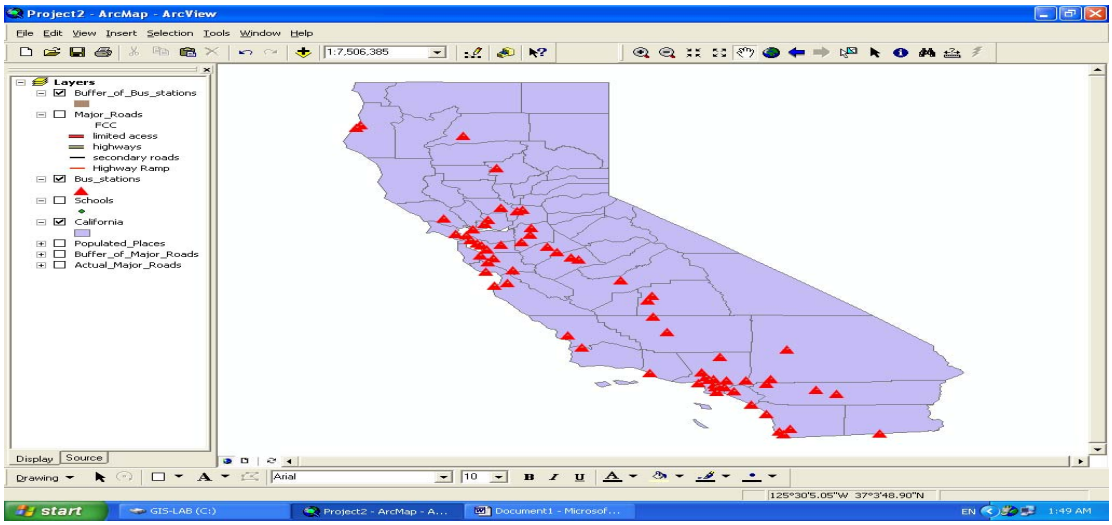


Figure 8 Map of California along with bus stations and buffer of bus stations

- As an example to select the site that is rich in facilities and should have a school. In other words establishing the new school facility in the area I have buffered the highway for 2 kilometers assuming that the school should not be on the highway for various reasons. Here the brown color shows the buffer of road and a buffer of bus station the region around these buffers is very much suitable in setting a new school facility.

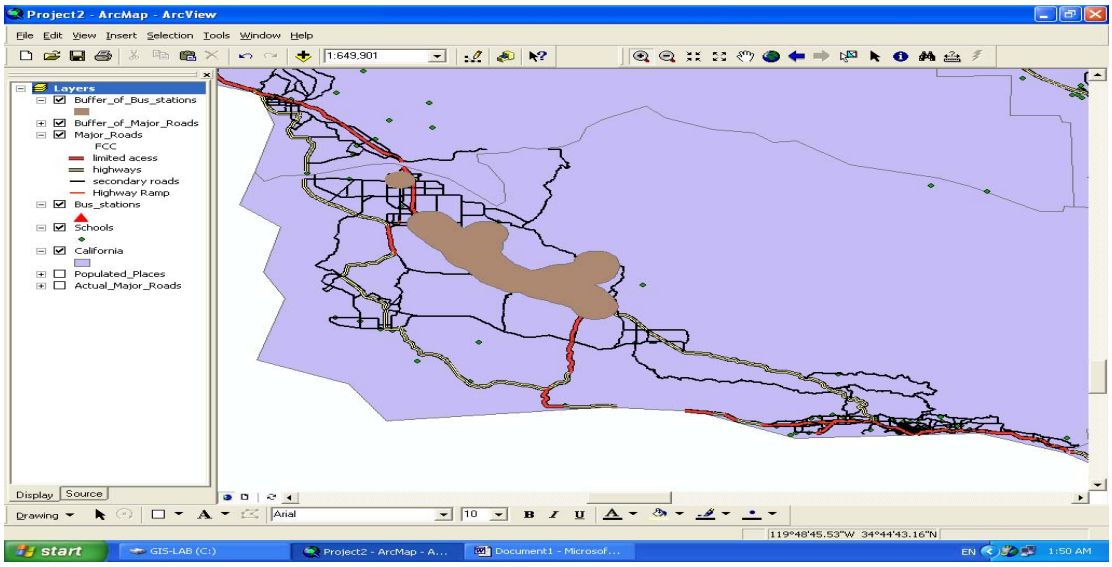


Figure 9 Map of California showing the area rich to establish new school facility

- For further analysis a small county of California El Dorado is selected and existing school facility there is evaluated for further decision making in selecting a new facility. The figure below shows the map of El Dorado along with schools present there.

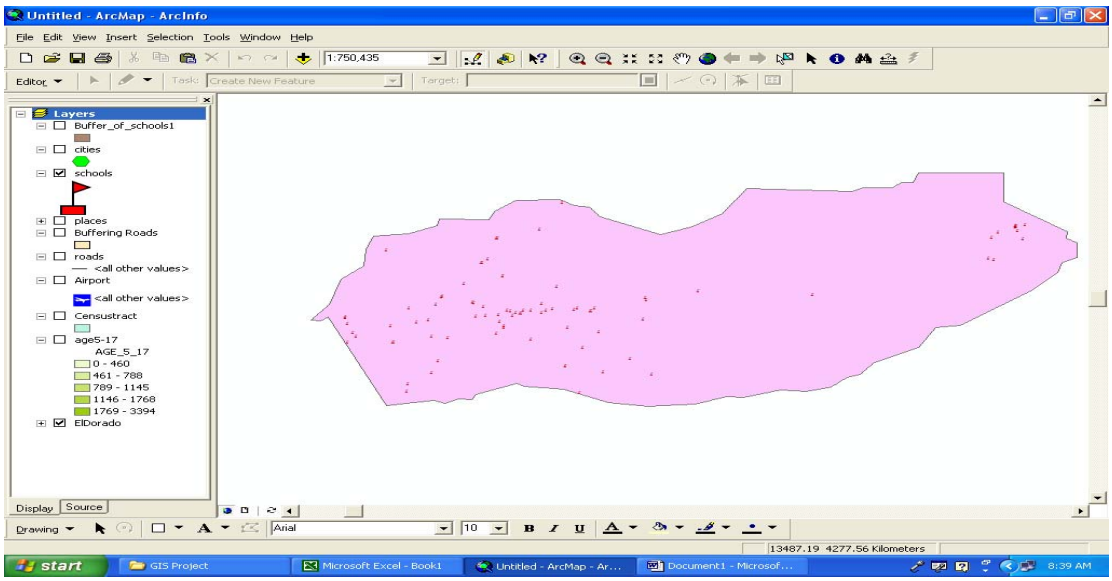
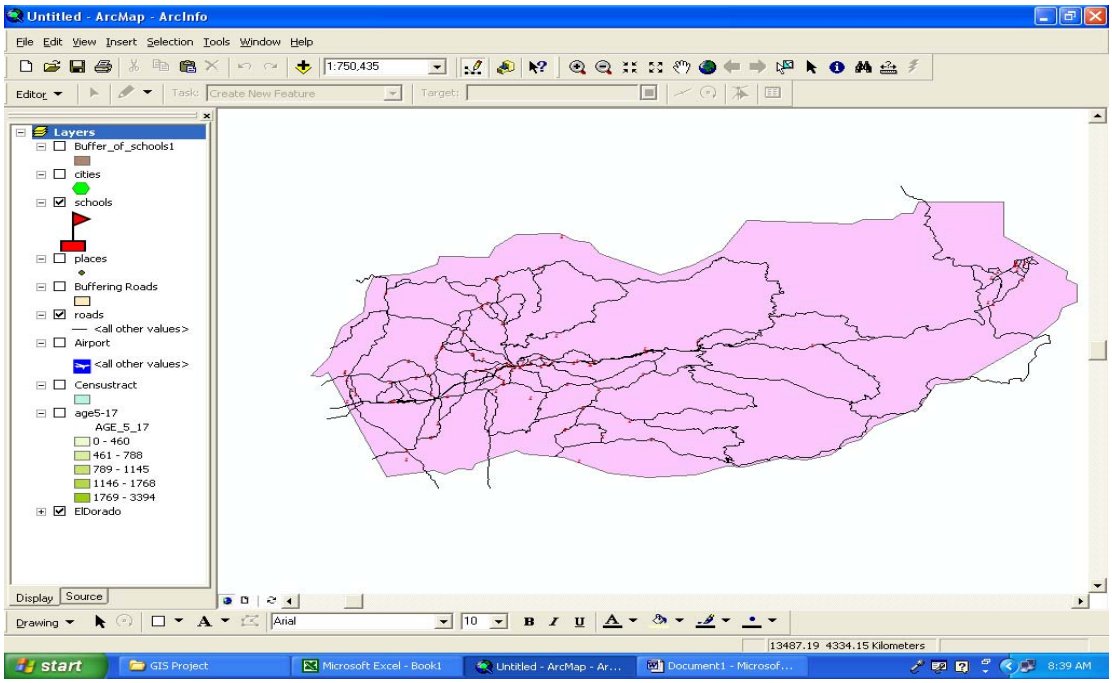


Figure 10 Map of El Dorado with the existing schools

❖ To check the accessibility of the schools the road network of the area is laid on the map and it was noticed that all the schools are lying on the roads which are accident prone areas to make it clear the buffer of 0.5 kilometers along each side of the road is laid that included all the schools except three which are away from the roads. This is represented in the figure below.



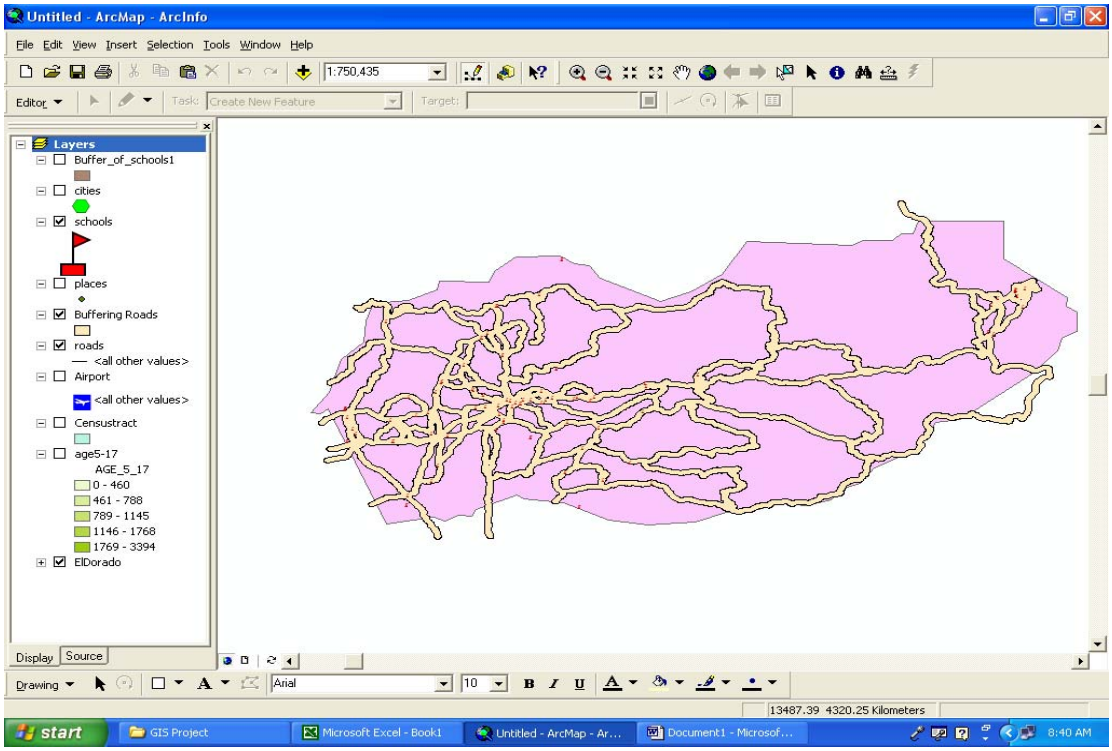


Figure 11 & 12 Map showing El Dorado along with Roads and buffered Roads

❖ Now the number of schools present there are buffered for one kilometer distance and the distance near by road and near to other schools are rich in establishing a new school facility.

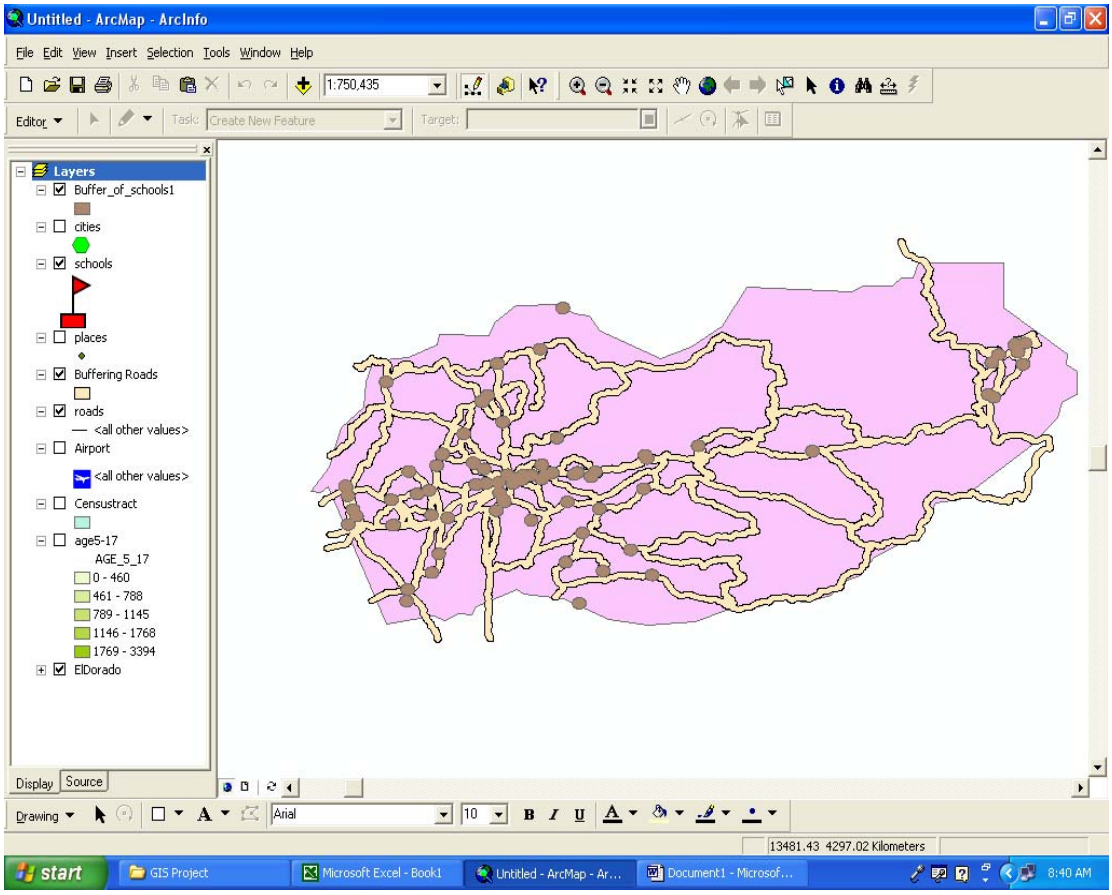


Figure 13 Map of El Dorado along with Buffered School and Roads

❖ Now we have laid the layer of census tract on the map of El Dorado in order to study based on population in the area. The population also serves as the criteria in selecting a school and recommending a school in a particular area. This is clearly mentioned in the figure below.

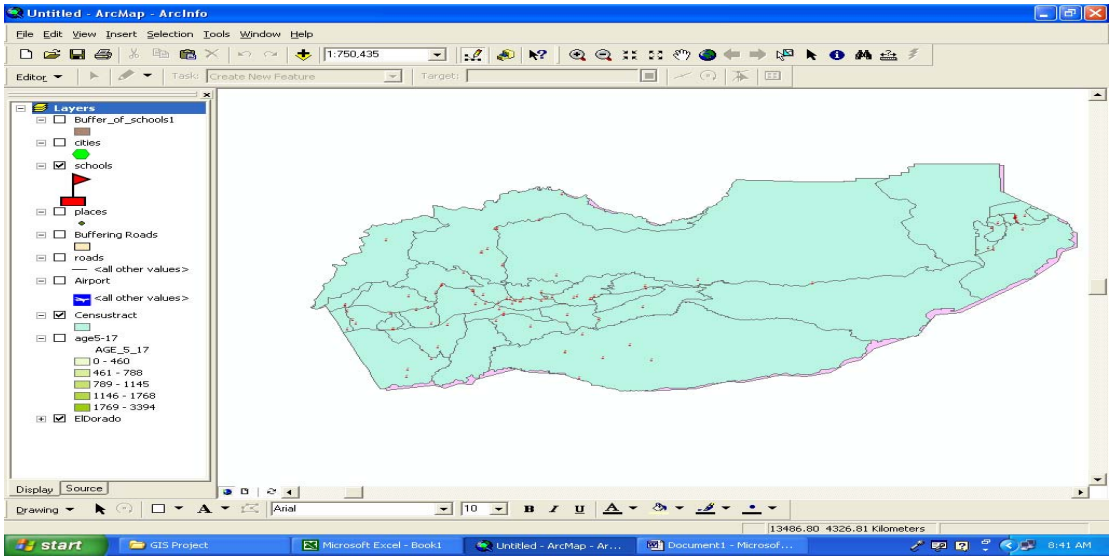


Figure 14 Map including Census tracts of the El Dorado

- The census tracts above are studied and the age group of population 5 to 17 is taken in to consideration for further analysis and a separate layer according to intensity of population in the area depicted with the lightness and darkness of the color is laid. This implies the darker the region the more the population of students in that area. This is shown clearly in the map below.

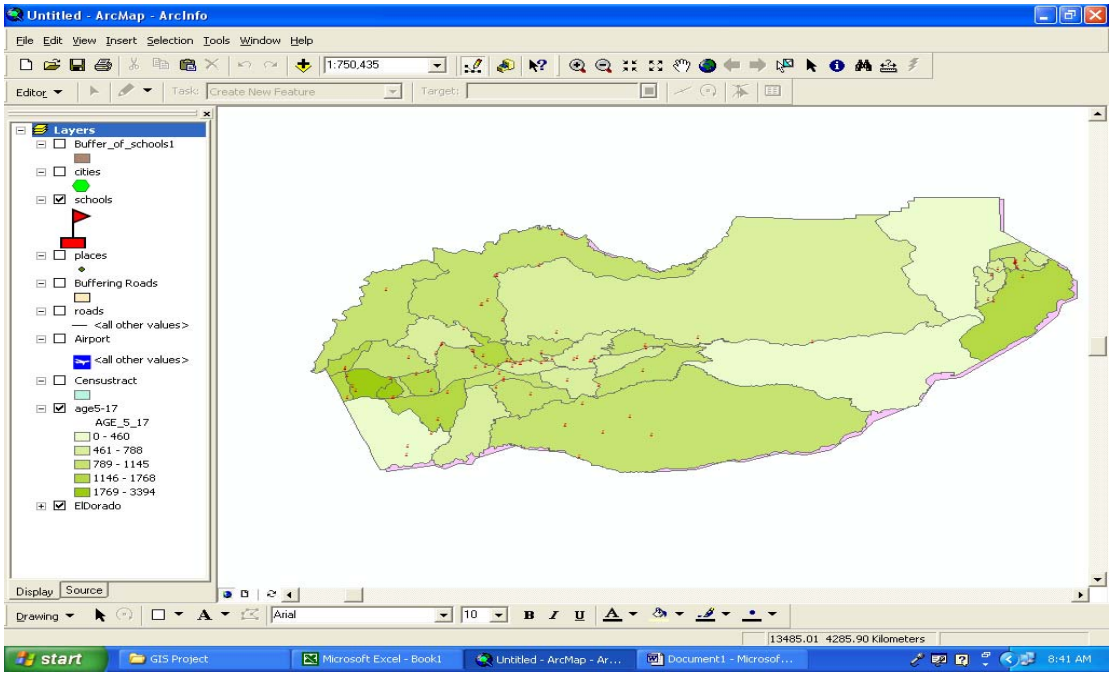


Figure 15 Map showing intensity of population of age 5 to 17 in different tracts

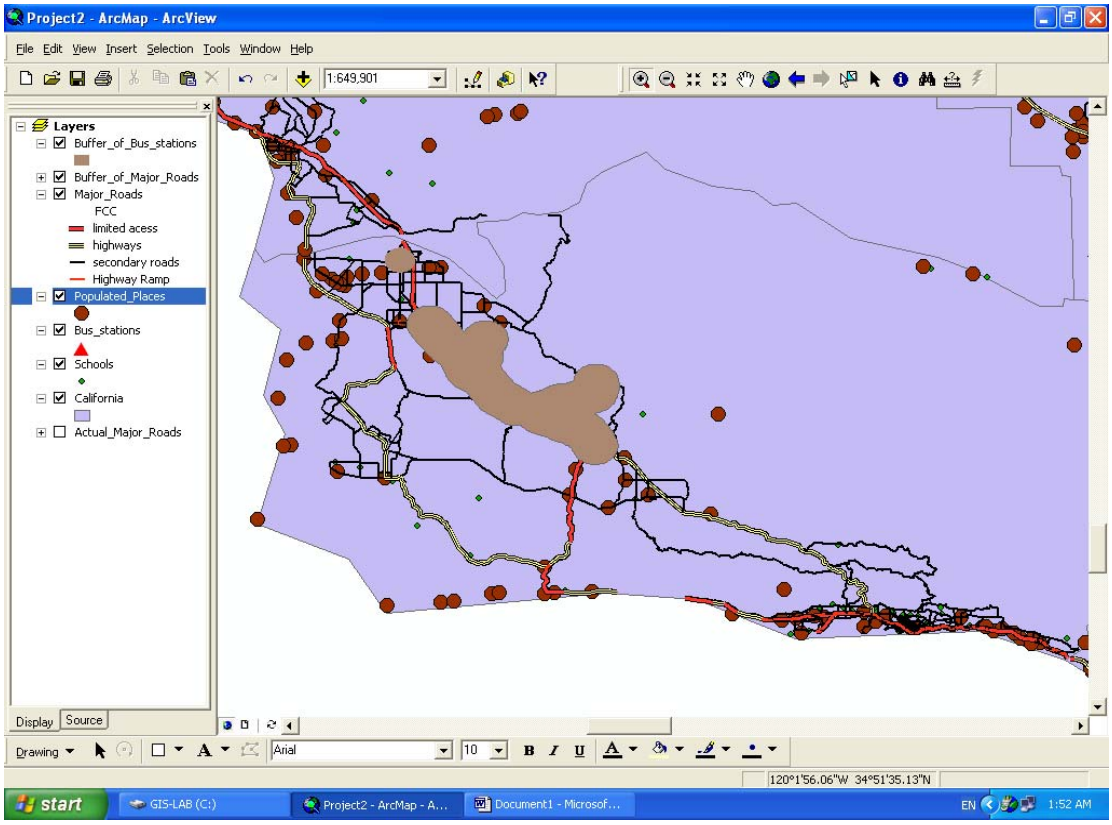
- At the end an example of site selection in the California for school facility and the analysis of existing schools in El Dorado and recommendation of new facility in the areas that do not have school facility is done in the next section.

7.0 FINDINGS & RECOMMENDATIONS

An example of selecting a site based on some assumptions in the map of California is very well explained in the figure below.

The assumptions here are

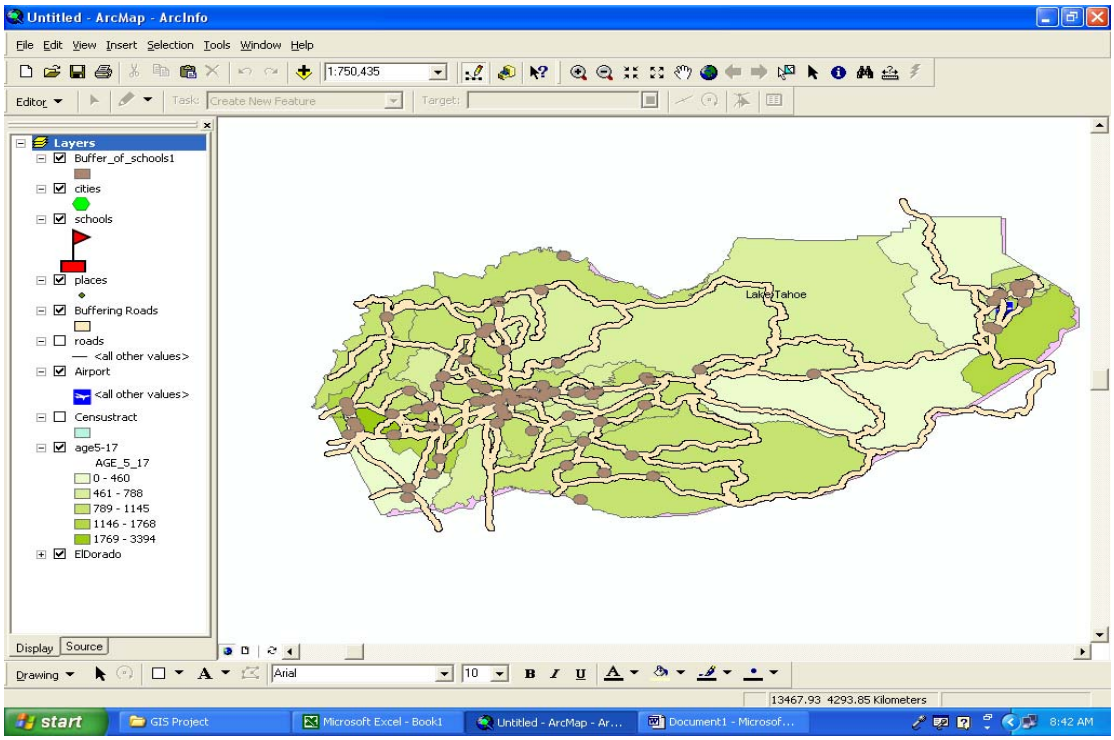
1. The new facility that is to be established should be near to the road that is why a buffer of 2 Kilometers is laid as shown.
2. It should also be near to the bus station so a buffer of one kilometer is laid around the bus station as shown.
3. It should be located near by populated places.



The round brown color spot here is buffer of bus station, brown long part is buffer of road and small round spots in dark color are populated places. This implies that any places in the intersection zone of the entire three criterions are best suited for the establishment of new school facility.

In the second section of this project some schools have been suggested in the area of El Dorado based on population of age group 5 to 17 and reviewing the existing school facility there. The assumptions in this case are

1. The new facility that is to be established should be near to road i.e., a buffer of 0.5 kilometer around the road is laid.
2. There should be one school for a population of 500 of age group 5 to 17 is assumed.
3. It should away from the existing schools at least one kilometer so a buffer around the school is also laid.



In the figure above the buffered road net work is shown clearly and brown spots indicate the buffered existing schools in the area. The varied green color shows the variation in the population of age group of 5 to 17 in each tract. The table below shows analysis of the area and the remarks section will aid in recommendations.

FID	*AREA*	*POPULATION 2001*	*POPULATION OF AGE 5-17*	*# OF SCHOOLS*	*# OF Schools REQUIRED*	*REMARKS*
35	82.00544	3249	807	3	0	
36	0.20199	260	23	0	0	
37	2.86271	4125	778	0	2	
38	9.87283	5175	1000	6	0	More schools exist
39	1.66565	5883	1074	0	3	No school exist
40	2.0741	4327	740	1	1	
41	4.17693	4220	764	0	2	No school exist
42	71.01022	6394	1219	2	1	
43	6.66783	3135	596	2	0	
44	124.2828	1192	161	0	1	No school exist
45	69.21711	4709	990	1	1	
46	137.9521	5908	1089	5	0	More schools exist
47	481.1022	2806	525	4	0	More schools exist
48	7.42032	5694	1463	2	1	
49	4.72123	5928	1416	1	2	Less than required
50	11.72123	7499	1851	4	0	
51	55.23106	1951	371	3	0	More schools exist
52	23.90635	3808	840	1	1	
53	9.45101	5915	1182	3	0	
54	26.85896	5886	1237	4	0	
55	3.99058	9418	2091	0	5	No school exist
56	1.86483	5257	1020	0	3	No school exist
57	25.09614	2735	550	3	0	More schools exist
58	19.55589	4398	905	5	0	More schools exist
59	10.2276	5807	1167	5	0	More schools exist
60	14.23107	5137	937	4	0	More schools exist
61	8.07277	4861	760	5	0	More schools exist
62	18.12978	3442	634	5	0	More schools exist
63	12.68918	4698	890	2	0	
64	305.9643	4952	918	6	0	More schools exist
65	188.4935	92	13	1	0	
66	15.84807	2231	474	2	0	More schools exist
67	11.01108	2514	510	0	2	No school exist
68	30.79284	5360	1074	1	2	Less than required
69	10.2922	5703	1051	2	1	
70	38.53467	2656	506	0	1	No school exist
71	22.80388	5296	1027	3	0	

If you see remarks column where no school exists and the population exists then that is the area of serious concern. To locate that area in El Dorado map use FID number of that area.

8.0 REFERENCES

1. Chan, T. O., and Williamson, I. P., 1995a, Justification of GIS as an infrastructure investment - some observations regarding GIS management in Victoria. In *Proceedings of the 23rd Annual International Conference and Technical Exhibition of the Australasian Urban and Regional Information Systems Association Incorporated*, (Melbourne, 20th-24th November 1995: AURISA '95) pp. 492-503.
2. Pettit, C., and D. Pullar, 1999. An integrated planning tool based upon multi-criteria evaluation of spatial information. Computers, Environment, and Urban Systems, Vol. 23, pp. 799-808.