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GIS based Road Safety and Traffic Accident Data Analysis

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ABSTRACT: Road accidents in the present era are contributing to major deaths due to increase in vehicular density. It has been predictable that over 3 lakhs persons die and 1.5 lakhs persons are injured every single year in road accidents all over the world. A sustainable transport system must provide mobility and accessibility to all urban residents in a safe and environment friendly mode of transport. This is a complex and difficult task when the needs and demands of people are not only different but also often conflicting. If a large proportion of the population cannot afford to use motorized transport modes – public / private – then they have to either walk or ride bicycles for their mobility. The nature of urban road traffic safety and the ways in which the problems created by road traffic conflict need to be reviewed to promote Urban Road Safety. A particular interest is taken in the impact of road safety issues on the well being of the urban vulnerable road users. From this perspective, the study will identify and investigate the particular problems facing the urban vulnerable road users as a result of road accidents. The urban vulnerable road users may be particularly disadvantaged, as compared to others. The urban vulnerable road users may also be at a disproportionately higher risk to involvement in accident because of the nature of their travel and locational characteristics (e.g. greater dependence on walking and low cost forms of informal public transport).

KEYWORDS: Accidents, Traffic, Arc view,

I.INTRODUCTION

A geographic information system (GIS) is a computer system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. GIS allows us to, understand, interpret, question, and visualize data in many ways that reveal relationships, patterns, and trends in the form of globes, maps, reports, and charts. A geographic information system (GIS) is a powerful tool for managing large amounts of various data. Geographic Information systems (GIS) represent a powerful new means to efficiently manage and integrate the numerous types of information necessary for the planning, design, construction, analysis, operation, maintenance, and administration of transportation systems and facilities. (GIS) usage provides spatial analysis, improved display capacities and data integration capabilities.

Objectives- To address road safety and to carry out analysis of accidents using GIS.

II. DESIGN CONSIDERATIONS OF GIS

Analyzing traffic accident data is an important step in improving road safety in any transportation network. The ability to do this quickly and efficiently requires suitable information system backed by GIS to focus on identifying and prioritizing safety improvements that are most beneficial to users of the transportation network. To identify a suitable GIS, the following objectives were defined:
The selected GIS should be capable of providing:
• Electronic access to accident data; maps and plots of accidents;
• Accident summary reports;
• Data and charts for accident reports;
• Accident rates using traffic volumes;
• User-friendly, data-entry interface; and
• Import functions for accident data in a pre-defined electronic format.

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Additionally, the GIS should be capable of supporting multiple users, be cost effective and be relatively user friendly. After researching available products, we selected the ARCVIEW3.1 as the GIS-based software that allows users flexibility in displaying and generating an unlimited number of accident reports. The approach was to define diversified GIS software in terms of capabilities, availability to a wide range of users, computing power, usability, and budget consideration. Having the diverse background and magnitude of the potential users in mind, the conclusion was to adopt a simple PC based system. Another factor in choosing the basic GIS software was the defined need to integrate images and other data with the vector and tabular data that are the backbone of any geo-referenced data management system that is being considered. This factor was triggered by the desire to enable the use and incorporation of photo-logging data as well as incorporating images from other data sources. The ability to incorporate images of features adds a new dimension to the information system in terms of analysis, decision-making and display. Several methodologies and approaches can be adopted for integrating GIS into transport planning applications. In order, to integrate GIS and transport planning for accident evaluation purposes, there are two main methods in use: the complete integration method and the add-on approach. The complete integrated approach involves development of new forecasting packages or modifying existing ones to run entirely within the GIS to produce outputs useful for accident evaluation as well as transport planning. The main disadvantages of this method relate to the time and effort required in re-development or modification of the existing model. The add-on approach aims to augment existing transport models. It merely provides an extension to the models already being used, and hence the users would only need to learn how to use the add-on program. Its main disadvantage involves the issue of compatibility and how to design a single program to fit on each of the many different models in use. Finally going through the merits and demerits of both the approach, the complete integration method was adopted so as to enable its use by as many users as possible.

III. COMPONENTS OF THE SYSTEM

The system is designed as a practical program for the analysis of the road accident impacts. It is ideal for use by the stock holders of road safety in evaluating road accidents. It provides the capabilities for testing different hypothesis on road safety management. The results of the system enable both a global analysis as well as a local analysis. Computations are on a link-by-link basis and aggregated to obtain the overall network level impacts. It is developed using the ARCVIEW3.1 GIS based software. It contains four main modules (namely Data manager, Models, Output and Scenarios) each of which contains a group of functions and tools used to perform specific purposes are described below. The modules are embedded in a form of toolbox like structure and operate in the form of pop-up and pull-down menus. It is easy to use, completely mouse driven and uses the standard Arc view tables. The user is presented with a step-by-step guide to all operations. All input data and output are saved in Arc view format keeping everything simple and uniform.

A. Data Manager Module

This module serves as a data capture and input facility system. It presents options that enable the user to create and manage the input data required in the analysis. It has three sub-modules namely “raster image capture”, “network”, and “workspace”, each of which performs a separate and unique function. Through these the system organizes and manages the input data files into a single unified data sharing facility for use by all the separate accident models. The “raster image capture” module enables the user to create input file containing land use information by heads-on digitizing (that is digitizing based on screen image). It uses aerial photographs (raster images) of the area, road network layer, and a comprehensive database containing detailed information on each property in the area. When activated the program overlays the street network layer onto the raster image, these include the location x and y coordinates, distance from start node of the link are saved to a data file in feature image format. The accuracy of the values obtained depends on the accuracy of the coordinates of the street network being used. The street network must therefore be digitally accurate in order to obtain accurate location of each property. Geo-referencing of the map was done using arcview9 software. The “network” module assists the user in generating a map layer from the data files imputed. These are the theme file (usually defined by the point, polygon a line) and the link description files i.e. the table, which contains the type of the accident, time and date etc. The user may add additional attributes interactively. The “workspace” module is used to build a new workspace or open an existing workspace to be used in the analysis. A workspace or view in ARCVIEW3.1 is a term used to represent a saved configuration of a working session. It details which ARCVIEW Tables and windows opened and used in any particular session. This module organizes various used files and tables into a unified data set and also helps to keep track of all processes and outputs during any modeling session.

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B. Models Module

This module presents options for the estimation and evaluation for a range of planned effects viz., identifying high crash zones, providing detail information about the accidents in a particular area, selection of streets by the user and finding the shortest route, database querying and visual effects. Each of the above activity is carried out using a separate layer but shares a common data structure and makes use of the graphics display of the GIS in displaying the output. The visual effects module is designed to provide no computational functions but serves more as a planning and administrative tool. It was added to provide the user a tool for viewing photographs of specific links, intersections and special roadway features of interest. It allows the user to click on a link or intersection or a feature of interest after which an associated plan image of the feature will be displayed. The process is achieved by linking the individual road features in the network layer to scan or aerial photographs of the network. The ARCVIEW hot link functions are then used to display the images. It should be noted that several images might be acquired for a particular geographic feature. In such situations the system offers the variety of images to the user who may choose to view some or all.

C. Output Module

Normally, the results for each model for any transport scenario are displayed immediately after processing on the screen for viewing and subsequent printing. At a later stage during the modeling process, the output module enables the user to re-view on the screen and to generate hard copies, output results of previous runs. The output results are shown in the form of map displays, graphical charts are tabular text files. The output provides users immediate information about the impact of alternate proposals and policies in the very early design stage. The output may be used to provide an overall transport network plan for the region. These results may be used to provide an up-to-date report on the state of the road safety system. The information gained from such reporting will encourage a move from mere reporting to a proactive means of planning for a better urban road safety

IV.CASE STUDY OF PUNE CITY

Pune city is an important urban center in Maharashtra and a rapidly growing metropolis of the country. The metropolitan area of Pune extends over 809 sq km. The Pune Metropolitan Area (PMA) consists of Pune Municipal Corporation (PMC), the Pimpri-Chinchwad Municipal Corporation (PCMC), Cantonment Boards of Pune and Kirkee and some villages. The total length of road network in PMC area is about 1800 kms.The importance of Pune as an industrial centre has grown rapidly since the 1960's when industrial expansion in Mumbai region was curtailed. Consequently Pune has become a major centre in the state, having attracted engineering industry such as motor vehicle manufacturing plants buses, cars and motorcycles. In addition to this, a number of multi-national companies have manufacturing bases within the city. Much of the local industry is concentrated along the main Pune-Bombay highway, enabling manufactured goods to be dispatched.As per 2001 census population of the Pune city is a home to 26 lakhs people and 1.5 lakh vehicles. The city has experienced steep enormous population growth due to inward migration of both skilled and unskilled labour for rising industrial base and service sector. It still remains a favorite destination for students as well as retired community. For the last two decades Pune has registered a steep growth in number of public-private vehicles. But the road infrastructure and the utilities have not expanded in commensurate with increase in number of vehicles.The city manifests all the problems of a metropolis like increase in traffic congestion, speed reduction, environmental pollution high incidence of road accidents and degradation of quality of life. The problem of road accidents has been brought out by an unprecedented growth in motorized vehicles which is further aggravated by the interstate truck movement that cuts through the Pune city. The growth of vehicles in Pune has assumed extraordinary proportions, especially in the case of two wheelers. So far there are about 15.6 lakh vehicles registered in PMC and PCMC area out of which more than 12 lakh vehicles are two wheelers.Public transport has always been a hallmark of good transportation system. Commuters in Pune are heavily dependent on the personalized mode of transport like two wheelers and the public transport has always taken a back seat. Maxuimum number of accidents occurs from 0900 to 1300 hrs in the morning and 1800 to 2200 hrs in the evening. Two wheelers, three wheelers and cars are involved in maximum number of accidents. Two wheeler riders alone are involved in more than 45% of fatal accidents and 39% of the fatal accident victims are pedestrians. Thus pedestrians and two wheeler riders in Pune city are the most vulnerable road users exposed to high risk of road accidents on Pune city roads.

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A. Data Collection

The data on fatal accidents and serious injury accidents for one year from January to December 2007 was taken up in this project. The accident data used in the project are the secondary data obtained from the Traffic Police branch, Pune. The data was in local language and it was translated into English; it was done with the help of the local Pune person who knows geography of Pune city. The map showing all the corridors of PUNE was obtained from the Ground Water Survey and Analysis Department (GWSAD), Shivajinagar, Pune.

B. GIS Software (ARCVIEW 3.1)

The different layers created using GIS software (ARCVIEW 3.1) are shown in the ARCVIEW screen at Figure 1 below:

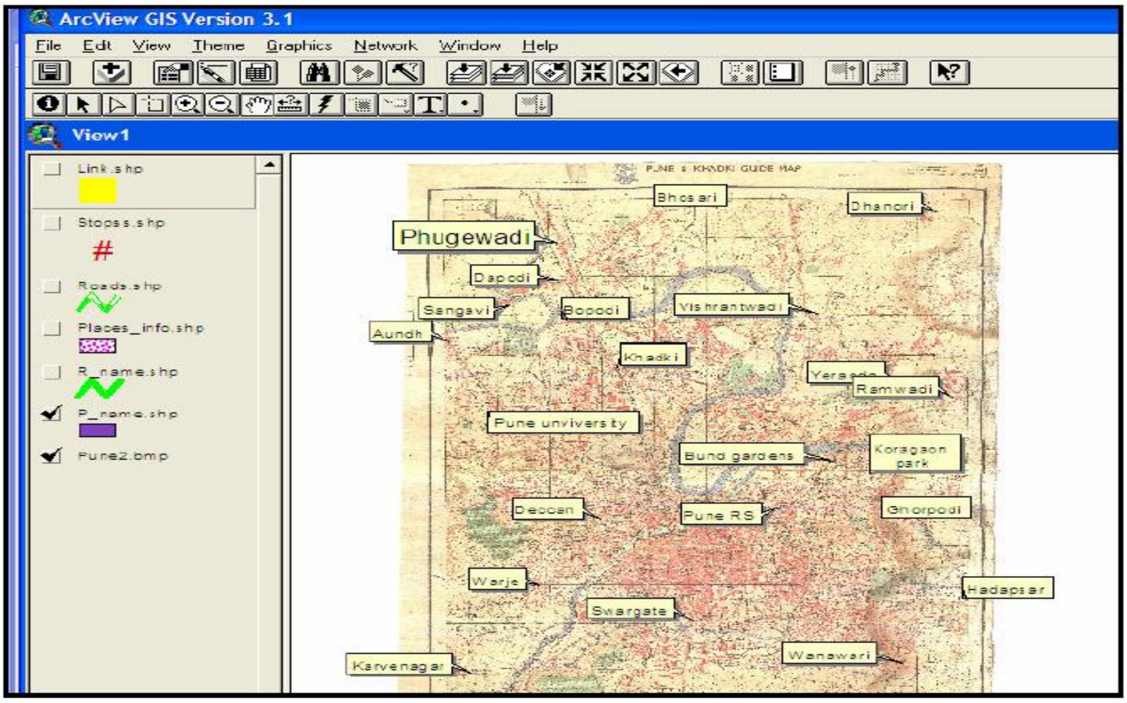

Fig. : 1 – Different Layers Created

Geo-referencing and digitizing are the primary step to be carried out for developing GIS information system. Geo-referencing is a process to establish a relationship between an image (row, column) co-ordinate system and a map (x, y) coordinate system.Digitizing is the process of encoding geographic features in digital form as X, Y co-ordinates. It is carried out in order to create spatial data from existing documents and hardcopy maps. After completion of the above mentioned processes, the next step was creation of different layers namely, place info, road name, stop, link, label etc. These layers would be stored in the memory with .shp extension. Using ARCVIEW9 software, which is the latest version available and highly effective and accurate, the geo referencing of Pune city map was carried out. The remaining modules of the project I worked using the ARCVIEW3.1.

C. Database

By using the accident database on fatal and serious accidents, the following fields were created in ARCVIEW3.1 viz., road name, place name, accident details, number of persons injured / died, type of vehicles involved and date & time, as shown at Figure 2 below:

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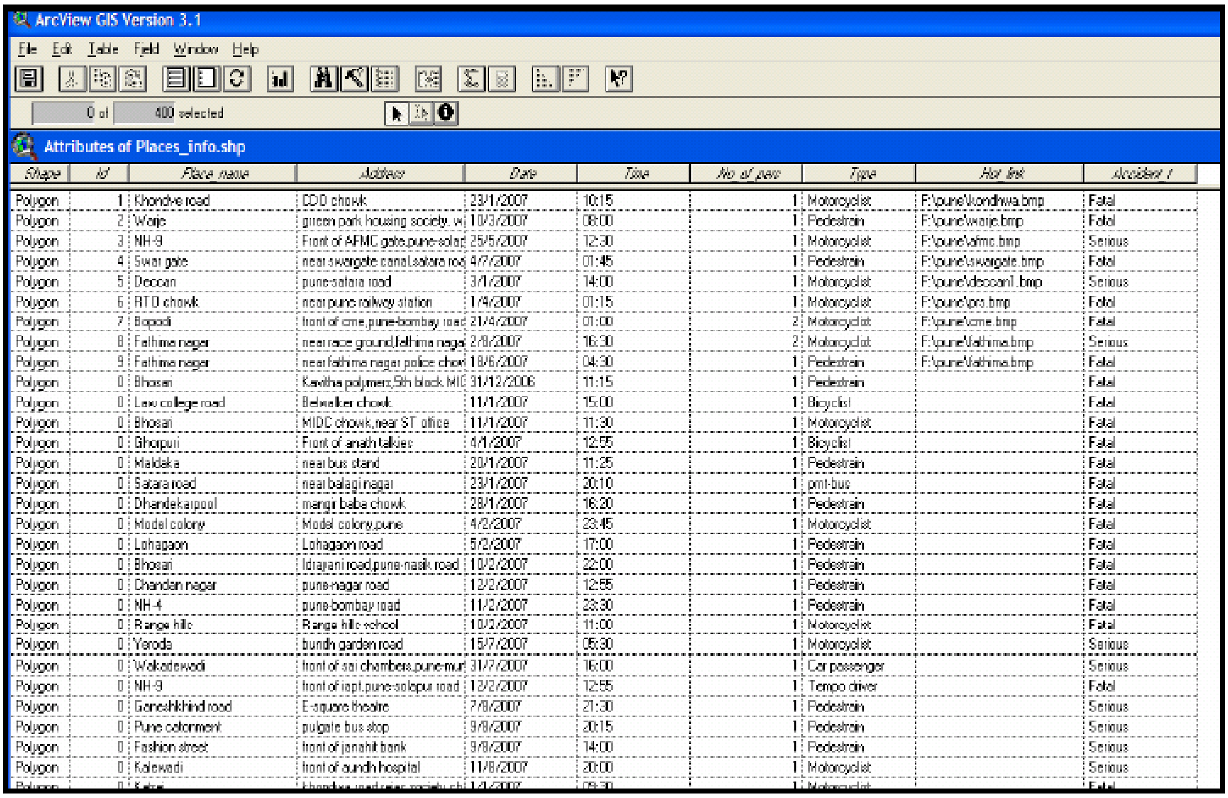

Shape	Id	Place name	Address	Date	Time	No of pers	Type	Hot link	Accident t
Polygon	1	Khondve road	CDD chowk	23/1/2007	10:15	1	Motorcyclist	F:\pune\kondhwa.bmp	Fatal
Polygon	2	Warje	green park housing society, w	10/3/2007	08:00	1	Pedestrain	F:\pune\warje.bmp	Fatal
Polygon	3	NH-9	Front of AFMC gate,pune-solap	25/5/2007	12:30	1	Motorcyclist	F:\pune\afmc.bmp	Serious
Polygon	4	Swar gate	near swargate canal,satara ro	4/7/2007	01:45	1	Pedestrain	F:\pune\swargate.bmp	Fatal
Polygon	5	Deccan	pune-satara road	3/1/2007	14:00	1	Motorcyclist	F:\pune\deccan1.bmp	Serious
Polygon	6	RTO chowk	near pune railway station	1/4/2007	01:15	1	Motorcyclist	F:\pune\prs.bmp	Fatal
Polygon	7	Bopodi	front of cme,pune-bombay road	21/4/2007	01:00	2	Motorcyclist	F:\pune\cme.bmp	Fatal
Polygon	8	Fathima nagar	near race ground,fathima naga	2/8/2007	16:30	2	Motorcyclist	F:\pune\fathima.bmp	Serious
Polygon	9	Fathima nagar	near fathima nagar police chow	18/6/2007	04:30	1	Pedestrain	F:\pune\fathima.bmp	Fatal
Polygon	0	Bhosari	Kavitha polymers,5th block MI	31/12/2006	11:15	1	Pedestrain		Fatal
Polygon	0	Law college road	Belwalker chowk	11/1/2007	15:00	1	Bicyclist		Fatal
Polygon	0	Bhosari	MIDC chowk,near ST office	11/1/2007	11:30	1	Motorcyclist		Fatal
Polygon	0	Ghorpuri	Front of anath talkies	4/1/2007	12:55	1	Bicyclist		Fatal
Polygon	0	Maldaka	near bus stand	20/1/2007	11:25	1	Pedestrain		Fatal
Polygon	0	Satara road	near balagi nagar	23/1/2007	20:10	1	pmt-bus		Fatal
Polygon	0	Dhandekarpool	mangir baba chowk	28/1/2007	16:20	1	Pedestrain		Fatal
Polygon	0	Model colony	Model colony,pune	4/2/2007	23:45	1	Motorcyclist		Fatal
Polygon	0	Lohagaon	Lohagaon road	5/2/2007	17:00	1	Pedestrain		Fatal
Polygon	0	Bhosari	Idrayani road,pune-nasik road	10/2/2007	22:00	1	Pedestrain		Fatal
Polygon	0	Chandan nagar	pune-nagar road	12/2/2007	12:55	1	Pedestrain		Fatal
Polygon	0	NH-4	pune-bombay road	11/2/2007	23:30	1	Pedestrain		Fatal
Polygon	0	Range hills	Range hills school	10/2/2007	11:00	1	Motorcyclist		Fatal
Polygon	0	Yeroda	bundh garden road	15/7/2007	05:30	1	Motorcyclist		Serious
Polygon	0	Wakadewadi	front of sai chambers,pune-mu	31/7/2007	16:00	1	Car passenger		Serious
Polygon	0	NH-9	front of iapt,pune-solapur road	12/2/2007	12:55	1	Tempo driver		Fatal
Polygon	0	Ganeshkhind road	E-square theatre	7/8/2007	21:30	1	Pedestrain		Serious
Polygon	0	Pune catonment	pulgate bus stop	9/8/2007	20:15	1	Pedestrain		Serious
Polygon	0	Fashion street	front of janahit bank	9/8/2007	14:00	1	Pedestrain		Serious
Polygon	0	Kalewadi	front of aundh hospital	11/8/2007	20:00	1	Motorcyclist		Serious

Fig. : 2 – Database

The major advantage of creating GIS database as shown in fig: 3 is that it includes data about the spatial location and the shape of the geographic features recorded as points, polygons, lines, grids cells, areas or tins as well as their attributes. Using the excel sheet the fatal and serious accidents were sorted separately into different categories viz., place of accident, time, date, victim type etc.

D. Hyperlink (hot link)

Hot links help us to access virtually any data or application directly from a view. A hot link is followed by clicking on a feature in a theme with the Hot Link tool, Arc View performs an action using an input value that feature has for a specified field in the theme's attribute table. The action and the field are specified in the Hot Links panel of the Theme Properties dialog. Each theme in a view can have its own hot link definition. There is no default hot link definition. Hot links have to be defined before they can be used. Snaps of the main road & chowk, snaps of important landmarks are shown in Figur3 below.

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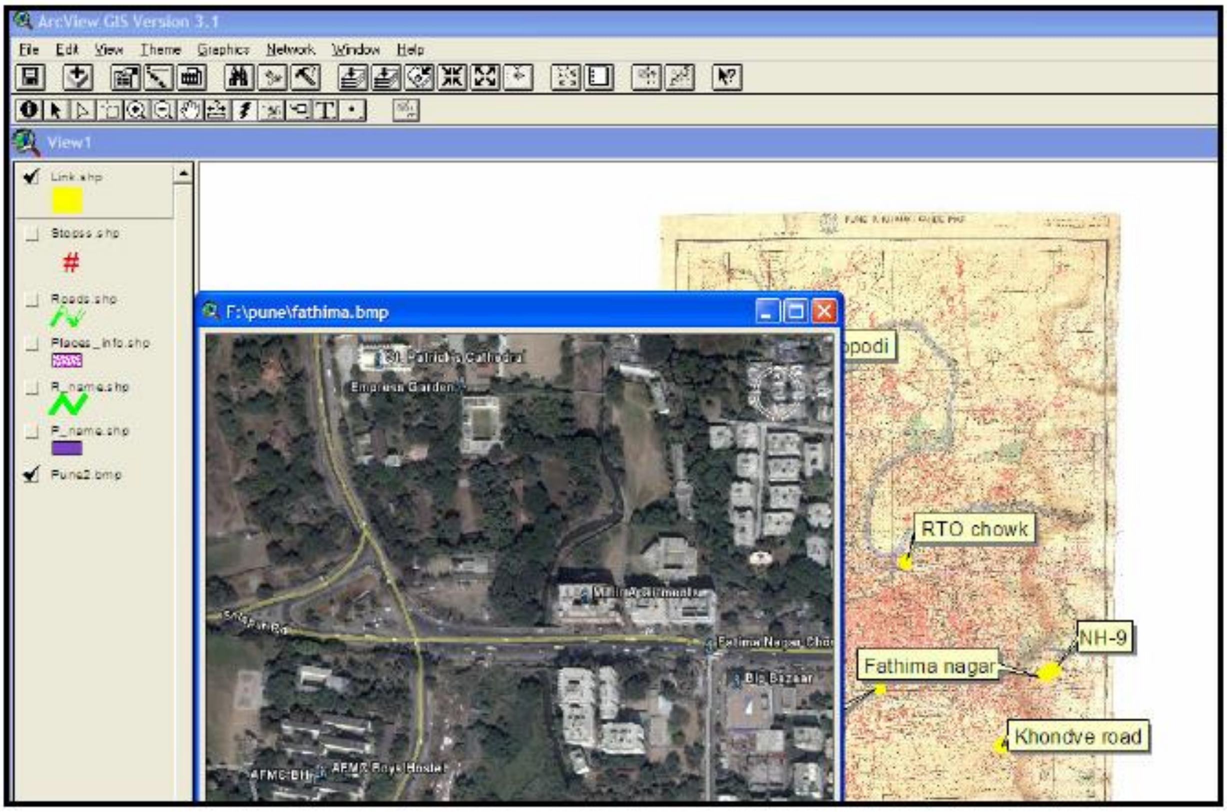

Fig. : 3 – Hyperlinks

E. Analysis using Query Builder

To build a query, choose a Field, an Operator and then a Value. We can build a query selecting options through the query text box. By default, the query is contained within parentheses, depending on the complexity of the query. If the Update Value choice is on, select a field name to list its value. Field names are always enclosed in square brackets ([]). If the required value in the query is not in the Values list, enter the same into the query text box.

E.g. 1 : To select all the information about the place *'Bopodi'*, the following query can be used :

Query: ([Place_name] = "Bopodi")

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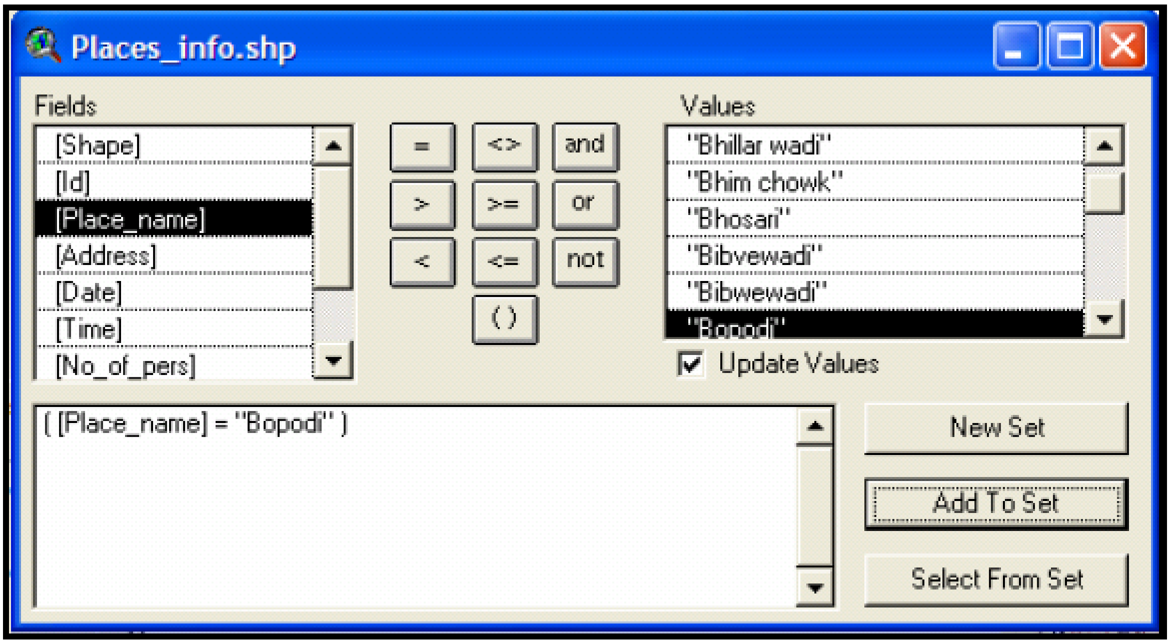

Fig. : 4 – Query - 1

V. RESULTS

In the identify Results box, we can the get the output of the query and all the information related to the query will be displayed as shown in the Figure 5 and in the corresponding theme table the results will be highlighted as shown in Figure 6.

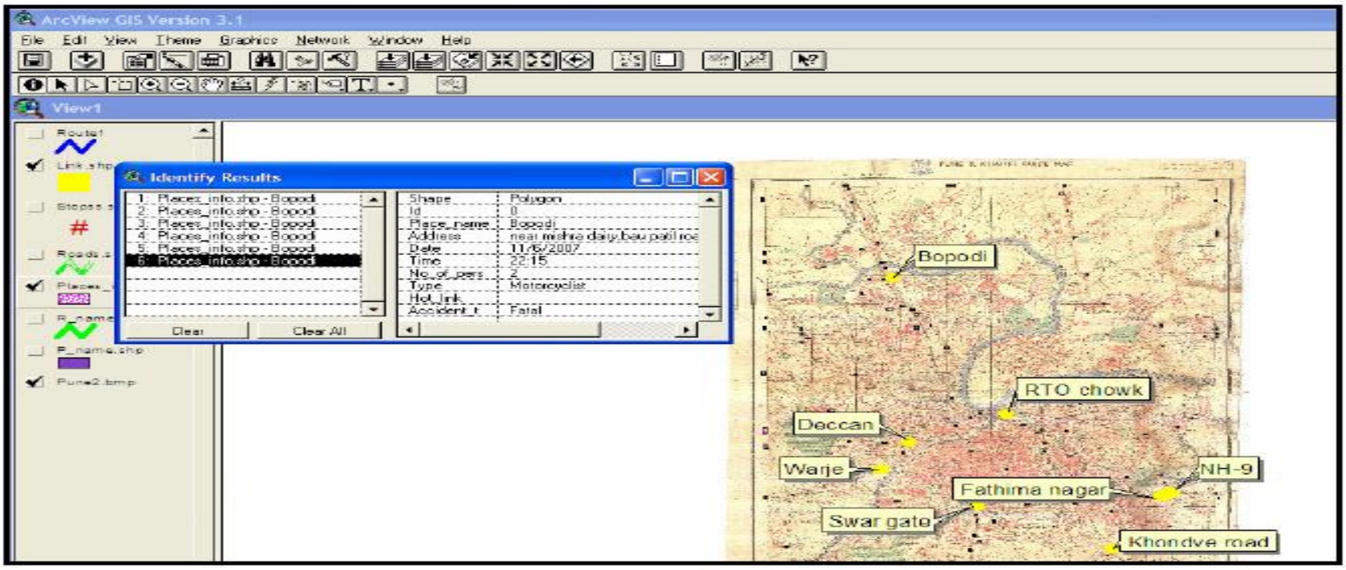

Fig. : 5 – Result – 1 Display

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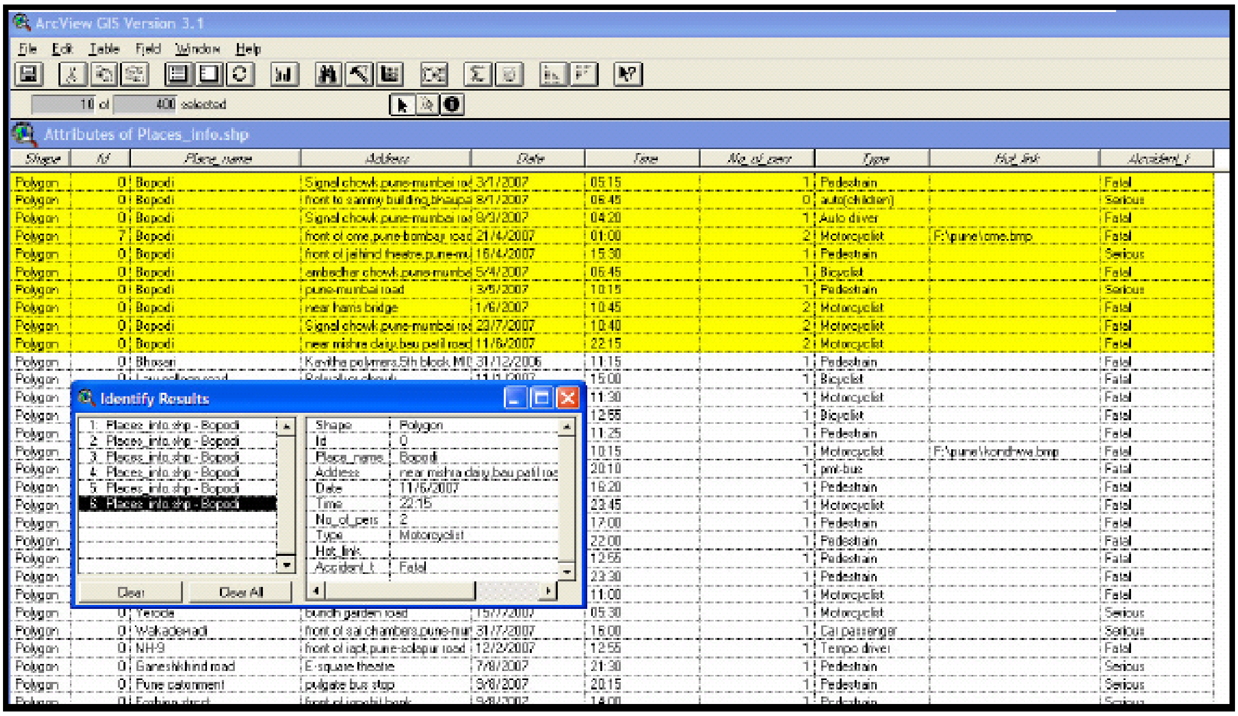

Fig. : 6 - Result – 1 Database

E.g. 2: To select all the accident, which has happened before a specific time, we could use:
Query: ([Time] < “02.13”)

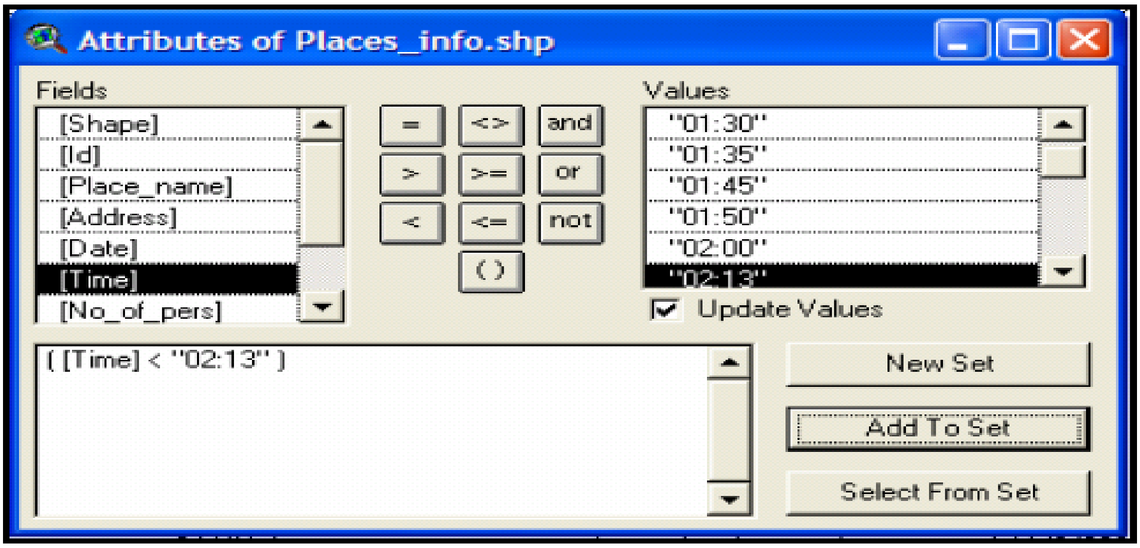

Fig. : 7 – Query - 2

Result: All the accidents, which have happened before 02:13 will be highlighted as shown in Figure 8 below. There are 32 accidents totally which has happened before 02:13,to group them together, use promote button and the result would be grouped as shown in Figure 9 below.

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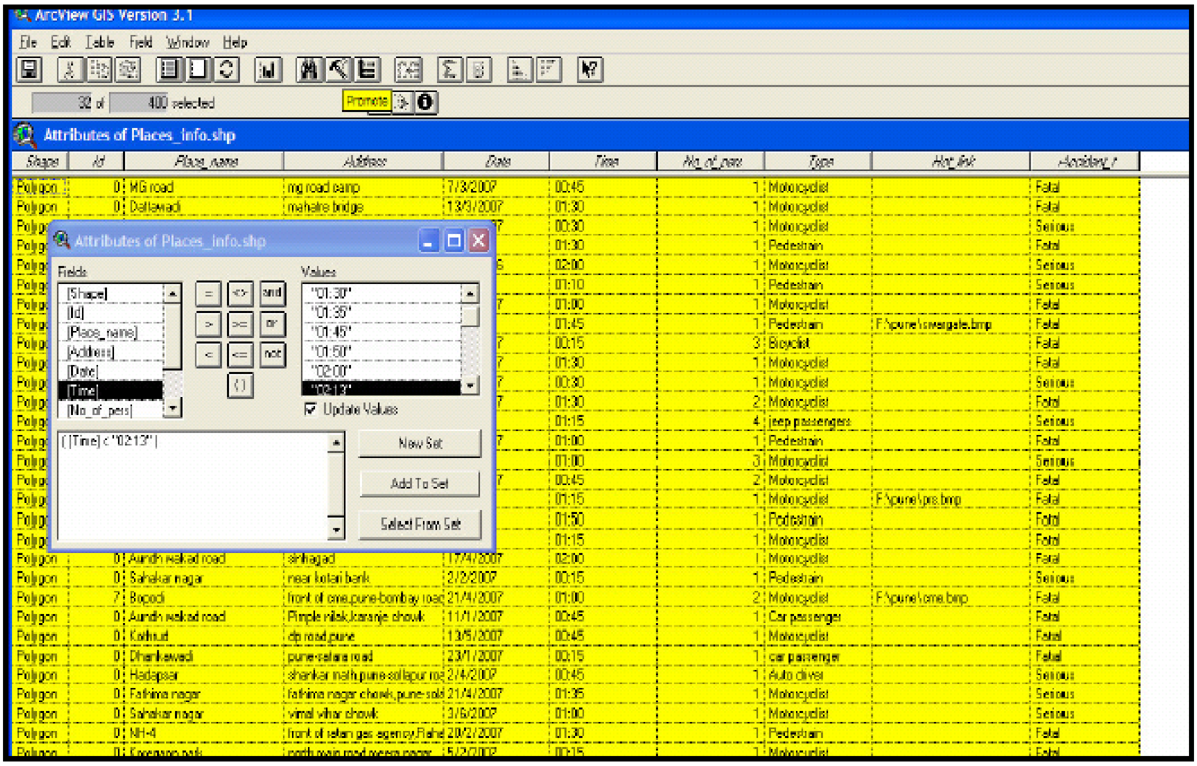

Fig. 9 – Promoted Result

By using the query builder, we can get the result for any question, which is helpful for on the spot analysis of the accident.

The percentage share of vulnerable road users among the total victims can be found out by firing a single query. Similarly, the percentage share of two wheelers involved in total number of accidents can also be found out from the accident database using the query facility instantly.

A. Network Analyst

The Arc View Network Analyst is an extension product designed to help use road networks more efficiently. It can solve common network problems on any theme containing lines that connect. This theme can be a shape file, ARC/INFO coverage, or a CAD drawing. Before solving a problem, we can model networks precisely, including setting up average travel times, one-way streets, prohibited turns, overpasses and underpasses, and closed streets. It also helps to find out efficient travel routes, determine which facility or vehicle is closest, generate travel directions and also to find a service area around a site, etc. Figures 10.1, 10.2 and 10.3 below shows how to find the best route between stop1 and stop 2 by using network analyst, loading stops in the route box and querying as to find the best route will give the desired result as highlighted in blue colour along with the information of the directions displayed in the direction dialog box

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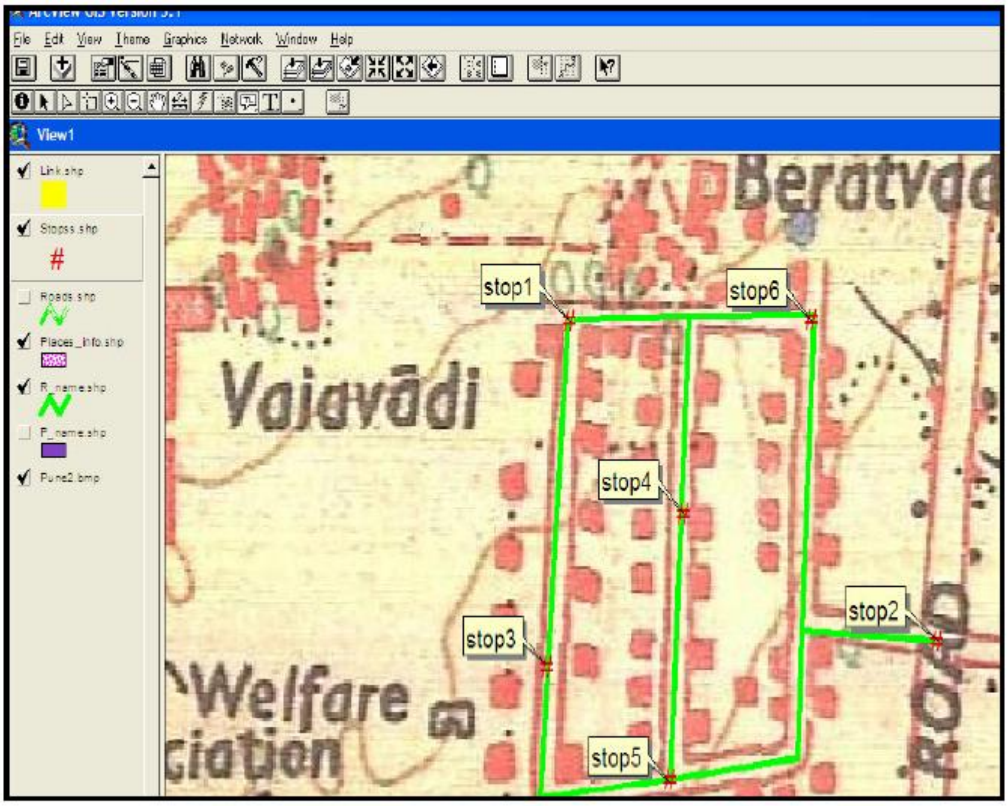

Fig. 10.1 – Network Analyst

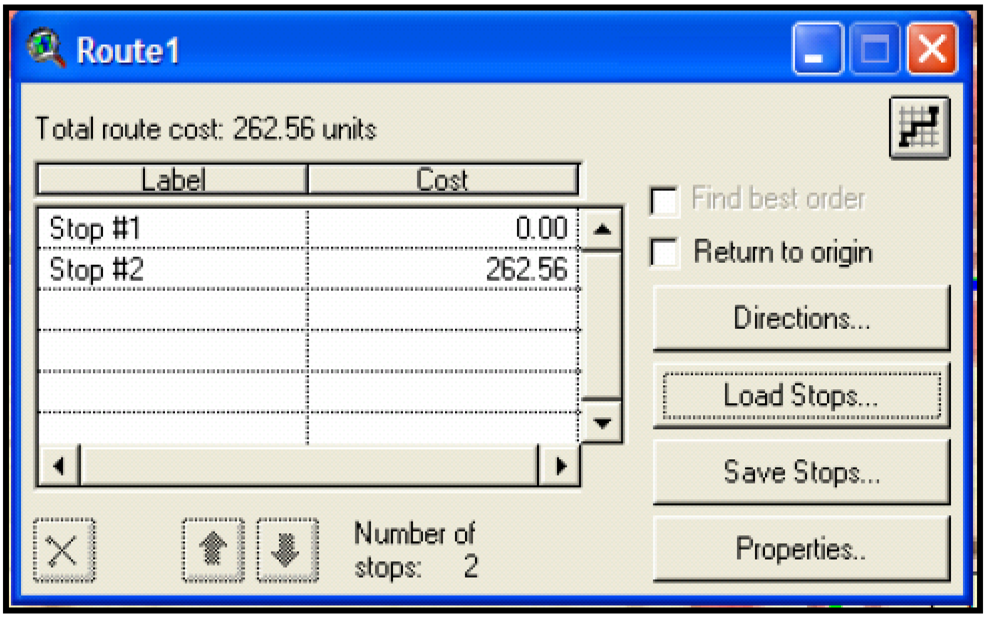

Fig. 10.2 – Route Dialog Box

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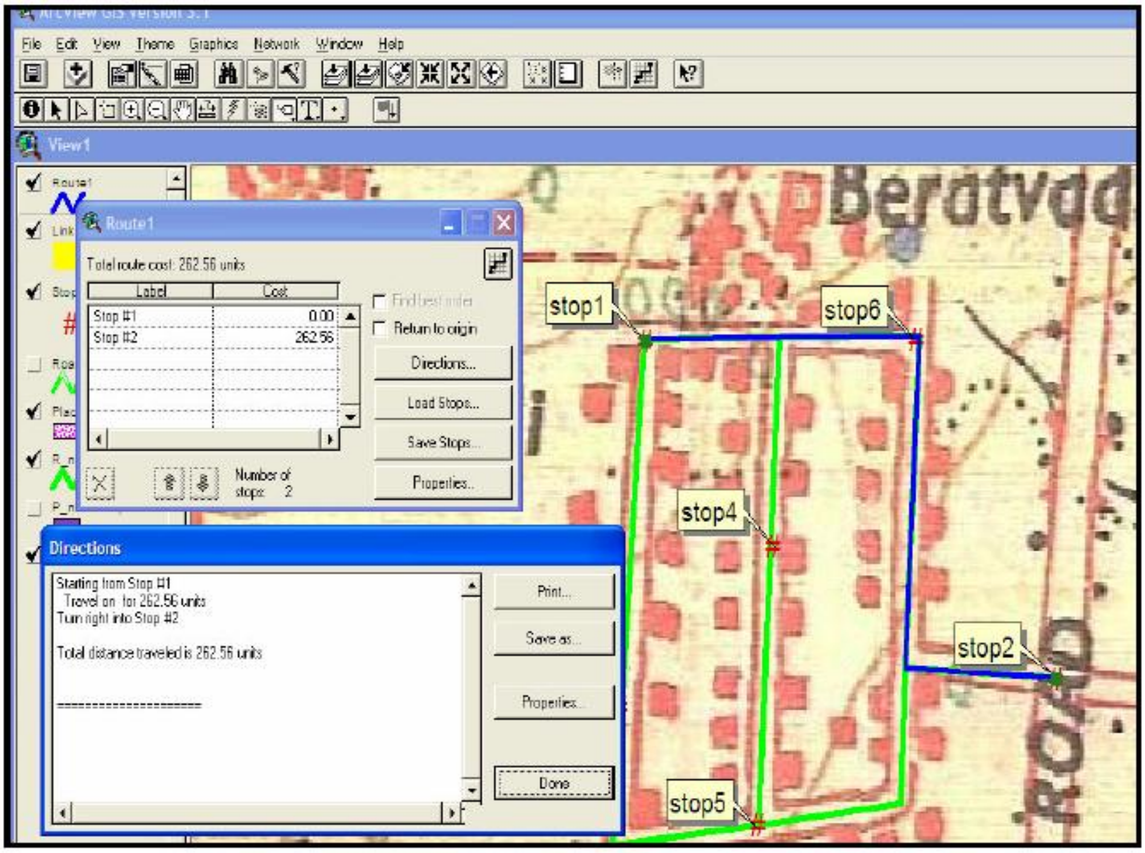

Fig. 10.3 – Result and Direction Dialog Box

VI.CONCLUSION

This article is focused on management of accident data and performing tasks such as accident analysis and safety studies. To start with, these studies can be taken up on a priority basis along the Mumbai road, Solapur road, Nashik road and Ahmednagar road, which have been found to be the major accident-prone roads in the city as a result of this entire exercise. GIS-based technology is useful especially while conducting corridor analysis, pedestrian safety studies and accident analysis. It provides the tools required to review area-wide safety and prioritize safety improvements that will give maximum impact. It also allows to update the GIS components, such as street network and other layers, with updated data. The Arc View version allows overlaying the accident data with several other layers such as two wheeler routes and transit centers, etc. Additionally, it permits a view of the actual roadway geometry in collision diagrams and enables the urban planners for on the spot analysis.

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