International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 8, August-2018

ROAD INFRASTRUCTURE SAFETY MANAGEMENT USING GIS

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Abstract— The goal of this research is to identify and analyze the accident hotspots on a road network. To develop a model to optimize the individual risk on a road network and to suggest necessary improvements and safety measures to reduce the road accidents. This research work was carried out in four steps. The first part of the research was to identify the methods and models for identification of Individual Risk on the regional road network and to study GIS application for Identification of Individual Risk on the regional road network. The second part of the research deals with the case study and a research methodology has been proposed. An Interactive Model for Identification of Individual Risk on the Regional Road Network Using Arc GIS software is developed. In the third part of the research the accident data was analyzed by using Crash Severity Method. In the last part of the research the results obtained was discussed. By analyzing the accident data the various causes of accidents was identified. Finally the research is concluded by suggesting remedial measures and provisions for traffic safety are suggested.

Key words: Geographic Information System (GIS), Road Network, Accident hotspots, Accident prone locations.

I. INTRODUCTION

It has been evaluated that India right now represents almost 10% of street mishap fatalities around the world. What's more, more than 1.3 million individuals are truly harmed on the Indian streets consistently. Consequently, movement security has turned into a noteworthy region of worry for the experts. The advancement of urban transport framework has not kept pace with the activity request both as far as quality and amount. Thus the utilization of customized transport for the most part bikes and middle of the road open transport is developing at a fast speed. The lopsided Growth in the street length alongside unapproved infringements on street space, absence of activity and path train and insufficiencies in rush hour gridlock control have added to the expanding issue of clog in urban territories. Recognizable proof of hotspots is an efficient procedure of distinguishing street segments that experience the ill effects of an unsatisfactory high danger of accidents. These recognized locales are regularly known by different terms in writing, for example, risky areas, hotspots, dark spots, need venture areas, impact inclined areas, or hazardous sites. GIS enables roadway offices to precisely catch and examine auto collision data and additionally distinguish perilous expressway portion areas with high mishap rates. GIS, joined with complex factual investigation and business insight apparatuses, helps thruway builds better comprehend the reasons for mischances at these areas and discover methods for decreasing them. The fundamental preferred standpoint of utilizing GIS is its capacity to get to and break down spatially conveyed information regarding its real spatial area overlaid on a base guide of the territory of scope that permits examination impractical with the other database administration frameworks. The principle advantage of utilizing the GIS isn't only the easy to understand visual access and show, yet additionally the spatial examination capacity and the relevance to apply standard GIS functionalities, for example, topical mapping, outlining, organize level investigation, concurrent access to a few layers of information and the overlay of the same, and also the capacity to interface with outside projects and programming for choice help, information administration, and client particular capacities.

II. LITERATURE REVIEW

Mohamed S. Adrees (2016), Proposed A Framework for Using GIS to Enhance Traffic Safety in Sudan to enhance tasks, lessen costs, encourage new joint investigation keeping in mind the end goal to produce premium and loan support to the leader. Reference data is given to control future endeavours and bolster the organs of the State to create and enhance GIS programs for traffic safety.

Evangeline Muthoni Njeru (2016), has proposed GPS & GIS in Road Accident Mapping and Emergency Response Management reducing the number of accidents based on the accident reports thus increasing the level of road safety and fast delivery of emergency services. He proposed a framework by developing the maps where high no. of accidents occurs and providing with nearest hospitals, fire stations and police stations with the shortest route to reach them.

Pawan Deshpande (2014), Road Safety and Accident Prevention in India. Tending to street security in complete way underscores the need to include various organizations and areas like wellbeing, transport and police. The present investigation gives the extent and different measurements of street mischance in India. The examination on street mischances in this investigation will make mindfulness, rules and aid educated on road safety.

III. IDENTIFICATION OF ACCIDENT INDIVIDUAL RISK

GIS gives a system to illuminate models, for example, those used to estimate travel request and plan capital enhancements, and to help key basic leadership. Likewise, GIS applications that perform natural assessments shed light on the outcomes of different transportation options. GIS encourages information gathering, handling, and show as well as incorporates resource mapping with venture administration and planning instruments so development, operational, and upkeep costs can be midway overseen and represented. GIS enables parkway divisions to precisely catch and break down auto collision data and in addition recognize hazardous thruway portion areas with high mishap rates. GIS, joined with complex measurable examination and business knowledge devices, helps thruway designs better comprehend the reasons for mischances at these areas and discover methods for lessening them.

IV. CASE STUDY

Since 1990's Hyderabad has likewise joined to Banglore to contribute in development of Information Technology Sector of Indian Economy. In the North-West course of the city, they have made an uncommon zone named "Cyberabad" for the development of IT area in this locale. At the point when the Tech Boom started in Hyderabad from 1998, the majority of the land, Educational organizations, IT organizations and budgetary firms made Madhapur, Miyapur, Hitech City, Kondapur, Gachibowli, Raidurgam, Manikonda Village and Financial area as their home. As the city continued(s) get huge volume of drifting foreigners from the nation over, the Hyderabad Municipal Corporation partitioned the city for managerial purposes. The domains indicated above were described under a singular police territory called Cyberabad Metropolitan Police. During the time most of this additional to the name Cyberabad.

V. DATA COLLECTION

Accident data of different types were compiled from the records and files at office of the Traffic Police Department, Cyberabad. The accident statistics cover the whole area under the jurisdiction of Commissioner of Police. Data collection is of two types i.e. Spatial and Non Spatial. The spatial data provides exact geometric information such as location, boundary extend and road network. The available information about spatial data is called Non-Spatial data.

Table 1 Accident data of the year 2017 of Cyberabad Division

S.no	Name of the Police Station	Total accidents	Fatal	Non-Fatal	No. of deaths	No. of injured
I	Shamshabad Divn					
1	Shamshabad	93	41	52	41	78
2	Airport	102	25	77	29	98
3	Pahadisharief	37	13	14	14	22
	Total	232	79	143	84	198
II	Rajendranagar Divn					
1	Rajendranagar	175	38	157	38	176
2	Mailardevpally	86	21	65	21	87
3	Narsingi	124	57	90	60	133
4	Moinabad	71	21	50	21	64
	Total	456	137	362	140	460

S.no	Name of the Police Station	Total accidents	Fatal	Non-Fatal	No. of deaths	No. of injured
III	Madhapur Divn					
1	Raidurgam	94	20	74	20	72
2	Madhapur	86	17	59	17	52
3	Chandanagar	84	13	71	13	71
4	Gachibowli	97	15	72	16	76
	Total	361	65	276	66	271
IV	Kukatpally Divn					
1	Kukatpally	87	23	64	23	72
2	KPHB	103	19	94	19	84
3	Miyapur	117	29	108	31	106
	Total	307	71	266	73	262
V	Balanagar Divn					
1	Sanathnagar	43	9	24	9	29
2	Balanagar	83	19	64	20	84
3	Jeedimetla	80	20	60	20	74
4	Jagathgirigutta	45	6	29	6	39
	Total	251	54	177	55	226
VI	Pet Basheerabad Divn					
1	Shamirpet	97	46	51	50	87
2	Dundigal	105	50	65	56	107
3	Pet Basheerabad	106	35	101	37	142
4	Medchal	109	55	64	64	85
	Total	417	186	281	207	421
VII	Alwal Divn					
1	Alwal	47	11	33	11	31
2	Keesara	49	15	32	16	35
3	Kushaiguda	55	27	28	27	47
4	Neredmet	42	21	21	23	35
5	Jawaharnagar	81	24	63	24	84
	Total	274	98	177	101	232
VIII	Malkajgiri Divn					
1	Malkajgiri	86	29	56	31	79
2	Nacharam	71	22	49	24	67
3	Uppal	83	23	61	29	85
4	Medipally	66	27	38	33	73
5	Ghatkesar	81	17	71	19	132
	Total	387	118	275	136	436
IX	Vanasthalipuram Divn					
1	Hayathnagar	135	53	128	44	255
2	Meerpet	47	9	43	5	67
3	Vanasthalipuram	92	27	86	25	109
	Total	274	89	257	74	431
X	LB Nagar Divn					
1	LB Nagar	104	30	88	35	127
2	Saroornagar	81	24	92	25	97
3	Chaitanyapuri	48	11	38	6	63
	Total	233	65	218	66	287
XI	Ibrahimpatnam Divn					
1	Ibrahimpatnam	116	29	102	36	148
2	Manchal	42	20	34	16	70
3	Yacharam	48	10	20	9	32

4	Kandukur	46	13	25	10	35
5	Maheshwaram	39	16	30	7	42
6	Adibatla	86	31	80	26	114
	Total	347	119	291	104	441

The total accidents cases of the year 2017 of the Cyberabad division as shown in the table 4.1 are classified into three category. The total accidents ranging from 0 to 49 are classified as low risk accidents. The total accidents ranging from 50 to 99 are classified as medium risk accidents and the total accidents ranging from 100 to 200 are classified as high risk accidents.

VI. DATA PROCESSING

The accident spot areas are changed over into shape documents utilizing Arc GIS programming. The accident elements were included as characteristic information. Layering the image in ARC GIS and then traced on it using polyline in another layer after that image layer is closed and a layered map of Hyderabad is obtained. The crash data which were referenced to the number of kilometres were assigned to the related segments under the procedure of geo-coding using Linear Referencing tool in Arc GIS 10.1. As a result, the crash locations are presented by only a point symbol along the digitized map and in cases where more than one crash occurred in the same segment, it seems as if only one crash occurred at every specific location. In fact, the symbols coincide and the concentration of crashes which have occurred more than once cannot be conveyed precisely.

VII. CRASH SEVERITY METHOD

The severity method is based on converting each crash to a "property damage only" (PDO) equivalency. The severity of a crash is determined by the most severe injury involved in the incident regardless of the number of injuries (for example, if a crash has one A type injury and six C type injuries, then it is classified as an A type crash). The equivalent property damage only (EPDO) index is calculated using calibrated coefficients based on crash cost data and was last calibrated in 1995 (Highway Safety Manual, spring 2008). The severity index (SI) is basically the EPDO for the normal crash and is ascertained by isolating the EPDO by the quantity of accidents. This method is generally biased towards locations that have more severe crashes (such as rural locations) and is sensitive to the severity of the injuries involved in crashes.

$$EPDO = C_1\,(K+A) + C_2\,(B+C) + PDO \qquad (1)$$

$$SI = EPDO/N \qquad (2)$$

Where: K= One or more people are killed at the scene or die due to injuries received from the crash. A = One or more people receive incapacitating injuries that prevent the individuals from performing their normal activities for 24 hours or longer. B= One or more people receive injuries during the crash. C = No of people died on spot at the crash. PDO = No one is injured and only property is damaged be 1000. C1 = EPDO constant for K and A type crashes (currently, 12.0)

C2 = EPDO constant for B and C type crashes (currently, 3.0) SI = severity index N = Number of total crashes. The total accidents cases of the year 2017 of the Cyberabad division are classified into three category. The total accidents ranging from 0 to 49 are classified as low risk accidents. The total accidents ranging from 50 to 99 are classified as medium risk accidents and the total accidents ranging from 100 to 200 are classified as high risk accidents.

Table 2 Severity Index

S.No.	Individual Risk on Road Network	Severity Index
1	Low Risk Road Network	16.86
2	Medium Risk Road Network	17.56
3	High Risk Road Network	19.02

VIII. INTERACTIVE MODEL FOR IDENTIFICATION OF INDIVIDUAL RISK

The spatial techniques in GIS used to analyze road traffic accidents are presented. Spatial analysis is used to geographically specify the locations where the crashes occurred, and to assess specific patterns of distribution through map visualization. All the accidents hotspots are marked and their hotspots are connected by using the road network connecting the major roads. The softwares used is Google Earth Pro and the Arc GIS version 10.1. Arc GIS is a geographic information system (GIS) for working with maps and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database.

Step 1:

In the Figure 1 the accident locations and the road network are located clearly but the file format is KMZ i.e. it is accessible only in google earth and not in Arc GIS. The KMZ is the file format of google earth and to work on it in Arc GIS there is a procedure as shown in below steps.

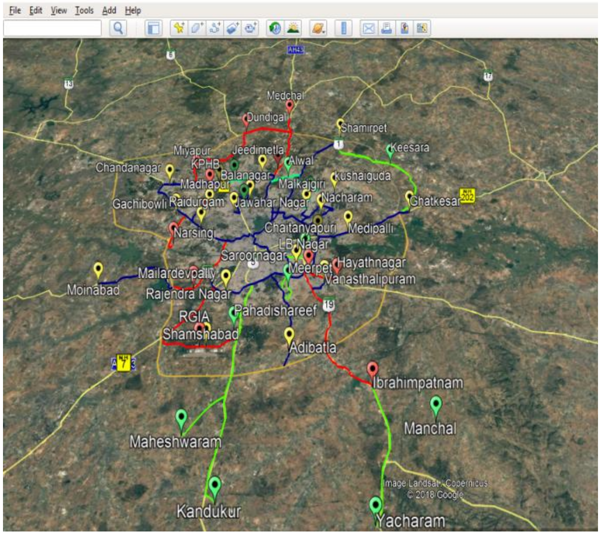

Figure 1 Locations of Accident Hot Spots and Road Network in Google Earth.

Step 2:

Since the file is in kmz format the procedure of converting the file and using it in Arc GIS is explained in this step. After opening the Arc GIS Software various option are displayed as shown. In the below figure Geoprocessing tool is used to import a file of other format. The Figure 1show to import a kmz file in Arc GIS and which tool is used to import the file. Here we are selecting Geoprocessing tool.

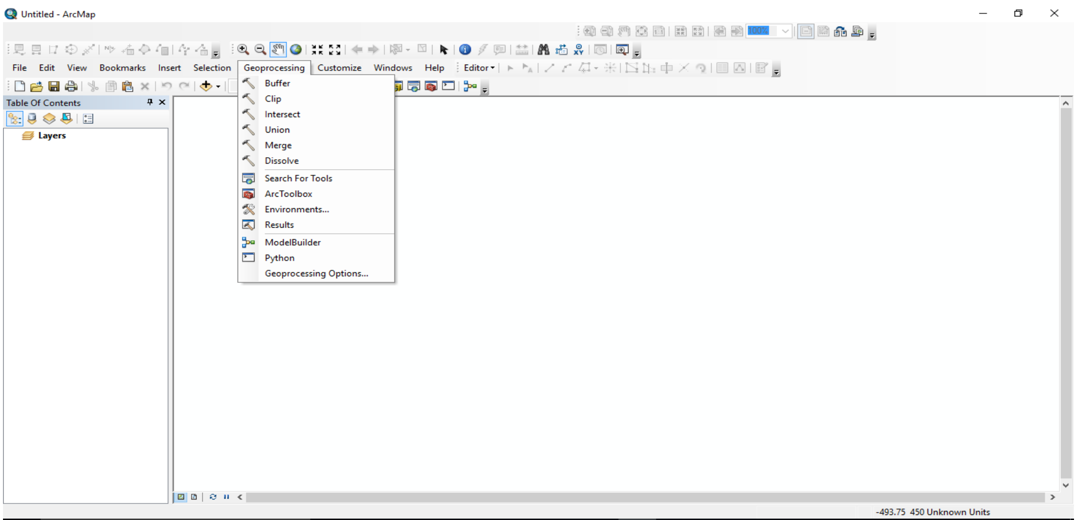

Figure 2 Selecting Geoprocessing tool

Step 3:

After selecting the Geoprocessing tools various options are displayed such as buffer, clip, intersect, union, merge, dissolve, search for toolbox etc . In this step we select Arc toolbox from Geoprocessing Tool. From geoprocessing tool we select Arc toolbox. Arc toolbox helps in the conversion of kmz file as presented in Figure 3.

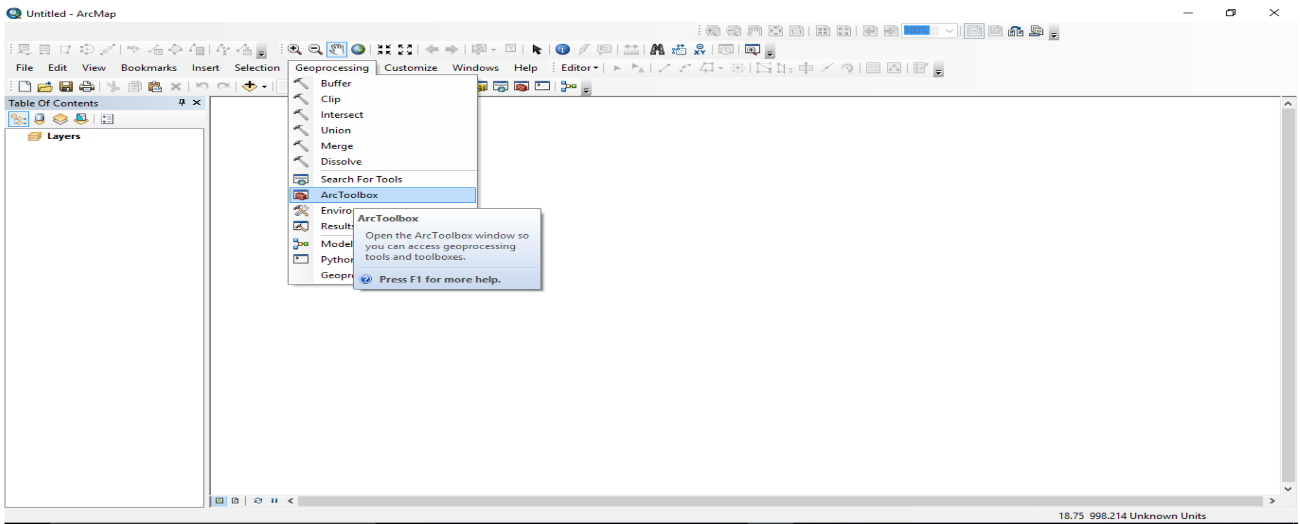

Figure 3 Geoprocessing Arc Toolbox

Step 4:

After selecting Arc toolbox it displays many other options such as3D analyst tools, analysis tools, catography tools, conversion tools, data management tools, editing tools, geocoding tools, network analyst tools, parcel fabric tools, server tools, spatial analyst tools, spatial statistics tools and tracking analyst tools. We have selected arc toolbox in previous step and now in this step the arc tool box after selection shows different options as shown in Figure 4.

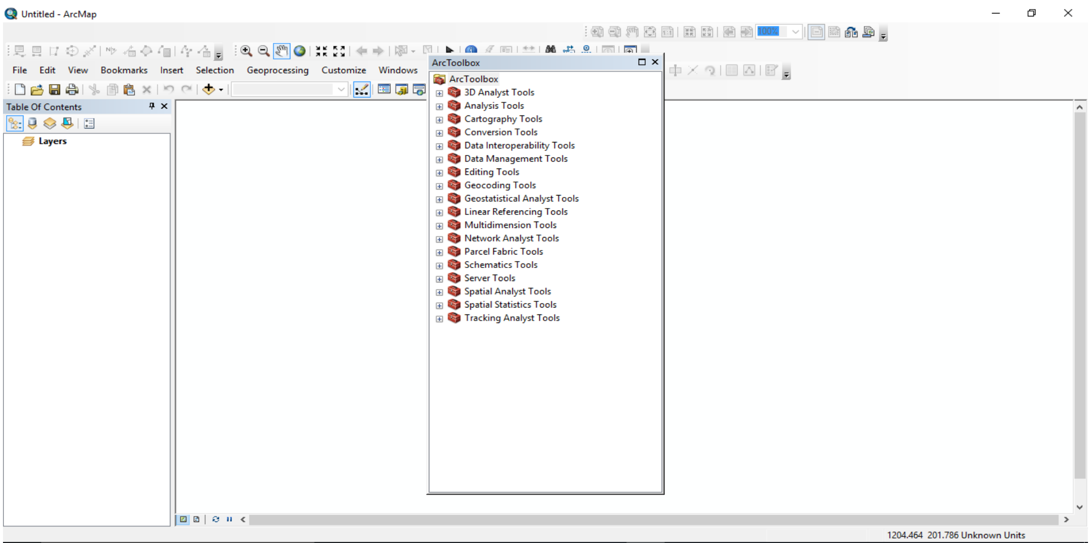

Figure 4 Arc Toolbox showing different options

Step 5:

From the Arc toolbox we select conversion tools whict various options like from gps, from kml, from raster, from wfs, to cad, to dbase, to kml, to shapefile. Now in this step we select the required option to import the file into Arc GIS. We select conversion tools from the options as shown in Figure 5.

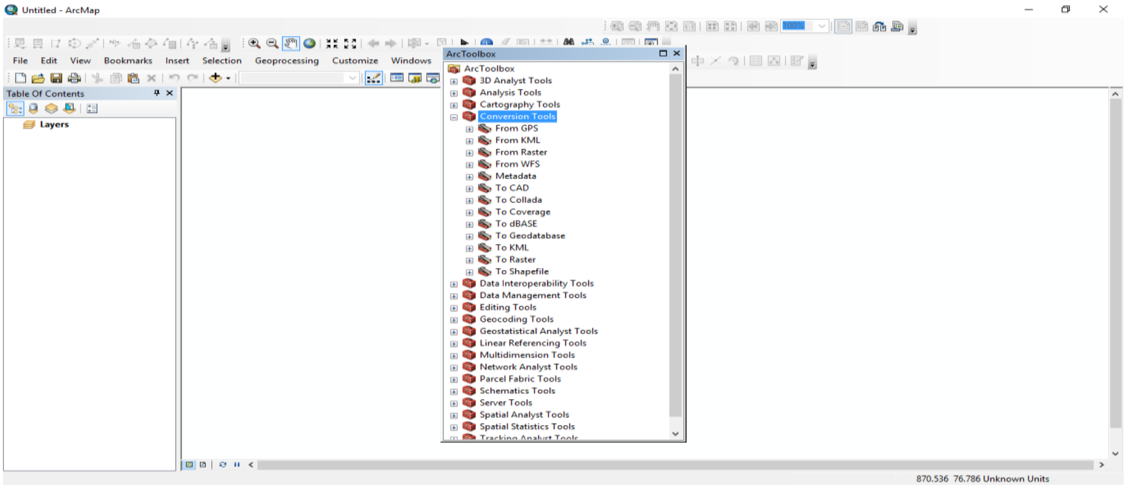

Figure 5 Select Conversion tools.

Step 6:

In this step from conversion tools we select from KML. Since accidents hot spots are in the kml format it has to be converted into the layers format which can be accessed in the Arc GIS. After selecting Conversion tools it displays more two options in it. We select From KML option as shown in Figure 6.

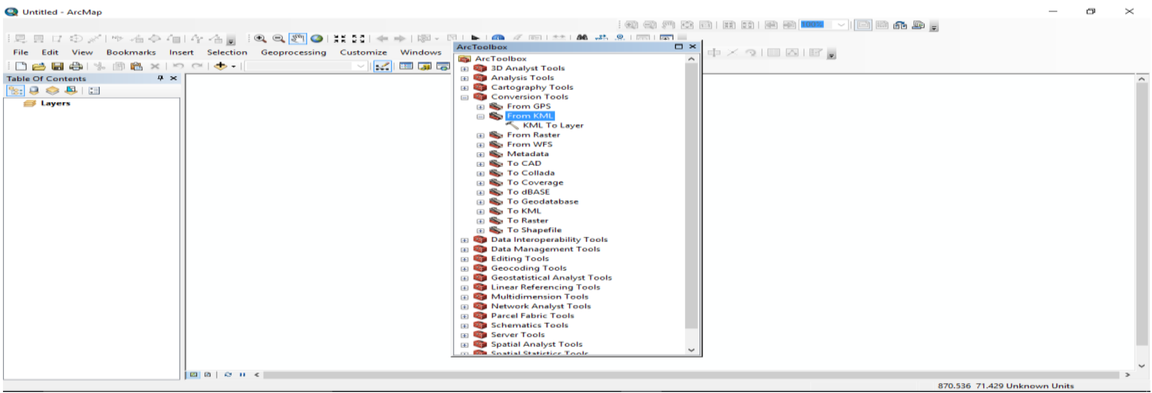

Figure 6 Selecting from KML in Conversion Tools.

Step 7:

In this step after selecting from kml again a new tool is shown kml to layer it is selected. Since the accidents hot spots are in the kml format it has to be converted into the layers format which can be accessed in the Arc GIS. After selecting from kml it shows one option kml to layer as shown in Figure 7.

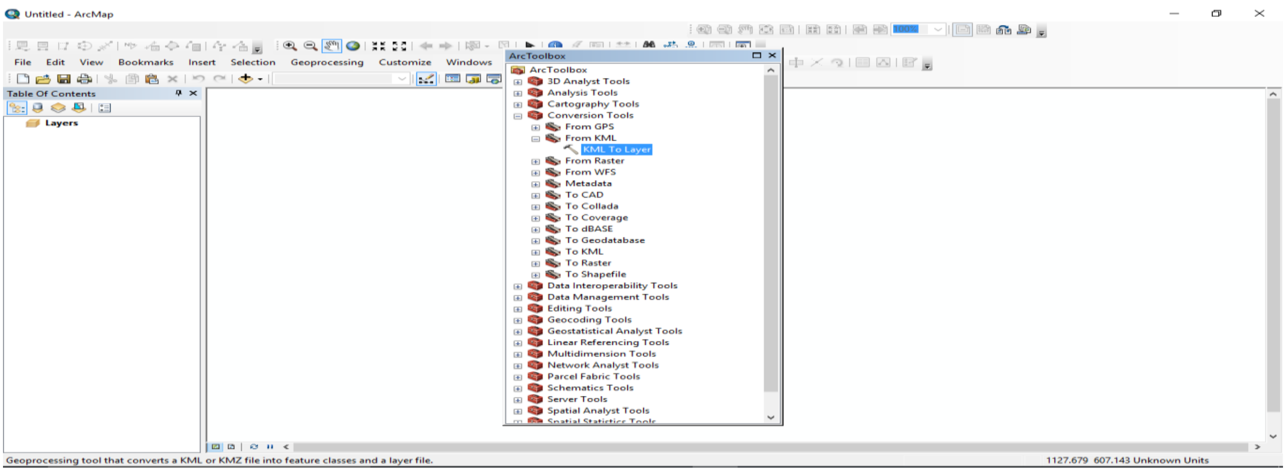

Figure 7 Selecting KML to Layer from KML

Step 8:

After selecting kml to layer a new dialog box appears on display. After selecting kml to layer it displays a new dialog box. The dialog box contains input kml file here we have to insert the file which has to be converted and output location where the converted file has to be saved as and we can also give output name which appears in the layers shown in Figure 8.

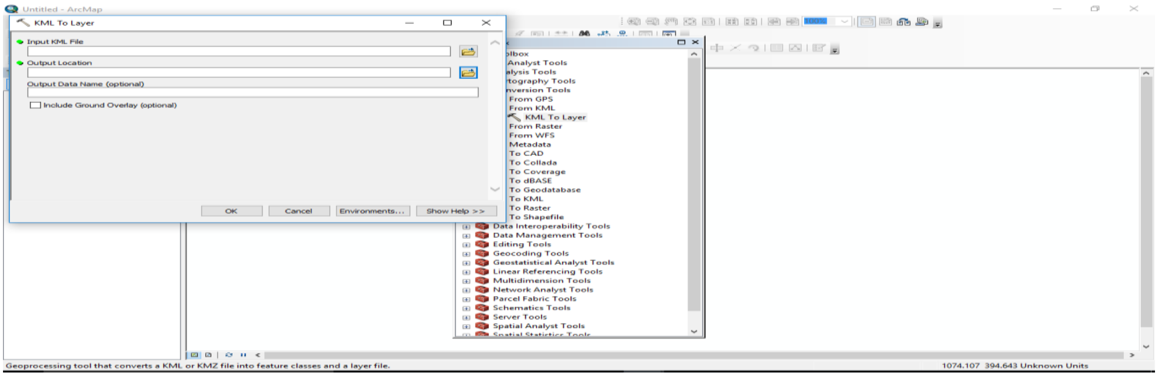

Figure 8 Selection of KML to Layer opens a new dialog box.

Step 9:

The dialog box consists of input and output options. In input we should open a kml file and in output we should select the location where we want to save our file. Now we input the file location which has to be imported and in output we select the desired location for output and click ok a shown in Figure 9.

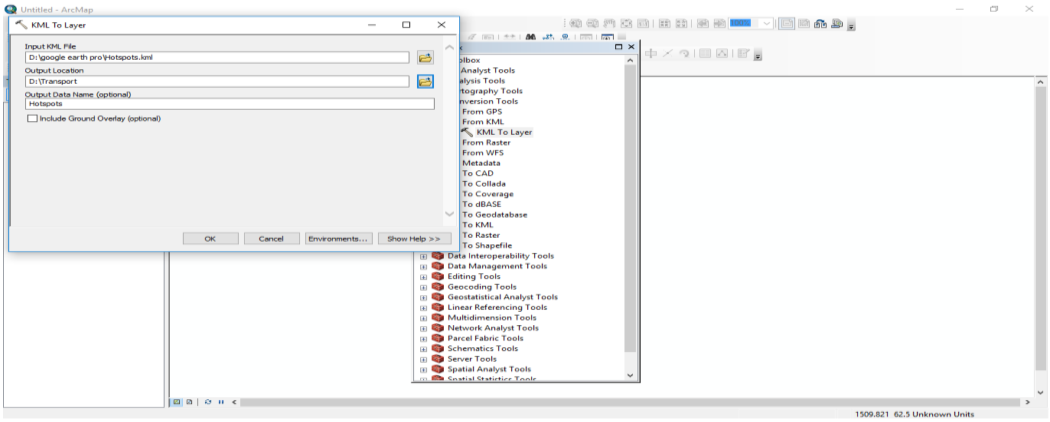

Figure 9 Browsing the file in Input KML file and selecting the output location.

Step 10:

When the file is opened it appears like this in Arc GIS. After clicking ok button the file which has to be imported is opened in Arc GIS and it displays all the accident hotspots such medchal, dundigal, miyapur, keesara, uppal adibatla, kbhp, shamshabad, narsingi, lb nagar, hayathnagar etc and the category of hotspots namely low, medium, high in the layers are displayed as shown Figure 10.

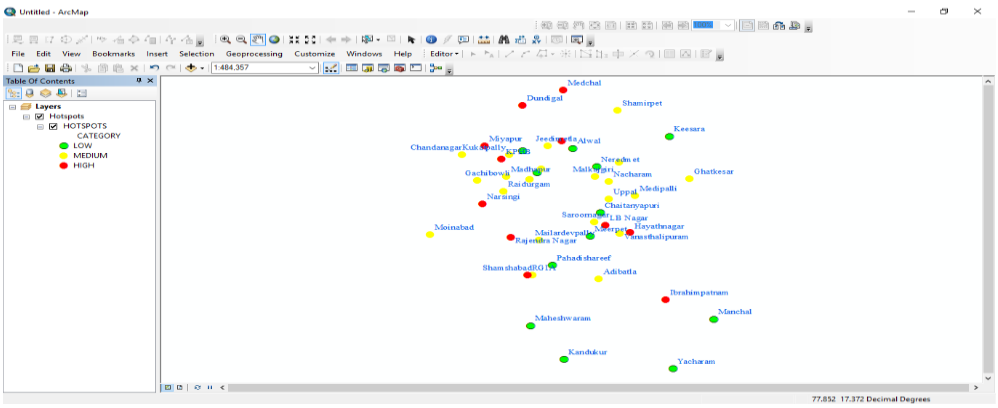

Figure 10 KML file is opened in Arc GIS.

Step 11:

When the file is opened it appears like this in Arc GIS. After clicking ok button the file which has to be imported is opened in Arc GIS and it displays in layers as shown.All the hotspots of high risk has been joined by regional road network on which high no. of accidents had occurred and this roads possess high risk to the individuals as shown in Figure 11.

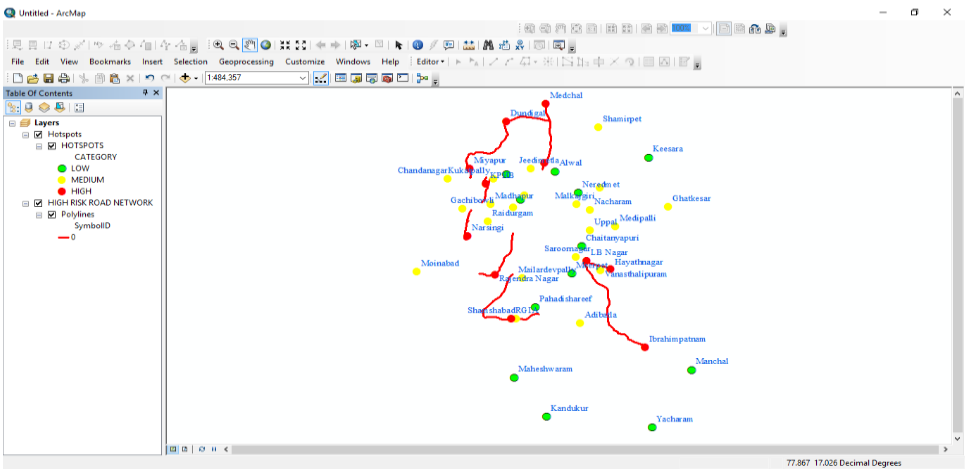

Figure 11 KML file is opened in Arc GIS.

Step 12:

When the file is opened it appears like this in Arc GIS. After clicking ok button the file which has to be imported is opened in Arc GIS and it displays in layers as shown .All the hotspots of medium risk has been joined by regional road network on which medium no. of accidents had occurred and this roads possess medium risk to the individuals as shown in Figure 12.

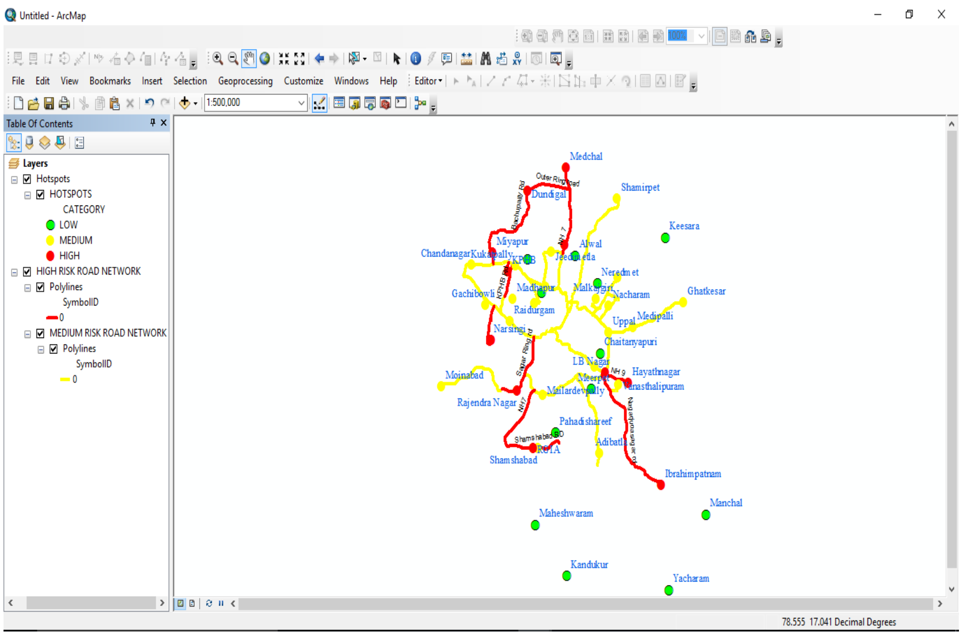

Figure 12 KML file is opened in Arc GIS.

Step 13:

When the file is opened it appears like this in Arc GIS. After clicking ok button the file which has to be imported is opened in Arc GIS and it displays in layers as shown. All the hotspots of low risk has been joined by regional road network on which low no. of accidents had occurred and this roads possess low risk to the individuals as shown in Figure 13.

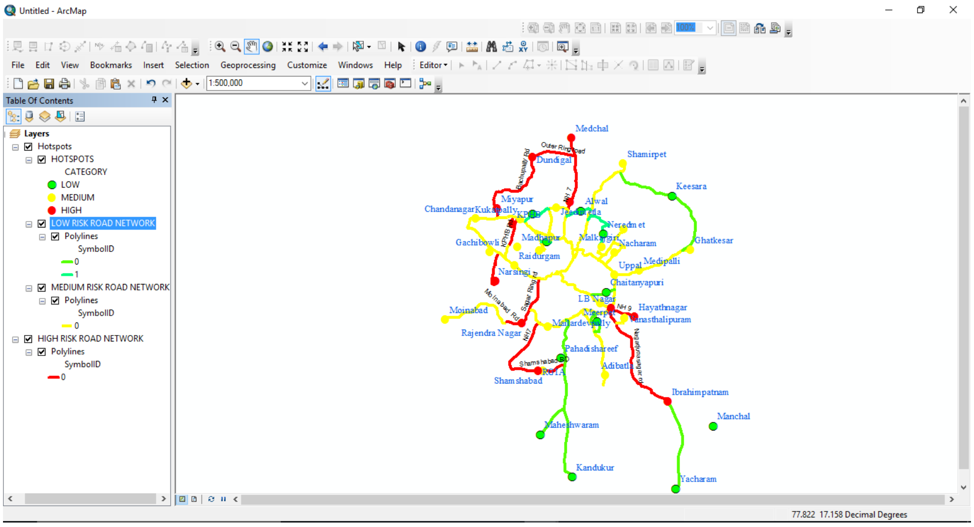

Figure 13 KML file is opened in Arc GIS.

Step 14:

Now save the map by selecting save option from file on the top of menu as shown below in the Figure 14.

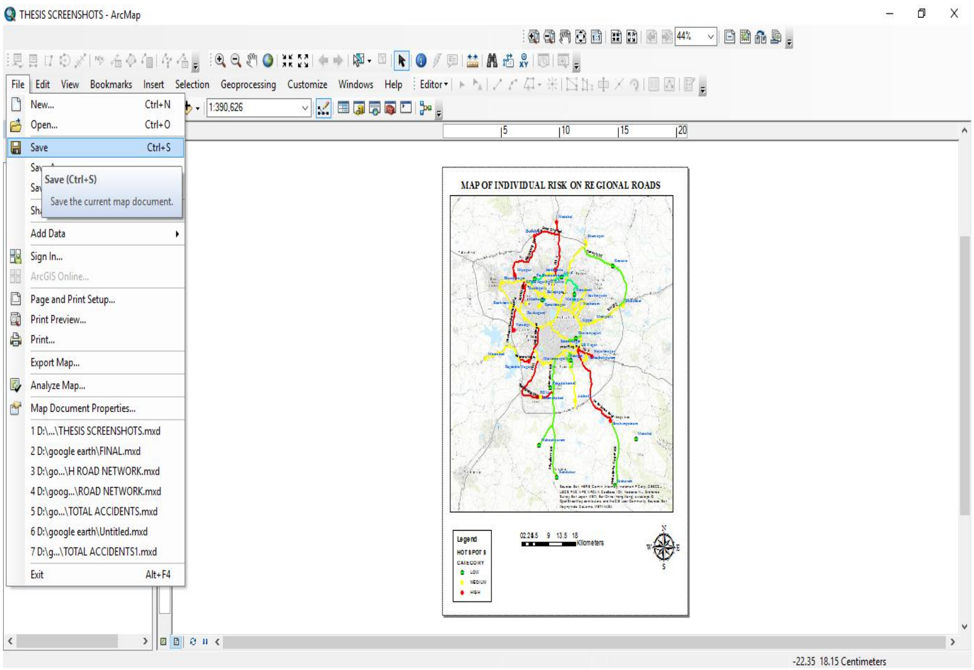

Figure 14 Save the Map

IX. INDIVIDUAL RISK ON ROAD NETWORK

The target of road safety framework administration is to guarantee that when road infrastructure is arranged, planned, manufactured and utilized the road risk can be methodically distinguished, surveyed for their results and eliminated. The consequences are measured with the number of accidents, injuries, fatalities and road accident costs. By using GIS we can present risk ranking in a clear and effective manner and better communicate the By using GIS we can present risk ranking in a clear and effective manner and better communicate the risks. This makes the tools a vital element of road infrastructure safety management. The total accidents are divided into three category namely low, medium and high. The accidents ranging from 0-49 where classified as low accidents road network, 50-99 as medium accidents road network and 100-200 as high accidents road network. All the police limits of Cyberabad where identified and they are connected by means of main roads.

As per the above classification the road network were classified as high risk road network, medium risk road network and low risk road network and are highlighted by using red, yellow and green colour respectively as shown in the Figure 15. GIS has been widely used for the geocoding of accident locations and developing maps of crashes. Not only for visual representation, GIS has also been used to enhance data integration and efficient handling of information from various source. With access to data on accidents and traffic, we can calculate the risk measures which will help us to identify safety levels on selected elements of the road. Sections can then be identified where accident risk, fatalities and injuries are the highest. This map can be used for various purposes. They help to inform motorists about the risk on the road network This helps them choose the lowest risk road and be extra careful when using high-risk sections. In addition, the maps help road authorities with making informed decisions about possible safety treatments.

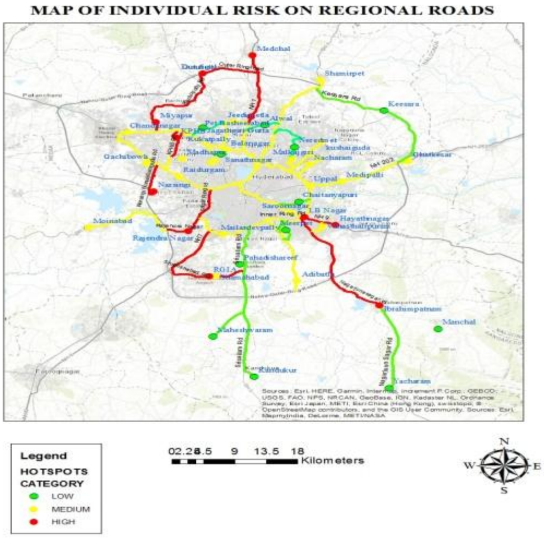

Figure 15 Map of Individual Risk on the Regional Road Network.

X. RESULTS

The severity index of the road network calculated on the basis of total accidents, fatal accidents, non-fatal accidents, no. of deaths and no. of injured by equivalent property damage only method. The severity index for low risk road network is 16.86 which is acceptable and can be further decreased. The severity index for medium risk road network is 17.56. The severity index for high risk road network is 19.02 which is very high and the road of these network should be properly maintained and necessary safety measures should be applied to prevent the accidents on the road network. The total accidents are divided into three category namely low, medium and high. The accidents ranging from 0-49 where classified as low accidents road network, 50-99 as medium accidents road network and 100-200 as high accidents road network. All the police limits of Cyberabad where identified and they are connected by means of main roads. As per the above classification the road network were classified as high risk road network, medium risk road network and low risk road network and are highlighted by using red, yellow and green colour respectively as shown in the Figure 15.

XI. CONCLUSION

By utilizing GIS we can exhibit hazard positioning in an unmistakable and viable way and better convey the dangers. This makes the tool an essential component of road infrastructure safety management. With access to data on accidents and traffic, we can calculate the risk measures which will help us to identify safety levels on selected elements of the road. Sections can then be identified where accident risk, fatalities and injuries are the highest. The Advancement of latest technologies and availability of innovative software the Accident Data shall be collected in an efficient and exhaustive manner which will enable in analyzing the cause of accidents and taking remedial measures. The crux of the problem of urban transport is congestion of traffic. This result in increased number of trips, increased journey time, travel cost, mental agony and reduced accessibility. Widening of roads is not possible due to the intense developments on either side of the road. Heterogeneity of traffic is another problem which causes severe congestion. This work gives a knowledge into the present situation of the movement state of the territory and shows out the most clumsy streets in the locale. It can also facilitate spatial data sharing within transportation agencies and between transportation department and other government agencies.

This geo database in turn can be fed into "expert" systems and so provide accurate recommendations to vehicle drivers the police, motoring organization and of course local authorities. All relevant organization and authorities have been attempted to reduce the number of accidents and mitigate the severity of those accidents in several ways. In order to reduce these serious situations, the first afford is we need to identify the locations of the accidental occurrence areas. The signals should be monitored in night time to control the night traffic. Mainly in night time nobody follows the signal which is the main cause of accidents. The movement of vehicles with high speed during night time is another cause of accidents. Potholes is the another cause of accidents because these are not visible clearly during night time for drivers especially two-wheelers. Take suitable enforcement measures to reduce the speed of vehicles.

XI. SCOPE FOR FURTHER STUDY

Finally, regarding the future aspects of the proposed methodology, there are several improvements that can be implemented in order to have a more user-friendly and automated system and to make data accessibly for all the road users and to implement various procedures to provide more safety on roads. By utilizing GIS instruments, and particularly the proposed system, a significant number of the issues, specified above, can be overseen. The usage of the strategy can contribute in numerous levels. Most importantly, the Road Accident Data Collection and Elaboration Procedure can be institutionalized. Secondly, the spatial dimension of the Road Accidents can arise into a major factor, for analyzing the facts and setting priorities. In such a way, Spatial Analysis can be implemented and Black Spots and Individual risk on the regional roads can be pointed out, supporting more reliable and focused surveys.

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