ES 680 Term project on

Mapping and Analyzing Road Accidents in India using GIS

Submitted in the partial fulfillment of the requirements for the Degree of

Masters of Technology

by

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Abstract

The use of GIS tools has revolutionized the way we analyze and understand data. This term project focuses on the spatial analysis of road accidents in India using GIS tools. We have gathered data from various sources, including government websites and research articles, and have analyzed it using ArcMap software. The project includes statistics on the total number of road accidents in India, state-wise distribution of accidents, and hotspots of accidents across the country. In addition to road accident data, we have also included information on the population and total km of roads in each Indian state and union territory. The project aims to identify the regions in India that are most prone to road accidents and to provide insights into the factors that contribute to road accidents. Overall, this project is an effort to increase awareness of road safety in India and to help policymakers make informed decisions to improve road safety. We hope that the findings of this project will contribute to the ongoing efforts to reduce road accidents in India and create safer roads for everyone.

Keywords : Indian Road Accident, GIS analysis

Chapter 1

Introduction

Road accidents are a major public health concern in India, with thousands of people dying and many more suffering from serious injuries each year. Despite efforts by the government and non-governmental organizations to improve road safety, the number of road accidents in India remains high. In this context, the use of Geographic Information Systems (GIS) tools can help understand the spatial patterns and trends of road accidents and identify the regions that are most prone to accidents. Given its penetration level in populated areas, road transport is India's most cost-effective transportation mode for freight and passengers. In India, exposure to unfavourable traffic conditions is significant due to record rates of motorization and rising urbanisation spurred by rapid economic expansion. As a result, traffic accidents, injuries, and fatalities have remained unacceptably high. Road traffic accidents are the greatest cause of mortality worldwide and the primary cause of death in the United States. Mortality among people aged 15 to 49 years. Road accidents in India killed over 1.5 lakh lives and injured over 3.8 lakh persons in 2021. Because road accidents result from multiple factors interacting, multi-pronged measures are required to reduce the number of accidents and fatalities. As a result, the Ministry of Road Transport and Highways has launched a proactive policy approach to road safety, enlisting the active participation of all stakeholders across the country. The country achieved an exceptional decline in accidents and fatalities in the previous year, 2020. This is largely due to the rare Covid-19 pandemic epidemic and the resulting nationwide lockdown, notably between March-April 2020, followed by progressive unlocking and decreasing confinement measures. Accident metrics continued a similar trajectory until 2019 when a dramatic drop occurred in 2020 owing to the Covid-19 epidemic. Table 1.1 shows that main accident indicators fared better in 2021 than in 2019. On average, road accidents have reduced. Uttar Pradesh (21, 227 i.e. 13.8%) topped the States in respect of the number of persons killed due to road accidents, followed by Tamil

Nadu (15,384 i.e. 10%). State-wise details are given in section below of this report. The main factors of the road accident are population, total road length and the number of vehicles for the corresponding state. Interestingly population density is not a factor in accidents.

1.1 Objectives of the report

Objectives of this report are as follows :

- To study state-wise road accident statistics for the past four years.
- To study the impacts of the factors like the population, population density, total road length and total number of vehicles running on road accidents.

1.2 Organization of the Report

The study is composed of three chapters. The first chapter introduces the present situation of Indian road accidents. Then I mentioned the study areas where is study is pulled off. Then I mentioned the data sets I have used to feed into the ArcMap software. Then I mentioned the software and methodology I used in the study. Then comes the ”Result and discussion” section, where I have analysed various components of the data set and visualised them using different symbologies, which included the Total number of fatal accidents analysis for four years, Roadlengths distribution analysis, how the population is affected, the no of traffic police and if this number can make a change in road accidents and Hotspot analysis. At last, I have concluded the report with a ”Conclusion and Summary” section.

Chapter 2

Literature Review

The alarming rise in road accidents in India and its various causes. It highlights the need for effective traffic management systems, improved road infrastructure, and proper traffic rules and regulations enforcement Singh, 2017. The use of GIS to analyze road accidents in India. It presents a case study of the city of Pune and shows how GIS can identify accident-prone locations and suggest improvements to reduce the number of accidents. The various data sources can be used to collect information on road accidents, road infrastructure, and traffic volume. It also shows how GIS can be used to develop a road safety index that can be used to prioritize safety interventions. Many studies highlight the importance of using GIS tools and techniques to analyze and address road accidents in India. They emphasize the need for effective traffic management systems, improved road infrastructure, and proper enforcement of traffic rules and regulations to ensure the safety of road users. The Ministry's and other stakeholders' proactive commitment to road safety has helped to minimise road fatalities throughout the years. Aside from that, the Motor Vehicle Amendment Act 2019 "the motor vehicles (amendment) act, 2019 (no. 32 of 2019) - morth", n.d., st, which went into effect on September 1, 2019, helped to reduce road accidents. The MVA Act 2019 contains features such as increased fines for traffic offences, electronic monitoring of the same, higher penalties for juvenile driving, and so on. In this project, the data are taken from the Ministry of road transport and Highways, the Indian census board, Wikipedia and the Indian Traffic Department.

The number and speed of vehicles on the roads have increased significantly in recent years. Still, the quality of the roads and the vehicles' safety standards have not been satisfactory. Moreover, people have not been given adequate instructions and training to enhance their driving skills and promote safe driving practices. The primary objective of this study is to investigate and compare various types of traffic accidents concerning their spatial distribution. The central

zone witnessed more accidents than the other four zones, with heavy vehicles being the primary cause of such accidents. The narrow width of the roads forces heavy vehicles to move onto the carriageway, creating conflicts with other vehicles. The city witnessed a greater number of non-fatal accidents due to reduced journey speed. Most accidents occurred during the day, and driver error was the most significant cause, particularly Swipe and Rear-end collisions, which were more prevalent in non-fatal accidents. Logistic regression analysis revealed that Rear-end Swipes were significant factors in non-fatal accidents. GIS data can be modified multiple times to manage various data types, including spatial and non-spatial data Jalegar and Begum, 2017. GIS data is user-friendly and can be analyzed using spatial and non-spatial queries. Route analysis and proximity analysis can be used to find the best routes and nearest facilities to any location. The mapping data generated by GIS is highly beneficial in decision-making. Khan et al., 2018

Chapter 3

Materials and Methods

3.1 Study Area

India is a country located in South Asia, bounded by the Indian Ocean to the south, the Bay of Bengal to the southeast, and the Arabian Sea to the southwest. It is bordered by Pakistan to the west, China and Nepal to the north, Bhutan to the northeast, and Bangladesh and Myanmar to the east. India has a land area of approximately 3.3 million square kilometres and a coastline of about 7,500 kilometres. Its geographic coordinates are 20.5937^o N, 78.9629^o E. Figure 3.2 shows the study area.

Area and Population of Cyberabad is approximately 360 sq.km and 8 lakh, study area of Hyderabad can be seen in. The area proposed for the study is presented in Figure **??**. There are 28 states and 8 Union territories in India.

3.2 Data and Data Sources:

Ministry of Road Transport and Highways: This is the website of the Indian government ministry responsible for developing and maintaining national highways and major roads in the country.

Census of India: This is conducted by the Office of the Registrar General and Census Commissioner of India, Ministry of Home Affairs, Government of India, and provides detailed demographic data.

Open Government Data (OGD) Platform India: This is an initiative of the Indian government to provide free access to various datasets collected by government agencies. The used data are provided in the subsequent tables below 3.2 and 3.1.

- Population data : https://www.populationu.com/india-population

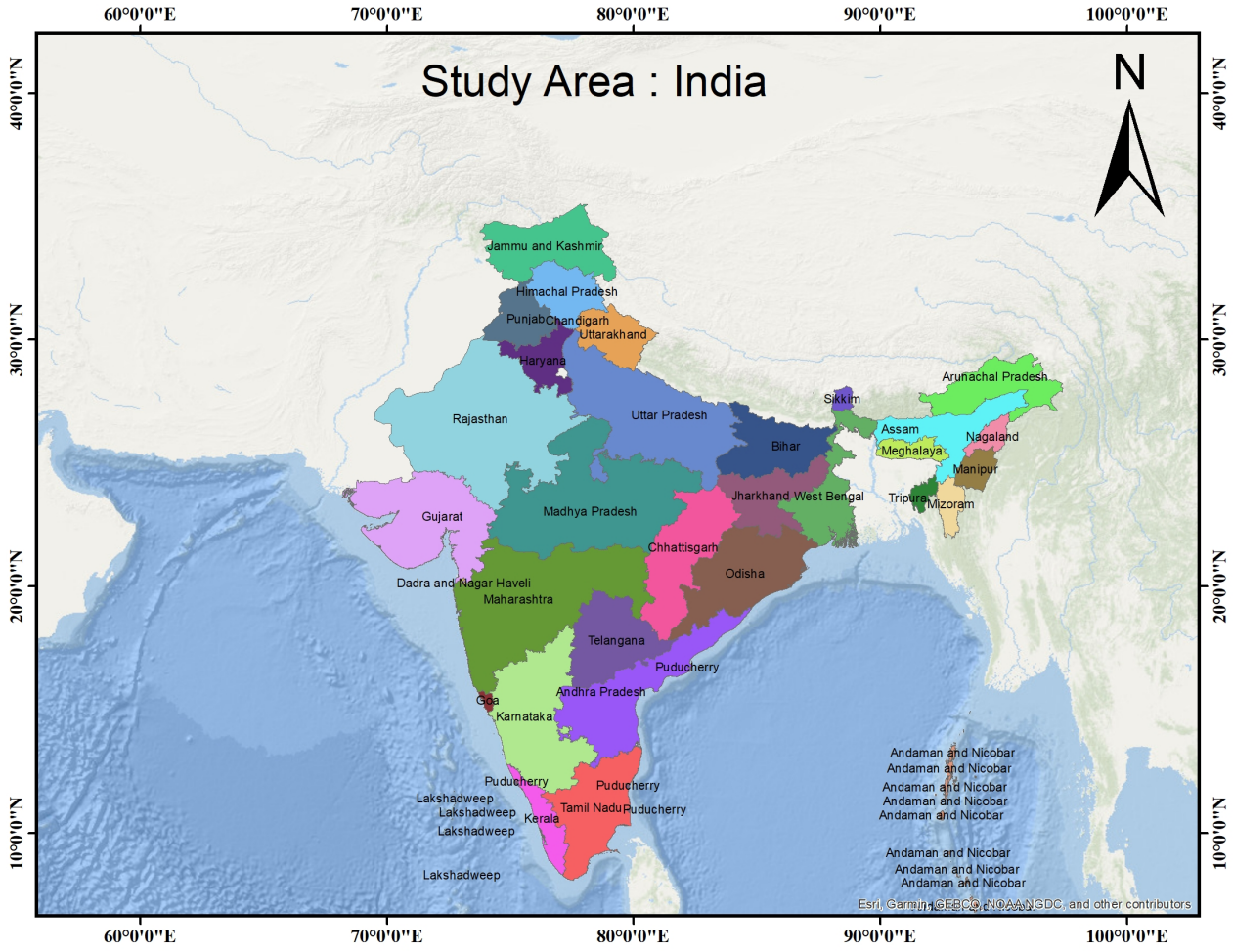

Figure 3.1: Location of Study Area, India

- Road length data : wikipedia.com
- Road accident data: https://morth.nic.in
- Total number of vehicles : https://www.ceicdata.com/en/indicator/india

3.3 Software and tools used

The data were analysed and processed using MS Excel and ArcMap 10.8. Various graphs "ESRI documentation: Up-to-date documentation for arcgis and more", n.d. and thematic maps have been prepared to interpret and explore the results. GIS (Geographical Information System) is used to prepare thematic maps and to have a visual impact on the type and different scatter maps.

Table 3.1: State/UT-wise number of accidents over past four years and their rank depending upon 2021 data"Road Accident in India,2021", 2022

State/UT	**2018**	**2019**	**2020**	**2021**	**Ranking**
Andaman and Nicobar Islands	18	20	12	19	35
Andhra Pradesh	6998	7389	6531	7585	7
Arunachal Pradesh	134	108	61	150	26
Assam	2829	3019	2483	2893	18
Bihar	6244	6731	6197	7061	9
Chandigarh	97	100	50	94	29
Chhattisgarh	4217	4603	4234	4982	12
Dadra and Nagar Haveli	52	48	61	71	30
Delhi	1657	1433	1163	1206	19
Goa	248	283	213	218	23
Gujarat	7176	6726	5622	6825	10
Haryana	4806	4684	4181	4403	14
Himachal Pradesh	926	930	734	871	20
Jammu and Kashmir	809	762	623	642	22
Jharkhand	3261	3414	2775	3221	17
Karnataka	10093	10060	9084	9458	5
Kerala	4069	4183	2823	3262	16
Lakshadweep	1	0	0	1	36
Madhya Pradesh	9721	10182	9874	10806	4
Maharashtra	12098	11787	10773	12554	3
Manipur	122	146	112	99	28
Meghalaya	165	169	130	150	26
Mizoram	39	46	41	48	32
Nagaland	35	24	46	56	31
Odisha	4861	4844	4391	4756	13
Puducherry	225	143	133	158	25
Punjab	4479	4190	3646	4250	15
Rajasthan	9295	9471	8363	9055	6
Sikkim	51	61	34	40	34
Tamil Nadu	11375	9813	7559	14747	2
Telangana	6051	6472	6429	7080	8
Tripura	194	224	179	181	24
Uttar Pradesh	19364	19731	17075	19026	1
Uttarakhand	797	750	592	742	21
West Bengal	5185	5120	4582	5405	11

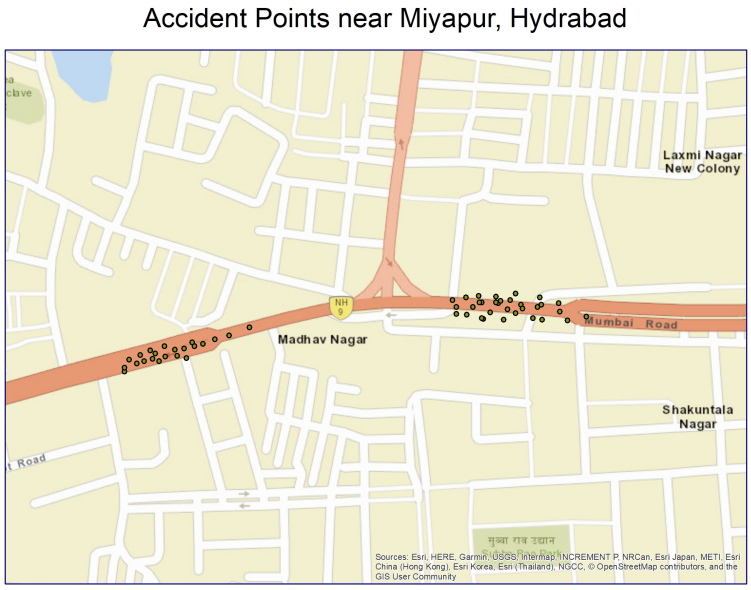

Figure 3.2: Location of Study Area, India

3.4 Methodology

Different steps have been followed for this project using Excel and ArcMap. They are summed up as follows:

- Collect the data for road length, population, registered vehicles, and number of traffic police from reliable sources.
- Collect the shape file for India from a reliable source.
- Clean the data in Excel to ensure that it is in the correct format and there are no errors or missing values.
- Load the shape file in ArcMap.
- Load the data in ArcMap and ensure that it is in the correct format.
- Dissolve the Shape file on the same state name or UT name to create a new shapefile with a single polygon for each state or UT.
- Join the attribute table on the name of the states to add the data to the shapefile.
- Find the area of the states using geometric calculation in ArcMap.

- Convert string to numeric files in ArcMap using the field calculator.
- Find the population density by dividing the population by each state's area using the field calculator in ArcMap.
- Use different symbologies for different years and attribute fields to create maps and visualizations.
- Identify the states with the highest risk of road accidents by calculating the area per kill using a hotspot tool to highlight these states.

For hotspot analysis, the weight allocated to each accident is expressed as its Identification Number (ID) to account for accident severity. The population field of the kernel density function is chosen as the aforementioned ID. This makes it easier to count each accident based on the weight allocated to it. The population variable is set to "None" if there is no severity or if the analysis is based on event points. The main equation govern for the 'same is :

$$f(x) = \frac{3}{nh^2\pi} \sum_{i=1}^{n} (1 - \frac{1}{h^2}[(x - x_i)^2 + (y - y_i)^2])^2$$

where: h is termed as bandwidth, radius or smoothing factor; K is kernel and f is estimator of probability density function. The kernel estimator depends upon choice of bandwidth (h), hence appropriate bandwidth should be determined according to purpose of study

Table 3.2: State/UT wise statistics (Population, total road length, numbers of vehicles "India population", n.d.

State/UT	**Total Road Length (km)**	**Population**	**Registered Vehicles**	**Number of Traffic Police**
Andhra Pradesh	99,077	49,386,799	15,216,199	20,890
Arunachal Pradesh	8,195	1,383,727	163,287	3,082
Assam	37,532	31,205,576	6,422,290	8,771
Bihar	94,163	102,714,667	11,915,166	24,350
Chhattisgarh	55,125	29,797,880	5,674,266	5,711
Goa	3,702	1,610,516	571,886	869
Gujarat	88,745	63,872,399	23,432,637	16,971
Haryana	26,273	28,204,231	8,143,788	9,871
Himachal Pradesh	16,401	7,656,509	1,313,175	2,699
Jharkhand	28,574	33,020,491	3,547,710	5,839
Karnataka	121,597	67,562,686	23,718,258	16,645
Kerala	34,077	35,699,443	8,683,888	10,414
Madhya Pradesh	172,821	84,516,795	16,798,504	14,594
Maharashtra	237,596	123,144,223	40,446,233	30,982
Manipur	4,090	2,855,794	239,804	1,850
Meghalaya	7,633	3,116,897	341,622	2,420
Mizoram	3,535	1,197,023	90,078	2,139
Nagaland	4,428	1,978,502	184,348	1,843
Odisha	94,163	45,439,358	7,944,227	9,693
Punjab	11304	30355185	12908126	15000
Rajasthan	260383	68936999	20291066	20000
Sikkim	4023	671720	74348	500
Tamil Nadu	119840	75695000	30841890	40000
Telangana	27778	37220000	12060406	8000
Tripura	8966	3992000	551798	2000
Uttar Pradesh	353835	240928000	63959673	40000
Uttarakhand	38154	11082752	1720361	2500
West Bengal	92525	96906000	18717043	25000

Table 3.3: Data Table

id	X	Y
1	8722883.644	1978654.418
2	8722851.039	1978646.513
3	8723295.653	1978697.891
4	8723390.504	1978717.652
5	8723391.492	1978706.783
6	8723425.085	1978700.855
7	8723401.372	1978695.915
8	8723357.899	1978698.879
9	8723363.827	1978712.712
10	8723366.791	1978724.568
11	8723336.162	1978729.508
12	8723329.246	1978721.604
13	8723326.282	1978709.747
14	8723336.162	1978704.807
15	8723369.755	1978696.903
16	8723368.767	1978715.676
17	8723343.078	1978715.676
18	8723314.425	1978717.652
19	8723293.677	1978718.64
20	8723262.06	1978712.712
21	8723274.904	1978702.831
22	8723293.677	1978698.879
23	8723304.545	1978705.795
24	8723311.461	1978718.64
25	8723311.461	1978725.556
26	8723289.725	1978726.544
27	8723273.916	1978724.568
28	8723257.12	1978721.604
29	8723282.808	1978712.712
30	8723321.342	1978696.903

Table 3.4: Accident data in Miyapur, Hydrabad

id	X	Y
31	8723345.054	1978710.735
32	8723317.39	1978720.616
33	8723290.713	1978718.64
34	8723262.06	1978703.819
35	8722943.914	1978666.274
36	8722930.081	1978668.25
37	8722920.201	1978660.346
38	8722923.165	1978648.489
39	8722896.488	1978650.466
40	8722895.5	1978663.31
41	8722888.584	1978644.537
42	8722880.68	1978647.501
43	8722877.715	1978658.37
44	8722864.871	1978652.442
45	8722860.919	1978641.573
46	8722845.110	1978631.693
47	8722845.110	1978636.633
48	8722869.811	1978644.537
49	8722911.309	1978651.454
50	8723002.207	1978687.023
51	8722976.519	1978677.142
52	8722958.734	1978672.202
53	8722933.045	1978663.310
54	8722908.344	1978659.358

Chapter 4

Result and Discussion

4.1 Percentage of the total accident in different years

The results obtained from the whole analysis are as follows, we can find from the visualisation of different years of road accident counts. For 2018 The top five states were Uttar Pradesh, Tamilnadu, Maharastra, Rajasthan and Madhya Pradesh. These all data are for fetal accidents so people are losing their lives in Uttar Pradesh most, as 8 to 10% **??** of the total fetal accidents happens in UP only. Other top states are sharing the percentage between 5 to 8%.

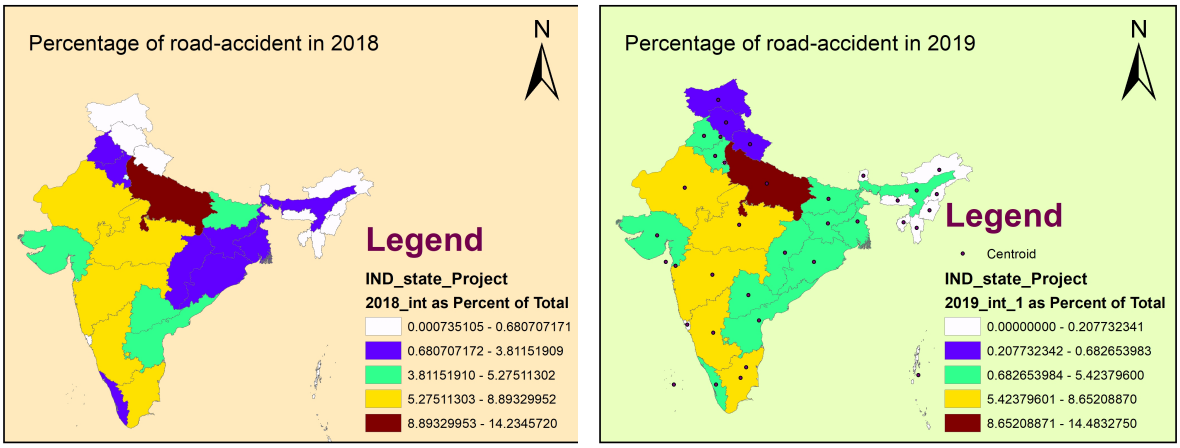

Figure 4.1: Accident number(percentage) in 2018 and 2019

2019,2020 repeats the same result as 2018. The top five states were Uttar Pradesh, Tamilnadu, Maharastra, Rajasthan and Madhya Pradesh. All these data are for fetal accidents, so people are losing their lives in Uttar Pradesh most, as 8 to 10% **??** of the total fetal accidents happens in UP only. Other top states are sharing the percentage between 5 to 8%.

States like Madhya Pradesh, Karnataka, Kerala, Tamil Nadu and Telangana, with the highest

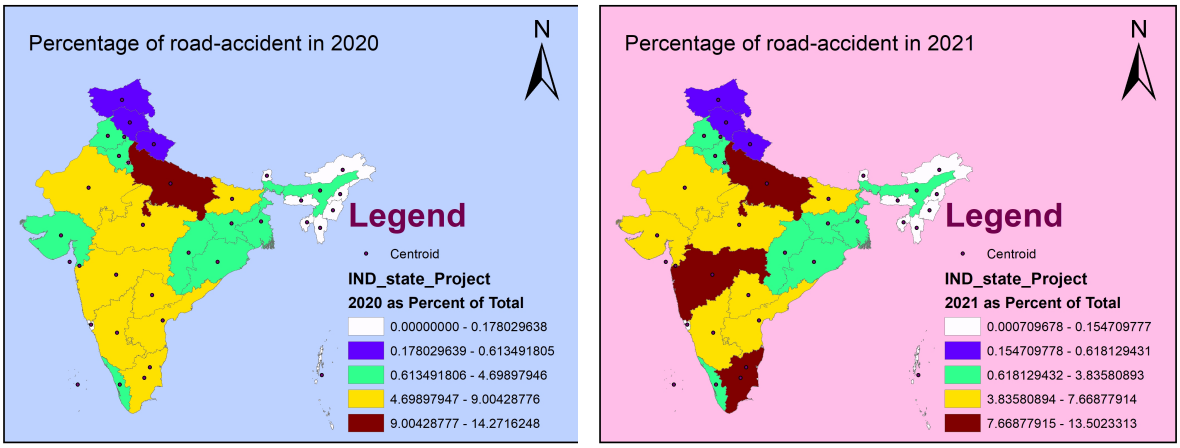

Figure 4.2: Accident number(percentage) in 2020 and 2021

share of accidents and fatalities in 2021 registered accident severity rate lower than all India average. Uttar Pradesh, Maharashtra, Gujarat, Rajasthan and Andhra Pradesh are top amongst the States in the number of fatalities, shown accidents severity rates higher than the national average.

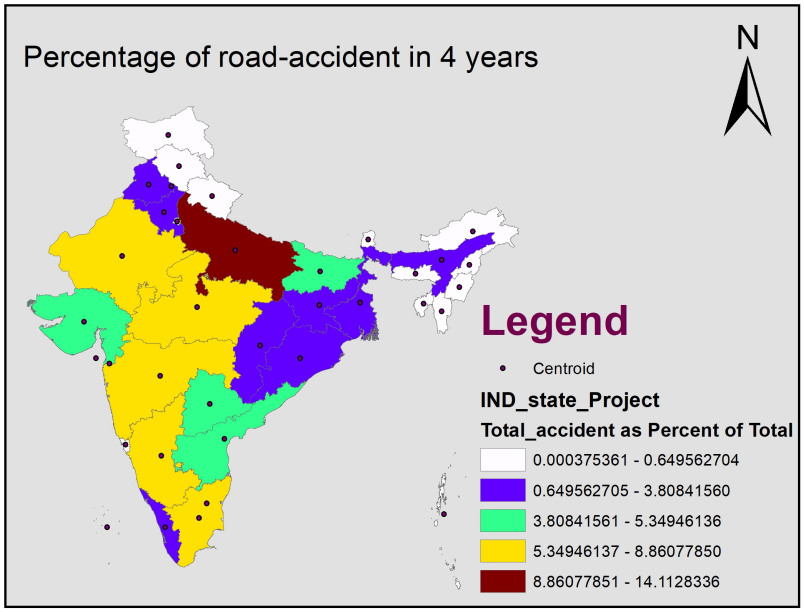

Figure 4.3: Total distribution of accidents in 4 years

4.2 Road lengths distribution

Now having known the percentage of the total accidents now, the total road length of the states will give us a vision of the related factors for increasing road accidents reasons. From figure **??**, we

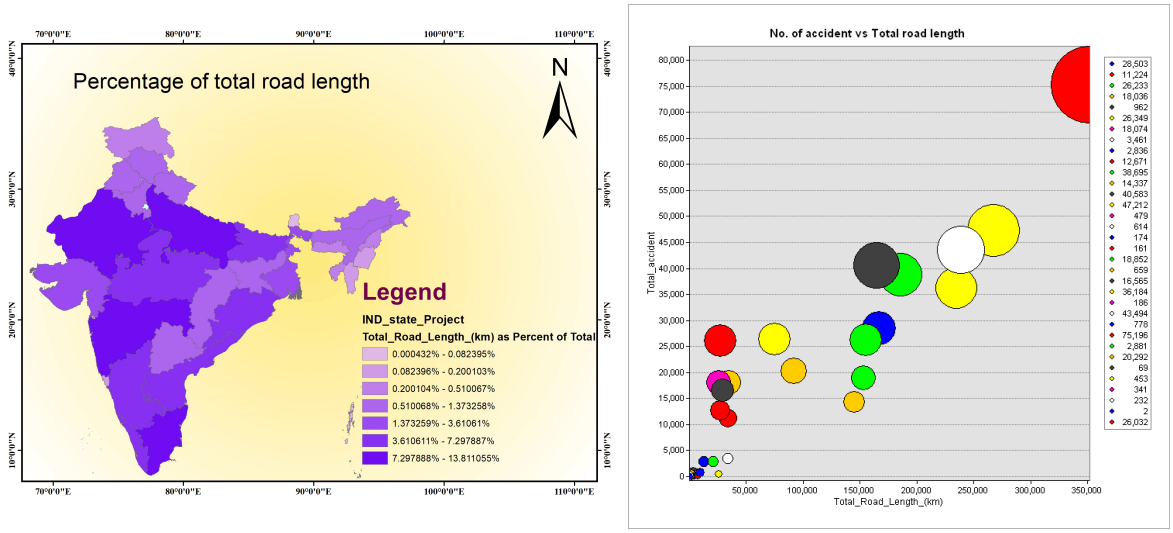

Figure 4.4: Road length distribution and relation with number of accident

can see that most road lengths are shared by the states Uttar Pradesh, Maharastra, Rajasthan and Tamilnadu, followed by Karnataka, Madhyapradesh with the total lengths respectively 352000, 267452, 239000,235000,186000 and 165000 km. So there is a direct connection between the road length to the number of fatal accidents counts. The bubble plot is also depicting the same. Some states have less road length, but they possess more serious accidents per km; those states are riskier of having a fatal road accident we will see those states in the later sections.

Now let's look into the total overall analysis for all four years. In the figure 4.6, it can be found that there is a decline in the number of fatal accidents. The clear reason is the lockdown during the COVID-19 period when almost all vehicles were not performing, so eventually, there was a downfall in the number of accidents. While the overall number of accident deaths climbed from 1,31,714 in 2020 to 1,53,972 in 2021, representing a 16.9 per cent rise on average over the previous year. Except for Puducherry and Manipur, all states had a rise in fatalities in 2021 compared to the same time in 2020. The more detailed delineation can be found in the figure **??** below.

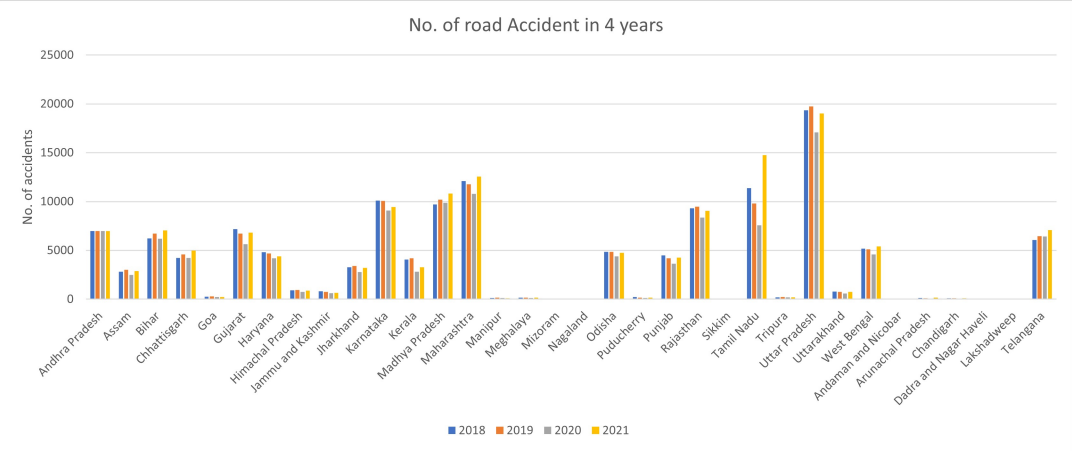

Figure 4.5: Number of fatal accidents in four years in each state

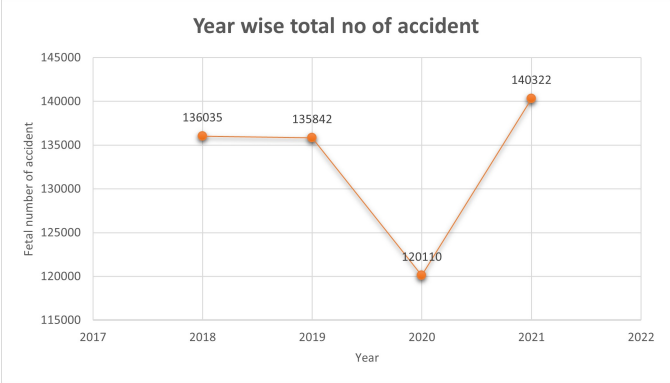

Figure 4.6: Total number of fatal accidents in each year and the delineation in 2020

4.3 Population and area distribution

Along with the road length distribution, the states' populations are also responsible for the number of accidents in their respective states. As we can see, the are occupied, and the total populations most percentages come under the states Uttar Pradesh, Maharastra, Tamilnadu, and Rajasthan extra. Uttar Pradesh, Maharastra, Tamilnadu, and Rajasthan populations are respectively 241930444,123144223, 77881463, and 83286210. West Bengal also has 4 -8 % of the population, but the number of accidents in West Bengal is comparatively less for other populated states. In the figure 4.3 we can find the same.

Now let's look into the population density and its effect on the total number of accidents, In figure 4.3 it is clearly visual there is no significant indication from the population density which states may have the most number of accidents. On top of that, the scatter plot is showing the same as there is no significant change only depending upon the population density as it is not

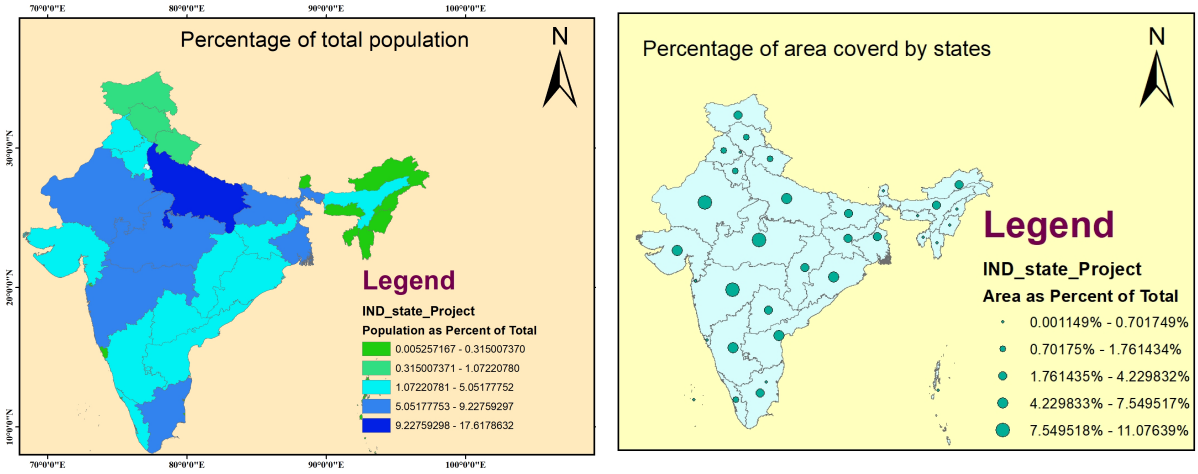

Figure 4.7: Population and area of states effect

influencing the number of road accidents. The scatter is not showing any type of correlation with a number of accidents in that state.

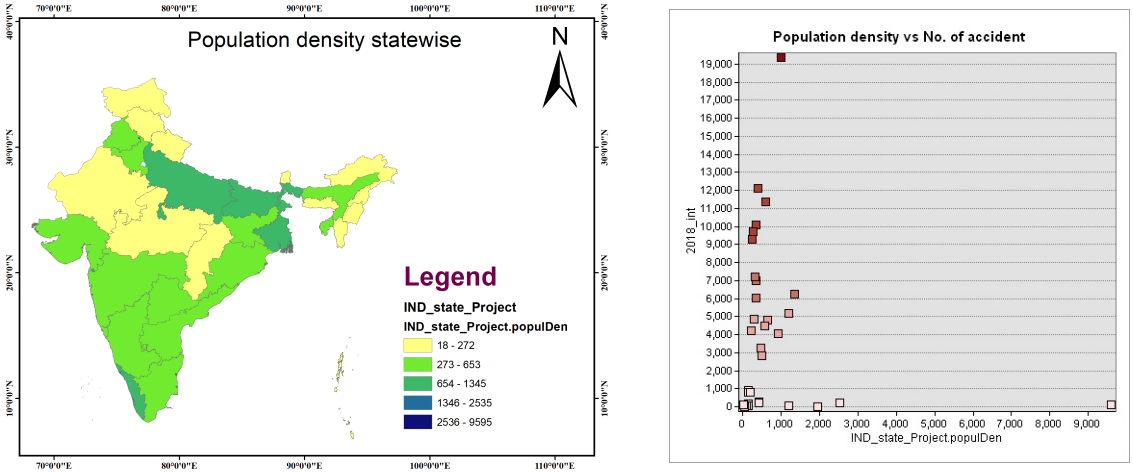

Figure 4.8: Population density and its affect

Now let's look into the accident per 1 lakh population per each state, This study will give more instance points of view on which states are riskier and where the no of death due to road accidents is higher compared to their number of populations.

Figure 4.9 is showing the number of accidents per 1 lakhs people viz the density of accidents where we can find the most dance accident state is Tamilnadu with 19 fatal accidents per 1 lakhs people followed by Telangana and Chhattisgarh and Haryana. Maybe the youth attitude can a possibility for this kind of number. In the next section, we will see if the number of traffic police can help with the number of accidents or if they have some effect on the number of accidents.

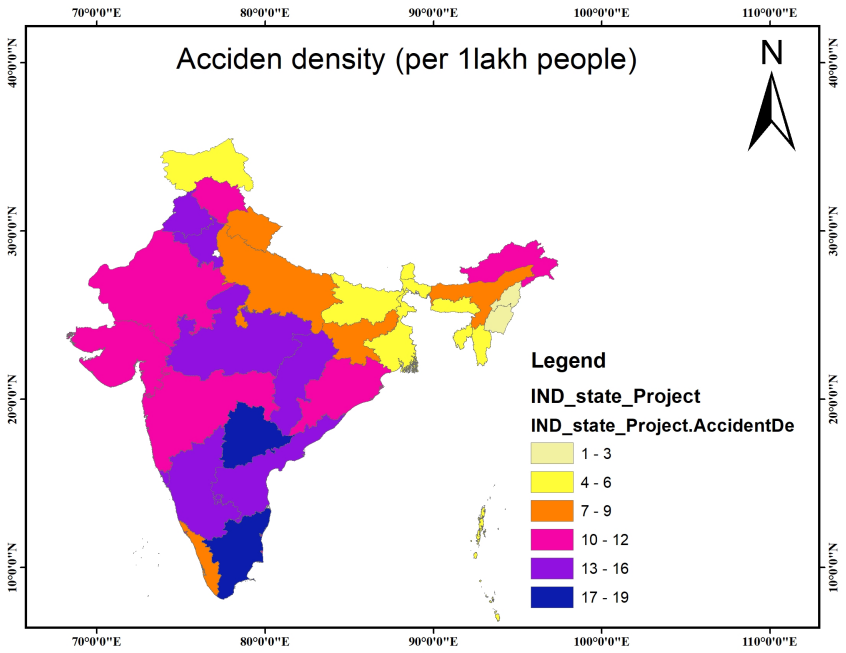

Figure 4.9: Number of accidents per 1 lakh people

4.4 Analysis of the number of Traffic police

In general, the common understanding is if there is more traffic police then there may be less number of accident happens, we will see in this section if it is maintained in the Indian context. If we observe the 1st figure can come to the conclusion that the number of traffic police is

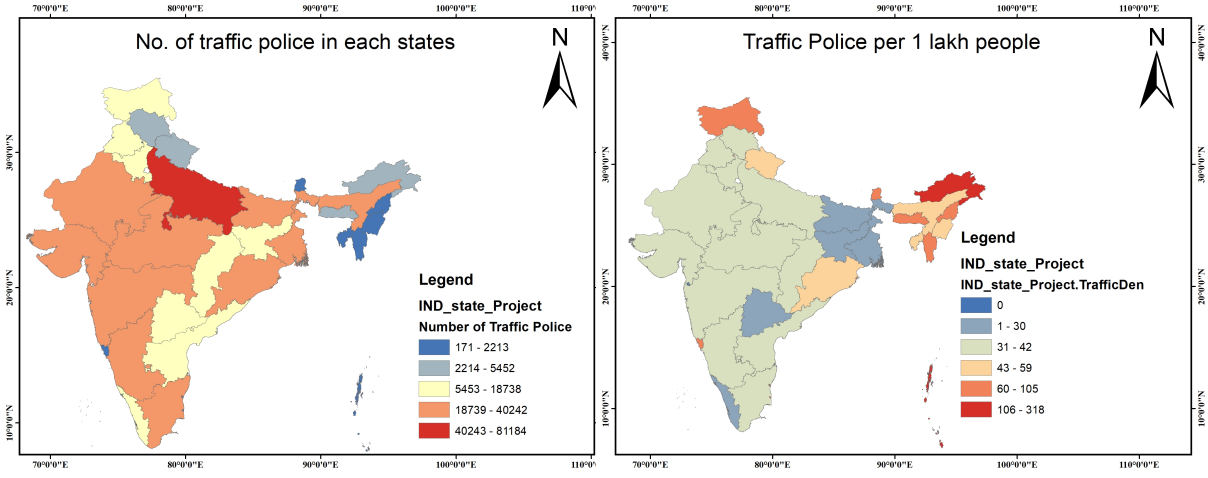

Figure 4.10: Number of Traffic Pollice and number of Traffic police per 1 lakhs people

influencing the number of fatal accidents. But if we observe the 2nd figure we can find the states who have the most number of accidents have very less traffic police per 1 lakh person. In this study, I find states like Uttar Pradesh, Maharastra, and Tamilnadu all are in the least top 10 list of

having traffic police per 1 lakh people. Though is seems to be a very crucial point, let's see the scatter plot for a better understanding of how exactly it affects the number of road accidents. As

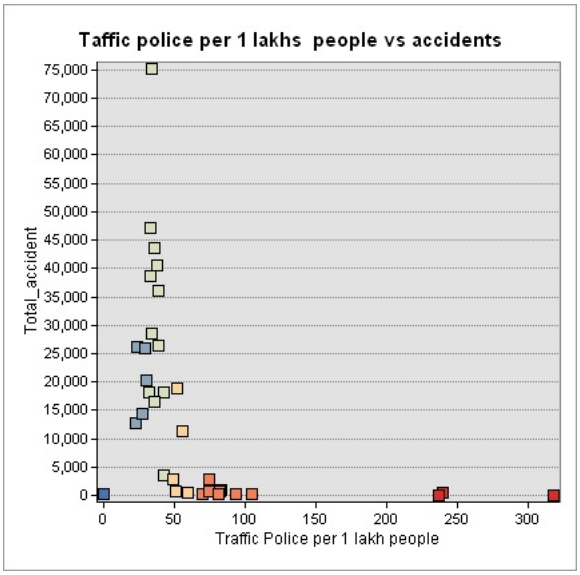

Figure 4.11: Total accident variation with traffic police per 1 lakhs people

we can see here up to a fixed number of traffic police density, there is no such relation with the number of fatal road accidents as it is increasing even with the increasing traffic police density in some cases. So, we can not exactly and extremely Raleigh on increasing the number of traffic police per every 1 lakh people.

4.5 Hostpot Anlysis

As I mentioned earlier, there are some states with low numbers of people and low total road lengths, even then those states have a number of accidents that are higher than expected those places are more risky than other states. A hotspot analysis in ArcMap Sree and Sundar, 2015 can reveal those states. In this analysis, the z-score has been plotted, where if the Z-score is more, the risk is less if the z-score is high, the risk is high. I have not gotten the exact coordination of the accident places for the whole of India, where I can do the kernel density test on how risky those places are. But I have found a small data set of "Miyapur" in Hyderabad, and I have performed the density analysis with the kernel function mentioned in the methodology section to find the more sensitive areas for happening an accident (using heatmap Netek et al., 2018). The study area is already mentioned in the previous section. The result is shown below 4.5.

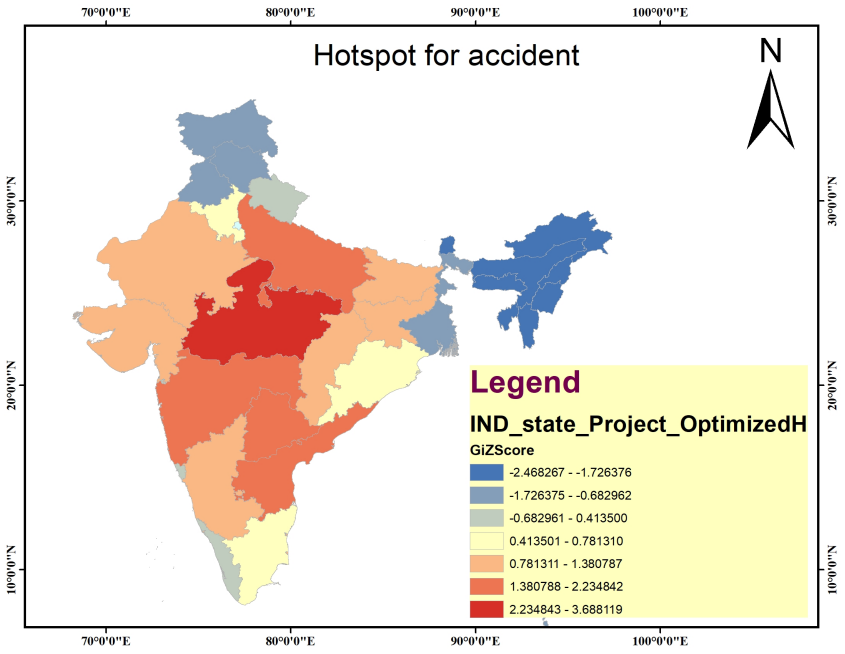

Figure 4.12: Hotspot states (more risky)

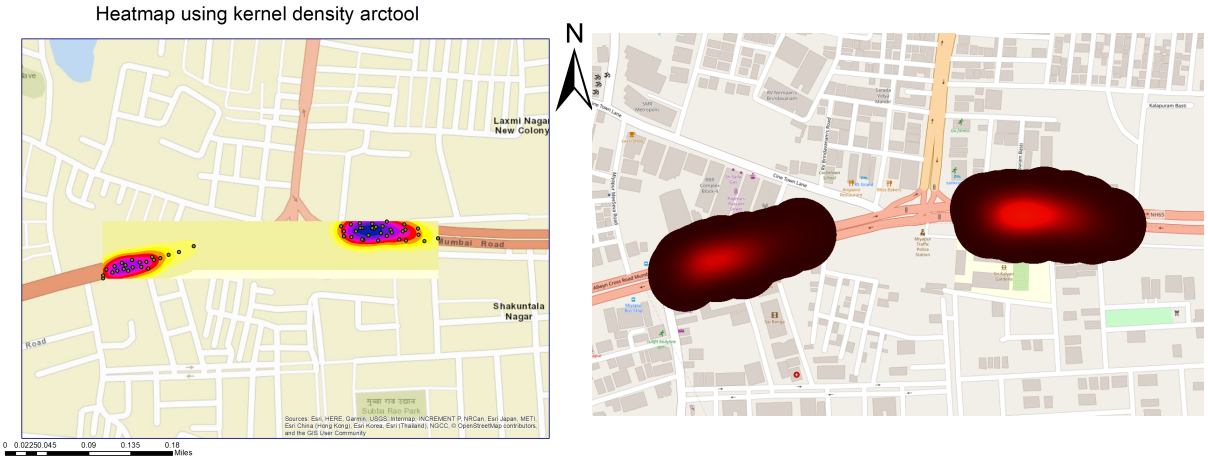

Figure 4.13: 2 Generate Hot Spot for the area of 'Miyapur' in Hydrabad

In this figure 4.5, the left one is the Belda area in West Bengal, where the accident points are digitized. I have performed the Kernel Density analysis to find the accident-prone areas with a radius of 100 meters. The data is not published data it is scratched data only with the name of the places, I digitised as I know the place so I know most of the places, Some place that were unknow to me I just put in between two points .

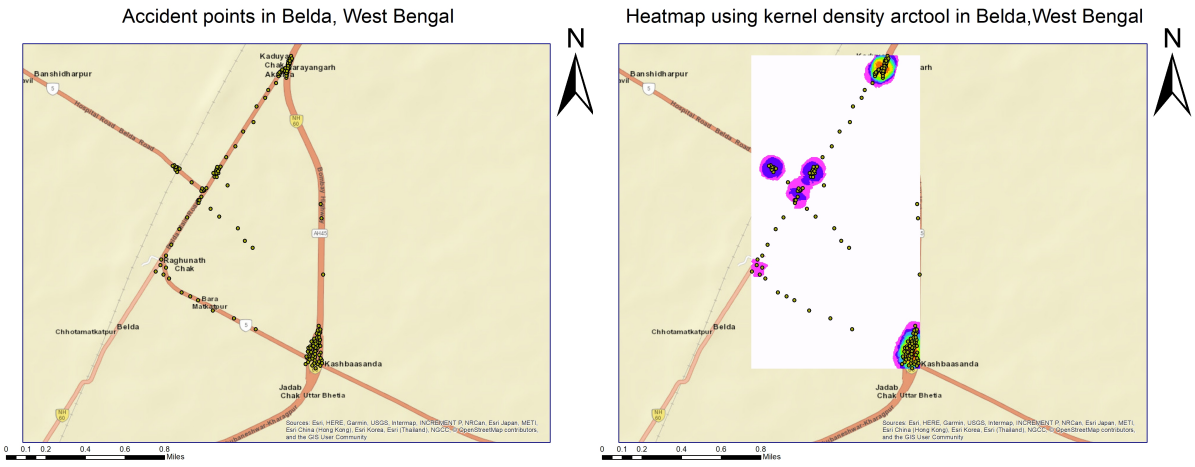

Figure 4.14: Hostpot for road accidents in Belda area of West Bengal using Kernel Arc Tool

Chapter 5

Conclusion and Summary

In conclusion, this term project involved analyzing the road network, population, registered vehicles, and traffic police data of Indian states and UTs to determine the level of risk associated with road accidents in each region. The project started with collecting the necessary data and shapefiles for India. The data was then cleaned and loaded into ArcMap for further analysis.

The shapefile was dissolved on the same state name or UT name using the dissolve tool. The attribute table was joined on the name of the states to facilitate further analysis. The area of each state was calculated using geometric calculations, and the population density was computed using field calculator.

Different symbologies were used to represent different years and different attribute fields, which made it easy to compare and contrast the data. Finally, hotspot analysis was carried out to determine the most risky state based on area per kill. Apart from the youth attitude, several other factors could be responsible for the high density of accidents in these states. One of the reasons could be the lack of awareness about traffic rules and safety measures. It could also be due to inadequate infrastructure and road maintenance, which can lead to more accidents. Additionally, the rapid increase in the number of vehicles on the roads can be a contributing factor.

Furthermore, it is important to note that the high number of accidents results in loss of life and has a significant economic impact. The cost of medical treatment, vehicle repairs, and loss of productivity can be enormous.

Therefore, it is crucial to promote road safety awareness and strictly enforce traffic rules. This can be achieved by conducting regular safety campaigns, implementing stricter penalties for traffic violations, and improving the infrastructure and maintenance of roads. Only through collective efforts can we reduce the number of accidents and ensure safer roads for everyone.

The total number of accident deaths increased from 13,542 in 2020 to 15,350 in 2021, recorded an increase of 13.4 per cent relative to the same period last year, which is higher than all India's average increase of 16.9 per cent.

Overall, the project was successful in achieving its objectives of identifying the states and UTs with the highest risk of road accidents and providing insights into the factors contributing to the risk. The project can be further improved by incorporating additional data sources such as road quality, weather conditions, and driver behavior, which can provide a more comprehensive understanding of road safety in India.

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