IDENTIFYING ASPHALT PAVED ROAD ACCIDENT'S BLACK SPOT LOCATION USING
GIS AND ASI METHOD: A CASE STUDY IN ASSOSA TOWN

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ABSTRACT: *Road traffic accidents are the top leading causes of death and disability globally, with a top-heavy number occurring in developing countries. Today, however, a certain blight or difficulty has settled in the world increasingly, people face difficulties when moving from place to place. This study aims to identify asphalt paved road traffic accident black spot locations in Assosa town, by ASI method and GIS platform from 2015 to 2019. The necessary information for this study were collected from field observation and daily records. Data analysis was made using Accident severity index method (ASI) and ArcGIS10.5. The result of the study shows that, 156 asphalt paved road traffic accidents were occurred in the town within the study period. Unevenly distributed 156 spatially identified asphalt road traffic accidents have occurred in 44 different accident spots of the study area. Also, 22 asphalt paved road traffic accident Black Spots. It was concluded that, the frequency of occurrence of accidents and number of casualties is rising from time to time in town.*

Key Words: *Asphalt paved road, Accident severity, ArcGIS, Black spot location, Accident Spots*

1. INTRODUCTION

Roadways can be constructed for many reasons. Though, mostly a number of roads are built to facilitate the transport of people and goods, which is so important to promote development. (Robinson & Thagesen, 2004).Paved road with the asphalt cement is the best pavement option for everybody trips from one location to another location for different purposes using various transport modes. It is known that road is a route or way on land between two locations that could be a paved or unpaved road, if not, improved to allow pedestrian to move by their foot or some form of transportation for the movement of motorized and non-motorized entities (Indiatimes, 2019). The burden of road traffic injury is excessively formed by pedestrians, cyclists, and motorcyclists, in which it is higher in developing countries. (Abbasi, 2002). According to WHO 2018 report, on the

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safety of road, in Africa, the death rates of traffic injuries are higher in Africa relatively higher sub-Saharan. Relatively greater than ninetieth (90%) deaths occurred by traffic accidents has been observed in low- and middle-income countries. No progress has been seen in minimizing the number of deaths from road traffic accidents in the countries categorized as low-income country. (Slow, 2020). As of WHO 2017, deaths caused on road traffic accidents in Ethiopia was 27,140 or 4.27% of total injuries. Traffic injuries can be taken as a major obstacle in developing countries; particularly serious in Ethiopia. In the study area (Assosa town), the obstacle was considered as the main feature of the town that damages the life of human and the properties of people. The severity of the accident ranges from property damage and to death of people (Gumuz, 2019).

Despite of road paved with the asphalt has fixed vehicles, improper planning, design, and maintenance of the existing roads caused an insufficient transportation. Since the volume of traffic becomes greater than road capacity, resulting in traffic congestion and conflict among various road users, and placed a greater burden on people's health from a reduction in physical activity (Ababa, 2019). Researchers defined Black spots as the locations along similar road wherever crashes are common   during the occurrence of fatal injuries due to road accidents (George ,2018). the hazardousness of a spot along the road can be indicated by Accident Severity Index (ASI) which is dimensionless value (George, 2018). In this study, Accident Severity index method was used to determine the Black spot location of injuries.

2. MATERIAL AND METHODOLOGY

2.1 Study Area

Assosa town, capital city of Benishangul-Gumuz region is located 678 km from capital of Addis Ababa and 90 km from Sudan, on 10º 03' latitude north and 34º 32' longitude East and 1,525 MSL. Assosa was founded by Sheik Hojale Al-Hassan in 1929 E.C. The population of the town is 42,924 from this (21891 male and 21,033 female) people live in the town and the time zone are UTC+3(EST) (Zone, 2020).
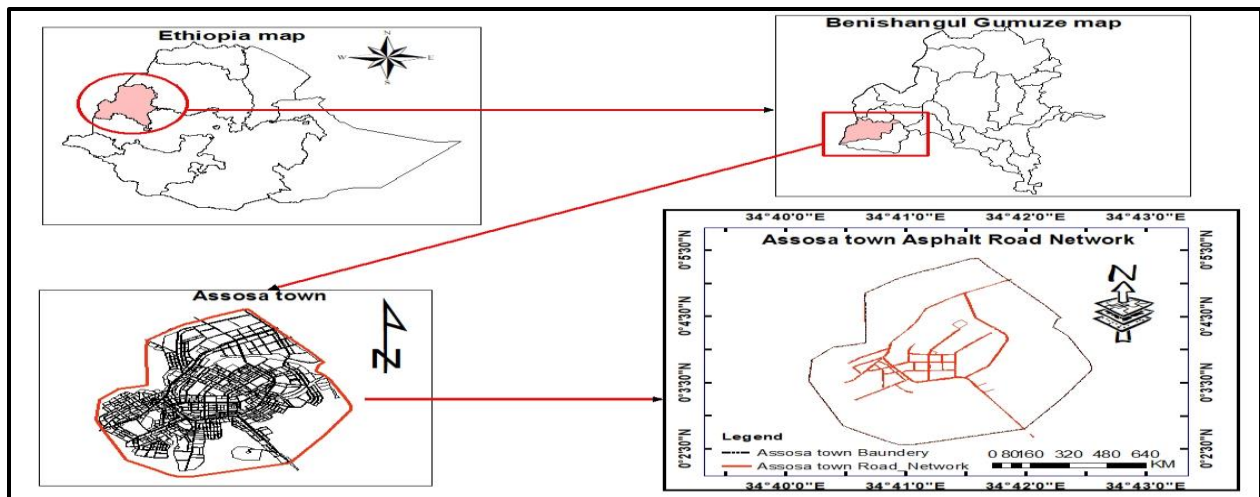
Figure 1 Location of study area (Source; Extracted from GIS)

2.2 Data type and sources

Both primary and secondary sources of data were used for the study. The primary data were obtained as a basic field survey which include measuring, capturing photos and locating the traffic accident spots along the roads of the town using the 'Add Placemark' tool in Google Earth Pro and Global Mapper. Secondary data were collected from the daily accident recording file that was taken from the Assosa town traffic office. The summary of types and sources of data that were used in the study are shown in below Table 1.

Table 1: Data type and source

No,	Data	Data type	Data source
1	Accident data of Assosa town	Secondary	Assosa town traffic Office, B/G/R/S Road and Transport office
2	Locating of accident spots	Primary	field Survey, Global mapper, Google Earth Pro and AutoCAD
3	Vehicle related data	Secondary	Assosa town transport office, B/G/R/S road and transport office
4	Road type, quality and road infrastructure	Secondary	Assosa town Administration Infrastructure Asset Management and Plan office
5	Assosa town Map	Secondary	Assosa town Administration Land Management staff
6	Road Network	Primary	Google Earth Pro and AutoCAD/ town Master plan
7	Image samples	Primary	Field survey

8	Road data	primary	Filed Observation
9	Additional Information of accident of Assosa town	Primary	Filed Observation and

2.3 Software, Materials and data processing

The software and material used for this study include: Google Earth Pro and Auto Cad software both used to extract and digitizing the study area for identifying accident spots. Global Mapper 12 and GPS were used to take the Coordinates of the accident spots. To check allocated point in the field, hand held GPS, Mobile Topographer and the X-Y coordinate were used. In order to ease the analysis of the data and to locate the accident spots in Google Earth pro, and Global mapper, all accident spots of the town were assigned with a special code. Following the data filter, editing and data coding procedures for four years' accident database of the town was made in an Excel format.

Table 2: Types of Materials to be used

No	Types of software we have use	resolution	Purposes
1	ArcGIS10.5	-----	For creating shape file. For produce the black spot location map
2	GPS	----	Collecting X,Y data of accident point
3	Google earth	-----	For Generating, road network

2.4 Data Analysis Methods

After adding the location of traffic accident along asphalt paved road in Global mapper and Google earth as point data, it has to be saved as place of the XY point with KML. The four years' accident data which was arranged in Excel format was filtered and rearranged using table for further application of MS excel software. Then it was saved as CSV (comma delimited) format and converted in to shape file using ArcGIS 10.5 software. To know the frequency and ASI value of accident, spot location was linked to the above-mentioned shape file in to the Arc Map. Spatio-temporal accident spots and Black Spot location maps of each year were prepared for analysis. Using input data like accident spot special codes, total accident spot cause, accident spot name, and accident year, accident type like fatal, serious, slightly, and ASI value.

2.5 GIS and ASI Method

To conduct this study, a step by step method was followed. Based on preliminary studies the requirement analysis was done for setting data requirements and for getting criteria affecting the traffic accident analysis. The Eqn.1 has been used:

$$ASI = N_fW_f + N_sW_s + N_mW_m \text{ --- (1)}$$

Where, N_f =No. of fatal accidents at the spot in the last 4 years

W_f=Weight assigned to fatal accident=6

N_s=No. of serious accidents at the spot in the last 4 years

W_s=Weight assigned to serious accident=3

N_m=No. of minor accidents at the spot in the last 4 years

W_m=Weight assigned to minor accident=1

3. RESULT AND DISCUSSION

3.1 Characteristics of Asphalt Paved Road Traffic Accidents in Assosa town

Before starting the identification of black spots, it is important to look at the characteristics of the total accidents database because of the general characteristics of the accident are needed,

Table 3: General recorded asphalt paved road traffic accident situation in Assosa 2008-2012 E.C.

Year	General recorded accident 2008-2012			Total	Out of town recorded			Total	In town recorded			Total
	Fatal	Serious	Minor		fatal	serious	Minor		fatal	serious	Minor	
2008	0	4	31	35	0	1	2	3	0	3	29	32
2009	0	3	10	13	0	0	2	2	0	3	8	11
2010	1	25	35	61	0	5	13	18	1	20	22	43
2011	6	24	49	79	3	1	3	7	3	23	45	72
Total	7	56	123	186	3	7	20	30	4	49	103	156

(Source: Compiled from Assosa town Traffic office and BGRS Road and Transport 2019.)

3.2 Temporal Variation of Asphalt Paved Road Accidents by Hour of the Day (2008-2012 E.C.) in Assosa Town

The occurrence of traffic accidents along asphalt paved road can vary within the 24 hours of a day. The human-related, road-related, vehicle related and environmental factors have a greater impact on the variation of accident distribution within the hour of a day.
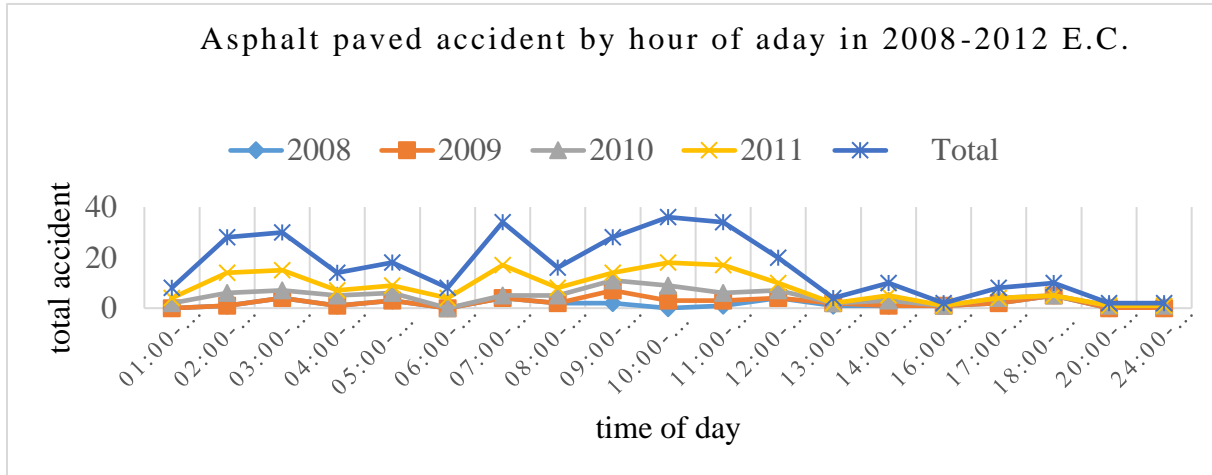
Figure 2: Graphical comparison of crashes per hour of a day 2008-2012. E.C.

3.3 Daily Distribution of Asphalt Paved Road Accidents in Assosa Town

Fig. 3 shows the daily occurrence of traffic accidents along the asphalt road within the Assosa town for the year 2008-2012 E.C.
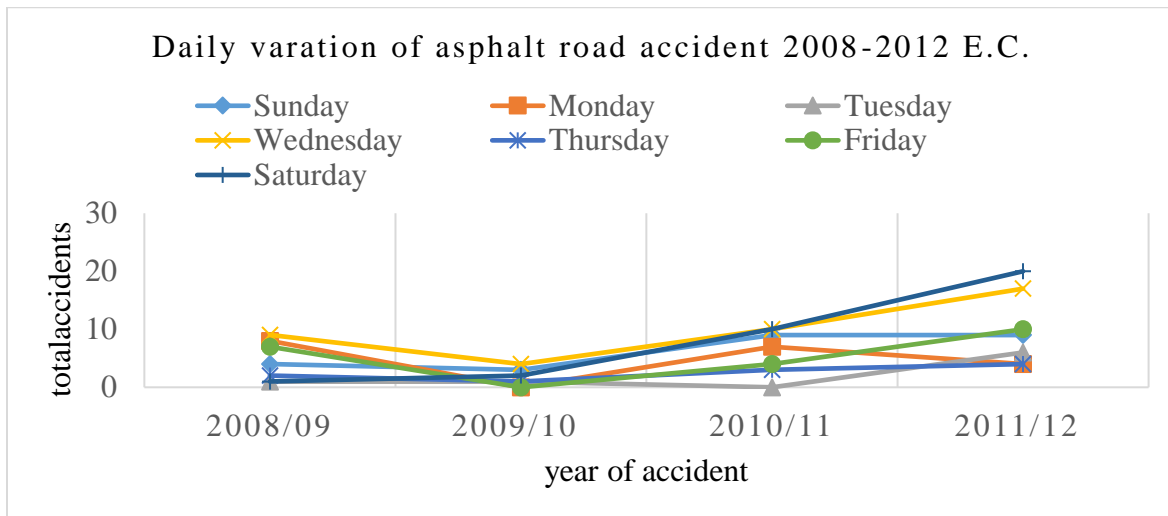
Figure 3: Graph of daily variation of asphalt paved accident in Assosa town 2008-2012 E.C.

3.4 Monthly Variation of Asphalt Paved Road Accidents in Assosa Town

Similar to the variation in the distribution of accidents within the 24 hours of a day, there is a difference of traffic accident frequencies between the different months of a year.
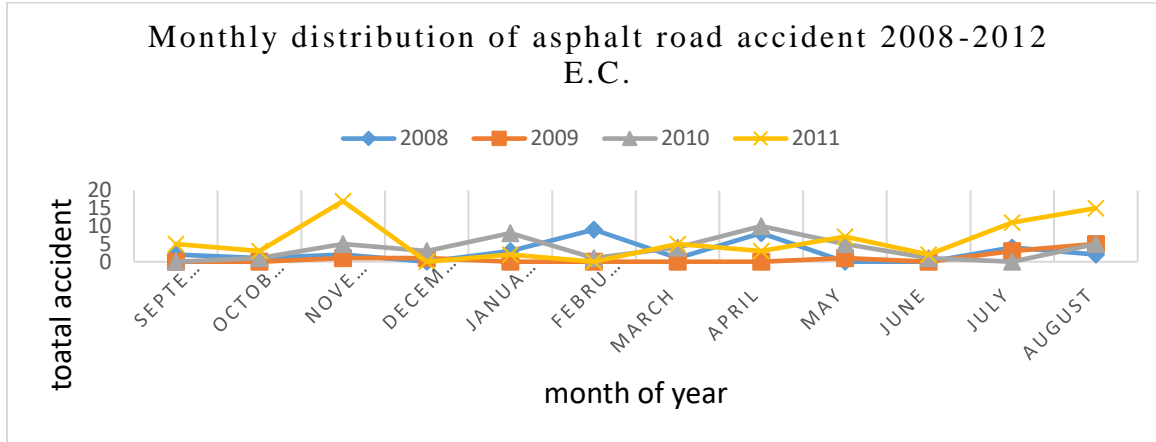
Figure 4: Graph of seasonal variation of asphalt paved accident in Assosa town 2008-2012 E.C.

3.5 Vehicle and Traffic Accidents in Assosa Town

Some vehicle categories have been involved in traffic accident observations within the town during the last four years. There were various entire types or model of vehicles in the town relation to their contribution to traffic crashes. Vehicles using public transport are more frequently involved in road traffic accidents than other vehicle categories.

**Table 4: Vehicle category and asphalt paved road accident in Assosa town 2008-2012 E.C.**

Vehicle Category	Vehicle Type	Accident Year				Total	% age
		2008	2009	2010	2011		
Public Transport	Minibus	1	0	3	0	4	2.6
	Three Wheel Motor (Bajaj)	18	7	19	36	82	51.3
	Bus	2	0	5	3	10	6.4
Government Transport	3F or pick up car	1	1	5	6	13	8.3
	Cobra or V8	1	0	1	0	2	1.3
	Ambulance	2	0	0	0	2	1.3
Freight Transport	Trucks	1		2	1	4	2.6

Bicycle		0	0	1	0	1	0.6
Motor Bicycle		6	3	7	22	39	24.4
Automobile		0	0	0	2	2	1.3
Total		32	11	42	70	156	100.0

(Source: Compiled from Assosa traffic office and BGRS Road and transport office 2019 G.C.)

3.6 The Spatial Distribution of Road Accidents Spots and Black Spot location in Assosa Town in 2008/09

In 2008 E.C., Assosa town shows the occurrence of 32 and 40 ASI value spatially identified. The accidents were unequally distributed throughout the asphalt road in the year. According to the criteria set, the location showed the ASI value was four or more than four traffic accidents were defined as accident black spot location. Accordingly, as shown in table 3 and fig. 4 location was identified as road traffic accident spots and accident black spot location. The spatial distribution of asphalt paved road traffic accident spots and Black spot location in Assosa town in 2008 E.C. is shown in fig. 5.
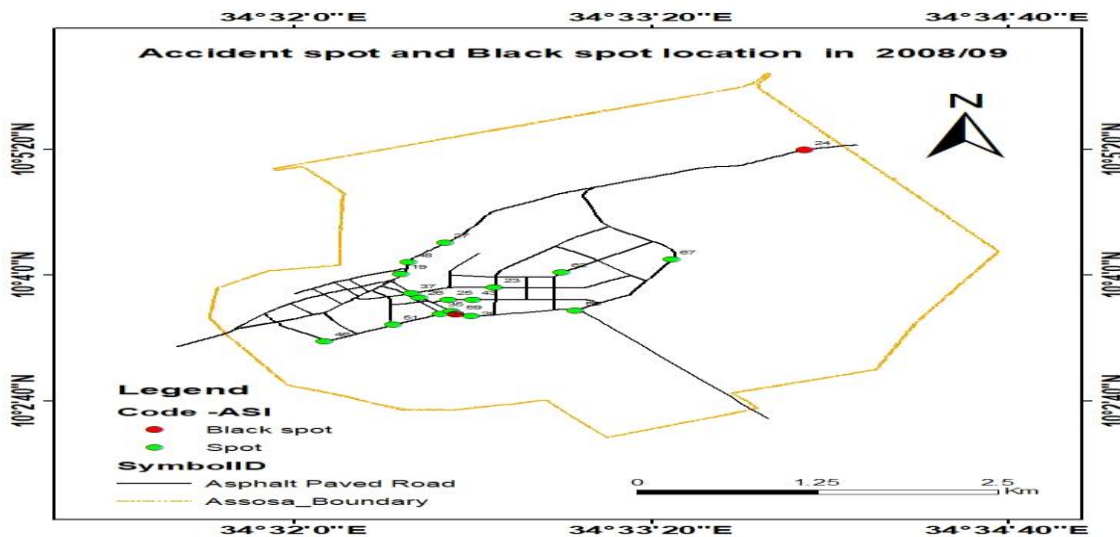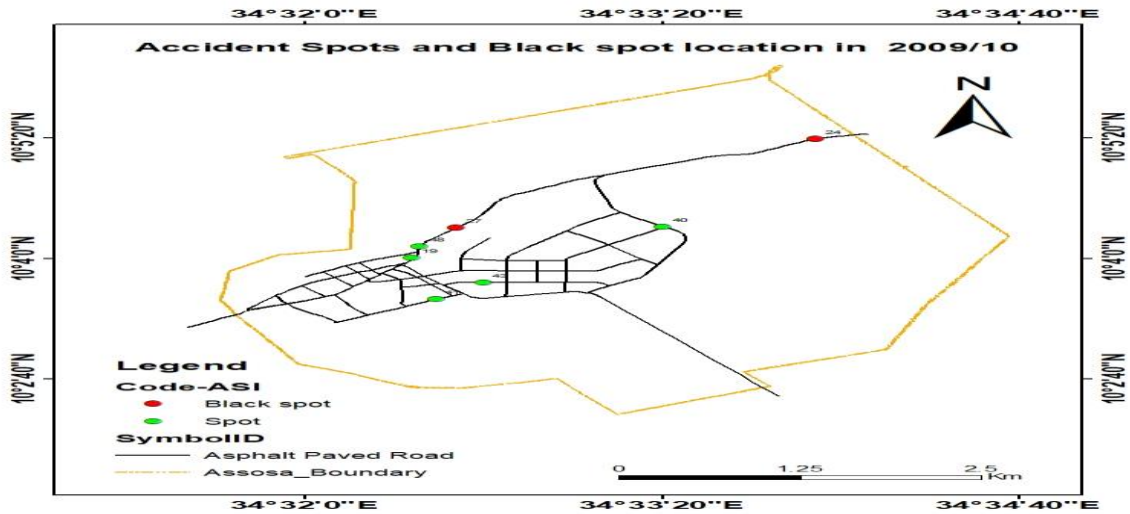

Figure 5: Spatial distribution of accident spots and black spot location Assosa town 2008/09 E.C.

3.7 The Spatial Distribution of Asphalt Paved Road Accident Spots and Black Spot location in Assosa Town in 2009/10 E.C.
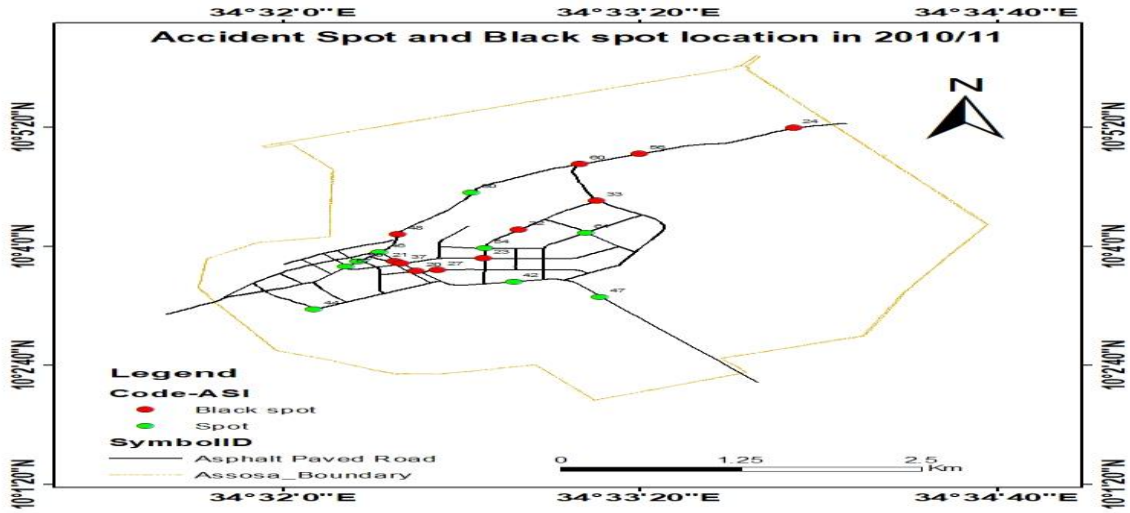
In 2009 E.C., Assosa town shows the occurrence of 11 frequencies and 17 ASI value spatially identified road traffic accidents. The accidents were unevenly distributed throughout the paved road in Assosa town. As described in table 3 and fig. 5, the location was identified as road traffic accident spots and Black spot location in 2009/10 E.C. The spatial distribution of asphalt paved road traffic accident spots and Black spot locations in Assosa town in 2009 E.C. is shown in fig.6.

Figure 6: Spatial distribution of accident spots and black spot location in Assosa town 2009/10 E.C.

3.8 The Spatial Distribution of Road Traffic Accidents Spots and Black Spot location in Assosa town in 2010/11

In 2010 E.C, Assosa town shows the accident frequency of 43 and 86 ASI value spatially identified traffic accidents. The accidents were unequally distributed throughout the road in Assosa town during this year. As described in table 3 and fig.7 locations are identified as asphalt paved road traffic accident spots and black spot locations in Assosa town in 2010/11 E.C.

Figure 7: Spatial distribution of accident spots and black spot location in Assosa town 2010/11 E.C.

3.9 The Spatial Distribution of Traffic Accidents Spots and Black Spot location in Assosa town in 2011/12 E.C.

In 2011 E.C., Assosa town shows the accidents occurrence of 70 and 131 ASI value spatially identified road traffic accidents. The accidents were unevenly distributed throughout the asphalt paved road in Assosa town in this year.
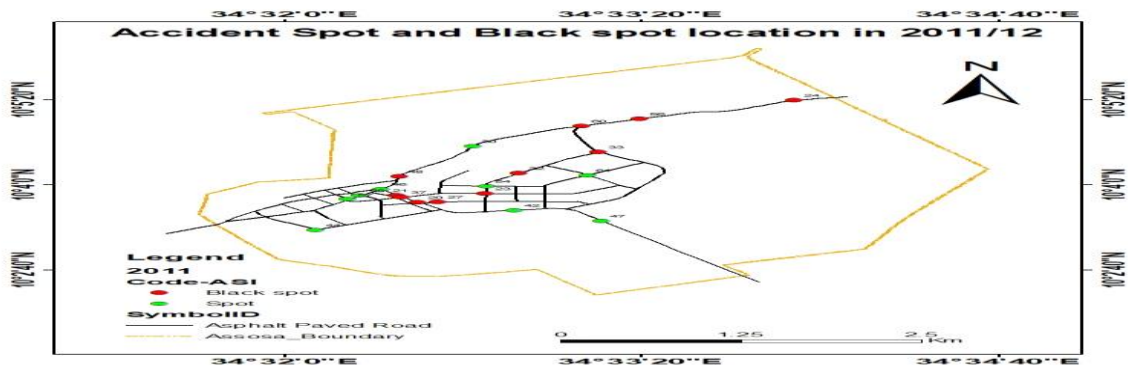
Figure 8: Spatial distribution of accident spots and black spot location in Assosa town 2011/12

3.10 Road Traffic Accidents Occurrence in All Accident Spot location in Assosa town from 2008-2012 E.C.

The total frequency and ASI value of road traffic accidents occurrence in Assosa town from 2008 to 2012 shows many variations among the road of the town. The distribution of ASI value as well as the frequency of traffic accidents occurrence in the accidents spots shows both spatial and temporal variation.
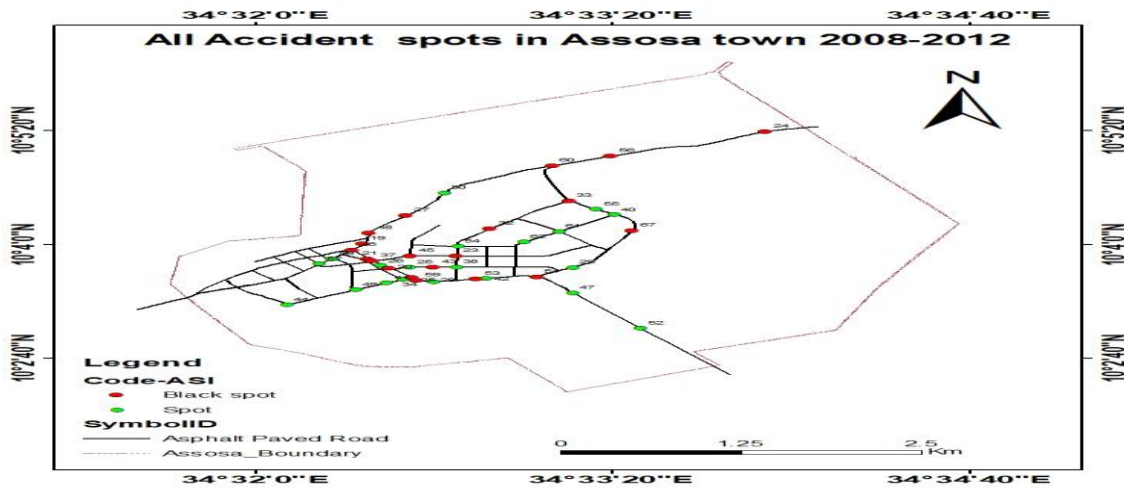
Figure 9: Spatial distribution of accident occurrence in all spots 2008-2012 E.C.

3.11 Top Ten Paved Road Traffic Accident Black Spot location in Assosa Town 2008-2012 E.C.

It is discussed in the previous part that, about 44 accidents spots 23 accident black spot locations have been identified in town from 2008 to 2012 E.C. This part however. focused only on the top 10 most severe accident Black spot locations identified in the town in the whole study period. Out of 44 accident spots, 156 accidents were recorded from all of Assosa town in the study period.

The black spot locations were ranked according to the severity value of the location. The concept of this method was that the number of fatal or injury accidents at a location is given a greater weight than property damage-only accidents. The accident severity value of the road located in Assosa University are 1 fatal, 5 serous, 13 slightly are occurred in four-year study year and give weighted value for fatal 6, serious 3, and minor 1was used that was computed by using Eqn.1.

ASI = NfWf + NsWs + NmWm

    = 1*6+5*3+15*1

    = 6+15+15

    ASI = 36

In this calculation, the four-year accident severity index value is the location value of ASI which was higher than other location values where the location is, accident blackspot location otherwise accident spots. For instance, the calculated location of the Assosa university ASI value is 36, so the location of Assosa University was categorized as the highest accident occurrence and ranked in black spot location.

In the Accident severity index value (ASI), a value of 36 has occurred in the road located in Assosa University, 25 have occurred in Awra Godana, 21 have occurred in ETV Station, TVETI College 18 and 17 have occurred in the location of Taf oil station. The top 10 accident Black Spot location has shown on Table 5, Figure 10.

In addition to this, 5 out of the top 10 accident Black Spots are found in the location of Blue-star Driving center 15, S.t Mikel Church 14, BGRS Health office 13 and Deribe Hotel 11 in the town. The remaining location have out of top 10 Black spot location. Show in table 4.15 below Accident Severity Index Value of all accident spot location in 2008-2012 E.C. For each location the equation was applied and calculated.

Table 5: Top 10 asphalt paved road accident Black spot location in Assosa town 2008-2012 E.C.

FID	Black Spot Location Name	spot - code	Year 2008-2012			Frequency	ASI Value	Rank
			Fatal	Serious	Minor			
6	Assosa university	24	1	5	15	21	36	1
9	Awra Godana	27	0	5	10	15	25	2
5	ETV Station	23	1	4	3	8	21	3
42	TVETI College	60	0	5	3	8	18	4
38	Taf oil station	56	1	1	8	10	17	5

15	Bluster /Tina chaff	33	0	4	3	7	15	6
30	Mikel Church	48	0	2	8	10	14	7
14	Health Office	32	0	3	2	5	11	8
19	Derbay Hotel	37	0	2	5	7	11	9
2	Abay Bank	20	1	1	0	2	9	10

(Source: Compiled from Assosa town traffic and road and transport office of BGRS 2019 G.C.)
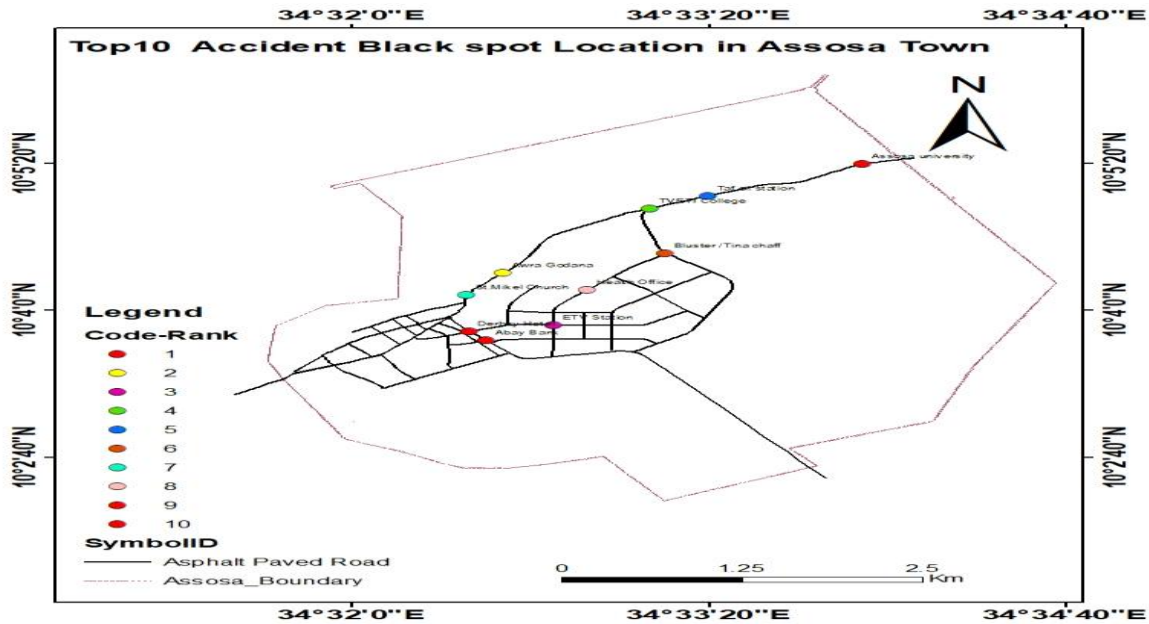
Figure 10: Top 10 accident black spot location in Assosa town in 2008-2012 E.C.

3.12 Engineering Solution for Black Spots

Accident countermeasure application was separated into two major categories; high cost accident countermeasure of the long term and the other one is low cost countermeasure of a short term (Azmi & Zainal, 2009). But this paper mainly discusses about low cost countermeasures at accident black spots where it is defined as simple low cost measures which can significantly improve road safety problems at hazardous sites. Researchers stated that over speeding was the common and critical reason for the occurrences of frequent number of accidents along the selected black spot locations (Berhanu, 2000). Providing various traffic sign is the recommended solution.

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4.CONCLUSIONS

This study shows that the frequency and occurrence of characteristics of road traffic accidents in the Assosa town which exhibit variations from year to year. The traffic accident casualties of the town were mainly belonging to the productive age groups and especially male. Some casualties have lost their lives; others have got serious or slight injuries due to road traffic accidents.

The frequencies of accidents have shown an increasing trend in the study period. Among the various reasons causing frequent road traffic accidents in Assosa town, failure to give way for vehicles, speed driving, failure to give way for pedestrians, improper turning, and failure to respect the right-hand rule contributed much to the unhappiness of road crashes in the town.

Traffic accidents in temporarily variation are random in the town in terms of time of day, day of week, month of year, year and location. The daytime between 6 am to 12 pm was the highest day time occurrence of accidents than nighttime, and in the weekday of Wednesday and Saturday. In month of year occurred in August and November, and three wheel (Bajaj) and motorcycle vehicle type was the higher.

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