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Effect of Improper Urban - Land - Use on Road Safety in Debre Markos Town, Ethiopia

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Abstract: In this era of rapid economic development in developing countries, high interest in urbanization, and increasing urban functional land uses, many towns emerge unplanned. In addition, the need for transportation to mobilize goods and travelers, which frequently produces accidents in many towns and cities, several findings show that road traffic accidents occur in an urban area because of the vehicle, driver, environment, and other related factors. However, this study investigated the improper usage of urban land for different functions as additional accident factors, which is the root and still hidden problem for road traffic accidents in an urban area. The aim of this study is to recognize the kinds of urban land use that are highly associated with traffic accidents and to advise on the most efficient strategy for reducing these serious accidents. A method for this study was by identifying areas where frequent accidents were recorded and probably related to the use of the land in this area. Two selected cluster areas of about 6.5 km^2 were investigated to determine the relationship between road traffic accidents and the functional land uses. Hence, a direct link between functional land use and road accidents was investigated. A general prediction model for forecasting vehicle accidents related to land use has been developed using variable responses, with functional primary land use and traffic volume. Overall, the study found that traffic accidents on roads in urban centers and public institutions were particularly associated with congested, limited, and centralized commercial land use and unbalanced traffic generation and attraction land use. Most crashes have occurred in commercial and terminal land-use type. Almost 67% of the accident were recorded on zone-1, which was 39.4% commercial and 22.9% residential whereas, commercial proportion is only 2.9% and residential is 59.9% in case of zone-2. The multivariate accident prediction model for different land-use types as developed and presented, formed by several parameters, like Average Annual Daily Traffic (AADT) as an exposure variable, and land use types; residential (R), Commercial (C), social and municipality (SM), terminal (T), government administration (GA), green (G) and industry (I). Prediction model shows that unlike other land use types, commercial land-use type is highly correlated with predicted accidents and minimum increment in the area of commercial land type will significant improvement of road safety issues.

Keywords: Improper Urban Land Use, Negative Binomial Regression, Traffic Accident, Debre Markos

1. Introduction

1.1. Background of the Study

Proper planning and defining urban land for a variety of functionality needs massive work, but it is a vital part of overall growth, sustainable development and road safety improvement as well. However, in most cases, especially in the history of urban extension in our country, cities are being built without a plan, making it difficult to adapt urban land use to the appropriate criteria. As a result, the inability to make urban infrastructure as standard as possible and the development of public recreation such as green space, road and commercial network to the required standard will not be conducive to living and health and will hamper the city's economic, social and political development.

The main purpose of this study is to show the major problems caused by urban land-use problems in road safety and to contribute to the urban land use policy and manual in the light of the results of the study and the stakeholders. It is no exaggeration to say that Debre Markos is one of the most prominent towns in the country. During the data collection, it

was learned that the use of urban space starts with the quality of planning, arbitrary use of non-planning space, such as temporary use of green spaces; there are many problems with network security. Also, the market for recreational, recreational, road, and reserve spaces, such as the proposed residential area, may not be included in the plan as it should be, and individuals may unnecessarily use those included in the use of urban space. The five-year traffic accident also shows that many accidents have been reported in high-traffic areas, public, and government-built, religious institutions along the highway. According to the author, the root cause of all these problems is improper usage of urban land.

1.2. Statement of the Problem

Recent studies show that transportation and urban land use shall be integrated. According to [1] investigated the relationship between zonal land-use and road traffic congestion. The incremental of human activity intensities is approaching intolerance limits, and increases the risk of varies disasters and road traffic crashes [2].

In Debre Markos frequent accidents used to produced especially in commercial and terminal areas than residential areas. Therefore, urban land-use should be planned to minimize road traffic accidents and safety improving approaches.

Several decisions define journey needs, travel modes, as properly as visitors' conditions, which all have an impact on users' protection and the capability of the street community. Conversely, choices made regarding street community transport making plans have an impact on land-use making plans [3].

Proper land-use planning is an efficient way to prevent road safety problems sustainably because the decisions shall take before the urban development of a lot or an area or before a new road is built. It is indeed essential to intervene as quickly as viable to integrate transportation and land use planning [3, 6]. Using the hourly traffic, the model indicated that higher accident risk associated with congestion and afternoon rush hour [4, 5] modeled the monthly accident frequency.

However, this integrated technique presents primary challenges, mainly due to the range of events involved, the distribution of jurisdictions amongst them, and their sometimes-competing interests.

In Debre Markos, improper land using obvious, that is the road safety condition is deteriorating by improper use of the urban -land. However, road safety problems depend on many factors like road surface conditions, the capability of vehicle drivers, atmospheric and other factors, and such causes of problems existing widely, this study partly tries to answer the impacts of informal urban land use on road safety.

1.3. Review of Related Literature

1.3.1. Traffic Accident Issues

Nowadays traffic accident becomes one of the world's worst health issues. "Any accident involving a tool designed generally for, or being hired on the time mainly for, transport humans or product from one area to a distinct might be known as road traffic accident" [6].

1.3.2. Global Road Safety Issues

Road traffic safety may be a complicated system consisting of three main subsystems: drivers, vehicles, and roads. Analysis of the accident-land use relationship is that the nearest and direct place of accidents occurred. Vehicle crashes, as an instance of unplanned incidents, no longer simplest affect typical traffic conditions but have also been seemed because the eighth leading motive of dying in all age groups globally [7].

1.3.3. Land Use and Transport Interaction

Land use selections for different activates influence urban road traffic safety-related issues. Land-use changes influence traffic generate and attract; generating traffic (such as parks, industrial and retail facilities, high-density housing, schools, [8]. Moreover, the high proportion of commercial land use causes the highest level of traffic congestion [9].

Relative to other issues, limited scholars' studies on the links between land-use and road traffic accidents. Stronger land use policies are needed to enhance the quality of life in the urban areas [10].

1.3.4. Land Use and Transport Planning

It is necessary to understand the processes and deciding to be ready to improve and land use coming up with and transport planning integration between the two independent services of governed sectors. In several countries, there are several authorities managing land use development parts, like land-use allocation, land use strategy formations, and land-use conversions from rural, farmland to residential, or business separate to move coming up with. Urban residential, commercial and business and mixed residential-commercial land uses had the highest Severe crashes risk exposure levels [11].

1.3.5. Integrated Land Use and Transport Planning

Transport planners concerned within the plan's formulation had a focus on land area and short trips and try to seek minimum traffic density of developments. Uncontrolled urban growth in automotive possession and usage of land-use area and would rapidly result in main city transport congestion. These warnings were taken seriously and led the government to formulate an integrated urban land transportation policy with the subsequent key strategies:

1) Integration of land use and transportation getting to minimize the need for travel;
2) Development of a comprehensive road network, besides as capability maximization;
3) Management of the auto-population and additionally the demand for road usage to alleviate traffic congestion;
4) Provision of quality transport choices, as well because of the event of mass transit and lightweight rail.

1.4. Regression Models

These models have most commonly used to relate accident frequency with explanatory variables. The result of the model strongly relies on the choice of the regression technique.

1.4.1. Linear Regression

The earlier traffic accident studies used ordinary or normal

linear regression models, which follow the assumption of a normal distribution for the dependent variable, a constant variance for the residuals, and the linear relationship existing between dependent and independent variables. However, the conventional linear regression method should be used with caution because of the problems associated with non-negative and error terms.

1.4.2. Poisson Regression Model

Recommended generalized linear model using Poisson distribution error structure as a means to describe the random, discrete, and non-negative accidents. Poisson regression assumes an exponential relationship between response and explanatory variables.

1.4.3. Multiple Linear Regression Model

Multiple Linear Regression (MLM) model was adopted as a superior alternative to accommodate the over dispersion. The negative binomial regression model has been widely employed in vehicle accident analysis for rural highways, arterial roadways, urban motorways, and rural motorways [12]. When considerable zeros and extremely low mean values are observed in accident numbers, the negative binomial model is significantly unreliable to fit the data, and the dispersion parameter can be misstated.

2. Material and Methodology

2.1. Research Method

The research uses both primary and secondary resources for quantitative data. Quantitative data and analysis were applied to determining the relationship between road traffic accident rate and urban land use. Observation, direct field measurements, and secondary data (from Debre Markos city traffic police officers) were the main sources of quantitative data. Furthermore, observation around some accident-prone urban land use around road corridors was performed.

2.2. Description of the Study Area

Debre Markos located in the East Gojam zone of the Amhara Region, Ethiopia. It has a latitude and longitude of 10°20’ N 37°43’ E coordinates: 10°20’ N 37°43’ E, and an elevation of 2,446 meters.

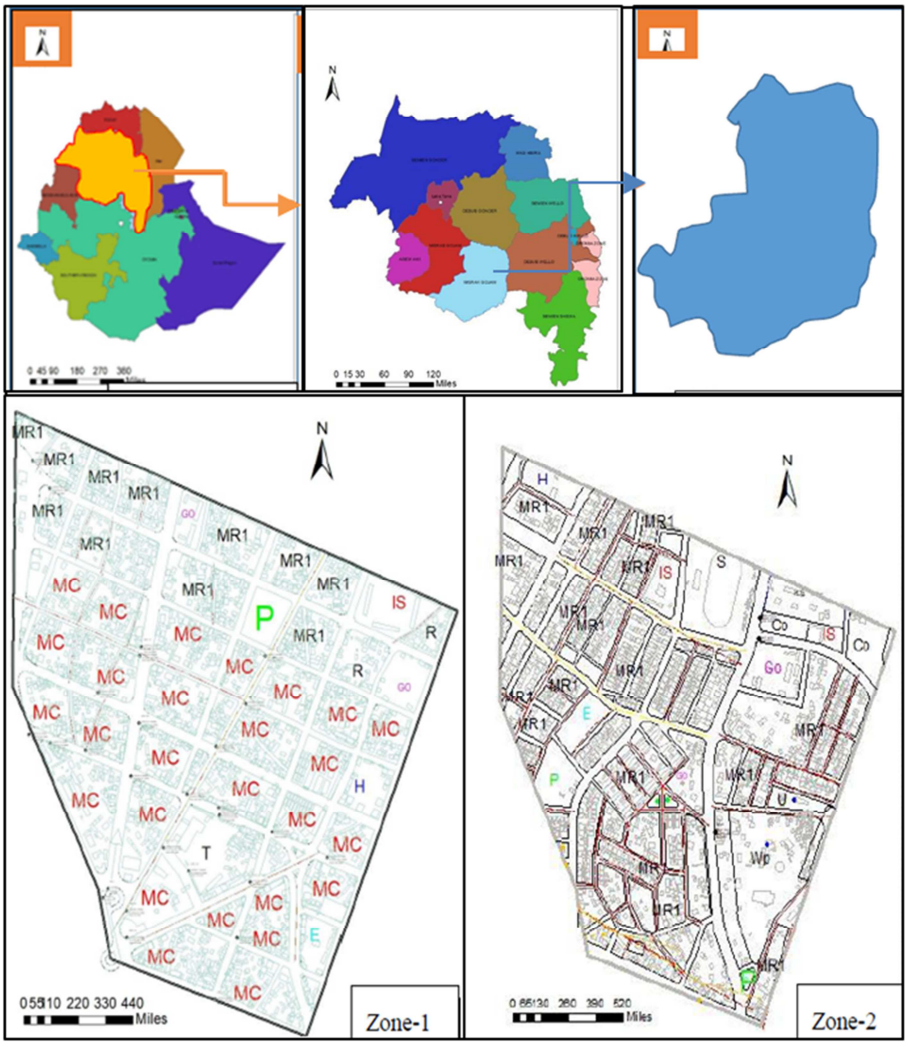

Figure 1. *Study Area Map.*

2.3. Data and Data Collection Techniques

The primary data; traffic volume data, collected from main road sections of the town. Secondary data; road traffic accident data, collected from Debre Markos town police commission, and land use type data collected from Debre Markos town urban development municipal service.

2.3.1. Accident Data

Five-year traffic police recorded road traffic accident data in the study area between 2014 and 2018 obtained from the local government traffic accident and data unit. The traffic police attending the traffic accident records a wide variety of relevant data.

2.3.2. Traffic Volume Data

Primary data (traffic volume count) was collected from Debre Markos town at selected main junctions and straight sections to obtain a daily variation of traffic volume. Traffic data collected in selected straight sections on all days of a week at different road sections in the selected town from 7.00 am - 8.00 pm to get maximum and minimum traffic volume by using a video camera and manual counting method.

2.3.3. Land-Use Data

Land-use can be classified in two ways, either functional or physical. Functional land-use classification based on the activity taking place on the land (e.g., services/offices, residential, industry, or vacant land, etc.). The physical land-use classification depends on the shape and form of the land or the building on it (e.g., high-rise industrial buildings, low-rise non-residential buildings, detached housing, semi-detached housing, and open area).

The appropriate type method will depend on the examined goals The objective of this study is the link between injuries concerning road users and land-use sorts. Human activity related to land-uses that has more relevance than physical properties. Therefore, functional land-use types were used in this study.

When the residential, industrial and trade uses were clustered along, the overall accident rate would increase by 1.3% [1]. Because of the high density of population and an outsized range of varicolored strains typically clustered in such areas, there have been increasing risks between individuals and vehicles. Moreover, additional retail uses and industrial zones are typically thought-about to own a high financial condition that was related to a larger frequency of collisions.

State transport authorities do transport coming up with thanks to this, every accountable authority follows its own set of ways and policies. Integration between authorities is not a frequent observe, especially in Ethiopia. This lack of organization and coming up with between agencies ends up in several difficulties, like administration and implementation of needed vital transport systems. Land-use policies need careful coming up with and coordination between urban planners, architects, engineers, developers, and public health professionals [14]. System designers are entities that the layout and operation of the street delivery device, such as infrastructure administrators, the car enterprise, delivery providers, and the actors accountable. for various support systems, such as the police, driving schools, and emergency services, health care, and rehabilitation professionals [15].

Land-use data had been amassed the usage of the structural plan of the town maps using AutoCAD 2012 and GIS software tool. Where necessary the land-uses are clarified by site visits. Each spatial analysis is based on, about 70 blocks within carefully define analysis zones.

The two zones, zone-1 and zone two are equal in size that is 698, 364m^2. For zone-1 land use, since the center part of the town, almost 40% of the land use pattern type is commercial, and high traffic attraction and congestion are expected. Similarly, zone-2 is more about residential almost 60% of the land use type is residential and where the sources of traffic are generated.

Table 1. *Land use distribution of analysis zones.*

S/N	Variable	Symbol	Zone-1	Zone-2
			%	%
1	Resident	R	22.9	59.9
2	Commercial	C	39.4	2.9
3	Terminal	T	3.3	0
4	Government and administration	GA	2.1	5.3
5	Social and Municipality	SM	2.2	7.5
6	Green area	G	1.1	2.7
7	Industry and Storage	I	1.8	1.8
8	Roads	Ro	27.2	19.9

Sources: Debre Markos town urban development service and combined by author.

Accordingly, the land-use distribution within each analysis zone (and) shown in Table 3, the proportion of trip generators (R) is greater in zone-2 (59.9%) than in zone-1 (22.9%) while, population density in zone - 2 is greater than in zone-1. Also, the proportion of trip attractors SM, GA, C, T, G), and (zone-1 is lower in zone-2 (18.4%) than in zone-1 (48.1%).

Road transport accidents, in the study year, are more intense within zone-1 than in zone-2 nearly by 32%. it might conclude that the greater the proportion of trip attractors in a certain zone, the more accidents, regardless of either of traffic volumes or a proportion of trip generators gave rise to road accidents.

The study by [13] has shown, geo-referencing crash locations is a key tool to find urban factors that impact crashes. This was made possible using the record location of an accident by the police of the town, which can be identified by its coordinates, or the precise location marks of crashes is established by the procedure.

3. Results and Discussion

3.1. General Analysis of Road Crash Trend

This also chapter focuses on the preliminary analysis of data to develop a model for different urban land use type traffic accidents. Before model development, highly correlated variables should have filtered and removed from the list of independent variables. Then using the final selected variable, the model developed by multiple regression linear modeling technique.

3.2. Accident Related to Land Use in the Study Zones

Table 2 below shows the number of crashes produced over the 5-year period per area by land use category. The overall number of crashes produced per area of land is different in different land-use types.

Table 2. *Number of accidents per area of land –use.*

Variable	Symbol	Total Area	Total Accident	Accident/Area Ratio
Resident	R	0.828	29	35.0
Commercial	C	0.423	151	357.0
Terminal	T	0.033	82	2484.8
Government Admin.	GA	0.074	54	729.7
Social & Mun.	SM	0.097	54	556.7
Green area	G	0.038	10	263.2
Industry	I	0.035	18	514.3

3.3. Accident Prediction Model Development Process

The accident prediction model is usually developed using a multivariate modeling technique. The model may include ordinary linear regression models and nonlinear regression models such as Poisson and negative binomial regression method. First, the accident frequency is discrete and hence does not follow the normal distribution, which is one of the basic requirements of the linear regression technique. Furthermore, the variance in the accident frequency is not constant but tends to increase as the flow increases. The number of accidents also cannot be negative while a normally distributed error structure implies a substantial probability of a negative number of accidents (road crashes), especially when the flow is small and the expected number of traffic accidents will also come to small or zero not negative.

The negative binomial regression interpreted as; Y_i is an independent random variable that follows a negative binomial distribution with expected value μ_i, then the probability function of Y_i is given by:

$$E(Y_i) = \mu_i = exp(Xi\beta) = exp\left(\sum_1^p x_{ij}\beta_j\right); \text{ i=1, n}$$

With α being the dispersion parameter, and α >0. The mean and variance of this negative binomial regression model are:

$$\text{Var } (Y_i) = \mu_i + \alpha\mu_i^2$$

The Poisson regression model analysis method can be regarded as a limiting model of the negative binomial (NB) regression model as α approaches zero.

The modeling of relationships between motor vehicle crashes and underlying factors has been investigated for extra than three decades. Recently, many highway protection studies have documented the use of Poisson regression models, poor binomial (NB) regression models, or both. Pearson's X^2 and the scaled deviance (G^2) are two common test records that have been proposed as measures of goodness-of-fit (GOF) for Poisson or NB fashions.

Table 3. *Variable description for zone-1.*

Variable	Symbol	Description	Value	
			Min	Max
No road traffic accidents	NRTA	Number of road Traffic Accident record for the last five years (2014 - 2018) on zone-1	5	25
Traffic volume	AADT	Average annual daily traffic	7288	5534
	R	Residential type land use	1,020	4,200
	C	Commercial type land use	1,250	13,600
	T	Terminal type land use	0.000	22,713
Land use area (m^2)	GA	Government sector type of land use	1200	3500
	SM	Social and municipality type of land use	6767	8,404
	G	Green area type of land use	2200	3500
	I	Industrial type of land use	3600	4200

Table 4. *Result of General Multivariate Accident Prediction Model for the Zone-1.*

Variable	Coefficient	Standard Error	t-value	P-value
R	-.301	.0490	164.843	0.000
C	.592	.0369	320.049	0.013
T	.751	.0324	369.126	0.000
GA	-.411	.0500	134.562	0.000
SM	-.582	.0377	238.696	0.000
G	-.601	.0675	70.732	0.000
I	-.510	.0722	57.644	0.003
α (dispersion parameter)	0.058	0.0282		

Table 5. *Goodness of the fit results for zone-1.*

Number of data	157
Number of parameters	7
Degree of freedom	148
Pearson χ^2	8.577
Scaled Deviance G2	171.533
Result	Accepted

Therefore, table 5 above shows the result of the goodness of the fit for the general multivariate accident prediction model. It can see from the table that the Pearson χ^2 and Scaled Deviance G^2 values of the resulting model are lower than the critical χ^2 value, which means that the general multivariate accident prediction model passes the goodness of the fittest [16].

Final Regression Model Result:

$$\mu=EXP\ (3.57 - 0.3R - 0.6C - 0.75T - 0.41G - 0.58SM - 0.6GA - 0.51I)$$

4. Conclusion

The research found that different land-use types in a specific zone or town influence road traffic crash frequencies as stated above. Commercial land use types have relatively higher significance than others do. Also, another important finding from this research is that centralized land-use types are, highly influences road traffic crashes, and found that land-use types have statistically link with the accident prediction model.

A similar increase within the proportion of residential land-use provides a factor of decrease in 0.17 of the mean of traffic accidents. Corresponding factors for the zone-2 zone area unit 0.06 and 0.01 for a rise of 10% within the proportion of residential and commercial land use respectively.

The two zones affect in terms of traffic accidents. Within the zone-2 zone, there is limited statistically significant proof of an association between retail land-use and traffic accidents.

The analysis of vehicles accidents within the zone-2 prompts the top that the mean variety of traffic crashes with the extent of retail land-use and, to a slighter degree, with the extent of residential land-use. Commercial land use has significant implications for traffic accidents. Associate in the growth of 0.10 within the extent of commercial land-use in summation of the zones evaluated to create the mean variety of vehicle accidents by an element of 0.89. A comparative increment within the extent of residential land-use provides parts of 0.18, which is lesser.

Based on the research analysis and results previous accidents recorded in the past five years could be minimized by properly using the land; decentralizing the use of commercial and terminal land-use types and increasing these types of areas in each zone.

we can also conclude that separately increasing all types of land use area has a role in reducing traffic accident, but the factor of accident reduction significance differs for different urban land-use types. Similar increasing of proportional area, produce expected different traffic outcomes as shown examples above.

In general, proper land use planning and land use within the consideration of transport and road safety issues have a great role in accident reduction remedial actions. Especially by decentralizing and optimizing commercial land uses in a town, traffic safety could be well improved.

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