Jimma University

School of Graduate Studies

Jimma Institute of Technology

Faculty of Civil and Environmental Engineering

Highway Engineering Stream

Evaluation of Pedestrian Behavior at the Different Road Crossing Facilities: A Case Study in Gambella Town

A Thesis Submitted to School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirement of Degree of Master of Science in Civil Engineering (Highway Engineering).

By:

Balam Obang Opiew

February, 2021

Jimma, Ethiopia

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DECLARATION

I, the undersigned, declare that this thesis entitled: "**Evaluation of Pedestrian Behavior at the Different Road Crossing Facilities: A Case Study in Gambella Town**" is my original work, and has not been presented by any other person for an award of a degree in this or any other University, and all sources of material used for this thesis had been duly acknowledged.

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As Master's Research Advisors, we hereby certify that we have read and evaluated this Msc Thesis prepared under my guidance by **Mr. Balam Obang** entitled: "**Evaluation of Pedestrian Behavior at the Different Road Crossing Facilities: A Case Study in Gambella Town**."

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ABSTRACT

Traffic accidents involving pedestrians have become a major safety problem in most of the developing countries particularly in Ethiopia. The majority of pedestrian accidents primarily occur in urban areas. The main objective of this study was to evaluate pedestrian behavior at the different road crossing facilities in Gambella town. Data collection was done through questionnaires, interviews, and field observations. A 95% confidence level was selected with a corresponding critical p value of 0.05. Pearson correlation test was used to identify the major factors affecting the pedestrian behavior within the road crossing facilities. From Pearson correlation, crosswalk surface condition, crosswalk marking visibility, road width, lane width, number of lanes, crosswalk holding area, and curbside parking were found significantly affecting the pedestrian behavior within the road crossing facilities. Multiple linear regression model was developed to evaluate the influence of road crossing parameters on the movement of pedestrian. Except for road width, all the predictors were found statistically significant to predict the movement of pedestrian. Crosswalk surface condition, crosswalk marking visibility and crosswalk holding area were positively correlated with the movement of pedestrian while lane width, number of lanes and curb side parking were negatively correlated with the movement of pedestrian. Field observation was conducted on each crosswalk of existing intersection. From field observation, poor crosswalk surface condition, inadequate holding area, invisible crosswalk marking, curb side parking, lack of accessible curb ramp, curb cut, zebra crossing, raised median and splitter island were found as the geometric deficiencies of the intersections. Remedial measures were suggested for poor crosswalk surface, inadequate holding area, curb side parking and invisible crosswalk marking. For lack of accessible curb ramp, curb cut, zebra crossing, raised median and splitter island, AutoCAD was used to draw the geometry of each crosswalk of intersection.

Keywords*: Explanatory variables, Pedestrian behavior, Regression analysis, Road crossing parameters*

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ACRONYMS

AutoCAD Automatic Computer Aided Design

CARRS-Q Centre for Accident Research and Road Safety Queensland

CRTASR China Road Traffic Accident Statistics Report

CTRG Conference of Transportation Research Group

DOI Digital Object Identifier

DOT Department of Transport

EDRI Ethiopian Development Research Institute

FWHA Federal Highway Administration

IJET International Journal of Engineering and Technology

IJETR International Journal of Engineering and Technical Research

IJRASET International Journal for Research in Applied Science and Engineering Technology

IJSDR International Journal of Scientific Development and Research

IRJET International Research Journal of Engineering and Technology

ISBN International Standard Book Number

NRSC National Road Safety Commission

RII Relative Importance Index

TRB Transportation Research Board

TRIPP Transportation Research and Injury Prevention Programme

TRL Transportation Research Laboratory

WHO World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 **Background of the Study**

Road transport is one of the widely used transportation systems and provides the highest proportion of transport services. It provides benefits both to nations and individuals by facilitating the movement of goods and people from place to place. In addition, it enables increased access to jobs, market, education and healthcare [1].In Africa, over 80% of goods and people transported by roads and in Ethiopia road transport accounts for over 90% of freight and passenger movements in the country. However, the rapid development of road transportation has brought increased road traffic accidents that resulted in loss of life, injury to person and damage to property [2].

Road traffic accident (RTA) can be defined as an incident on a way or street open to public traffic, resulting in one or more persons being injured or killed and involving one moving vehicle. Thus, RTA is a collision between vehicles, between vehicles and pedestrians, between vehicles and animals, or between vehicles and geographical or architectural obstacles [3]. According to Global Status Report of 2015, more than 1.2 million people die each year and 50 million are injured due to road traffic accidents. More than 90% of road traffic deaths occur in low and middle income countries, yet these countries have just 54% of the world's registered vehicles [4].

The African region is known for having the highest numbers of fatalities compared to other regions around the world. The situation of road traffic accidents is most severe in Sub Saharan Africa, where the lives of millions are lost and significant amount of property is damaged. In Ethiopia, the situation has been worsened as traffic flow and collision among vehicles and pedestrians have increased consequently due to increased number of vehicles. Despite government efforts in the road development, road traffic accidents remain to be one of the major problems of the road transport sector in Ethiopia [5].

Globally, the estimated road traffic death rate in Ethiopia is 25.3 per 100, 000 population and recorded as the highest death rate in the world [6]. A study conducted by [7] indicated that in 2005, there were total of 217 road traffic accidents in Dire Dawa City and in 2009 the total number of road traffic accidents increased to 322. In Gambella, according to the Ethiopian Federal Police Commission report, 86 road traffic accidents were recorded in 2017 and this figure increased in 2018 to 143 [8]. A large number of deaths and injuries occur annually as a result of road traffic accidents among pedestrians, especially in low income countries. Each year 400,000 pedestrians die due to road traffic accidents worldwide [9]. In Ethiopia, among those killed in road traffic accidents, 71.3% were pedestrians, 23.1% were passengers and 5.6% were drivers [10]. A study conducted by [11] confirmed that pedestrians account for the highest proportion of road traffic deaths in urban areas: Gondar, Bahir Dar and Dessie accounted for 86.3%, 54.8% and 48.5% respectively.

In developed countries, however road traffic accidents involving pedestrians are declining due to continued investment in infrastructure and safety programs. Studies on the pedestrian accidents in developing countries are limited because safety interventions have just begun in recent years and the focus of road safety interventions is more on improving the safety of drivers than pedestrians [12]. Several studies have examined the factors that influence the frequency and severity of traffic accidents involving pedestrians. Most of these studies have focused on collision between vehicles and pedestrians at certain locations especially intersections [13]. A study revealed that pedestrian accident is influenced by several human and environmental factors, demography, roadway characteristics and vehicular characteristics [14].

1.2 **Statement of the Problem**

Globally, over 1.2 million people die and 50 million are injured each year due to road traffic accidents [15]. More than 90% of road traffic deaths occur in low and middle income countries. Of them 70% involve pedestrians with 35% being children [16]. According to Global status report on road safety 2013, about 273, 000 pedestrians were killed in 2010, which accounted for 22% of the world road traffic deaths and the highest proportion of these deaths occurred in developing countries [17]. In china, the death rate among pedestrians is relatively higher compared to other countries in the world. For instance in 2007, 21106 pedestrians were killed which accounted for 25.85% of total road traffic deaths [18].The situation was even worse in India, where, 57% of road fatalities from 2008 to 2012 were pedestrians in Mumbai [19].

In Ethiopia, according to the Federal Police Commission report, the death rate due to car accident is significantly increasing from time to time among passengers and pedestrians. A total of 25,110 accidents and 3415 fatalities were recorded in Addis Ababa during 2000-2009. The majority of fatalities were pedestrians (87%) followed by passengers (9%) and drivers (4%) [7].

In developing countries, pedestrians are facing problems while crossing at unsignalized intersection under mixed traffic condition. Risk of pedestrian injury increases in environments where there is a lack of adequate infrastructure for pedestrians, and where vehicles are allowed to travel at high speeds [20]. A study conducted by [18] confirmed that most of the pedestrian accidents occur when pedestrians are crossing the road. For instance, a study in Ghana found that 68% of pedestrian deaths occurred when pedestrians are attempting to cross the road [21]. Similarly, a study conducted on traffic accidents among children in Addis Ababa revealed that regarding the movement of the children during the accidents, 64.4%of the accidents occurred while the children were crossing the road [22].

In Ethiopia, most of pedestrian fatalities and injuries could be due to speeding, absence of median and pedestrian refuge island, walking along the roadway, illegal crossing behavior and narrow roadway width [23]. Analysis of crossing behavior of pedestrian is very important in order to ensure the safety of pedestrian at road crossing facilities [24].

In developed countries, several studies have been conducted on pedestrian crossing behavior at intersections and midblock. However, in Ethiopia, few researchers have undertaken studies on pedestrian crossing behavior at signalized intersection. Moreover, the focus of these studies was limited on the effect of pedestrian characteristics and traffic characteristics on pedestrian crossing behavior at signalized intersections. Thus, it is necessary to evaluate pedestrian crossing behavior at different pedestrian facilities. For this reason, the main objective of this study is to evaluate pedestrian behavior at the different road crossing facilities.

1.3 **Research Questions**

1. What are the major factors affecting the pedestrian behavior causing accident within the road crossing facilities?

2. Which road crossing parameters influence the movement of pedestrian using regression analysis?
3. What remedial measures can be suggested at different crosswalk points found to be prone to pedestrian accidents?

1.4 **Objectives of the Study**

1.4.1 **General objective**

The general objective of this study is to evaluate pedestrian behavior at the different road crossing facilities.

1.4.2 **Specific objectives**

The specific objectives to be covered under this study are:

- To identify the major factors affecting the pedestrian behavior causing accident within the road crossing facilities
- To evaluate the road crossing parameters which influence the movement of pedestrian using regression analysis
- To suggest remedial measures at different crosswalk points found to be prone to pedestrian accidents

1.5 **Limitation of the Study**

The focus of this study is to identify the major factors affecting the pedestrian behavior causing accidents within the road crossing facilities and evaluate the road crossing parameters which influence pedestrians' movement using regression analysis. To conduct this study, the researcher faced some limitations. Factors like pedestrian volume, traffic volume, and vehicle speed were not included due to the time frame's limitation. The aim of this study was to select study sites prone to pedestrian accidents in the Town. However, the researcher selected study sites based on pedestrian crossing volume and traffic volume because of poor report of pedestrian accidents in the official road traffic accident statistics of Gambella Town. During the field observation, the researcher did not measure the crosswalk width at each intersection due to the crosswalk markings' invisibility. Thus, the crosswalk width was not included in the present study. Furthermore, during the early stage of the site visit, traffic signals were not working. Hence, green time and red time were not included in the study.

1.6 **Scope of the Study**

In this study, questionnaire, interview, and field observation were conducted to identify the major factors affecting the pedestrian behavior and evaluate the road crossing parameters which influence the movement of pedestrian using regression analysis. The study did not include other towns outside of Gambella town. Therefore, the scope of this study is limited on evaluation of pedestrian behavior at the different road crossing facilities in Gambella town.

1.7 **Significance of the Study**

Nowadays, road traffic accidents involving pedestrians become serious problems all over the world, particularly in developing countries such as Ethiopia. To reduce pedestrians' involvement in road traffic accidents, an investigation of risk factors causing pedestrian accidents is very important. Therefore, the present study evaluates the pedestrian behavior at the different road crossing facilities in Gambella town. It is expected that the results of this study lead to better understanding of pedestrian crossing behavior and support policy makers in their decision making regarding the improvement of road crossing facilities in Gambella Town. Furthermore, the study will help to create more awareness of road safety to pedestrians and other road users.

1.8 **Thesis Organization**

This study is organized into five chapters. Chapter one gives brief overview of the study's background, statement of the problem, research question, objectives of the study, limitation of the study, study's scope and significance of the study. Chapter two deal with the review of related literature. Chapter three describes research methodology, including the study area, description of the selected intersections, research design, study duration, population of the study, sampling technique & sample size, equipment and instrument used, data collection method, study variables, data processing and analysis, and data quality assurance. Chapter four presents detail of results and discussion. Chapter five draw conclusion and recommendations based on the results and discussion.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 **Magnitude of Pedestrian Accidents**

2.1.1 **Global situation**

With the rapid growth of motorization in the developing countries, pedestrian safety is a serious problem. Pedestrians are probably the most vulnerable road users in traffic, especially when they interact with vehicles. Accidents involving pedestrians can take place in rural or urban areas and most of these accidents occur when pedestrians are crossing the road [17, 25]. Signalized intersections are expected to ensure safety by giving the right of way for traffic movement including pedestrians. However, the provision of signalized pedestrian crossing facility may not ensure the safety of pedestrian due to some reasons such as traffic violation and unsafe signal phasing. Signalized pedestrian crossing facility located at high speed intersection with turning vehicles may become a hazard to the pedestrian safety [26]. At midblock, the pedestrian crossing is completely different and complex crossing location when compared with signalized and unsignalized intersection crosswalks. Midblock crosswalks are hazardous when compared with intersection crosswalks even though there no turning vehicles. Studies have shown that midblock crosswalks account for the highest number of pedestrian accidents because of higher vehicle speed and the increase in risk-taking behavior of pedestrians due to an increase in waiting time [27].

While crossing location is important and presents risks for pedestrians, it is only one of the determinants of the complex pedestrian crossing process. In this process, vehicular traffic related factors (volume, speed, etc.), factors associated with physical space (number of lane, road width, etc.), the interaction between pedestrians and vehicles as well as behavior of drivers and pedestrians have significant roles [28]

In developing countries, adequate pedestrian facilities are often neglected and seldom automatically incorporated at the planning and design stage of road project. A significant proportion of both urban and rural communities in developing nations frequently rely on walking as their sole means of transport. Despite that, limited attention is devoted to the provision of pedestrian facilities. In environments where there is a lack of adequate pedestrian facilities, pedestrians are forced to use roadway for walking and cross busy road with high traffic volume which put them in conflict at high risk of death and injury [23]. A study conducted in India indicated that pedestrian accidents become a major safety problem all over the world, especially in developing countries as a result of high population density, rapid urbanization growth and lack of adherence to traffic regulation by both drivers and pedestrians and in their study they found that pedestrians account for 65% of the traffic accident deaths and out of these, 35% are children [29].

Like in other low and middle income countries, pedestrian accident in Africa is higher compared to high income countries [17]. A study conducted in Kenya, found that pedestrian fatalities accounted for 42% of all road traffic accident deaths [30]. In Egypt also [31]found that traffic accidents involving pedestrians accounted for 75% of all road traffic accidents. In Ghana, pedestrian accidents account for over 60% of all road user deaths [21].

2.1.2 **Pedestrian accidents in Ethiopia**

In Ethiopia, pedestrians and passengers of commercial vehicles are the most vulnerable road users, whereas in high-income countries traffic accidents involve primarily privately owned vehicles with the diver being the main car occupant injured or killed [3]. A study conducted on road traffic accidents among children in Addis Ababa depicted that almost all children affected by road traffic accidents were pedestrians (97.5%), (2.3%) were passengers and (0.2%) were bicyclists [22]. Pedestrian safety research in Ethiopia has been relatively rare due to the limitations of resources and institutional capacity in the field and this shortcoming is shared by other developing countries. Therefore, the existence of critical gaps in current knowledge regarding pedestrian accident problems in developing countries is inevitable. Moreover, developing countries reveal difference in driver and pedestrian behaviors, road design, site characteristics, pedestrian demography and crossing group effects compared to western countries. Generally, poor integrated land use and transport planning, lack of convenient pedestrian facilities and street lighting forced pedestrians to illegal crossings [12].

2.2 **Pedestrian crossings**

A pedestrian crossing is a point on a road where pedestrians cross the road. Pedestrian crossings sometimes referred to as crosswalks and they are provided at intersection or midblock. The place where two or more roads meet or cross each other is called a junction or intersection [17]. The pedestrian crossing facilities are the most relevant elements that need to be considered to improve the safety of pedestrians [32].

Marked crosswalks are pedestrian crossing facilities that are designated by surface markings whereas **unmarked crosswalks** are pedestrian crossing facilities that do not have lines or words painted on the roadway. **Mid-block crossings** are pedestrian crossing facilities that are not located at intersections. **Uncontrolled crossings** are pedestrian crossing facilities that are not controlled by either traffic signals or stop signs. **Controlled crossings** are pedestrian crossing facilities that are controlled by either traffic signals or stop signs [33].

2.3 **Type of pedestrian crossing facilities**

According to [34] pedestrian crossings are broadly classified as, at grade and grade separated pedestrian crossings.

1. At grade pedestrian crossing, is defined as the place where pedestrians cross the carriage way at the same level as that of the vehicular movement. This includes crossing at intersection and midblock.
2. Grade separated pedestrian crossings, is defined as the place where pedestrians and vehicles cross the carriage way at different level. Underpass and overpass come under this type of pedestrian crossing.

2.4 **Pedestrian road crossing behavior**

Pedestrian crossing behaviors must be understood in detail to improve their safety [35]. Previous studies have used theories and methods to gain practical understanding of pedestrian's behavior and the interaction between driver and pedestrian at pedestrian crossings [29]. Similarly, several studies have been conducted on pedestrian road crossing behavior at intersection and mid-block locations. The importance of these studies is related to the evaluation of pedestrian facilities, traffic control elements and road safety treatments by means of before and after crossing studies on pedestrians' behavior as well as safety [36]. Pedestrian safety and capacity analysis of intersection depend on pedestrian crossing behavior [37].

At uncontrolled intersection or midblock, pedestrians search for appropriate gaps between vehicles in the traffic stream [29]. However, at signalized intersections, pedestrians have green signal time during which they should cross, while they have to wait during pedestrian red time [38].

2.5 **Factors affecting pedestrian road crossing behavior**

Several researches have examined factors that influence the road crossing behaviors of pedestrians, including the physical environment (e.g., road width and type of street), road user variables (e.g., demographic characteristics), and social factors (e.g., the number of pedestrians in group attempting to cross) [18]. In addition,[39] discussed the impact of the street environment, including traffic conditions, roadway characteristics, and signal control characteristics on crossing behaviors of pedestrians.

Several studies have examined differences in pedestrian behavior by gender and age. Male pedestrians tend to violate traffic rules more frequently than females and are more likely to cross in risky situations. Young adults and adolescent pedestrians are generally more likely to commit violations than older pedestrians ([18]. Specific built environments such as road width and street connectivity greatly influence pedestrian crossing behavior which leads to collision between pedestrian and vehicle [40].

2.6 **Statistical modeling techniques**

Several statistical modeling techniques have been used to model the relationships between road geometry, site characteristics, traffic characteristics and pedestrian accidents as well as pedestrian movement on roadway segments or intersections.

A study conducted by [41] developed a random parameter negative binomial (RPNB) model to estimate pedestrian crash prediction model on two way two lane rural roads in Ethiopia. The expected number of pedestrian crash was the dependent variable. The explanatory variables included in this study are categorized into five categories: exposure variables, roadway characteristics, spatial or land use characteristics, pedestrian crossing group effect and demographics of pedestrian crossing volumes. In addition, [42] conducted a study to identify the various factors affecting pedestrian level of service at signalized intersections. The study carried out to develop a model for pedestrian level of service of signalized intersections in Vijayawada city and Bhubaneswar city based on pedestrian’s perception of safety and comfort. The main factors considered for the development of the model were through traffic, left turning traffic, right turning traffic, number of pedestrians, number of lanes and pedestrian delay. Stepwise regression analysis was performed to identify which factors affecting pedestrian level of service and the model was developed with those influencing factors.

In Dhaka city [43] carried out a study on the analysis of pedestrian crossing speed and waiting time at intersections. Two Multiple linear regression (MLR) models were developed to identify factors affecting pedestrian crossing speed and waiting time of pedestrians. The explanatory variables considered for modeling pedestrian crossing speed were intersection control type, gender, age, crossing stage, crossing pattern, crossing direction, crossing group size, baggage handling, mobile usage, compliance with control direction, crossing location and vehicle flow. Furthermore, the explanatory variables included for modeling waiting time of pedestrians were intersection control type, gender, age, crossing group size, minimum gap, waiting location, compliance with control direction and vehicle flow. In addition, [14] investigated the relationship between the pedestrian exposure and different traffic parameters in few junctions of Thrissur city. The factors included in the study were traffic volume, pedestrian volume, road width, shoulder width and median width. Multiple Linear Regression model was used to find out the significance of these factors in pedestrian crashes.

In Madhya Pradesh state [44] conducted a study to identify the critical factors affecting crossing behavior of pedestrians at Bhopal city. A multiple linear regression model was developed to determine the relationship pedestrian crossing speed and pedestrian characteristics. The explanatory variables included in the study were gender, age, group size, utilization of crosswalk, compliance with signal, way of crossing, carrying baggage or luggage and use of cell phone.

In Egypt also [31]investigated and modeled pedestrian road crossing behavior at uncontrolled midblock. In particular, two aspects of pedestrian crossing behaviors at midblock locations were examined, namely the size of traffic gaps accepted by pedestrians and the decision or not to cross the street. A lognormal regression model was developed in order to examine the effect of various parameters on the size of traffic gaps accepted by pedestrians. The parameters included for the model were vehicle speed, crossing width, age, frequency of attempts a pedestrian makes before crossing, and pedestrian rolling gap. A binary logit model was also developed in order to examine the effect of various parameters on the decision of pedestrians to cross the street or not. The parameters included were size of traffic gap, vehicle speed, pedestrian rolling gap and frequency of attempts before crossing.

A study carried out by [45] examined the influencing factors and formulated a model for the pedestrian crossing speed at signalized intersection crosswalks. The explanatory variables were operational characteristics (cycle length, green time for pedestrians), geometric features (crosswalk width, crosswalk length, width of pedestrian islands, nature of land use, presence of guard rails, classification of road, visibility of cross markings, crosswalk surface condition, separate bicycle path) and flow characteristics (average pedestrian flow, average traffic flow, average traffic speed, average crossing time, average pedestrian delay). Correlation analysis at 95% confidence interval was performed to test the significance of these factors on pedestrian crossing speed. Then Stepwise Multiple Linear Regression (MLR) model was developed using Statistical Package for Social Science (SPSS).

A study undertaken by [46] investigated and identified factors affecting pedestrian's intensity based on selected critical time to collision. Using an ordered logit model, the risk taking behavior of pedestrians was modeled based on their risk intensity. The factors included in the model were individual characteristics (pedestrian with object in hand, pedestrian with company, pedestrian speed, running pedestrian, the direction of pedestrian look, gender, age, pedestrian dressing type), environmental conditions (crossing length, the number of lanes, day time, curbside parking, pedestrian crossing or not crossing zebra crosswalk, existence of violating pedestrian in red time for crossing pedestrian, pedestrian crossing direction), traffic conditions (waiting time, crossing type, time to collision, speed of approaching vehicle, pedestrian volume, vehicles volume, the number of pedestrian in waiting area).

A study conducted by [47] investigated the factors influencing pedestrian level of service at crosswalks of signalized intersection and developed a model for pedestrian overall satisfaction score for pedestrian crossing at signalized intersection.

The parameters included in the model were crosswalk surface condition, crosswalk marking, crosswalk holding area, crosswalk width, crosswalk length, motorist behavior, left turning vehicles volume, left turning vehicles speed, pedestrian flow, red timing for pedestrian, green timing for pedestrian. Pearson correlation was used for identification of most appropriate factors influencing pedestrian level of service. Factors which have high correlation with pedestrian level of service were considered in the model development. Then multivariate regression model was performed to develop the mathematical equation for pedestrian overall satisfaction at signalized intersection crosswalk.

A study of [48] identified factors which influence the level of service of crosswalks at signalized intersections and to develop a regression model to determine the pedestrian level of service of crosswalks at signalized intersections. The various factors considered in the development of model were crosswalk surface condition, crosswalk width, crosswalk marking, roadway width, number of lanes, pedestrian crossing time and pedestrian delay time. Multiple Linear Regression model was developed to determine the pedestrian level of service of crosswalks at signalized intersection.

In Addis Ababa [49] conducted a study on the behavior of pedestrian crossing at signalized intersection in Addis Ababa. Student t-test and one way ANOVA test were used to identify factors affecting pedestrian crossing speed while Mann-Whitney U test and Kruskal-Wallis one way ANOVA test were used to identify dominant factors affecting pedestrian signal and crosswalk compliance. The various factors considered for Student t-test and one way ANOVA test were gender, age group, pedestrian group size and crossing signal phase while for Mann-Whitney U test and Kruskal-Wallis one way ANOVA test were gender, age group and pedestrian group size. Gender, age group and pedestrian group size were found as the dominant factors affecting pedestrian crossing speed whereas age group and pedestrian group size were found as the significant factors affecting pedestrian signal and crosswalk compliance. Multiple Linear Regression model was developed to study the effect of significant factors on pedestrian crossing speed. Binary logistic regression model was also developed to study the effect of significant factors on pedestrian signal and crosswalk compliance.

2.7 **Countermeasures to Improve Pedestrian Safety**

The improvement of road safety has become the main priority of transportation needs due to high costs of traffic accidents in urban and rural roads. Authorities of safety affairs and transportation are trying to reduce traffic accidents by increasing traffic safety through the enforcement of road traffic laws, education and engineering [50]. Thus, countermeasures to improve pedestrian safety can be classified as engineering, enforcement, and education [17].

2.7.1 **Engineering**

There are clearly many inadequacies in the provision of road infrastructure for pedestrians. This can be seen in the high exposure of pedestrians walking along the roads where there are no sidewalks, having to cross where there are no pedestrian facilities, and being at risk at night due to lack of adequate lighting. While full provision of pedestrian facilities is excessively expensive for existing roads, it is possible to incorporate sidewalks and crosswalks into new roads without large additional cost. For existing roads, the focus should be placed on locations where pedestrian volume and risk are the highest. For instance, pedestrian accidents have often been observed to cluster in urban areas [12].

According to [51] effective engineering countermeasures designed to reduce pedestrian injury can be categorized as follows:

- **Separation of pedestrians and vehicles by time**. This includes installation of traffic signals at intersections, exclusive traffic signal phasing for the pedestrian crossing signal, adequate yellow and all red signals for vehicles to allow for clear intersections during the pedestrian crossing phase, automatic pedestrian detection in lieu of pedestrian push buttons, traffic signs and pavement markings that encourage pedestrians to look for conflicts, and flashing lights installed in the pavement at crosswalks that are designed to allow drivers to yield to pedestrians.
- **Separation of pedestrians and vehicles by space**. This includes sidewalks, refuge islands located in the medians of two-way streets, curb extensions, and repositioning stop lines further away from the crosswalk in order to increase the distance between the pedestrian and the vehicle.
- **Engineering measures designed to increase visibility of pedestrians**. This includes increased intensity of roadway lighting as well as lights at pedestrian crossings at night, parking restrictions or roadway design to reduce parking near crosswalks, and bus stop relocation to reduce pedestrians entering the roadway in front of a stopped bus.
- **Measures to reduce vehicle speeds**. This includes roundabout, lane narrowing, adjustments in roadway curvature, pedestrian refuge islands, and speed humps.

At present, engineering treatments for pedestrians are not common practice in developing countries, as there is a lack of awareness of the wider economic benefits of these measures. One way of addressing this need is through the development of planning guides or manuals for pedestrian facilities in developing countries [12].

2.7.2 **Education**

Engineering measures will have a limited impact if pedestrians and drivers do not know how they should behave and interact. Road safety education for pedestrians would involve alerting them to road traffic rules and there is a similar need for drivers to understand their legal requirements, such as when pedestrians have right of way. This is only part of the answer, however, if there is insufficient infrastructure to enable pedestrians and drivers to comply with the law [12].

Moreover, campaigns and road safety education could address the problem of noncompliance of pedestrians with crossing regulations, but absence of relevant data of illegal pedestrian crossing behavior makes this difficult [52]. School children are at risk of involvement in a pedestrian accident because they are difficult to see and in many developing countries there are large numbers of school children; providing education at school about safe crossing should assist in reducing their risk [12]. A study conducted by [53] confirmed that pedestrian safety education can improve children's knowledge of road crossing task and can change observed road crossing behavior.

2.7.3 **Traffic law enforcement**

Engineering treatments to pedestrian facilities and education about rules and rights are of little assistance to pedestrians if they fail to comply with traffic laws aimed at enhancing pedestrian safety. Illegal crossing is a major problem in aggravating pedestrian accidents in developing countries and includes people deliberately ignoring infrastructure provided for safety reasons [12]. The aim of enforcement is to control the behavior of pedestrian and driver at intersection and midblock locations [17].

2.7.4 **A Combined Approach**

In developing countries, the difficulty with an enforcement approach on its own is that there are many places where crossing illegally is `the only way to cross the road at all. This suggests engineering, education and enforcement go together [12].

2.8 **Summary of the related literatures**

Review of related literature indicated that plenty of researches have been conducted on pedestrian road crossing behavior in developed countries. Furthermore, major factors affecting pedestrian road crossing behavior have been well investigated and appropriate statistical modeling techniques to determine the relationship between geometric characteristics, pedestrian characteristics, traffic characteristics and pedestrian road crossing behavior were well applied in western countries. However, little researches have been conducted on pedestrian road crossing behavior in developing countries particularly in Ethiopia. Moreover, a study on the behavior of pedestrian crossing at signalized intersection in Addis Ababa identified the major factors affecting crossing behavior of pedestrian and developed two statistical models in order to find out the significant effect of factors on the crossing behavior of pedestrian. The two statistical models focused only on pedestrian characteristics and traffic characteristics. In contrast, this study aims to identify the major factors affecting the pedestrian behavior and develop a multiple linear regression model by incorporating road crossing parameters which influence the movement of pedestrian.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 **Study Area**

The study was conducted in Gambella People's National Regional State, Gambella Town. The region is located in the southwestern part of Ethiopia and borders of the Oromia region to the north and east and the Southern Nations, Nationalities, and People's Regional State to the south and South Sudan to the west. Gambella is a name for both the region and the city, located about 753 kilometers west of Addis Ababa, at an elevation of 526 meters above sea level. The town is founded on the bank of Baro River, Ethiopia's widest and the only navigable river. The town covers a total area of 15.5757km^2, and its geographical location is 8°15'N latitude, 34°35'E longitude with an estimated population of 66,100.

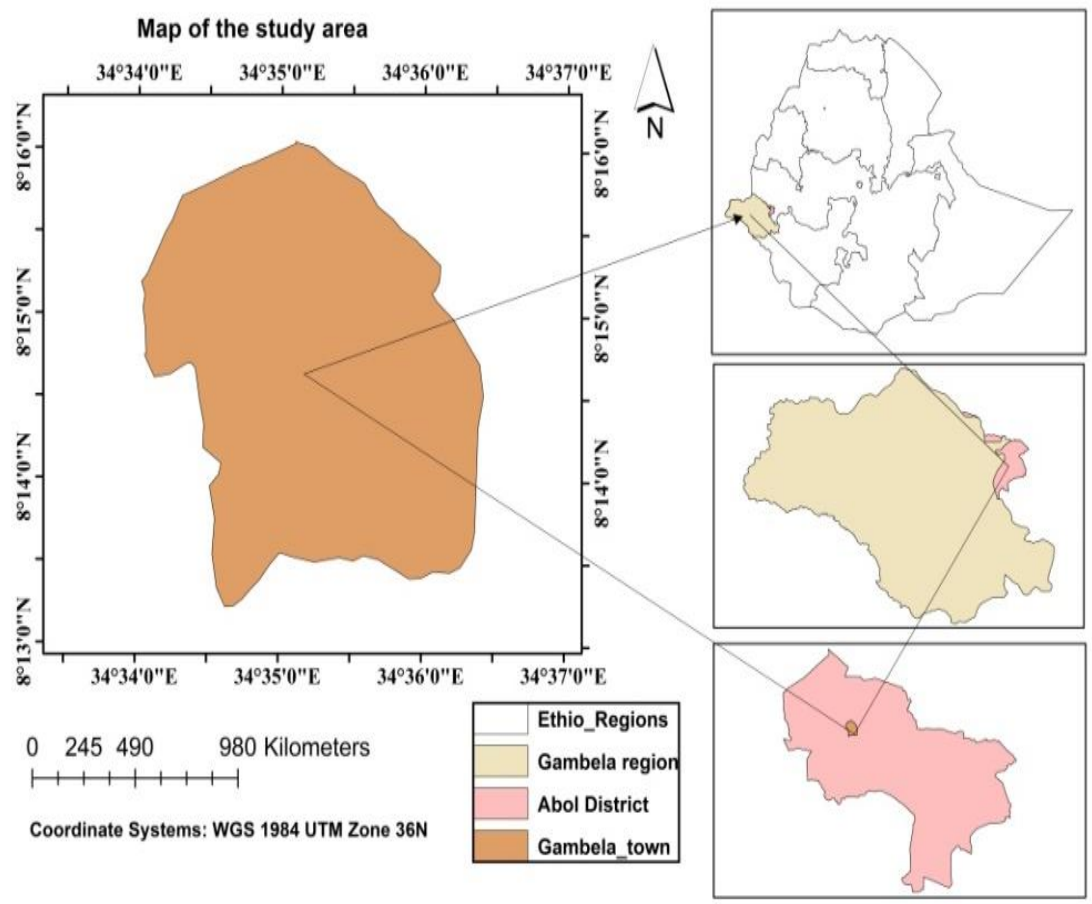

Figure 3.1: Map of the study area (Source: ArcGIS)

3.1.1 **Description of the Selected Intersections**

In Gambella town there are 9 intersections. Roundabouts, T-intersections and Four-Legged Intersections are the most common in the town. Out of 9 intersections, 6 intersections were selected based on pedestrian crossing volume and vehicle volume. The selected intersections varied in terms of traffic characteristics and geometric characteristics. The crosswalks were either four-lane divided or two-lane undivided carriageways.

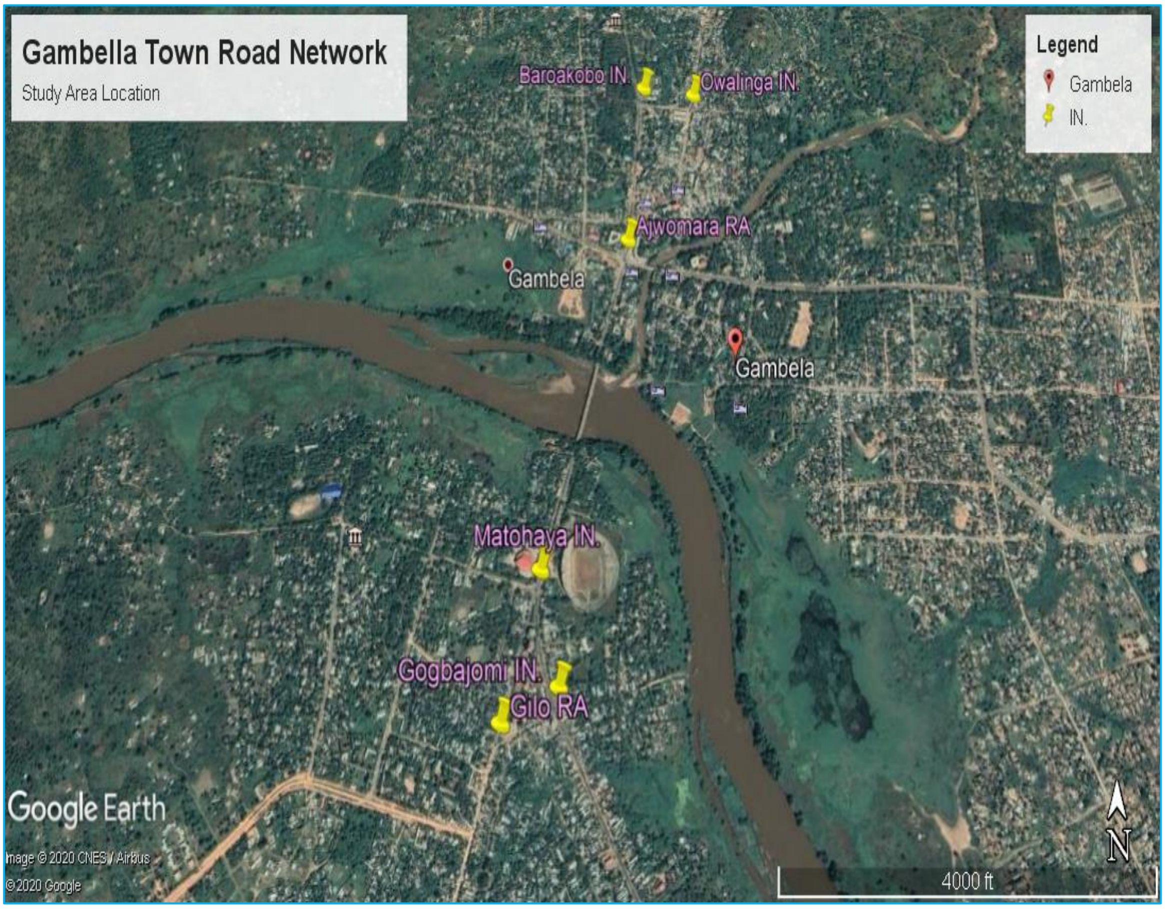

Figure 3.2: Location of selected intersections in Gambella Town (Source: Google Map)

A. Gilo Intersection

Gilo intersection is a Three-Legged Roundabout located at the entrance to the town. The area is surrounded by shops, hotels, offices, bars and other public facilities. It has three approaches known as GRRA approach, Gogbajomi approach and Matohaya approach. All of the three approaches are two lane (one lane in each direction) two-way highways.

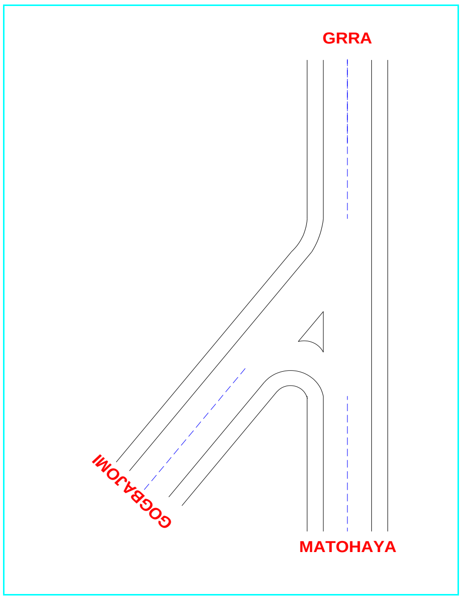

Figure 3.3: Gilo Roundabout (picture and Layout view)

B. Owalinga Intersection

Owalinga intersection is a Four-legged Intersection which is located around the office of Ethiopian airline. The area is surrounded by shops, church, bank, hotel and other public facilities. It has four approaches known as Ajwomara approach, Omininga approach, Tierkidi approach and Baro Akobo approach. All the four approaches are two lane (one in each direction) two-way highways.

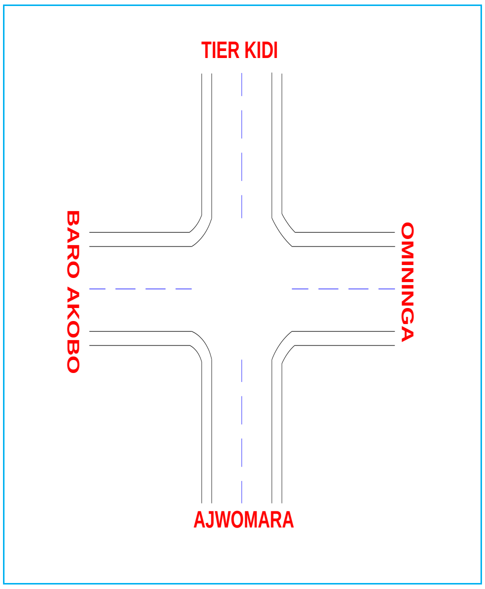

Figure 3.4: Owalinga Intersection (picture and layout view)

C. Gogbajomi Intersection

Gogbajomi intersection is a T-Intersection located near to matohaya intersection. This is the third top most traffic congested intersection which is surrounded by shops, banks, hotels, bars, pharmacies, school, church, vendors and other public facilities.

It has three approaches known as Comboni approach, Matohaya approach and Gilo approach. Both Comboni approach and Matohaya approach are major highways with four lanes (two lanes in each direction) while Gilo approach is a minor road with one lane in each direction.

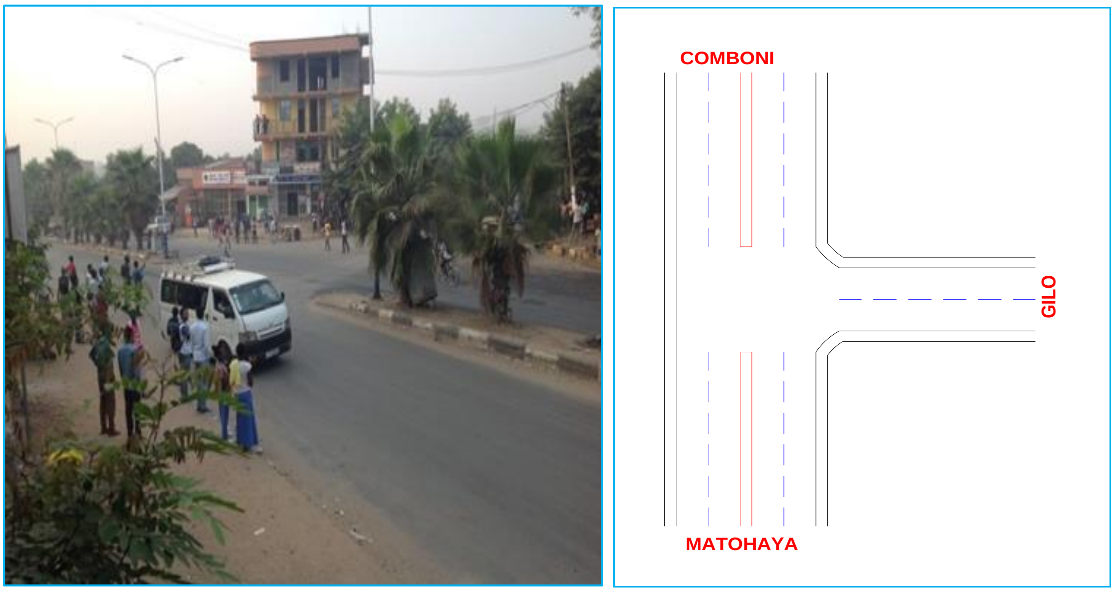

Figure 3.5: Gogbajomi Intersection (picture and layout view)

D. Matohaya Intersection

Matohaya intersection is a Four-Legged Intersection located around Gambella stadium. This is the second most traffic congested intersection in the town. It is traffic signal controlled intersection but it was controlled by traffic police officer due to the signals were not working during the early visit of the researcher to the site. The area is surrounded by shops, offices, bars, vendors, pharmacies, school and other public facilities. It has four approaches known as Gogbajomi approach, Baro Bridge approach, Gambella Hospital approach and Gilo approach. Both Gogbajomi approach and Baro Bridge approach are major highways with four lanes (two lanes in each direction) while Gambella Hospital approach and Gilo approach are minor road with one lane in each direction.

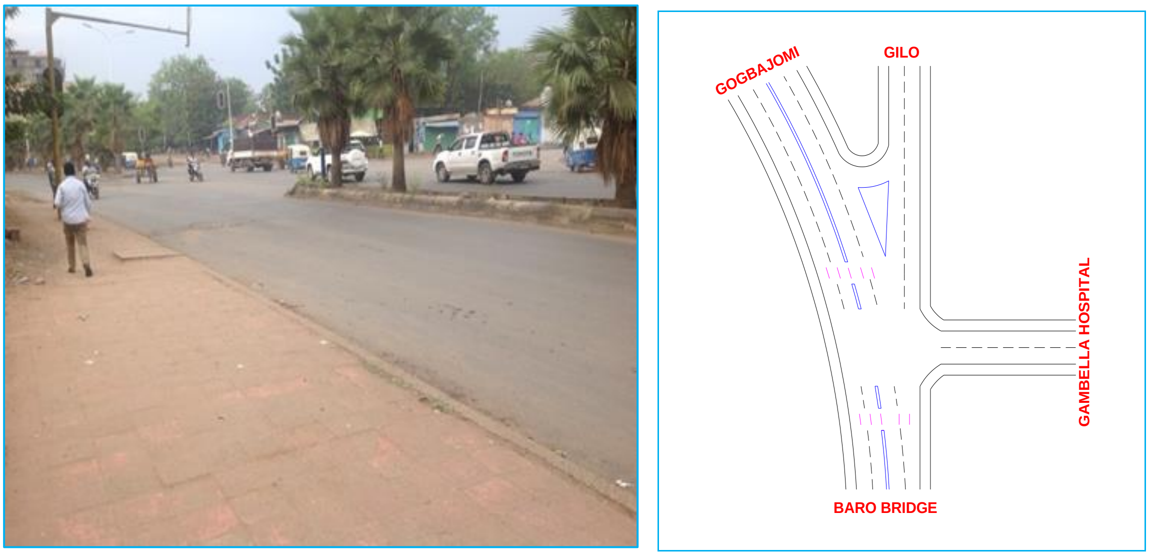

Figure 3.6: Matohaya Intersection (picture and layout view)

E. Ajwomara Intersection

Ajwomara intersection is a Four-Legged Roundabout located at the center of the town. This is the most traffic congested intersection among all the other types of intersections in the town. It is a traffic police controlled intersection. The area is surrounded by shops, banks, offices, hotels, bars and other public facilities. It has four approaches known as Baro Bridge approach, Jabjabe Bridge approach, Wibur P/School approach and Abattoir approach. Baro Bridge approach, Wibur P/School and Abttoir approach are four lanes divided two way highways while Jabjabe Bridge approach is a four lanes undivided two-way highway.

Figure 3.7: Ajwomara Roundabout (picture and layout view)

F. Baro Akobo Intersection

Baro Akobo intersection is a T-Intersection which is located around Gambella Peoples' National Regional State administration office. It is a traffic signal controlled intersection but the signals were not working during the early stage of the site visit. A lot of public offices, schools, hotel and other public facilities are found at this area. It has three approaches known as Wibur P/School approach, Owalinga approach and Donbosco approach. Both Wibur P/School approach and Donbosco approach are major highways with four lanes (two lanes in each direction) while Owalinga approach is a minor road with one lane in each direction.

Figure 3.8: Baro Akobo Intersection (picture and layout view)

3.2 **Research Design**

In this study both quantitative and qualitative study design were employed. Because, the mixture of the two study design gives better explanation as the information missed by one might be captured by the other and thus an enhanced and integrated result may emerge from the analysis. The quantitative data were collected using questionnaire and interview while qualitative data were collected using field observation checklist. The overall process of this study was presented as follows:

- ✓ To identify the major factors affecting the pedestrian behavior causing accident within the road crossing facilities, relative importance index based on the respondents' responses was calculated to rank the major factors. Furthermore, Pearson correlation analysis was performed using Statistical Package for Social Science (SPSS) to test the major factors' statistical significance.

- ✓ To evaluate the road crossing parameters which influence the movement of pedestrian using regression analysis, Multiple Linear Regression model was developed to evaluate the influence of road crossing parameters on the movement of pedestrian.
- ✓ To suggest remedial measures at different crosswalk points found to be prone to pedestrian accidents, field observation was conducted on each crosswalk of intersection under the study. Based on the result of the field observation, remedial measures to improve pedestrian's movement were recommended. Moreover, AutoCAD Version 2016 was used to draw the geometry of each crosswalk at intersection.

3.3 **Study Duration**

The study was conducted in Gambella town from August 2019 to December 2019.

3.4 **Population of the Study**

All pedestrians in Gambella town were the study's population.

3.5 **Sampling Technique & Sample Size**

3.5.1 **Sampling Technique**

In this study convenience sampling technique was applied. Convenience sampling is a type of nonprobability sampling that depends on data collection from members of the study population who are easily accessible, available or willing to participate in the study. Convenience sampling technique is applicable to both quantitative and qualitative studies, although it is mostly used in quantitative studies.

3.5.2 **Sample Size**

To determine the sample size for population that is large, greater than 10,000, Yismaw, and Ahmed (2015) used an equation developed by Cochran (1963):

$$\boldsymbol{n = \frac{z^2 X(p) X(1-p)}{d^2}} \qquad Eqn(1)$$

Where

$\boldsymbol{n}$ = The required sample size for the study

$\boldsymbol{z}$ =Critical value$(= 1.96)$ is selected based on confidence level. Most researchers recommend 95% confidence level.

$\boldsymbol{p}$ = The proportion of people the researcher is expected to have the basic knowledge about the problem (pedestrian behavior, 50% in this case).

$\boldsymbol{d}$ =Margin of error (sometimes called confidence interval) is the range in which the true value of the population is estimated to be and is expressed in percentage. The recommended value is 5%$(= 0.05)$.

$$\boldsymbol{n = \frac{z^2 X(p) X(1-p)}{d^2}}$$

$$\boldsymbol{n = \frac{1.96^2 X(0.5) X(1-0.5)}{0.05^2}}, \quad \boldsymbol{n = 384.16}$$

Thus, the overall calculated sample size was **385** pedestrians.

3.6 **Equipment and Instrument Used**

For this study, the instruments used for data collection are questionnaire, interview and field observation.

A. Questionnaire

A structured questionnaire was used to collect quantitative data from pedestrians. The questionnaires were comprised of close ended questions. The type of scales used to measure the items on the questionnaire was three scales. The questionnaire form was only designed in the English language. For pedestrians with low literacy level, questionnaire items were translated into local language during interview.

B. Personal Interview

Paper and Pencil Interviewing (PAPI) was conducted at the different selected intersections under the study. Paper and Pencil Interviewing (PAPI) is the most frequently used method for collecting data. It represents a process of personal interviewing where the data collector holds a printed-out questionnaire, reads the question to the respondent, and fills the questionnaire's answers. This type of personal interview method was used because large amounts of data can be collected in a short period of time and in a cost effective way.

C. Field Observation

Field observation on each crosswalk of six intersection was carried out using checklist. The checklist was prepared according to selected variables (i.e., crosswalk marking visibility, crosswalk surface condition, curb side parking, curb ramp, curb cut, zebra crossing, splitter island, raised median and waiting area).

3.7 **Data Collection Method**

To achieve the main objective of this study, both primary and secondary data were collected. Before actual data collection, short term training was given by the researcher to data collectors on how to collect the data required for this study.

3.7.1 **Primary Data**

The primary data were obtained from pedestrians through questionnaire and interview. The pedestrians were conveniently selected at each location and questionnaire forms were distributed to each pedestrian. In addition, to obtain the required number of respondents in a short period time and in a cost effective way, personal interview was conducted at each location. The pedestrians were interviewed after immediately crossed the road at each crosswalk location.

3.7.2 **Secondary Data**

The secondary data were collected through field observation on crosswalks of intersections under the study. The checklist was prepared based on the selected variables (i.e., crosswalk marking visibility, crosswalk surface condition, curbside parking, curb ramp, curb cut, zebra crossing, splitter island, raised median and waiting area). Furthermore, road width, lane width, number of lanes and median width were measured on each approach of the selected intersection using roller meter.

3.8 **Study Variables**

3.8.1 **Dependent Variable**

- Movement of pedestrian

3.8.2 **Independent Variables**

- Crosswalk surface condition

- Crosswalk marking visibility
- Lighting condition
- Road width
- Lane width
- Number of lanes
- Driver yielding behavior
- Crosswalk holding area
- Curbside parking

3.9 **Data Processing and Analysis**

The data was checked for completeness and accuracy after data collection; then, it was cleaned, coded, and entered into the computer for further analysis. Before the statistical analysis method introduced, some important terms are discussed below:

- ✓ **ANOVA:** It is expressed as an F-test value which is used to determine whether the overall regression model is a good fit for the data.
- ✓ **P-value:** It indicates whether the relationship between each independent variable and dependent variable is statistically significant.
- ✓ **R-square**: It is also known as the coefficient of determination. It is the percentage of the dependent variable's variation that is explained by the independent variables.
- ✓ **Adjusted R-square**: It is a modified version of R-square that has been adjusted for the number of predictors in the model. Every time the predictor is added into the model, the R-square increases, even if the predictor is insignificant but the Adjusted R-Square increases only when the predictor is significant and affects the dependent variable.
- ✓ **The standard error of estimate**: It provides the absolute measure of the typical distance that the data points fall from the regression line. If the points are far from the regression line, the linear model does not fit the data very well (R-square is low, and the standard error of estimate is high). If the points are near the regression line, the linear model fits the data very well (R-square is high, and the standard error of estimate is low).
- ✓ **Pearson correlation coefficient(R)**: The Pearson correlation coefficient (sometimes called the Pearson's r) is a statistic measuring the linear correlation

between dependent variable and independent variables. It has value between +1 and -1. A value of +1 indicates a positive linear correlation, 0 indicates no linear correlation, and -1 indicates a negative linear correlation.

3.9.1 **Method of data analysis for major factors affecting pedestrian behavior**

Relative Importance Index was calculated based on the respondents' responses to rank the major factors affecting pedestrian behavior. Moreover, Pearson Correlation Analysis was performed to test the statistically significance of major factors affecting pedestrian behavior. Factors with a p-value of less than 0.05 (p<0.05) were considered as the significant factors affecting pedestrian behavior.

3.9.2 **Method of data analysis for regression analysis on road crossing parameters influencing pedestrian’s movement**

Multiple Linear Regression analysis was applied to evaluate the influence of road crossing parameters on the pedestrian’s movement. Those variables with a p-value of less than 0.05 (p<0.05) from the result of Pearson Correlation Analysis were recruited for multiple linear regression analysis. SPSS software was used for statistical data analysis.

Multiple Linear Regression analysis is one of the statistical methods that assess the relationship between several independent variables and dependent variable. The main aim of multiple linear regression analysis is to either explain or predict the dependent variable using a set of independent variables. As a prediction model, it investigates the extent to which independent variables can predict the dependent variable. As an explanation model, the relationship between the dependent variable and independent variables can be examined in terms of the sign, value, and significant value [54].

Dependent variable: - Movement of pedestrian

Independent variable: - Road crossing parameters (i.e., Crosswalk Surface Condition, Crosswalk Marking Visibility, Road Width, Lane Width, Number of Lanes, Crosswalk Holding Area and Curb Side Parking)

The model is written in the form of $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n$ $\quad Eqn(2)$

Where: $Y =$ Dependent (response) variable

$X_1, X_2, \ldots\ldots x_n =$ Independent (explanatory) variables

$\beta_0, \beta_1, \beta_2, \dots \dots \beta_n$ = Regression coefficients (estimating parameters)

Multiple Linear Regression assumptions: - before running a multiple linear regression, the data must be checked if it meets the required assumptions.

Table 3.1: Multiple Linear Regression assumptions

Assumptions	Description
Continuous dependent variable	The dependent variable must be measured on a continuous scale
Linear relationships	There should be a linear relationship between the dependent variable and independent variables
Multicollinearity	The independent variables should not be highly correlated with each other
Homoscedasticity	The variance of the residuals should be the same at each level of the independent variables
Normally distributed residuals	The residuals should be normally distributed
Outliers/influential cases	There should be no significant outliers.

The model fulfilled all six required major assumptions. Therefore, the data best fitted the developed, multiple linear regression model.

3.9.3 **Method of data analysis for suggested remedial measures at different crosswalk points found to be prone to pedestrian accidents**

Field observation was conducted on crosswalks of the selected intersections. Based on the results of field observation, remedial measures were suggested and AutoCAD Version 2016 was used to draw the geometry of each crosswalk of intersection.

3.10 **Data Quality Assurance**

Before conducting the actual data collection, the designed questionnaire form was tested with few pedestrians in order to ensure the appropriateness and correctness of the designed items. It also assured us whether the questionnaire items are understandable for pedestrians with different literacy level. The questionnaire was revised after the results of initial survey. The training focused on understanding the research question, sampling technique, data handling, ethical conduct, and data quality was given to the data collectors for one day. The data collectors were two lectures and two teachers selected based on their previous experience in data collection. During data collection, the principal investigator visited each data collector at each study site to review the questionnaire and check for completeness and accuracy.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 **Identification of Major Factors Affecting Pedestrian Behavior**

4.1.1 **General Information or Respondents Profile**

1) Sex

Of the 385 respondents who responded to the survey, 66.75% of data was collected from males and 33.25% from females. Table 4.1 below shows the percentage of the sex distribution of the respondents.

Table 4.1: Sex of the respondents

Sex	Frequency	Percentage (%)
Male	257	66.75
Female	128	33.25
Total	385	100.0

2) Age

With regard to age, 7.79% reported age above 50 years, followed by 10.65% of respondents between 36 and 50 years, 31.69% between 18 and 25 years old, and 49.87% between 26 and 35 years old. Table 4.2 below shows the percentage of the age distribution of the respondents.

Table 4.2: Age of the respondents

Age	Frequency	Percentage (%)
<18	0	0
18-25	122	31.69
26-35	192	49.87
36-50	41	10.65
>50	30	7.79
Total	385	100.0

3) Level of Education

As shown in table 4.3 below, 8.31% of the respondents had primary school, 13.25% secondary school, 24.15% diploma, 52.47% degree, and 1.82% above degree.

Table 4.3: Level of education of the respondents

Education	Frequency	Percentage (%)
Illiterate	0	0
Primary school	32	8.31
Secondary school	51	13.25
Diploma	93	24.15
Degree	202	52.47
Above degree	7	1.82
Total	385	100.00

4) Occupation

In terms of occupation, 10.13% respondents were laborers, 55.84% students, 31.17% civil servants or public servants and 2.86% businessmen or women. Table 4.4 below summarizes the occupation status of respondents.

Table 4.4: Occupation of the respondents

Occupation	Frequency	Percentage (%)
Laborers or daily workers	39	10.13
Students	215	55.84
Civil servants or public servants	120	31.17
Businessmen or women	11	2.86
Total	385	100.00

4.1.2 **Major Factors**

Based on the outcome of intensive review of related literatures and field observations, several possible factors affecting pedestrian behavior within the road crossing facilities were identified. The selected factors are listed in the table 4.5 below.

Table 4.5: Selected variables and descriptions

Variable	Measure	Description
Crosswalk surface condition	Ordinal	0 for not important 1 for moderate 2 for important
Crosswalk marking visibility	Ordinal	0 for not important 1 for moderate 2 for important
Lighting condition at the crosswalk	Ordinal	0 for not important 1 for moderate 2 for important
Road width	Ordinal	0 for not important 1 for moderate 2 for important
Lane width	Ordinal	0 for not important 1 for moderate 2 for important
Number of lanes	Ordinal	0 for not important 1 for moderate 2 for important
Driver yielding behavior	Ordinal	0 for not important 1 for moderate 2 for important
Crosswalk holding area	Ordinal	0 for not important 1 for moderate 2 for important
Curbside parking	Ordinal	0 for not important 1 for moderate 2 for important

4.1.3 **Ranking of Major Factors using Relative Importance Index (RII)**

The relative importance index was employed to rank the major factors affecting pedestrian behavior. To obtain the ranking of different factors from the responses of pedestrians, the Relative Importance Index (RII) was computed using the RII Equation [55]:

$$RII = \frac{\sum W}{(A * N)} \qquad Eqn(3)$$

Where,

W is the weightage given to each factor by the respondents (ranging from 0 to 2),

A is the highest weight (i.e., 2 in this case)

N is the total number of respondents.

As a result, the ranking of the major factors based on the respondents' responses was done using the Relative Importance Index (RII), which was computed using an equation. The results of the analysis are presented in table 4.6. Moreover, road width ranked as the first major factor followed by lane width. Then crosswalk surface condition, lighting condition at crosswalk, crosswalk holding area, curbside parking, crosswalk marking visibility, driver yielding behavior, and number of lanes ranked third, fourth, fifth, sixth, seventh, eighth and ninth respectively.

Table 4.6: Ranking of major factors affecting pedestrian behavior

Factors	0	1	2	W	RII	Rank
Crosswalk surface condition	0	198	187	572	0.743	**3**
Crosswalk marking visibility	0	220	165	550	0.714	**7**
Lighting condition at a crosswalk	0	200	185	570	0.740	**4**
Road width	0	117	268	653	0.848	**1**
Lane width	0	129	256	641	0.832	**2**
Number of lanes	0	194	151	496	0.644	**9**
Driver yielding behavior	0	234	151	536	0.696	**8**
Crosswalk holding area	0	210	175	560	0.727	**5**

Curbside parking	0	218	167	552	0.716	**6**

4.1.4 **Pearson Correlation Analysis on Group of Factors**

Pearson Correlation Analysis was performed to test the statically significance of major factors affecting pedestrian behavior. A 95% confidence level was selected with a corresponding p-value of 0.05. All the variables with a p-value less than 0.05 ($p<0.05$) were considered as the major factors and the other variables with a p-value greater than 0.05 ($p>0.05$) were excluded. The Pearson Correlation Analysis was done using the statistical package for social science (SPSS) version 23. Table 4.7 below shows that factors, crosswalk surface condition, crosswalk marking visibility, road width, lane width, number of the lane, crosswalk holding area and curbside parking were found to be the major factors affecting the pedestrian behavior. However, lighting condition and driver yield behavior with p-value greater than 0.05 ($p>0.05$) were excluded.

Table 4.7: Pearson correlation analysis of factors affecting pedestrian behavior

Variable	Correlation value	P-value
Crosswalk surface condition (CWSC)	-.105	0.040
Crosswalk marking visibility (CWMV)	.321	0.000
Lighting condition (LC)	-.035	0.496
Road width (RW)	-.282	0.000
Lane width (LW)	-.283	0.000
Number of lane (NOL)	-.382	0.000
Driver yield behavior (DYB)	-.022	0.669
Crosswalk holding area (CWHA)	.211	0.000
Curbside parking (CSP)	-.116	0.023

4.2 **Regression Analysis on Road Crossing Parameters influencing Pedestrians' movements**

4.2.1 **Averages User's Score**

Rank order scale was designed for the level of difficulty of movement of pedestrians as they used the particular crosswalk. The score of the scale was ranging from 0 to 10. Score

10 means very comfortable to cross and 0 means extremely difficult to cross. Respondents were requested to record their perception on a scale how comfortable they felt as they crossed the crosswalk. The scores given by the respondents were considered as dependent variable for the analysis. As shown in the table 4.8, the averages of user's score were computed for each crosswalk using the answers of respondents.

Table 4.8: Average user's scores

Location	Crosswalk	Number of respondents	Average user's score
1	1	21	3.142857
	2	21	4.047619
	3	22	3.045455
2	1	16	4.125
	2	16	3.5625
	3	16	4.0625
	4	16	5.0625
3	1	21	3.952381
	2	21	5.095238
	3	22	4.318182
4	1	16	4.5625
	2	16	3.625
	3	16	3.4375
	4	16	4.1875
5	1	16	5.3125
	2	16	3.125
	3	16	3.875
	4	17	4.70588
6	1	21	4.428571
	2	21	4.380952
	3	22	4.545455

4.2.2 **Multiple Linear Regression Analysis**

Multiple linear regression analysis was used to evaluate the influence of road crossing parameters on pedestrian's movement. Multiple linear regression analysis is the most commonly used technique of regression analysis. A Multiple Linear Regression model is a statistical tool for understanding the relationship between dependent variable and two or more independent variables.

4.2.3 **Model Development**

Multiple Linear Regression model was developed to evaluate the influence of road crossing parameters on pedestrian's movement. For developing the model, major factors that were significant from the result of Pearson Correlation Analysis were considered for this model. Then Multiple Linear Regression model was developed using the Statistical Package for Social Science (SPSS) version 23 software.

4.2.4 **Assumptions of Multiple Linear Regression Analysis**

To develop a good Multiple Linear Regression model, six major assumptions need to be fulfilled: continuous dependent variable, linear relationship between the dependent variable and the predictors, absence of multicollinearity among the predictors, constant variance(homoscedasticity) within the error term, the normal distribution of residuals, and there should be no significant outliers within the data.

Assumption≠1: Continuous dependent variable

The dependent variable should be measured on a continuous scale. The dependent variable is the movement of pedestrian which was expressed as the average user's scores computed from the responses of the respondents as shown in the table 4.8 above.

Assumption ≠2: Linear relationship

The relationship between the dependent and each of the independent variable should be linear. Simple way to check this is by producing scatter plot of each independent variable and dependent variable. In the fig 4.1, fig 4.2, fig 4.3, fig 4.4, fig 4.5**,** fig 4.6 and fig 4.7 below, scatter plots of dependent variable versus each of the independent variable are presented, showing that there is significant evidence for the existence of the linear relationship.

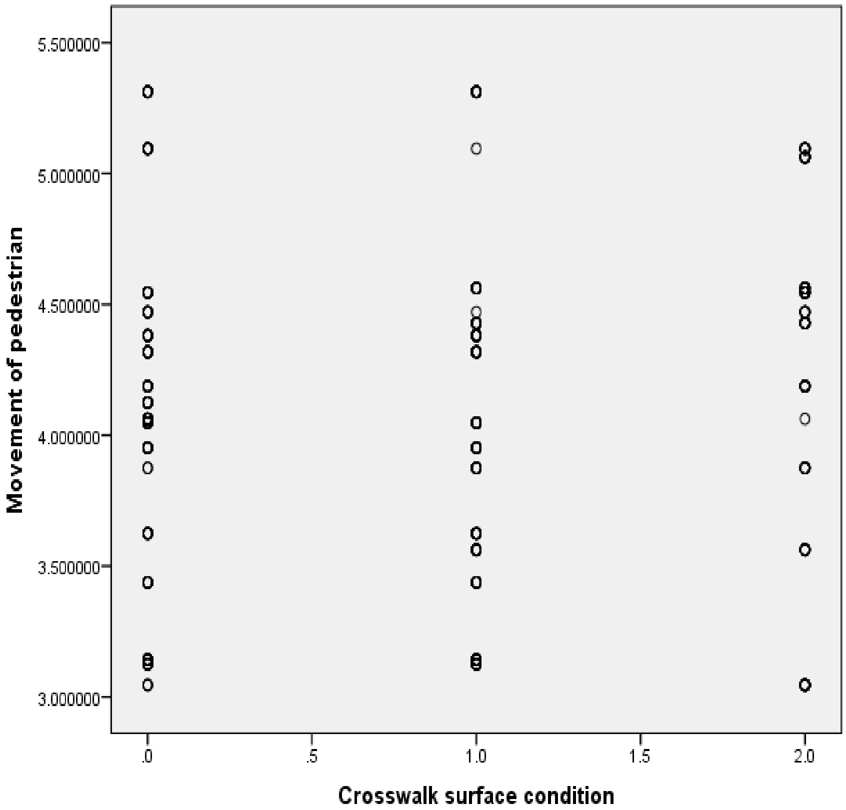

Figure 4.1: Scatter plot of movement of pedestrian versus crosswalk surface condition

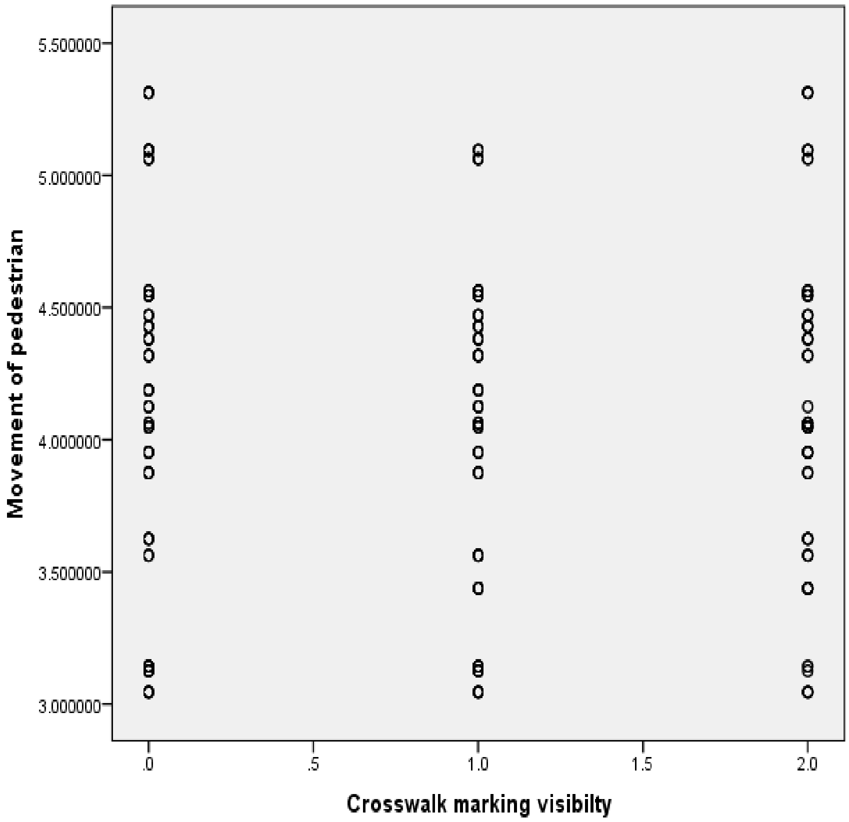

Figure 4.2: Scatter plot of movement of pedestrian versus crosswalk marking visibility

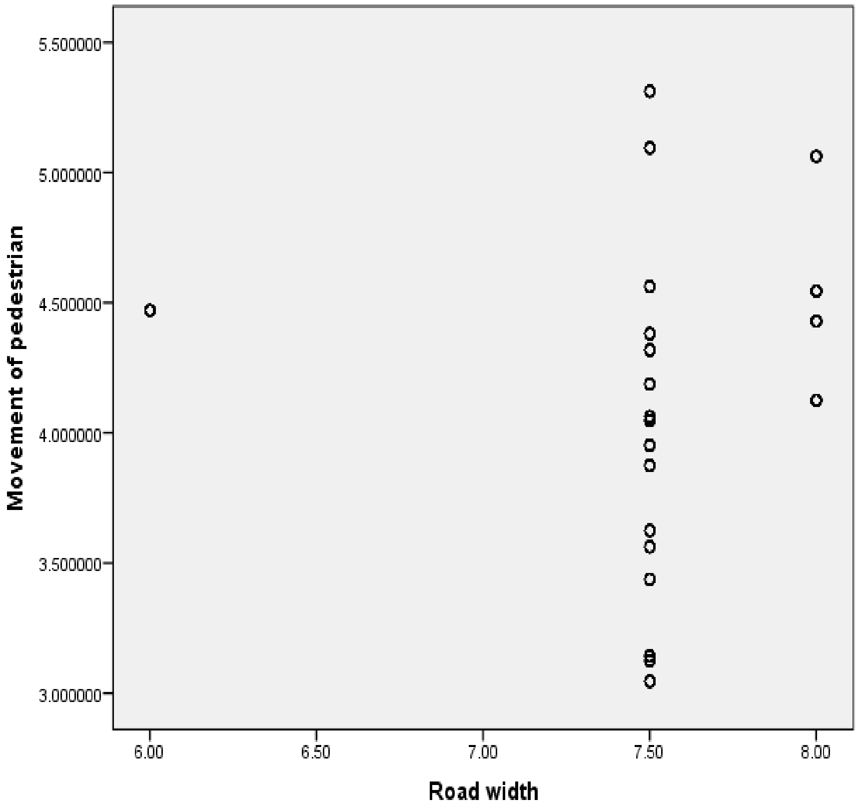

Figure 4.3: Scatter plot of movement of pedestrian versus road width

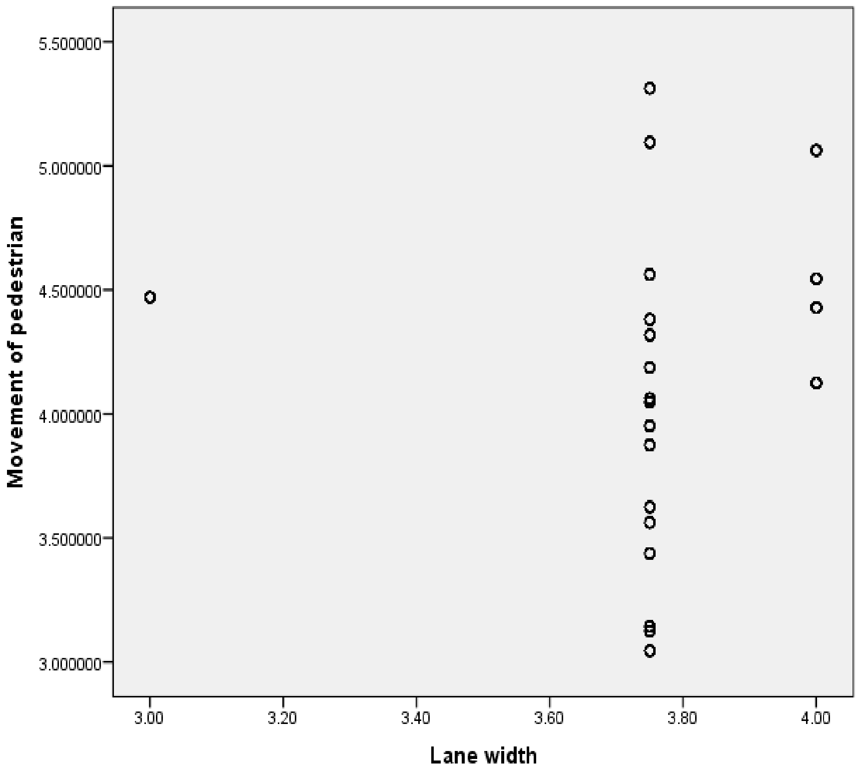

Figure 4.4: Scatter plot of movement of pedestrian versus lane width

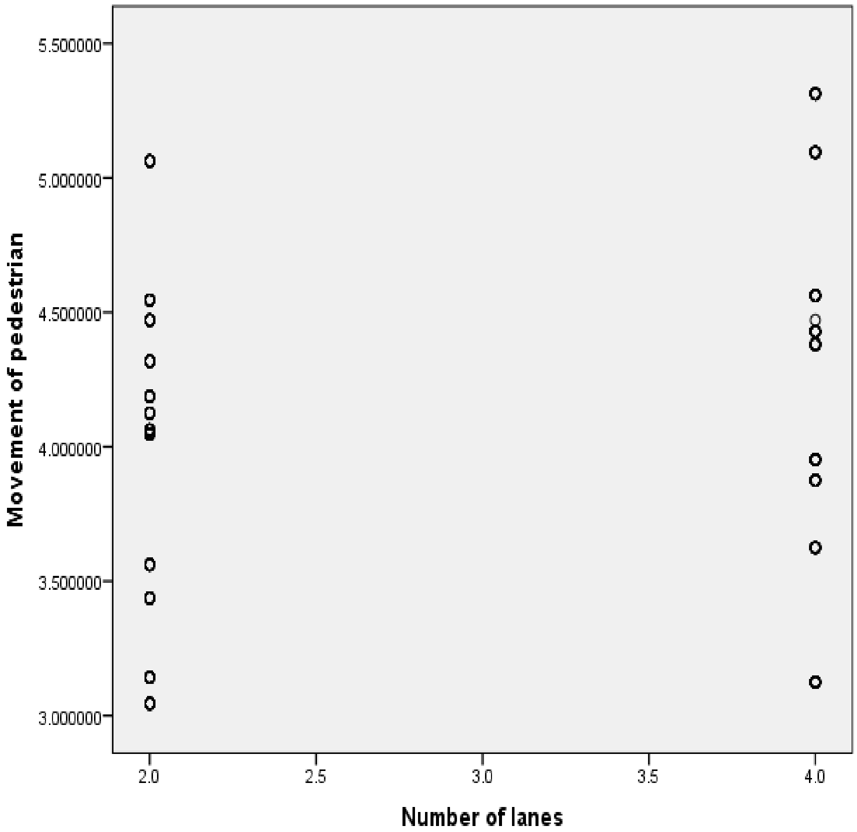

Figure 4.5: Scatter plot of movement of pedestrian versus number of lanes

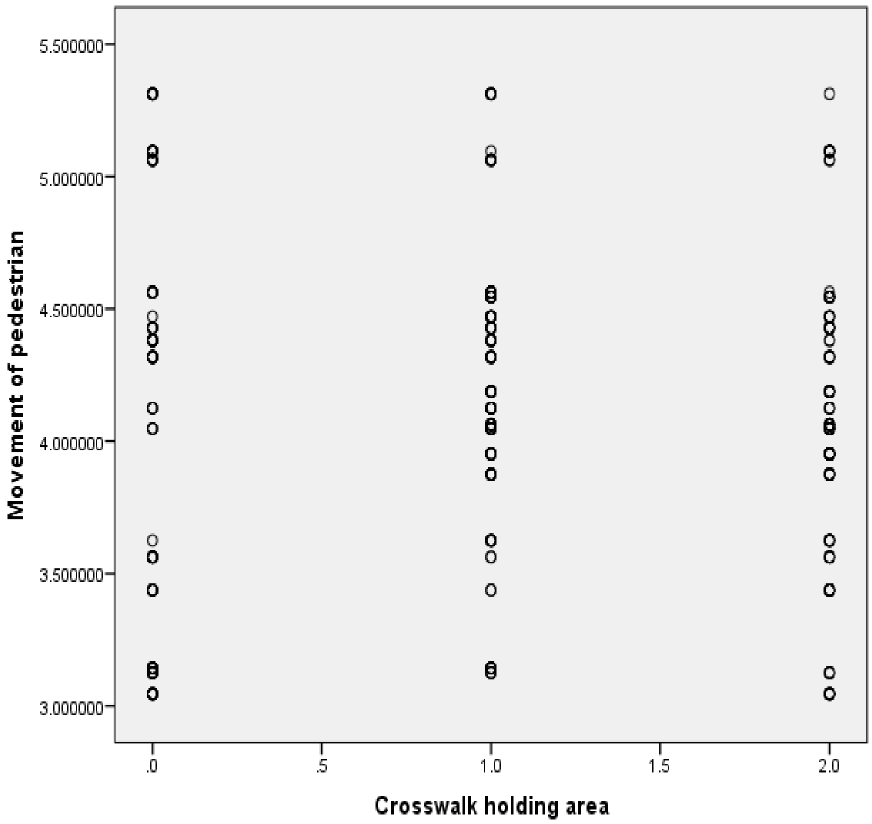

Figure 4.6: Scatter plot of movement of pedestrian versus crosswalk holding area

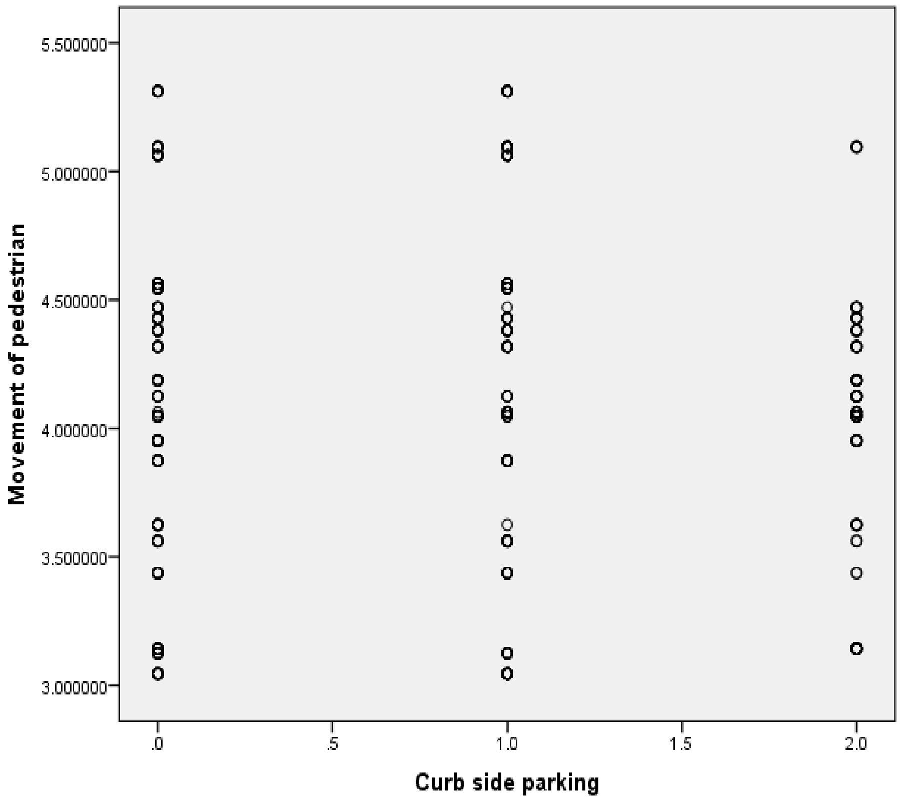

Figure 4.7: Scatter plot of movement of pedestrian versus curb side parking

Assumption ≠3: Multicollinearity (the predictor variables should not be highly correlated with each other).When two or more predictor variables are highly correlated with each other, they do not provide unique or independent information in the regression model. One way to detect multicollinearity is by using tolerance and its reciprocal, called variance inflation factor (VIF).

If VIF is less than (<1) or greater than (>10) and tolerance is less than (<0.1) then multicollinearity is likely to occur. From the table 4.9 below, the variance inflation factor (VIF) for all the independent variables is between 1-10, while tolerance for all the independent variables is greater than (>0.1), so there is no multicollinearity.

Table 4.9: Multicollinearity diagnostics of the independent variables

Variable	Tolerance	VIF
Crosswalk surface condition (CWSC)	0.700	1.428
Crosswalk marking visibility (CWMV)	0.658	1.521
Lane width (LW)	0.596	1.677
Number of lane (NOL)	0.799	1.251

Crosswalk holding area (CWHA)	0.649	1.541
Curb side parking (CSP)	0.597	1.675

Assumption ≠4: Homoscedasticity (variances along the line of best fit have to remain similar as it moves along the line). To test the homoscedasticity (equality of variances) of data, scatter plot of standardized residuals versus standardized predicted values is analyzed. As shown in the figure 4.8 below, spread of the residuals around the line seems to have approximately similar pattern and therefore satisfy the assumption of equality of variance.

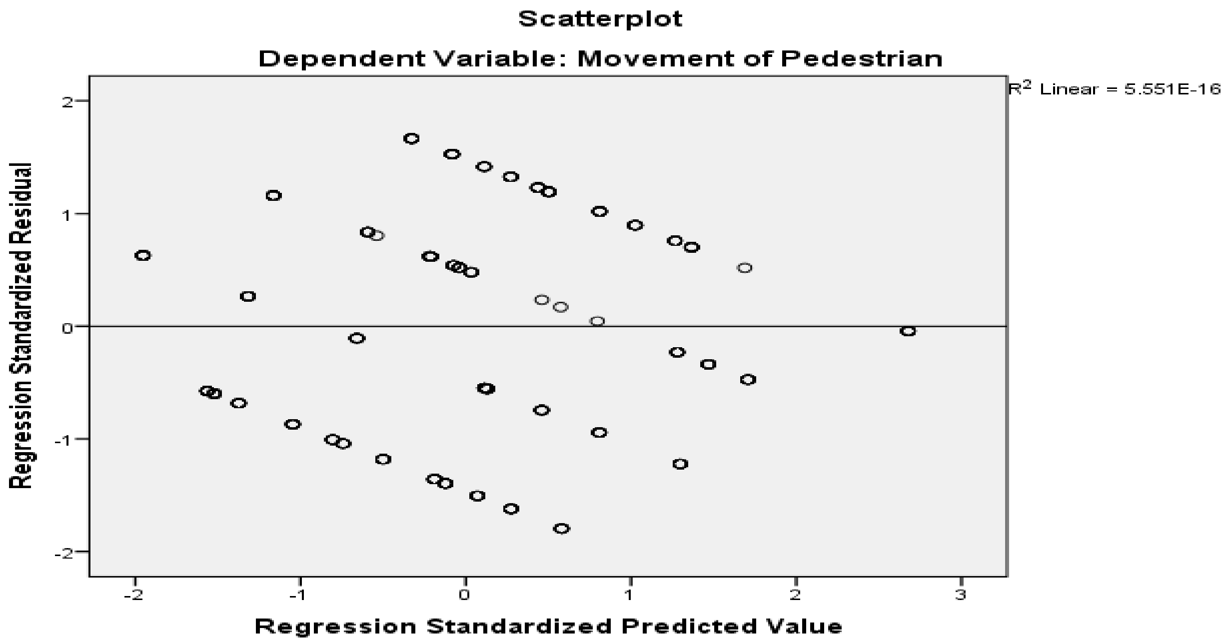

Figure 4.8: Scatter plot of standardized residual versus standardized predicted value

Assumption ≠5: There should be no significant outliers in the data. Significant outliers can affect the regression equation that is used to predict the value of the dependent variable based on the independent variables. It can change the output that SPSS produce and reduce the predictive accuracy of the results as well as the statistical significance. When running multiple liner regression analysis on SPSS, significant outliers can be checked using Cook's Distance. A predictor variable with Cook's Distance value greater than 1 is a significant outlier and can cause serious problem in statistical analyses. In this study, significant outliers were checked using Cook's Distance and all the value of Cook's Distance for all the predictor variables were less than 1 as shown in the table c-5 of appendix c. Therefore, significant outliers did not exist in the data.

Assumption ≠6: The values of residuals must be normally distributed. From the figure 4.9 below, the histogram shows that residuals are approximately normally distributed, thereby satisfying the normality assumption.

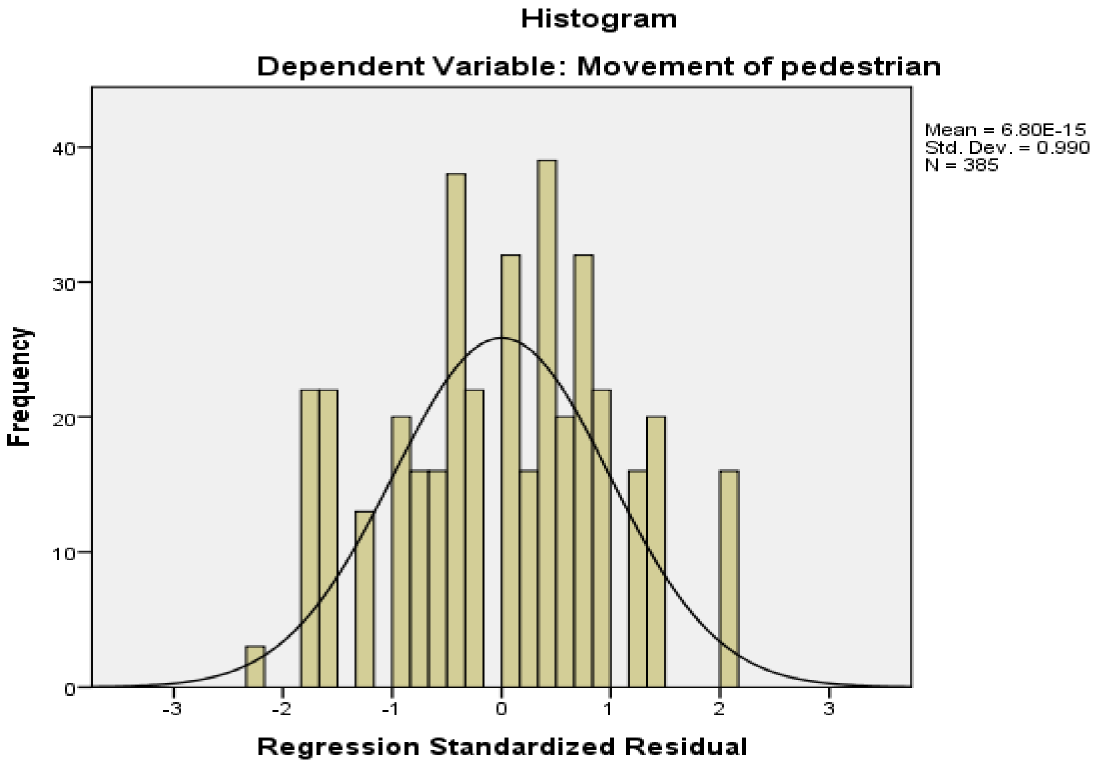

Figure 4.9: Histogram of movement of pedestrian

4.2.5 **Analysis of Variance of the model**

The F-ratio in the Analysis of variance table tests whether the overall regression model is a good fit for the data. Table 4.10 shows that the independent variables statistically significantly predict the dependent variable, $F(6,378) = 100.501$ and $p < 0.05$ (i.e., the regression model is a good fit of the data).

Table 4.10: Analysis of Variance for the developed multiple linear regression model

Model	Sum of Square	df	Mean Square	F	Sig.
Regression	74.761	6	12.460	100.501	0.000[b]
Residual	46.865	378	0.124		
Total	121.626	384			

Table 4.11 shows a coefficient of determination (R-sq) value that indicates the percentage of variation in the dependent variable that can be explained by the predictors. The value of coefficient of determination (R-sq) was 0.775 for this study, which means that 77.5% of variation in the movement of pedestrian has been explained by the predictors (i.e., Road Crossing Parameters) with only 22.5% not being explained by the predictors but rather by other variables which were not included in the study.

Table 4.11: Model summary of the developed multiple linear regression

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.880	0.775	0.771	0.269

The descriptive statistics of this model, presented in table 4.12 below, show that the explanatory variables (i.e., Crosswalk Surface Condition, Crosswalk Marking Visibility, Lane Width, Number of Lanes, Crosswalk Holding Area and Curb Side Parking) were found to be statistically significant with p-value <0.05 but, the explanatory variable, road width was excluded from the analysis in the SPSS. It was indicated that the effect of road width on pedestrian's movement can be explained using other variables.

Table 4.12: Result of the developed multiple linear regression model

Model	Unstandardized coefficient		Standardized coefficient		
	B	Std.Error	Beta	t	Sig.
Constant	4.623	0.475		9.742	0.000
CWSC	0.297	0.043	0.264	6.914	0.000
CWMV	0.809	0.046	0.699	17.765	0.000
LW	-0.914	0.130	-0.290	-7.011	0.000
NOL	-0.373	0.020	-0.657	-18.384	0.000
CWHA	0.296	0.043	0.271	6.848	0.000
CSP	-0.177	0.038	-0.194	-4.691	0.000

The final multiple linear regression equation with all the significant explanatory variables is written as:

$$\mathrm{Y} = 4.623 + 0.297\mathrm{CWSC} + 0.809\mathrm{CWM} - 0.914\mathrm{LW} - 0.373\mathrm{NOL} + 0.296\mathrm{CWHA} - 0.177\mathrm{CSP} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad Eqn\ (4)$$

$$\mathrm{MOP} = 4.623 + 0.297\mathrm{CWSC} + 0.809\mathrm{CWM} - 0.914\mathrm{LW} - 0.373\mathrm{NOL} + 0.296\mathrm{CWHA} - 0.177\mathrm{CSP} \quad \ldots\ldots \quad Eqn\ (5)$$

Where:

$MOP =$ Movement of Pedestrian, $CWSC =$ Crosswalk Surface Condition,

$CWMV =$ Crosswalk Marking Visibility, $LW =$ Lane Width, $NOL =$ Number of Lane, $CWHA =$ Crosswalk Holding Area, $CSP =$ Curb Side Parking

4.2.6 **Application of the Developed Equation (Existing against Predicted)**

The constant term value of 4.623 is interpreted in absolute terms to be the pedestrian movement changes when road crossing parameters are set to zero and all other factors are held constant.

Crosswalk surface condition and crosswalk marking visibility had a significant effect on pedestrian movement with a positive sign. It is inferred that an increase in the value of crosswalk surface conditions and crosswalk marking visibility results in increased pedestrians' movement. This may be due to pedestrian prefers crosswalk with a smooth surface to crosswalk with a cracked surface. It is also expected that cracked surfaces can accumulate water during the rainy season, forcing pedestrian to cross at the undesignated pedestrian crossing. Regarding crosswalk marking visibility, drivers yield to pedestrians more at a crosswalk with high marking visibility than at crosswalk with low marking visibility. This is because crosswalks with high marking visibility can significantly increase driver's daytime yielding behavior. The percentage of pedestrians using the crosswalk is also expected to increase at a crosswalk with high marking visibility than crosswalk with invisible marking. This finding is consistent with the previous study, which showed that crosswalk surface condition and crosswalk marking visibility significantly influenced pedestrian satisfaction level with positive sign indicated that an increase in the quality of crosswalk surface condition and crosswalk marking visibility result in an increase of pedestrian satisfaction level [47]. Besides, [48] concluded that pedestrian level of service at a signalized intersection crosswalk is greatly influenced by crosswalk surface conditions and crosswalk marking visibility.

The width of the lane was found negatively associated with the movement of pedestrian. It negative sign indicates that the decrease in the width of lane leads to an increase of pedestrians’ movement. The reason is that when the width of lane increase, the crossing distance of pedestrian increase which put the pedestrian at higher risk of being struck by a vehicle while crossing the road. Another reason is that narrower lanes mean lower vehicle speed and shorter crossing distance, reducing the risk of pedestrian accident. The use of narrower lanes may provide space for geometric features that enhance pedestrian safety, such as medians and adequate sidewalk width. Similar as suggested by [56], as lane width increases, the pedestrians need to cover longer crossing distance and encounter more number of vehicles which increase pedestrian-vehicle conflict. Besides, [57] found that the wider lane statistically affects traffic accident occurrence with a positive sign, indicating that the number of traffic accidents increases as the lane width increases.

The estimated coefficient for the number of lanes was found to be negative. It implies that the decrease in the number of lanes increases pedestrians' movement. This is due to vehicles on the roads with more lanes operated at a higher speed, which leads to collision between pedestrian and vehicle. Another reason is that vehicles traveling along the roads with more lanes have more lane changing and overtaking opportunities. A similar finding was found in the study of [58] which stated that with the increase of vehicle lanes, pedestrian-vehicle conflict rise accordingly. In addition [59] found that more lanes significantly affect pedestrian severity with a positive sign, indicating that an increase in the number of lanes results in increased pedestrian accidents.

The crosswalk holding area was found to be a significant parameter that influences the movement of the pedestrian. Its positive estimated coefficient indicates that as crosswalk holding area increases, there is an increase in pedestrians’ movement. The reason is that pedestrians are expected to use crosswalks with a large enough holding area to accommodate them while waiting to cross the road than crosswalks with the insufficient waiting area. An inadequate waiting area at the intersection is expected to force pedestrians to wait in the traffic lane, leading to a collision between pedestrians and vehicles. This finding is consistent with the study conducted by [47]which suggested that crosswalk holding area has the highest influence on pedestrian satisfaction level over the other factors with a positive coefficient value that shows that as the holding area to accommodate pedestrian during waiting at the corner of pedestrian crossing increase, their satisfaction level for that intersection also increase. Similarly, [60] confirmed that space at the corner includes both hold area and circulation areas, significantly affect the pedestrian level of service of crosswalks at intersections.

Curbside parking was found to be negatively associated with the movement of the pedestrian. Its negative sign indicates that the decrease of curbside parking near the intersection increases pedestrians’ movement. The reason is that pedestrians must be able to see and be seen by approaching vehicles. Visibility should not be obscured by parked vehicles, trees, or street furniture. This is because the influence of curbside parking on pedestrians' safety crossing the road is caused by parked vehicles blocking a driver's sightline. Moreover, curbside parking creates a visual barrier between vehicles and crossing pedestrians, especially children and people using wheelchairs. This finding is line with the study carried out by [46] which suggested that curbside parking near the intersection is another variable that had a positive impact (0.1762) in increasing the pedestrians' risk-taking possibility. The model's positive coefficient implies that pedestrian' risk-taking possibility increases with curbside parking. In addition, [61] suggested that lack of visibility due to parked cars makes drivers unaware about on-coming pedestrians’ entries into the roads, thus, causing pedestrian-automobile conflicts and even sometimes fatalities as well.

4.3 Suggested Remedial Measures on How to Improve the Condition of the Existing Road Layout

Field observation was conducted on the crosswalks of the selected intersections. Based on the results of field observation, remedial measures were suggested and AutoCAD was used to draw the geometry of each crosswalk of intersection. Problems found during the field observation and the remedial measures that were suggested based on the result of field observation are presented below.

4.3.1 Gilo Roundabout

Observed problems at Gilo Roundabout

1. Poor crosswalk surface condition
2. Accessible curb ramp was not provided on both sides of the road
3. Curbside parked vehicles reduced the sigh distance
4. Zebra crossing markings were not provided at each crossing location.

Figure 4.10: Poor crosswalk surface condition and lack of accessible curb ramp and lack of zebra crosswalk marking

Figure 4.11: Curb side parking near roundabout

Suggested remedial measures

1. Crosswalk surface condition should be improved through routine checks and maintenance
2. Curb ramp should be provided at each crosswalk to assist mobility of pedestrian
3. Zebra crossing markings should be provided at each crosswalk points
4. Traffic regulation such as prohibiting curb side parking at intersections and pedestrians’ crossings should be enforced.

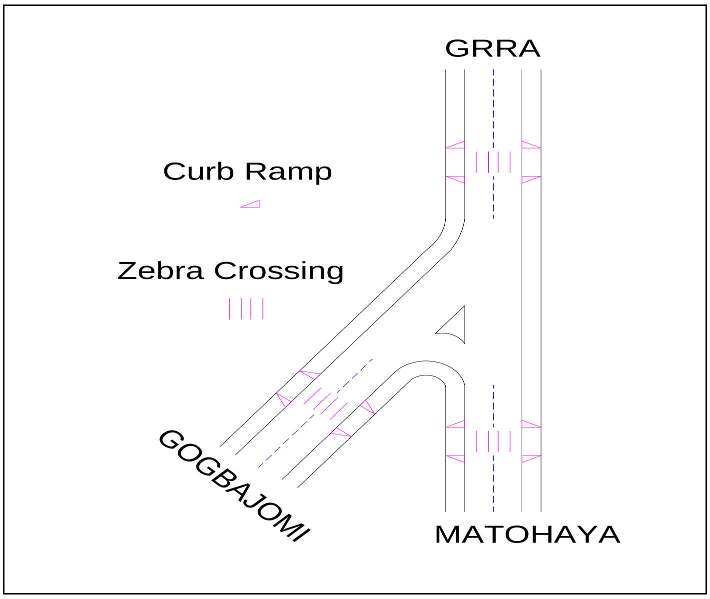

Figure 4.12: Suggested improvement layout of Gilo roundabout

4.3.2 **Owalinga Intersection**

Observed problems at Owalinga Intersection

1. Poor crosswalk surface condition
2. Accessible curb ramp was not provided on both sides of the road
3. No zebra crossing markings

Figure 4.13: Poor crosswalk surface condition, lack of accessible curb ramp and no zebra crossing marking

Suggested remedial measures

1) Crosswalk surface condition should be improved through routine checks and maintenance
2) Curb ramp should be provided at each crosswalk to assist mobility of pedestrian
3) Zebra crossing marking should be provided at each crossing

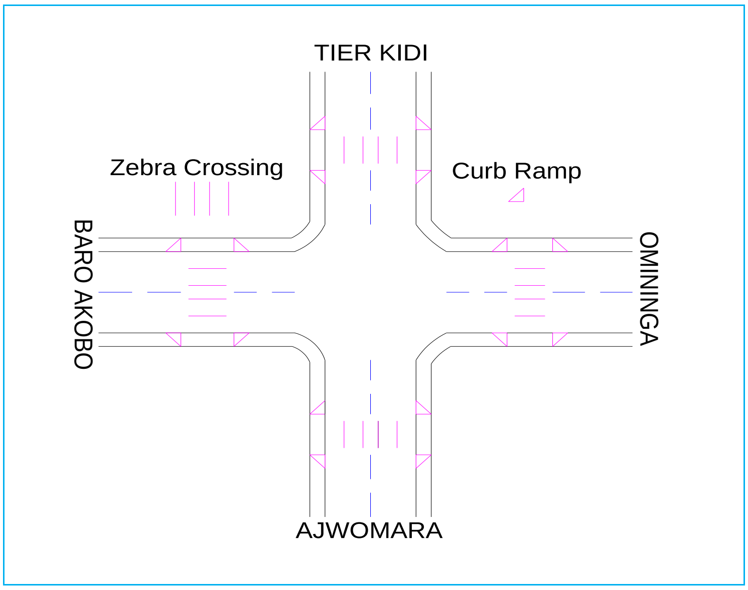

Figure 4.14: Suggested improvement layout of Owalinga intersection

4.3.3 **Gogbajomi Intersection**

Observed problems at Gogbajomi Intersection

1) Curb cut and curb ramp were not provided
2) Most of the vehicles were parked on the curb side which reduce the sight distance
3) Insufficient waiting area due vendors occupied sidewalk
4) Zebra crossings were provided at crosswalk location

Figure 4.15: Lack of curb cut and curb ramp to enhance pedestrian crossing

Figure 4.16: Curb side parking near intersection

Figure 4.17: Insufficient waiting area

Suggested remedial measures

1) Curb cut and curb ramp should be provided in the median and in the edge of sidewalk at each crosswalk of the intersection
2) Traffic regulation such as prohibiting curb side parking at intersections and pedestrians' crossings should be enforced.
3) Restriction of activities such as vendors occupying space near crosswalk at each intersection should be enforced
4) Zebra crossing should be provided at each crosswalk location

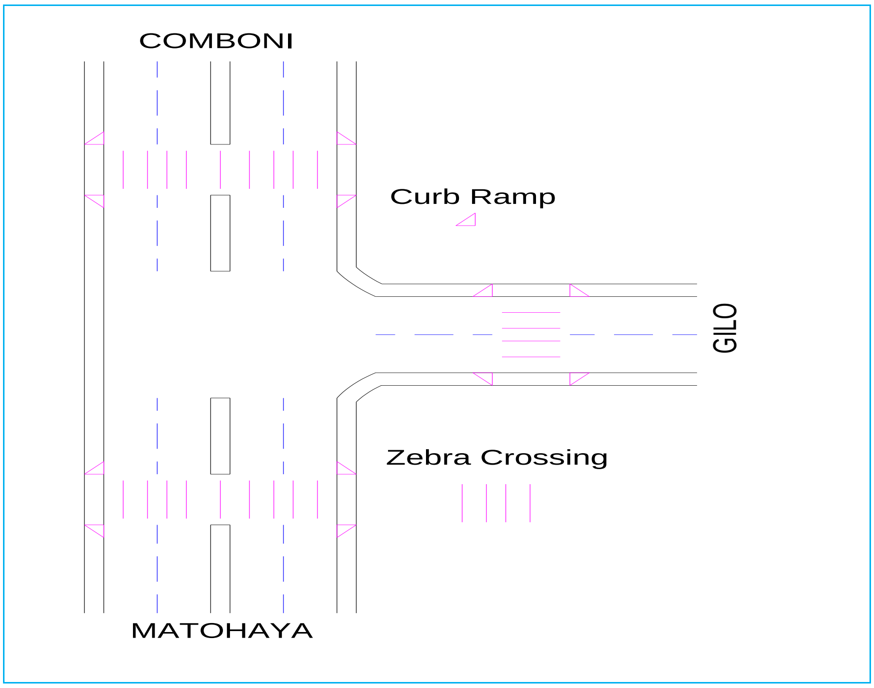

Figure 4.18: Suggested improvement layout of Gogbajomi intersection

4.3.4 **Matohaya Intersection**

Observed problems at Matohaya Intersection

1) Invisible zebra crossing markings
2) Accessible curb ramp was provided on either side of the road
3) Zebra crossing marking was not provide at Gambella Hospital approach and Gilo approach

Figure 4.19: Lack of accessible curb ramp on either side of crosswalk

Figure 4.20: Invisible zebra crossing marking

Suggested remedial measures

1) Accessible curb ramp should be provided on both sides of the road for safe crossing of pedestrians
2) Zebra crossing markings should be improved through routine maintenance and checks
3) Zebra crossing should be provided at Gambella Hospital approach and Gilo approach

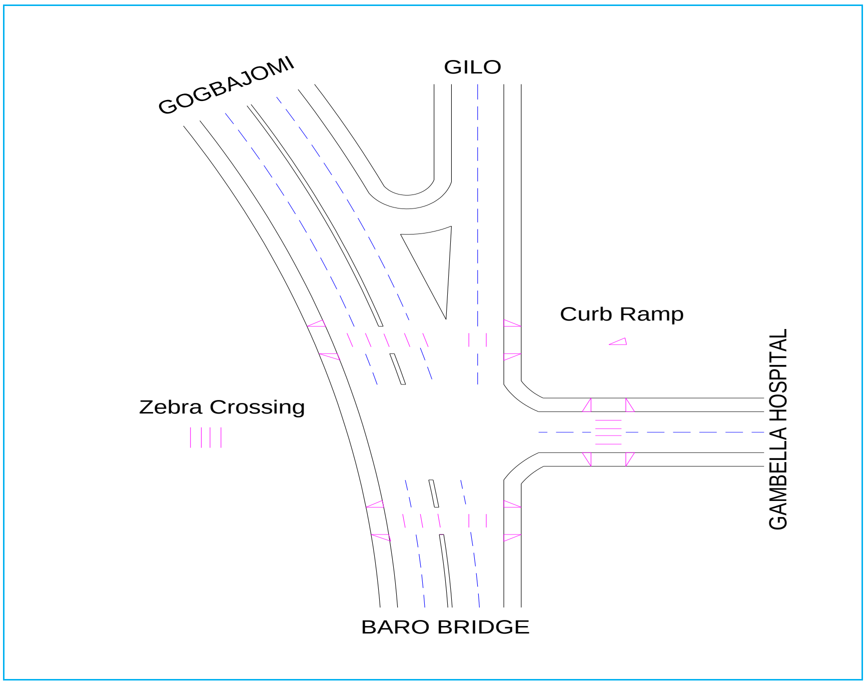

Figure 4.21: Suggested improvement layout of Matohaya intersection

4.3.5 **Ajwomara Roundabout**

Observed problems at Ajwomara Roundabout

1) Accessible curb ramp was provided on either side of the road
2) Invisible zebra crossing markings
3) Crosswalk surface condition was very poor with some cracks and potholes on it
4) There was no raised median at Jabjabe Bridge
5) There was no splitter island at all approaches of the roundabout
6) There was no zebra crossing at Jabjabe Bridge approach

Figure 4.22: Lack of accessible curb ramp on either side of the crosswalk and invisible crosswalk marking

Figure 4.23: Poor crosswalk surface condition

Suggested remedial measures

1) Curb ramp should be provided on both sides of the road for safe crossing of pedestrians
2) Zebra crossing markings should be improved through routine maintenance and checks
3) Crosswalk surface should be improved through routine maintenance and checks
4) Raised median should be provided at Jabjabe Bridge approach
5) Splitter island should be provided at all approaches of the roundabout
6) Zebra crossing should be provided at Jabjabe Bridge approach

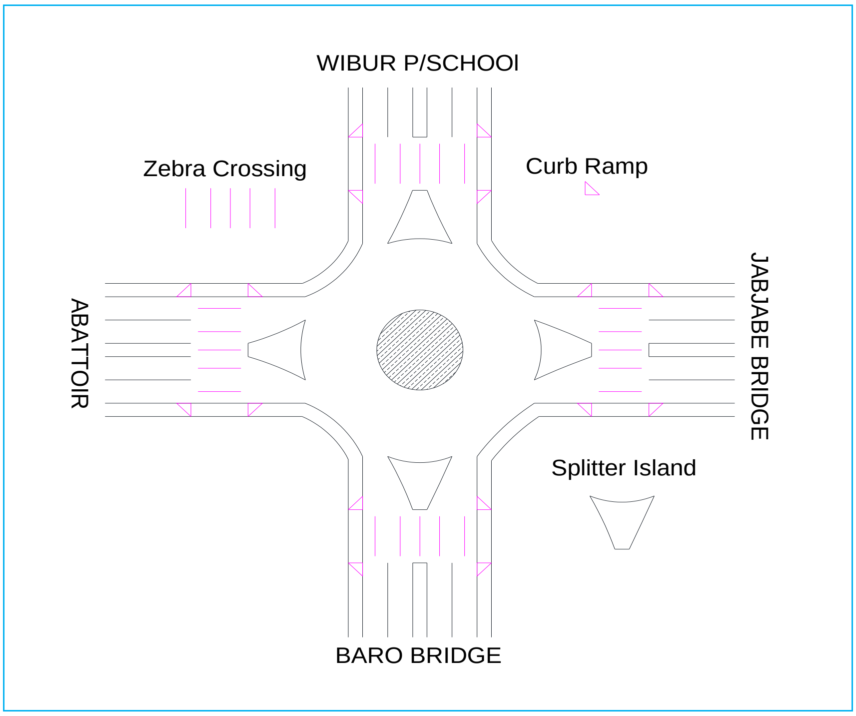

Figure 4.24: Suggested improvement layout of Ajwomara roundabout

4.3.6 **Baro Akobo Intersection**

Observed problems at Baro Akobo Intersection

1) Accessible curb ramp was not provided on both sides of the road
2) Invisible zebra crossing markings
3) Zebra crossing was not provided at Owalinga approach

Figure 4.25: Lack of curb ramp and invisible zebra crossing marking

Suggested remedial measures

1) Accessible curb ramp should be provided on both sides of the road for safe crossing of pedestrians
2) Zebra crossing markings should be improved through routine maintenance and checks
3) Zebra crossing should be provided at Owalinga approach

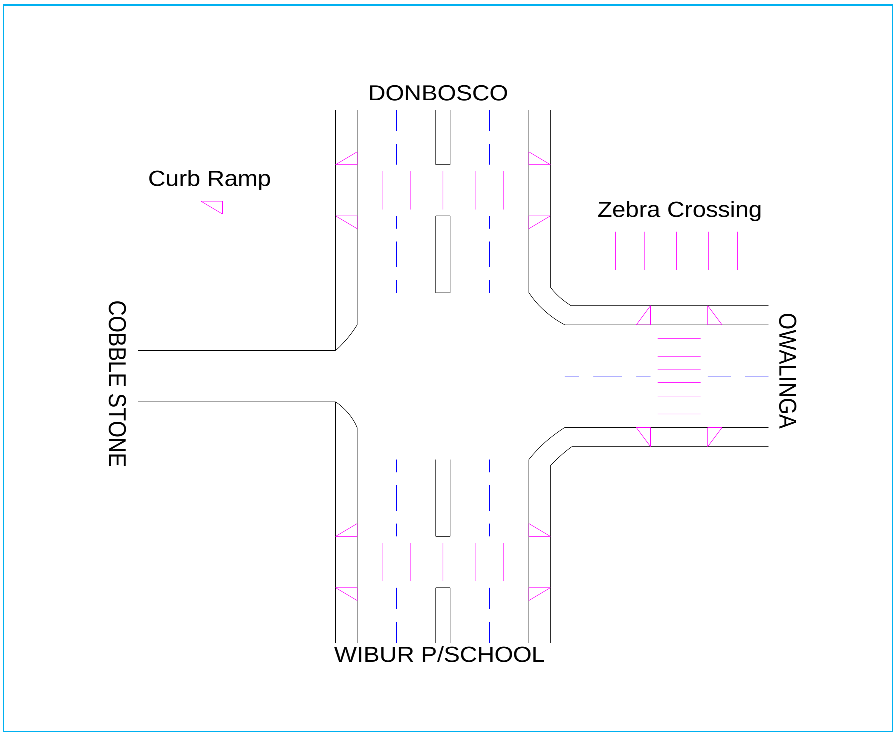

Figure 4.26: Suggested improvement layout of Baro Akobo intersection

4.3.7 **Comparison of existing intersection geometric characteristics with the standards**

Some of the problems of existing intersections observed during field observation were the improper designs of roadway. The existing values of cross section elements of each intersection were measured and compared with ERA geometric design manual, AASHTOO geometric design manual and Gambella town master plan. As shown in the table 4.13 below the measured road width and lane width at each intersection are too wider compared to ERA Standard, AASHTOO standard and Master plan. Wider road width and lane width put pedestrians at higher risk while crossing the road. In addition, the measured median width is less than ERA Standard, AASHTOO Standard and master plan which is not sufficient to accommodate pedestrians waiting to cross the second half of the road.

Table 4.13: Comparison of existing intersection geometric characteristics with ERA, AASHTOO and Master Plan

No.	Roadway Element	ERA Values 2013	AASHTOO Values (2001)	Master Plan Values	Observed Values
1	Road Width	6m-7.3m 6.6m (urban)	6m-7.3m 6.6m (urban)	6m-8m	6.34m-8.34m
2	Lane Width	3m-3.65m 3.3m (urban)	3m-3.65m 3.3m (urban)	3m-4m	3.17m-4.17m
3	Median Width	1.5m-9.2m 5m (urban)	1.2m-24m 3m-6.6m (urban)	3m	1.70m-1.78m

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 **Conclusion**

The present study identified the major factors affecting pedestrian behavior within the road crossing facilities and evaluated the road crossing parameters which influence the movement of pedestrian using regression analysis. Major factors were tested by performing Pearson correlation analysis and also multiple linear regression model was developed to evaluate the influence of road crossing parameters on the movement of pedestrian. Field observation using checklist was also conducted on each crosswalk of the selected intersection in order to suggest remedial measures on how to improve the condition of the existing road layout.

The results of Pearson correlation showed that crosswalk surface condition, crosswalk marking visibility, road width, lane width, number of lanes, crosswalk holding area and curb side parking were found significantly affecting the pedestrian behavior within the road crossing facilities.

On the other hand, the results of Multiple Linear Regression model showed that crosswalk surface condition, crosswalk marking visibility, lane width, number of lanes, crosswalk holding area and curb side parking were found to be statistically significant with a p value less than 0.05 but, road width was excluded from the analysis in SPSS. It was indicated that the effect of road width on the movement of pedestrian can be explained using other variables. Crosswalk surface condition and crosswalk marking visibility were positively correlated with the movement of pedestrian. It is inferred that an increase in the value of crosswalk surface condition and crosswalk marking visibility results in increased pedestrians' movement. In addition, lane width and number of lanes were negatively associated with the movement of pedestrian. It implies that the decrease in the value of lane width and number of lanes increase the movement of pedestrian. Crosswalk holding area was found positively related with the movement of pedestrian. It indicates that as crosswalk holding area increase, there is an increase in the movement of pedestrian. Besides, curb side parking was found negatively correlated with the movement of pedestrian. It shows that the decrease of curb side parking near intersection increase the movement of pedestrian.

The results of field observation showed that poor crosswalk surface conditions, inadequate holding area, invisible crosswalk marking, curb side parking, lack of accessible curb ramp, curb cut, zebra crossing, raised median and splitter island were found as the geometric deficiencies of the crosswalk of intersections. Remedial measures were recommended for poor crosswalk surface conditions, inadequate holding area, curb side parking and invisible crosswalk marking. Furthermore, for lack of accessible curb ramp, curb cut, zebra crossing, raised median and splitter island, AutoCAD Version 2016 was used in order to draw the geometry of each crosswalk at intersection.

5.2 **Recommendation**

The following recommendations of the study are forwarded:

- Crosswalk surface conditions should be improved through routine checks and maintenance.
- Crosswalk markings at intersections should be visible to pedestrians both day and night by routine checks and maintenance.
- Road width and lane width should be provided as minimum as required at the intersections to shorten crossing distance.
- A minimum number of lanes at the intersections should be provided to shorten crossing distance.
- Adequate crosswalk area should be provided for holding or accommodating pedestrians while waiting to cross the road.
- Traffic regulation such as prohibiting curbside parking at intersections and pedestrians' crossings needs to be enforced.
- Median width should be sufficient enough to accommodate pedestrians waiting to cross the second half of the road.

In addition to the above recommendations the following future research area related to this study is also recommended.

- Evaluation of Pedestrian Crossing Behavior at Mid-block

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APPENDIX A

GEOMETRIC DATA COLLECTED ON EACH INTERSECTION

Table A-1: Geometric data for Gilo Roundabout

	Gilo Intersection				
Type	**Roundabout**				
Approach	No. of Lane	Road Width	Lane Width	Median Type	Median Width
Matohaya	2	7.68m	3.84m	Undivided	0
Gogbajomi	2	7.64m	3.82m	Undivided	0
GRRA	2	7.58m	3.79m	Undivided	0

Table A-2: Geometric data for Owalinga Intersection

	Owalinga Intersection				
Type	**Unsignalized Four Leg Intersection**				
Approach	No. of Lane	Road Width	Lane Width	Median Type	Median Width
Baro Akobo	2	7.60m	3.80m	Undivided	0
Tier Kidi	2	8.18m	4.09m	Undivided	0
Omininga	2	7.75m	3.875m	Undivided	0
Ajwomara	2	8.18m	4.09m	Undivided	0

Table A-3: Geometric data for Gogbajomi Intersection

	Gogbajomi Intersection				
Type	**Unsignalized T- Intersection**				
Approach	No. of Lane	Road Width	Lane Width	Median Type	Median Width
Comboni	4	7.58m	3.79m	Divided	1.75m
Matohaya	4	7.60m	3.80m	Divided	1.75m
Gilo	2	7.58m	3.79m	Undivided	0

Table A-4: Geometric data for Matohaya Intersection

	Matohaya Intersection				
Type	**Signalized Four Leg Intersection**				
Approach	No. of Lane	Road Width	Lane Width	Median Type	Median Width
Gogbajomi	4	7.58m	3.79m	Divided	1.75m
Baro Bridge	4	7.58m	3.79m	Divided	1.75m
Gilo	2	7.58m	3.79m	Undivided	0
Gambella Hospital	2	7.60m	3.80m	Undivided	0

Table A-5: Geometric data for Ajwomara Roundabout

	Ajwomara Intersection				
Type	**Roundabout**				
Approach	No. of Lane	Road Width	Lane Width	Median Type	Median Width
Baro Bridge	4	7.58m	3.79m	Divided	1.70m
Wibur PS	4	7.68m	3.84m	Divided	1.70m
Abattoir	4	7.68m	3.84m	Divided	1.75m
Jabjabe Bridge	4	6.34m	3.17m	Undivided	0

Table A-6: Geometric data for Baro Akobo Intersection

	Baro Akobo Intersection				
Type	**Signalized T- Intersection**				
Approach	No. of Lane	Road Width	Lane Width	Median Type	Median Width
Wibur PS	4	8.34m	4.17m	Divided	1.74m
Donbosco	4	7.58m	3.79m	Divided	1.78m
Owalinga	2	7.88m	3.94m	Undivided	0

APPENDIX B

RESULTS OF PEARSON CORRELATION ANALYSIS

Table B-1: Correlation of movement of pedestrian with crosswalk surface condition, crosswalk marking visibility and lighting condition at crosswalk

Correlations

		MOP	CWSC	CWMV	LCCW
MOP	Pearson Correlation	1	-.105*	.321**	-.035
	Sig. (2-tailed)		.040	.000	.496
	N	385	385	385	385
CWSC	Pearson Correlation	-.105*	1	-.319**	.108*
	Sig. (2-tailed)	.040		.000	.035
	N	385	385	385	385
CWMV	Pearson Correlation	.321**	-.319**	1	-.817**
	Sig. (2-tailed)	.000	.000		.000
	N	385	385	385	385
LCCW	Pearson Correlation	-.035	.108*	-.817**	1
	Sig. (2-tailed)	.496	.035	.000	
	N	385	385	385	385

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table B-2: Correlation of movement of pedestrian with crosswalk surface condition, crosswalk marking visibility and lighting condition at crosswalk

Correlations

		MOP	RW	LW	NOL
MOP	Pearson Correlation	1	-.282**	-.283**	-.382**
	Sig. (2-tailed)		.000	.000	.000
	N	385	385	385	385
RW	Pearson Correlation	-.282**	1	1.000**	.110*
	Sig. (2-tailed)	.000		.000	.030
	N	385	385	385	385
LW	Pearson Correlation	-.283**	1.000**	1	.109*
	Sig. (2-tailed)	.000	.000		.032
	N	385	385	385	385
NOL	Pearson Correlation	-.382**	.110*	.109*	1
	Sig. (2-tailed)	.000	.030	.032	
	N	385	385	385	385

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table B-3: Correlation of movement of pedestrian with crosswalk surface condition, crosswalk marking visibility and lighting condition at crosswalk

Correlations

		MOP	DYB	CWHA	CSP
MOP	Pearson Correlation	1	-.022	.211**	-.116*
	Sig. (2-tailed)		.669	.000	.023
	N	385	385	385	385
DYB	Pearson Correlation	-.022	1	.428**	.467**
	Sig. (2-tailed)	.669		.000	.000
	N	385	385	385	385
CWHA	Pearson Correlation	.211**	.428**	1	.351**
	Sig. (2-tailed)	.000	.000		.000
	N	385	385	385	385
CSP	Pearson Correlation	-.116*	.467**	.351**	1
	Sig. (2-tailed)	.023	.000	.000	
	N	385	385	385	385

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX C

RESULTS OF MULTIPLE LINEAR REGRESSION ANALYSIS

Table C-1: Output of model summary of the developed MLR model

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.880[a]	.775	.771	.269

a. Predictors: (Constant), Curb side parking, Number of lanes, Crosswalk marking visibility, Lane width, Crosswalk surface condition, Crosswalk holding area

b. Dependent Variable: Movement of pedestrian

Table C-2: Output of ANOVA for the developed MLR model

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	74.761	6	12.460	100.501	.000[b]
	Residual	46.865	378	.124		
	Total	121.626	384			

a. Dependent Variable: Movement of pedestrian

b. Predictors: (Constant), Curb side parking, Crosswalk marking visibilty, Lane width, Number of lanes, Crosswalk surface condition, Crosswalk holding area

Table C-3: MLR output

Coefficients[a]

Model		UC		SC	t	Sig.	Collinearity	
		B	SE	Beta			T	VIF
1	(Constant)	4.623	.475		9.742	.000		
	CWSC	.297	.043	.264	6.914	.000	.700	1.428
	CWMV	.809	.046	.699	17.765	.000	.658	1.521
	LW	-.914	.130	-.290	-7.011	.000	.596	1.677
	NOL	-.373	.020	-.657	-18.384	.000	.799	1.251
	CWHA	.296	.043	.271	6.848	.000	.649	1.541
	CSP	-.177	.038	-.194	-4.691	.000	.597	1.675

a. Dependent Variable: Movement of pedestrian

Table C-4: Excluded variable in the SPSS

Excluded Variables[a]

Model	Beta In	t	Sig.	PC	Collinearity		
					T	VIF	MT
1 RW	20.799[b]	3.359	.001	.170	2.588E-5	38643.025	2.588E-5

a. Dependent Variable: Movement of pedestrian

b. Predictors in the Model: (Constant), Curb side parking, Crosswalk marking visibility, Lane width, Number of lanes, Crosswalk surface condition, Crosswalk holding area

Table C-5: Cook's Distance values

Cook's Distance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00001	16	4.2	4.2	4.2
	.00007	22	5.7	5.7	9.9
	.00007	22	5.7	5.7	15.6
	.00054	16	4.2	4.2	19.7
	.00058	16	4.2	4.2	23.9
	.00062	16	4.2	4.2	28.1
	.00069	16	4.2	4.2	32.2
	.00070	16	4.2	4.2	36.4
	.00074	22	5.7	5.7	42.1
	.00082	16	4.2	4.2	46.2
	.00101	22	5.7	5.7	51.9
	.00155	13	3.4	3.4	55.3
	.00180	16	4.2	4.2	59.5
	.00211	20	5.2	5.2	64.7
	.00221	22	5.7	5.7	70.4
	.00258	16	4.2	4.2	74.5
	.00300	22	5.7	5.7	80.3
	.00355	20	5.2	5.2	85.5
	.00551	16	4.2	4.2	89.6
	.00620	20	5.2	5.2	94.8
	.01079	16	4.2	4.2	99.0
	.04563	4	1.0	1.0	100.0
	Total	385	100.0	100.0	

APPENDIX D

QUESTIONNAIRE SURVEY

Pedestrian Questionnaire

This questionnaire is designed to gather specific information which will help to evaluate pedestrian behavior at the different road crossing facilities in Gambella town, in Partial Fulfillment of the Requirements for the Degree of Master of Science in Highway Engineering. The information that you will provide to me will be of significant for the successful completion of this study. Therefore, I am here by kindly requesting your cooperation to give genuine information.

Section 1: Personal Details

Gender Male ☐ Female ☐

Age Less than 18 ☐ 18-25 ☐

26-35 ☐ 36-50 ☐

Above 50 ☐

Level of Education Illiterate ☐ Primary School ☐

Secondary School ☐ Diploma ☐

Degree ☐ Above Degree ☐

Occupation Labor ☐ Civil servant or public servant ☐

Businessman or woman ☐

Section 2: Identification of major factors affecting the pedestrian behavior causing accident within the road crossing facilities

Which of the following do you think are the major factors affecting the pedestrian behavior causing accident within the road crossing facilities? Please rank the factors in order of importance as per the scale shown in the table below.

	0	1	2			
	Not Important	Moderately Important	Important	Answer		
Item No.	Parameters			0	1	2
1	Crosswalk surface condition					

2	Crosswalk marking visibility			
3	Lighting condition at crosswalk			
4	Road width			
5	Lane width			
6	Number of lane			
7	Driver yielding behavior			
8	Crosswalk holding area			
9	Curb side parking			

Section 3: Evaluation of road crossing parameters which influence the movement of pedestrians

Which of the following road crossing parameters do you think influence the movement of pedestrians? Please rank the parameters in order of quality as per the scale shown in the table below.

Item No.	Parameters					
1	0	1	2	Answer		
	Poor	Moderate	Good			
				0	1	2
	Crosswalk surface condition					
2	0	1	2	Answer		
	Not Visible	Slightly visible	Highly visible			
				0	1	2
	Crosswalk marking visibility					
3	0	1	2	Answer		
	Poor	Moderate	Good			
				0	1	2
	Lighting condition at crosswalk					
4	Road width			This part is left for the researcher		
5	Lane width					
6	Number of lane					
7	0	1	2	Answer		
	Poor	Moderate	Good			
				0	1	2
	Driver yielding behavior					
8	0	1	2	Answer		
	Holding area not available	Not sufficient to accommodate pedestrian	Sufficient to accommodate pedestrian			
				0	1	2
	Crosswalk holding area					
9	0	1	2	Answer		
	Most crossing	Some crossing	Most crossing			

	points are blocked	points are blocked	points are not blocked			
				0	1	2
	Curb side parking					

Finally, would you please give a score of level of difficulty of movement while using this crosswalk based on your experience from 0 to 10; where, [0-Extremely difficult to cross] and [10-Very comfortable to cross]

0	1	2	3	4	5	6	7	8	9	10

APPENDIX E

CHECK LIST

OBSERVATION CHECK LIST

Are crosswalk surfaces in good condition?

Are crosswalk markings visible enough to be seen by both driver and pedestrian?

Are there curb cuts and curb ramps at all crosswalk points?

Are there parked vehicles which reduce sight distance at intersection?

Is sufficient holding area provided at each crosswalk location?

Are medians and splitter islands of enough width provided at all approaches of roundabout?

Are zebra crossings provided at all crosswalk locations?