An Analysis of Pedestrian Traffic Safety in Public School Zones in Cagayan de Oro City

Jefferson Jr VALLENTE [a], Ferven CABUGAO [b], Anabel ABUZO [c]

[a,b,c] *Civil Engineering Department, Xavier University – Ateneo de Cagayan, Cagayan de Oro , 9000, Philippines*
[a] *E-mail: jvallente@xu.edu.ph*
[b]*E-mail: fcabugao@xu.edu.ph*
[c]*E-mail: aabuzo@xu.edu.ph*

Abstract: Pedestrian accident data from local agencies in Cagayan de Oro shows how unsafe the roads are especially to school children. In studying the five representative schools based on accident and traffic data, an assessment such as on a non-modified walkability with a rating at 49.93 indicates that school zones are poor with respect to the pedestrian infrastructures, facilities and motorist traffic behavior. Results on vehicle speed have shown that most vehicles have failed to observe the desired speed limit of 20kph based on the local traffic code for most school zones. Furthermore, a GIS-based Pedestrian Accident Risk model with a kernel smoothing interpolation was designed by incorporating traffic data, walkability and exposure factors shows moderate to high risk of pedestrians on all schools.

Keywords: Pedestrian Risk, Walkability, Pedestrian Facilities, School Zone, GIS, Accidents.

1. INTRODUCTION

Road Transportation provides benefits both to a nation and individuals by facilitating the movement of goods and people. It enables increased access to jobs, economic markets, education, recreation and health care which in turn have direct and indirect positive impacts on the health of populations (World Heath Organization, 2009). However, hypermobility according to Schiller et al. (2010) which is the increase in more driving, longer trips for people and rapid urbanization coupled with the increase in vehicle ownership especially motorcycles among third world countries poses undesirable consequences and considerable pressure on road safety, traffic congestion and traffic control devices. Congested roads and poor facilities for pedestrians are the most pervasive transport problems affecting cities in developing countries of which 73.4% of infrastructure deficiencies in Asian cities as perceived by local experts have poor facilities for pedestrians (UN-Habitat, 2013).

Various undesirable consequences of hypermobility and urbanization in many cities have made planners realize that attempts to only encourage city growth by improving facility performances impose greater social costs than benefits. In emerging cities like Cagayan de Oro the trend of reported accidents though independent in nature from each year shows a decreasing trend for a five year analysis as shown in figure 1. Studies in major metropolitan areas in the country also shows the same trend but the issue of underreporting as shown by ADBs report on road traffic accidents in the country misrepresents the real issue (Asia Development Bank, 2010). While road safety is improving in developed countries, the situation seems to be getting worse in third world countries, where providing transportation infrastructure such as roads are geared toward improving the mobility of people is prioritized. According to Sigua and Palmiano (2005) the issue on pedestrian road safety especially in the Philippines shows that very young people at 15 years old and below comprises the most vulnerable age group. Also, fatalities due to road accidents are frequent in third world countries comprising 90% of the world's road fatalities of which majority are road users. Policies and institutions related to pedestrians and walking environments in Asia shows that generally, there is lack of relevant policies dedicated to institutions and political support that cater the needs of the pedestrians (Leather, Fabian, Gota, & Mejia, 2011).

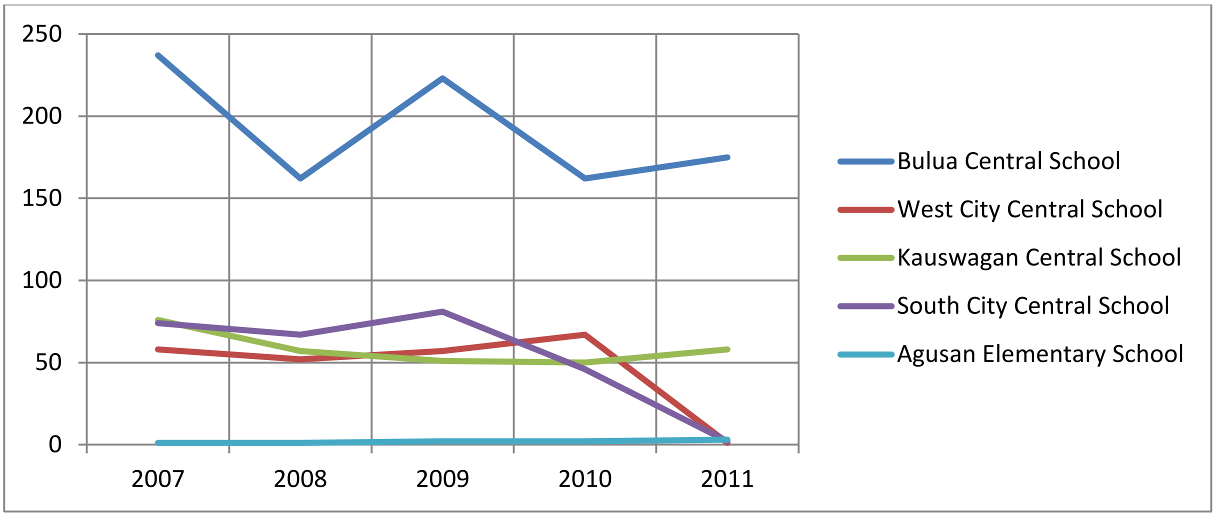

Figure 1. Road accidents in the top five selected pedestrian generator schools in the city

Pedestrians especially children are among the most vulnerable road users as they travel to and from school. Even so, road traffic injuries in school zones are poorly recorded; in fact the national road accident database is prone to errors as these tasks are done manually (ADB-ASEAN Regional Road Safety Program, 2010). Strong public awareness is also non-existent and needs to be initiated, concerned agencies that should monitor and/or preserve traffic safety for children needs to enforce existing standards in order to accommodate the growing population of cities, control the growth of hypermobility and develop sustainable transportation modes. However, third world countries like the Philippines have poor implementation on traffic safety and road maintenance, such as dilapidated pavement signs and markings traffic signs and signals. The government's response to these issues is not as immediate as its response to other equally imperative issues. Furthermore, road accident underreporting in the Philippines is a huge issue of which undermines the government from doing actions. Such figures are evident by a report by ADB (2010) which emphasizes an alarmingly high cost of road accidents.

Since road and traffic maintenance poses a problem, increasing traffic accidents poses grave threat to most road users. The unreliable data on road accidents also mislead government officials at multi-level as to the real nature of road safety in the country. Several studies have been proposed regarding pedestrian risk such as a study by Lassarre (2006) et.al. which proposes accident risk based from the the concept of risk exposure. This study however attempts to incorporate indicators such as exposure, vulnerability and hazard. With this issues being considered, this research aim to develop a model to identify risks in schools while integrating traffic, pedestrian facilities, basic traffic orientation and the general road environment. To quantify pedestrian accidents in cost for future engineering mitigation measures a simple multiple regression models was also developed taking into consideration the current accident rate, vehicle registration and the school population.

2. REVIEW OF RELATED LITERATURE

Road accidents in most Asian countries rank as one of the most fatal causes of mortality, this is evident in a report made by the International Federation of Red Cross and Red Crescent Societies (IFRC) which reveals that road accident kills 3,000 people every day of which eighty-six (86%) percent of the fatalities are among developing countries. This situation is an escalating issue on the health, social and economic disaster for developing and transition countries (Global Road Safety Partnership). Furthermore, in the Philippines alone over 96,000 Filipino children are killed or injured on the road, while 35,000 are injured while they walk on roads. As many as 11 Filipino children are killed or injured on the road and four Filipino children are injured while walking on roads (Consunji, 2005).

Road traffic injuries place a heavy burden, not only on global and national economies but also household finances. Many families are driven deeply into poverty by the loss of breadwinners and the added burden of caring for members disabled by road traffic injuries (WHO, 2004). A study made by Murray, Palmer and Sayer (2000) revealed an average, 20 percent of all people killed in traffic accidents in developing countries are aged under 15. This is twice as high as in the developed world. Roads in developing countries are often more unsafe roads in industrial countries and the traffic safety problems faced by the children will often be greater in the developing world. Absence of traffic education can leave children exposed to unnecessary risk. Since the traffic circumstances and problems faced by such children are very different, it is inappropriate to simply use teaching materials from developed countries. Local materials need to be developed. Although these may be based on principles and materials from developed countries, they will need to be adapted to reflect the needs, problems, and circumstances of relevance to local children.

2.5 GIS Risk Mapping

The approach of using GIS based maps is prevalent in DRRM (Disaster Risk Reduction Management). Researches made by Lo & Oreta (2011), Lo et. al 2009) and Angeles et. al. (2012) provided extensive use of GIS in risk mapping for disasters. The framework of these researches is derived from the HEVR equation otherwise known as the Risk equation which was also used by the proponents of this study. Using GIS together with Spatial Analysis spatial pattens of accidents using exploratory spatial analysis methods based on local measures (Kernel density estimation clusters) allows to map the distribution of accidents and to select sites which deserve further investigations (Banos & Richard, 2000). Combination of GIS and spatial Statistics have also been introduced which has given relevant contribution to spatial identification of accident hotspots (Truong & Somenahalli, 2011). Spatial analysis on road accidents an d perception survey integration on treating locations for crash concentrations are well developed by Schneider, Ryznar, and Khattak (2001), furthermore they developed a model on spatial approach for recommending measures for improving pedestrian safety. According to Driss et.al. (2012) by means of local index of spatial autocorrelation an index of dangerousness can be identified, the intensity of the dangerous character depends on the value of the index, while the length of the black zones depends on the number of neighbouring pieces taken into account in calculating the index.

2.6 Walkability in Asian Cities

There are many different ways to consider “walkability” (Krambeck, 2006). In well developed countries, walkability discussions are focused on encouraging mode shifts from motorized to non-motorized vehicles for short trips, or on promoting walking as a healthy leisure activity. Whereas is developing countries, walking is often considered in terms of providing mobility for the poorest residents. Some urban planners tend to think of walkability in terms if a city's spatial land use arrangement, favoring mixed-use zoning over segregated uses Krambeck (2006) added.

For most Asian countries Walkability is measured using the Asian Walkability Index (AWI), this survey involved rating road stretches from 1to 5 for each parameter (1 being the lowest and 5 the highest) in each area types. The averages for each of the parameters were translated into a rating system from 0 (lowest score) to 100 (highest score). The method of deriving the "walkability rating" in this study differs from the GWI as the latter is influenced by the number of people walking (pedestrian count) during the time of the survey and the length of the stretch being surveyed. One of the limitations of the field walkability surveys is the subjectivity of responses, as they greatly depend on the individual assessments of the surveyor, especially in this case, where there were various organizations and individuals involved in carrying out the surveys.

A recent walkability survey of Asian countries assessed by ADB has found out that the average walkability rating in the educational areas is 54.81 out of 100. This is very significant as accident statistics often show that school children are prone to road accidents. This suggests that schools and colleges may not provide quality sidewalks or convince city authorities to further improve the pedestrian environment in their vicinity (Leather, Fabian, Gota, & Mejia, 2011).

3. METHODOLOGY

Related researches on site specific pedestrian risk analysis is important before implementing traffic engineering measures but methodologies are quite few most especially on focusing communities and vulnerability which is used in disaster risk analysis. Also, measures do not address a holistic solution for pedestrian accidents. This analysis is favored to be used by the researchers instead of complicated equations since the adaptability of local government officials with the disaster framework is more pronounced and institutionally integrated at all levels. Pedestrian Risk Index as used in this research utilizes vulnerability assessment is defined as "a set of conditions and processes resulting from physical, social, economical and environmental factors, which increase the susceptibility of a community to the impact of disasters" (UNISDR, 2007). Calculating for a pedestrian risk score is normalized for a range values within 0 to 1.000 across all scores. A normalization scheme will enable a range of values of not greater than 1.000 which was used for the classification of the pedestrian risk intensity (i.e. low, medium and high). For each parameter namely exposure and vulnerability, the classification utilizes a feature scaling normalization procedure of rating using equation 1 the indices using the standard values such as from walkability, accident occurrence, and pedestrian density. Moreover, the usage of the vulnerability context can be used to identify different components of the pedestrian risk.

$$x' = \frac{x - \min(x)}{\max(x) - \min(x)} \tag{1}$$

where,

x' : the value for a certain survey area
min(x) : minimum value for every parameter
max(x) : maximum value for every parameter

Based on the preliminary analysis on on-site selection South City Central School, West City Central School, Bulua Central School, Kauswagan Central School and Agusan School were chosen. A questionnaire based sampling survey was used to assess the basic orientation of selected students.

The research methodology integrates traffic data, pedestrian facility investigation walkability based on the study of (Leather, Fabian, Guta, & Mejia, 2011) and vulnerability factors from the schools socio-demographic data in which the study involved four (4) phases. First, a site selection involved a set of criteria which was based on the traffic volume, road accidents, school population and proximity of schools to arterial roads. Second, after selecting five (5) critical schools a primary data collection involving traffic volume count, speed survey, walkability survey and pedestrian count survey were used, also secondary data from various government agencies were compiled. Third a data analysis using the risk was adjusted to fit into a pedestrian risk equation which was used to determine risk prone within school zones. A walkability analysis using the Asian Walkability Index was also used determine how safe and convenient school zones are to pedestrians. Fourth and the last phase involved recommendations such as engineering measures which can be applied in school upon consideration of the apparent costs that these mitigations may incur, the measures to be considered are the standard but often non-existent measures within the school zones.

$$PRi = Hs \times Ps \times Vs \tag{2}$$

where,

PRi : pedestrian risk index,
Hs : hazard score,
Ps : population score,
Vs : vulnerability score,

Hazard score is defined by historical pedestrian accident factor, traffic volume factor and vehicle speed factor. Since all schools have a history of pedestrian accidents the score for all schools is 1.000. The scoring for traffic volume factor varies for every school with a normalization factor which is based on both the maximum and minimum traffic volume available for the city. The same procedure is also used for vehicle speed which varies significantly based on vehicle traffic characteristics of the roads adjacent to the chosen schools.

$$Hs = Pa(1 + (TVf + VSf) \leq 1.000 \tag{3}$$

where,

Pa : pedestrian accident hazard score, and
TVf : traffic volume factor
VSf : vehicle speed factor

A vulnerability scoring was also utilized which integrates the sociologic factors taken from the National Statistics Coordination Board data. Sociologic factors include the economic capacities of the greater population of the city taking into consideration that those who belong at most to the poverty threshold has the least capacity to handle injuries and death from road accidents.

$$Vs = PFfx(1 + BTOf) \leq 1.000 \tag{4}$$

where,

PFf : physical facility factor, and

BTOf : basic traffic orientation factor

A computation of basic traffic orientation also considers a difficulty index to calculate not the intelligence of the students but mostly on the basic traffic orientation that the school children were taught. Moreover, the physical factor is based on the pedestrian facility assessment based on the walkability scores. After computations were made and setting the threshold values based on different scenarios a spatial analysis is enforced using a GIS model done in ArcGIS version 10.0 which estimates the overall risk values of a given area. Kernel density or estimation function was utilized due to its ability to statistically identify significant accident locations using the pedestrian risk values. Apart from selecting the sample points taken in the survey of the pedestrian infrastructures an interpolation calculation using kernel smoothing has been used to produce a spatial analysis of nearby areas. Specific engineering measures considering local standards for pedestrian safety are to be selected based on the pedestrian risk model results.

4. RESULTS AND DISCUSSIONS

Walkability field survey result shows an overall ranking of 49.93 for pedestrian facilities for five representative schools in Cagayan de Oro City. The passing value of 60.00 which is based from the walkability score thresholds of the Asian Walkability Index (Leather, Fabian, Guta, & Mejia, 2011) shows that all five (5) schools have poor ratings as shown in Table 1. These would mean that further development in pedestrian infrastructure and better management and enforcement of traffic rules and regulations are needed for these facilities.

Table 1. Walkability Field Survey Results

Parameter	Bulua Central School	**Kauswagan Central** School	West City Central School	South City Central School	Agusan Elementary School
1. Walking Path Modal Conflict	63	56	60	66	48
2. Availability Of Walking Paths	60	36	58	29	36
3. Availability Of Crossings	60	40	55	20	28
4. Grade Crossing Safety	69	56	55	69	48
5. Motorist Behavior	60	60	68	69	56
6. Amenities	66	40	60	40	32
7. Disability Infrastructure	26	20	45	20	20
8. Obstructions	51	32	48	43	36
9. Security from Crime	77	68	60	40	56
Walkability Score	59	45	56	44	40
Rating	Bad	Bad	Bad	Bad	Bad

Taking into consideration the risk model results, each component were also scored to produce a final Pedestrian Risk Index (PRi). The results indicate that schools are exposed to medium to high risk especially at road intersections where most schools are located. Attached also in the appendices are the GIS kernel smoothing spatial interpolation results. The sample point values of the spatial interpolation results as observed in Table 2 which shows most school zones at medium to high levels of risk. The schools with the highest risk results are observed in Figure 2 - Agusan Elementary School and Figure 2 - Bulua Central School, as observed from the spot speed analysis from Table 3 both of this schools' roads fail to allow a designated speed limit. One factor for this result is due to the fact the this schools are located in a major roadway.

Table 2. Pedestrian Risk Index Results

Location	Risk Component				Remarks
	Vulnerability	Exposure	Hazard	Pri	
Bulua Central School					
BP1	0.758	0.833	1.000	0.632	Medium
BP2	0.821	0.417	1.000	0.342	Medium
BP3	0.744	0.306	1.000	0.227	Medium
BP4	0.771	0.231	1.000	0.178	Medium
BP5	0.771	0.297	1.000	0.229	Medium
BP6	0.771	1.000	1.000	0.771	High
West City Central School					
WC1	0.802	1.000	1.000	0.802	High
WC2	0.802	0.500	1.000	0.401	Medium
WC3	0.829	0.400	1.000	0.332	Medium
WC4	0.829	0.325	1.000	0.269	Medium
WC5	0.788	0.400	1.000	0.315	Medium
WC6	0.816	0.370	1.000	0.302	Medium
WC7	0.802	0.445	1.000	0.357	Medium
WC8	0.816	0.395	1.000	0.322	Medium
Kauswagan Central School					
KC1	0.785	0.172	1.000	0.135	Medium
KC2	0.832	0.239	1.000	0.199	Medium
KC3	0.881	0.258	1.000	0.228	Medium
KC4	0.881	1.000	1.000	0.881	High
KC5	0.821	0.108	1.000	0.089	Medium
South City Central School					
SC1	0.797	1.000	1.000	0.797	High
SC2	0.863	0.150	1.000	0.129	Medium
SC3	0.821	0.064	1.000	0.074	Medium
SC4	0.832	0.089	1.000	0.041	Medium

SC5	0.821	0.050	1.000	0.041	Medium
SC6	0.853	0.097	1.000	0.083	Medium
SC7	0.853	0.131	1.000	0.111	Medium
Agusan Elementary School					
AE1	0.864	1.000	1.000	0.864	High
AE2	0.911	0.208	1.000	0.190	Medium
AE3	0.894	0.208	1.000	0.190	Medium
AE4	0.875	0.097	1.000	0.085	Medium
AE5	0.911	0.117	1.000	0.106	Medium

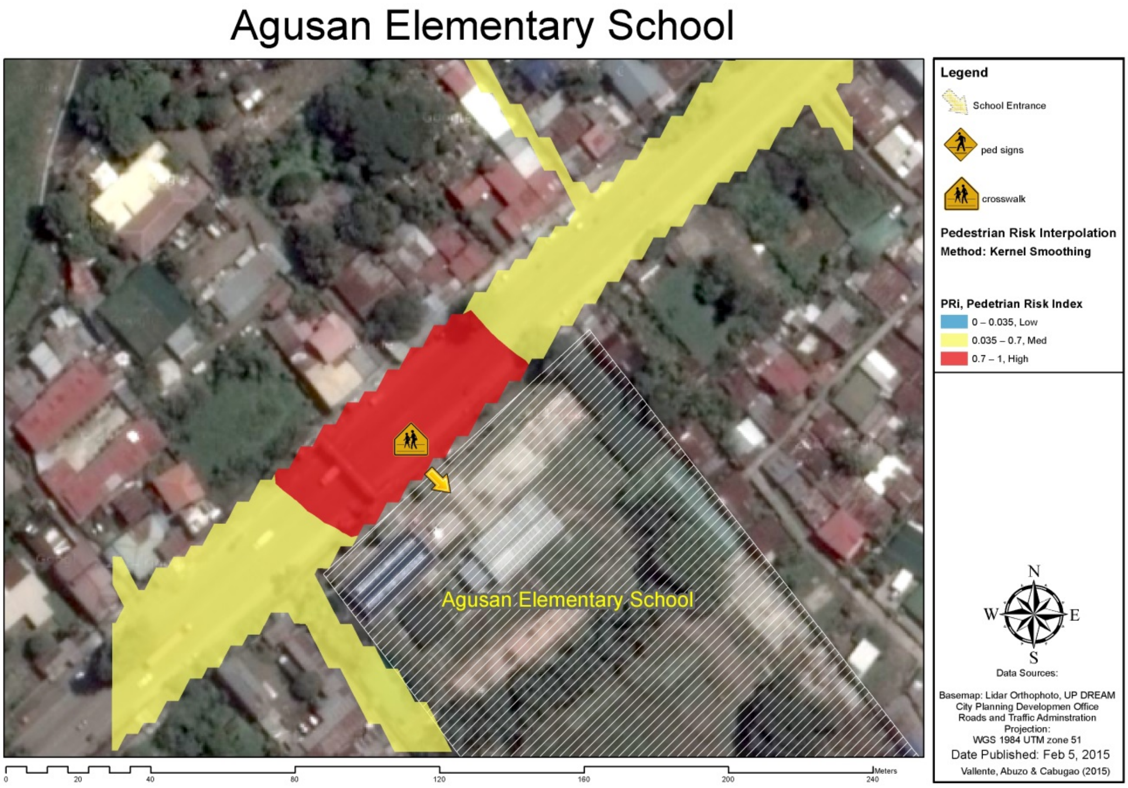

Figure 2. GIS with kernel smoothing result for Agusan Elementary School

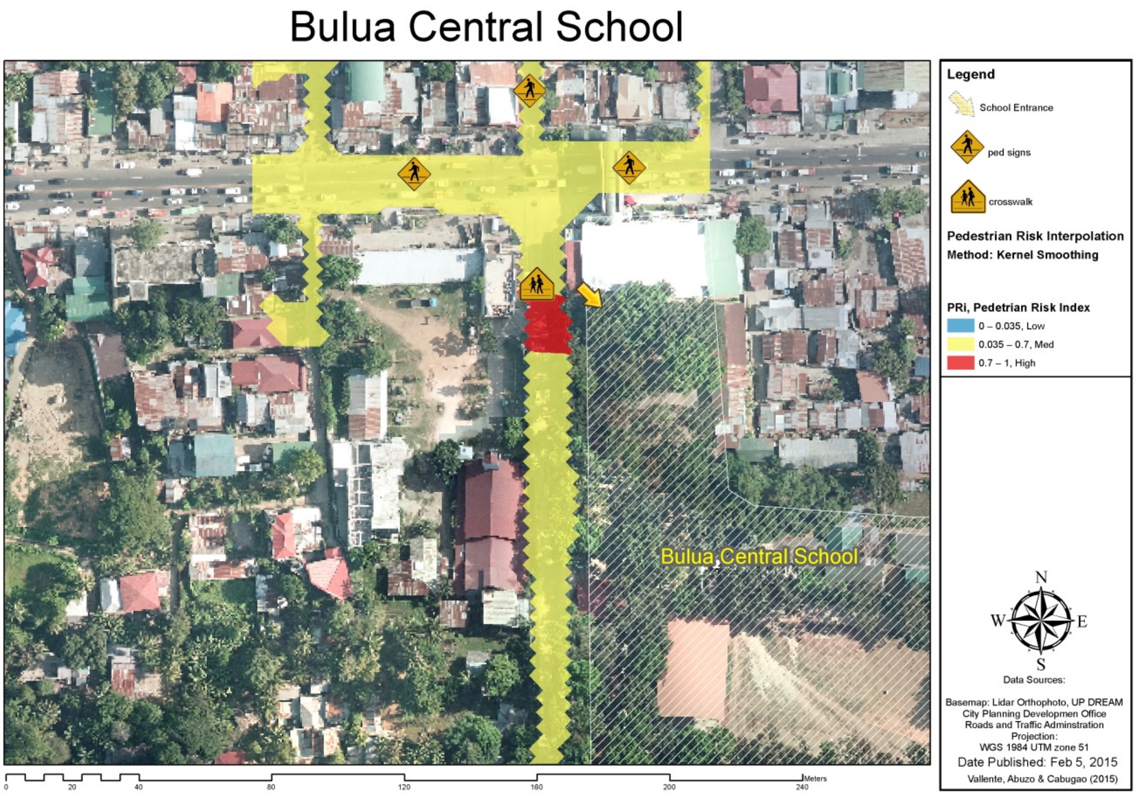

Figure 3. GIS with kernel smoothing result for Bulua Central School

Table 3. Spot Speed Results

Location	School Name	Average Speed 50th Percentile (kph)	Average Speed 85th Percentile (kph)
Kauswagan Road	Kauswagan Elementary School	20	27
Rotunda Bridge	West City Central School	35	41
21st St. Nazareth	South City Central School	25	21
Agusan Highway	Agusan Elementary School	35	35
Bulua Highway	Bulua Central School	45	46

5. CONCLUSIONS

The results showed that the vehicles passing along these schools have failed to observe the desired speed limit in school zones as stated in Traffic Code of Cagayan de Oro. The Walkability field survey shows an overall ranking of 49.93 for pedestrian facilities for five representative schools in CdeO which would mean that further development, management and enforcement is needed for these facilities for a safer pedestrian infrastructures. From the results acquired in the difficulty index and from the standard z-score, all schools find the need for traffic safety education. Also based from the Multiple Linear Regression models most roads adjacent to schools will experience an increase in population, vehicle registration and deteriorating pedestrian facilities influences the increase in accident rates. With regards to thee recommendations for the specific needs to improve the safety of the primary students of the following schools:

1) Use clear and obvious signs.
2) Pedestrian crossing (white lines across streets) for safety of the school children shall be established in front of school gates.
3) Proper enforcement and assistance to children in crossing the streets should be considered to avoid accidents in the accident hot spots.
4) Drivers shall observe a careful and prudent speed of 20kph approaching pedestrian facilities and 30kph when passing through school zone area as stipulated in the local traffic code. The use of traffic calming facilities such as humps to reduce speed shall be provided in school zone areas before pedestrian facilities.

6. ACKNOWLEDGEMENT

We wish to thank the Department of Education Cagayan de Oro City, Roads and Traffic Administration, Xavier University Engineering Resource Center, Civil Engineering Department of Xavier University, Engr. Alech Madeleine Abogado and Engr.Yvanie Yorvania Ebana. To them we would like to express our deep gratitude for their generous support in this academic research

7. REFERENCES

Ares, L. E., Sigua, R. G. (1999). Pedestrian Accident Analysis Measuring Accident Potential at Intersection. *Future Direction of Transportation Policies* , 1-17.

Asia Development Bank. (2010). *ADB-ASEAN Regional Road Safety Program: The cost of road traffic accidents in the Philippines.* Manila: Asian Development Bank.

Asian Development Bank. (2010). *Road Safety Education for Children.* Retrieved May 4, 2012, from Asia Development Bank: http://www.adb.org

Department of Public Works and Highways. (2005). *Current Efforts by the Public Sector that Address the Road Safety Problem.* Manila: DPWH.

Leather, J., Fabian, H., Guta, S., & Mejia, A. (2011). *Walkability and Pedestrian Facilities in Asian Cities: State and Issue.* Mandaluyong City: Asian Development Bank.

Palmiano, H. S. (2008). 5th Road Safety Conferences. *University of the Philippines - National Center for Transportation Studies.* Manila: UP-NCTS.

Pyta, V., & McTierman , D. (2010). Development of a model for Improving Safety in School Zones. *Australian Road Safety Research, Policing and Education Conference.* Caberra.

Schiller, P. L., Bruun, E. C., & Kenworthy, J. R. (2010). *An Introduction to Sustainable Transportation: Policy, Planning and Implementation.* London: Earthscan.

Sigua, R. G., & Palmiano, H. S. (2005). Assessment of road safety in the ASEAN region. *Eastern Asia Society for Transportation Studies* , *5*, 2032-2045.

"Traffic Code of the city of Cagayan de Oro". (ON 10551-2007). Text from: Article VII. Office of the City Council. PP 14-20.

UN-Habitat. (2013). *State of the World's Cities 2012/2013.*

UNISDR. (2007). Retrieved February 19, 2014, from UNISDR: http://www.unisdr.org/files/5654_DRRtoolsCCAUNFCC.pdf

WHO. (2004). *World report on road traffic injury prevention.* Geneva: Worl Health Organization.

World Heath Organization. (2009). *Global status report on road safety: time for action.* Retrieved April 24, 2012, from http://www.who.int/violence_injury_prevention/road_safety_status/2009)