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Potential Effect of Traffic Signalling System in Catbalogan City, Philippines

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Abstract: The increasing volume of traffic suggests an improving economy. On the other hand, worsening traffic may cause negative economic and environmental consequences. One way of managing traffic is with the use of signalling system. The study examined the potential effect of signalling system on key intersections in the City of Catbalogan, Philippines using SYNCHRO Studio 8.0. The three scenarios tested in the study include the current traffic condition, traffic without Rickshaw (pedicab) and a situation where Rickshaw was replaced with motorized tricycles. Using traffic signalling systems have improved traffic flow of Curry Avenue – Del Rosario St. and Curry Avenue – San Roque St while San Roque-Mabini Avenue intersection showed unfavorable results. The removal of Rickshaw improves traffic flow but replacing it all with motorized tricycle will result in severe traffic and negative environmental consequences.

Keywords: traffic lights, pollution, travel time, traffic management, traffic simulation

1. Introduction

Emerging cities experiences about traffic today is almost similar to post World War II scenario of now first world countries like those in Europe. Traffic in towns is a problem even before the days of motorized vehicles (Headicar, 2015). Communities derive their economic and social rationale from being the center of activities, but as they grow the movement, the conditions of streets worsen affecting everyone (ibid). As the country improves its socio-economic situation, so is the people's capacity to buy vehicles increases. In Metro Manila, car registration has grown an average of 5% year on year (Rubite & Tiglao, 2004). The rise in car ownership has overcome capacity limits of existing roads, most of which were old roads not designed to carry a high volume of traffic. Increased number of vehicle ownership or volume of traffic is undeniably a function of an economy, but it can also cause significant economic losses if not strategically managed. Metro Manila for example losses at least PhP 2.4 billion daily and will increase to PhP 6 billion if traffic congestion is not addressed (JICA, 2014). Metro Manila traffic is dubbed as one of the worst in the world (Quito et al., 2016). In the year 2000, industrial emissions are almost equal to vehicular emissions (Krupnick et al., 2003). Bad traffic condition worsens vehicle exhaust containing high levels of nitrogen oxide, sulfur dioxide and carbon dioxide posing health risks to people (Zhang & Batterman, 2013; Hermes, 2012).

While traffic woes are in advanced stages in many parts of the world, cities in the provinces like Catbalogan are starting to feel it. Catbalogan City is the capital of the

Samar Province, Philippines, has a population of 103,879 (PSA, 2016). The city is the center of trade and commerce compounded with the fact that it is a major hub along the Pan-Philippine Highway (NEDA, 2011) which adds to the traffic volume in the city. The city competitiveness is continuously improving; it moved from 103 out of 136 in 2015 to 46 out of 142 in 2015 (NCC Philippines, nd.) making it the better-performing city in Samar Island. This economic achievement can only be sustained if the worsening traffic is addressed early on. The quality and quantity of transport infrastructure influence the attractiveness and desirability of urban regions (Small & Verhoef, 2007).

As the city grows, traffic volume also grows with it. Catbalogan City implements franchise cap on the number of motorized tricycle and Rickshaw. It, however, does not have control over the purchase and regulation of other type of vehicles. Like many cities, the increased number of vehicles resulted in problems such as parking difficulties, loss of public space, high maintenance costs, accidents, and safety. Traffic congestion occurs because of too many vehicles, land use patterns, employment patterns, income levels, car ownership trend, infrastructure investment, etc. (ECMT, 2007). In response to the growing traffic concern, the city implemented traffic control measures and had proposed a revision of its traffic and transport ordinance (LGU, 2017). The said strategies, however, lacks scientific studies and is limited only on traffic flow directions, parking restriction, prohibition of local transportation facilities from using selected routes, apprehension of unregistered vehicles from using the city roads, etc. In the past few years, at least three traffic schemes were introduced on the ground, perhaps as as an experiment, confusing the public every time the traffic rules are replaced with another set of rules.

Some solution to traffic congestion includes; adding more capacity by increasing the size of highway or provision of mass transportation system; operating existing capacity with more efficiency; encouraging travel and land use patterns that use the system in less congestion and producing ways – travel demand management; non-automotive travel modes; and land use management (DOT FHA, nd.).

Roads in Catbalogan has no traffic signaling system and only uses traffic enforcers who are not technically trained to managed traffic issues. Roads have traffic signs and other road markings like pedestrian lanes, but none of it is seriously taken. This scenario is worsened because many licensed drivers have limited knowledge of traffic rules and laws or simply do not follow them (Malabanan, 2014). With the complexity of traffic problem management, the study only explored on the traffic signaling system using a computer software for analysis on how it affects travel time and pollution contribution.

2. Objective

This study presented the traffic characteristics and evaluated the effectiveness of traffic signal in selected intersection in downtown Catbalogan City, specifically it;

2.1 Determined the traffic characteristics in selected areas in Catbalogan City in terms of:

a. Routes
b. Volumes

2.2 Determined the effectiveness of traffic control in unsignalized and proposed signalized intersection in terms of:

a. Delay
b. Number of stops
c. Travel time
d. Fuel consumption
e. Pollutant emission (Co, Nox, VOC)

3. Methodology

The study explores the potential impact of providing traffic signalling system to selected intersections of Catbalogan City, Philippines.

3.1 Research Design

The study utilizes experimental research design considering three scenarios in three intersections. Variables were manipulated to analyse impact. Effects of the proposed provision of traffic signalling system were performed using the SYNCHRO Studio version 8 and SimTraffic.

Figure 1. The three intersection under investigation

3.2 Research Environment

The intersections subjected to analysis are the following; Curry Avenue – Del Rosario St., Curry Avenue – San Roque St. and San Roque St. – Mabini Avenue. Traffic characteristics along these routes intersecting the three junctions were also analysed. Each of the intersections had a traffic performance and geometric design (different widths of legs) which are different from each of the other. Several aspects regarding traffic route direction, intersection design, and road environment were considered such as the speed, traffic volumes at the minor road and the major road, geometric design of the intersections.

The three intersections were selected as these were the busiest and most congested intersection during peak hours.

3.3 Research Instrumentation

Aside from the software (SYNCHRO and SimTraffic), the researchers also collected traffic data from the CCTV footages of the City of Catbalogan. An actual survey and traffic observation were also performed. Measuring tools were used to determine intersection geometric feature. Satellite images from Google Map were also used. Secondary data from Land Transportation Office (LTO) and records from LGU Catbalogan on the registered Rickshaw and motorized vehicles were also used.

3.4 Research Procedures

3.4.1 Traffic Volume Determination

Traffic data were collected in a typical day (not a holiday or no special occasion and normal weather). The selected intersections were recorded four days in a week (Monday, Wednesday, Friday, and Sunday) during peak hour at three hours durations (one hour for each; A.M, Noon and P.M) for each intersection in a day. The City CCTV footages along the three intersections were used to complement actual observation. The video capture contains information such as the traffic volume for each road and direction of the vehicle, etc. The footages have one hour video for every peak hour at each site started at 7:00 to 8:00 AM (morning peak hour), followed at 12:00 NN to 1:00 PM peak hour, then lastly, 5:00 to 6:00 PM peak hour.

The period of the volume determination was divided into 15-minute intervals distributed over the time of data counting. The footages were replayed to retrieve the required data information for the study.

Figure 2. Sample CCTV Video (shown is a photo grab) Capture along Del Rosario St. – Curry Avenue Intersection

3.4.2. Road Intersection Characteristics

Geometric characteristics of the intersection are key information needed in the computer simulation. Traffic flow direction, lane width, and road length were necessary for the analyses including the future traffic plans of the city.

3.4.3 Modelling

Traffic simulation was performed using Synchro Studio 8.0 and SimTraffic by Trafficware. The simulation program allowed the researchers to import an image as a background. The image background served as a template or map so that it can replicate the intersection in Synchro Studio 8.0 (see Figure 19). After inputting the intersection characteristics, they defined simulation parameters such as lane setting, volumes setting, timing setting and phasing setting. The latest volume counts on each road in all directions were collected from CCTV Footages. First, the network was built by creating lanes and giving the available number of lanes in each direction. Make route choices input volumes define signal control and assign them to the intersection. After the simulation parameters were established, SimTraffic was initiated to perform the simulation for the different scenarios for both signalized and un-signalized intersections. Three scenarios (with and without signalling system) were observed to determine the effectiveness of traffic control for each intersection. The scenarios were:

a) Performance of unsignalized and signalized intersections through the level of service.
b) Performance of unsignalized and signalized intersections through Measure of Effectiveness (MOE). (Tricycle volume excluded)
c) Performance of unsignalized and signalized intersections through Measure of Effectiveness (MOE). (With tricycle replaced by motorized tricycle)
d) Performance of unsignalized intersection considering:

d.1 With tricycle replaced by motorized tricycle

d.2 Tricycle volume excluded

When the simulation was completed, the software created reports outlining measures of effectiveness of the intersection like the level of service. Also, the simulation report estimated the number of liters of fuel consumed as well as emissions released into the atmosphere.

4. Results and Discussion

4.1 Traffic Characteristics

The traffic characteristics used in the software analysis were only traffic volume and the traffic route. The later consists of geometric features and traffic directions and the traffic volume. The city has constantly been replacing their traffic scheme one after the other. The forgoing characteristics are true to September 2016 conditions.

4.1.1 Routes Characteristics

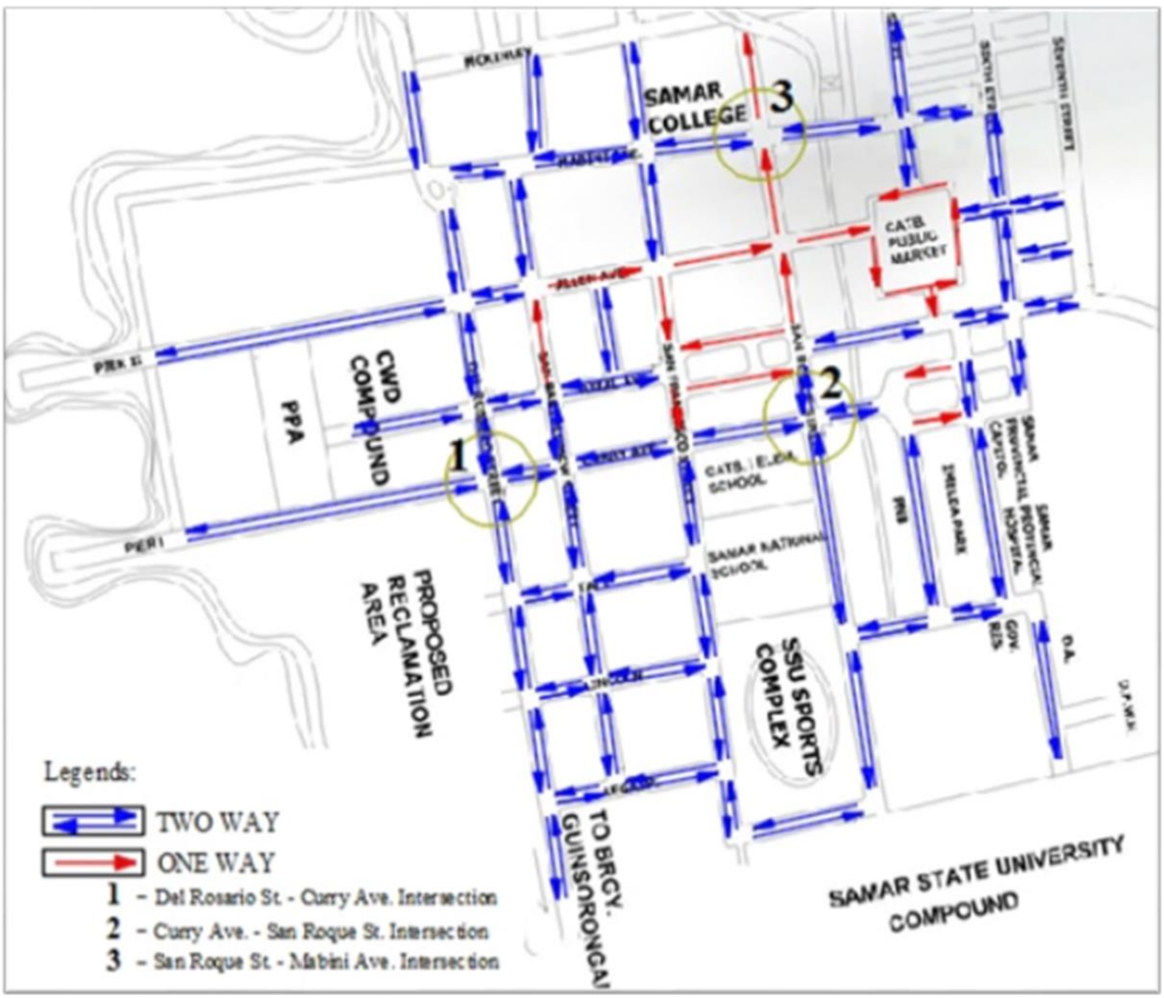

Figure 3.Traffic Flow in Selected Portion of Downtown Catbalogan City

Table 1. Geometric Features for the Selected Intersections

Intersection name	Approach name In each Road	Lane group	Direction	Form width (m)	No. of lanes	One way or Two way
Del Rosario St. - Curry Avenue	From Catb.1	1	EB	14	2	Two way
	From SMCC	2	NB	8.3	2	Two way
	From Pier 1	3	WB	14	2	Two way
	From Ubanon	4	SB	8.3	2	Two way
Curry Avenue – San Roque St.	From Imelda Park	1	EB	14	2	Two way
	From SC	2	NB	6.6	2	Two way
	From Pier 1	3	WB	14	2	Two way
	From SSU	4	SB	6.6	2	Two way
San Roque St. – Mabini Avenue	From Patag	1	EB	11.4	2	Two way
	From SC	2	NB	6.6	2	One way
	From Church	3	WB	11.4	2	Two way
	From SSU	4	SB	6.6	2	One way

Del Rosario Street is a two-lane roadway having a length of 0.982 km and a form width of 11.7 m. It is part of Maharlika highway or considered as a major road in the City. For this study at its intersection with Curry Avenue, the northbound will be called Road to SMCC and the southbound will be called Road to Ubanon. Curry Avenue is also a major road and a part of Maharlika highway which has two-lane divided highway section. The length of the road is 0.576 m with a form width of 14 m. For this study, the eastbound will be called Road to Pier 1 and the westbound will be called Road to Catbalogan 1 but in its intersection, with San Roque Street its westbound will be called Road to Imelda Park. San Roque Street is a two-lane divided highway section. The length of the road is 0.504m with a form width of 6.6 m. For this study in the intersection with Curry Avenue, the northbound will be called Road to SC and the southbound will be called Road to SSU. In the northern part of this street, the intersection is with Mabini Avenue which also a two-lane roadway having a length of 0.622 m and a form width of 11.4 m. For this study, its eastern section will be called Road to Church and its western section will be called Road to Patag.

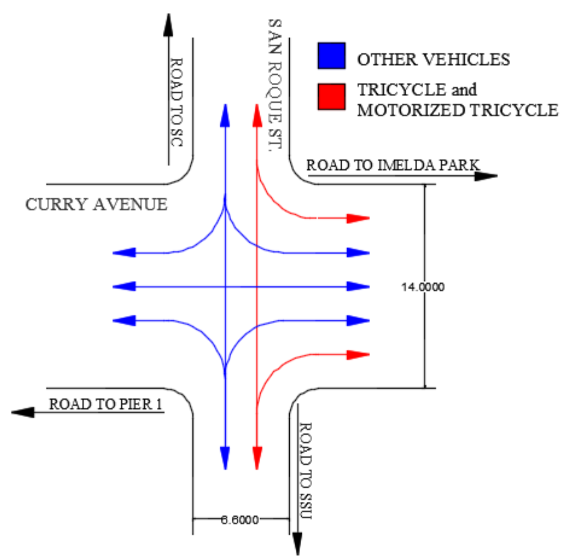

Figure 4.Current Route of Vehicles in Del Rosario St. – Curry Avenue Intersection

Much of the study area is commonly used by commuters, with residential and commercial land uses. Table 1 shows the existing lane geometry of the study intersections, this include number of lanes, and lane widths in the selected intersections.

Del Rosario Street - Curry Avenue Intersection is a four-arm intersection. It corresponds to the vehicles entering directions to Pier 1, Barangay Ubanon, Saint Mary's College of Catbalogan (SMCC) and Catbaloagan1 / Imelda Park. The heavy as well as light trucks, PUJ vehicles and UV vehicles coming from Pier 1 enters into the route going to Catbalogan 1or to SMCC. In this intersection, tricycles and motorized tricycles can only enter and exit from Pier 1 and Ubanon. All vehicles on the other hand can enter and exit in all lanes of the intersection.

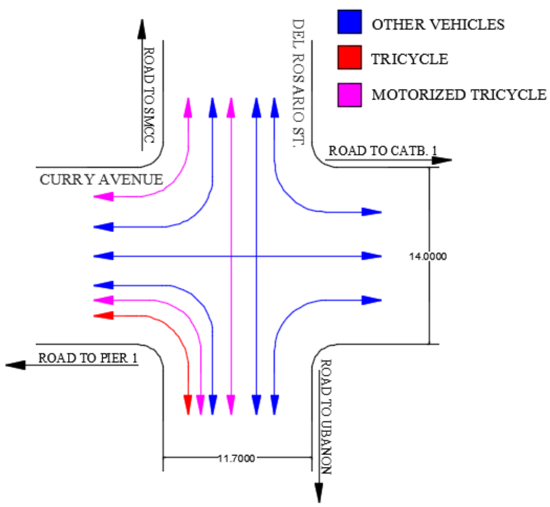

Figure 5.Current Route of Vehicles in Curry Avenue – San Roque Intersection

Curry Avenue – San Roque Street Intersection is a four-arm intersection. It lets the vehicles enter the directions to Samar State University, Imelda Park, Samar College (SC) and Pier 1. Since the intersection is busy, the tricycles and motorized tricycles coming from Samar State University are not allowed to enter the route to Pier 1. All vehicles, on the other hand, can enter and exit in any direction. Significant number of heavy and light trucks, PUJ vehicles, UV vehicles enters the route to SC leading them to another highway access outside the city.

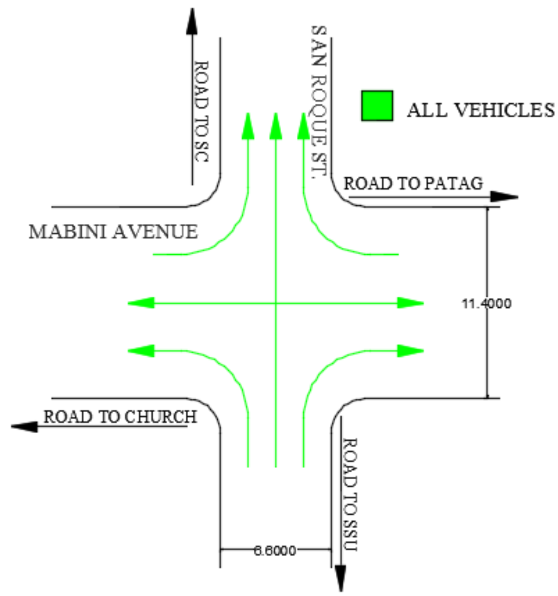

Figure 6.Current Route of Vehicles in Mabini Avenue – San Roque Intersection

San Roque Street – Mabini Intersection is a four-arm intersection. It lets the vehicles enter the directions to the Church/SMCC, Barangay Patag, SC and SSU. The San Roque Street is a one way road while the Mabini Avenue is a two-way traffic. This intersection is frequently having congestion. The adjacent academic institution to the intersection added volume of road users. The thriving business activities in the area especially along San Roque Street including vehicle parking along side of the roads add to the congestion in the area.

Figures 3 to 6 showed the current route direction of vehicles implemented by the City of Catbalogan. These routes were implemented to improve the traffic flow. In the past, vehicles including motorized tricycles (3 seaters and 6 seaters) as well as Rickshaws can freely move without restriction. Such movement of public transportation system is shorter but travel time is longer due to traffic congestion. In the current routes, vehicles need to turn around two (2) to three (3) blocks to get into a destination, in the past, it only need one corner. Time of travel and distance of travel is also associated to fuel consumption.

4.1.2 Traffic Volume Characteristics

Figures 8 to 10 showed the traffic counts of the three selected intersections in Catbalogan City. The peak hour count traffic volumes in each road were used in the simulation. Figure 7 shows a typical scenario along Curry Avenue – San Roque St. and Figure 8 is the volume of traffic from the various station in the same intersection. Going NE (see Figure 7), is the portion of Del Rosario St going to the Church/SMCC, SW is towards Ubanon, Left is the Curry Avenue going to Pier 1 and going Right is to Catbalogan 1.

Figure 7. Del Rosario St. – Curry Avenue Intersection, 12:00-1:00 PM

The roads shown (going left and up) in the picture is a portion of the national highway and is serving all types of vehicles like busses, trucks, and others. The city passenger terminal for PUVs, the port exit and one of the city's public market is found in the vicinity of the port area (going left in the picture).

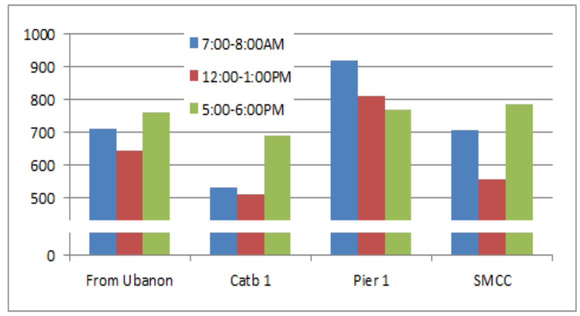

Figure 8. Del Rosario St. – Curry Avenue Intersection Average Peak Hour Volume

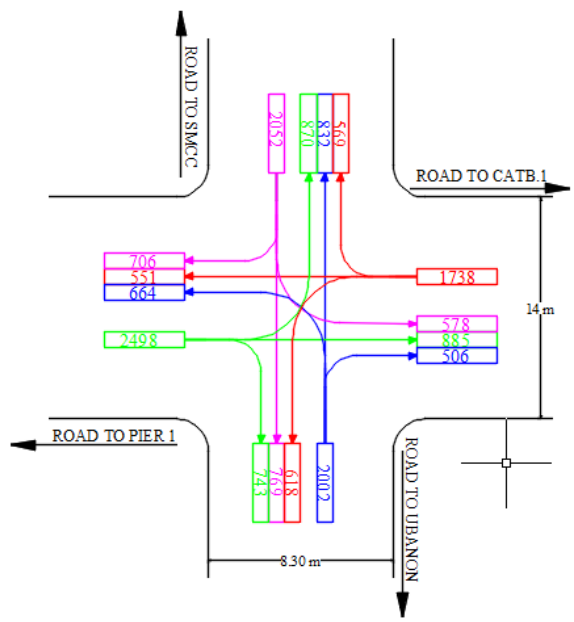

Figure 9. Traffic Flow along Del Rosario St. – Curry Avenue Intersection

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Figure 10. Curry Avenue-San Roque Intersection 7:00-8:00 AM

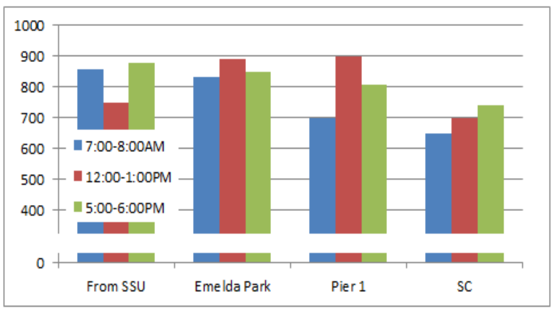

Figure 11. Curry Avenue – San Roque St. Intersection Average Peak Hour Volume

Shown in Figure 10 is a photo grab from CCTV footage about 7:00 in the morning. Traffic going to the right in the picture is a portion of San Roque St. Far right ahead is towards SSU and HEI with more than 6,000 enrolled students (SSU, 2016). Also found along this street is the Justice Building, one of the main entrances of Catbalogan I Central School with a little less than 3000 students, Eastern Visayas Regional Science High School with 195 students and one of the gates of Samar National School serving more than 5000 students (DepED, 2015). This section of the road is likely serving up to about 15,000 students, employees and other road users on a daily basis and at least three times a day, morning, noontime and late afternoon. Rickshaws and 3 seaters motorized tricycle are restricted in using the road to Pier 1, but it appears some violates this ordinance.

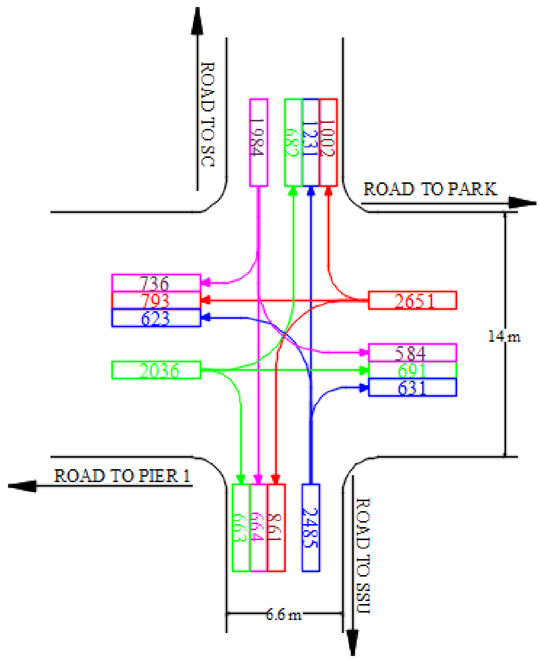

Figure 12. Traffic Flow along Curry Avenue – San Roque St. Intersection

Figure 13. San Roque St.-Mabini Avenue Intersection, 5:00-6:00 PM

The San Roque-Mabini Avenue intersection has received the highest number of traffic observed. A total of about 15,990 vehicles passed this intersection in the late afternoon. The bulk of the vehicles come from the Patag District area, one of the densest residential areas in Catbalogan. This was the heaviest traffic volume recorded by the researchers on all observations made.

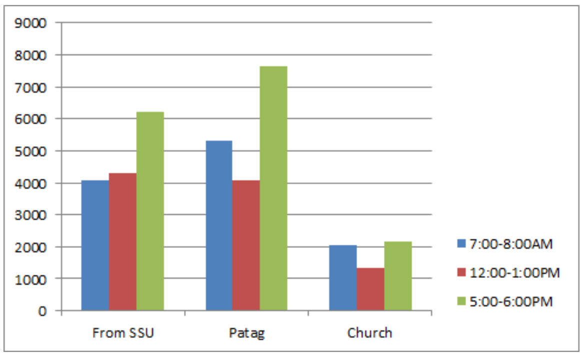

Figure 14. San Roque St.-Mabini Avenue Intersection Average Peak Hour Volume

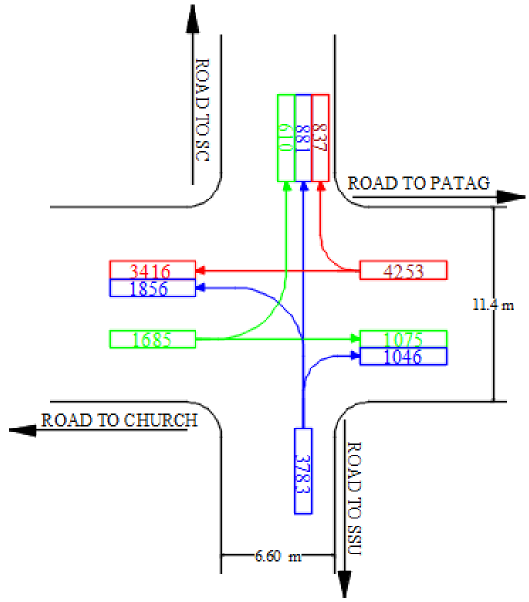

Figure 15. Traffic Flow along San Roque St.-Mabini Avenue Intersection Average Peak Hour Volume

The route from Patag to the intersection and towards the San Bartholomew Church also receives vehicles entering Catbalogan City from the south.

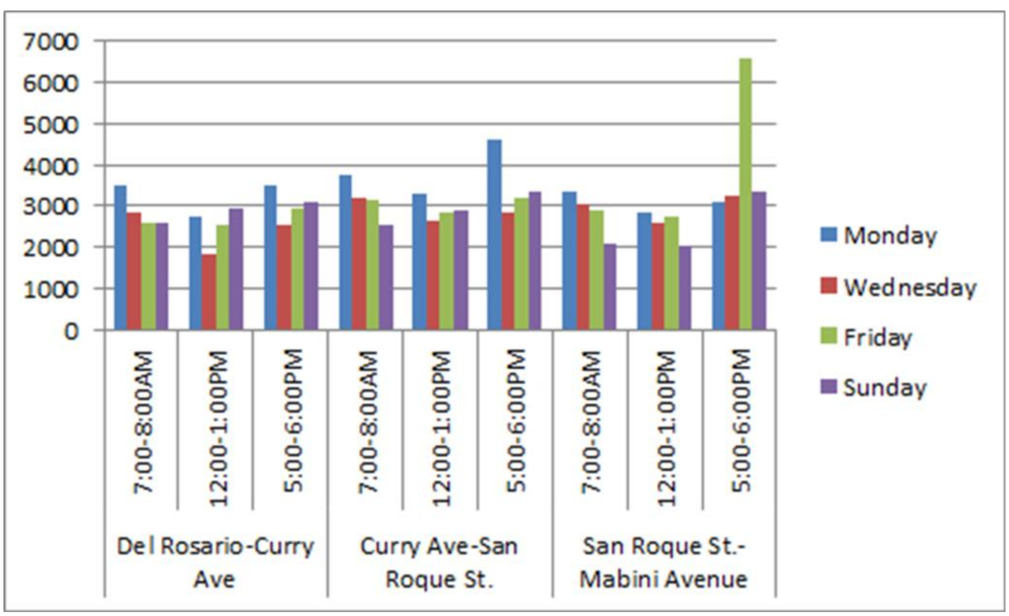

Figure 15. Average Traffic Volume

Figure 17. Unsignalized (left) and Signalized (right) Simulation at Del Rosario St. - Curry Avenue Intersection

Figure 18. Unsignalized (left) and Signalized (right) Simulation at Curry Avenue – San Roque St. Intersection

Figure 19. Unsignalized (left) and Signalized (right) Simulation at San Roque St. – Mabini Avenue Intersection

Adding to the traffic volume are elementary to graduate students of the Samar College (SC) is found along this intersection and the Saint Mary's of Catbalogan (SMCC) is located near the church. Shown in Figure 11 is a photo grab from the CCTV footages of the City. From the SE side is a one-way traffic, moving to the left (towards the Church, SMCC), the NE side is towards the Patag District and NW side is towards the SC gate.

Shown in Figure 16 is a September 2016 average traffic characteristics along the three intersections observed. Monday's registers peak volume of traffic but a considerable peak, the highest observed along San Roque St. and Mabini Avenue for Friday's with about 6,589 vehicles. This is probably because, on Fridays, temporary residents (students and employees/workers) of Catbalogan return to their respective residences outside of Catbalogan. On Monday's, students and employees/workers return to Catbalogan from a weekend break.

4.2 *Sig*nalized and Un-signalized Traffic Flow Simulations

The collected traffic volume and geometry data were used in developing Synchro models of the three study sites were.

Table 2. Peak Hour Average Control Delay and Level of Service for a 15 Minutes Period

Intersections	Un-signalized Intersection			Signalized Intersection		
	AM	Noon	PM	AM	Noon	PM
Del Rosario St. – Curry Avenue	10	9	11	8	7	8
	B	A	B	A	A	A
Curry Avenue-San Roque St	11	11	11	8	7	7
	B	B	B	A	A	A
San Roque St. – Mabini Avenue	11	11	17	9	9	12
	B	B	C	A	A	B

LOS Criteria: *A-Free Flow* *B-Reasonably Free Flow* *C-Stable Flow* *D-Approaching unstable Flow* *E-Unstable Flow* *F-Forced or Breakdown Flow*

Table 3. Average Peak Hour Volume Performance of MOEs without Rickshaw (pedicab)

Intersections	Un-signalized Intersection			Signalized Intersection		
	Total Hours Delayed	Number of Stops	Hours Travel Time	Total Delay	Number of Stops	Hours Travel Time
Del Rosario St. – Curry Avenue	2,895	6,372	2,919	2,240	10,445	2,264
Curry Avenue-San Roque St	3,181	6,581	3,206	2,943	13,266	2,960
San Roque St. – Mabini Avenue	2,342	6,325	2,468	2,787	12,993	2,823

Table 4. Average Peak Hour Volume Performance of MOEs where Rickshaw Volume was replaced with Motorized Tricycle

Intersections	Un-signalized Intersection			Signalized Intersection		
	Total Hours Delayed	Number of Stops	Hours Travel Time	Total Delay	Number of Stops	Hours Travel Time
Del Rosario St. – Curry Avenue	5,427	8,406	5,460	4,298	18,825	4,331
Curry Avenue-San Roque St	6,964	9,460	6,999	5,628	24,242	5,651
San Roque St. – Mabini Avenue	6,492	9,719	6,548	6,887	29,676	6,942

4.2.1 Effectiveness of Signalling System to Traffic Flow

The Curry Avenue – San Roque St. operates at Level of Service (LOS) B in all peak period due to the consistency of vehicles entering in the area and the same also in Del Rosario St. – Curry Avenue intersection but it differs only in noon which experienced a free flow movement. On the other hand, San Roque St. – Mabini Avenue intersection experienced at LOS B during the AM and MN peak periods, and operate acceptably with LOS C as the highest delay in PM periods. Based on the analysis, it produced a 147 average vehicle enters during PM periods which is highest in the other study area.

Signalized intersection analysis was performed for the study under conditions for the AM, NN and PM peak hour level of service. According to the LOS comparison results, each intersection will experience a significant improvement after conversion to a signalized intersection. It showed an improvement in performance of all periods from LOS B to LOS A and LOS C to LOS B in each intersection. At this condition, a traffic control signal may be effective.

4.2.2 Effects on Time of Travel

Catbalogan City mixed traffic makes the analysis complicated. Rickshaw speed is dependent on the driver and speed cannot be controlled in the same manner as motorized vehicles are. In many cities around the Philippines, Rickshaw are removed from downtown roads to improve traffic. The same however may not be environmentally beneficial specially when replaced with motorized counterpart. The effects of removing Rickshaw are positive in terms of traffic flow. On the other hand, replacing it all with a motorcycle is a different story.

Table 3 shows a scenario where Rickshaw is not allowed to traverse downtown Catbalogan City, and some motorized tricycle is maintained. Table 4, on the other hand, is a scenario where Rickshaw was replaced with a motorized tricycle.

Simulation has shown that when a signalling system is used, improvements were observed. The total delay and total travel time for both Del Rosario St. – Curry Avenue and Curry Avenue – San Roque St. intersections was reduced even if there was an increased number of stops. However San Roque St. – Mabini Avenue intersection showed the increase in the delays and travel time of vehicles.

If Rickshaw is excluded in these routes, the delay and travel time were decreased by 23% for Del Rosario St. - Curry Avenue intersection and 8% in the Curry Avenue – San Roque St. intersection. San Roque St. – Mabini Avenue intersection showed an increase of 14% travel time. There was an increase of 64% to 105% number of stops due to the signaling system, but these resulted in better travel time for vehicles passing the Del-Rosario-Curry Avenue and the Curry Ave-San Roque intersections.

The same effect was observed when the Rickshaws are replaced with the motorized tricycle. The travel time has improved up to 20% for Del Rosario St. - Curry Avenue intersection and 19% in the Curry Avenue – San Roque St. intersection. Meanwhile, San Roque St. – Mabini Avenue intersection showed a less satisfying result because it increased by 6% with the number of stoppage of vehicles increased between 124 to 205%.

Table 5. Fuel Consumption and Pollutant Emission without Rickshaw (pedicab)

Intersections	Un-signalized Intersection				Signalized Intersection			
	Liter of Fuel Consumed	Pollutant Emission (kg)			Liter of Fuel Consumed	Pollutant Emission (kg)		
		CO	NOx	VOC		CO	NOx	VOC
Del Rosario St. – Curry Ave.	8,108	150.8	29.1	34.8	6,307	117.3	22.6	27.0
Curry Avenue-San Roque St.	8,905	165.6	32.0	38.2	8,346	155.2	30.0	35.8
San Roque St. – Mabini Ave.	6,858	127.6	24.6	29.4	7,865	146.3	28.2	33.7

Table 6. Fuel Consumption and Pollutant Emission without Rickshaw (pedicab) where Rickshaw Volume was replaced with Motorized Tricycle

Intersections	Un-signalized Intersection				Signalized Intersection			
	Liter of Fuel Consumed	Pollutant Emission (kg)			Liter of Fuel Consumed	Pollutant Emission (kg)		
		CO	NOx	VOC		CO	NOx	VOC
Del Rosario St. – Curry Ave.	15,154	281.9	54.4	65.0	12,065	224.4	43.3	51.8
Curry Avenue-San Roque St.	19,421	361.2	69.7	83.3	15,983	297.3	57.4	68.6
San Roque St. – Mabini Ave.	18,173	338.0	65.2	78.0	19,336	359.7	69.4	82.9

There was an observed increase in the number of delays, number of stops and hours of travel when a Rickshaw-less traffic compared to a total motorized tricycle scenario. The total number of hours delayed increased between 91 to 147%, the number of the stoppage by 80 to 128% and total hours of travel time will increase by about 90 to 146%. Rickshaws are slow thus affecting all vehicles caught in between them but replacing it all with motorized tricycle is not a good idea.

4.2.2 Effects on Cost of Travel and Pollutants

Fuel consumption is closely related to traveling distance, delay and number of stoppage at each intersection. For a vehicle trip of a given length, the number of stops, acceleration and deceleration cycles, and speed changes can affect Carbon Monoxide (CO), Oxides of Nitrogen (NOx), and Volatile Organic Compounds (VOC) Emissions. (Koa, 2011 et al.).

Table 5 shows the environmental effects on a scenario where Rickshaw was removed from the traffic equation. Table 6 is a scenario where Rickshaw was converted to a motorized tricycle. This scenario will naturally increase the pollutants as a result of more vehicles burning fuel. If the time of travel is improved, the volume of fuel burned is reduced, and emission of pollutant is lowered.

Based on travel time and number of stoppage, the amount of Carbon Monoxide (CO), Nitrogen Oxides (NOx), and Volatile Organic Compounds (VOC) were estimated. About 22% of the pollutant was reduced because of the signaling system in the Del Rosario and Curry Avenue intersection. Reduction of 6% of pollutants was also observed at San Roque and Curry Avenue while San Roque St – Mabini Avenue intersection resulted to increase in the number of pollutants by about 15%. Amount of pollutant emitted in a scenario where all Rickshaw were replaced with motorized tricycle showed similar behavior, but percent reduction along the There was a significant reduction of these Curry Avenue-San Roque St. was higher at 17%.

Naturally, if Rickshaw (which does not use fuel to run) is replaced with a motorized tricycle, air pollutant will increase. CO, NOx, and VOCs will increase between 91 to 146%.

5. Conclusion and Recommendation

Catbalogan growing traffic will require the installation of signaling system to manage it. The effect of the use of signaling system is not the same in the three intersections evaluated. This suggests that signaling system must be suited to the traffic condition of the intersection.

Replacement of Rickshaws with motorized tricycles will have increase negative environmental impact due to higher CO, NOx and VOC emission.

The use of traffic signaling system is recommended for the Del Rosario and Curry Avenue and Curry Avenue-San Roque St. intersection but not for San Roque St. Mabini Avenue intersection.

An expanded data set for simulation will improve the findings of the study. Consideration of various traffic schemes like changing of traffic flow direction maybe considered in the simulations to have varied options to select.

Traffic design must undergo thorough analysis before implementation. On-site experimentation of traffic schemes must not be recommended. The use of computer simulations using real and larger data set will improve chances that the traffic scheme will be successful.

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