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Alleviating Traffic Congestion in Prishtina

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Honors Project

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List of acronyms

CFI – Continous Flow Intersection

WBR – West Bound Right

EBR – East Bound Right

NBR – North Bound Right

SBR – South Bound Right

EBRD – European Bank of Reconstruction and Development

Abstract

This Honor Project paper analyzes the problem of traffic congestion in Prishtina. Firstly, factors that cause traffic congestion are identified. Understanding these factors provides some clues on potential contra measures. Secondly, economic and social effects are discussed to evaluate the importance of alleviating traffic congestion. Lastly, based on the existing city models, different strategies to resolving this problem are presented. In doing so, various designing and simulation tools are used to visualize and compare different scenarios. The research methodology for this project includes literature review, site visits, an in-depth interview, and surveys.

I. Chapter 1 – Problem Statement

The automobile has become a predominant way of traveling nowadays. The increasing number of households along with the increasing number of cars that a household owns hastens the increasing rate of traffic delay in the urban areas (*"US Department of Transportation,"* 2013). This suggests that this problem is growing exponentially and it should be persistently addressed in order to avert its negative consequences. Traffic jams hinder mobility, contribute in air pollution, waste fuel, and impede economic growth (*"A Toolbox for Alleviating Traffic Congestion,"* 1989).

Traffic congestion has become an increasing problem in Prishtina as well. This phenomenon is vastly present during the rush hours of 8 to 9 AM and 4 to 5 PM. Taking into account that it negatively influences the economic and environmental aspect of society, resolving this issues is crucial for social well-being.

This project conducts a careful analysis of factors that cause traffic blockages and uses this information to come up with different techniques and strategies to improve the existing situation.

II. Chapter 2 – Literature Review

A. Traffic Congestion

According to Institute of Transporting Engineers, traffic congestion is a situation where "there are more people trying to use a given transportation facility during a specific period of

time than the facility can handle with what are considered to be acceptable levels of delay or inconvenience" (*"A Toolbox for Alleviating Traffic Congestion,"* 1989). Traffic congestion is a result of phenomenon called traffic waves. Traffic wave "occurs when cars slow down, and the slowing trend continues backward -- like a domino effect." The higher the demand for that specific road the bigger the traffic wave is (*"Traffic Causes,"* 2007).

1. What Causes Traffic Congestion?

Factors contributing to traffic congestion can be divided in two groups: Traffic Disturbances and Network Overload (*"Traffic Causes,"* 2007). Traffic disturbances are temporary occurrences and only impact traffic as they happen. These include accidents, harsh weather conditions, and road constructions. An accident can cause a road blockage or slow down traffic flow as drivers try to understand what is happening. Likewise, bad weather conditions can cause drivers to slow down as they worry for their safety. Also, road construction can cause reduction of lanes thereby forcing drivers to crowd the open lanes. Consequently, traffic congestion can be highly increased by these factors, but because of their randomness, not much can be done to prevent such incidents. Since Traffic Disturbances are temporary and unpredictable in nature, the focus of this paper will be Network Overloads.

In Network Overload fall all the cases where the road congestion is caused either by decreased capacity of the road or increased demand for transportation. In other words, contributors to network overloads can be divided in supply factors and demand-increase factors. Starting with physical factors, the biggest contributors to this category are bottlenecks (*"Traffic Causes,"* 2007).

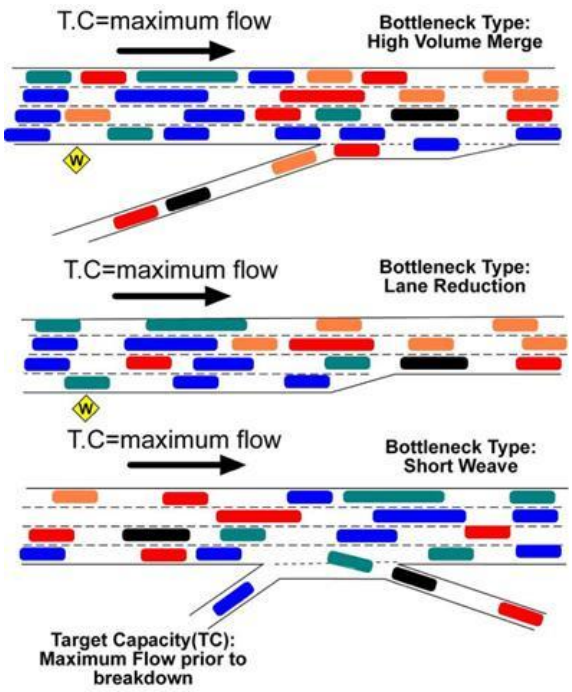


Figure 1: Bottleneck Types (*"Traffic Causes,"* 2007)

Bottlenecks are narrowed roads that lead to increased congestion when demand for traffic is higher than supply. Based on road structure, there are different types of bottlenecks. High volume merge bottleneck occurs when another line is merged to the existing road; lane reduction bottleneck occurs when the number of lanes is reduced causing two or more lanes to merge into one; whereas short weave bottleneck occurs when one line is added to the road while another one goes out (*"US Department of Transportation,"* 2013). As it is shown in Figure 1, these road structures lead to delays, thus causing traffic congestion.

Another physical factor of traffic congestion is road intersections. According to Atomode (2013), "urban road intersections easily become the worst hit of traffic delay. This is because, at intersections, vehicular flows from several different approach (link/edge) making either left-turn, through and right-turn movements seek to occupy the same physical space at the same time" (p.6). In addition to vehicular flows, there are also pedestrians who need space to pass the streets thereby making the situation even worse.

The third physical factor of traffic delay can be considered the presence of heavy transport vehicles. Due to the number of stops that buses have to make throughout their daily routine, and that fact that the majority of the time there are no designated lanes for buses, they

end up unintentionally delaying vehicles behind them, thereby adding to traffic congestion (Doçi and Bajraktari, 2011).

However, not all traffic congestions are caused by physical restrictions; there are cases when the demand of a road increases more than the capacity that specific road can withstand. These factors are called demand factors. Increasing of population living in urban areas and a number of vehicles per household lead to increase in the demand for roads (*"A Toolbox for Alleviating Traffic Congestion,"* 1989). Because of weak public transportation, people will be encouraged to use their cars instead, thus adding to the demand for roads. Moreover, increases in job opportunities, inadequate parking spaces, poor urban planning, economic growth, signal failure, and other important factors contribute in increasing demand for road usage (Kiunsi, 2013).

2. Impacts of Traffic Congestion

Traffic congestion has various negative impacts ranging from economic loss to adverse environmental and social impacts.

Because the roads are free of charge, there will be no financial incentive that would stop drivers from overusing the roads until the point where the road begins to collapse through continuous congestion (Elisonguo, 2013). By doing so, each driver incurs a private and public cost when they drive. The private cost includes the journey time and fuel used, whereas the public cost includes the "cost imposed to the community in the form of noise, accident risk, fumes, etc" (Roth, 1965, p.49). Both of these costs will increase with the increase of traffic congestion (p.49). Drivers waste more time and fuel if they are stuck in a traffic jam. The wasted time is the "time that could be used productively and there is an economic cost attached to it which, although difficult to measure, can be significant" (Robinson, 1986). Only in the United States the "annual economic burdens range from $83 billion to $124 billion" from traffic delay (Levy, 2010). In addition, Traffic congestions make it difficult for emergency services to perform effectively (*"Economics Online,"* 2012).

Traffic congestion forces vehicles to stay longer in roads, thereby increasing the emission of air pollutants. According to Robinson (1984), the emission of Carbon Monoxides and

Hydrocarbons is higher at speeds less than 20km/h. These tail-pipe emissions harm our green environment thus leading to health problems. According to Currie and Walker (2011), the main contributors to air pollution are motor vehicles (p. 65). Half of the carbon monoxide (CO), one third of Nitrogen Dioxide (NO_2), and 29 percent of hydrocarbons (HC) in the atmosphere are released from cars only (p.65). Carbon monoxide (CO) reduces the oxygen in blood thereby reducing the accessibility of oxygen for organs. This poses a health risk, particularly to those with heart problems (par. 2). Nitrogen oxides (NOx) stimulate respiratory problems and increased sensitivity to allergens. Nitrogen oxides also contribute in formation of ground-level ozone and acid rain which can damage vegetation. Hydrocarbons (HC) can cause respiratory problems as well. They participate in formation of ground-level ozone too (*"Cars and air pollution,"* par.2-5).

Besides economic and environmental harms, traffic congestion can also influence the social and psychological being of the citizens. As Robinson (1984) states, "nobody enjoys being caught in a traffic jam; it is likely to make the blood pressure jump a few notches and induce the unlikeliest people to use language that would make a sailor blush." That is, road rage or a similar emotional state would be among outcomes of congestion. In addition, the noise that is caused by heavy traffic streams which reaches 90db creates an undesirable environment (Robinson, 1984). Furthermore, when the line of traffic becomes large and the waiting time becomes intolerable for someone, these individuals will seek alternative ways to avoid traffic congestion. By doing so, they will cause local residents great distress (Robinson, 1984).

B. Traffic Congestion in Prishtina

After the war in Kosovo, not much progress has been achieved in alleviating traffic congestion in Prishtina. Demand for transport is increasing due to increasing population working and/or living in Prishtina. Public transportation is a big issue due to insufficient number of buses operating in the city. Moreover, the lack of parking spaces incentivizes people stay longer on the road or park illegally thereby worsening the condition. On the supply side, because of inadequate number of lanes, roads are too narrow to withstand transport requirements. Also, these roads have to meet at some point, thus creating intersections that are the key element causing traffic delays (Fazliu, 2015).

Deputy Mayor of Prishtina, Dardan Sejdiu, states that some steps have been taken regarding this issue and the results will be seen soon. He said that "the signing [in March, 2015] of a 10 million euro agreement with the European Bank for Reconstruction and Development (EBRD) will see the first new buses in Prishtina in the autumn and will start to accomplish Ahmeti's promise for regulation of urban traffic (Fazliu, 2015). Moreover, Mayor of Prishtina, Shpend Ahmeti, points out that the regulation of traffic urban will encourage citizens to leave their cars at home and use urban traffic instead, thereby reducing the traffic congestion in Prishtina (Fazliu, 2015). In addition, Ahmeti promised that the problem of deficiency of parking spaces will be addressed as well, as this is one of the contributors to our problem (Fazliu, 2015).

Looking from another perspective to this problem, the road capacity to grasp the demand for transportation in Prishtina is low. One of the major contributors from this category is road intersections. According to Doçi and Bajraktari (2011) "Congestions in intersections are created due to high number of vehicles, increased number of pedestrians and improper regulation of traffic signalization" (p. 285). In a study conducted by Doçi and Bajraktari, "the crosslink between Agim Ramadani Str. In North-South Direction and Eqrem Qabej Str. In East-West direction" during the peak hours, the number of vehicles per hour (vhp) reached up to 1050 per lane (p. 286).

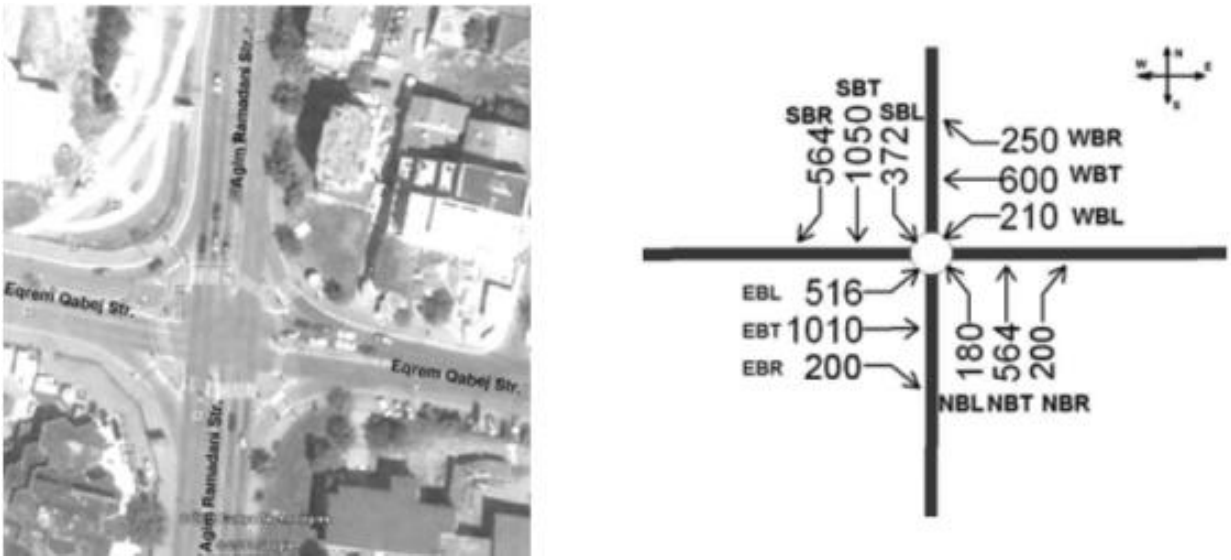
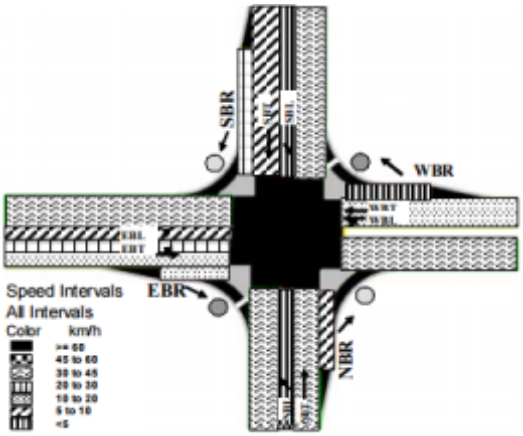


Figure 2: Agim Ramadani Str. Intersection (Doçi and Bajraktari, 2011)

Figure 2 shows a satellite view of this intersection and the results from the survey conducted by Doçi and Bajraktari (2011). Each number represents vehicles per hour circulating in a specific lane of this intersection during 8÷9 AM and 5÷6 PM. The numbers tell that demand for this intersection exceeds its capacity limits (2011).

Furthermore, Doçi and Bajraktari (2011) used these numbers as input parameter to do computer simulations using module software called SimTraffic. Based on input parameters, this software does calculations and generates outputs. The table below shows the output parameters from the software.



	Case 1
Total Delay (hr)	51.3
Delay / Vehicle (s)	255.9
Stop Delay (hr)	38
Total Stops	2050
Stop/Vehicle	2.84
Travel Distance (km)	1876.5
Travel Time (hr)	92.3
Avg Speed (km/h)	21
Fuel Used (l)	428.6
CO Emissions (g)	5038
Vehicles Entered	891
Vehicles Exited	553
Hourly Exit Rate	3318
Denied Entry of veh After	77

Figure 3: Table of Results (Doçi and Bajraktari, 2011)

These output parameters on the table do not only tell the delay that this intersection causes, but also tells more about fuel consumption and CO emissions. Doçi and Bajraktari (2011) were interested in studying the right turn lanes, as they are named in the Figure 3 with Westbound Right, Northbound Right, Eastbound Right, and Southbound Right. Based on software calculations, "that intersection in current condition already works above its capacity limits by 113.7%" (Doçi and Bajraktari, 2011).

C. Two Cases: London and Baton Rouge

Dealing with traffic congestion factors does not promise a full elimination of this problem; however, minimizing this issue to satisfactory levels can be achievable. Two approaches that should be used to improve this problem are:

1. Deal with the demand side by decreasing the number of cars demanding transportation.

2. Deal with supply side, by increasing the road capacity.

Following are two case studies that demonstrate that the afore mentioned approaches help in reducing traffic congestion. London has enforced policies that decrease the demand of cars in urban areas, whereas Baton Rouge has implemented innovative designs that increase the road capacity.

1. London: Congestion charge

In February 2003, London implemented the congestion charge idea to fight the traffic congestion in the city. Nonresident drivers using private vehicles will be charged with £5 ($8.60) to drive their cars in the center of city between 7:00 am and 6:30 pm. Public transport and taxis are exempt from the charge. To enforce this policy, security cameras are placed strategically throughout the city. These cameras can capture the license plates and verify if the driver has paid the fee. Violators are fined with £80 ($138) and in some cases their vehicles are impounded (Apostol, 2005).

Figure 4: Congestion Charging Zones' Signs in London (Apostol, 2005)

The congestion charge zone in London covers eight square miles of the city. There are directional signals and road markings that tell you when you are approaching or leaving the

congestion zone. Signs for advance information tell you more about operation hours ("Congestion Charge," 2015).

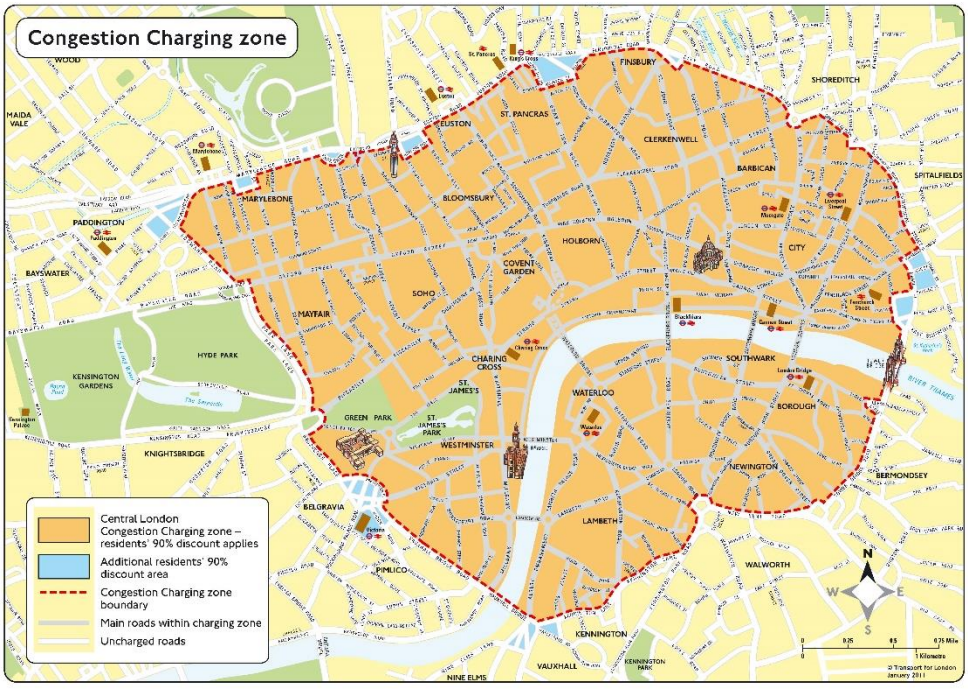


Figure 5: Map of Congestion Zone in London (*'Congestion Charge,"* 2015)

Congestion charge is considered a success in London. Only six months after implementation congestion rate dropped by 30%. Revenues collected from fines rounded from $138 million to $172 million annually in the following years. This amount is used to improve overall transport system in the city (Apostol, 2005). Additionally, this policy implementation has positively impacted the city by decreasing the release of greenhouse gases by 20% annually (Apostol, 2005).

2. Baton Rouge: Continuous Intersection Flow

Baton Rouge is an example of a city that has made huge improvements relieving traffic congestion. This city was first to implement Continuous Flow Intersection (CFI) design for roads (*"Louisiana's Major Cities show Improvement on Traffic Congestion Report,"* 2015).

Figure 6: Continuous Flow Intersection (Lee, 2013)

A Continuous Flow Intersection is an "innovative at-grade intersection that removes conflicting left turns at an intersection by placing the turning movements several hundred feet in advance of the main intersection" (Lee, 2013).

This design allows left turn and mainlines through movements to happen simultaneously, thereby reducing traffic delay on intersection. Additionally, a high percentage of accidents on intersections occur while making the left turn. Since this design eliminates the left turns, less accidents on intersections will occur (*"First 'Continuous-Flow' Intersection in Louisiana Opens in Baton Rouge,"* 2015).

Moreover, this design has proven to be the most cost-effective one. The first CFI in Baton Rouge made a huge difference in traffic congestion. As Bruce said, "the average delay for each car crossing the intersection during pre-Hurricane Katrina evening rush-hour traffic was 225 seconds, or about 4 minutes. With the opening of the CFI turn lanes, the time elapsed is

estimated to be 30 seconds per car - an improvement of almost 90 percent" (*"First 'Continuous-Flow' Intersection in Louisiana Opens in Baton Rouge,"* 2015).

III. Chapter 3 - Methodology

A mix of research methods were used to collect relevant information regarding traffic congestion in Prishtina. These methods were designed to study the economic, environmental and social impacts of this phenomenon.

Primary research included conducting an individual in-depth interview with a representative from the Municipality of Prishtina. The steps that the local government has taken, or is planning to take in the future regarding this problem were discussed through the interview. Additionally, the questions aimed to identify the most congested areas in the city and the factors that cause traffic congestion in Prishtina.

Furthermore, site visits in the identified areas for traffic congestion were conducted. The first one was conducted on a Friday during the peak hours, from 4 to 5 PM. The second one was conducted on a Saturday, at the same schedule and the same location. The purpose of these observations was the quantification of the vehicular volume circulating on these sites. Recordings done by the camera were later used to calculate the number of cars flowing in each lane of the intersection separately. The findings were used as input to traffic software (Synchro 8.0) which calculated the output parameters relevant for this study. These output parameters, among others, include: total delay (in hours), delay per vehicle (in seconds), fuel consumption (in litters), and tail-pipe emissions (in grams).

Most importantly, based on inputs, the software also provided visual simulations of the intersections. These simulations, together with reports, generated by the program helped in comparing different scenarios; Friday 4pm to 5pm and Saturday same time. The alterations represent the effects of jobs in increasing traffic congestion. The program will also make it possible to redesign current intersections applying the CFI (Continuous Flow Intersection) design as a recommended solution to reducing traffic congestion. Afterwards, the program will generate 2D and 3D simulations and generate outputs that will indicate the effectiveness of these designs in terms of economic and environmental impacts.

Lastly, surveys were used to gather qualitative and quantitative information on the social and economic impacts of traffic congestion in Prishtina. Due to time and budget limitation convenient sampling methods were used. The sample consisted of 110 randomly selected citizens who live in Prishtina. This sample size does not represent the true population; however, qualitative information gathered from the survey are relevant to this project. The surveys were conducted face to face and online using Google Forms.

As secondary source, online materials were a useful starting point. The main sources include: Institute of Transportation Engineers, the UK Government's website, US Department of Transportation and other credible sources from Walley and other libraries.

IV. Chapter 4 – Results and analysis

The research techniques used for this study provided relevant information starting from the identification of the factors that cause traffic congestion to the economic, environmental and social impacts of this phenomenon.

A. Interview Results

1. Inadequate Public Transportation

According to the representative from the Municipality of Prishtina, the main factor causing the increased demand for roads is the inadequate public transportation in Prishtina. The number of busses that the "Urban Transport" of Prishtina has is not enough to serve all the citizens of the city for their daily transport. "If you look at the cars, most of them have only one person, and that is the driver" said him. He further explains: - "The deficiency of the public transportation encourages people to use their cars to travel in the city." In other words, if citizens were offered an adequate and accessible public transportation, they would economically be more incentivized to use it, instead of their cars. However, the Municipality of Prishtina has signed an agreement with the European Bank for Reconstruction and Development which will offer a grant for buying "51 low-entry diesel EURO VI standard compliant buses." He claims that the EBRD has closed the tender with a winning company, and these busses will be added to the public transportation of Prishtina after few other procedures had been completed, among others, redesigning the road infrastructure and voting of this agreement on the parliament. The Municipality Representative

also explained that “The new busses will also have GPS system that would let the passenger waiting on a bus stop know where the buss he/she is waiting for is and the time it will take to arrive.”

2. Parking Spaces

Another concerning issue in the city of Prishtina is the lack of parking spaces. According to the representative of the Municipality of Prishtina, the impossibility of the drivers to park their cars in the city forces them to stay on the roads thereby adding to the demand for roads. Sometimes these cars are parked illegally, thus making it difficult for pedestrians and other cars to pass. He said that, on September 2014, the Municipality of Prishtina initiated the founding of “Prishtina Parking” enterprise. According to him, this project will improve the organization of the parking system in the city by offering services of the latest technologies. The use of these services will be charged and the time will be limited to 3 hours per car for nonresidential vehicles. The collected revenues from this project will be used by the municipality to create new parking spaces, underground garages, and green parks. As he stated, this project will significantly help in the reduction of traffic congestions in Prishtina.

3. Road Ring

Furthermore, the representative from the Municipality of Prishtina stated that the third contributor to traffic congestion in Prishtina is the lack of the outer road ring. In some cases, people who do not have Prishtina as their destination have to go through the city to reach their endpoint. “The outer ring road will take the load of these city roads by providing an alternative option” said him. Additionally, this ring road will be linked with the Ibrahim Rugova highway. One problem the municipality is facing is the expropriation process. However, the linkage of the Ibrahim Rugova highway with this ring road will make it more cost effective and doable for the project to be implemented in near future.

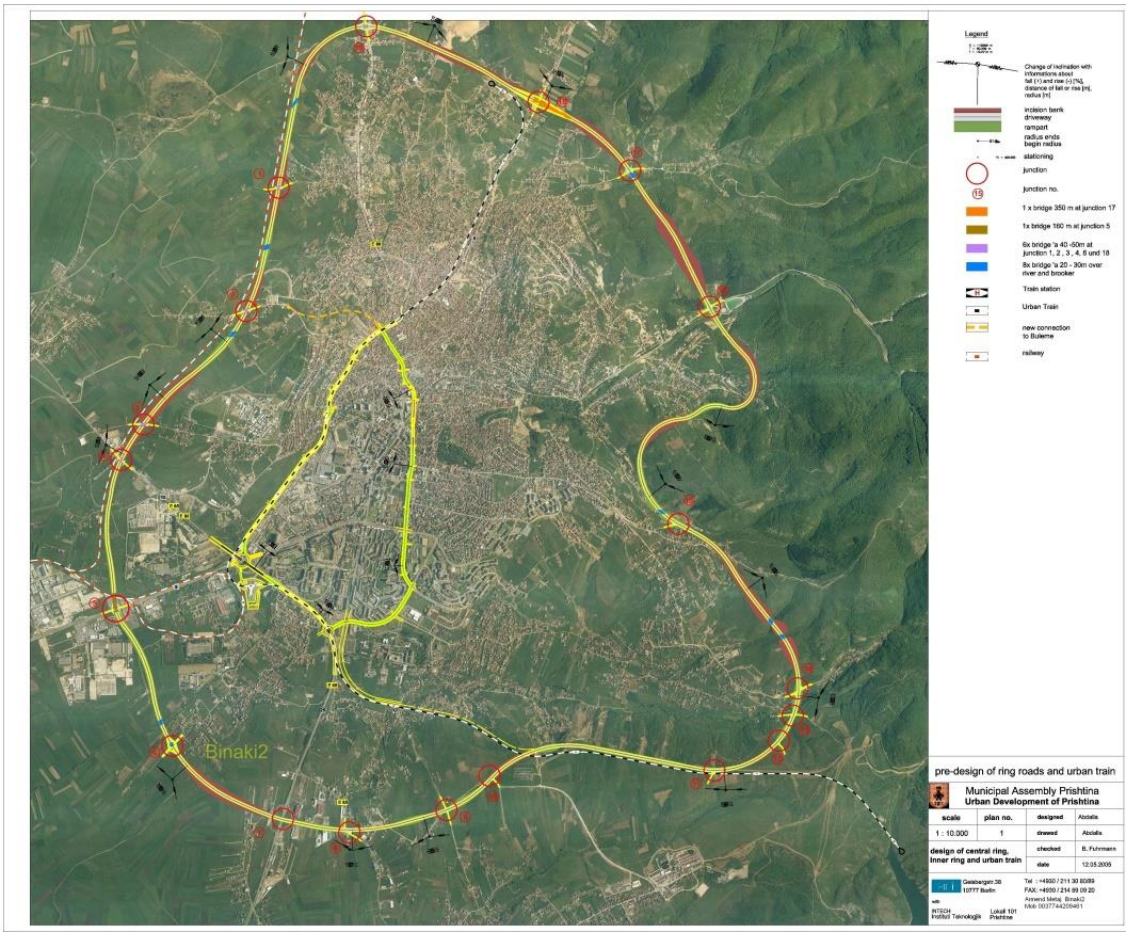


Figure 7: Inner and outer road ring in Prishtina

In a nutshell, the improvements on the public transport, parking places and the ring roads will take time to implement, but officials from the Municipality of Prishtina seem to be confident that these three projects will substantially reduce the traffic congestion in Prishtina.

B. Field Study Results

Until these three projects are fully implemented the problem of traffic congestion continues to dominate in the city. The results from the field observation quantify the economic and the environmental effects of this phenomenon. The figure below shows the vehicular volume on the intersection of Xhorxh Bush and Eqrem Çabej which is located in the center of the city. According to Municipality Representative, this intersection is one of the most congested areas in the city.

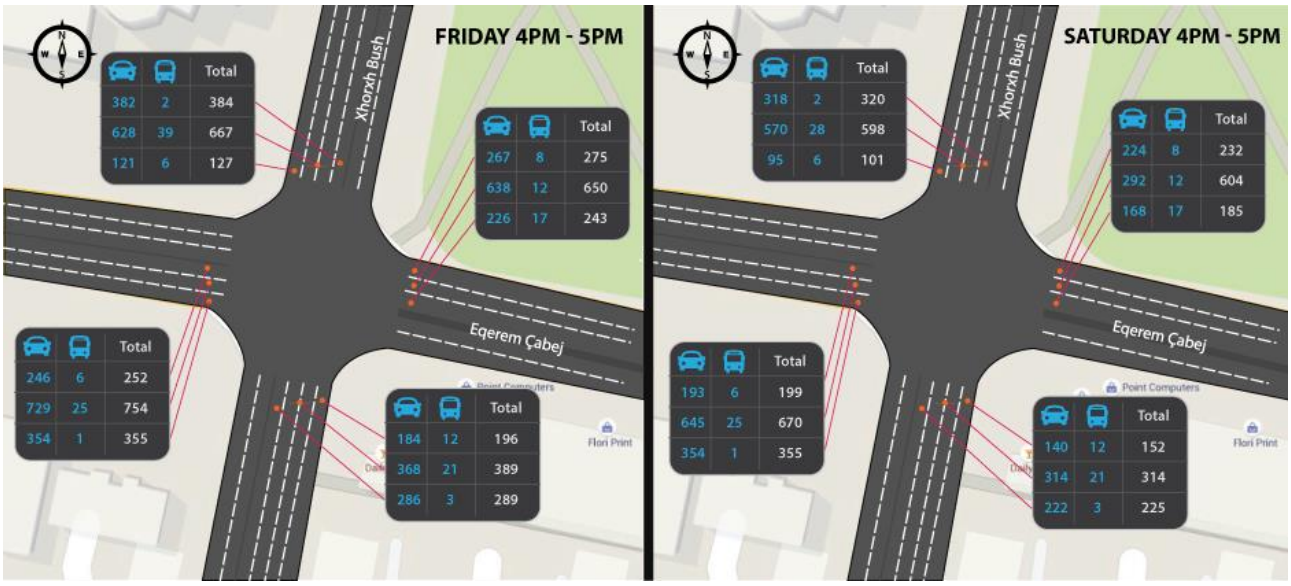


Figure 8: Observation Study

The intersection on the left shows the number of regular and heavy vehicles recorded on each lane separately. The most loaded one is the middle lane on the west with 754 vehicles and the total number of vehicles recorded is 4581. The right side shows the volume of cars at the same location and the same time but in a non-working day. The numbers show a decrease in volume. The total number of vehicles recorded on Saturday from 4 to 5 pm is 3955. That is, in working days, there is 16% increase in demand for road compared to the non-working days. The differences on these two scenarios explain the influence of jobs located in Prishtina in crowdedness of roads.

The same intersection was designed in the software and the volumes were used as input to generate the output values that represent the economic and environmental impacts.

Figure 9: Intersection Design and Inputs in Synchro 8.0

The intersection was designed based on the road structure, the number of lanes, timing of light signals, and the number of pedestrians. These numbers were obtained by the observational study done at the site. The arrows next to the numbers indicate the vehicular direction on that specific line. After the inputs were given, the program simulated the scenario and conducted a report with calculated parameters. Only the data relevant for this study will be discussed in this paper.

SimTraffic Performance Report
Baseline

Total Network Performance

FRIDAY 4PM - 5PM	
Total Delay (hr)	26.9
Total Del/Veh (s)	125.8
Speed Delay (hr)	23.5
Speed Del/Veh (s)	109.8
Stop Delay (hr)	22.1
Stop Del/Veh (s)	103.1
Enter Delay (hr)	3.4
Enter Del/Veh (s)	16.1
Total Stops	601
Stop/Veh	0.78
Travel Dist (mi)	237.4
Travel Time (hr)	34.5
Avg Speed (mph)	8
Fuel Used (gal)	14.6
Fuel Eff. (mpg)	16.2
HC Emissions (g)	120
CO Emissions (g)	4345
NOx Emissions (g)	384
Vehicles Entered	661
Vehicles Exited	571
Hourly Exit Rate	3426
Input Volume	14016
% of Volume	24
Denied Entry Before	0
Denied Entry After	107
Density (ft/veh)	92
Occupancy (veh)	187

SimTraffic Performance Report
Baseline

Total Network Performance

SATURDAY 4PM - 5PM	
Total Delay (hr)	18.0
Total Del/Veh (s)	85.6
Speed Delay (hr)	17.7
Speed Del/Veh (s)	84.4
Stop Delay (hr)	16.4
Stop Del/Veh (s)	78.2
Enter Delay (hr)	0.3
Enter Del/Veh (s)	1.4
Total Stops	566
Stop/Veh	0.75
Travel Dist (mi)	232.2
Travel Time (hr)	25.4
Avg Speed (mph)	9
Fuel Used (gal)	12.2
Fuel Eff. (mpg)	19.0
HC Emissions (g)	105
CO Emissions (g)	3906
NOx Emissions (g)	330
Vehicles Entered	665
Vehicles Exited	550
Hourly Exit Rate	3300
Input Volume	11958
% of Volume	28
Denied Entry Before	2
Denied Entry After	1
Density (ft/veh)	114
Occupancy (veh)	151

Figure 10: Network Performance Report

1. Economic Impacts

The economic impacts of the traffic congestion are measured through gallons of fuel wasted and time delay in hours. The software generated pertinent values for both scenarios; Friday and Saturday. The total delay in hours reached 26.9 on Friday from 4pm to 5pm. During this time, 14.6 gallons (55.3 liters) of fuel were used. In other words, one hour of traffic congestion cost the city a waste of 26.9 hours of productivity time and 55.3 liters of fuel. Compared to Friday, Saturday's finding resulted in a decrease in numbers where the delay time totaled to 18 hours and fuel used totaled to 12.2 gallons (46.2 liters).

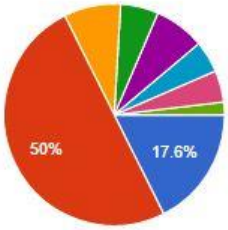
2. Environmental impacts

As discussed throughout this analysis, the gases released from cars contribute in harming the environment as well. Traffic congestion adds to this occurrence. To tell how much of environmental harm comes from this intersection, the program calculated the values for tail-pipe emissions during the recorded time. The volume of un-burnt hydrocarbon (HC) emissions totaled to 120 gallons (454.2 liters); Carbon Monoxide (CO) emissions totaled to 4345 gallons (16,447.6 liters); whereas Nitrogen Oxides totaled to 384 gallons (1453.6 liters). That is, 4,849 gallons (18355.5 liters) were released in the atmosphere only during that hour on Friday. In comparison, on Saturday the total volume released gases decreased to 4341 gallons (16,432.5 liters).

C. Survey Results

The focus of the survey was to identify social impacts of traffic congestion in Prishtina. The sample consisted of 110 people.

1. Age

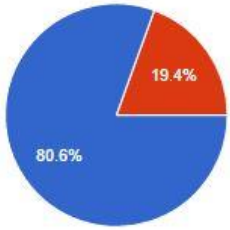


15-20	19	17.6%
21-25	54	50%
26-30	9	8.3%
31-35	6	5.6%
36-40	8	7.4%
41-50	5	4.6%
50+	5	4.6%
Prefer not to answer	2	1.9%

Figure 6 - Respondents' age

Based on results, 67.3 percent of the participants were 25 years or younger, whereas the rest were older than 25 years.

2. Living Area

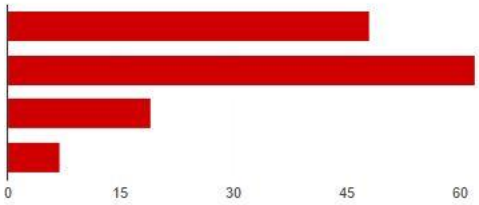


Urban	87	80.6%
Rural	21	19.4%

Figure 72 - Respondents' living area

As seen in figure 12, the largest share of the survey participants (80.6 percent) live in urban area.

3. Transportation use

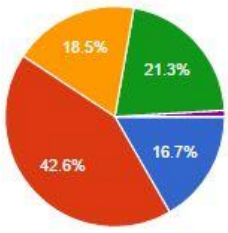


Personal car	48	44%
Bus (Public Transportation)	62	56.9%
Taxi	19	17.4%
None	7	6.4%

Figure 83 - Respondents' transportation means

The survey results indicate that 55.5 percent of participants use public transportation; 44 percent uses personal cars; 17.4 percent uses private taxies; whereas 6.4 percent do not use any of the given transportation means.

4. Time spent in traffic jams within a day



0-10 minutes	18	16.7%
10-30 minutes	46	42.6%
30-60 minutes	20	18.5%
1-2 hours	23	21.3%
2-4 hours	1	0.9%
more than 4 hours	0	0%

Figure 94 - Respondents'' time wasted in traffic every day

Research findings showed that more than 40 percent of the respondents spent up to 30 minutes in traffic jams. Another 40 percent (18.5% and 21%) claim to waste 30-60 minutes and 1-2 hours accordingly. Under normal conditions, ceteris paribus, an individual is expected to work 8 hours per day, 40 hours per week. Assuming that a year has 48 weeks (excluding holidays), multiplying 40 hours per week with 48 weeks gives 1920 hours per year. Multiplying

delay time in traffic with the number of working days per year gives the number of working hours lost per year. Then, dividing this number with 8 (the number of hours a person is expected to work daily) gives the number of working days a person spends on traffic. Therefore, applying this formula to each time interval gives the values on number of days within a year, on average, participants spend in congestions, ceteris paribus. The table below shows the calculated values.

Percentage of respondents	Days per year spend in traffic
16.70%	0-5 days
42.60%	5-15 days
18.50%	15-30 days
21.30%	30-60 days
0.90%	60-120 days

In addition, if not converted into working hours, the time lost due to congestion could also be spent with family or doing other social leisure.

5. Road rage

Figure 105 - Respondents' experience in road rage

Data shows that almost half of the surveyed drivers experienced road rage when delayed in traffic. Results showed that 45.7% calimed that they have experienced road rage in traffic at least once.

6. Important meeting

Figure 116 - Respondents' important meeting absence

The findings showed that 76.2% of the respondents have missed at least one important meeting because of the traffic delays. Missing an important business meeting can be a negative turnover for someone's career (Elisonguo, 2013).

7. Alternative solutions

Figure 127 – Respondents that have found alternative solutions

The research findings indicate that 39.8 percent of the participants find alternative solutions to avoid traffic congestions. As discussed throughout this paper, when driver seek alternative solution, they may cause distress to local residents.

8. Fired from jobs because of traffic delay

Figure 138 - Respondents fired from jobs

The results also showed that 10.4 percent of the respondents have been fired at least once due to traffic delay. Getting fired from a job can be depressive for an individual. On the other side,

human resources are substantial for a company to remain competitive in the market (Elisonguo, 2013).

9. Emotional State

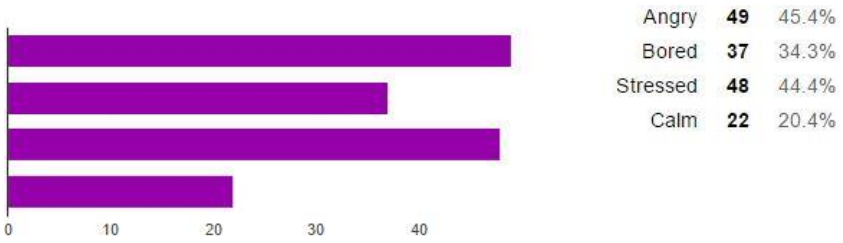


Figure 149 - Respondents' emotional state

Consequently, traffic congestions yield undesirable social outcomes. Participants were asked about their emotional state when they get stuck in traffic jams. They answered as following: 45.8% get frustrated; 33.6% get bored; 44.6% get stressed; 20.6% stay calm. Data shows that, most of the participants who claimed to be experiencing adverse emotions belonged to older age groups.

V. Chapter 5 – Discussion and Recommendations

As previously stated, traffic congestion is a growing problem that leads to a number of socio-economic and environmental issues. Based on literature review, congestion is a result of an inefficient road supply coupled with the relatively increasing demand. Thus, the number of cars demanding roads outweighs the capacity that roads can supply-- to the point that it causes congestion in traffic. In general, findings indicate that the major problems contributing to this issue are: inadequate public transportation, insufficient infrastructure design, lack of road rings, insufficient parking spaces, and so on. Hence, following the research analysis and reviewed literature for this project, the basic recommendations for decongesting the city are: reducing demand of road space and increasing supply of road space.

A. Decrease the demand for road space

Decreasing the demand for roads is the most effective remedy for reducing congestion. The graph below illustrates the demand and supply of roads when the roads are free of charge. Before any change in demand, the congestion is at point A. A decrease in demand shifts the curve from

D to D1 thereby causing the congestion point to decrease from A to B (*"Economics Online,"* 2012).

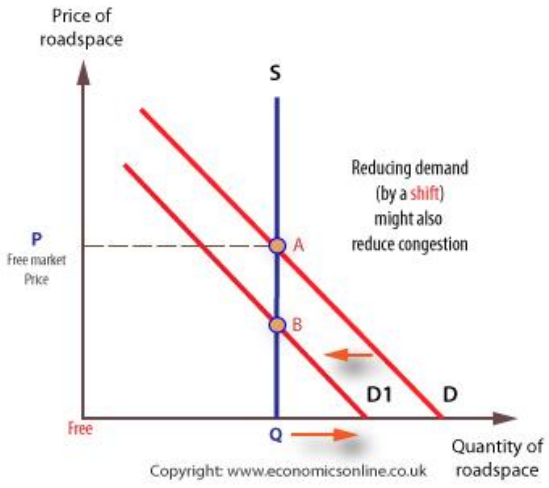


Figure 20 - Reducing demand

The municipality of Prishtina is working on improving public transportation services and increasing the number of parking spaces in Prishtina. However; when one considers the population size (taking into account that the number of jobs in the city is increasing), this approach may not lead to the desired results in the long term. Therefore, strategies for minimizing congestion in the city could be supported by applying congestion charge zones in the center of the city similar to the case of London. This would require nonresidential driver to pay a small fee to travel inside the congestion zone. Determining this zone requires further infrastructural analysis; however, it would preferably cover the inner circle area (see Fugre 7), where the drivers have access to the bypass roads which are less congested during the day. The implementation of road price policy would encourage people to use bypass roads or public transportation instead. The revenues collected from road charges can be used to subsidy public transportation. This policy can be controversial; however, it has proven to have positive effects in the countries that have implemented road pricing policies. According to the London Transportation (public transportation organization), it is estimated that the impact of road pricing saw a reduction of 50,000 vehicles per day.

B. Increasing the supply of roads

The other basic remedy for reducing congestion is by increasing the supply of roads. As it is presented in the graph below, an increase in supply causes the supply curve to shift from S to S1, thus leading to a decrease of the congestion point from A to B (*"Economics Online,"* 2012).

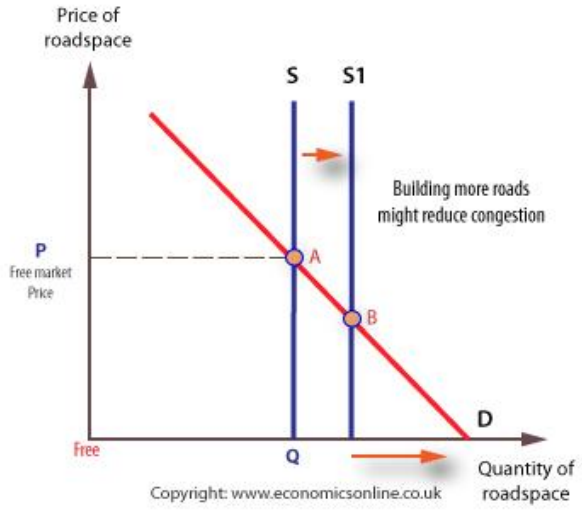


Figure 152 - Increasing supply

The government could increase the road supply by constructing new roads that would offer citizens more commuting alternatives. As the representative of the Municipality of Prishtina stated, an outer road ring will be built outside the city of Prishtina. This ring road could allow drivers to bypass the city if they are traveling to a destination other than Prishtina, leading to a perceivable decline in congestion.

1. Continuous Flow Intersection

Another physical approach to relieving congestion would be applying the continuous flow intersection (CFI) in some of the most congested intersections in the city. This innovative intersection design reduces the conflict points that leads to increased green time at the intersection ("*A UDOT Guide to Continuous Flow Intersections*", p.9). The picture below shows a 4-leg CFI applied on the Xhorxh Bush and Eqrem Çabej Intersection at the center of Prishtina. The total surface area of the intersection has not been changed; only a few lane designs have

been altered and signal timing has been added to the crossovers. The colored arrows indicate the direction of cars entering and leaving the intersection.

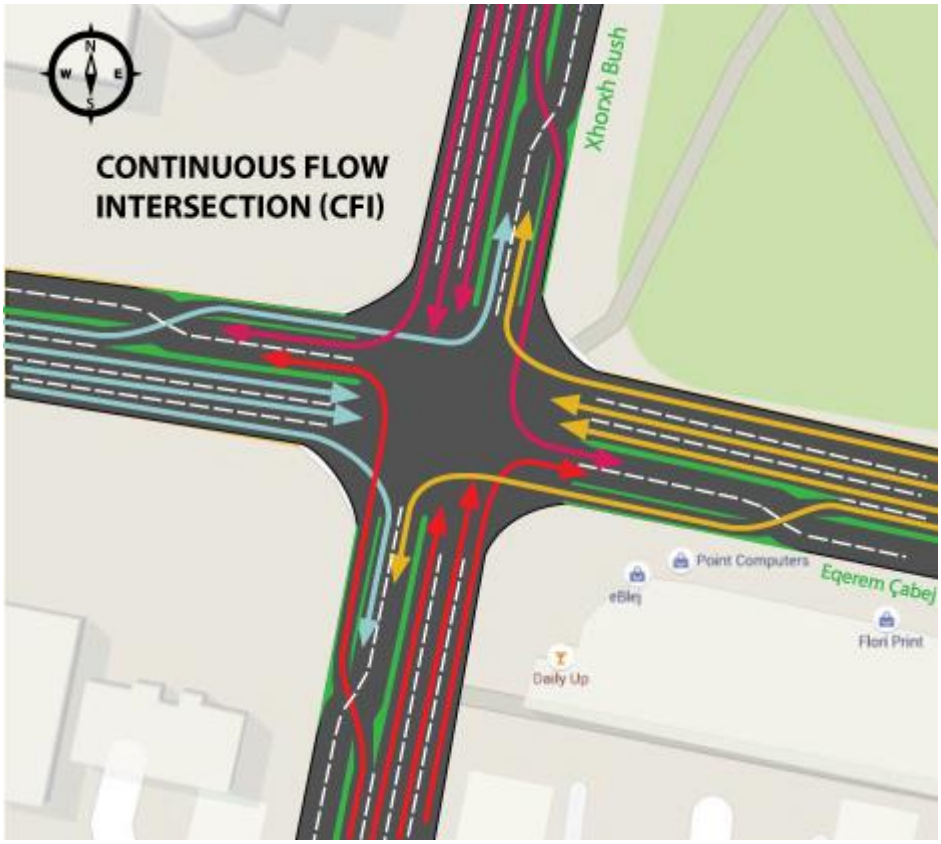


Figure 163 - CFI on Xhorxh Bush and Eqrem Çabej intersection

According to operational and observational study performed by UDOT, "CFI can potentially improve the capacity of an intersection between 30% and 70%" ("*A UDOT Guide to Continuous Flow Intersections*", p.7). Therefore, applying similar designs to the other crowded intersections in the city could also contribute in alleviating traffic congestion.

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VII. Appendices

A. Appendix A

Informed Consent Form for Social Science Research

A.U.K/RIT

Title of Project: *Alleviating Traffic Congestion in Prishtina through innovative designs*

Principal Investigator: Begatim Berisha, AUK Student

Rrruga Isa Kastrati, p.n. Matiqan

Prishtinë 10000

049-544-374; begatimb@auk.org

1. **Purpose of the Study:** The purpose of this research study is to explore how the traffic congestion in Prishtina negatively influences the economic and environmental aspect of society.

2. **Procedures to be followed:** You will be asked to answer *6 questions* during this interview.

3. **Duration:** It will take about *15* minutes to complete the interview.

4. **Statement of Confidentiality:** Your participation in this research is confidential. The data will be used only for this research study.

5. **Voluntary Participation:** Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this form for your records.

_____ _____

Participant Signature Date

_____ _____

Person Obtaining Consent Date

B. Appendix B

Interview Questions

1. In your opinion, can you explain the causes of traffic congestion in Prishtina.
2. What is the Municipality of Prishtina doing in regard to improving Public Transportation?
3. Is there any update from the agreement that the municipality has signed with the European Bank of Reconstruction and Development?
4. Can you identify the most congested areas in the city?
6. The Major of Prishtina, Mr. Shpend Ahmeti has mentioned that the implementation of Congestion Charge zone in Prishtina would contribute to alleviating traffic congestion. Is the municipality planning to implement such policies in the future, and do you think this policy will be effective in Prishtina?
7. The lack of parking spaces in Prishtina is one of the contributors to traffic congestion. Has the Municipality addressed this problem?

C. Appendix C

Survey Questions

Your Gender?

a. Male
b. Female

Your age?

_____

Do you live in Prishtina?

a. Yes
b. No

Do you live in urban or rural are?

a. Urban
b. Rural

Are you employed or student?

a. Employed
b. Student
c. Employed and Student
d. None

What transportation mean do you use for traveling?

a. Personal Car
b. Public bus
c. Taxi
d. None

On average, how much time within do you waste due to traffic congestion.

a. 0-10 minutes
b. 10-30 minutes
c. 30-60 minutes
d. 1-2 hours
e. 2-4 hours
f. more than 4 hours

What time of the day do you usually commute?

a. 08:00 – 09:00
b. 16:00 – 17:00
c. other

Can you specify your most frequent route within the city?

_____

On your daily commuting, do you encounter traffic congestion?

a. Yes
b. No
c. Sometimes
d. Never

What do you think are the biggest contributors to traffic congestion?

a. Low supply of roads
b. Increased number of cars demanding roads
c. Weak signaling
d. Other

Have you ever experienced, or been involved in, road rage due to traffic delay?

a. Yes
b. No

Have you ever missed any important meeting because of traffic delay?

a. Yes
b. No

Have you found an alternative road to avoid congestion?

a. Yes
b. No

Have you ever lost your job because of traffic delay?

a. Yes
b. No

How does being stuck in congestion affect your emotional state?

a. I get frustrated
b. I get bored

c. I get stressed
d. I feel calm