Increasing Feasibility and Efficiency of Shuttle Service inside NUST H12 Campus

Final Year Project UG-2017

BACHELOR'S OF

CIVIL ENGINEERING

NUST Institute of Civil Engineering

School of Civil and Environmental Engineering

National University of Science and Technology Islamabad, Pakistan

This is to certify that the

Final Year project Title

Increasing Feasibility and Efficiency of Shuttle Service inside NUST H12 Campus

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has been accepted towards the requirements

for the undergraduate degree

in

CIVIL ENGINEERING

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DEDICATION

We would like to dedicate our works to our parents, our teachers our institution NUST and all our friends. We executed our work with the impressive assurance and determination and applied best of ourselves to the errand at hand.

DECLARATION

It is hereby reverently and truthfully declared that all the work alluded to this thesis is composed by us and it has not been submitted by any institution, in whole or in part in any previous application for a degree. Any references to the work done by any other person or University have been appropriately cited.

ACKNOWLEDGEMENTS

In the name of Allah, the most Beneficent, the most Merciful as well as peace and blessings be upon Prophet Muhammad, His servant and final messenger.

We would express our sincerest gratitude to our supervisor Assistant Professor Malik Saqib without whose support, motivation to remain positive, and guidance this thesis wouldn't have been possible. We are also extremely grateful to the university students who filled the survey forms which helped us to acquire data for this Final Year Project of ours. Moreover, a special thanks to Dr. Junaid from IGIS department who helped us regarding the ArcGIS software.

Moreover, we feel very lucky having the people around us from our teachers to our friends and family who supported us and had influenced us into becoming who we are today.

Last but not the least, we are grateful to the National University of Sciences and Technology (NUST) for providing us an environment to achieve what we have always dreamt of and enabling us to play our part for the betterment of humanity.

ABSTRACT

National University of Science and Technology H12 campus is spread over 707 acres of land comprising departments, Administration block, Male and Female hostels, Mosque, Cafeterias. Campus has a vast area and reaching the desired destination on time becomes difficult for the students and staff. In order to improve the mobility of students and staff inside the campus an efficient shuttle service system is required. The current operating shuttle service system is not efficient enough to accommodate the requirements of students and staff inside the campus. In order to cope with the rising concern this project has been brought into account. The project will focus on improving the efficiency of the shuttle system inside the campus by following a proper route and time schedule. Proper location of shuttle stops inside the campus will be directed. Project will focus on fulfilling the demands of individuals which were obtained through survey. Students and staff will be able to reach desired destinations on time by following the time schedule of the shuttle system.

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CHAPTER 01

INTRODUCTION

1.1 Location

The shuttle service project is designed in NUST H-12 campus Islamabad. The major concern of the location selection is to cover the area facilitating students by providing the shuttle service to minimize inter-department travel time.

Figure 1: Project location NUST H-12 sector

1.2 Background

Development of university campuses over large areas require a system of shuttle service to facilitate mainly students, teachers, and other staff. NUST H-12 campus comprises a total 4 km square of land with a major road network of length 5.5 km connected with minor roads. As NUST accommodates students from all over the country and also from other countries, therefore, most of them are living in hostels inside NUST campus. Survey indicates that there is a large number of students living in hostels with no transportation facility. So, this huge area and numbers demand for an efficient public

transit system to be employed on campus. Although, shuttle service is currently running in campus. But a study revealed that current shuttle service is not fulfilling the requirements of students. NUST is expanding very fast from previous some years and increases number of seats for students each year. Population trends show that there will be much more demand for shuttle service in the next 5 years. So, there is a direct need of re-considering current shuttle service for scheduling and re-routing it according to the present and future demands.

1.3 Problem statement

NUST has the 2nd biggest campus in Islamabad, consisting of 707 acres, although it is designed in a way that male dominant institutes are close to boys' hostel and female dominant departments are closer to girls' hostel. But still the average distance between boy's hostel and a female dominant department and girl's hostel and male dominant department is 2km, it is about 25-30 minutes' walk, also NUST as irregular terrain, which makes it even difficult to walk all the way every day. Not all the students are allotted hostels inside NUST, so they have to accommodate in H-13 private hostels. Average distance from h-13 to departments is around 2.5 km.

Considering this problem NUST introduced its own free of cost shuttle service, these are electric powered vehicles with max speed 40 Kmph. These shuttles have a sitting capacity of 9-11 people. But there are some problems with this shuttle service. Following are some of the problems:

- No defined route
- No defined schedule
- Less number of vehicles available
- No defined stops

These issues have serious effects on students, as most of the students are unable to take benefit from this shuttle service, because they don't know whether the shuttle will come or not or is it worth waiting for the shuttle as it is always fully occupied. It also causes problems for students living in hostels as they have to skip their lunch because 25 minutes' walk one way is not a wise decision.

1.4 Objectives

The objectives of the project are:

- Define routes for shuttles.
- Make a schedule of shuttle service.
- Define bus stops inside campus.
- Optimize usage of shuttle service.
- Analyze supply and need demand and take effective measures.
- Effective modeling and simulation of complete system.

1.5 Scope

The scope of this project can be best described as:

- Effective transportation system; minimizing delays.
- Fulfilling traffic needs; minimize congestion, queuing.
- Reducing vehicular density; greater user accommodation then other vehicles.
- Achieving economy by making use of solar power/electric vehicles (reducing fuel costs).
- Achieving Effective parking system by reducing vehicular density.
- Healthy environment: minimizing the use of fuel/petroleum products which yield hazardous gases on burning.
- Improving safety by:
    - controlling Vehicular density
    - controlling Volumes
    - safe Speeds
    - effective routing

1.6 Methodology

The methodology adopted for the project design/execution is described as:

- Sample data collection by circulating the google forms to determine the demand.
- Digitization of the sample data.
- Expansion of data to convert simple data to population data.
- Statistical analysis.
- ArcGIS analysis which includes the formation of trend lines.
- Trip generation and distribution.
- Route selection and route assignment.
- Optimal Shuttle requirement on each route.

CHAPTER 02

LITERATURE REVIEW

2.1 General

This chapter describes the literature that is the basis of the project. The key concerns that originated in the project are: what are the major issues regarding the operation of a shuttle service? What are the possible solutions to such problems? and which factors influence the project execution?

This chapter addresses the issues of the users regarding the operation of shuttle services and the possible solutions to the problems and the techniques which are used in solving such problems.

2.2 McGill University Canada (University Transportation system) Report by Shaw et al

This study described the concerns of the university students regarding the campus transportation system. The students were not satisfied by the transportation service in university. The students were asked about their problems regarding the service by using survey forms, emails, messages, and random interviews.

The report stated that the main barrier regarding the inefficiency of available shuttle service in university was “long commute time” and “inaccessibility to stops and services”.

The analysis showed that there was a problem of inappropriate routing which adds to the travel time and causes accessibility issues to some students and thus the demand was not fulfilled.

2.3 Geospatial Analysis of Shuttle Bus Stops within the Urban Milieu (A Case Study of University of Ghana)

The aim was to introduce new bus stops keeping in view movement of passengers and to introduce optimized routes to avoid delays and cover maximum area on campus. The data was collected from two major sources: participatory observation and GPS trackers were installed in the busses to track their movement. **ArcGIS 10.2.1** was used to generate a map and patterns of bus movement and 200 meters buffers were made around the bus's stopping area to find the most appropriate bus stops.

The study concluded that there was a need for optimal siting of the bus stops at the various locations. Bus stops optimization mainly aims at distributing a set of bus stop locations that can mostly satisfy public transport demand and maintain adequate walking accessibility and cover sufficient service areas with minimal number of stops.

2.4 A deterministic IP model for optimizing bus scheduling in a private transportation system

Purpose of this study was to optimize the model for scheduling of private transportation system deterministically. In this transit system, vehicles pick employees and drop them to their desire destinations making different trips along various routes from campus and different housing apartments.

The model was based on integer programming. In this model, traffic data should be deterministic. For example, departure times and times of round trips of all passenger traffic should be deterministic to decide constraints which will define the model formulation. Using the deterministic departure times and round-trip times of all trips, Gantt charts were created to show the start and finish times of trips. To remove scheduling conflicts, scheduling conflict matrix was constructed based on the deterministic timings of trips.

An illustrative example was solved in GAMS 22.6 using the CPLEX solver. All trips were assigned with the minimum weighted number of vehicles by eradicating scheduling conflicts. The results of this model i.e., scheduling and number of buses required, showed the accuracy of the model.[4]

2.5 Application of “SERVQUAL” in campus shuttle service

The aim was to schedule and optimize campus shuttle service to avoid long queues and provide cheap alternatives for expensive private transportation systems. This study adopted the scope of service model to assess UCC campus shuttle service, they used SERVQUAL which is based on the "GAP model" of service quality which facilitates quantification of the gap between customers' expectations of a service and their perceptions of the actual service delivered.

A questionnaire was made and was filled by 300 random people who use this shuttle service. Efforts were made to reduce the gap between expectations and reality. Developed optimization model by the help of data acquired from the people. Routes were reworked to focus majority of people who use shuttle service for educational purposes. Bus stands were improved to meet passenger's expectations. Extra busses were introduced to avoid long queues. During specific times i.e., 8:00 AM to 10: AM and 4:00 PM to 6:00 PM special routes were introduced.

2.6 Challenges regarding the project

The above literature review concluded the following challenges in the proceeding of project:

- Route modeling: optimal route identification/selection.
- Ridership modeling: demand and capacity analysis.
- Vehicle efficiency: life cycle, operating condition and performance.
- Stop station area planning: pick-up and drop locations.
- ITS: vehicle demand, availability, tracking and timings.
- Shuttle maintenance programs.

2.7 Different problems regarding shuttle service

The above literature review concluded the following issues/problem are the causes of ineffectiveness of shuttle service system:

- Long commute time.
- Inaccessibility to the service or stops.
- Improper stop area planning.
- Crowdedness level due to improper demand analysis.
- Safety and services issues.
- Excessive delays.
- Inappropriate Routing.
- Reliability issue.

2.8 Possible solutions to the concern problems

The possible solutions to the above-mentioned problems are:

- Proper scheduling plan.
- Proper routing analysis.
- Stop stations area planning.
- Data accuracy and demand and capacity analysis.
- Improve vehicular efficiency.
- Effective volume control.
- Analyzing the travelling trend with respect to time constrained.
- Route overlapping to minimize delay.

CHAPTER 03

SURVEYS

3.1 Introduction

Project is to check the feasibility of campus shuttle service, increase its efficiency and define the routes so that maximum trips of students are covered, NUST consists of large area of 707 acre and students have to travel long distance to attend their classes or to enjoy recreation facilities, to know the feedback of current shuttle service and to get an idea of trip generation we have designed a survey form to extract maximum information from respondents. The purpose of this project is to let more people use Campus shuttle as a mode of transport, it will discourage the use of personal transport inside campus and also reduce the inter-campus travel duration. As the shuttles are electrically powered so they also help reduce Carbon dioxide emission and other harmful emission gasses.

3.2 Surveys

Surveys are the most Important and crucial step of a project in its designing phase, In our project we want to check the feasibility of campus shuttle service so survey results were of great importance, to check whether it is required or not, Our second step was to find the optimum route to maximize the efficiency of shuttles.

Our Team developed a survey form in which questions were to be asked from NUST students regarding their trips inside NUST, moreover it was designed to collect data from both frequent users and ones who do not get a chance to travel via shuttle.

When we were designing our Survey form following points were taken under consideration:

- What is the Goal of the survey?
- How can we integrate collected data in our project?
- What is our target audience?

An online survey was done, Google form survey was sent to different departments of NUST, a decent number of responses were collected.

The Survey was divided into three main parts:

1. Hostelites
2. Day scholars
3. General Questionnaire

3.3 Hostelites

NUST offer residence for international students and students living outside Islamabad and Rawalpindi, we designed our form in such a way to extract most of the useful information from these students, many students go back to their hometown at weekends thus decreasing the user count of Shuttle service.

One of the most important factors of any project is its cost. This is the major task for the Transportation engineer to design the project which is cost effective. Surveys have huge influence on the design as results and data analysis form surveys tell us about work needed to do, and in this way, it makes the project more economical.

Every hostelite was asked about his hostel and does he/she have personal transport and how often they go home, the purpose of these questions was to know the Trips originated from hostel to various gates at start of weekend and trips originated from gates to hostel at end of weekend. As you can see in figure 2.

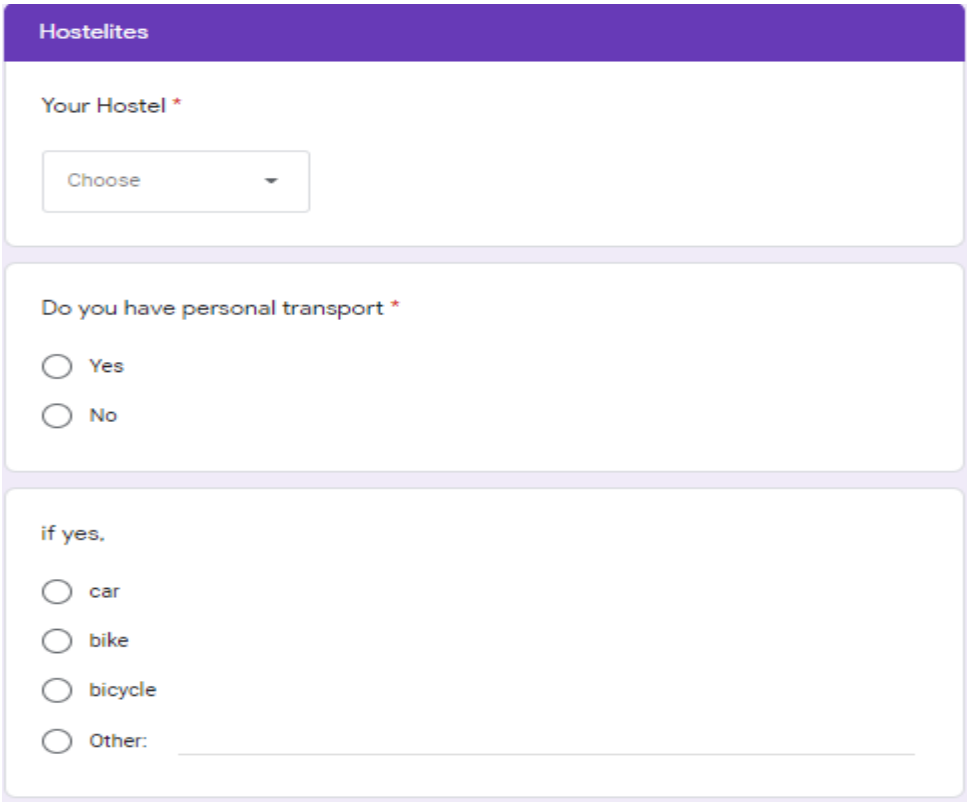
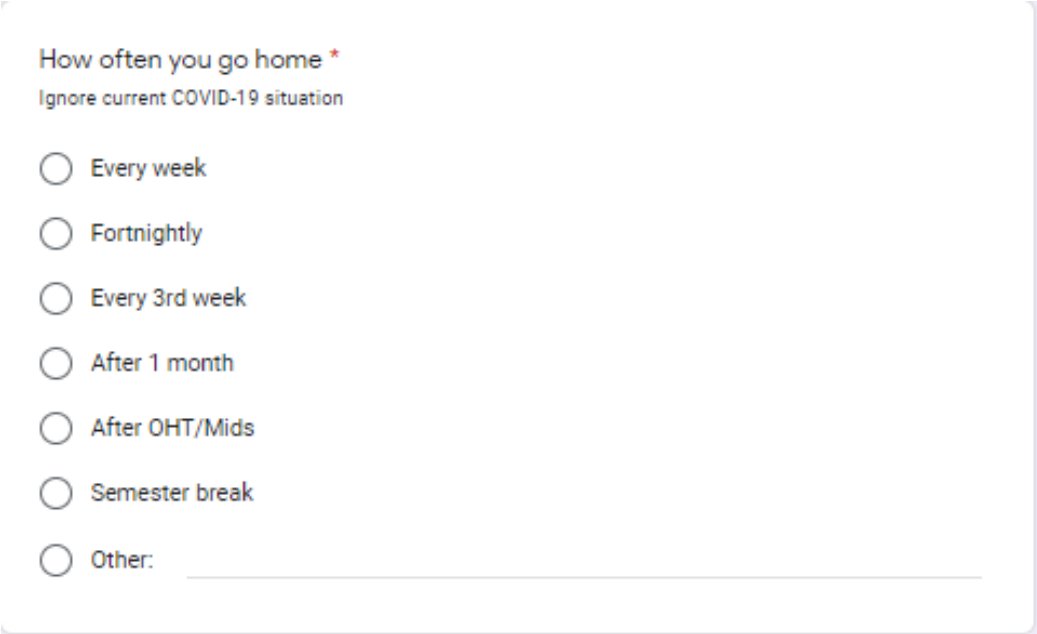


Figure 2: Survey form

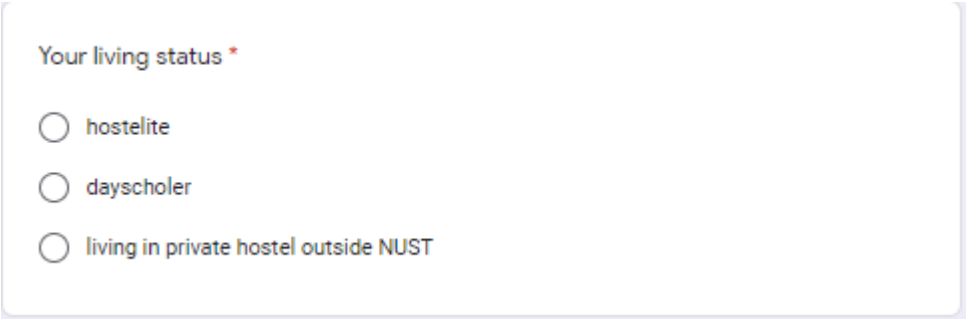
While asking about how often they go home we asked them to ignore this Pandemic situation so results will be valid even after the pandemic is over as shown in figure.



3.4 Day Scholar

Students who come to university on daily basis are regarded as day scholars, in NUST there are two types of Day Scholars:

- Students who live in Islamabad or Rawalpindi.
- People from out of station living in private hostels due to unavailability of hostel inside campus.



Students from Islamabad usually travel via NUST transportation system, also they own their own personal transport, and students living in private hostels usually walk to hostel and are heavily dependent on campus shuttle service.

Every day scholar was asked about his mode of transport, and in case of NUST transport what is his pickup and drop-off point as shown in figure.

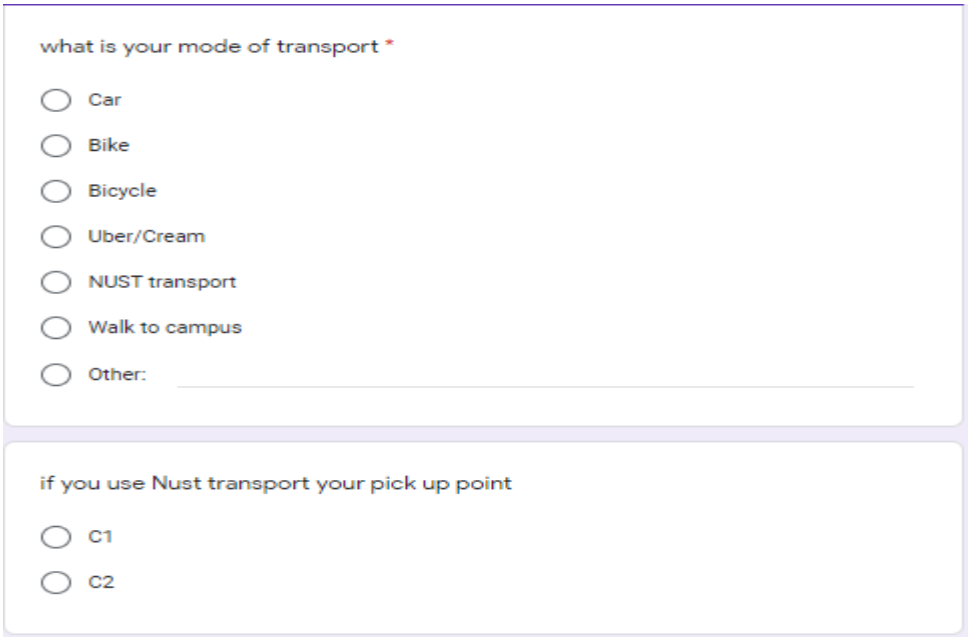
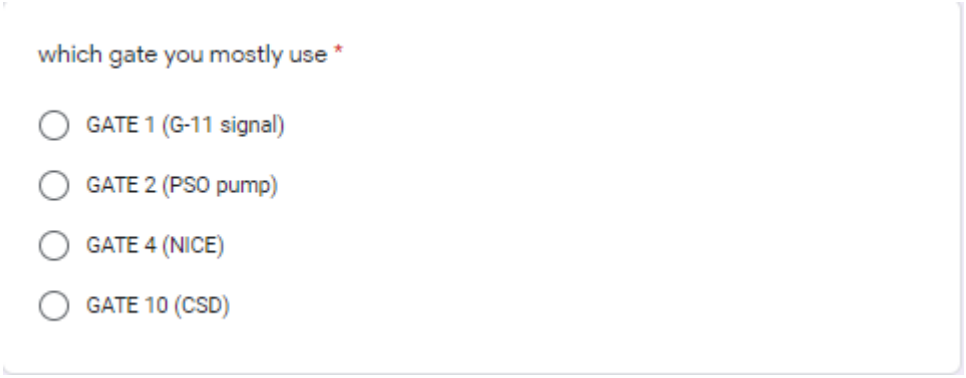


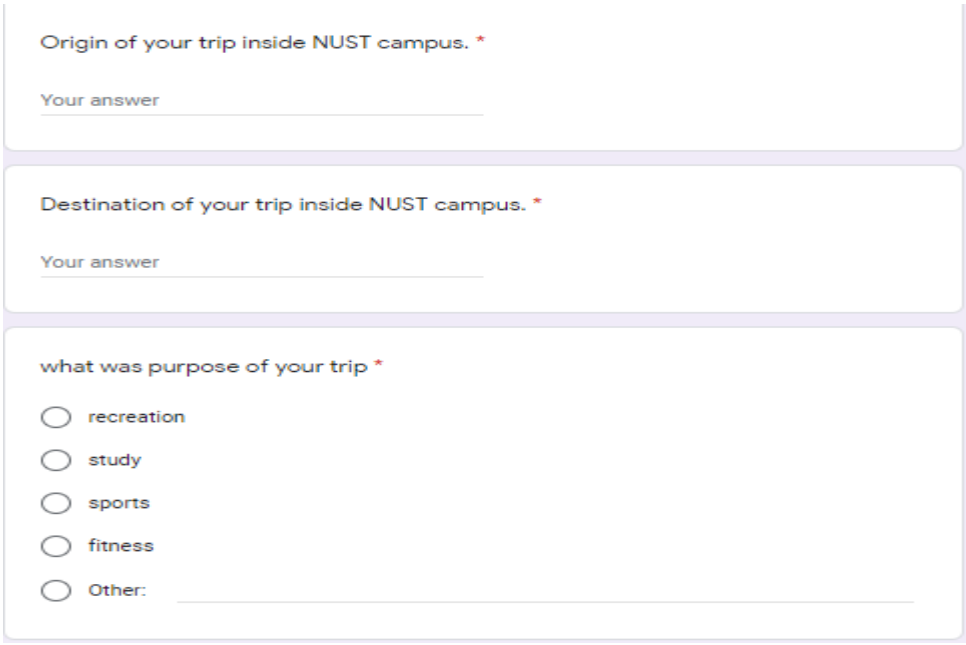
Figure 3.4

We asked the respondents who are day scholars about the gate they most frequently use it was asked to know the demand on each gate.

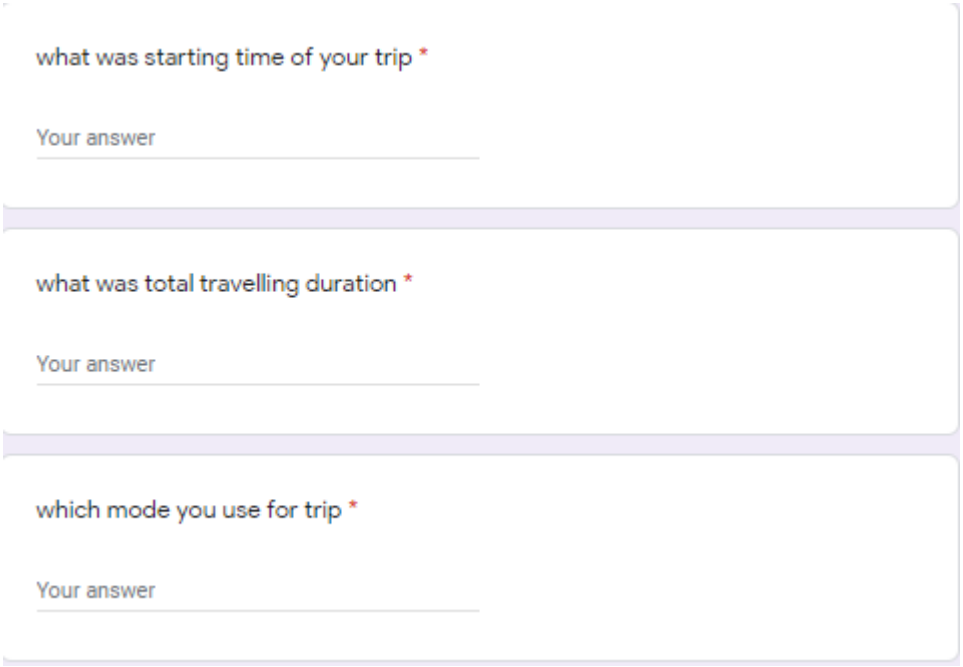


3.5 General Questionnaire

After Hostelites and Day scholar part there was a general questionnaire which was same for both, in this section we asked our respondents about their origin of trip, destination of trip, time taken during travel, time of travel and purpose of trip, the reason these questions were asked to get the idea of trip generations, and trend lines. As you can see in figure 3.6 origin, destination and purpose of trip was asked.



To know the average travel duration of respondents while travelling inside campus due to various reasons we asked respondents about your average travel duration. As shown in figure.



CHAPTER 4

SURVEY RESULTS

4.1 General

We conducted online survey from students of all departments of university, from data collected from this survey we did analysis on Microsoft Excel, further this data was converted into graphical form, those graphs were then converted into statements for accurate objectives of the questions.

We use ArcGIS to draw lines from Origin to destination to acquire broad vision of students travelling inside campus, these trend lines show the number of students on different routes which helped us selecting the optimum route.

4.2 Results of survey

Answers to the different questions were converted into graphs using Microsoft excel, this helped us converting sample data into population data.

301 online forms filled by almost every department of NUST, responders gender ratio was 75% male and 25% female as shown in figure 3.

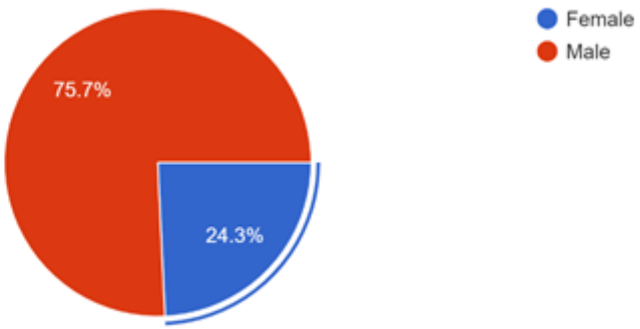


Figure 3 Chart Showing Gender Information

2. Undergraduate and postgraduate ratios were 83% and 17% respectively, as shown in figure 4.

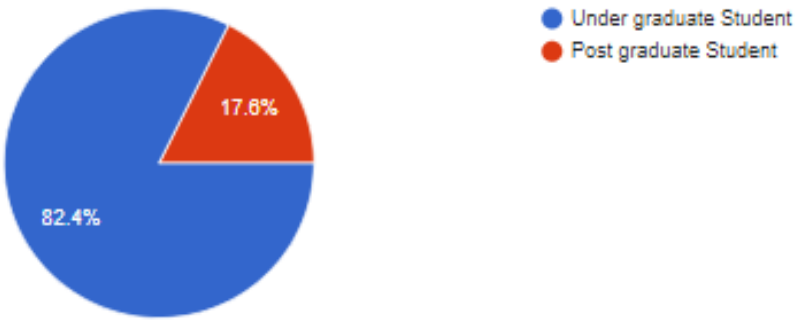


Figure 4: Pie chart showing UG/PG response ratio

3. Living status of students was 68.4% Hostelites, 23.9% Day scholars, 7.6% Students living in private hostel as shown in figure 5.

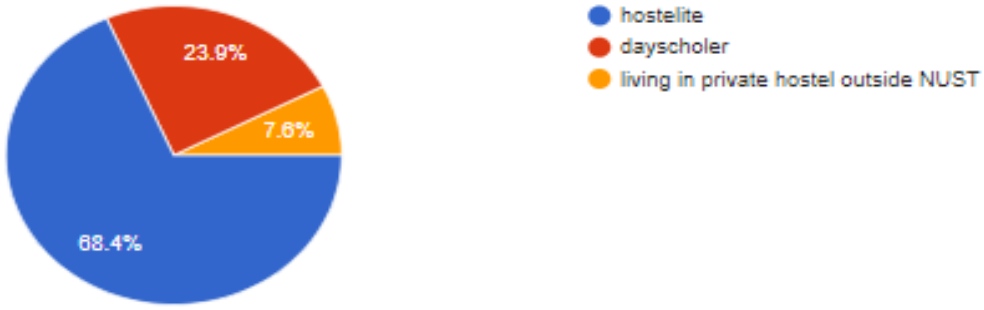


Figure 5: Students' Living Status Chart

4. We collected data from almost all the schools of NUST as shown in figure 6.

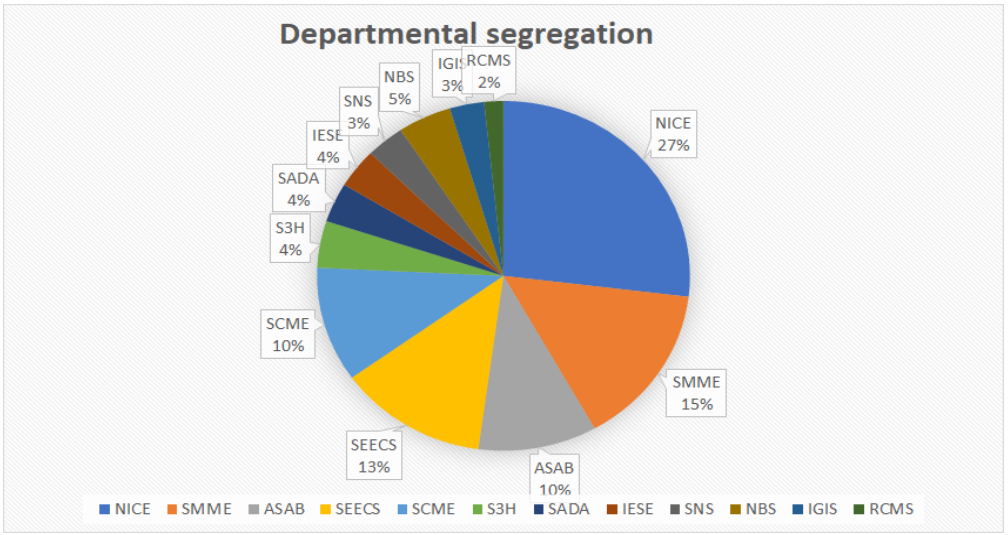


Figure 6: Departmental Distribution Chart

5. Most of the Trips were during 8:30-9:30 as shown in figure 7.

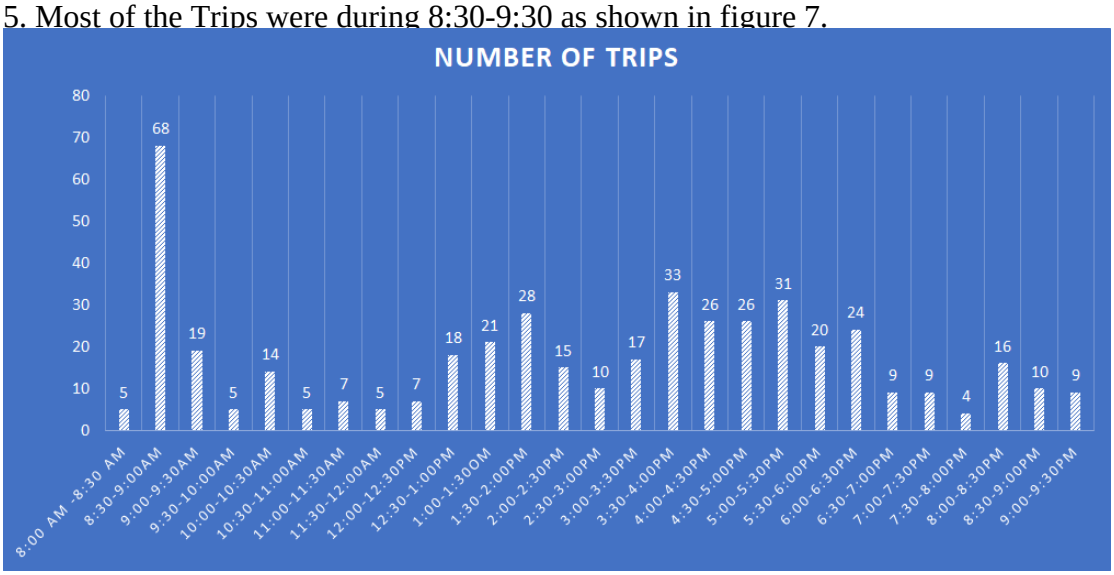


Figure 7: Bar chart showing trip generation at different time.

4.2.1 Hostelites

We have divided our survey in three parts Hostelites, day scholars, general questionnaire.

200 online forms were filled by students living in hostel, the ratio of students having personal transports was 89.3% do not have personal transport while 10.7% have their own personal transport as shown in figure 8.

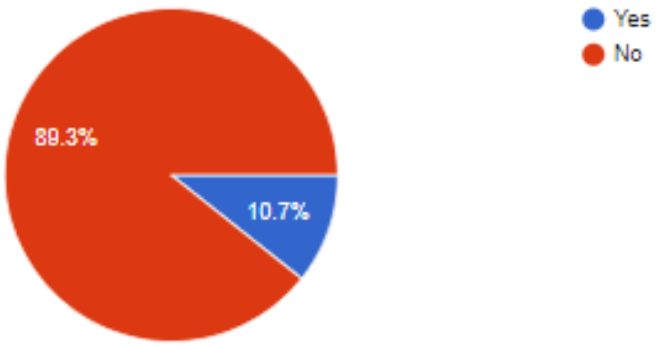


Figure 8: Personal Transport Data chart

Most of the university students tend to go to home at least once a month as shown in figure.

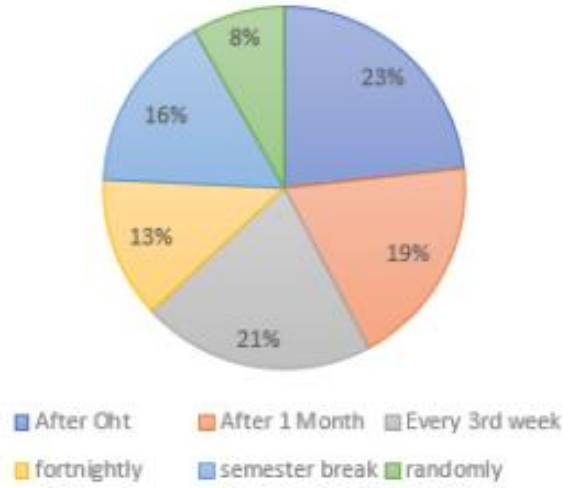


figure 4.8

Purpose of trip of hostelites ware generally either study or recreation as shown in figure 9.

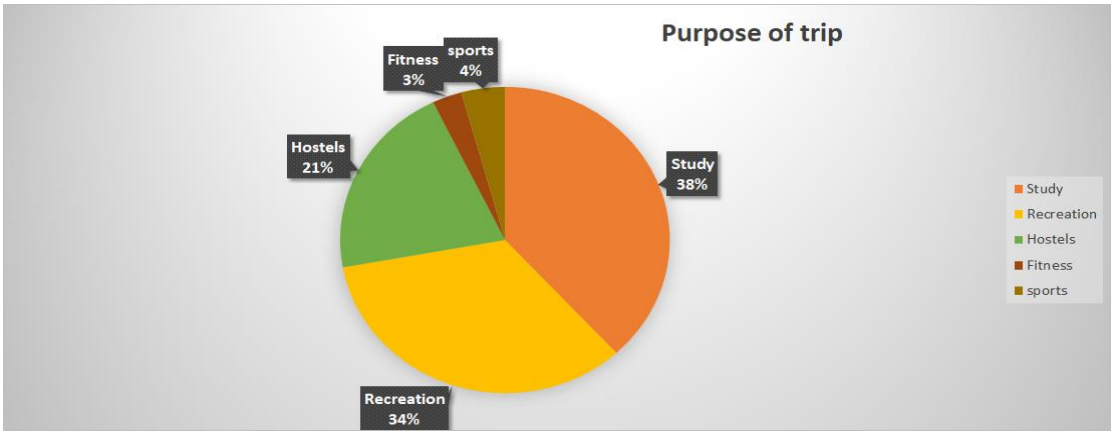


Figure 9: Chart showing trip purpose

445 trips data was collected and most common mode of travel for hostelites was found out to be walking as shown in figure 10.

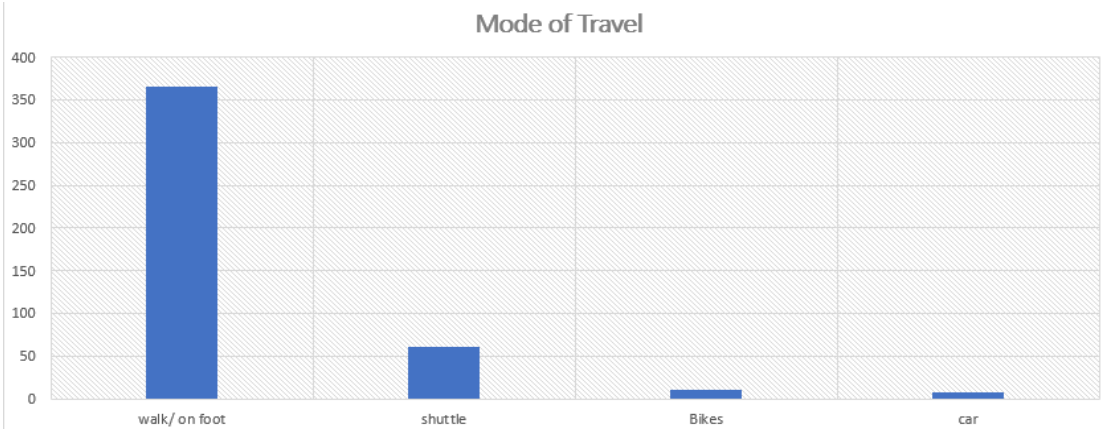


Figure 10: Chart showing mode of travel of hostellites.

4.2.2 Day scholars

Students living in Islamabad, Rawalpindi and in private hostels are day scholars as they come to university in daily basis, around 100 of our respondents were day scholars.

Most of the day scholars own their personal transport some come via NUST transportation system and few walks to campus as shown in figure 11.

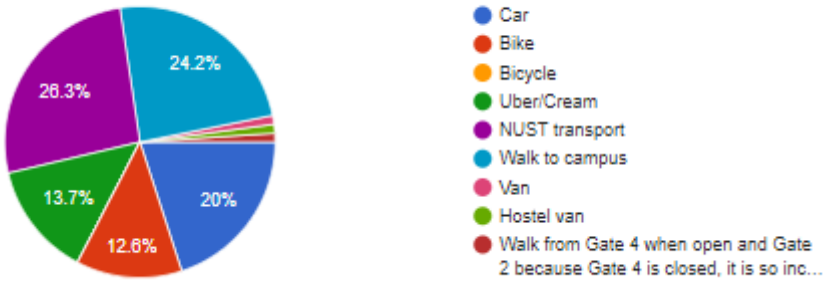


Figure 11: Chart showing mode of travel of Day scholars.

It was found out that most of the day scholars use gate no 2 and gate no 1 for entering inside campus as shown in figure 12.

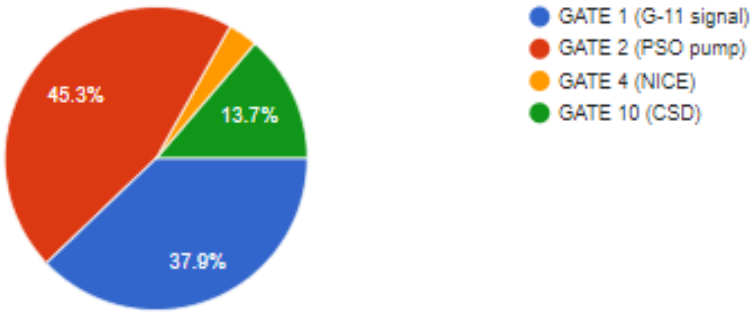
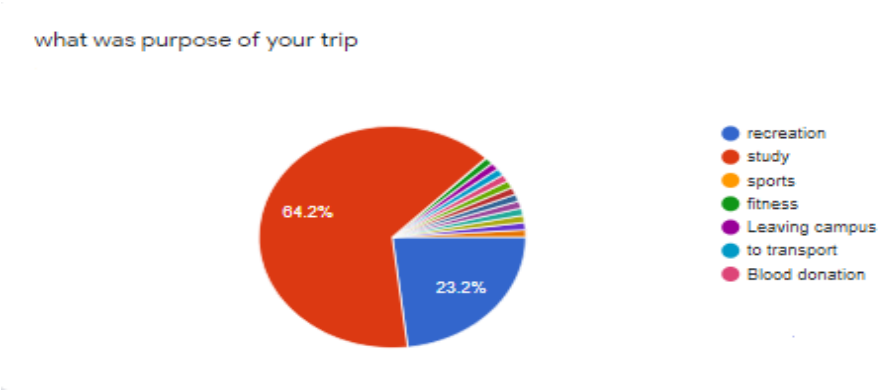


Figure 12: University Gates utilization response chart.

Purpose of trips of day scholars was generally either study or recreation as shown in figure.



Mode of transport for intra campus travel for day scholars was also found out to be walking, following is data of 191 trips travelled by day scholars.

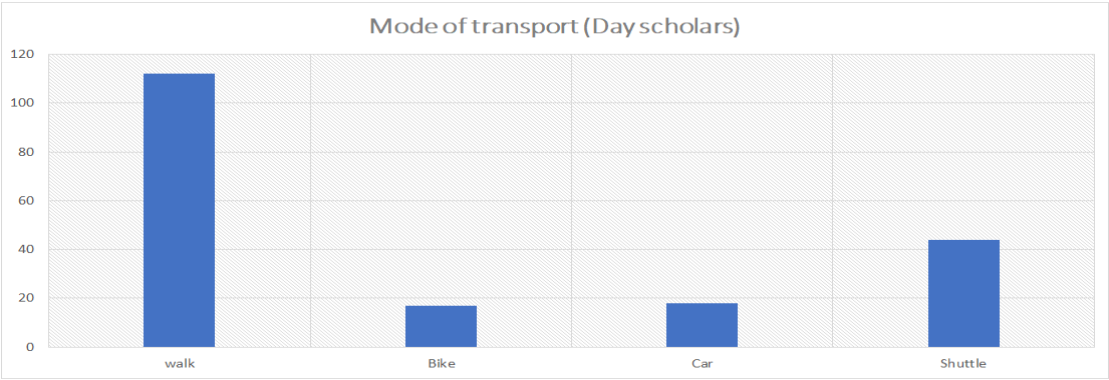


Figure 13: Bar chart showing day scholars' mode of travel within campus.

CHAPTER 05

ANALYSIS

5.1 Defining Nodes (Origins/Destinations):

Sample data was analyzed on the basis of origins and destinations. According to the survey data collected, some of the origins/destinations were very near to each other. These origins/destinations were then grouped to make a single node. For example, a student from Razi Hostel and another student from Ghazali Hostel made their trips to IESE and C1 respectively. So, there were two different origins and destinations involved. As these places are very close to each other, we grouped them to single origin "Male Hostel" and single destination "C1/SCME/IESE". Trip counts were added after grouping. Following are the nodes which would serve as origin and destination points of trips:

- Male_Hostel
- Female_Hostel
- Gate_1
- Gate_2
- SADA/IGIS/ASAB
- S3H_NBS
- SMME/SNS
- NICE
- SEECS/C2
- C1/SCME/IESE
- Gym
- Rumi
- Library/MainOffice
- CSD

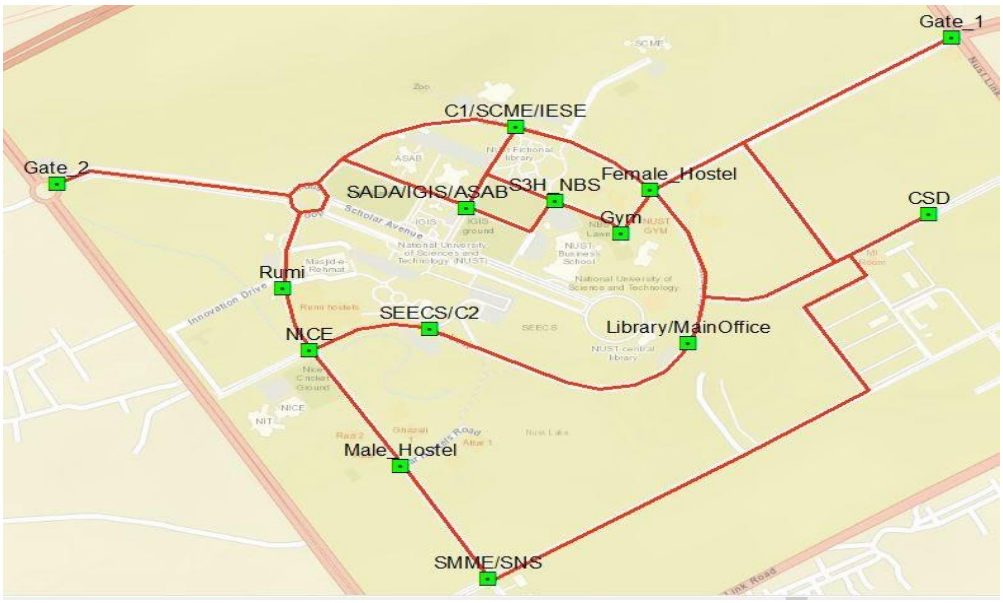


Figure 14 Origin/Destination Nodes

5.2 Statistical Analysis of Data:

Different filters were applied on the survey data collected to digitize data according to the required statistics for further analyses and modelling. After defining nodes, filters were applied to determine the nodal segregation of trips. Data of this analysis was then used for trip generation and trip distribution over routes. Following map shows proportions of going and coming trips to each node.

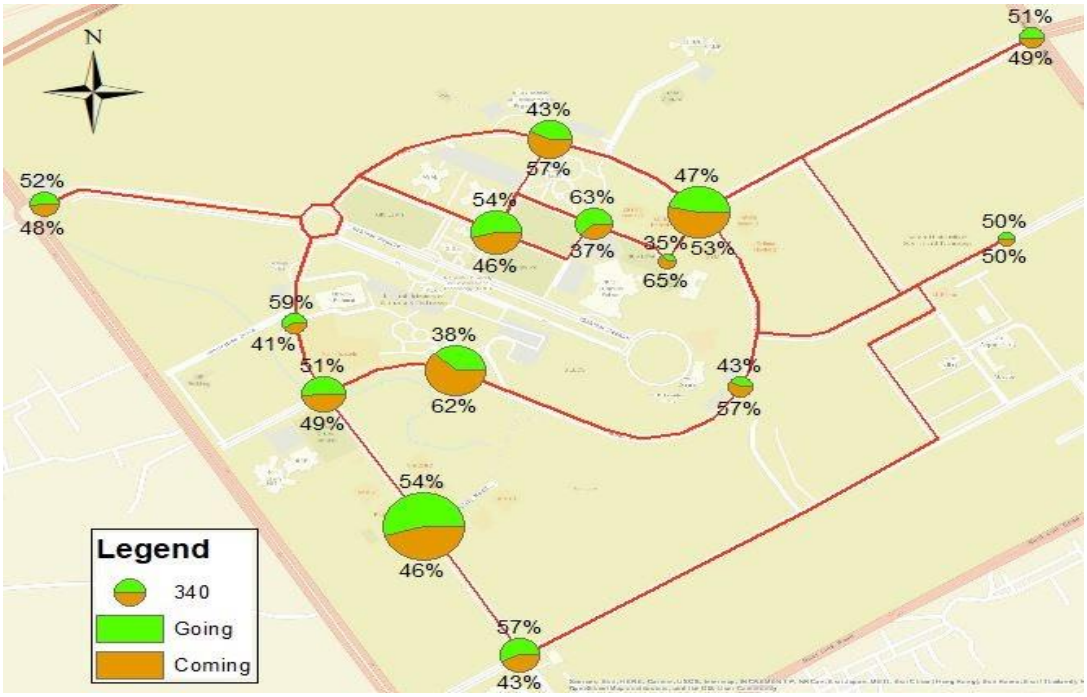
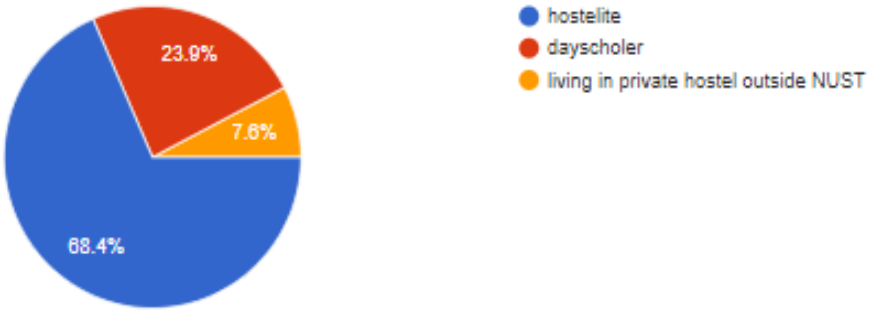
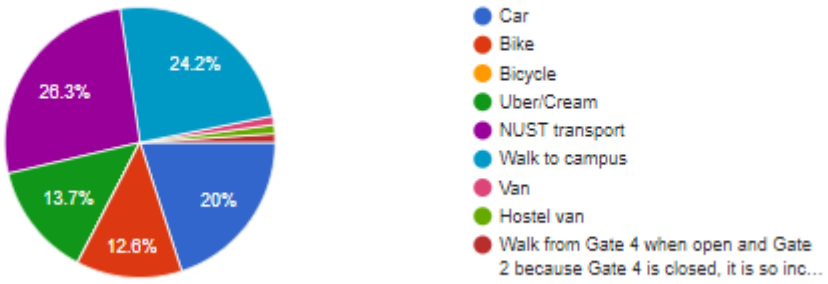


Figure 15 Directional Distribution of trips

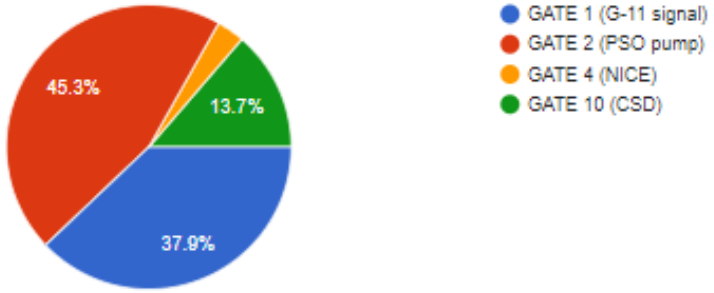
Data collected through the survey consisted of different categories of potential users of shuttle service. The Cross-Classification method was used to determine the actual demand of shuttle service. For example, Day scholars data was classified according to transportation data and their entrance/exit in campus data to get the exact percentage of those who will need shuttle service inside campus.



Transportation Data of Day Scholars.



Entrance/Exit Data of Day Scholars in campus.



5.3 Spread of Sample Over Population

We collected sample data through survey forms. Then sample data was multiplied with percentages of population clusters digitized from survey form. Firstly, we calculated the trip factor by dividing the number of trips of a certain group with the total number of survey participants of that group. Data is expanded by multiplying the total population of the same group with the trip factor. Expanded data shows the number of trips of the total population of each group.

5.4 Origin-Destination Matrix

After verifying data, the OD Matrix is constructed. Rows of OD Matrix represent origins of trips and columns represent destinations. This matrix shows all data of trips from all origins to all destinations. Data Analysis techniques are applied to verify O-D Matrix. This matrix further will be used for network analysis in ArcGIS.

	Male Hostel	Female Hostel	Gate 1	Gate 2	SADA/IGIS/ASAB	S3H/NBS	SMME	NICE	SEECS/C-2	C1/SCME/IESE	Gym	Rumi	LIBRARY/Main office	CSD
Male Hostel	0	0	0	0	238	74	113	236	265	119	79	0	76	25
Female Hostel	0	0	0	0	90	48	70	16	198	126	0	0	27	23
Gate 1	0	0	0	0	22	27	17	15	19	0	0	0	0	0
Gate 2	0	0	0	0	31	21	14	25	48	19	0	0	0	0
SADA/IIGIS/ASAB	168	202	19	15	0	0	0	0	52	0	0	24	9	0
S3H/NBS	89	134	27	21	0	0	0	0	22	0	0	11	0	0
SMME	138	59	17	14	0	0	0	0	36	16	0	14	5	0
NICE	185	21	15	25	0	0	0	0	47	26	0	0	0	0
SEECS/C-2	193	128	19	48	0	0	0	0	0	46	0	12	4	0
C1/SCME/IESE	118	95	0	22	0	0	0	10	25	0	0	17	0	0
Gym	39	0	0	0	0	0	0	0	0	4	0	0	0	0
Rumi	0	0	0	0	34	11	14	0	35	24	0	0	0	0
LIBRARY/Main office	68	20	0	0	0	0	0	0	0	0	0	4	0	0
CSD	25	23	0	0	0	0	0	0	0	0	0	0	0	0

Figure 16: Origin-destination matrix.

5.5 Network Analysis Through ArcGIS

Network Analyst is a tool in ArcGIS which is used to define better routes for public transportation. After assigning the shuttle stops, Network Analyst calculates the shortest route and represents the stops with the located symbol. The arrangement of stops can be changed on the Network Analyst Window and it is very convenient to update the new stops and routes in Network Analyst. In addition to this, barriers and roadblocks can be added while performing network analysis. Solution of analysis will provide the shortest alternative routes in the network.

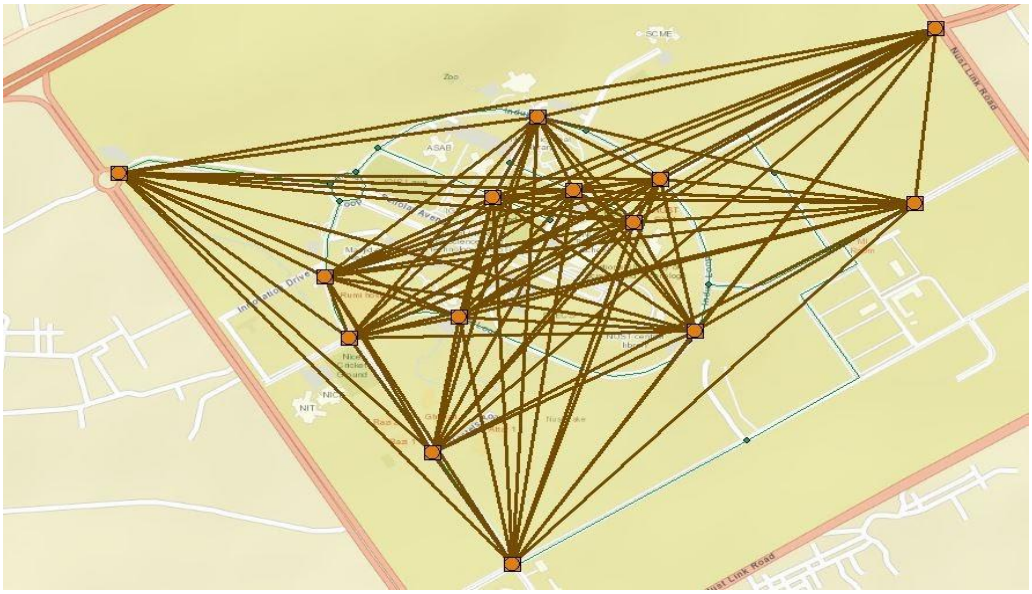


Figure 17: Network Analysis Through ArcGIS

ArcGIS Network Analyst was used to determine shortest paths between origins and destinations. Firstly, road network shapefile was obtained by vectorizing data. Then, origins and destinations were assigned to that network. New Network dataset was constructed by using a road network shapefile. Time impedance was set by assuming shuttle service average speed 20 km/h. Then, Network analysis was performed by keeping barriers' layers off. Results of network analysis showed the shortest route from each origin to each destination. Network lines show trips from each origin to each destination.

Table

Lines

ObjectID	Shape	Name	OriginID	DestinationID	DestinationRank	Total_Time	Total_Length
1	Polyline	Male_Hostel - Male_Hostel	1	1	1	0	0
2	Polyline	Male_Hostel - SMME/SNS	1	7	2	1.210438	403.478944
3	Polyline	Male_Hostel - NICE	1	8	3	1.242979	414.326057
4	Polyline	Male_Hostel - Rumi	1	12	4	1.847057	615.68517
5	Polyline	Male_Hostel - SEECS/C2	1	9	5	2.171067	723.688307
6	Polyline	Male_Hostel - SADA/IGIS/ASAB	1	5	6	4.276288	1425.428004
7	Polyline	Male_Hostel - Library/MainOffice	1	13	7	4.339379	1446.458255
8	Polyline	Male_Hostel - Gate_2	1	4	8	4.449509	1483.168193
9	Polyline	Male_Hostel - C1/SCME/IESE	1	10	9	4.628354	1542.783271
10	Polyline	Male_Hostel - S3H_NBS	1	6	10	5.140429	1713.474548
11	Polyline	Male_Hostel - Gym	1	11	11	5.728878	1909.624136
12	Polyline	Male_Hostel - Female_Hostel	1	2	12	5.814623	1938.205757
13	Polyline	Male_Hostel - CSD	1	14	13	6.603511	2201.168193
14	Polyline	Male_Hostel - Gate_1	1	3	14	8.364513	2788.168193
15	Polyline	Female_Hostel - Female_Hostel	2	2	1	0	0
16	Polyline	Female_Hostel - Gym	2	11	2	0.44852	149.506494
17	Polyline	Female_Hostel - S3H_NBS	2	6	3	1.036969	345.656081
18	Polyline	Female_Hostel - C1/SCME/IESE	2	10	4	1.186269	395.422486
19	Polyline	Female_Hostel - Library/MainOffice	2	13	5	1.529244	509.747502
20	Polyline	Female_Hostel - SADA/IGIS/ASAB	2	5	6	1.90111	633.702626
21	Polyline	Female_Hostel - Gate_1	2	3	7	2.580115	860.037564
22	Polyline	Female_Hostel - CSD	2	14	8	2.850116	950.037564
23	Polyline	Female_Hostel - SEECS/C2	2	9	9	3.697556	1232.51745
24	Polyline	Female_Hostel - Rumi	2	12	10	3.967566	1322.520587
25	Polyline	Female_Hostel - NICE	2	8	11	4.571644	1523.8797

Figure 18: Network Analysis Attributes Table.

5.6 Location-Allocation Analysis

This analysis is performed on the same network dataset created for network analysis. Network shapefile for each origin was made separately and trips field was added in the attribute table to represent the number of trips from one origin to different destinations. Location-Allocation analysis was applied by assigning trips field to weight of trend lines. Symbology of trend lines was changed to graduated symbols to show the trend of trips. Attribute table of lines shows route length and route time to each destination. Then these trends were used for trip generation and trip distribution in design.

Figure 19: Location-Allocation Analysis

5.7 Trend lines:

Trend lines were created on ArcGIS software using the information about the number of trips generated. These trend lines were marked from different origins to destinations. The thickness of these trend lines was dependent on the frequency of trips made. These trend lines helped in noticing the busiest route inside the campus. These trend lines were generated from each origin to all other destinations.

Figure 20: Trend Lines

CHAPTER 06

FACILITY DESIGN

6.1 Trip Generation

The trip generation data was collected from survey forms, where the students were asked about their daily routine i.e., various origins and destinations to get an estimate of shuttle service demand at different locations. The results of survey form give the data of trips generated at different schools and hostels. The sample data was expanded to population data by performing simple multiplication of percentages of response to the population of certain schools. The results of the survey form are shown in the following origin-destination matrix:

	Male Hostel	Female Hostel	Gate 1	Gate 2	SADA/IGIS/ASAB	S3H/NBS	SMME	NICE	SEECS/C-2	C1/SCME/IESE	Gym	Rumi	LIBRARY/Main office	CSD
Male Hostel	0	0	0	0	238	74	113	236	265	119	79	0	76	25
Female Hostel	0	0	0	0	90	48	70	16	198	126	0	0	27	23
Gate 1	0	0	0	0	22	27	17	15	19	0	0	0	0	0
Gate 2	0	0	0	0	31	21	14	25	48	19	0	0	0	0
SADA/IIGIS/ASAB	168	202	19	15	0	0	0	0	52	0	0	24	9	0
S3H/NBS	89	134	27	21	0	0	0	0	22	0	0	11	0	0
SMME	138	59	17	14	0	0	0	0	36	16	0	14	5	0
NICE	185	21	15	25	0	0	0	0	47	26	0	0	0	0
SEECS/C-2	193	128	19	48	0	0	0	0	0	46	0	12	4	0
C1/SCME/IESE	118	95	0	22	0	0	0	10	25	0	0	17	0	0
Gym	39	0	0	0	0	0	0	0	0	4	0	0	0	0
Rumi	0	0	0	0	34	11	14	0	35	24	0	0	0	0
LIBRARY/Main office	68	20	0	0	0	0	0	0	0	0	0	4	0	0
CSD	25	23	0	0	0	0	0	0	0	0	0	0	0	0

Figure 21: Trip Generation (O-D Matrix)

6.2 Trip distribution

The trips were distributed at different possible route keeping in view the following aspects:

- shortest route,
- public trends,
- origin-destination response data,
- mode of transport selected by students and
- demand estimate of the certain facility.

The trips were distributed in such a way that all the possible routes were assigned with the trips, so that not a single route was left unchecked. The following figure shows the trip distribution on each link or route:

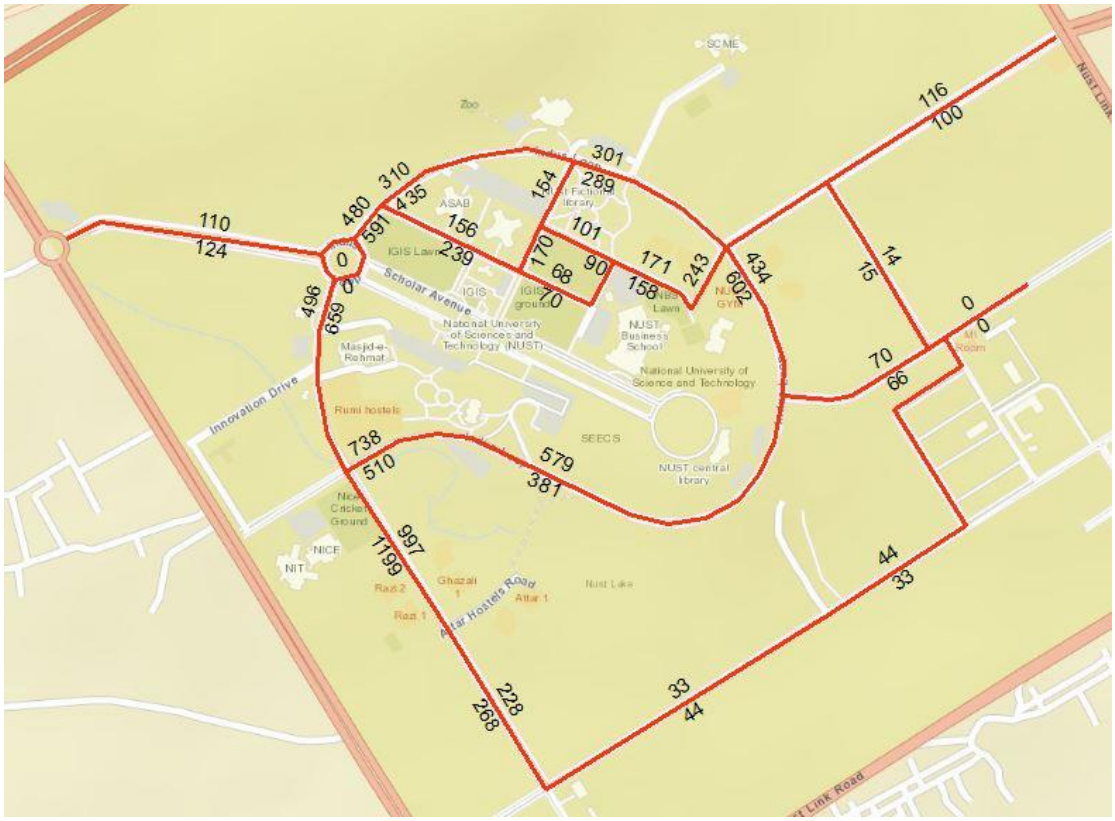


Figure 22: trips distribution on each link.

6.3 Route selection

The routes were selected by analyzing the trip distribution data. The routes or links with the maximum traffic were taken into consideration. The routes were selected analyzing the trend lines created on the ArcGIS software which described the trend of students traveling between different locations. The routes were selected ensuring that the maximum users could use the service. The following figure shows the route selected for the analysis:

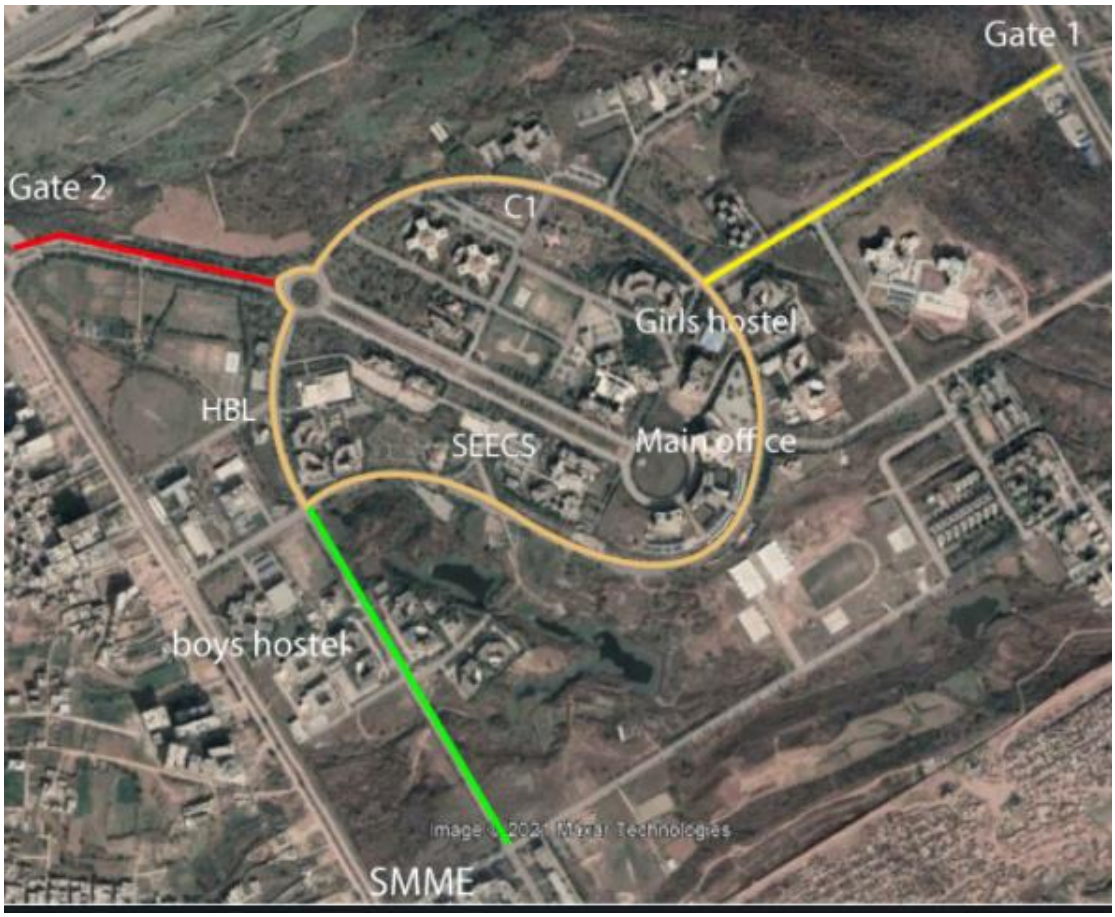


Figure 23: Selected Route for shuttle operation.

6.4 Stop Stations Allocation

The allocation of stops on the selected routes was done keeping in view the following aspects:

- Maximum demand.
- Common stations for nearby schools.

- Appropriate distance between the stops considering the delays in acceleration and deceleration of vehicle.
- Cycle time allocation.

The following figure shows the location of stops on the selected routes:

Figure 24: Stops Stations Allocation

6.5 Demand determination on each route

The traffic data on each link was analyzed and the link with maximum traffic corresponding to a certain route was taken as the demand on each route for analysis. The demand on each route was determined keeping in view the following aspects:

- Directional distribution of trip.
- Trips generated at each stop.
- Short distance Links were considered as walking distances.

The following table shows the demand on each route:

Route #	Demand (pasengers)
1	130
2	1400
3	120
4	270

Figure 25: User demand (passengers) per day

6.6 Trip assignment

The number of trips required were calculated by dividing the number of users, using a certain link/route by the shuttle capacity. The capacity of each shuttle is 10 passengers per vehicle excluding driver. The following table shows the trips required on each route:

Route #	Trips
1	13
2	140
3	12
4	27

Figure 26: Trips required per day on the selected routes.

6.7 Shuttle Bus Requirement on each route

6.7.1 Route 1

Total Distance =2* 575 + 3070=4.220 km.

Average speed of shuttle = 20 km/hr

Time = 12.7 min.

Stops time = 7 * 0.5 min. = 3.5 min.

Delay in acc./decel. = 3 min.

Engine rest time = 5 min.

Total cycle time = 12.7+3.5+3+5 = 25 minutes approx.

Trips required = 13 (excluding Indus loop) + 40 trips on the Indus loop (route 2) per day.

Applying 2 vehicles on the route will satisfy the above requirement as each vehicle will take 2 trips per hour.

For peak hour with 22% of ADT, trips required are 3 trips which will be covered with 2 vehicles.

Headway = 15 minutes.

Figure 27: Route 01 final

6.7.2 Route 2

Total Distance = 3.070 km.

Average speed of shuttle = 20 km/hr

Time = 9.2 min.

Stops time = 6 * 0.5 min. = 3 min.

Delay in acc./deacc. = 2.5 min.

Engine rest time = 5 min.

Total cycle time = 9.2+3+2.5+5 = 20 minutes approx.

Trips required = 140 - 2*40 (adjusted in route 1 and route 3 allocation)

Trips required = 60 per day

Applying 3 vehicles on the route will satisfy the above requirement as each vehicle will take 3 trips per hour.

Headway = 4 minutes.

The shuttle will be available at each stop every 4th minute.

For peak hour with 22% of ADT,

trips required are 31 trips which will be covered with 3 vehicles of Indus loop and 4 vehicles from route 1 and 3 operating at a speed of 30 km/hr for which the cycle time is 12 minutes.

Figure 28: Route 02 final.

6.7.3 Route 3

Route 3 calculations are same as route 1:

2 vehicles

headway = 15 minutes

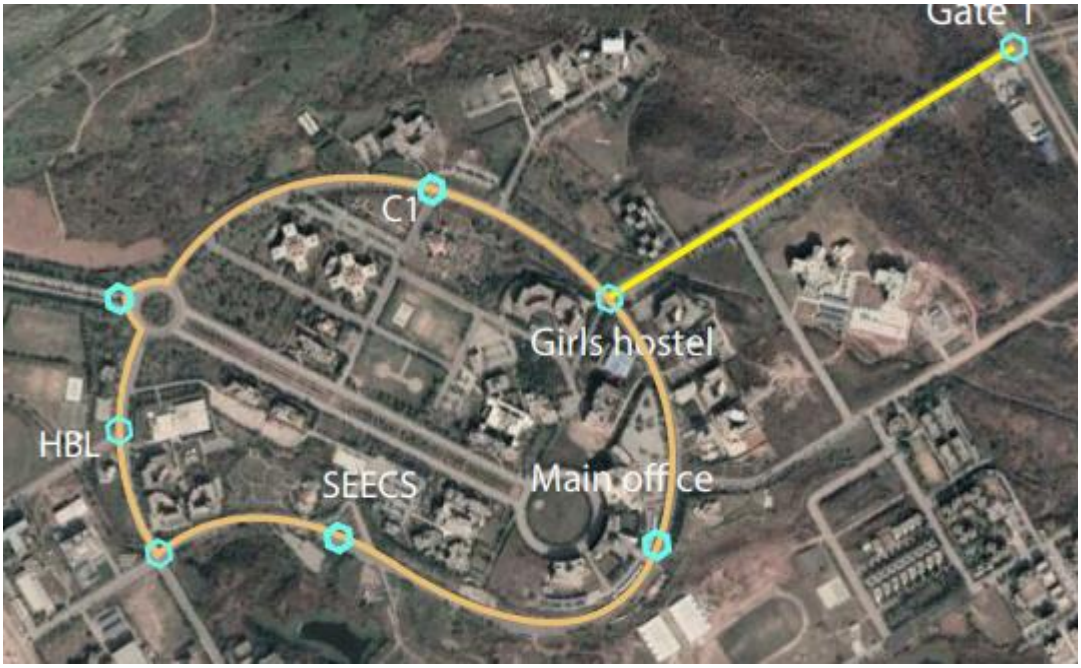


Figure 29: Route 03 final

6.7.4 Route 4

Total Distance =2* 830 meters=1.66 km.

Operating speed of shuttle= 20 km/hr.

Operating speed of shuttle at peak hour= 25 km/hr.

Time = 4 min.

Stops time = 2 * 0.5 min. = 1 min.

Delay in acc./decel. = 3 min.

Total cycle time = 15 minutes approx.

Total cycle time peak hour = 10 minutes approx.

Trips required = 27 per day

For peak hour with 22% of ADT,

trips required are 6 trips Applying 1 vehicle on the route will satisfy the above requirement as each vehicle will take 6 trips per hour.

Headway = 10 minutes.

Figure 30: Route 04 final

CHAPTER 07

CONCLUSION AND RECOMMENDATIONS

7.1 Summary

The survey data collected from the students about their traveling routine was observed and analyzed using the transportation planning techniques. A proper schedule for the operation of the shuttle service was designed according to the required demand. The efficiency of the shuttle service was increased by optimizing the available routes and an effective shuttle service operation schedule was designed. The schedule of operation and the number of shuttles were designed keeping in view the operating capacity of the shuttle i.e the required charging time and the travel capacity per vehicle. ArcGIS analysis was done for the stops station allocation and the various stops were allocated to fulfill the travelling needs of the university's students.

7.2 Conclusion

The results of our project consists of optimized routes, stops and efficient scheduling of shuttle service inside campus. It was evident from the surveys we collected that there is a very need of proper planning of public transportation (shuttle service) planning inside H-12 campus as it comprises a large area of land. Also, results of our surveys showed that there is a large population of students enrolled who did not own personal transportation. Therefore, most of the travelers inside campus required an efficient public transportation system to complete their manoeuvres.

Survey was conducted to get the information about the potential users of shuttle service. Every sector of NUST population was covered in the survey. Then, survey data was analysed to get traffic volumes on different routes. All the information of traffic volumes on different routes, shuttle service capacity and charging duration, routes' lengths were modeled to design the shuttle service facility.

An efficient design of shuttle service will provide maximum coverage to all potential users and will help in reducing the usage of personal transport which will help in controlling the atmospheric pollution. Through the application of solar electric vehicles, the project also covers the 7th (Affordable and Clean Energy) and 13th (Climate Action) United Nations Sustainable Development Goals.

7.3 Discussion

Current shuttle service system is not meeting the requirements of students and staff for travelling inside the campus due to irregular operation schedule and ineffective routes. Proposed shuttle service system will accommodate the travelling needs of students and staff inside the campus. Demand of students and staff have been kept into consideration

while working on the project. The scheduling of the shuttle system has been done while noting the demand of students and staff. students and staff will be able to reach their desired destinations by adopting the defined route.

7.4 Limitations

Some of the limitations in project were due to these difficulties:

- Students were reluctant to fill the survey forms.
- Schedule of working on the project was disturbed due to Covid-19.
- We were unable to get required survey data due to Covid restrictions.
- We used the weighted percentage concept for the expansion of sample data which may not be the exact representation of travel demand of the population as the survey counts were limited.
- The travel routine of the students was restricted due to the pandemic as the hostel students and the day scholars were assigned with alternate working days.

Due to the above mentioned reasons the survey data was hindered and so the travel demand of the students was not exactly predicted.

7.5 Future Recommendations

Some of the future recommendations are:

- Shuttles can be replaced with other vehicles which have greater capacity for passengers.
- Economy analysis of the project should be done to achieve the efficiency in the allotted budget.
- Proposed shuttle service system should be implemented inside the campus.
- Students should be made aware about the timings of shuttle service.
- Proper stop station infrastructure must be designed to accommodate the passengers waiting for the shuttle.
- Parking area planning in the campus should be done as this project, if effectively implemented, will reduce the number of personal transport and the parking requirement in the campus will change.
- Environment Impact Analysis can be done to study the effect of use of electrical vehicles instead of fuel operating vehicles.

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9. unhyuk Park and Byung-In Kim, 2010, "The school bus routing problem: A review", European Journal of Operational Research, vol. 202, no. 2, pp. 311-319.

Appendix A

Timewise Trip generation

8:30-9:00 a.m.						
		DESTINATIONS				
		NICE	IE/IESE/C1/IGIS/SADA/A	SEECS/C2	MME/SNS	3H/NBS
ORIGINS	Male Hostel	133	171	43	61	34
	Female Hostel	8	82	58	70	48
	Gate 1	32	15	0	0	0
	Gate 2	30	10	0	15	12

9:00-9:30 a.m.			
		DESTINATIONS	
		NICE	SCME/IESE/C1/IGIS/SADA/ASAB
ORIGINS	Male Hostel	17	27
	Female Hostel	8	23
	Gate 1	0	29
	Gate 2	0	12

12:30-1:00 p.m.				
		DESTINATIONS		
		C-2/SEECS/KYBO	C-1	Male Hostel
ORIGINS	SADA/IESE/SCME	27	walk	9
	S3H/NBS	14	walk	5
	G2	16	0	0
	NICE	13	15	walk
	SMME	6	8	28

1:00-1:30 p.m.						
		DESTINATIONS				
		Gate1	C1	Seecs/C2	Gate 2	female hostel
ORIGINS	NICE	0	12	15	0	13
	female hostel	0	0	35	0	0
	Male hostel	0	0	71	0	0
	ASAB	0	walk	0	6	68
	Seecs	0	0	0	25	2
	SMME	0	0	0	4	7
	S3H	0	0	0	17	52

1:30-2:00 p.m.							
		DESTINATIONS					
		SADA/NBS/S3h	SMME	NICE	SCME	Male hostel	female hostel
ORIGINS	female hostel	24	0	0	0	0	0
	Male hostel	40	42	46	0	0	0
	C2	14	0	0	18	31	26
	C1	0	0	0	0	35	0

2:00-2:30 p.m.			
		DESTINATIONS	
		Library	Male hostel
ORIGINS	ASAB	9	0
	female hostel	27	0
	C2	0	26
	Male hostel	35	0
	C1	0	29

3:00-3:30 pm						
		DESTINATIONS				
ORIGINS		Library	SMME	Male hostel	C2	Gate 2
	Male hostel	2	10	0	1	0
	Rumi	0	2	0	0	
	SMME	4	0	12	0	1
	ASAB	2	0	0	0	4
	Gate 2	0	2	0	0	0
	C1	0	0	29	1	0
	SEECS	5	0	35	0	0

3:30-4:00 pm							
		DESTINATIONS					
ORIGINS		Male hostel	SMME	C1	IESE	Gate 2	female Hostel
	ASAB	53	0	0	0	5	47
	Gate 2	0	4	0	2	0	0
	NICE	walk	0	12	0	0	8
	NBS	50	0	0	0	0	0
	S3H	0	0	walk	0	0	47
	C2	27	0	0	0	0	31
	SMME	22	0	0	0	0	32

4:00-4:30pm								
		DESTINATIONS						
Origin		C2	C1	female Hostel	SMME	Male hostel	Gate 1	Gate 2
	SMME	10	8	5	0	25	0	0
	NICE	0	8	0	0	0	0	0
	C2	0	0	22	8	27	0	0
	ASAB	0	0	49	0	40	0	0
	Male hostel	43	34	0	0	0	0	0
	female Hostel	31	0	0	0	0	0	0

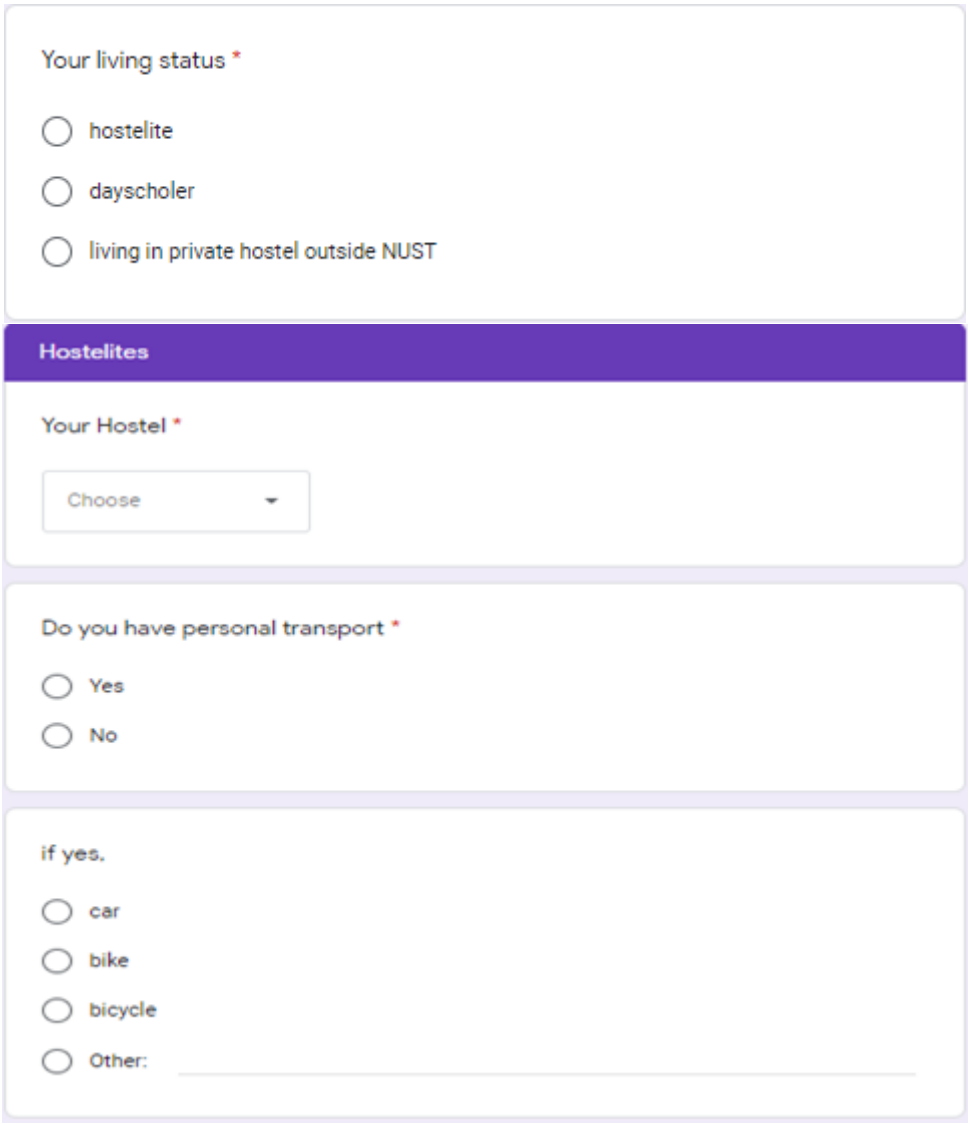
4:30-5:00 pm								
		DESTINATIONS						
Origin		SMME	Gate 1	female Hostel	Male hostel	C2	HBL	C1	ASAB
	Gate 2	4	0	0	0	18	0	0	5
	SMME	0	0	6	31	0	0	0	0
	C2	0	0	18	35	0	0	0	0
	Male hostel	0	0	0	0	22	6	41	0

5:00-5:30pm							
		DESTINATIONS					
Origin		C2	female Hostel	C3	C1	Male hostel	Gym
	female Hostel	30	0	0	0	0	0
	SMME	0	5	8	12	11	0
	ASAB	22	38	0	0	66	0
	Male hostel	77	0	0	23	0	20
	NICE	0	0	0	0	walk	0
	S3H	0	35	0	0	34	0

5:30-6:00pm								
		DESTINATIONS						
Origin		female Hostel	Gate 2	IESE	SMME	C2	Male hostel	C1	Gym
	C2	29	0	0	0	0	12	0	0
	C1	walk	5	0	0	0	25	0	0
	Gate 1	0	0	0	0	0	0	0	0
	Gate 2	0	0	2	4	0	0	0	0
	female Hc	0	0	0	0	31	0	0	0
	SEECS	0	0	0	0	0	86	0	0
	NICE	0	0	0	0	0	0	13	0
	SMME	4	0	0	0	11	9	0	0
	Male host	0	0	0	0	0	0	19	39
	Gym	0	0	0	0	0	39	0	0

6:00-6:30pm						
		DESTINATIONS				
Origin		C2	C1	Gym	Libraray	CSD
	female Hostel	23	0	0	0	23
	Male hostel	44	21	20	22	25

Survey form


Your living status *
hostelite
dayscholer
living in private hostel outside NUST
Hostelites
Your Hostel *
Choose
Do you have personal transport *
Yes
No
if yes,
car
bike
bicycle
Other:

How often you go home *

Ignore current COVID-19 situation

- ◯ Every week
- ◯ Fortnightly
- ◯ Every 3rd week
- ◯ After 1 month
- ◯ After OHT/Mids
- ◯ Semester break
- ◯ Other: _____

Your living status *

- ◯ hostelite
- ◯ dayscholer
- ◯ living in private hostel outside NUST

Origin of your trip inside NUST campus. *

Your answer

Destination of your trip inside NUST campus. *

Your answer

what was purpose of your trip *

- ◯ recreation
- ◯ study
- ◯ sports
- ◯ fitness
- ◯ Back to hostel
- ◯ Other:

what was starting time of your trip *

Your answer

what was total travelling duration *

Your answer

which mode you used for trip *

Your answer

Origin of your second trip inside NUST campus. *

Your answer

Destination of your second trip inside NUST campus. *

Your answer

what was purpose of your second trip *

- ◯ recreation
- ◯ study
- ◯ sports
- ◯ fitness
- ◯ Back to hostel
- ◯ Other: _____

what was starting time of your second trip *

Your answer

what was total travelling duration of second trip *

Your answer

which mode you use for second trip *

Your answer

do you want to continue for 3rd trip *

- ◯ yes
- ◯ submit form

what is your mode of transport *

- ◯ Car
- ◯ Bike
- ◯ Bicycle
- ◯ Uber/Cream
- ◯ NUST transport
- ◯ Walk to campus
- ◯ Other: _____

if you use Nust transport your pick up point

- ◯ C1
- ◯ C2

which gate you mostly use *

- ◯ GATE 1 (G-11 signal)
- ◯ GATE 2 (PSO pump)
- ◯ GATE 4 (NICE)
- ◯ GATE 10 (CSD)

Origin of your trip inside NUST campus. *

Your answer

Destination of your trip inside NUST campus. *

Your answer

what was purpose of your trip *

- ◯ recreation
- ◯ study
- ◯ sports
- ◯ fitness
- ◯ Other:

what was starting time of your trip *

Your answer

what was starting time of your trip *

Your answer

what was total travelling duration *

Your answer

which mode you use for trip *

Your answer

Gender *

- ◯ Female
- ◯ Male

Department *

Choose

Batch *

Choose

you are a *

- ◯ Under graduate Student
- ◯ Post graduate Student