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Lastly, what are we without our friends and family? I take this opportunity to thank them all for having ushered unconditional love and support during tough times and for hearing me out.

Avijit Kumar Dash

IIT Bombay

June, 202

Abstract

In this report work has been done to appreciate and understand on rural transportation to improve its efficiency and ways of representing it. We have focused on Shahapur taluka in our study. A rudimentary decision support system for Shahapur Taluka, Thane district, Maharashtra, has been designed using a GIS-based graphical interface. We look at the many data formats that have been received and try to figure out how they are related. Maharashtra State Road Transportation Corporation (MSRTC) is the primary provider of rural transportation services. We begin by doing a review of the literature on public transportation, with a focus on India and rural Maharashtra. Then we'll look at Shahapur Taluka as a case study, as well as the Shahapur Taluka bus depot. We'll go through the most important data formats and how they're related. To depict the key data set, Form-4, we employed graph theory as a tool. This is referred to as digital geography. Finally, some suggestions for the extra problems identified in the field are provided in this report.

Keywords: Network, Graph Theory, Sinnar Taluka, Demographics, Operational data, Bus Depot

Chapter-1

Introduction:

The current project endeavors to replicate and improve Mr. Sudanshu Kulkarni's public transportation work in the Shahapur taluka of Thane district, Maharashtra. The project concentrates on public transportation and considers it a developmental service. The methods of reproducing, analyzing, and improving the existing tools and techniques employed in a bus depot so that core-level administrators can take better and improved judgments in public transportation as a development service. In that case, numerous analyses have been done on various datasets such as form-4, ticketing (ETIM) data, route (Master) data, stop location data, geographical information, and related data.

Scope of the Project:

This project's scope is restricted to bus transportation in Shahapur Taluka and related data formats used in bus terminals. This project covered Shahapur taluka and surrounding talukas if and only if a bus service is available to the other taluka from Shahapur.

Chapter Organization

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Broad Societal Concern

The following is the Broad Societal Concern (BSC):

“What improvement can be made on Public transportation service provisioning at Shahapur Taluka.”

Research Question(s)

1. How can data structures be used to represent a rural public transportation system?
2. Dataset needed to develop the framework: –
    a. Shahapur census data and thane district road network data.
    b. Form 4, Master data, ETIM data, and Terminals location data.

Objective

1. To generate a GIS-based decision support system.
2. To map Form 4 data in a GIS.
3. To enable social benefits accounting of services offered by Shahapur Taluka Bus depot.

Methodology

1. Basic analysis of the Development of Digital Geography of Shahapur Taluka, Maharashtra.

Proposed Outputs

1. For decision-making, a GIS-based ICT framework or digital geography on ShahapurTaluka.

Chapter-2

Shahapur Taluka Bus Depot

About

Shahapur is one of the seven talukas of the Thane district. It operates around 65 buses on 270 routes for approximately 80 villages in Taluka.

Google Street Map 3D image of Shahapur Depot

Organisation of Bus-Depot

A depot manager oversees each bus station. The depot manager is in charge of the entire bus depot and its departments.

i) ***Traffic:*** The cashier, clerical section, traffic control office, announcement section, ticket vending section, rest houses, and waiting area are all sections of the traffic department. The traffic department is in charge of crew shift scheduling, ensuring that the depot adheres to the division office's timetable (Form 4). Several operational aspects, as well as report generation, have been restored.

ii) ***Workshop:*** The workshop department is in charge of maintaining the buses that are currently in service. They are also responsible for assisting any bus in the event of a catastrophe, tyre blowout, or other similar situations.

Chapter 3

Digital Geography

Geographic Information Systems (GIS) are computer programs that store, analyze, and display data about geographic locations on the Earth's surface. GIS works on several levels. At its most basic level, geographic information systems technology is utilized for computer cartography or simple map creation. GIS can be used to display things like route spread and information on hospitals, schools, and businesses, among other things.

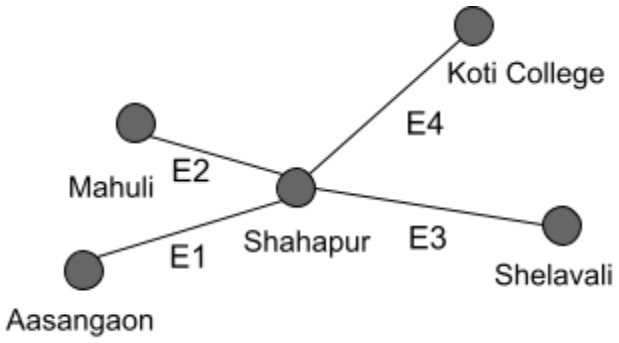
In our case, the mapping of MSRTC operational data on a GIS-based graphical interface will be based on digital geography. Data structure techniques from graph theory will be used to create Digital Geography.

Graph Theory

A graph is an undirected graph for distinguishing from a directed graph is a pair G = (V, E).

1. **Node** is represented by **V**, also known as the vertex.

2. **An edge** is a connection between a network's nodes (or vertices). Edges can be directed, which means they can point from one node to another. It is represented by **E.**



A sample graph

E = {E1, E2, E3, E4}

V = {Aasangaon, Shahapur, Mahuli, Shelavali, Koti College}

More on Graphs

Adjacent Node: The term "adjacent" refers to any two nodes connected by an edge or any two edges connected by a node. Like: there is a node called v that is said to be adjacent if there is another node u and there is an edge E(u,v) or E(v,u) between them.

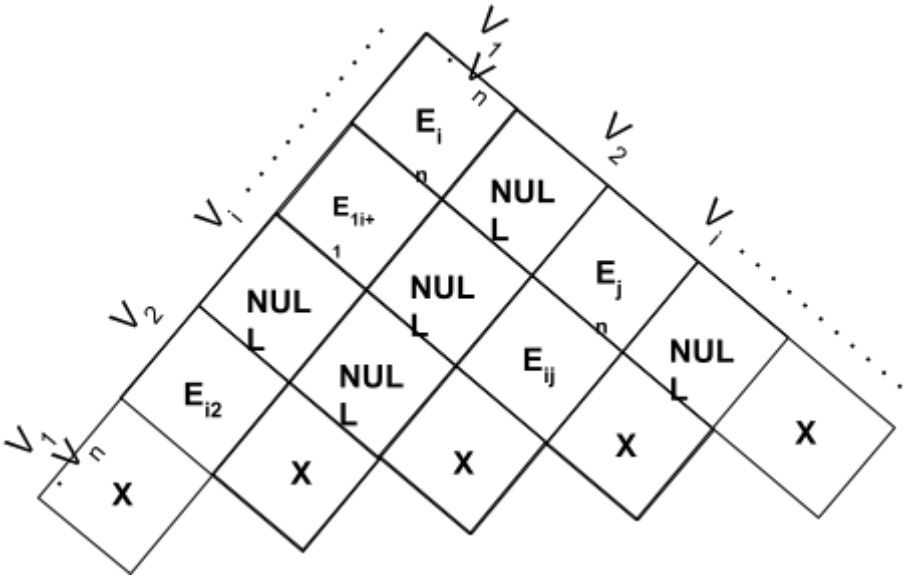
Degree of Node: The number of edges that pass through a node in a graph determines its degree. It is denoted as deg(v).

What is Digital Geography?

Digital geography is an undirected, planar graph G= (V, E) where:

V is a set of vertices.

E is a set of edges.



Schematic of Digital Geography

Properties of a Vertex

a. Each vertex is a *Point* geometry.
b. Each vertex has a latitude and longitude.
c. A vertex may have an attribute such as school, marketplace, hospital, etc.

Properties of an Edge

a. Each edge is a *Polyline* geometry.

b. Each edge e is an ordered vertices (v_i, v_j) such as v_i and v_j **ε** V.
c. An edge cannot have intermediate points belonging to V.
d. An edge subsequently can have further attributes like type of road, length of the edge, traffic on edge, the profitability of the edge, etc.

Route-segment,

A route segment RSi, is a path between two termini. It is an ordered set of edges.

i.e. $RS_i = \{ E_{i1}, E_{i2}, E_{i3}..E_{in}\}$

where, n= number of edges in RSi and $\{E_{i1}, E_{i2}, E_{i3}...E_{in}\} \varepsilon E$

$E = RS_1 \cup RS_2 \cup RS_i .. \cup RS_m$ where m= number of Route segments in RS.

Chapter - 4

Dataset

Available Dataset

i)) MSRTC data of the Road network of Thane district.

ii) Set of Bus Stops obtained.

iii) Polygon file of villages of Shahapur.

iv) Bus stop sequences of routes from Master data.

v) ETIM dataset.

Problems with existing system

1) Lack of convergence of Transportation, GIS, and Demographics data

2) Lack of GIS data at taluka level Problem

3) Absence of a unified database for demand estimation and service provisioning

Tools and Technology used for the project

Application: QGIS 3.22 Biatowieza

Tools: pgadmin4

DBMS: PostgreSQL

Scripting: Python 3

OS: Windows 10 and Ubuntu 20.04 LTS

System Configuration

a. QGIS and PostGIS must be connected by a DB connection.
b. Python 3 is already installed in the system.
c. All the shapefiles are imported in the form of PostGIS tables.

Dataset used:

List of attributes

Form-4

Sr.	Attribute Name	Values	Description	Table Name
1	arrival	Time	Arrival-time of a bus at a given time at a particular terminal.	From-4
2	duty_id	Character Varying	A crew member's duty_id is a kind of id that provides so that the crew does not change.	From-4
3	d_eng	Place Names	Destination terminal name in English.	From-4
4	d_mar	Place Names	Destination terminal name in Marathi.	From-4
5	depart	Time	Departure time of a bus at a given time at a particular terminal.	From-4
6	distance	Kilometer	Distance between source and destination terminal.	From-4
7	road_seg	Name	This is the same route segmentation.	From-4
8	service_id	Character Varying	A service id is a particular service between terminals at a given time.	From-4
9	s_eng	Place Names	Source terminal name in English.	From-4
10	s_mar	Place Names	Source terminal name in Marathi.	From-4
11	schedule_id	Numeric	A schedule_id is an id that is given so that the bus does not change.	From-4

Stops

Sr.	Attribute Name	Values	Description	Table Name
1	name	Place Names	Stop name	Stop Location
2	name_mar	Place Names	Stop name in Marathi.	Stop Location
3	taluka	Place Names	Taluka name of a stop.	Stop Location
4	village	Place Names	Village name of a stop	Stop Location
4	wkt	Geom	Latitude-Longitude for a stop	Stop Location

ETIM

Sr.	Attribute Name	Values	Description	Table Name
1	etim_no	Character Varying	ETIM no from which the ticket has been sold.	ETIM
2	from_stage_code	Place Names	Source terminal name (Short Form)	ETIM
3	route_no		Route no for every terminal to terminal	ETIM
4	ticket_id	Numeric	Auto-generated id no for tickets.	ETIM

5	ticket_number	Numeric	Individual ticket no for every person	ETIM
6	till_stage_code	Place Names	Destination terminal name (Short Form)	ETIM
7	total_amt	Numeric	Ticket selling amount for a day	ETIM
8	ticket_date	Date	Ticket selling date	ETIM
9	ticket_date_actual	Date	Ticket selling date (formatted)	ETIM
10	ticket_time	Time	Ticket selling time	ETIM
11	trip_no	Character Varying	Trip no for every route no	ETIM

Sr.	Attribute Name	Values	Description	Table Name
1	from_stop_cd	Place Names	Source terminal name (Short Form)	Master
2	Route_kms	Kilometer	Distance of that route	Master
3	route_no	Numeric	Route no for every terminal to terminal	Master
4	till_stop_cd	Place Names	Destination terminal name (Short Form)	Master
5	via_stop_cd	Place Names	Intermediate terminal between source and destination.	Master

List of Tables and their attributes

Sr.	Table Name	Unique Key Attribute	Other Attribute	Added Attribute	Table name of that additional attributes
1	Form-IV	**(schedule, duty id, and service id)**	source, destination, arrival time, departure time, distance	Geometry point. Route No.	Those attributes taken from - Stops Location, and Master File table
2	Stop Location	**Wkt point (lat-long)**	Name, name_mar, village, taluka, taluka_mar		
3	ETIM	**(ticket_id, trip_no, route_no)**	etim_no, ticket_number, from_stage_code, till_stage_cod, total_amt, ticket_date, ticket_date_actual, ticket_time		
4	Master	**route_no**	Route_kms, from_stop_cd,till_stop_cd, via_stop_cd		

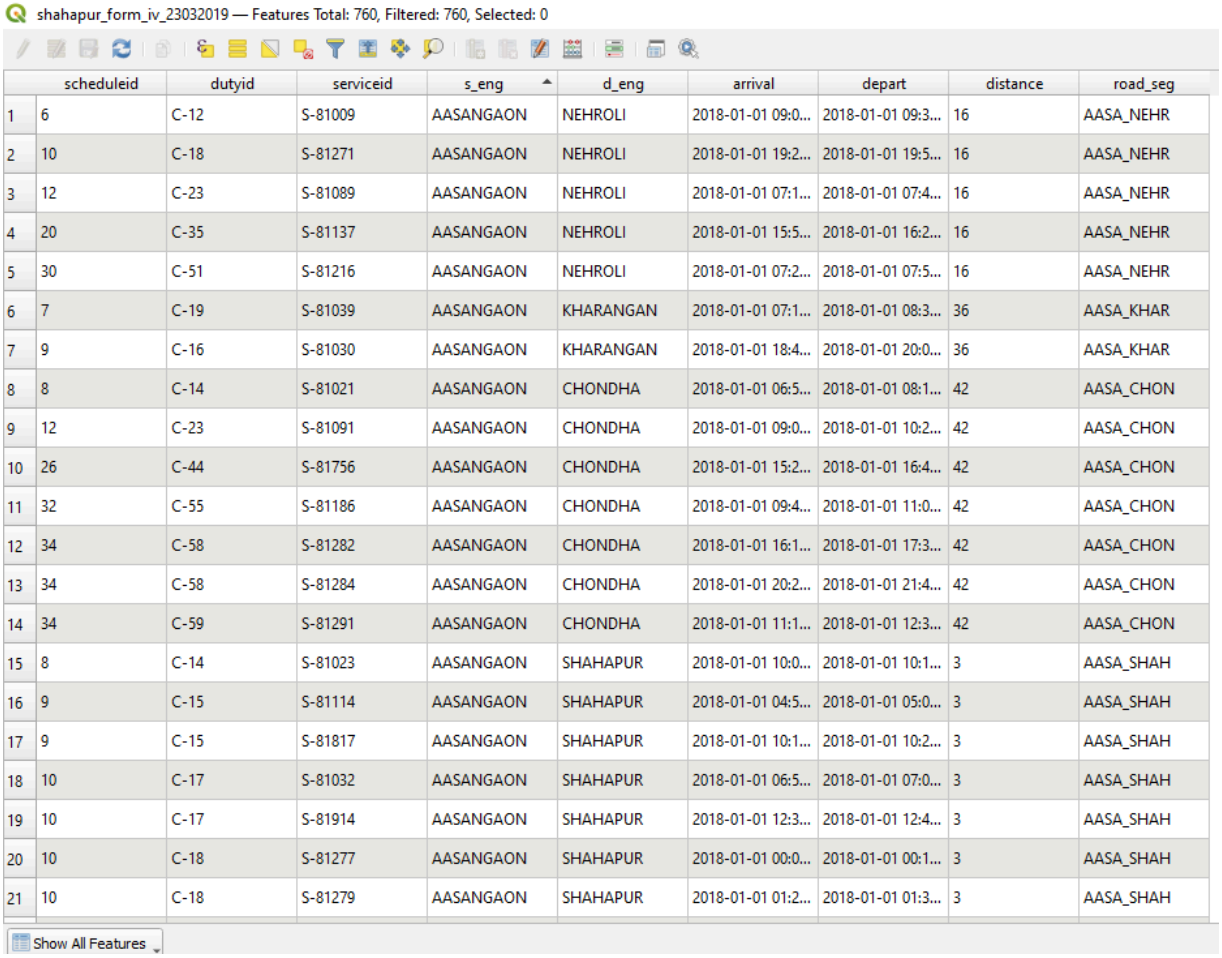
Snapshots for the dataset that has been used for the project.

1. **Form-IV:**

Form 4 is a bus timetable created and maintained at the Division level with the help of the Depot manager of that specific taluka. It is one of the most important datasets for our

research. It has several attributes: schedule id, Duty id, service id, and places are the essential attributes.

In the dataset, every row contains information about the schedule id of a bus, duty_id of crew members, service_id of a bus, Source termini, destination termini, the arrival time of the bus, departure time of the bus, distance from source to destination, and the route segment name.


shahapur_form_iv_23032019 — Features Total: 760, Filtered: 760, Selected: 0

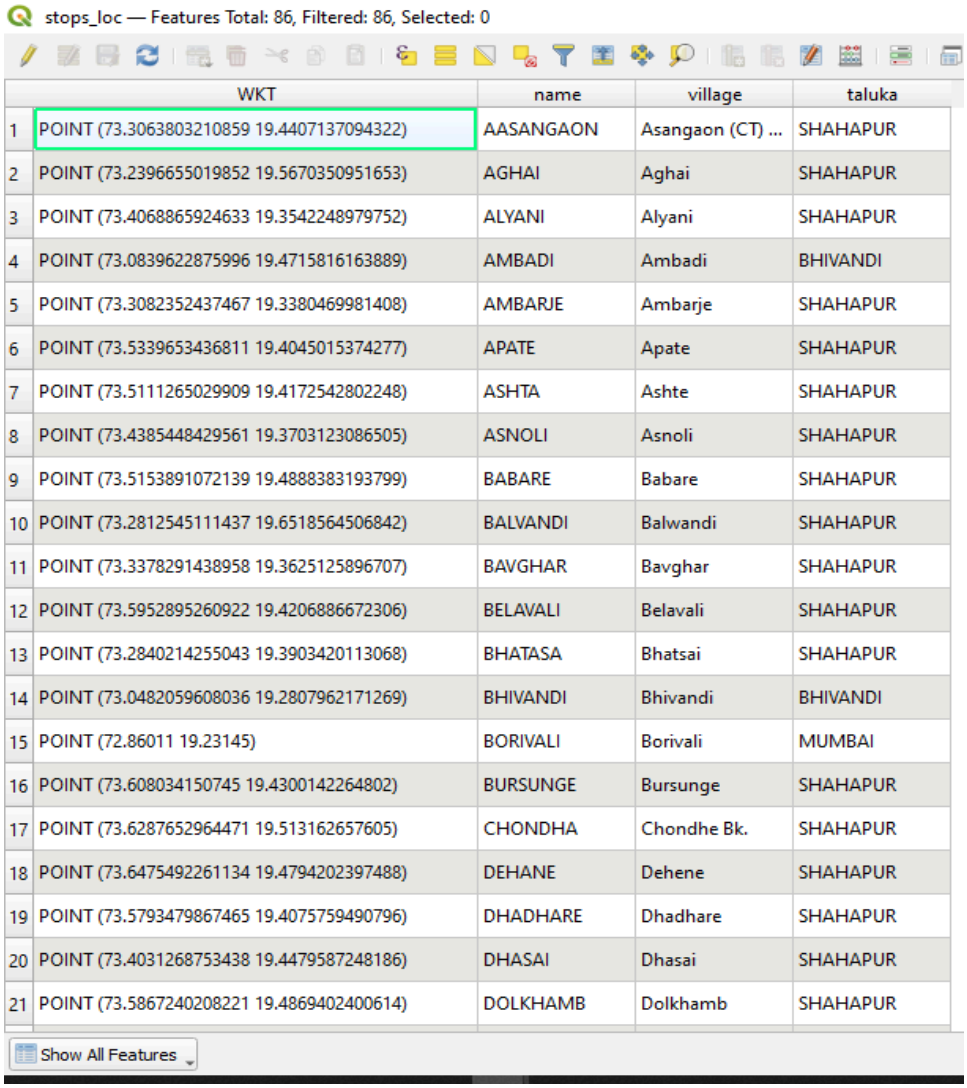
	scheduleid	dutyid	serviceid	s_eng	d_eng	arrival	depart	distance	road_seg
1	6	C-12	S-81009	AASANGAON	NEHROLI	2018-01-01 09:0...	2018-01-01 09:3...	16	AASA_NEHR
2	10	C-18	S-81271	AASANGAON	NEHROLI	2018-01-01 19:2...	2018-01-01 19:5...	16	AASA_NEHR
3	12	C-23	S-81089	AASANGAON	NEHROLI	2018-01-01 07:1...	2018-01-01 07:4...	16	AASA_NEHR
4	20	C-35	S-81137	AASANGAON	NEHROLI	2018-01-01 15:5...	2018-01-01 16:2...	16	AASA_NEHR
5	30	C-51	S-81216	AASANGAON	NEHROLI	2018-01-01 07:2...	2018-01-01 07:5...	16	AASA_NEHR
6	7	C-19	S-81039	AASANGAON	KHARANGAN	2018-01-01 07:1...	2018-01-01 08:3...	36	AASA_KHAR
7	9	C-16	S-81030	AASANGAON	KHARANGAN	2018-01-01 18:4...	2018-01-01 20:0...	36	AASA_KHAR
8	8	C-14	S-81021	AASANGAON	CHONDHA	2018-01-01 06:5...	2018-01-01 08:1...	42	AASA_CHON
9	12	C-23	S-81091	AASANGAON	CHONDHA	2018-01-01 09:0...	2018-01-01 10:2...	42	AASA_CHON
10	26	C-44	S-81756	AASANGAON	CHONDHA	2018-01-01 15:2...	2018-01-01 16:4...	42	AASA_CHON
11	32	C-55	S-81186	AASANGAON	CHONDHA	2018-01-01 09:4...	2018-01-01 11:0...	42	AASA_CHON
12	34	C-58	S-81282	AASANGAON	CHONDHA	2018-01-01 16:1...	2018-01-01 17:3...	42	AASA_CHON
13	34	C-58	S-81284	AASANGAON	CHONDHA	2018-01-01 20:2...	2018-01-01 21:4...	42	AASA_CHON
14	34	C-59	S-81291	AASANGAON	CHONDHA	2018-01-01 11:1...	2018-01-01 12:3...	42	AASA_CHON
15	8	C-14	S-81023	AASANGAON	SHAHAPUR	2018-01-01 10:0...	2018-01-01 10:1...	3	AASA_SHAH
16	9	C-15	S-81114	AASANGAON	SHAHAPUR	2018-01-01 04:5...	2018-01-01 05:0...	3	AASA_SHAH
17	9	C-15	S-81817	AASANGAON	SHAHAPUR	2018-01-01 10:1...	2018-01-01 10:2...	3	AASA_SHAH
18	10	C-17	S-81032	AASANGAON	SHAHAPUR	2018-01-01 06:5...	2018-01-01 07:0...	3	AASA_SHAH
19	10	C-17	S-81914	AASANGAON	SHAHAPUR	2018-01-01 12:3...	2018-01-01 12:4...	3	AASA_SHAH
20	10	C-18	S-81277	AASANGAON	SHAHAPUR	2018-01-01 00:0...	2018-01-01 00:1...	3	AASA_SHAH
21	10	C-18	S-81279	AASANGAON	SHAHAPUR	2018-01-01 01:2...	2018-01-01 01:3...	3	AASA_SHAH

Show All Features

Figure: Attribute table of Form-IV

2. **Bus stop termini:**

This dataset contains information about the bus stops and their geometry that is necessary for graphically visualizing the data. This dataset contains information on the geometry point of termini, the name of those termini, the village name where the termini are situated, and the taluka name.


stops_loc — Features Total: 86, Filtered: 86, Selected: 0

	WKT	name	village	taluka
1	POINT (73.3063803210859 19.4407137094322)	AASANGAON	Asangaon (CT) ...	SHAHAPUR
2	POINT (73.2396655019852 19.5670350951653)	AGHAI	Aghai	SHAHAPUR
3	POINT (73.4068865924633 19.3542248979752)	ALYANI	Alyani	SHAHAPUR
4	POINT (73.0839622875996 19.4715816163889)	AMBADI	Ambadi	BHIVANDI
5	POINT (73.3082352437467 19.3380469981408)	AMBARJE	Ambarje	SHAHAPUR
6	POINT (73.5339653436811 19.4045015374277)	APATE	Apate	SHAHAPUR
7	POINT (73.5111265029909 19.4172542802248)	ASHTA	Ashte	SHAHAPUR
8	POINT (73.4385448429561 19.3703123086505)	ASNOLI	Asnoli	SHAHAPUR
9	POINT (73.5153891072139 19.4888383193799)	BABARE	Babare	SHAHAPUR
10	POINT (73.2812545111437 19.6518564506842)	BALVANDI	Balwandi	SHAHAPUR
11	POINT (73.3378291438958 19.3625125896707)	BAVGHAR	Bavghar	SHAHAPUR
12	POINT (73.5952895260922 19.4206886672306)	BELAVALI	Belavali	SHAHAPUR
13	POINT (73.2840214255043 19.3903420113068)	BHATASA	Bhatsai	SHAHAPUR
14	POINT (73.0482059608036 19.2807962171269)	BHIVANDI	Bhivandi	BHIVANDI
15	POINT (72.86011 19.23145)	BORIVALI	Borivali	MUMBAI
16	POINT (73.608034150745 19.4300142264802)	BURSUNGE	Bursunge	SHAHAPUR
17	POINT (73.6287652964471 19.513162657605)	CHONDHA	Chondhe Bk.	SHAHAPUR
18	POINT (73.6475492261134 19.4794202397488)	DEHANE	Dehene	SHAHAPUR
19	POINT (73.5793479867465 19.4075759490796)	DHADHARE	Dhadhare	SHAHAPUR
20	POINT (73.4031268753438 19.4479587248186)	DHASAI	Dhasai	SHAHAPUR
21	POINT (73.5867240208221 19.4869402400614)	DOLKHAMB	Dolkhamb	SHAHAPUR

Show All Features

Figure: Attribute table of trimmi

3. ETIM:

Every conductor for any bus service must obtain an ETIM from the cashier, as well as cash change. Many charging connections may be found in the cashier's cabin, where unused ETIMs can be charged. TRIMAX is responsible for the data handling of these ETIM. ETIM data is real-time ticketing information created by the conductor when issuing tickets and saved in ETIM equipment administered by TRIMAX. The information has been compiled (ticket id, waybill number, ETIM number, trip number, route number, ticket code, ticket number, from stage code, till stage code, total amt, ticket date actual, ticket time).

Shahapur_July-2019 — Features Total: 297, Filtered: 297, Selected: 0

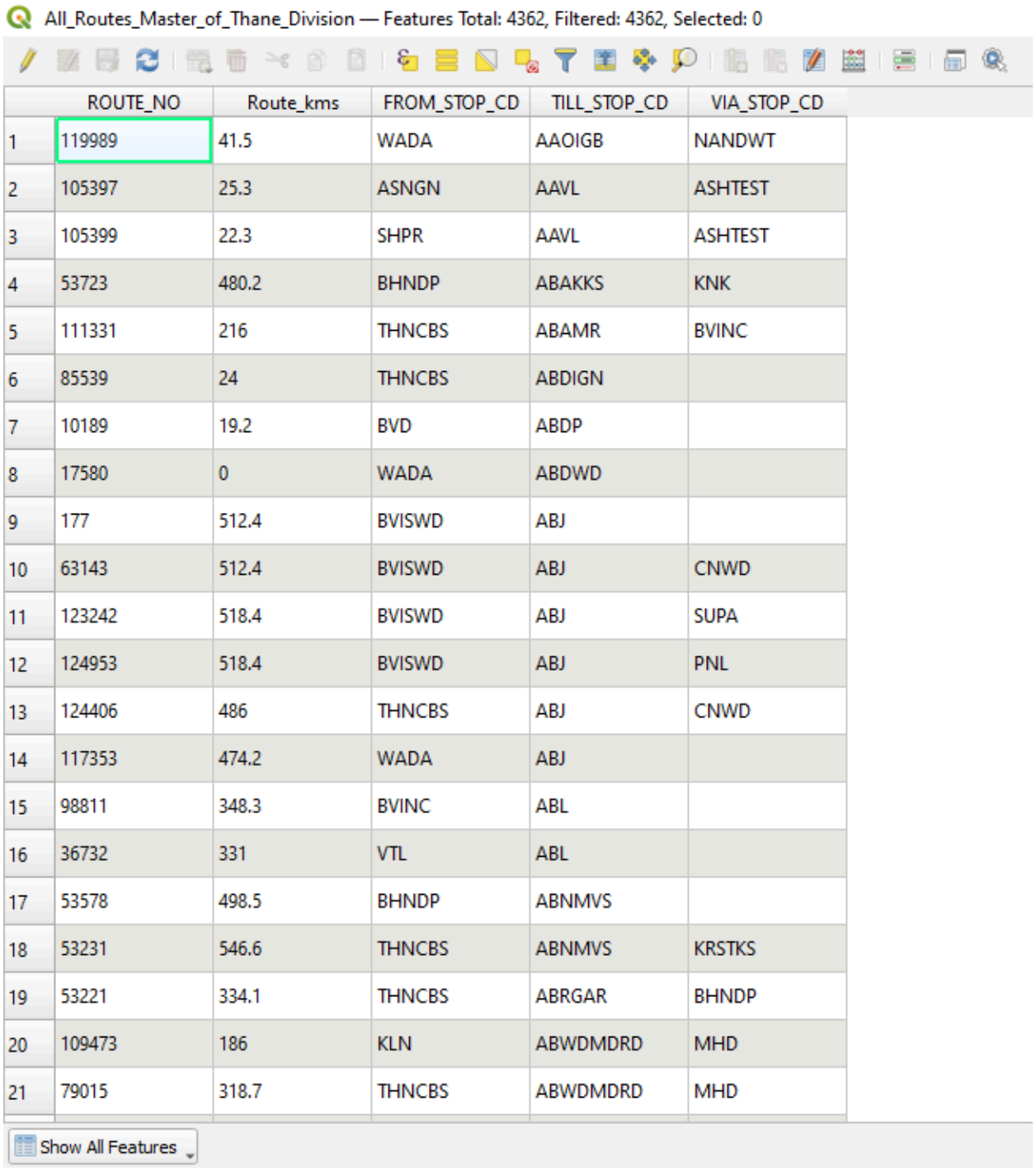
	ticket_id	etim_no	trip_no	route_no	ticket_number	from_stage_code	till_stage_code	total_amt	ticket_date	ticket_date_actual	ticket_time
1	52022847	SHP05053	000M3797	44351	3544	SHPR	PUNADEST	0	29/06/19	2019-06-29	05:50:08
2	52022848	SHP05053	000M3797	44351	3545	KSRA	NSKCBS	8900	29/06/19	2019-06-29	07:08:37
3	52022849	SHP05053	000M3797	44351	3546	KSRA	MLG	5400	29/06/19	2019-06-29	07:09:23
4	52022850	SHP05053	000M3797	44351	3547	KSRA	DHL	42800	29/06/19	2019-06-29	07:09:49
5	52022851	SHP05053	000M3797	44351	3548	KSRA	ARVIDD	12900	29/06/19	2019-06-29	07:10:40
6	52022852	SHP05053	000M3797	44351	3549	KSRA	NSKCBS	8900	29/06/19	2019-06-29	07:10:55
7	52022853	SHP05053	000M3797	44351	3550	KSRA	MLG	22400	29/06/19	2019-06-29	07:11:07
8	52022854	SHP05053	000M3797	44351	3551	KSRA	NSKCBS	8900	29/06/19	2019-06-29	07:11:16
9	52022855	SHP05053	000M3797	44351	3552	KSRA	DHL	56800	29/06/19	2019-06-29	07:12:03
10	52022856	SHP05053	000M3797	44351	3553	KSRA	DHL	28800	29/06/19	2019-06-29	07:13:46
11	52022857	SHP05053	000M3797	44351	3554	KSRA	NSKCBS	17800	29/06/19	2019-06-29	07:14:33
12	52022858	SHP05053	000M3797	44351	3555	KSRA	NSKCBS	8900	29/06/19	2019-06-29	07:14:51
13	52022859	SHP05053	000M3797	44351	3556	KSRA	NSKCBS	8900	29/06/19	2019-06-29	07:15:03
14	52022860	SHP05053	000M3797	44351	3557	KSRA	NSKCBS	8900	29/06/19	2019-06-29	07:15:11
15	52022861	SHP05053	000M3797	44351	3558	KSRA	NSKCBS	8900	29/06/19	2019-06-29	07:15:21
16	52022862	SHP05053	000M3797	44351	3559	KSRA	CNVD	16900	29/06/19	2019-06-29	07:16:04
17	52022863	SHP05053	000M3797	44351	3560	KSRA	NSKCBS	8900	29/06/19	2019-06-29	07:16:20
18	52022864	SHP05053	000M3797	44351	3561	KSRA	NSKCBS	8900	29/06/19	2019-06-29	07:16:34
19	52022865	SHP05053	000M3797	44351	3562	KSRA	DHL	28400	29/06/19	2019-06-29	07:16:49
20	52022866	SHP05053	000M3797	44351	3563	KSRA	DHL	28400	29/06/19	2019-06-29	07:17:27
21	52022867	SHP05053	000M3797	44351	3564	KSRA	MLG	22400	29/06/19	2019-06-29	07:18:01

Show All Features

Figure: Attribute table of ETIM

4. Master Data:

The Master data describes the route information. The route information is made up of the order of bus stops on the route, and the distance between bus stops.



	ROUTE_NO	Route_kms	FROM_STOP_CD	TILL_STOP_CD	VIA_STOP_CD
1	119989	41.5	WADA	AAOIGB	NANDWT
2	105397	25.3	ASNGN	AAVL	ASHTEST
3	105399	22.3	SHPR	AAVL	ASHTEST
4	53723	480.2	BHNDP	ABAKKS	KNK
5	111331	216	THNCBS	ABAMR	BVINC
6	85539	24	THNCBS	ABDIGN	
7	10189	19.2	BVD	ABDP	
8	17580	0	WADA	ABDWD	
9	177	512.4	BVISWD	ABJ	
10	63143	512.4	BVISWD	ABJ	CNWD
11	123242	518.4	BVISWD	ABJ	SUPA
12	124953	518.4	BVISWD	ABJ	PNL
13	124406	486	THNCBS	ABJ	CNWD
14	117353	474.2	WADA	ABJ	
15	98811	348.3	BVINC	ABL	
16	36732	331	VTL	ABL	
17	53578	498.5	BHNDP	ABNMVS	
18	53231	546.6	THNCBS	ABNMVS	KRSTKS
19	53221	334.1	THNCBS	ABRGAR	BHNDP
20	109473	186	KLN	ABWDMDRD	MHD
21	79015	318.7	THNCBS	ABWDMDRD	MHD

Figure: Attribute table of Master data

To complete the project, we mostly used QGIS, Python script, and SQL queries.
After getting all of those datasets we stored those in the PostGIS database and access them from there when we needed them.

Explain that these tables are stored in PostGIS and

Chapter

the Calculation of total distance and time

From-4 is the crucial dataset. Most of the columns are important for getting various information. From all of them, three important columns are arrival time, departure time, and distance from source to destination. We can use this information to get the total distance covered by the services running within the taluka as well as how much time they are taking to cover that distance. The total distance covered by the services is 19101 KM; Among them, Shahapur, covers the highest distance 5177 KM, and the lowest distance covered by Shei is 9KM. Besides this distance, Aasangaon covered 1874 KM, Thane covered 1602 KM, and Nashik covered 1088 KM. These are the area that covered more than a thousand Kilometers.

To cover the 19101 KM area took 37640 Minutes overall. More than ten thousand Minutes took to cover the Shahapur area means 5177 KM, and it's precisely 10410 Minutes. The shortest time to cover the distance is 20 Minutes for Shei and Bursunge. Other than this Aasangaon area took 3535 Minutes to cover the total length, the Thane area took 3030 Minutes to cover the entire distance, the Murbad area took 1880 Minutes to cover the whole distance, the Bhivandi area took 1785 Minutes to cover the entire distance, Nashik area took 1565 Minutes to cover the entire distance, Kasara area took 1125 Minutes to cover the total distance, Wada area took 1020 Minutes to cover the entire distance. These areas took more than a thousand minutes to cover the whole length.
The process of calculating distance and time is given below:
Using this dataset, we have analyzed several things, like calculating how much distance it covers in a single day and how much time it took to cover that distance.

Query: SELECT s_eng, sum(distance) as distance, sum(df) as ttime

FROM (SELECT scheduleid, dutyid, serviceid, s_eng, s_mar, d_eng, d_mar, distance, road_seg, extract(epoch from depart - arrival)/60 as df
FROM public.shahapur_form_iv_23032019) as s group by s_eng order by distance DESC;

Service count per minute:

After calculating the total values, we tried to determine how many services are active per minute and visualize them. For this, we have used a Python script and a Google excel sheet.

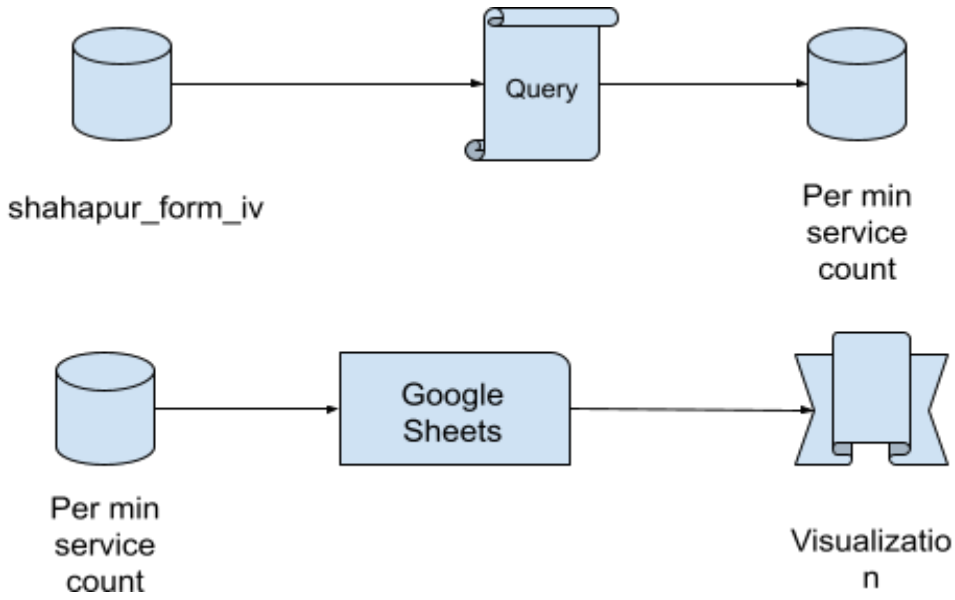


Figure: Input, Processing, and output for per-min service count for shahapur

This step is for the service counted per minute from from-4. The python script is used to generate the service count and then we take that result and used a google sheet for further processing. After creating the google sheet for the data, we used the Google Sheets visualization technique to process the data. In this step, we have not used any script as it was easy to do in google sheets.

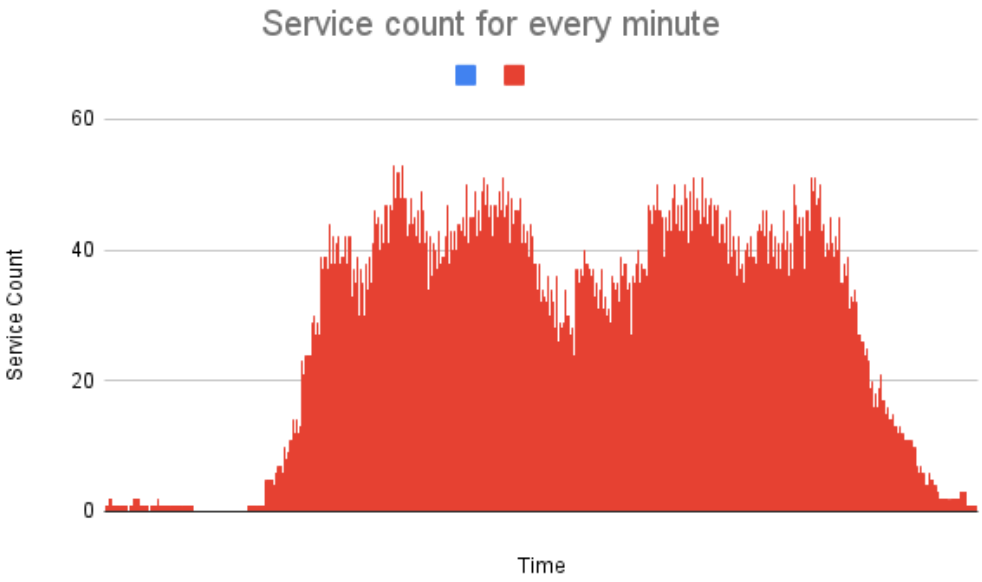


Figure: Visualization of service count per minute

	A	B	C
1	Date	Time	Service_count
2	2018-01-01	0:05:00	1
3	2018-01-01	0:06:00	1
4	2018-01-01	0:07:00	1
5	2018-01-01	0:08:00	1
6	2018-01-01	0:09:00	1
7	2018-01-01	0:10:00	2
8	2018-01-01	0:11:00	2
9	2018-01-01	0:12:00	2
10	2018-01-01	0:13:00	2
11	2018-01-01	0:14:00	2
12	2018-01-01	0:15:00	2
13	2018-01-01	0:16:00	1
14	2018-01-01	0:17:00	1
15	2018-01-01	0:18:00	1
16	2018-01-01	0:19:00	1
17	2018-01-01	0:20:00	1
18	2018-01-01	0:21:00	1
19	2018-01-01	0:22:00	1
20	2018-01-01	0:23:00	1
21	2018-01-01	0:24:00	1

Figure: Attribute for service count

Now we begin with the description of the GIS data obtained from elsewhere.

Road Network

1. **Polygon file of Villages in Shahapur Taluka with the Census data. This is as follows:**

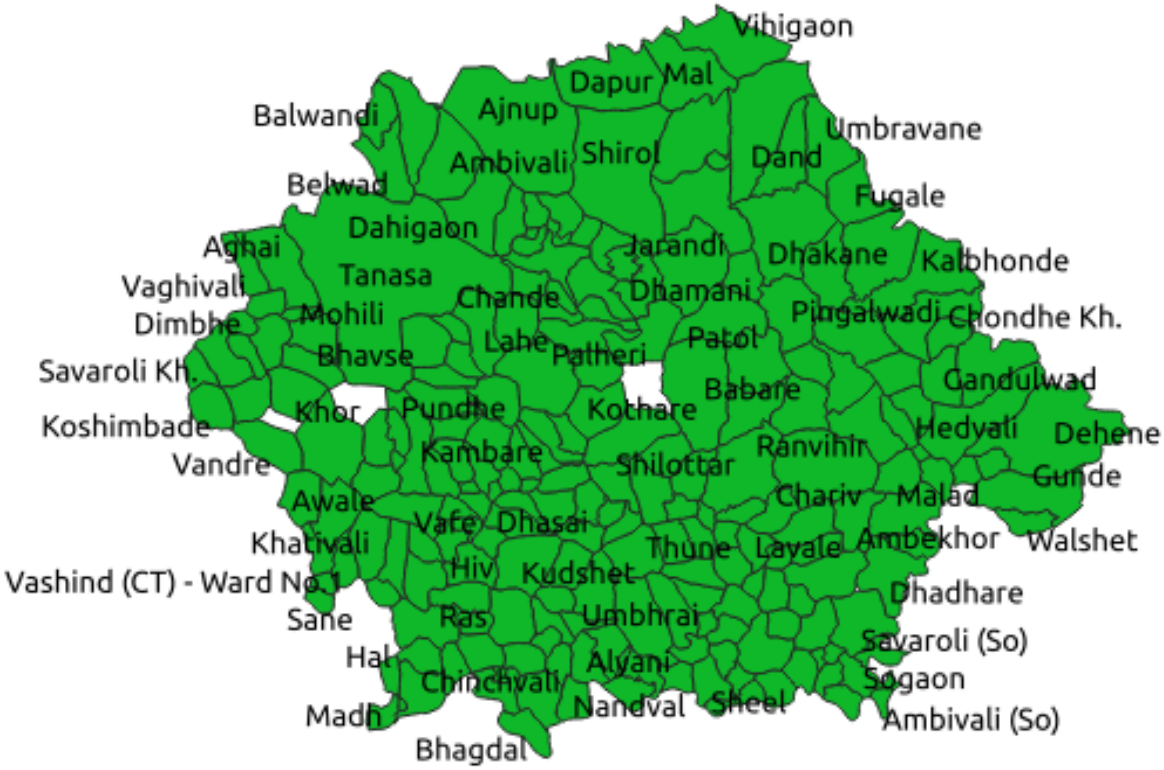


Figure: Shahapur Taluka boundary (census polygon data)

	district_c	district_n	taluka_cod	taluka_nam	census_201	ward_no	area_name	area_type	hh_tot_tot	hh_tot_g	hh_tot_l	hh_tot_d	hh_res_tot	
1	517	Thane	4167	Shahapur	552767	0	Patol	Rural	100.00000	30.60000	53.20000	16.20000	76.00000	2
2	517	Thane	4167	Shahapur	552791	0	Hedvali	Rural	100.00000	79.30000	13.20000	7.40000	97.50000	7
3	517	Thane	4167	Shahapur	552909	0	Dahivali	Rural	100.00000	8.00000	84.20000	7.70000	92.60000	7
4	517	Thane	4167	Shahapur	552713	0	Koshimbade	Rural	100.00000	40.50000	59.00000	0.50000	93.50000	3
5	517	Thane	4167	Shahapur	552756	0	Vashala Bk	Rural	100.00000	77.60000	17.40000	5.00000	99.70000	7
6	517	Thane	4167	Shahapur	552820	0	Shilottar	Rural	100.00000	34.90000	59.70000	5.40000	96.80000	3
7	517	Thane	4167	Shahapur	552690	0	Aghai	Rural	100.00000	64.00000	31.30000	4.70000	98.40000	6
8	517	Thane	4167	Shahapur	552794	0	Ranvihir	Rural	100.00000	58.50000	28.90000	12.50000	99.00000	5
9	517	Thane	4167	Shahapur	552879	0	Khutghar	Rural	100.00000	81.50000	16.10000	2.40000	99.60000	8
10	517	Thane	4167	Shahapur	552796	0	Babare	Rural	100.00000	46.00000	49.20000	4.80000	98.40000	4
11	517	Thane	4167	Shahapur	552904	0	Vithobache...	Rural	100.00000	79.40000	10.50000	10.00000	98.60000	7
12	517	Thane	4167	Shahapur	552883	0	Nadgaon (L...	Rural	100.00000	42.20000	55.40000	2.40000	98.60000	4
13	517	Thane	4167	Shahapur	552704	0	Sakharoli	Rural	100.00000	59.00000	40.40000	0.60000	92.10000	5
14	517	Thane	4167	Shahapur	552711	0	Vehlonde	Rural	100.00000	16.30000	69.20000	14.50000	98.30000	1
15	517	Thane	4167	Shahapur	552873	0	Valshet	Rural	100.00000	77.80000	21.00000	1.20000	100.00000	7
16	517	Thane	4167	Shahapur	552714	0	Piwali	Rural	100.00000	85.00000	14.40000	0.60000	99.40000	8
17	517	Thane	4167	Shahapur	552754	0	Umbravane	Rural	100.00000	15.00000	55.00000	30.00000	82.50000	1
18	517	Thane	4167	Shahapur	552889	0	Lenad Bk.	Rural	100.00000	52.70000	45.50000	1.80000	95.80000	4
19	517	Thane	4167	Shahapur	552817	0	Kulhe	Rural	100.00000	30.90000	63.90000	5.20000	99.00000	2

Show All Features

Figure: Attribute table of Shahapur taluka polygon census file.

2. Road network of Undivided Thane source: MRSAC

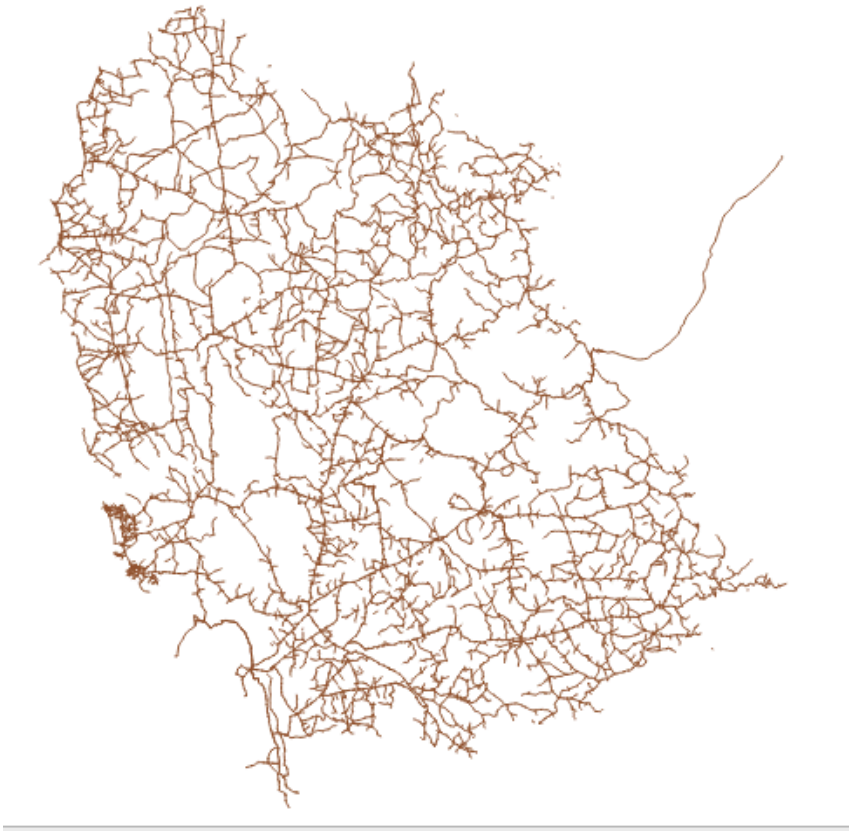


Figure: Road Network

	LENGTH	ROAD0_	ROAD0_ID	TALUK_CODE	SRIMS_CODE	PWD_TYPE	PWD_CODE	ROAD_TYPE	TALUK	TYPE	SUB_TYPE	LENGTH_M	ROAD_CODE
1	2735.89825	2332	921	0031	60	VR-79	003160079	Village Road	Wada	Metalled - Black To...	Village Road	2735.90000	0104
2	500.17343	2334	860	0031	60	VR-82	003160082	Village Road	Wada	Metalled - Black To...	Village Road	500.17000	0104
3	682.37101	2375	849	0031	60	VR-78	003160078	Village Road	Wada	Metalled - Black To...	Village Road	682.37000	0104
4	1613.91428	2451	844	0031	60	VR-70	003160070	Village Road	Wada	Metalled - Black To...	Village Road	1613.91000	0104
5	1817.14157	2461	846	0031	60	VR-73	003160073	Village Road	Wada	Metalled - Black To...	Village Road	1817.14000	0104
6	942.37994	2462	841	0031	60	VR-71	003160071	Village Road	Wada	Metalled - Black To...	Village Road	942.38000	0104
7	395.11637	2494	849	0031	60	VR-94	003160094	Village Road	Wada	Metalled - Black To...	Village Road	395.12000	0104
8	13.58840	2495	846	0031	60	VR-75	003160075	Village Road	Wada	Metalled - Black To...	Village Road	13.59000	0104
9	879.24492	2500	842	0031	60	VR-71	003160071	Village Road	Wada	Metalled - Black To...	Village Road	879.24000	0104
10	2487.05431	2507	846	0031	60	VR-75	003160075	Village Road	Wada	Metalled - Black To...	Village Road	2487.05000	0104
11	888.02937	2510	848	0031	60	VR-75	003160075	Village Road	Wada	Metalled - Black To...	Village Road	888.03000	0104
12	1849.02677	2521	848	0031	60	VR-75	003160075	Village Road	Wada	Metalled - Black To...	Village Road	1849.03000	0104
13	670.14172	2544	851	0031	60	VR-74	003160074	Village Road	Wada	Metalled - Black To...	Village Road	670.14000	0104
14	506.05274	2549	843	0031	60	VR-65	003160065	Village Road	Wada	Metalled - Black To...	Village Road	506.05000	0104
15	1913.76887	2567	858	0031	60	VR-76	003160076	Village Road	Wada	Metalled - Black To...	Village Road	1913.77000	0104
16	11.12728	2568	860	0031	60	VR-77	003160077	Village Road	Wada	Metalled - Black To...	Village Road	11.13000	0104
17	51.62424	2569	860	0031	60	VR-77	003160077	Village Road	Wada	Metalled - Black To...	Village Road	51.62000	0104
18	1237.38994	2571	701	0031	40	MDR-25	003140025	Major Distr...	Wada	Metalled - Black To...	District Road	1237.39000	0103
19	1236.75904	2573	843	0031	60	VR-71	003160071	Village Road	Wada	Metalled - Black To...	Village Road	1236.76000	0104

Figure: Road network attribute table (A part of it)

3. Bus termini:

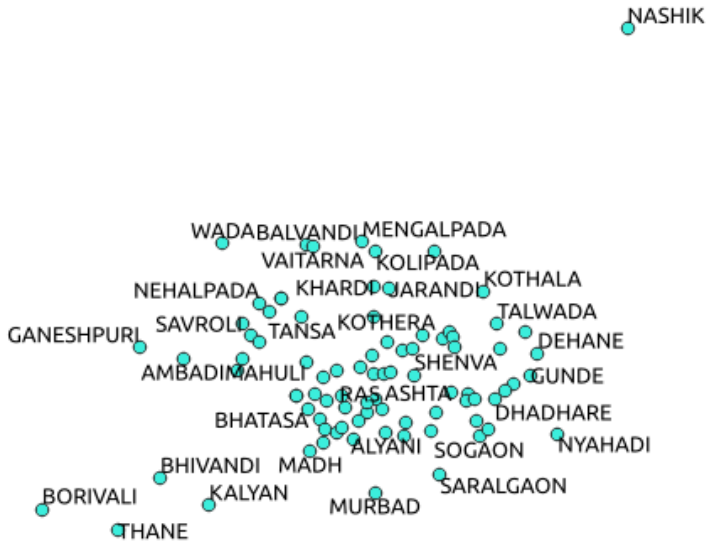


Figure: Bus stop location

	name	name_mar	village	taluka	taluka_mar
1	BHIVANDI	भिवंडी	Bhivandi	BHIVANDI	भिवंडी
2	GANESHPURI	गणेशपुरी	Ganeshpuri	BHIVANDI	भिवंडी
3	AMBADI	अंबाडी	Ambadi	BHIVANDI	भिवंडी
4	SAVROLI	सावरोली	Savaroli Kh.	SHAHAPUR	शहापुर
5	RATALEPADA	रताळेपाडा	Koshimbade	SHAHAPUR	शहापुर
6	PIWALI	पिवळी	Piwali	SHAHAPUR	शहापुर
7	VASHIND	वाशिंद	Vashind (C…	SHAHAPUR	शहापुर
8	VASHIND_B	वाशिंद बु.	Vashind (C…	SHAHAPUR	शहापुर
9	BHATASA	भातसा	Bhatsai	SHAHAPUR	शहापुर
10	SHERE	शेरे	Shere	SHAHAPUR	शहापुर
11	SHEI	शेई	Shei	SHAHAPUR	शहापुर
12	AMBARJE	अंबर्जे	Ambarje	SHAHAPUR	शहापुर
13	MADH	मढ	Madh	SHAHAPUR	शहापुर
14	WADA	वाडा	Vada	VADA	वाडा
15	MASAVANE	मासवणे	Masavane	SHAHAPUR	शहापुर
16	BAVGHAR	बावघर	Bavghar	SHAHAPUR	शहापुर
17	AASANGAON	आसनगाव	Asangaon (…	SHAHAPUR	शहापुर
18	SHAHAPUR	शहापुर	Shahapur (…	SHAHAPUR	शहापुर
19	SHELAVALI	शेलवली	Shelwali (K…	SHAHAPUR	शहापुर

Figure: Attribute table of bus termini

These are all the census data; the shortest path can be determined using this data. In qgis, there is a toolbox called “Network Analysis” we can use this tool to obtain the shortest route. We can use the shortest path (point to layer) shortest path (layer to point) to get the most straightforward way. The obtained direction is given below:

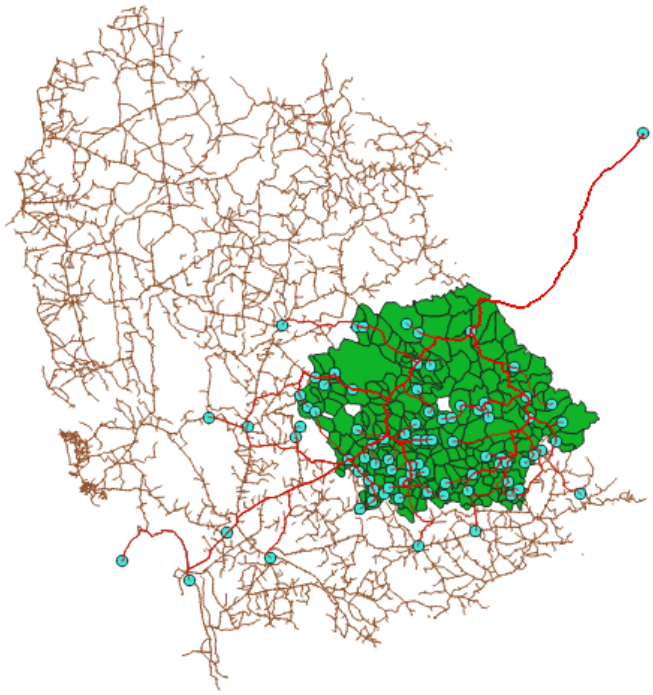


Figure: a combination of all three census data

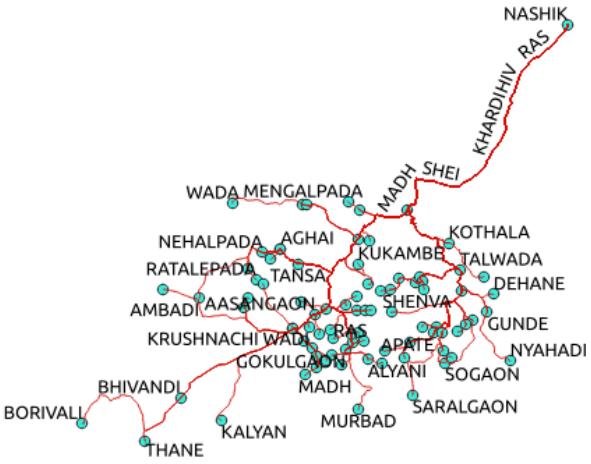


Figure: Generated road network using “Network Analysis tool”

The generated road network was created using the “Network Analysis Tool” shortest path. It is a tool that is already there in QGIS. It helps to create road networks easily, just need to select the start point and end point for creating the network. After that, it will start processing the road network. But after creating the network we have found that the network is not completed, it has

some missing roads that are already there in the form-4. So we decided to do it another way and that is described below.

We can filter terminal locations by Shahapur taluka only and create those road networks.

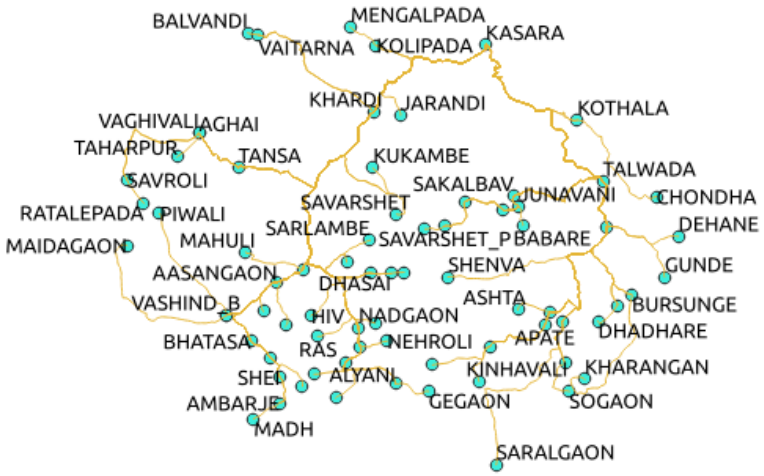


Figure: Road network for those who fall under Shahapur taluka

Shahapur Road networks creation:

After that, we recreated the Shahapur taluka road network using form-iv, Road network census data, and Shahapur village census data using QGIS.

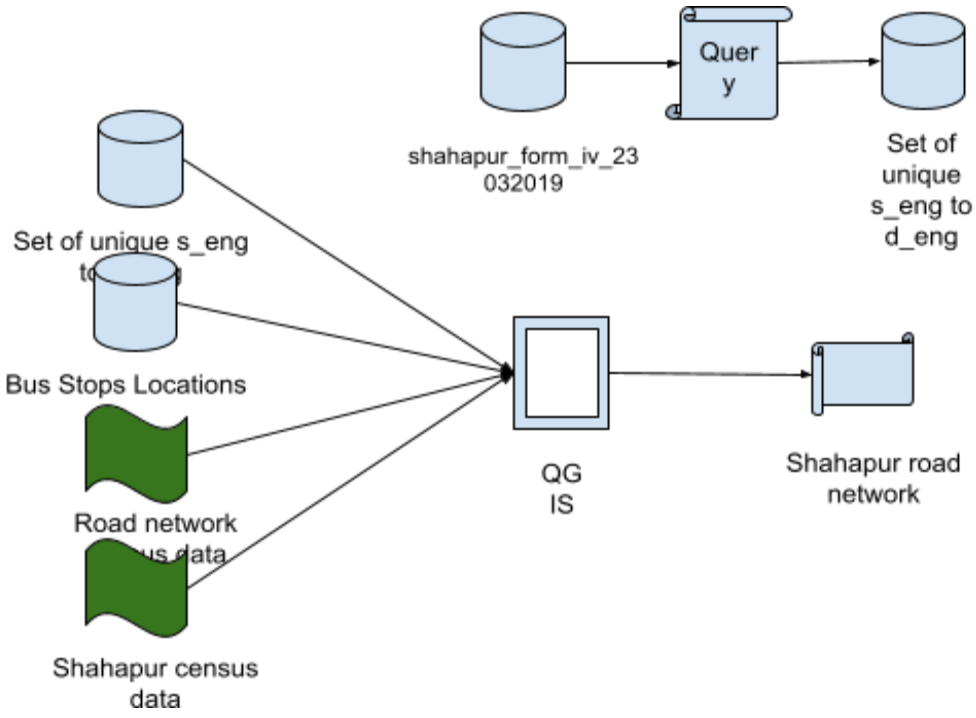


Figure: Input, Processing, and output for Shahapur road network

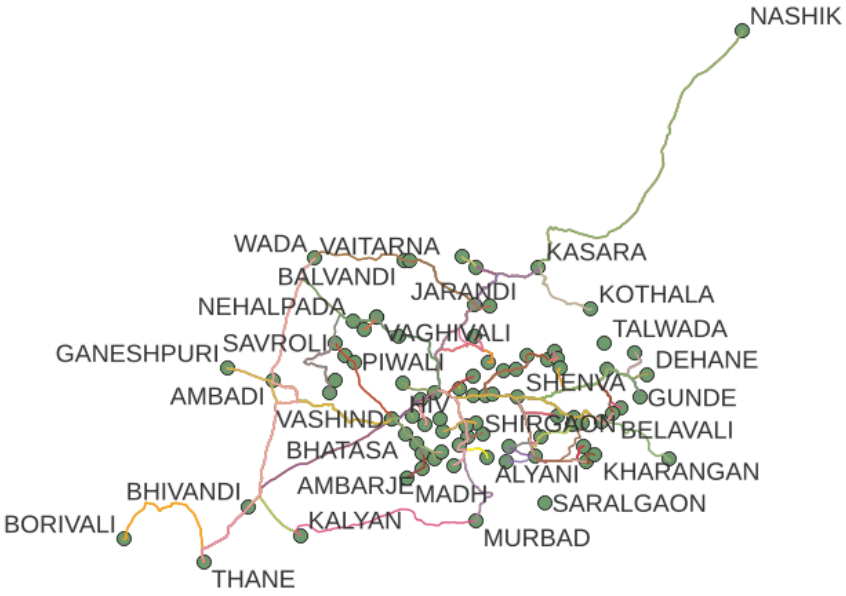


Figure: Generated Complete Shapefile of the route segments

We have created the road segment routes using a network analysis processing toolbox, and we have primarily used the Shortest path (point-to-point) analysis technique to generate the digital geography of the route network.

Trips passing through

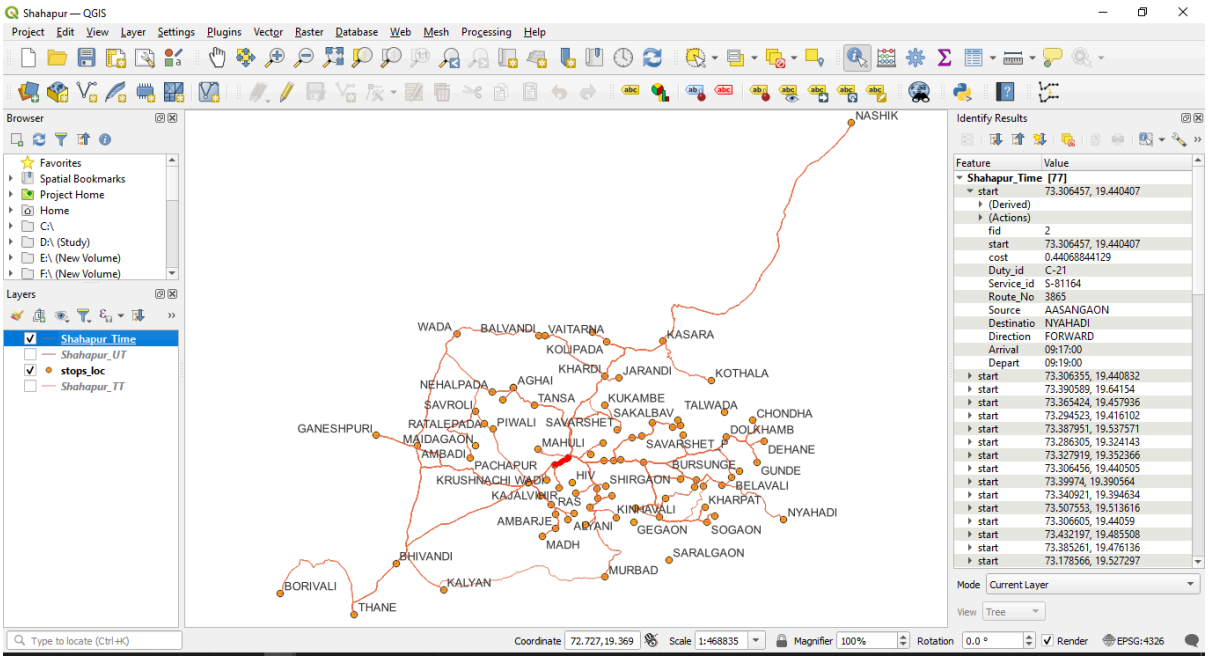


Figure: Trips passing through the selected route segment

The lines in the figure with orange colors represent the ST-road Network, which is used by State Bus Transport services. The points depicted are bus stops in Shahapur Taluka. The red line indicates a specific route segment about which we want to learn more. All details linked to the selected route segment are provided in the right panel under "Identify Features." Simply click on the line displayed on the map to select a route segment.

Shahapur_Time_Final — Features Total: 4853, Filtered: 78, Selected: 0

	fid	start	end	Duty_id	Service_id	Route_No	Source	Destinatio	Direction	Arrival	Depart	Actual_Arr	Actual_Dep
1	2	73.306457, 19.4...	73.679679, 19.3...	C-21	S-81164	3865	AASANGAON	NYAHADI	FORWARD	09:17:00	09:19:00	9:15:00	11:00:00
2	53	73.306355, 19.4...	73.389656, 19.4...	C-15	S-81244	3859	AASANGAON	SHIRGAON	FORWARD	05:32:00	05:34:00	5:30:00	6:00:00
3	92	73.390589, 19.6...	73.306359, 19.4...	C-49	S-81209	68725	KOLIPADA	AASANGAON	BACKWARD	11:19:00	11:21:00	10:25:00	11:30:00
4	146	73.365424, 19.4...	73.306453, 19.4...	C-54	S-81884	65528	KOTI COLLEGE	AASANGAON	BACKWARD	16:46:00	16:48:00	16:35:00	16:55:00
5	162	73.294523, 19.4...	73.328207, 19.4...	C-13	S-81014	12728	KRUSHNACHI ...	SHAHAPUR	BACKWARD	15:10:00	15:17:00	14:35:00	15:25:00
6	193	73.387951, 19.5...	73.306489, 19.4...	C-72	S-81393	12725	KUKAMBE	AASANGAON	BACKWARD	08:17:00	08:20:00	7:40:00	8:30:00
7	216	73.286305, 19.3...	73.328462, 19.4...	C-27	S-81663	16557	MADH	SHAHAPUR	BACKWARD	06:34:00	06:36:00	6:00:00	6:50:00
8	262	73.327919, 19.3...	73.328238, 19.4...	C-32	S-81898	13167	MASAVANE	SHAHAPUR	BACKWARD	11:35:00	11:37:00	11:10:00	11:50:00
9	464	73.306456, 19.4...	73.595398, 19.4...	C-88	S-81835	95447	AASANGAON	BELAVALI	FORWARD	18:17:00	18:19:00	18:15:00	19:45:00
10	590	73.39974, 19.39...	73.306418, 19.4...	C-12	S-81010	12725	NEHROLI	AASANGAON	BACKWARD	09:57:00	09:59:00	9:35:00	10:05:00
11	695	73.340921, 19.3...	73.306515, 19.4...	C-35	S-81140	129583	RAS	AASANGAON	BACKWARD	19:19:00	19:25:00	19:00:00	19:25:00
12	726	73.507553, 19.5...	73.306387, 19.4...	C-64	S-81315	18339	SAKALBAV	AASANGAON	BACKWARD	12:08:00	12:11:00	11:15:00	12:25:00
13	729	73.306605, 19.4...	73.586808, 19.4...	C-46	S-81054	3863	AASANGAON	DOLKHAMB	FORWARD	15:05:00	15:05:00	15:05:00	15:35:00
14	781	73.432197, 19.4...	73.306407, 19.4...	C-96	S-81351	82868	SARANGAPURI	AASANGAON	BACKWARD	06:46:00	06:48:00	6:15:00	6:55:00
15	800	73.385261, 19.4...	73.306407, 19.4...	C-46	S-81055	16509	SARLAMBE	AASANGAON	BACKWARD	15:57:00	15:59:00	15:40:00	16:10:00
16	834	73.178566, 19.5...	73.328185, 19.4...	C-100	S-81785	91061	SAVROLI	SHAHAPUR	BACKWARD	09:10:00	09:12:00	8:30:00	9:30:00
17	978	73.306355, 19.4...	73.511886, 19.5...	C-54	S-81233	75002	AASANGAON	JUNAVANI	FORWARD	17:02:00	17:04:00	17:00:00	18:00:00
18	1024	73.3283, 19.451...	73.294669, 19.4...	C-13	S-81013	12692	SHAHAPUR	KRUSHNACHI ...	FORWARD	13:42:00	13:49:00	13:35:00	14:25:00
19	1104	73.328196, 19.4...	73.286422, 19.3...	C-27	S-81662	3885	SHAHAPUR	MADH	FORWARD	05:02:00	05:04:00	5:00:00	5:50:00
20	1123	73.328236, 19.4...	72.9805, 19.197...	C-10	S-81907	16838	SHAHAPUR	THANE	BACKWARD	19:31:00	19:32:00	19:30:00	21:10:00
21	1201	73.306593, 19.4...	73.629062, 19.5...	C-14	S-81021	3855	AASANGAON	CHONDHA	FORWARD	06:51:00	06:52:00	6:50:00	8:10:00

Advanced Filter (Expression) 533,2736,2983,3028,3043,3059,3077,3109,3149,3177,3233,3275,3364,3402,3403,3411,3491,3558,3585,3597,3630,3761,3880,3967,3981,4042,4088,4233,4236,4259,4363,4403,4410,4639,4690,4826) Apply

Figure: Attribute table for trips passing through the selected route segment.

The table shows the attributes of the selected route segment from the ST road network.

ETIM analysis for highest and lowest income route:

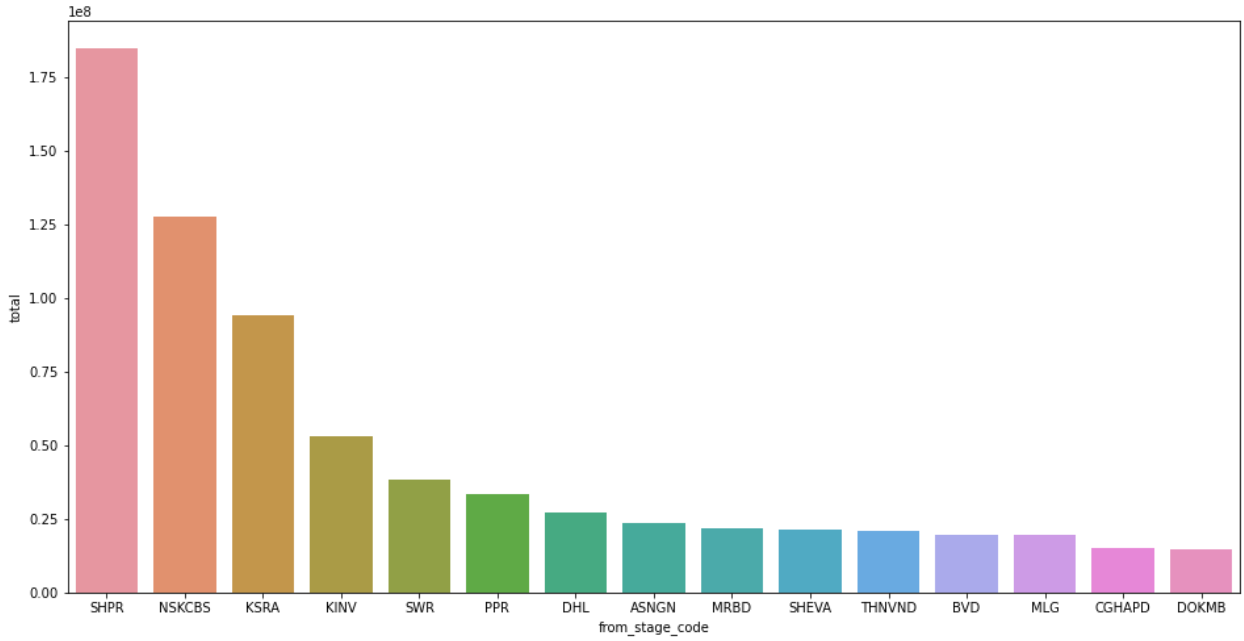


Figure: Route where income is higher than other

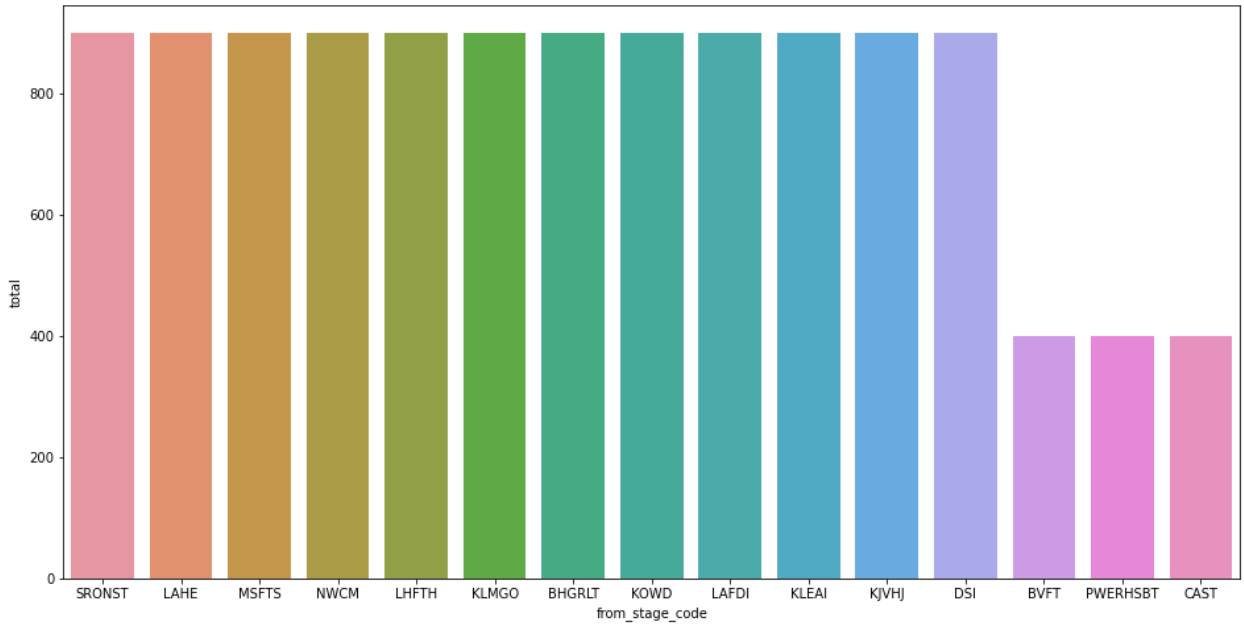


Figure: Route where income is lower than other

For example, we have taken the first and last 15 routes.

We need the ETIM dataset to analyze the ETIM data. Here I have used a python script to get the desired result. An illustration of that query given below:

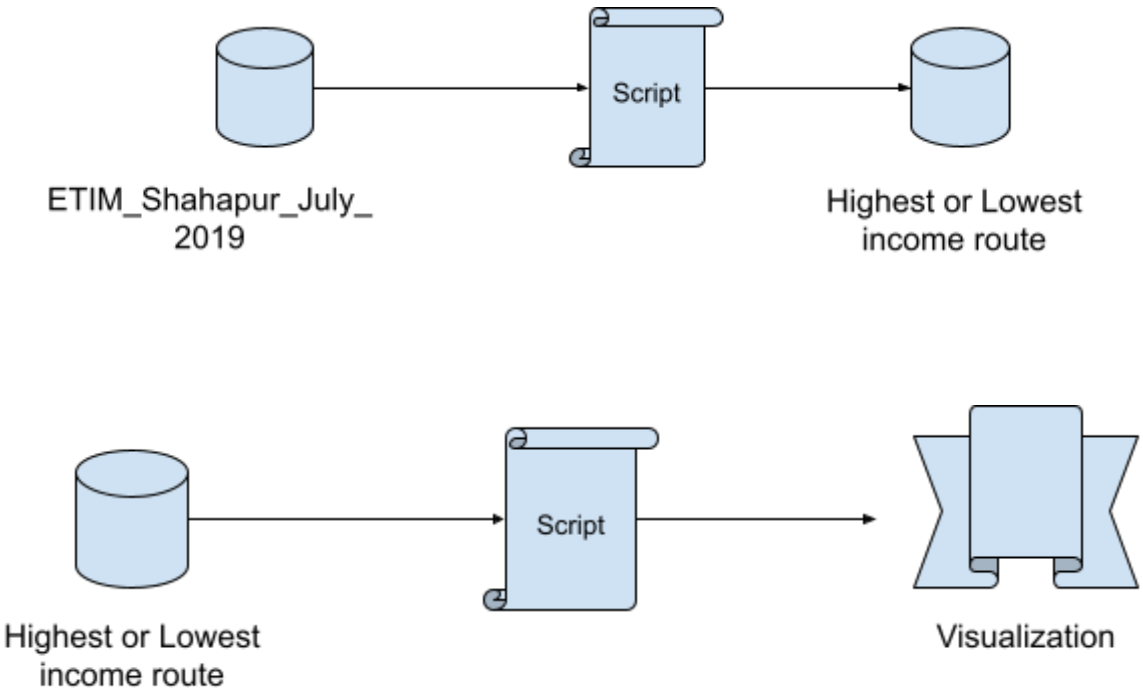


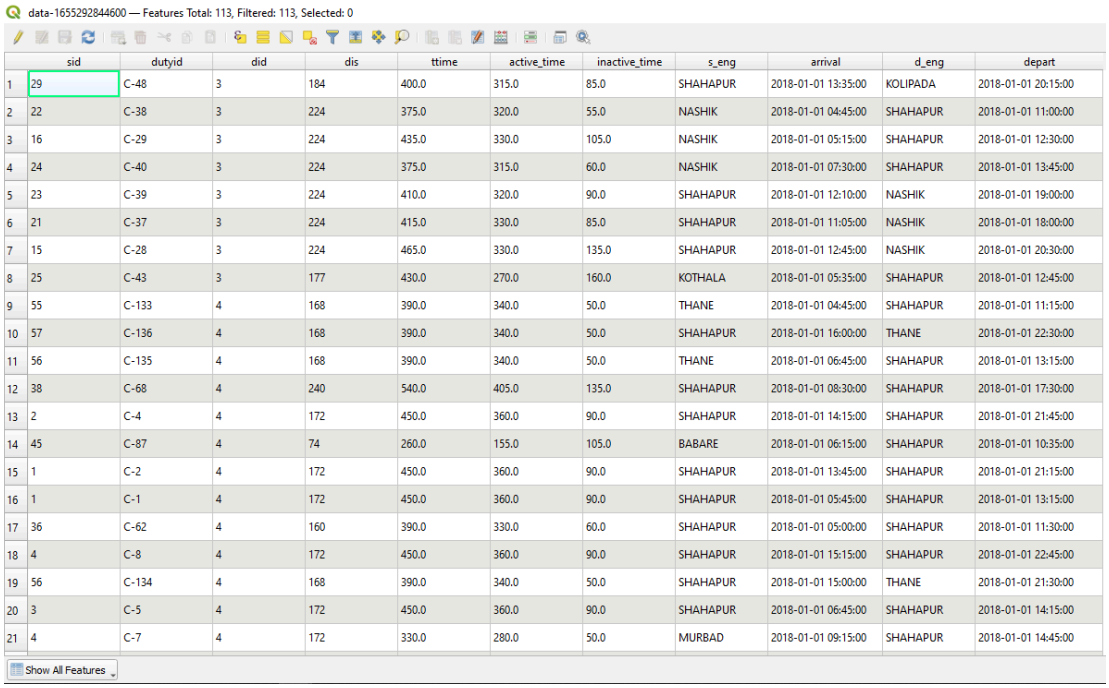
Figure: Input, Processing, and Outputs blocks for ETIM analysis

Active-Inactive time for crew members:

An SQL query is used to find out every crew member's active and inactive time.

Query: SELECT

```
(SELECT s.scheduleid as sid FROM public.shahapur_form_iv_23032019 s where
s.dutyid=shp.dutyid order by s.arrival limit 1),
dutyid, count(dutyid) as did, sum(distance) as dis,
extract(epoch from
(SELECT s.depart FROM public.shahapur_form_iv_23032019 s where s.dutyid=shp.dutyid
order by s.depart DESC limit 1) -
(SELECT s.arrival FROM public.shahapur_form_iv_23032019 s where s.dutyid=shp.dutyid
order by s.arrival limit 1)
)/60 as ttime,
sum(df) as active_time,
(extract(epoch from
(SELECT s.depart FROM public.shahapur_form_iv_23032019 s where s.dutyid=shp.dutyid
order by s.depart DESC limit 1) -
(SELECT s.arrival FROM public.shahapur_form_iv_23032019 s where s.dutyid=shp.dutyid
order by s.arrival limit 1)
)/60  - sum(df)) as inactive_time,
(SELECT s.s_eng FROM public.shahapur_form_iv_23032019 s where s.dutyid=shp.dutyid
order by s.arrival limit 1),
(SELECT s.arrival FROM public.shahapur_form_iv_23032019 s where s.dutyid=shp.dutyid
order by s.arrival limit 1),
(SELECT s.d_eng FROM public.shahapur_form_iv_23032019 s where s.dutyid=shp.dutyid
order by s.depart DESC limit 1),
(SELECT s.depart FROM public.shahapur_form_iv_23032019 s where s.dutyid=shp.dutyid
order by s.depart DESC limit 1)
FROM (SELECT scheduleid, dutyid, s_eng, d_eng, arrival, depart,  distance ,
extract(epoch from  depart - arrival)/60 as df
FROM public.shahapur_form_iv_23032019) as Shp group by dutyid order by  did ASC;
```


data-1655292844600 — Features Total: 113, Filtered: 113, Selected: 0

	sid	dutyid	did	dis	ttime	active_time	inactive_time	s_eng	arrival	d_eng	depart
1	29	C-48	3	184	400.0	315.0	85.0	SHAHAPUR	2018-01-01 13:35:00	KOLIPADA	2018-01-01 20:15:00
2	22	C-38	3	224	375.0	320.0	55.0	NASHIK	2018-01-01 04:45:00	SHAHAPUR	2018-01-01 11:00:00
3	16	C-29	3	224	435.0	330.0	105.0	NASHIK	2018-01-01 05:15:00	SHAHAPUR	2018-01-01 12:30:00
4	24	C-40	3	224	375.0	315.0	60.0	NASHIK	2018-01-01 07:30:00	SHAHAPUR	2018-01-01 13:45:00
5	23	C-39	3	224	410.0	320.0	90.0	SHAHAPUR	2018-01-01 12:10:00	NASHIK	2018-01-01 19:00:00
6	21	C-37	3	224	415.0	330.0	85.0	SHAHAPUR	2018-01-01 11:05:00	NASHIK	2018-01-01 18:00:00
7	15	C-28	3	224	465.0	330.0	135.0	SHAHAPUR	2018-01-01 12:45:00	NASHIK	2018-01-01 20:30:00
8	25	C-43	3	177	430.0	270.0	160.0	KOTHALA	2018-01-01 05:35:00	SHAHAPUR	2018-01-01 12:45:00
9	55	C-133	4	168	390.0	340.0	50.0	THANE	2018-01-01 04:45:00	SHAHAPUR	2018-01-01 11:15:00
10	57	C-136	4	168	390.0	340.0	50.0	SHAHAPUR	2018-01-01 16:00:00	THANE	2018-01-01 22:30:00
11	56	C-135	4	168	390.0	340.0	50.0	THANE	2018-01-01 06:45:00	SHAHAPUR	2018-01-01 13:15:00
12	38	C-68	4	240	540.0	405.0	135.0	SHAHAPUR	2018-01-01 08:30:00	SHAHAPUR	2018-01-01 17:30:00
13	2	C-4	4	172	450.0	360.0	90.0	SHAHAPUR	2018-01-01 14:15:00	SHAHAPUR	2018-01-01 21:45:00
14	45	C-87	4	74	260.0	155.0	105.0	BABARE	2018-01-01 06:15:00	SHAHAPUR	2018-01-01 10:35:00
15	1	C-2	4	172	450.0	360.0	90.0	SHAHAPUR	2018-01-01 13:45:00	SHAHAPUR	2018-01-01 21:15:00
16	1	C-1	4	172	450.0	360.0	90.0	SHAHAPUR	2018-01-01 05:45:00	SHAHAPUR	2018-01-01 13:15:00
17	36	C-62	4	160	390.0	330.0	60.0	SHAHAPUR	2018-01-01 05:00:00	SHAHAPUR	2018-01-01 11:30:00
18	4	C-8	4	172	450.0	360.0	90.0	SHAHAPUR	2018-01-01 15:15:00	SHAHAPUR	2018-01-01 22:45:00
19	56	C-134	4	168	390.0	340.0	50.0	SHAHAPUR	2018-01-01 15:00:00	THANE	2018-01-01 21:30:00
20	3	C-5	4	172	450.0	360.0	90.0	SHAHAPUR	2018-01-01 06:45:00	SHAHAPUR	2018-01-01 14:15:00
21	4	C-7	4	172	330.0	280.0	50.0	MURBAD	2018-01-01 09:15:00	SHAHAPUR	2018-01-01 14:45:00

Show All Features

Figure: Attribute table for active and Inactive time for every crew member

Chapter - 5

Conclusion

MSRTC is one of the essential services for rural Maharashtra's socio-economic development. The purpose of this report was to establish Shahapur taluka's Digital Geography in Thane, Maharashtra. The process for developing digital geometry has been designed in such a way that the majority of it may be replicated by anybody who has little knowledge of it. Through a GIS-based graphical interface, this digital geography will assist us in better understanding the operation of the Shahapur Taluka bus depot. This Digital Geography is an attempt to digitalize the operation of Maharashtra Public Bus Transport and assess the process of the Bus Transportation System, which may aid us in making various decisions for the depot.

Chapter - 6

Future Work

Development of a web-based application:

If MSRTC develops a web-based solution, the traffic department's workload will be considerably reduced because it is a web-based platform that can be accessed from any computer system anywhere.

Development of an API:

An API can significantly reduce the burden, particularly in the case of ETIM and ABC data processing, as this data must be analyzed monthly.

Bibliography

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