Data Analysis of the MSRTC public bus transport system

Submitted in partial fulfillment of the requirements

of the degree of

Master of Science

by

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Dedicated to my beloved parents.

Thesis Approval

This thesis entitled **Data Analysis of the MSRTC public bus transport system** by **Ramya Sharma** is approved for the degree of **Master of Science**.

Examiners:

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Supervisor: Chairperson:

……………………………   ……………………………

Date: …………

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Declaration

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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CERTIFICATE OF COURSE WORK

This is to certify that **Ramya Sharma** (Roll No. 174050003) was admitted to the candidacy of Ph.D. degree on 17 July 2017, after successfully completing all the courses required for the Ph.D. programme. The details of the course work done are given below.

S.No	Course Code	Course Name	Credits
1	CS 601	Algorithms and Complexity	6
2	CS 742	Foundations of Network Security and Cryptography	6
3	CS 744	Design and Engineering of Computing Systems	6
4	CS 695	Topics in Virtualization and Cloud Computing	6
5	CS 756	Software Defined Networking and Network Function Virtualization	6
6	CSS 802	Seminar	4
7	HS 791	Communication Skills - I	PP
8	CS 792	Communication Skills -II	PP
		Total Credits	**34**

IIT Bombay

Date: Dy. Registrar (Academic)

Abstract

In this report we aim to look at rural public transport as a development service and focus on attempting to represent and analyze it, taking into account the enterprise and societal concerns. We started with surveying surrounding public transport and focus on for the case for rural Maharashtra, specifically Shahapur taluka. Then we overview key service provider Maharashtra State Road Transportation Corporation (MSRTC) and its operations. After that, we look at the role of MSRTC in rural transportation operations.

We have focused on Shahapur and Sinnar talukas in our study. We tried to map the geolocation of bus stands in Shahapur taluka and nearby regions. We observe the key data formats received and try to outline the cdonnections between them. We observe the anomalies in the data and try to generate better mdetrics for analysing the data which might be useful for MSRTC. Finally, when Covid-19 hit, we tried to implement GIS enabled timetable creation for medical healthcare access for people of rural Maharashtra through MSRTC.

Contents

List of Tables

List of Figures

List of Abbreviations

MSRTC   Maharashtra State Road Transport Corporation

MRSAC   Maharashtra Remote Sensing Application Centre

STU   State Transport Undertaking

GIS   Geographical Information System

ETIM   Electronic Ticket Issuing Machine

EPKM   Earning Per Kilometre

QGIS   Quantum Geographic Information System

PHC   Public Health Center

Chapter 1

Introduction

The work done in this report focuses at public transport and aims to look at it as a developmental service. Technological competence of any organization determines its developmental progress in the current world. The main goal of this study is to improve the said technological competence and look into the enterprise level planning of the State Transport Undertaking of Maharashtra(MSRTC). This study delves into the different methodologies to analyse and improve the existing tools and practices used in the bus depots like form 4, operational sheets, control charts, traffic data and related data analysis and incorporation of these in the implementation so that the work-load is reduced and higher efficiency and productivity can be achieved to deliver quality services. The main focus of the work is on the analysis of the real time ticketing data from the ETIM machines and then mapping this data on the operational data in such a manner that the resulting outcomes can be suggested to administrators in order to have better and effective decision making metrics. The methodology can be generalized for all of the rural districts of Maharashtra.
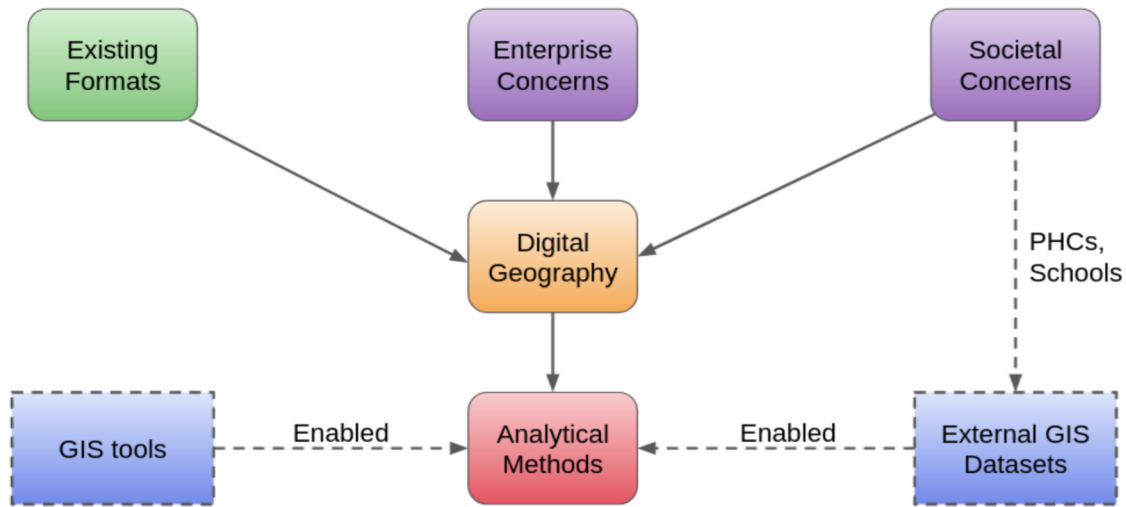
Figure 1.1: Objectives

1.1 Scope of the Project

The scope of this project is limited to Bus Transportation in Shahapur and Sinnar taluka. The nearby talukas are covered if and only if there is a bus service commuting to the said talkua. The big picture scope of the project is to see how multiple services can come together and generate a comprehensive studies for the bus service provisioning.

1.2 Research Question(s)

The research questions may be summarized as:

1. What are the gaps in the demand-supply of transportation in Shahapur taluka?

2. What can be the applications of the GIS-based framework (Digital geography)? How is it beneficial in transportation?

3. What can be the metrics for determining the performance for service provisioning of bus transportation?

1.3 Objectives

The objectives are categorized into two types:

- **Framework for collecting the data:**

    - Form4, Master data, ETIM data and ABC data are not coherent and there is no common denominator between them.

    - Integration of GIS with the route data will lead to data coherency along with locating other GIS features like schools, factories, markets and PHCs.

- **Proposing analytical methods to answer certain concerns:**

    - The current methodologies might not be enough to observe the route traffic data.

    - Introducing metrics like ridership and consistency will help the MSRTC and trimax to observe the traffic and keep the data coherent.

The final output analytical methods, as suggested by a combination of the objectives given above, will lead to a data observation format which is more visually appealing, information packed and extensively combines multiple metrices together. It is the next step towards digitization of India's government transport services.

1.4 Methodology

The following methodology was undertaken:

1. Visits to MSRTC head office, Nashik Division office and Sinnar taluka depot.

2. Meeting and interviewing various agents of service, i.e depot staff, bus depot manager, division traffic controller, general manager IT.

3. Meeting the representatives of outsource managed service agency(TRIMAX) of MSRTC.

4. Collecting the data from MSRTC and MRSAC.

5. Analysis of ETIM ticketing data and ABC monthly operational data.

6. Presentation at MSRTC office regarding suggestions after the analysis of the obtained data.

1.5 Proposed Outputs

The proposed outputs are:

1. A framework for social benefit accounting of Shahapur Taluka Bus depot.

2. Ascertaining the gaps in standard formats used by MSRTC.

3. Analysis of these gaps and suggestions to MSRTC.

Chapter 2

Introduction to MSRTC and Shahapur Bus Depot

Maharashtra State Road Transport Corporation is the State Transport Undertaking (STU) of MaharashtraCommittee et al. (2014)Website History of MSRTC (2017). It serves routes to towns and cities within Maharashtra and adjoining states. Before Covid-19, there were 18449 buses providing passenger services to people via 247 depots and 578 bus stations, which are located at Tehsils and major traffic centres. According to the annual report of the year 2016-17, this corporation carried out 206.61 crores effective kilometres operation Annual Report of MSRTC (2017-2018). Furthermore, the percentage Load Factor, also including the concession value in the same financial year was 68.75%. Also, the social value of MSRTC is brought out by the fact that it served 91.64% of villages in Maharashtra and 96.99% population within a range of 3 Km. In the same year, MSRTC faced Rs. 422 Crore losses, which approximately accounts for 5.64% of total revenue of Rs 7056 Crore. The percentage division of MSRTC services were as follows:

- 91.98% operations through Ordinary Services

- 7.02% operation through Semi Luxury service

- 0.99% through Air Conditioned services.

MSRTC also operated approx. 1.93 crores kilometers on for festivals and fairs and earned Rs 66.46 crore, which are about 0.94% of the total revenue earned. Moreover, MSRTC received revenue of Rs 58.60 crore from operating Casual Contracts, which were about 0.83% of total revenue, in the same financial year. Annual Report of MSRTC (2017-2018).

The corporation started using GIS based website and vehicle monitoring system since January 2020 that is capable of generating reports and 20 point meetings at division and depot level.

At division level depot wise basic information is collected and based on these information various analytic reports are submitted to Divisional Management for improvement in performance.

2.1 Transportation in rural areas

The transportation in rural areas can be observed as the demand generated by the masses and the supply provided, by both private and public vehicles.

2.1.1 Demand

Demand is the desire to purchase goods or service in exchange for monetary compensation. The demand for transportation arises due to many reasons as shown in fig 2.1. The demand is generated on the following basis:

- *Institutions*: The institutions generate traffic. People need to go to industries/factories, hospitals, schools and colleges. The demand is generated by both adults and children.

- *Geography*: The geographical terrain, the roads built on that terrain, the scenery (in case of tourist spots) also contribute towards generation of demand.

- *Society*: The society also creates demands. Usually, males own private vehicles like

6
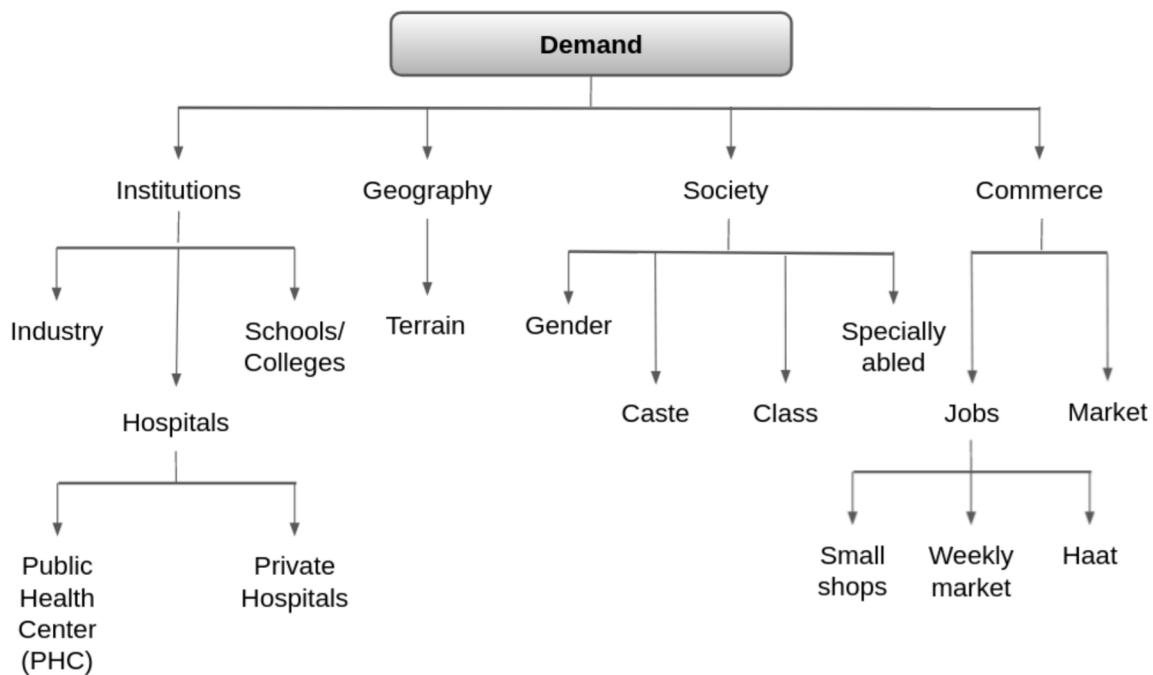
Figure 2.1: Demand for transportation

bicycles or motorcycles and females have to use public transportation. The probability of people with more money owning private vehicles also increases. Specially abled people may need customized vehicles, which might not be accessible to everyone. Hence they might rely on public transportation systems.

- *Commerce*: The jobs and market are one of the biggest reasons for the demand of transportation. People travel to different villages or cities for their job, to set up shops or to buy from the market. All this creates a demand for regular, timely transport system.

2.1.2 Supply

Supply is the total amount of goods or service available to the customers. The supply for the transportation requirements is fulfilled in the following ways (as shown in fig 2.2):

- **2 wheeler** - People who own 2 wheelers are independent travellers. But mostly these are driven by the male members of the family.

- **3 wheeler** - Autos are used by travelers or daily commuters for short distances.
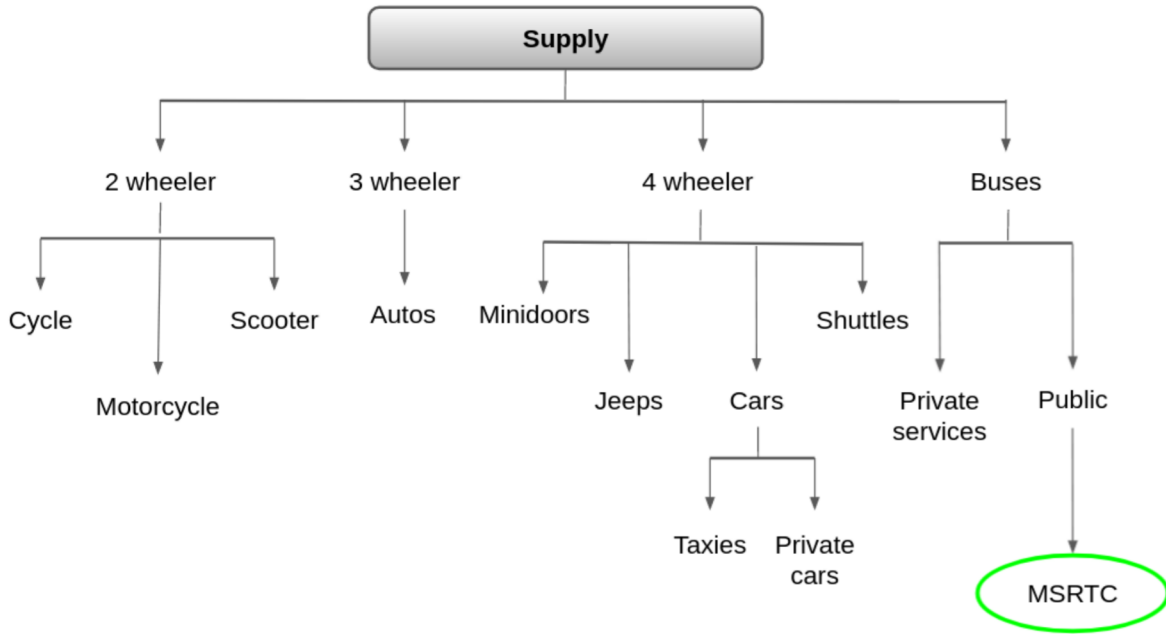
Figure 2.2: Supply for transportation

- **4 wheeler** - Four wheelers are both privately owned and rented vehicles. These vehicles are used by the daily commuters for short distance travel. These are economical and viable options for people for local travel.

- **Buses** - The buses belong to both public and private sector. Private buses are used by people for events like fairs or marriages. Public transportation like MSRTC is important for travellers because it is used by people for travel for industries, schools and markets.

2.2 Data received

2.2.1 Form 4

Form 4 is the Operational data calculated by using the previous year's travel data, which is used by MSRTC for scheduling crew members and trips. The form 4 consists of information about schedules, crew duties and bus service details among others, as shown in table 2.1. It is stored in the marathi font *priyanka* and edited in excel sheets. An instance of form 4 is shown in fig 2.3.

Form 4 data header	Description
Schedule id	The Schedule id of a schedule, i.e. a set of bus trips in such a way that the bus does not change.
Service id	The service id, where the service is a trip between termini.
Crew duty id	The crew duty id represents the combination of bus conductor and driver (as a crew) assigned to the bus service.
Source terminal	The origin bus stop of the schedule.
Destination Terminal	The destination bus stop of the schedule.
Distance	The kilometers between source and destination terminals.
Arrival Time	The bus arrival time at the terminal.
Departure Time	The bus departure time from the terminal.
Type of bus service	The category of bus service, for example, *Mofussil, obligatory, manav-vikas*
Op-maint schedule	The scheduled bus maintenance timings.
Waiting Time	The wait time assigned for change of crew duty.

Table 2.1: Entries in Form 4 data

Figure 2.3: Form 4 sample data

Form 4 data is generated in the division offices for all the depots. The form 4 data shows assigned crew as well.

2.2.2 Form 1

The bus schedules are generated on the basis of Form 1 data as shown in fig 2.4. Form 1 is the load factor data for the last year, containing both with and without concession data.

If for any trip the load factor is >80%, a new trip is introduced. On the other hand, If the ABC status of both up and down trip is C, then that trip may be cancelled.

अ.क्र.	मार्ग		अंतर	धाववेळ	एकूण मंजूर फेऱ्या		एकूण मंजूर कि. मी.		सरासरी भारमान		शेरा
	पासुन	पर्यंत			बारमाही (BASIC)	पुनरारंभी (TRS)	बारमाही (BASIC)	पुनरारंभी (TRS)	विनासवलत	सवलतीसह	
१	२	३	४	५	६	७	८	९	१०	११	१२
१	नाशिक	पंढरपुर	359	8.45	1		359.0		65	80	
२	पंढरपुर	नाशिक	359	8.45	1		359.0		65	80	
३	नाशिक	पाटोदा	278.3	7.10	1		278.3		61	72	
४	पाटोदा	नाशिक	278.3	7.10	1		278.3		64	76	
५	नाशिक	पुणे	212.8	5.00	4		851.2		68	82	
६	पुणे	नाशिक	212.8	5.00	4		851.2		65	68	
७	नाशिक	अ.नगर	171.7	4.15	4		686.8		70	87	
८	अ.नगर	नाशिक	171.7	4.15	4		686.8		57	68	
९	सिन्नर	नाशिक	31.3	1.00	76		2378.8		47	76	
१०	नाशिक	सिन्नर	31.3	1.00	76		2378.8		47	92	
११	नाशिक	शिर्डी	90.2	2.30	12		1082.4		79	90	
१२	शिर्डी	नाशिक	90.2	2.30	12		1082.4		68	85	
१३	सिन्नर	माळेगांव	8.9	0.15	12		106.8		39	100	
१४	माळेगांव	सिन्नर	8.9	0.15	12		106.8		22	74	
१५	सिन्नर	मुसळगांव	9	0.15	12		108.0		16	76	

Figure 2.4: Form 1 sample data

2.2.3 Master data

The Master data describes the route information.

There is two types of master data:

- **All routes master** - This data set contains the information about route number, the starting bus stop, the final bus stop, total kilometers and the division under which the route comes as shown in 2.2

- **All routes stops master** - This data set contains the information about route number, the order of bus stops on the route with the respective kilometers and the pricing scheme for the stops on the route as shown in 2.3.

	A	B	C	D	E	F	G	H
1	route_auto	route_no	bus_stop_cd	bus_stop_nm	stop_seq	sub_stage	stage_no	km
2	10321	134	KLN	KALYAN	1	SO	7	0
3	10388	134	SVJICK	SHIVAJI CHOWK	2	S-	7	1
4	10333	134	LCWKT	LAL CHOWKI	3	S-	7	2.2
5	10291	134	DRGONK	DURGADI OCTROI NAKA	4	OO	8	2.7
6	10385	134	SRAMMD	SHRIRAM MANDIR	5	O-	8	3.8
7	10323	134	KONQ	KON	6	O-	8	4
8	10324	134	KNPTBT	KON PETRL PUMP	7	O-	8	4.5
9	10383	134	SMRTH	SAMARTH	8	O-	8	5
10	10301	134	GSF	GOVE SARAVALI FATA	9	SO	8	5.7
11	10365	134	PPGNBT	PIMPALGAON	10	S-	8	6.2
12	10336	134	MALH	MALHOTRA	11	S-	8	6.7
13	10377	134	RBP	RANJNOLI BY PASS	12	S-	8	7
14	10378	134	SBMD	SAI BABA MANDIR	13	S-	8	8
15	10288	134	DNFC	DANDEKAR FACTORY	14	O-	9	10.2
16	10275	134	BVD	BHIVANDI	15	SO	9	11.5
17	10284	134	CVRA	CHAVINDRA	16	S-	9	14
18	10270	134	BDSIB	BODSAI	17	OO	10	14.5
19	10271	134	BHINAR	BHINAR	18	O-	10	16
20	10351	134	NIMLI	NIMBAVALI	19	O-	10	16.6
21	10402	134	VDPA	VADAPA	20	S-	10	19.2
22	10294	134	GGAMPD	GANGARAM PADA	21	OO	11	20
23	10319	134	KKBR	KUKUSU BORIVALI	22	O-	11	21
24	10273	134	BOIRPD	BHOIR PADA	23	O-	11	21.2
25	10407	134	WAHOLI	WAHOLI	24	O-	11	22.8
26	10390	134	TALV	TALAVLI	25	SO	11	24
27	10263	134	ARJLI	ARJOLI	26	S-	11	24.9
28	10362	134	PDGHA	PADGHA	27	OO	12	25.8
29	10396	134	TTPW	TATA POWER	28	O-	12	26.9
30	10290	134	DOHALE	DOHALE	29	SO	12	29.7
31	10322	134	KOHBA	KOSHIMBA	30	S-	12	31.1
32	10331	134	KHVF	KHADAVLI FATA	31	OO	13	32.4
33	10325	134	KSNE	KASANE	32	O-	13	33.9
34	10405	134	VHNDFT	VASHIND FATA	33	SO	13	35.9
35	10400	134	VASD	VASHIND	34	S-	13	36.8
36	10329	134	KTIV	KHATIVALI	35	OO	14	38.1
37	10404	134	VEALI	VEHALOLI	36	O-	14	40.4
38	10264	134	ARSF	ASANGAON RLY. STN. FATA	37	SO	14	41.9
39	10380	134	SHPR	SHAHAPUR	38	OO	15	46

Figure 2.5: Master data sample for Shahapur Bus stops

Master data header	Description
ROUTE_NO	The route number of the route.
Route_kms	The total kilometers on the route.
FROM_STOP_CD	The starting bus stop code of the route.
TILL_STOP_CD	The final bus stop code of the route.
DIVISION_CD	The division code under which this route comes.

Table 2.2: Entries in All routes master data

Master data header	Description
ROUTE_NO	The route number of the route.

BUS_STOP_CD	The bus stop code of the bus stop the route.
BUS_STOP_NM	The bus stop name of the bus stop the route.
STOP_SEQ	The sequence number of the bus stop the route.
SUB_STAGE	Pricing scheme of the ticket.
KM	The kilometers from the starting bus stop.
STATE_CD	The state code of the bus route.

Table 2.3: Entries in All routes stops master data

2.2.4 ETIM data

ETIM data is the real time ticketing information generated while issuing tickets by the conductor and stored in ETIM machines which are managed the TRIMAX company. Multiple trips can run on the same day for a route if the traffic on that route is high.

Some of the important data headers are shown in table 2.4 Sample ETIM data is shown in fig 2.7 and 2.8 for the month of July, 2019.

ETIM data header	Description
ticket_id	The id of the ticket issued
etim_no	The id of the ETIM machine
trip_no	Trip number of respective route. Matched with the ABC data's trip number.
route_no	Route number of respective route. Matched with Master data's route number.
bus_service	The category of bus service, for example, *Mofussil, obligatory, manav-vikas*
from_stage_code	The bus stop code from which the passenger got on.
till_stage_code	The bus stop code at which the passenger got down.
full_ticket	Number of full adult tickets issued on the ticket id
half_ticket	Number of half(kids) tickets issued on the ticket id

luggage_qty	Number of luggage issued on the ticket id
pass_qty	If there is a pass for the route, then the quantity for those passes
total_amt	The total amount for the ticket (in paisa)
ticket_date	The date on which the ticket was issued(short format: dd/mm/yy)
ticket_date_actual	The date on which the ticket was issued(format: dddd-mm-yy)
ticket_time	The time at which the ticket was issued
pass_id	The ID of the pass if the ticket was issued for a pass
insp_conc_code	If the ticket is for an inspection, this specifies which kind of inspection.
full_tkt_amt	The amount for the full ticket issued for adults(in paisa)
half_tkt_amt	The amount for the half ticket issued for kids(in paisa)
lugg_tkt_amt	The amount for the luggage ticket issued for luggage(in paisa)
divisionname	Name of the division office the ETIM machine issuing depot comes under.
divisioncode	Bus stand code of the division office the ETIM machine issuing depot comes under.
deponame	Name of the depot office the ETIM machine was issued for.
depocode	Bus stand code of the depot office the ETIM machine was issued for.

Table 2.4: Entries in ETIM data

There can be 73 types of concessions in ETIM data, some of which are shown in the figure 2.6.

CONCESSION_	CONCESSION_	CONCESSION_	CHILD_PERMIT	ADULT_PERMIT	IS_PARENTCON	PARENT_CONC	CONCESSION_DEVNAGIRI_NM
1	AA	ARJUN AWARD	N	Y	N	AA	अर्जुन पुरस्कार
2	AC	ANNUAL CONC	Y	Y	N	AC	वार्षिक सवलत कार्ड
47	ACS	AC 50% SCHEM	Y	Y	N	ACS	एसी ५०% योजना
3	AD	ADIWASI SEWA	N	Y	N	AD	आदिवासी सेवक पुरस्कार
4	AE	ADIWASI SEWA	N	Y	Y	AD	आदिवासी सेवक पुरस्कार सोबती
57	AH	AHILYABAI HOL	Y	Y	N	AH	अहिल्याबाई होळकर पास प्रवास
5	AS	SAHITYARATNA	N	Y	N	AS	साहित्यरत्न लोकशाहीर अण्णाभाऊ साठे पुरस्कार
6	ASE	SAHITYARATNA	N	Y	Y	AS	साहित्यरत्न लोकशाहीर अण्णाभाऊ साठे पुरस्कार सोबती
7	AW	ASHADHI EKAD	N	Y	N	AW	आषाढी एकादशी पुजा सन्मानित वारकरी
8	BE	BLIND ESCORT	N	Y	Y	BL	दिव्यांग व्यक्ती सोबती
43	BEC	BLIND ESCORT	Y	Y	Y	BLC	दिव्यांग व्यक्ती सोबती शहर
9	BL	BLIND	N	Y	N	BL	दिव्यांग व्यक्ती
44	BLC	BLIND CITY	Y	Y	N	BLC	दिव्यांग व्यक्ती शहर
10	CP	CANCER PATIE	Y	Y	N	CP	कर्करोग ग्रस्त रुग्ण
11	CT	SR. CITIZEN	N	Y	N	CT	जेष्ठ नागरिक
12	DA	DRONACHARY/	N	Y	N	DA	द्रोणाचार्य पुरस्कार
13	DE	DR. BABASAHE	Y	Y	Y	DM	डॉ. बाबासाहेब अांबेडकर समाजभूषण पुरस्कार सोबती
14	DK	DADOJI KONDA	N	Y	N	DK	दादोजी कोंडदेव पुरस्कार
74	DLY	DIALYSIS PATIE	N	Y	N	DLY	डायलिसिस ग्रस्त रुग्ण
15	DM	DR. BABASAHE	N	Y	N	DM	डॉ. बाबासाहेब अांबेडकर समाजभूषण पुरस्कार
16	EM	EMPLOYEE FRI	N	Y	N	EM	कर्मचारी मोफत पास
17	FE	FREEDOM FIGH	N	Y	Y	FF	स्वातंत्र सैनिक सोबती
18	FF	FREEDOM FIGH	N	Y	N	FF	स्वातंत्र सैनिक

Figure 2.6: Types of concessions

|	ticket_id	waybill_no	etim_no	trip_no	route_no	ticket_co	ticket_numbe	boarding_stage	boarding_s	from_stage_	alight_sta	alight_sta	till_stage_	full_ti	half_ti	lugga	pass	passenge	total_amt	ticket_date_actual	ticket_time
2	52164831	199154	SHP05130	00S81499	13972	0	424		17	O-	MLGST	15	SO	KUGR	1	0	0	0	1	1400	2019-07-11	09:42:45
3	52164832	199154	SHP05130	00S81499	13972	0	425		17	O-	MLGST	15	OO	SHPR	1	0	0	0	1	1900	2019-07-11	09:43:41
4	52164833	199154	SHP05130	00S81499	13972	0	426		17	O-	MLGST	15	OO	SHPR	1	0	0	0	1	1900	2019-07-11	09:44:23
5	52164834	199154	SHP05130	00S81499	13972	0	427		17	O-	SHEVA	15	OO	SHPR	2	0	0	0	2	3800	2019-07-11	09:47:35
6	52164835	199154	SHP05130	00S81499	13972	PS	428		17	O-	SHEVA	15	OO	SHPR	0	0	0	1	1	0	2019-07-11	09:48:45
7	52164836	199154	SHP05130	00S81499	13972	0	429		17	OO	STHGN	15	OO	SHPR	1	0	0	0	1	1400	2019-07-11	09:50:35
8	52164837	199154	SHP05130	00S81499	13972	PS	430		17	OO	STHGN	15	OO	SHPR	0	0	0	1	1	0	2019-07-11	09:51:27
9	52164838	199154	SHP05130	00S81499	13972	0	431		16	SO	STTRST	15	OO	SHPR	1	0	0	0	1	900	2019-07-11	09:55:00
10	52164839	199154	SHP05130	00S81499	13972	0	432		16	SO	STTRST	15	OO	SHPR	2	0	0	0	2	1800	2019-07-11	09:56:03
11	52164840	199154	SHP05130	00S81499	13972	0	433		16	SO	STTRST	15	OO	SHPR	1	0	0	0	1	900	2019-07-11	09:56:15
12	52164841	199154	SHP05130	00S81499	13972	0	434		16	SO	STTRST	15	OO	SHPR	1	0	0	0	1	900	2019-07-11	09:56:21
13	52164842	199154	SHP05130	00S81499	13972	0	435		16	SO	STTRST	15	OO	SHPR	1	0	0	0	1	900	2019-07-11	09:57:20
14	52164843	199154	SHP05130	00S81499	13972	0	436		16	SO	STTRST	15	OO	SHPR	1	0	0	0	1	900	2019-07-11	09:57:30
15	52164844	199154	SHP05130	00S81499	13972	0	437		16	SO	STTRST	15	OO	SHPR	1	0	0	0	1	900	2019-07-11	09:57:59
16	52164845	199154	SHP05130	00S81499	13972	CN	438		16	SO	STTRST	15	OO	SHPR	1	0	0	0	1	400	2019-07-11	09:58:08
17	52164846	199154	SHP05130	00S81499	13972	CN	439		16	SO	STTRST	15	OO	SHPR	1	0	0	0	1	400	2019-07-11	09:59:08
18	52164847	199154	SHP05130	00S81499	13972	0	440		16	OO	SLLIFT	15	OO	SHPR	2	0	0	0	2	1800	2019-07-11	10:00:50
19	52164848	199154	SHP05130	00S81499	13972	0	441		16	OO	SLLIFT	15	OO	SHPR	2	0	0	0	2	1800	2019-07-11	10:01:18
20	52164849	199154	SHP05130	00S81499	13972	0	442		16	OO	SLLIFT	15	OO	SHPR	1	0	0	0	1	900	2019-07-11	10:01:31
21	52164850	199154	SHP05130	00S81499	13972	PS	443		16	OO	SLLIFT	15	OO	SHPR	0	0	0	1	1	0	2019-07-11	10:02:09
22	52164851	199154	SHP05130	00S81499	13972	PS	444		16	OO	SLLIFT	15	OO	SHPR	0	0	0	1	1	0	2019-07-11	10:02:17
23	52164852	199154	SHP05130	00S81499	13972	0	445		15	S-	SPDAE	15	OO	SHPR	1	0	0	0	1	900	2019-07-11	10:05:30
24	52164853	199154	SHP05130	00S81500	12708	0	446		15	OO	SHPR	20	OO	SRAO	2	0	0	0	2	7800	2019-07-11	10:53:15
25	52164854	199154	SHP05130	00S81500	12708	0	447		15	OO	SHPR	18	SO	KINV	1	0	0	0	1	2400	2019-07-11	10:54:09
26	52164855	199154	SHP05130	00S81500	12708	CN	448		15	OO	SHPR	18	OO	UMARAI	1	0	0	0	1	900	2019-07-11	10:54:34
27	52164856	199154	SHP05130	00S81500	12708	0	449		15	OO	SHPR	16	OO	SLLIFT	1	0	0	0	1	900	2019-07-11	10:54:47
28	52164857	199154	SHP05130	00S81500	12708	CN	450		15	OO	SHPR	21	OO	SIOHMT	1	0	0	0	1	2400	2019-07-11	10:55:06
29	52164858	199154	SHP05130	00S81500	12708	0	451		15	OO	SHPR	18	SO	KINV	1	0	0	0	1	2400	2019-07-11	10:56:27
30	52164859	199154	SHP05130	00S81500	12708	0	452		15	OO	SHPR	16	OO	SLLIFT	1	0	0	0	1	900	2019-07-11	10:56:36
31	52164860	199154	SHP05130	00S81500	12708	0	453		15	OO	SHPR	17	O-	MLGST	1	0	0	0	1	1900	2019-07-11	10:57:06
32	52164861	199154	SHP05130	00S81500	12708	CN	454		15	OO	SHPR	17	O-	MLGST	2	0	0	0	2	1800	2019-07-11	10:57:32
33	52164862	199154	SHP05130	00S81500	12708	0	455		15	OO	SHPR	18	SO	KINV	1	0	0	0	1	2400	2019-07-11	10:58:07
34	52164863	199154	SHP05130	00S81500	12708	0	456		15	OO	SHPR	18	SO	KINV	1	0	0	0	1	2400	2019-07-11	10:58:39
35	52164864	199154	SHP05130	00S81500	12708	PS	457		15	OO	SHPR	20	OO	SRAO	0	0	0	1	1	0	2019-07-11	10:59:00
36	52164865	199154	SHP05130	00S81500	12708	0	458		15	OO	SHPR	20	OO	SRAO	1	0	0	0	1	3900	2019-07-11	10:59:19
37	52164866	199154	SHP05130	00S81500	12708	PS	459		15	OO	SHPR	18	SO	KINV	0	0	0	1	1	0	2019-07-11	10:59:46
38	52164867	199154	SHP05130	00S81500	12708	0	460		15	OO	SHPR	20	OO	SRAO	1	0	0	0	1	3900	2019-07-11	10:59:56
39	52164868	199154	SHP05130	00S81500	12708	0	461		15	OO	SHPR	22	OO	MRBD	1	0	0	0	1	5400	2019-07-11	11:00:30
40	52164869	199154	SHP05130	00S81500	12708	CN	462		15	OO	SHPR	20	OO	SRAO	1	0	0	0	1	1900	2019-07-11	11:00:55
41	52164870	199154	SHP05130	00S81500	12708	0	463		16	OO	SLLIFT	17	O-	SHEVA	1	0	0	0	1	900	2019-07-11	11:13:51
42	52164871	199154	SHP05130	00S81500	12708	0	464		16	OO	SLLIFT	17	O-	SHEVA	1	0	0	0	1	900	2019-07-11	11:14:18
43	52164872	199154	SHP05130	00S81500	12708	0	486		20	OO	SRAO	22	OO	MRBD	1	0	0	0	1	1400	2019-07-11	12:06:52
44	52164872	199154	SHP05130	00S81500	12708	0	465		17	O-	SHEVA	17	S-	BDSGN	1	0	0	0	1	900	2019-07-11	11:23:32
45	52164873	199154	SHP05130	00S81500	12708	0	466		17	O-	SHEVA	18	SO	KINV	1	0	0	0	1	900	2019-07-11	11:23:48
46	52164874	199154	SHP05130	00S81500	12708	0	467		17	O-	MLGST	18	SO	KINV	2	0	0	0	2	1800	2019-07-11	11:29:11

Figure 2.7: Sample ETIM dataset for the month of July(1)

2.2.5 ABC data

ABC operational data is calculated as the monthly summary data which is composed of total earning during a bus service, advanced booking, revenue earned by luggage, reservations, earning via concessions and various bus passes as shown in figure 2.9 and description of these data fields is shown in table 2.5. It also consists of EPKM (Earning Per Kilometer) and grade (A, B

Figure 2.8: Sample ETIM dataset for the month of July(2)

pass_id	insp_conc_code	full_tkt	half_t	lugg	lastupdate	lastup	bus_	actual_total	ttl_stages	actual_a	actual	actual_lu	per_adult	per_c	per_lu	version_t	divisionn	divisioncode	deponame	depocode	asn_amount
	0	1400	0	0	2019-07-11 14:51:34	SDL	44	1400	2	1490	745	100	1400	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	1900	0	0	2019-07-11 14:51:34	SDL	44	1900	2.5	1863	932	150	1900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	1900	0	0	2019-07-11 14:51:34	SDL	44	1900	2.5	1863	932	150	1900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	3800	0	0	2019-07-11 14:51:34	SDL	44	3800	2.5	1863	932	150	1900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	200
673	0	0	0	0	2019-07-11 14:51:34	SDL	44	0	2.5	1863	932	150	0	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	0
	0	1400	0	0	2019-07-11 14:51:34	SDL	44	1400	2	1490	745	100	1400	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
641	0	0	0	0	2019-07-11 14:51:34	SDL	44	0	2	1490	745	100	0	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	0
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1.5	1118	559	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	1800	0	0	2019-07-11 14:51:34	SDL	44	1800	1.5	1118	559	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	200
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1.5	1118	559	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1.5	1118	559	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1.5	1118	559	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1.5	1118	559	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1.5	1118	559	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	11	400	0	0	2019-07-11 14:51:34	SDL	44	400	1.5	1118	559	100	400	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	19	400	0	0	2019-07-11 14:51:34	SDL	44	400	1.5	1118	559	100	400	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	1800	0	0	2019-07-11 14:51:34	SDL	44	1800	1	745	373	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	200
	0	1800	0	0	2019-07-11 14:51:34	SDL	44	1800	1	745	373	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	200
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1	745	373	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
654	0	0	0	0	2019-07-11 14:51:34	SDL	44	0	1	745	373	100	0	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	0
654	0	0	0	0	2019-07-11 14:51:34	SDL	44	0	1	745	373	100	0	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	0
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	0.5	1000	500	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	7800	0	0	2019-07-11 14:51:34	SDL	44	7800	5	3725	1863	250	3900	0	200	MOFF	THANE	THN	SHAHAPUR	SHPR	200
	0	2400	0	0	2019-07-11 14:51:34	SDL	44	2400	3.5	2608	1304	200	2400	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	11	900	0	0	2019-07-11 14:51:34	SDL	44	900	3	2235	1118	150	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1	745	373	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	11	2400	0	0	2019-07-11 14:51:34	SDL	44	2400	6	4470	2235	300	2400	0	200	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	2400	0	0	2019-07-11 14:51:34	SDL	44	2400	3.5	2608	1304	200	2400	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1	745	373	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	1900	0	0	2019-07-11 14:51:34	SDL	44	1900	2.5	1863	932	150	1900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	11	1800	0	0	2019-07-11 14:51:34	SDL	44	1800	2.5	1863	932	150	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	200
	0	2400	0	0	2019-07-11 14:51:34	SDL	44	2400	3.5	2608	1304	200	2400	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	2400	0	0	2019-07-11 14:51:34	SDL	44	2400	3.5	2608	1304	200	2400	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
654	0	0	0	0	2019-07-11 14:51:34	SDL	44	0	5	3725	1863	250	0	0	200	MOFF	THANE	THN	SHAHAPUR	SHPR	0
	0	3900	0	0	2019-07-11 14:51:34	SDL	44	3900	5	3725	1863	250	3900	0	200	MOFF	THANE	THN	SHAHAPUR	SHPR	100
651	0	0	0	0	2019-07-11 14:51:34	SDL	44	0	3.5	2608	1304	200	0	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	0
	0	3900	0	0	2019-07-11 14:51:34	SDL	44	3900	5	3725	1863	250	3900	0	200	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	5400	0	0	2019-07-11 14:51:34	SDL	44	5400	7	5215	2608	350	5400	0	200	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	11	1900	0	0	2019-07-11 14:51:34	SDL	44	1900	5	3725	1863	250	1900	0	200	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1.5	1118	559	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1.5	1118	559	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	1400	0	0	2019-07-11 14:51:34	SDL	44	1400	2	1490	745	100	1400	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1	745	373	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	900	0	0	2019-07-11 14:51:34	SDL	44	900	1.5	1118	559	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	100
	0	1800	0	0	2019-07-11 14:51:34	SDL	44	1800	1.5	1118	559	100	900	0	100	MOFF	THANE	THN	SHAHAPUR	SHPR	200

or C) describing the quality of the bus service.

ABC data header	Description
Trip Number	Trip number of respective route. Matched with the ETIM data's trip number.
Route_from	The starting bus stop of the route.
Route_till	The final bus stop of the route.
Bus Service Type	The category of bus service, for example, *Mofussil, obligatory, manav-vikas*
Dept Time	The time at which the bus was scheduled to depart.
Kilometer	The total kilometers in the route.
Fare	Fare for a single full trip ticket.
Oper Trip	The number of days the trip ran for that month.
Operated Kilometer	The total number of kilometers the bus ran.

Psgrs Earning	The amount earned from the tickets issued.
% Load Factor	See formula
Net EPKM	See formula
ABC Status	Calculated ABC status for the trip

Table 2.5: Entries in ABC data

ABC Analysis Data For Month July Shahapur Depot

Sr No	Trip Number	Route Name	Bus Service Type	Dept Time	Kilo-meter	Fare	Oper Trip	Operated Kilometer	Psgrs Earning	Other Earning	Total Earning	Net Earning	Expt Earning	% Load Factor	Net EPKM	ABC Status	No Of Psgrs
1	L3767	SHAHAPUR to	OD	07:00	429.8	535	31	13323.8	601538	1464	603002	508672	738300	81.48	38.18	B	186
2	L3768	PANDHARPUR to	OD	07:30	429.8	535	30	12894	530689	957	531646	450749	707805	74.98	34.96	B	120
3	M3797	SHAHAPUR to	DO	05:30	255.8	320	31	7929.8	350841	99	350940	299702	439360	79.85	37.79	B	0
4	M3798	DHULE to	DO	12:30	307.9	395	31	9544.9	334064	767	334831	284916	537990	62.09	29.85	B	15
5	M3799	SHAHAPUR to	DO	06:30	255.8	320	27	6906.6	243587	45	243632	207839	376640	64.67	30.09	B	0
6	M3800	DHULE to	DO	13:30	255.8	320	26	6650.8	246688	106	246794	209861	364800	67.62	31.55	B	0
7	M4971	SHAHAPUR to	SL	08:50	212.1	365	31	6575.1	297744	187	297931	248909	402010	74.06	37.86	B	17
8	M4972	SWARGATE, PUNE to	SL	17:00	211.1	365	31	6544.1	190692	94	190786	158784	397265	48	24.26	C	18
9	M5050	SHAHAPUR to	DO	06:00	257.8	320	27	6960.6	296091	59	296150	250758	375360	78.88	36.03	B	0
10	M5051	SAKRI to	DO	13:30	257.8	320	26	6702.8	246257	349	246606	209229	368320	66.86	31.22	B	0
11	S81000	SHAHAPUR to	DO	13:45	14.2	20	13	184.6	5135	30	5165	4342	10940	46.94	23.52	C	0
12	S81005	ASANGAON to	OD	20:10	26.2	35	31	812.2	22413	0	22413	18513	46830	47.86	22.79	C	0
13	S81006	ASNOLI to	DO	05:50	26.2	35	31	812.2	24266	115	24381	20224	46795	51.86	24.9	B	0
14	S81007	ASANGAON to	DO	07:20	19.9	25	31	616.9	4757	119	4876	4072	33350	14.26	6.6	C	0
15	S81008	TEMBARA to	DO	08:11	19.9	25	27	537.3	15841	9	15850	13247	29150	54.34	24.65	C	0
16	S81009	ASANGAON to	DO	09:00	15.7	20	14	219.8	2029	31	2060	1715	12140	16.71	7.8	C	0
17	S81010	NEHAROLI to	DO	09:40	13	15	13	169	5814	5	5819	4888	8415	69.09	28.92	B	0
18	S81011	ASANGAON to	DO	10:20	19.9	25	24	477.6	9636	204	9840	8263	25950	37.13	17.3	C	0
19	S81012	TEMBARA to	DO	11:15	17.2	20	24	412.8	11177	15	11192	9332	20540	54.42	22.61	C	0
20	S81013	SHAHAPUR to	DO	13:30	24.1	30	29	698.9	15942	39	15981	13329	35880	44.43	19.07	C	0
21	S81014	KRISHNACHI WADI to	DO	14:30	24.1	30	29	698.9	11902	14	11916	9929	35430	33.59	14.21	C	0
22	S81015	SHAHAPUR to	DO	15:30	27.7	35	3	83.1	287	0	287	237	4445	6.46	2.85	C	0
23	S81016	KINHAVALI to	DO	16:40	27.7	35	4	110.8	2450	5	2455	2034	6125	40	18.36	C	0
24	S81017	SHAHAPUR to	DO	18:15	17.2	20	29	498.8	13215	3	13218	11027	23620	55.95	22.11	C	0
25	S81018	TEMBARA to	DO	19:00	17.2	20	29	498.8	4526	14	4540	3758	23700	19.1	7.53	C	0
26	S81019	SHAHAPUR to	DO	20:15	24.1	30	30	723	15739	13	15752	13084	36750	42.83	18.1	C	0
27	S81020	KRISHNACHI WADI to	DO	05:45	28	35	31	868	14967	15	14982	12494	44800	33.41	14.39	C	0
28	S81021	ASANGAON to	DO	06:50	42.3	50	30	1269	21855	71	21926	18207	60500	36.12	14.35	C	0
29	S81022	CHONDHA to	DO	08:45	42.3	50	30	1269	45239	9	45248	38100	61250	73.86	30.02	B	0
30	S81023	ASANGAON to	DO	10:05	2.7	10	2	5.4	0	0	0	0	830	0	0	C	0
31	S81025	SHAHAPUR to	DO	12:30	39.1	50	28	1094.8	28512	10	28522	23972	59850	47.64	21.9	C	0
32	S81026	DEHANE to	DO	14:00	39.1	50	28	1094.8	19422	17	19439	16206	59900	32.42	14.8	C	0
33	S81027	SHAHAPUR to	DO	16:20	18.8	25	30	564	12341	22	12363	10455	32125	38.42	18.54	C	0
34	S81028	BHATSA COLONY to	DO	17:10	21.5	30	31	666.5	11506	40	11546	9609	40020	28.75	14.42	C	0
35	S81030	ASANGAON to	DO	18:45	36.8	45	31	1140.8	32072	4	32076	26560	59805	53.63	23.28	C	0
36	S81031	KHARANGAN to	DO	05:30	36.8	45	31	1140.8	24477	149	24626	20464	59580	41.08	17.94	C	0
37	S81032	ASANGAON to	DO	06:55	2.7	10	27	72.9	857	82	939	790	11520	7.43	10.03	C	

Figure 2.9: Sample ABC dataset for the month of July

ABC data is of two types, with and without concession. ETIM/ABC data by Trimax does not have concession data as shown in fig 2.10. Types of concessions include Sr. citizen, Ahiliyabai (female students from 5th to 12 class, issued by and data provided by teachers), student pass etc. To determine the concession data, two surveys are performed, in July and November. These surveys find the number of students/concession pass holders and their timings for trips. If this concession data is added, then EPKM increases(along with load factor). Thus, the ABC status may also change as shown in fig 2.11. [VOC - Value Of Concession]

Maharashtra State Road Transport Corporation
Division Name : NASIK   Depot Name : SINNAR
Run Date : 02-07-2019   Run Time : 10:03:32
Account Head-Wise Concession Report For Route Mofussil For Month June 2019

Account Headwise Reimbursable Concessions (At actuals)

Account Head	Concession Type	Conn Code	Conn Rate %	No Of Psgrs	Actual Fare Recovere (A)	Fare	Reimb. Amount (B)	Total Amount (A+B)
111-A	T B PATIENT	TP	75.00	1	37.25	9	28	37
111-B	CANCER PATIENT	CP	75.00	34	1862.51	491	1395	1886
111-C	STUDENT ATTENDING	STE	50.00	9	1881.13	941	941	1882
111-D	STUDENT VISIT T	STF	50.00				0	
111-E	SICK STUDENT VISI	STS	50.00	1	268.2	134	134	268
111-F	STUDENT VISIT AT	ST	50.00	31	6045.45	3029	3029	6058
111-G	SR. CITIZEN	CT	50.00	174341	5275497.5800008	2610160	2610160	5
220320								
113-A	Sr. Citizens Shiv	CT	45.00				0	
113-B	Sr. Citizens Shiv	CT	30.00				0	0
111-H	BLIND ESCORT	BE	50.00	84	5164.66	2576	2576	0
113-G	Blind Escort Shiv	BE	45.00				0	5152
111-HW	HANDICAPPED EXEMP	HBW	100.00				0	0
113-G	Handicapped / Men	HE	45.00				0	0
111-I	HANDICAPPED / MEN	HE	50.00	272	12847.85	6423	6423	0
111-J	SPORT PERSON FOR	SG	33.33				0	12846
113-F	Blind Shivshahi S	BL	70.00				0	0
111-P	BLIND	BL	75.00	697	29972.28	7718	22540	0
111-Q	HANDICAPPED / MEN	HD	75.00	9936	422572.93000001	109394	109394	30258
426088								317494
113-F	Handicapped / Men	HD	70.00				0	
111-R	LEPROSY PATIENT	LP	75.00	1	37.25	9	28	0
111-Y	RESCUE HOME CHILD	RH	66.66				0	32
113-C	SICKLE CELL PATIE	SNH	100.00				0	0
113-D	RASHRAPITA MAHATM	RMG	100.00				0	0
113-E	KAUSHALYA SETU AB	KSA	66.67				0	0
113-H	HEMOPHILIA PATIEN	HOP	100.00				0	0
113-I	DURDHAR AAJAR PAT	HIV	100.00				0	0
113-J	DIALYSIS PATIENT	DLY	100.00	1	104.3	0	104	0
F	MLA / MLC / EX ML	VIP	100.00				0	104
G	PRESS REPORTER	PP	100.00	12	904.45	0	904	0
H	STUDENT ATTENDING	STC	50.00				0	904
I	SPORT - EDU TOURM	SE	50.00	8	1330.4	642	642	0
								1284
	Total				185028 5758526.2400000	2741524		2966400 5
707726								

Figure 2.10: ABC data at sinner depot

2.2.5.1 EPKM

EPKM is Earning Per Kilometer. This is one of the metrices used by MSRTC to see if a trip is profitable or not.

$$EPKM = \frac{passenger\ earning}{kms} \tag{2.1}$$

17

Figure 2.11: ABC data after adding VOC at sinner depot

2.2.5.2 Load Factor

Load Factor is the approximation of the people travelling in the bus. It is calculated as:

$$Load\ Factor\% = \frac{EPKM}{ExpectedRate} \tag{2.2}$$

Chapter 3

Creation of GIS based visual route information system for MSRTC

A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. GIS can be used to show things like spread of a disease, routes with information regarding hospitals and schools, etc.

In our case, Digital geography is going to be the mapping of MSRTC operational data on GIS-based graphical interface. For creating Digital Geography, data structure concepts of graph theory will be used.

In current systems used by MSRTC, the GIS data is not incuded in the operational data. Datasheets like ABC are created in excel and analysed manually, which wastes manpower and time, plus lacks the visual insights. These insights can be explored if we use digital geography.

3.1   What is Digital Geography?

A *digital geography* is an undirected, planar graph **G= (V, E)** Kulkarni (2018) where:

V is a set of vertices.

E is a set of edges.

3.1.0.1   Properties of a Vertex

property 1: Each vertex is a Point geometry.

property 2: Each vertex has a latitude and longitude.

property 3: A vertex may have an attribute as school, market place, hospital etc.

3.1.1   Properties of an Edge

property 1: Each edge is a Polyline geometry.

property 2: Each edge e is an ordered set of vertices (v_i, v_j) such that v_i and $v_j \varepsilon V$.

property 3: An edge cannot have intermediate points belonging to V.

property 4: An edge subsequently can have further attributes like type of road, length of the edge, traffic on the edge, profitability of the edge etc.

3.1.2   Route-segment

A route segment RS_i is a path between two termini. It is an ordered set of edges as shown in 3.1. i.e.

$$RS_i = E_{i1}, E_{i2}, E_{i3}..E_{in} \qquad (3.1)$$
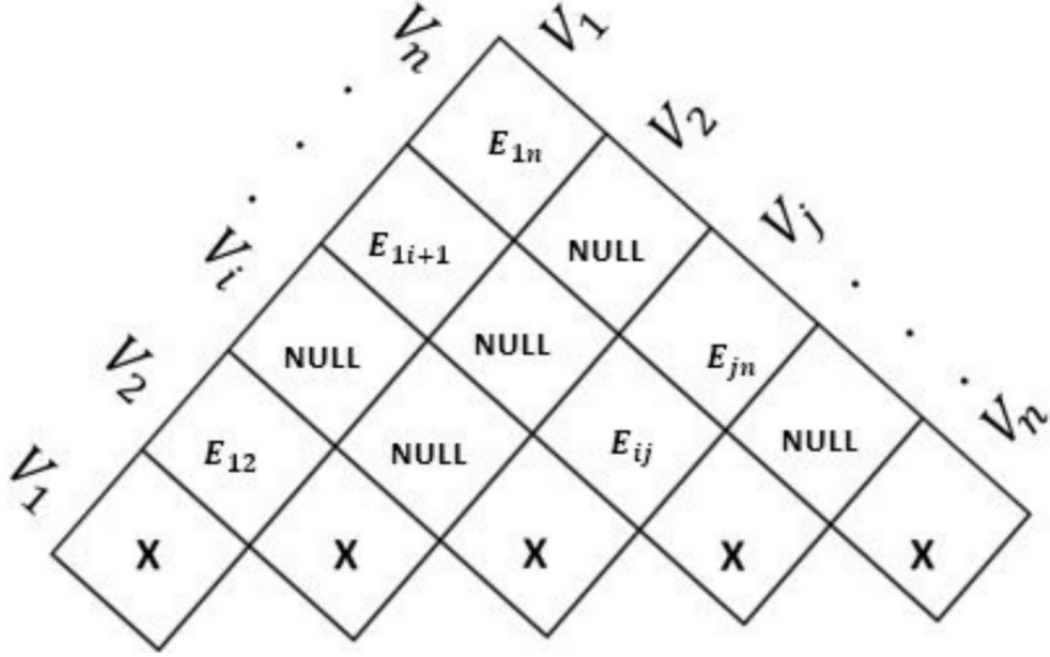
Figure 3.1: Schematic of Digital Geography

where, n= number of edges in RS_i

and $E_{i1}, E_{i2}, E_{i3}..E_{in} \varepsilon E$

$$E = RS_1 RS_2 RS_i..RS_m \qquad (3.2)$$

where, *m= number of Route segments in RS*

3.2 Earlier work

Previously, the list of all bus stands present in shahapur were manually searched on Google API
Kulkarni (2018) and noted down as shown in 3.2. They were plotted on the shahapur in QGIS
and projected on the roads to create Digital Geography of Shahapur taluka as shown in 3.3.

Figure 3.2: Manually generated Bus Stops

3.3 Generation of latitude and longitude of the bus stops

One of the important problems encountered while data collection for GIS visualization of the MSRTC services is the lack of coordinates for the bus stands, i.e. the MSRTC does not have the GPS location data of the bus stands for Shahapur (till Feb 2020). Previously, this work was done manually. We referenced an automation code to take the bus stop name and find the coordinates corresponding to that name inside Maharashtra.

Getting the data from the bus stand codes and names becomes tricky due to the ambiguity in the names.

The MSRTC data is messy. The bus stand names are non definitive and ambiguous. There is no proper distinction globally, or even locally that can identify the bus stops without the reference of the route they are on. For instance, one bus stand is named petrol pump, which without the initial route detail is not enough to identify the bus location. To position such a bus stand without any address, it becomes even more difficult.

Similarly, there are multiple villages with the name kinhavali in Maharashtra, it is difficult to find which kinhavali unless the route is mentioned in 3.4. But the initial approx GIS location

22
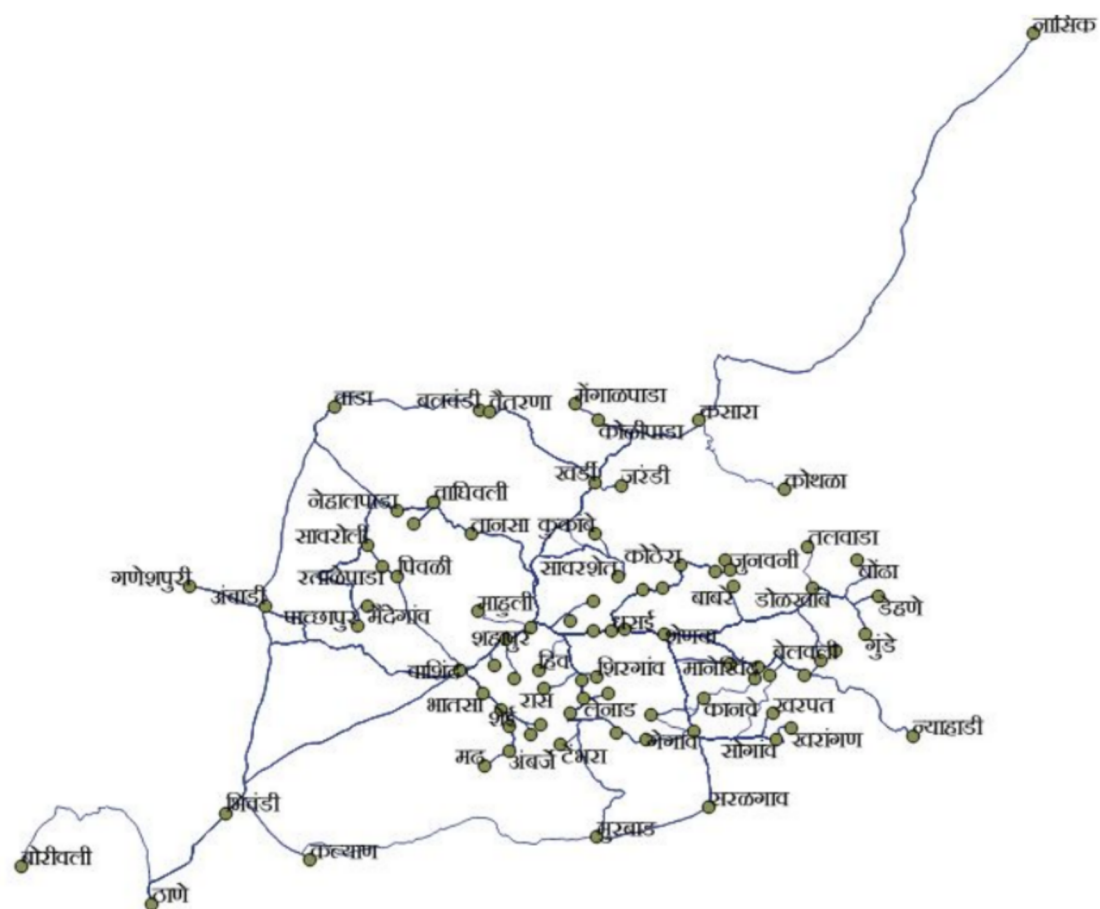
Figure 3.3: Generated Shapefile of the route segments
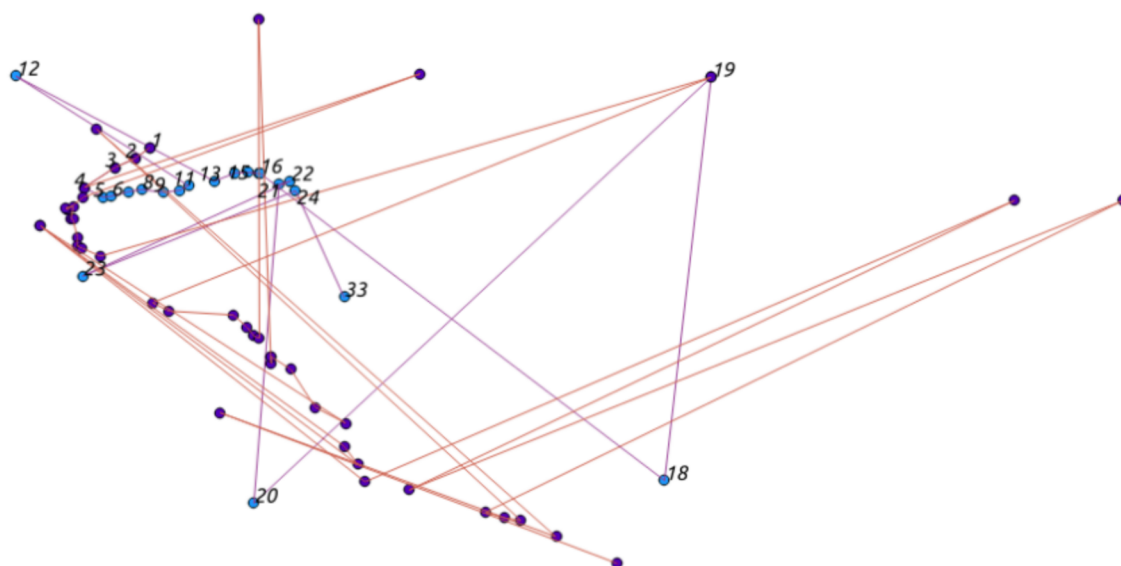
Figure 3.4: Automatic generation of latitude and longitude

of each bus stand was route independent.
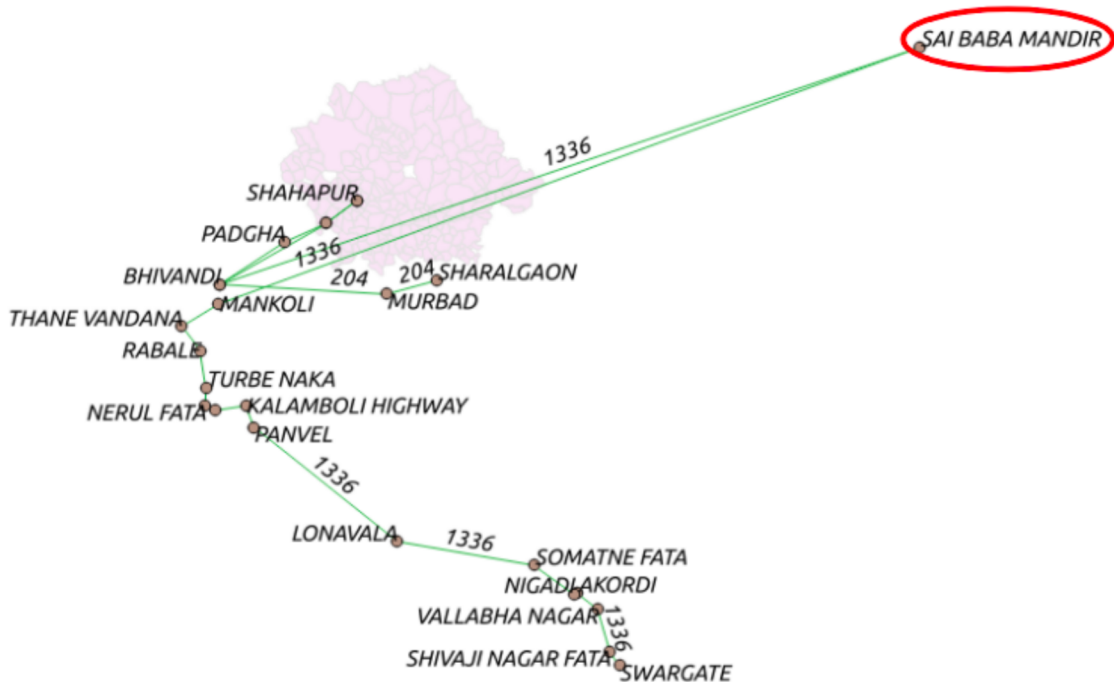
Figure 3.5: Correction in automatic generation of latitude and longitude

To correct this, we made an algorithm which checked the is the GIS data searched through the automatically allotted GPS locations and corrected (if possible) or removed the locations which seemed to not be on the path as shown in 3.5. This was done on the following premises:

1. The latitude and longitude of Shahapur bus stand is correct.

2. The next correct bus stop will be within 2 times the distance as given in the master file. This bus stop distance will be in reference to the last correct bus stop found on that route.

As we can see, even after improving the data by location, there seems to be some errors present. Applying this algorithm on every route would have been tedious and computationally expensive, without any assurance that the data we had gathered would have been correct or not. Using this inaccurate data would have been futile, hence this algorithm was discarded.

Chapter 4

Operational Analysis of Taluka Bus Depots

4.1 Coverage

4.1.1 Shahapur

Shahapur taluka is one of the 7 talukas in Thane district. It has the a total population of **309653** in the approximate area covered $1696.75 Km^2$.

The population covered by MSRTC bus network is **268626** which is **86.75%** of the total population. The area covered by State Transportation bus network is **1300.71** Km^2, covering **76.65%** of the total Shahapur taluka area as shown in 4.1Kulkarni (2018).
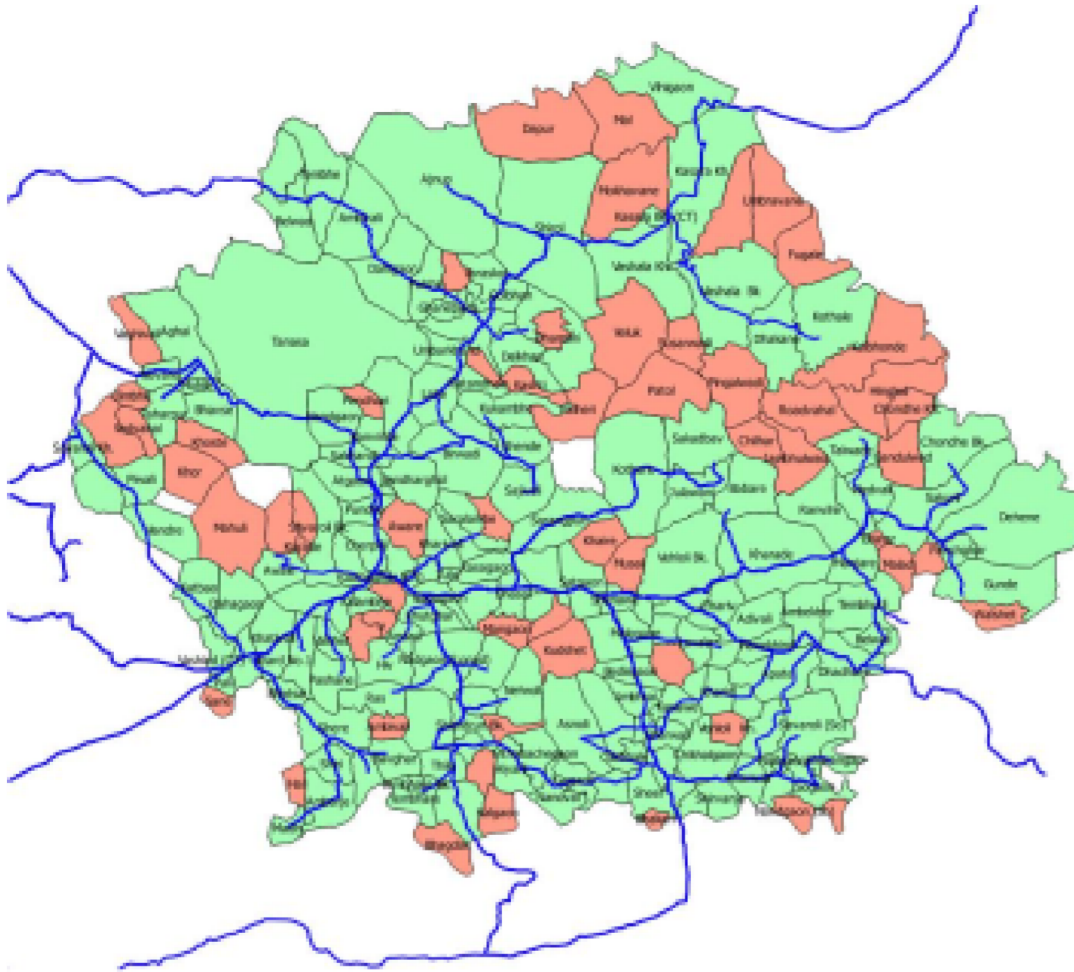
Figure 4.1: Coverage by bus Transportation in Shahapur Taluka

4.1.2 Sinnar

Sinnar taluka is among the 15 talukas of Nashik district. It has the total opulation of **65,299** in the approximate area covered $195 Km^2$.

4.2 Demographics and Transportation

In 4.2, equal quantile count method was used in QGIS to show the population density distribution in Shahapur. Where there were local stations, like *Vashind, Kasara bk., Asangaon* the population density was high. Similarly, *Kinhavali, Dolkhamb, Lenad* was another set of high population density area. The Upper area of Shahapur may be sparsely populated due to it being
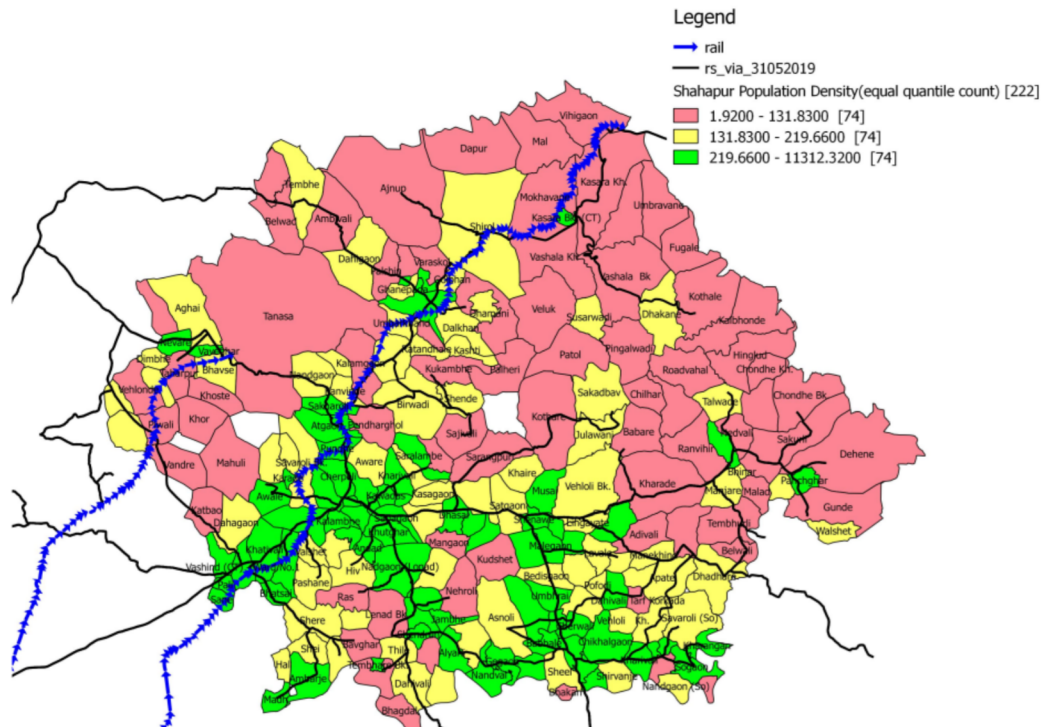
Figure 4.2: Trends of Population Density in Shahapur Taluka

a hilly terrain, when compared to the flat terrain of lower Shahapur.

When it comes to the demand of the routes, maximum population demand routes are Shahapur-Kasara, Shahapur-Nashik, Bhatasa-Khardi etc. All these routes originate in Shahapur Taluka. If Population demand per kilometer is considered, the routes change.

4.3 Punctuality Analysis

A system is reliable if all its components are functioning according to the schedule. Once cracks appear in the system, it is hard to maintain the reliability of the system. As buses are an economical option for the majority of population, it is essential for the services to be on time for smooth functioning of society.

During the survey and from the issued tickets(ETIM data), it was observed that buses are late quite often. This results in other services like servicemen of PHCs or local industries being late, or school children being late due to *manav-vikas* buses.

To account for real life issues, we have taken an error margin of 20 minutes was taken for bus arrival time analysis. If a bus exceeded this interval, it was considered late.

4.3.1 Methodology

SQL queries were used to observe these anomalies, on the pgAdmin Database by using ABC and ETIM datasets.

1. Mapped ABC trips with ETIM trips, by using the trip number attribute.

2. The departure time of the trip as given in ABC data set was compared with the first ticket issued time in ETIM data set (there is no attribute determining the start of a trip, so this is an assumption we have considered). These timings were mapped considering a buffer of 10 minutes.

3. After mapping, with the assumed trip start time and actual departure time, we can determine if a bus started on-time, was late, early or cancelled for that day.

4. The trip status can be described as follows:

    (a) **as scheduled** (started within 10 mins)

    If a trip's first ticket is issued within 10 minutes of its scheduled departure time, it is called to be as scheduled.

    (b) **as scheduled** (started within 10-20 mins)

    If a trip's first ticket is issued within 10-20 minutes of its scheduled departure time, it is called to be as scheduled.

    (c) **early**

    If a trip's first ticket is issued before its scheduled departure time, within the range of 20 minutes to 1 hour, the trip is called to be early.

    (d) **late**

    If a trip's first ticket is issued after its scheduled departure tim $7479\ 507^5 7 ding busstop) for the month of$

i. 65% of the total trips were on time or as per the schedule, out of which 45% trips started within a span of 10 minutes.

ii. For some reason, the punctuality is higher for trips going out of Shahapur (i.e. 53%) when compared with the trips coming to Shahapur (47%).

The cancelled trips should be announced for the ease of passengers. The punctuality should be observed monthly and future trips should be updated according to the performance of the trips by MSRTC.

4.4 Consistency

A route is said to be **consistent**, if the tickets are issued for only those bus stops which are mentioned in the route master file Website MSRTC ppt (2019). Sometimes tickets are issued on the stops which are not mentioned in that route's master file, such routes are called inconsistent routes.

Consistency checking is checking the percentage of tickets which were issued on the bus stops already stated in the master file Website MSRTC ppt (2019). Consistency checking is necessary because the bus stop on which the tickets were issued might not be in the master data (i.e. not an official stop for that route), but the bus driver stopped the bus on that stop or the bus stop might be in the official route (ETIM machine could generate a ticket to that stop), but was not stored in the master data.

Consistency checking is essential to maintain the coherency of the MSRTC datasets.

4.4.1 Methodology

SQL queries were used to observe these anomalies, on the pgAdmin Database by using master route and ETIM datasets.

i. Master and ETIM data mapped via the attribute route number.

ii. Collect the information of all the bus stops in the ETIM data for a particular route.

iii. The bus stops present in ETIM are compared with the bus stops in master data

for a particular route number.

iv. If both the list of bus stops match, it is called a consistent route.

v. If there is some extra bus stop left in master data, it is still called as a consistent route, as no bus ticket might have been issued for that particular bus stop for that particular route.

vi. If a ticket was issued on such a stop (in the ETIM data) which does not exists in the master data for that route, then that route is called **Inconsistent route**.

4.4.2 Reasons for Inconsistency

i. The bus stop on which the tickets were issued might not be in the master data (i.e. Not an official stop for that route), but the bus driver stopped the bus there Website MSRTC ppt (2019).

ii. The bus stop might be in the official route because then only the ETIM machine could generate a ticket to that stop, but was not stored in the master data Website MSRTC ppt (2019).

4.4.3 Results

- For Shahapur:
  - For the month of July, 2019, buses ran on 265 routes. Among them, 66 routes were not consistent routes.
  - Thus, approximately 75% of the routes are consistent routes for the month of July.
  - Buses stopped up to 5 such stops where the bus stops were not present in the route as shown in fig 4.3.
- For Sinnar:
  - For the month of July, 2019, buses ran on 228 routes. Among them, 19 routes were not consistent routes.
  - Thus, approximately 91% of the routes are consistent routes for the month

of July.

– Buses stopped up to 15 such stops where the bus stops were not present in the route as shown in fig 4.4.

route_no	no_bus_stops_etim	no_bus_stops_master	bus_stops_etim_not_in_master	no_bus_stops_etim_not_in_master
17527	19	20	{'SPDAE', 'CGHAPD', 'KMBAM', 'SLLIFT', 'KUGR'}	5
18344	15	18	{'SHEVA', 'MLGST', 'UMARAI', 'STHGN', 'SHST'}	5
65117	23	25	{'BVD', 'KBF', 'LALAFT', 'SBMD', 'RABP'}	5
3856	17	17	{'SLLIFT', 'CNWDI', 'DAAIFT', 'KUGR'}	4
3891	20	32	{'NSKCBS', 'KHRDI', 'PNDRGLT', 'BHGTWDT'}	4
13159	24	33	{'RAHD', 'BHGTWDT', 'PWRHOS', 'VINLI'}	4
107950	22	34	{'ATGO', 'ZDGA', 'VDLB', 'OZR'}	4
203	41	44	{'LONADPS', 'SWR', 'VBLN'}	3
3905	11	11	{'KOLIPDBT', 'UMEM', 'AJNP'}	3
16555	11	11	{'GLBHNBT', 'VACA', 'AHAMBT'}	3
17520	13	19	{'NSKCBS', 'WDVRE', 'GNDE'}	3
42722	21	21	{'OAGNN', 'ZDGA', 'VASD'}	3
44351	24	30	{'ARVIDD', 'SONNE', 'DHL'}	3
102169	27	44	{'KSBSST', 'ATGO', 'RAHD'}	3
1341	38	41	{'NGDH', 'NIRA'}	2
3606	5	11	{'RBP', 'SBBA'}	2
3865	26	25	{'MNJRA', 'DOKMB'}	2
3877	8	8	{'BHATPAD', 'LNADBD'}	2
3878	8	8	{'LNADKH', 'BHATPAD'}	2
12712	7	7	{'BHATPAD', 'LNADBD'}	2
12713	6	6	{'LNADKH', 'BHATPAD'}	2
12714	8	8	{'SNRN', 'BHATPAD'}	2
12728	10	10	{'ABAKAR', 'KUGR'}	2
13127	11	11	{'ABAKAR', 'KUGR'}	2
17531	12	12	{'SNRN', 'BHATPAD'}	2
29897	15	15	{'SPDAE', 'BDSGN'}	2
46964	12	12	{'SNRN', 'BHATPAD'}	2
92601	13	13	{'NYPD', 'KINV'}	2

Figure 4.3: Shahapur: Inconsistent routes with extra stops not present in the master data

route_no	no_bus_stops_etim	no_bus_stops_master	bus_stops_etim_not_in_master	no_bus_stops_etim_not_in_master
1470	22	85	{'SNGR', 'GHRO', 'DBD', 'NRYGN', 'BHSRI', 'NSKFT', 'NSKO', 'SNNR', 'NAEE', 'NWCBS', 'NSKOLD', 'ALPT', 'SMR', 'BOTA', 'RJGR'}	15
1143	22	26	{'MCR', 'GHRO', 'SGFTFT', 'NRYGN', 'NSKFT', 'NAEE', 'SNMNBP', 'NSKOLD', 'NSKRD', 'SMR', 'RJGR'}	11
77716	26	31	{'AJINRA', 'MEVN', 'CHOFS', 'KADIBD', 'ZGDEFT', 'NSKMRG'}	6
1511	22	22	{'LONIRA', 'KLHARAK'}	2
1514	21	22	{'LONIRA', 'KLHARAK'}	2
2725	30	30	{'MLANF', 'MSLSN'}	2
7116	12	13	{'DNASN', 'CHASSN'}	2
37252	11	12	{'BBAMNN', 'TKDSN'}	2
87222	29	30	{'NNDT', 'JMHEBRJ'}	2
1155	30	36	{'MRJN'}	1
2130	30	31	{'KUNW'}	1
2197	8	20	{'ITBS'}	1
7172	12	12	{'KWDRS'}	1
7174	14	14	{'PGLWDTNK'}	1
18701	18	18	{'SNNR'}	1
81293	31	30	{'SOTDABBE'}	1
88405	9	14	{'KABSN'}	1
91151	15	15	{'KWDRS'}	1
104994	23	24	{'KRGS'}	1

Figure 4.4: Sinnar: Inconsistent routes with extra stops not present in the master data

Resolutions for Inconsistency:

i. The bus stop should be permanently added to the master data, if the number of tickets issued are particularly high for this stop for that route across the month.
For Example: For route 3906(Shahapur- Mahuli), Asangaon Fata was added as

31

stop sequence number 2, when we analysed other routes which have Shahapur and Asangaon as consecutive bus stops Website MSRTC ppt (2019).

ii. If the number of tickets issued is low, we can ignore the tickets issued on that bus stop, as it might be an uncommon event.

4.5   Ridership

Ridership defines at a time how many passengers are travelling in a bus between consecutive stops. For example, figure 4.5 shows Ridership on 3rd July, 2019 for a trip 00S81428 on route SHAHAPUR-MAHULI.
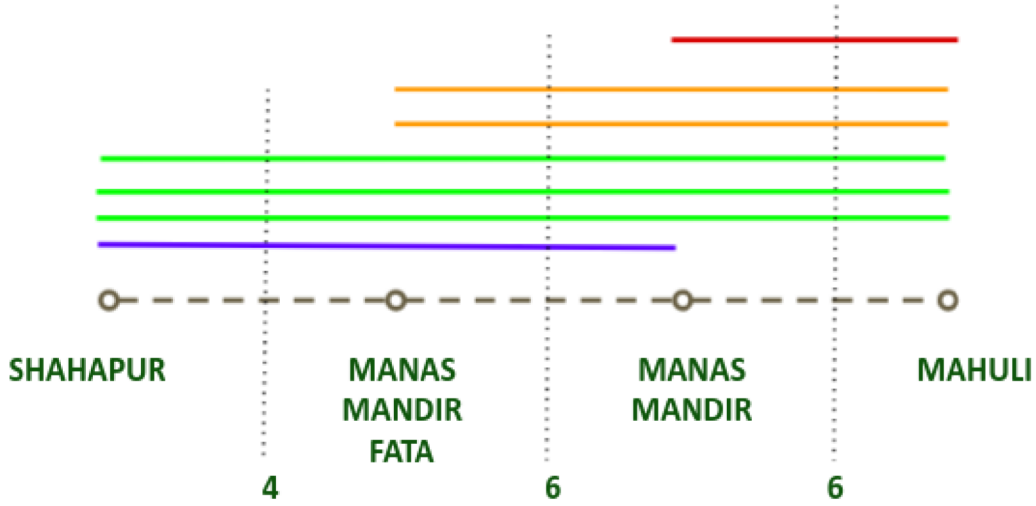
Figure 4.5: Ridership on 3rd July, 2019 for a trip 00S81428 on route SHAHAPUR-MAHULI

- **Weighted avg ridership** - The weighted average ridership calculated with distance as weights across all the month.

$$ridership_{weighted-avg} = \Sigma(ridership_{ij} * distance_{ij})/distance_{ij}, \qquad (4.1)$$

where i, j are two bus stops in the route, and i comes before j

- **Max ridership** - the maximum ridership observed across the entire month.

- **Standard deviation (σ)** - The standard deviation across the weighted average ridership per day across the entire month.

32

- P_1 **ridership** - Expected number of people (with 82% probability, mean + 1σ (std dev), according to Gaussian distribution) when compared to the seating capacity of the bus.

- P_2 **ridership** - Expected number of people (with 97.5% probability, mean + 2σ (std dev), according to Gaussian distribution) who will be in the bus when the seating capacity is exceeded.

- **Utilization** - Categorization on the basis of what percentage of bus was occupied:

  - α : P_1 ridership >=80% capacity

  - β : 50%<= P_1 ridership < 80%

  - γ : P_1 ridership < 50%

route_no	trip_no	max_ridership	weighted_avg_ridership	std_dev	P1 ridership	P2 ridership	dept_time	from_cd	till_cd	kilometer	abc_status	utilization
205	000M4971	61	18.19	6.60	24.79	31.38	8:50:00	SHAHAPUR	SWARGATE	212.1	B	β
65117	000M4972	49	10.36	6.55	16.92	23.47	17:00:00	SWARGATE	SHAHAPUR	211.1	C	γ
3906	00S81665	4	1.74	1.19	2.93	4.13	6:00:00	SHAHAPUR	MAHULI	9	C	γ
3906	00S81428	22	9.20	4.07	13.27	17.33	8:00:00	SHAHAPUR	MAHULI	9	C	γ
3906	00S81433	71	17.99	13.86	31.85	45.71	10:20:00	SHAHAPUR	MAHULI	9	C	β
3906	00S81435	33	17.89	7.49	25.38	32.86	11:20:00	SHAHAPUR	MAHULI	9	C	β
3906	00S81437	66	35.00	15.56	50.55	66.11	12:40:00	SHAHAPUR	MAHULI	9	B	α
3906	00S81439	51	26.20	11.47	37.67	49.14	14:15:00	SHAHAPUR	MAHULI	9	C	α
3906	00S81720	42	23.05	8.40	31.45	39.85	16:30:00	SHAHAPUR	MAHULI	9	C	β
3906	00S81448	33	19.01	7.82	26.83	34.65	18:05:00	SHAHAPUR	MAHULI	9	C	β
16567	00S81427	35	17.12	9.49	26.61	36.09	6:40:00	MAHULI	SHAHAPUR	9	C	β
16567	00S81429	87	44.30	17.21	61.51	78.72	8:35:00	MAHULI	SHAHAPUR	9	B	α
16567	00S81434	61	30.62	14.57	45.19	59.75	10:45:00	MAHULI	SHAHAPUR	9	B	α
16567	00S81436	29	9.70	7.46	17.16	24.62	12:00:00	MAHULI	SHAHAPUR	9	C	γ
16567	00S81438	20	9.60	5.01	14.61	19.62	13:15:00	MAHULI	SHAHAPUR	9	C	γ
16567	00S81440	32	13.64	6.98	20.62	27.61	14:50:00	MAHULI	SHAHAPUR	9	C	γ
16567	00S81446	67	12.12	17.62	29.74	47.36	17:05:00	MAHULI	SHAHAPUR	9	C	β
16567	00S81721	25	5.79	5.92	11.71	17.63	18:40:00	MAHULI	SHAHAPUR	9	C	γ

Figure 4.6: Final Ridership analysis for Shahapur

For instance, as we can see in the following table 4.6 we can see that out of 14 trips which ran across the month, 4 were categorized as gamma. As a suggestion, mini buses can be run on these trips with low load.

4.6 Traffic Analysis

An example route from Shahapur to Mahuli along with its return trips for an entire month was observed in 4.7. Initial trip from Shahapur to Mahuli almost ran empty because it was an operational trip, i.e. started off from Shahapur. Such observation can be made for multiple
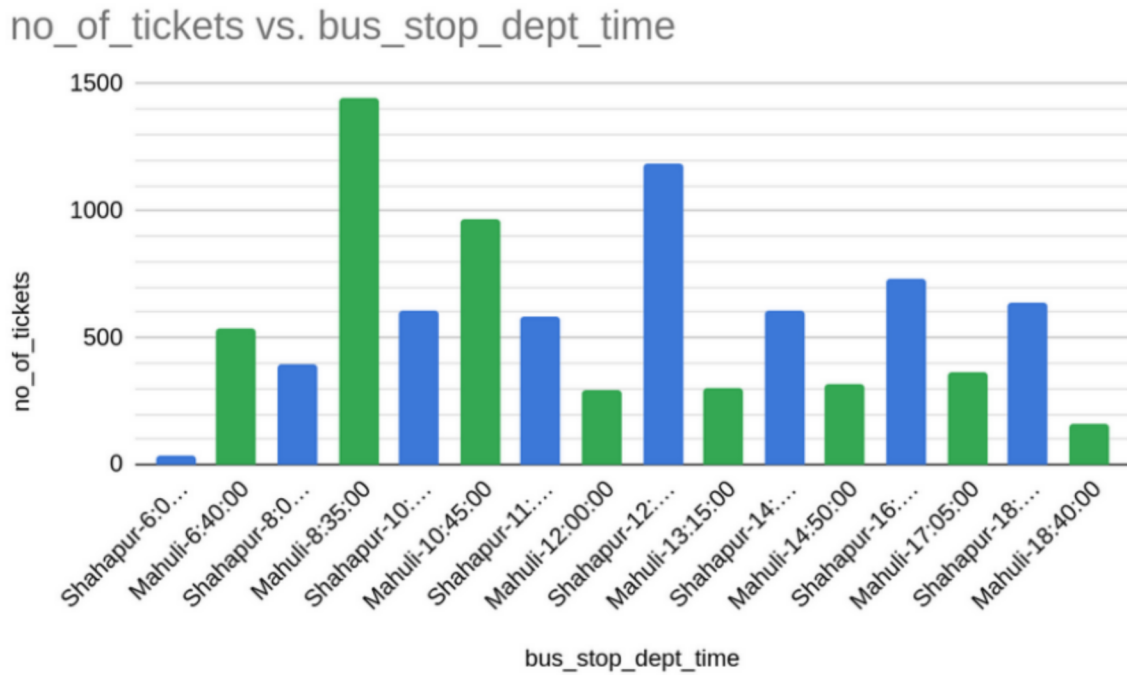
Figure 4.7: Ticket Issue Pattern for different timings of a day

trips and the trips which are not beneficial can be removed. These observations should be done before creation of new time tables.
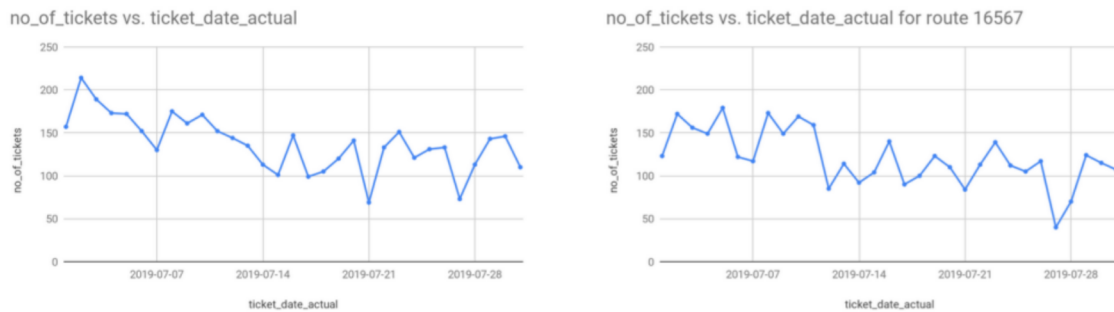
Figure 4.8: Tickets issued on all trips per day across a month for Shahapur-Mahuli route

Also, it can be observed in 4.8 that weekends have less amount of traffic on the same route. Hence less number of trips can be run on weekends and the profitable long route trips can be run from the same buses on weekends instead.

Another example can be taken for the route from Sinnar to Saikheda (route no 37263-37264). Again, it can be observed while Sinnar to Siakheda has lower number of people travelling on weekends, no such pattern is reflected in Saikheda to Sinnar route.
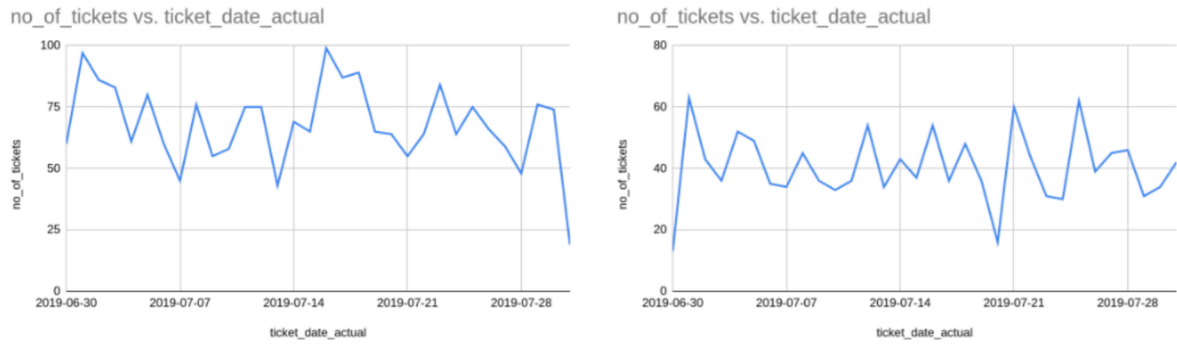
Figure 4.9: Tickets issued on all trips per day across a month for Sinnar-Saikheda route

4.7   Issues to be addressed

i. Master data is not synchronous with ETIM data. For instance, for the month of July, 2019 for sinnar taluka, ETIM data has 228 unique routes, out of which the following 12 routes in table 4.1 are not present in the master data of Nashik, i.e. 3.28% of the ETIM routes are inconsistent with the master data.

route_no
52495
1383
41718
42135
75091
75092
4891
50842
37625
42136
75085
7576

Table 4.1: ETIM routes not in Master data for sinnar

Similarly, for Shahapur taluka, for the month of July, 2019, ETIM has 274

unique routes, out of which the following 9 routes in table 4.2 are not present in the master data of Thane, i.e. 5.26% of the ETIM routes are inconsistent with the master data.

route_no
1510
3057
1401
375
1880
1878
2129
2724
7646

Table 4.2: ETIM routes not in Master data for Shahapur

ii. ABC data is not synchronous with ETIM data. For instance, for the month of July, 2019 for sinnar taluka, ABC data has 716 trips, out of which following 36 trips in table 4.3 are not in ETIM data. Hence, 5.03% of the ABC trips are not represented in ETIM data.

trip_no_abc
00M10080
0S224823
0S224826
0S224828
0S224832
0S224847
0S224849
0S224851
0S224858
0S224860

0S228004
0S228084
0S228116
0S228406
0S228408
0S228427
0S228428
0S228430
0S228431
0S228527
0S228569
0S228591
0S228699
0S228714
0S228715
0S228726
0S228742
0S228774
0S228789
0S228862
0S228863
0S228869
0S228900
0S228903
0S228956
0S279650

Table 4.3: ABC trips not in ETIM data for sinnar

Similarly, for Shahapur taluka, for the month of July, 2019, ABC data has 511 trips, out of which the following 3 trips in table 4.4 are not in ETIM data. Hence, 0.5% of the ABC trips are not represented in ETIM data.

trip_no_abc
00S81267
00S81583
00S81966

Table 4.4: ABC trips not in ETIM data for Shahapur

iii. ETIM data is not synchronous with the Master data. For instance, for the month of July, 2019 for sinnar taluka, ETIM has 695 unique regular(non extra trips), out of which the following 15 trips in table 4.5 are not in ABC data, i.e. 2.16% of the ETIM trips are not present in the ABC data.

trip_no_etim
0S228208
0S228092
0S228096
0S224883
0S228035
0S228048
0S228753
0S228510
0S228040
0S224886
0S224887
S22909001
0S228352
0S228811
0S228349

Table 4.5: ETIM trips not in ABC data for sinnar

iv. Form 4 data is not synchronous with any other data.

v. We do not have a way to confirm if a bus ran empty or the trip did not run at all on a day through ETIM data.

vi. Some trips are starting before the start time as and when compared with ABC data.

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Chapter 5

Covid-19 work

On March 11th, 2020, the World Health Organization (WHO) declared a novel coronavirus outbreak a global pandemic D and M. (2020).

Ministry of Health & Family Welfare released some guidelines on the proper healthcare for covid-19 casesWebsite Guidance Document (2020). To prepare for such times of difficulty and to ensure that even people of rural Maharashtra got proper healthcare in times of need, we started planning a course of action.

Objective: Create a timetable for scheduling the buses so that the people can visit the nearest PHC in case of medical issue during COVID-19 breakout.

5.1 Shahapur

As we do not have the GIS data for Shahapur, the next best approach, string matching for bus stops, was selected. There were 7 PHCs in Shahapur Website Arogya (2020), as shown in 5.1.

Figure 5.1: Public Health Centers in Shahapur taluka

5.1.1   Methodology 1 : assigning routes on the basis of villages covered

    i. Find out the active routes first, by combining ETIM, ABC and master data.

    ii. Find out all the villages that need to be covered by each PHC.

    iii. Select the routes which have PHC names (name of the PHC village) in their bus stops. Select the route with the maximum coverage of the list of the villages allocated to each PHC.

    iv. A route is considered if it has a PHC village as a bus stop. The route matching percentage with the list of all the villages that need to be covered by a PHC is checked. The route with the highest matching is selected on that basis. It is selected iff it has at least one village on route which was not covered by any other route before

This method is not efficient, as it covers only 9.35% of the total bus stands(although 26.94% villages were covered). Hence, it can not be expected that a large number of villages were

42

covered by this method.

5.1.2 Methodology 2: assigning routes on the basis of bus stands covered

    i. Find out the active routes first, by combining ETIM, ABC and master data.

    ii. From ETIM, find out all the list of bus stands that need to be covered (i.e. a ticket was issued on them)

    iii. A route is considered if it has a PHC village as a bus stop. The route matching percentage with the list of all the bus stops is checked. The route with the highest matching is selected on that basis.

    iv. Repeat till all the covered bus stops are exhausted in a mutually exclusive manner, i.e. at least one route has a bus stop which was not previously covered by any other routers.

Efficiency : 36%, still not effective enough to cover sufficient number of bus stands.

5.1.3 Methodology 3 : assigning routes on the basis of bus stands covered (1 hop coverage)

    i. Find out the active routes first, by combining ETIM, ABC and master data.

    ii. From ETIM, find out all the list of bus stands that need to be covered (i.e. a ticket was issued on them)

    iii. Select one main route for each PHC based on the PHC name (on the basis of maximum matching).

    iv. A route is considered if it has an intersecting bus stop with some route previously selected PHC route. The route matching percentage with the list of all the bus stops is checked. The route with the highest matching is selected on that basis.

    v. This process is repeated till maximum number of bus stops are covered (there is no new route left which has one more bus stop which was previously not included)

Problem with this data: majority of the intersecting routes which are selected are selected based on a single PHC (AGHAI) as you can see in 5.2. Also, for 90% coverage, >50 buses are required.

	route_no	from_cd	till_cd	percentage_match	phc_name	bus_stops_included	new_bus_stops	intersecting_bus_stops	intersecting_route
2	3865	ASANGAON	NEHADI	3.921569	AGHAI	TEMBHURLI, KHUTAL, NEHADI, SHIROSHI, PHANGLOSH...	10	TEMBHURLI	108898
3	3877	ASANGAON	GOKULGAON	0.784314	AGHAI	LENAD KHURD, GOKULGAON, BHATPADA	2	BHATPADA	124521
4	3878	ASANGAON	NEHAROLI	0.392157	AGHAI	BHATPADA, NEHAROLI	1	BHATPADA	124521
5	3891	SHAHAPUR	NASIK CBS	0.784314	AGHAI	KHAMBALE, JAWHAR FATA, TAKET FATA, ATGAON RLY....	2	PUNADE	82558
6	13159	NASIK CBS	SHAHAPUR	6.666667	AGHAI	KHAMBALE, KHARDI, JAWHAR FATA, TAKET FATA, ATG...	17	PUNADE	82558
8	16570	DHADRE	SHAHAPUR	0.392157	AGHAI	BHINGURALE, TEMBHURLI, MANJRA, BELAVALI	1	TEMBHURLI, MANJRA, BELAVALI	108898
9	16793	SHAHAPUR	WADA	4.705882	AGHAI	BELWAD, SONALA, PUNADE, AMBIVALI, ATGAON RLY. ...	12	PUNADE	82558

Figure 5.2: All intersections are Aghai in Shahapur

While trying to create a timetable and schedule buses, this is creating problems. We are not able to implement load balancing and scheduling a bus every 5 minutes might lead to inconsistencies. Even after being thoroughly checked, this solution does not seem correct.

The only solution seemed like is using a GIS based solution for selection of routes (performed on sinnar) instead of the textual data.

5.1.4 Conclusion

Due to lack of proper locations and GIS data, generating a consistent map or timetable for covid-19 facilities was difficult. Implementing important factors like load balancing and scheduling was generating many errors. Hence, the need for a GIS enabled technology for the bus system is a necessity for the MSRTC system.

5.2   Sinnar

As we had GIS data for Sinnar, there were two possible methdologies: by bus stand coverage or by % area coverage. Bus stand coverage with 1 hop coverage was selected here, as the area cover was taking a long time to evaluate (3-4 days).

5.2.1   Assumptions

- *average speed* = 30 km/hr (average speed of the bus)
- *bus stop time* = 2 min (the time for which the bus stops)
- *PHC stop time* = 10 min (the time for which the bus stops at a PHC nearby bus stop)
- *intersection stop time* = 30 min (the difference between the time when the first bus reaches the intersection point, this bus does not have a PHC on its route and the main bus, a bus which has a PHC on the route reaches the intersection point)
- *percentage cover* = 75 (minimum % cover of the bus stops required for the entire taluka)

5.2.2   Methdology

i. Take the calculated GIS data (nearest bus stop to the PHC) and the master data.

ii. Select the required bus stand % cover for the taluka.

iii. Find the routes on which a PHC lies (by selecting the nearest bus stops for PHCs), call these routes the main routes. Assign times to these routes.

iv. Define the intersection points.

v. On these intersection points schedule the buses as such that they reach 30 minutes before the PHC going bus reaches that stop.

vi. Create a time schedule based on these constraints.

Figure 5.3: Public Health Centers in Sinnar taluka
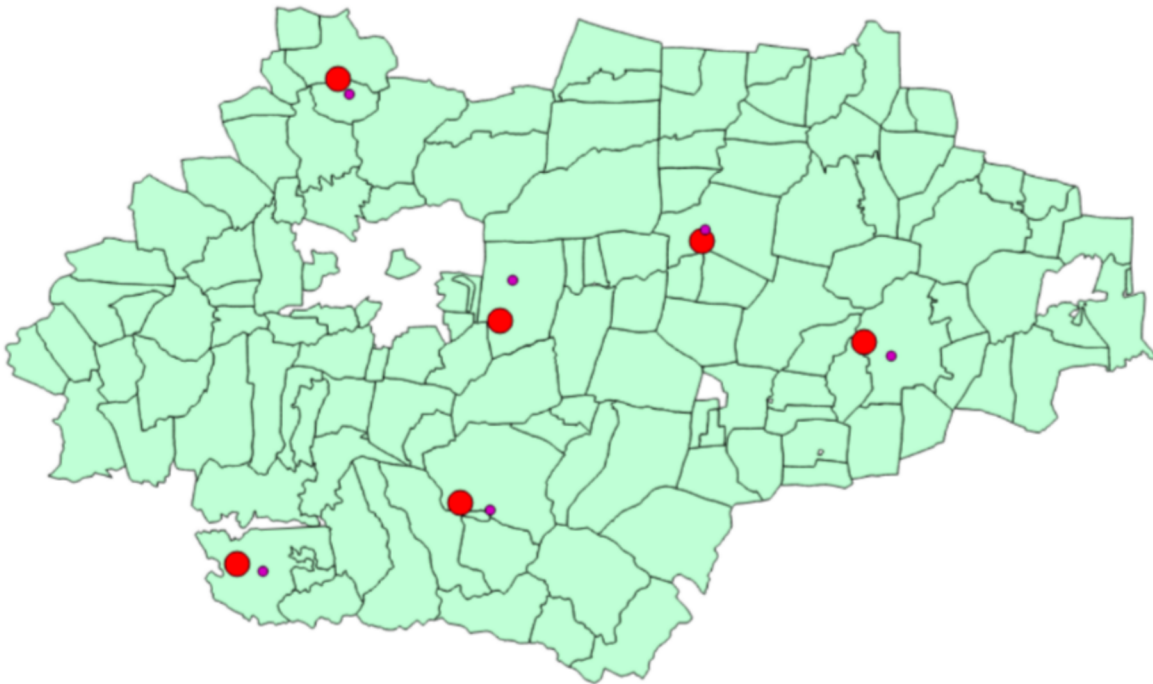
Figure 5.4: Bus stops near PHCs in Sinnar

Here in figure 5.3, all the PHCs in Sinnar are shown. The nearest bus stops selected with respect to each PHC are shown in figure 5.4. Finally, the routes for generated timetable are shown in 5.5. Green routes are the routes on which PHCs lie and Black routes are the 1 hop distance
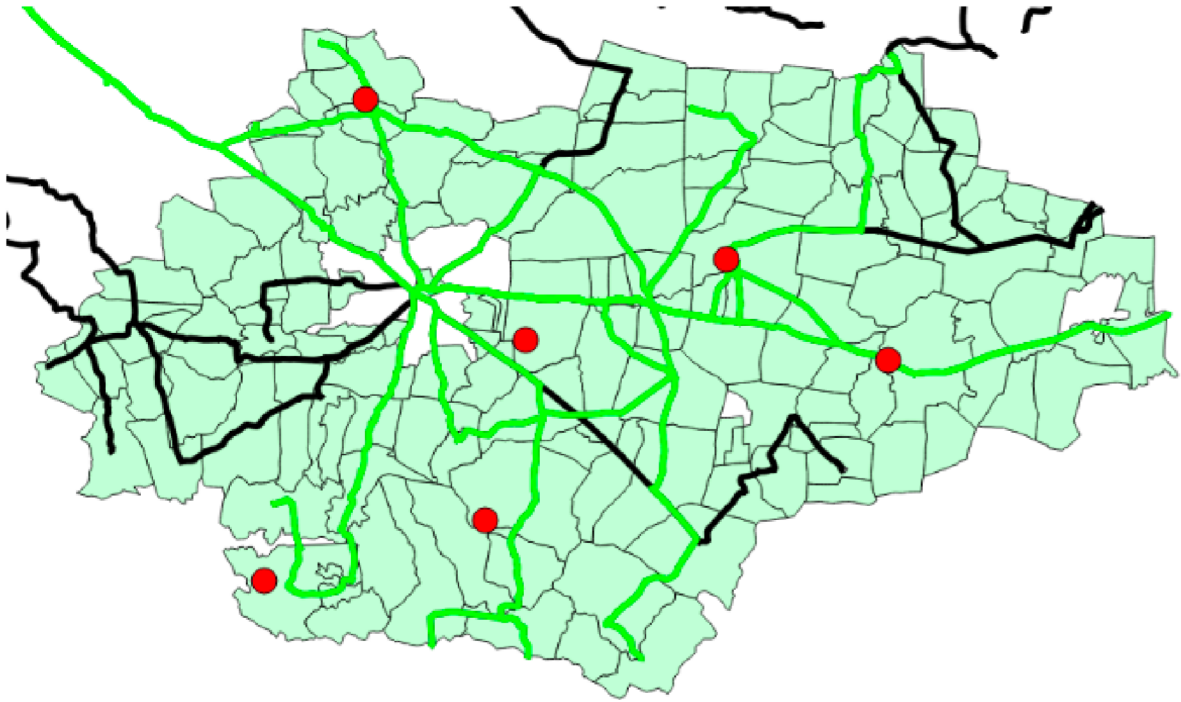
Figure 5.5: Sinnar final time table routes. Green routes are the routes on which PHCs lie and Black routes are the 1 hop distance routes.

routes.

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Chapter 6

Field Work

(18-21 Feb 2020) Field Visit for Nashik and Sinnar

6.1 Objective

The objective of this field visit was to understand the daily operations of a bus depot and observe how the techniques we have implemented like ridership and consistency analysis can prove beneficial for various such stakeholders. This field visit was conducted by two IIT Bombay students, Ms Ramya Sharma (PhD Scholar) and Mr Anshul Garg (Mtech student).

6.2 Depot structure

In order to gather information about the depot, the staff at the depot was interviewed by the students. The hierarchy of the staff is as shown in the image 6.1:
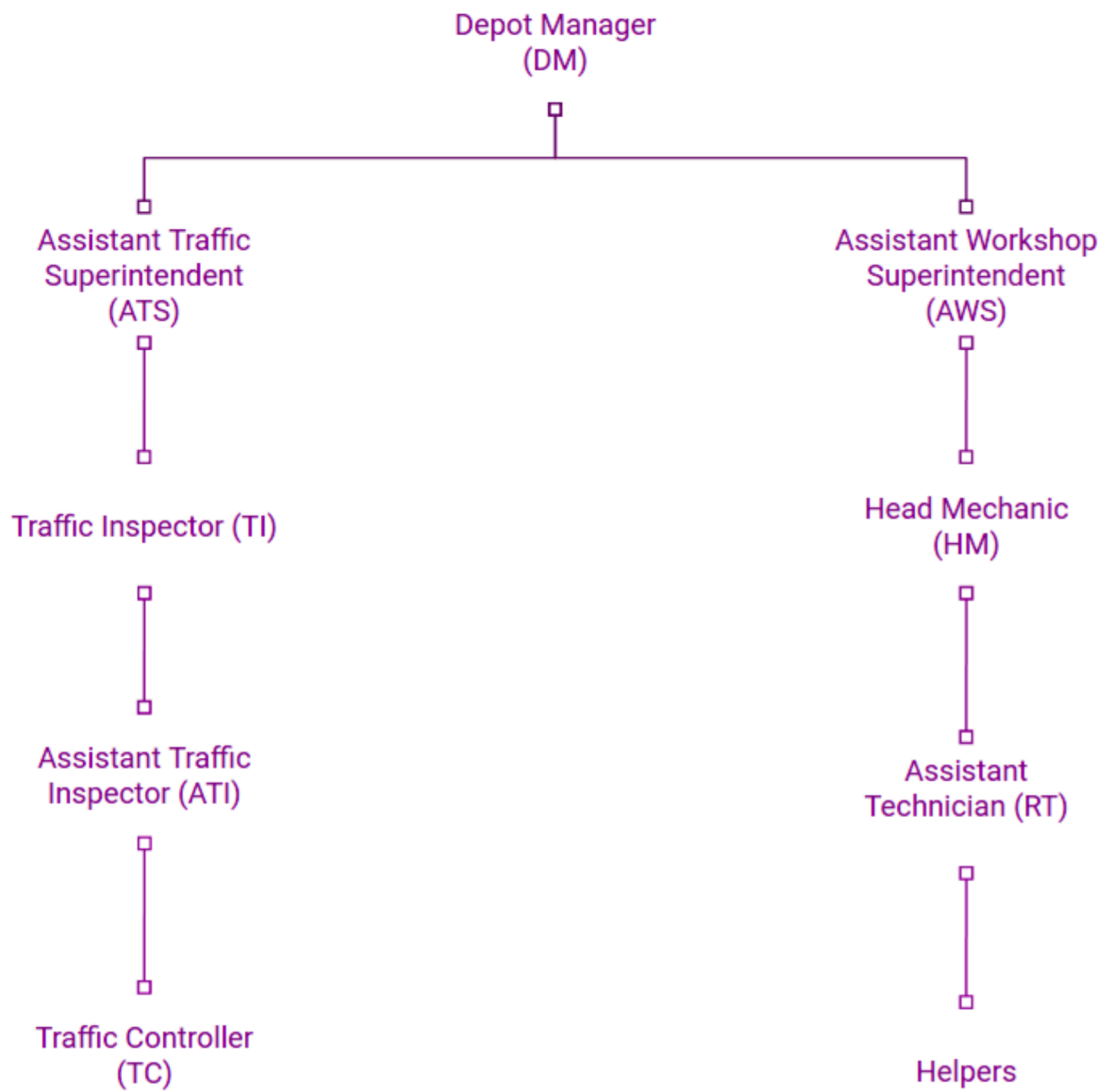
Figure 6.1: Hierarchy of a depot

6.2.1   Depot workings

- Majority of the work is done on excel sheets and manual data observations.

- The permission to introduce new trips or to cancel existing trips is given by taluka bus depot manager, after giving a notification to the divisional office.

- The trip introduction/cancelling decisions are taken on the basis of ABC data.

- Incoming or outgoing passenger analysis is usually not done on the bus stops, unless there is a huge difference in those numbers.

6.3 Trip details

If a trip is causing losses, it can be stopped. However, there are some trips which have to be kept functional even after incurring losses, as MSRTC also provides social service to the population of Maharashtra. These trips, which are not stopped, are:

- **Obligatory** - Every village must have 3 compulsory trips (one each in morning, afternoon and evening).

- **School** trips which pick up students for school/ drop students at school.

- **Operational** - If a trip has to start at the depot and travel empty to another bus stop once to pick up passengers, i.e. the original starting point of the trip is somewhere else, not the depot.

A trip can be stopped, if:

- The Load Factor of the trip is < (30-40%).

- There are student holidays (eg summers) going on.

- If the route is closed (damaged or flooded route).

- If the trip is ABC class C both ways (even operational trips can be closed in this case).

6.4 Introduction of new route

- A new route is introduced if there is a request or demand for that route. A demand application for the new route is sent to the Bus depot manager, some examples are shown in fig 6.2 and 6.3.

- After receiving the demand letters and justifying the demand, a Bus Depot manager proposes the new route to the Divisional Traffic office.

- Route survey is done with the approval of Divisional Traffic office, with trial buses. These trial bus run verifies the facilities (school, hospital, gram panchayat office) and accident chances (based on the road conditions like sharp turns or bad roads). This is done by the training inspector.

- If the route survey passes, then a new route is introduced. This new route can be closed if the promised load factor is not received.

6.5 Crew Scheduling

Crew scheduling is dynamic,i.e., it is done daily by the depot Traffic Inspectors(TI). TI manually enters the crew duty. A sample crew duty is shown in fig 6.4.

आमदार. सौ. सीमा महेश हिरे
नाशिक पश्चिम विधानसभा मतदारसंघ
मोबाईल : ९०११०६७९९९/९८२२०९९१४३
E mail : mlanashik125@gmail.com
seemahiray123@gmail.com

निवास – तुळजा, शारदा नगर, आनंदवल्ली शिवार, मते नर्सरी रोड, गंगापूर रोड, नाशिक ४२२ ०१३
संपर्क कार्यालय – शुभम पार्क, उत्तम नगर, नवीन नाशिक, नाशिक ४२२ ००९

जा.क्र.नाशिक (प)/59/2020

दिनांक:- 27/1/2020

प्रति,
मा. विभाग नियंत्रक,
महाराष्ट्र राज्य मार्ग परिवहन महामंडळ,
विभागीय कार्यालय, नाशिक.

विषय :- नाशिक शहर बस सेवेअंतर्गत निमाणी गोविंदनगर-कर्मयोगीनगर, सीबीएस, सातपूर सिडको, अंबड, कॉलेज रोड, गंगापूर रोड, नाशिकरोड अशी शहर बस सुरु करणेबाबत..
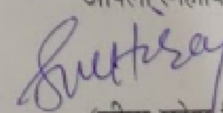
महोदय,

उपरोक्त विषयान्वये, मला प्राप्त निवेदनानुसार नाशिक शहर बस बस सेवेअंतर्गत गोविंदनगर कर्मयोगीनगर हा नवीन विकसित भाग असुन या ठिकाणाहून शहराच्या मध्यवर्ती ठिकाणी सीबीएस, गंगापूर रोड, कॉलेज रोड, सातपूर सिडक, अंबड या मार्गावर एकही बस जात नसल्याने या भागातील नागरिकांची तसेच विद्यार्थी वर्गांची मोठी गैरसोय होत आहे. परिणामी मुलांना शाळेत जाणे येणे तसेच या भागातील नागरिकांना सीबीएस, निमाणी व रेल्वेस्टेशन पर्यंत जाण्यायेण्यासाठी खाजगी वाहनांचा वापर करावा लागतो त्यामुळे खाजगी वाहनधारकांकडून मोठ्या प्रमाणात पैशांची मागणी केली जात असल्याने एकप्रकारे नागरिकांची लुटच होत आहे. आता उंटवाडी पुल सुरु झाल्याने बस जाणे येणेसाठी देखिल चांगला मार्ग तयार झालेला आहे.

नागरिकांच्या आग्रही मागणीचा विचार करता निमाणी गोविंदनगर-कर्मयोगीनगर, सीबीएस, सातपूर सिडको, अंबड, कॉलेज रोड, गंगापूर रोड, नाशिकरोड या मार्गावर शहर बस सुरु करणे आवश्यक आहे.

तरी निमाणी गोविंदनगर-कर्मयोगीनगर, सीबीएस, सातपूर सिडको, अंबड, कॉलेज रोड, गंगापूर रोड, नाशिकरोड या मार्गावरुन शहर बस सुरु करण्याबाबतची कार्यवाही आपल्या स्तरावरुन व्हावी याकामी संबंधितांना आदेश पारित करावे आपण केलेल्या कार्यवाहीची माहिती मला उलट टपाली अवगत करुन घ्यावी ही विनंती.

कळावे, धन्यवाद!

आपली स्नेहांकित,

(सीमा महेश हिरे)

43,,
93/02/2020

:- नागरिकांच्या निवेदनाची प्रत आपल्या अवलोकनार्थ.
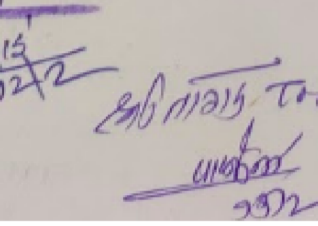
Figure 6.2: Demand letter example 1

प्रति,
मा. आमदार सिमाताई महेश हिरे
१२५,नाशिक पश्चिम विधानसभा मतदार संघ,
नाशिक.

दि. २५/०१/२०२०
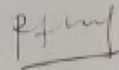
विषय:- शहर वाहतुक सेवा, महाराष्ट्र राज्य परिवहन महामंडळ अंतर्गत गोविंद नगर व कर्मयोगीनगर या परिसरात सिटी बस सेवा सुरु करणे बाबत..

मा. महोदया,

आम्ही खालील स्वाक्षरी करणारे गोविंदनगर व कर्मयोगीनगर या परिसरातील नागरीक विनंती करतो की, आमचे परिसरात अंदाजे १५,००० पेक्षा अधिक लोकसंख्या असुन सदर परिसरामध्ये मोठ्या प्रमाणावर ज्येष्ठ नागरीक, शाळेयविद्यार्थी व विविध ठिकाणी काम करणारे नागरीक राहत असुन, सदर परिसरात शहरामध्ये जाणे व येणे करीता सिटी बस सेवा उपलब्ध् नसल्याने नागरिकांच्या गैरसोय व अडचण निर्माण होत आहे. तसेच नाशिक शहरातील शाळा व कॉलेज यांच्या वेळे मध्ये आवश्यक असणारी सिटी बस सेवा उपलब्ध नसल्याने विद्यार्थांना शिक्षण घेणेकामी अडचण निर्माण होत आहे.

उक्त बाबींचा विचार करता गोविंद नगर व कर्मयोगीनगर या मार्गांद्वारे शहरातील सर्व परिसरामध्ये(सी.बी.एस/रेल्वे स्टेशन/निमाणी बस डेपो/गंगापुर रोड/कॉलेज रोड, महात्मानगर/पवन नगर सातपुर/ सिडको/अंबड व शैक्षणिक ठिकाणे इतर महत्वाचे परिसर)जाणारी सिटी बस सेवा उपलब्ध करुन द्यावी ही नम्र विनंती.

(सोबत परिसरातील नागरिकांच्या स्वाक्षरी असलेली यादी जोडलेली आहे.)

आपले विश्वासु

Figure 6.3: Demand letter example 2

54

जाणारी वाहने

वाहन क्र.	कर्तव्य क्र.	वाहन कुठे चालते	कि.मी.	चालक क्र.	वाहक क्र.	सुरुवाती वेळ	सुरुवाती प्रत्यक्ष वेळ	क्षेत्र
2604	43	वडझिरे	12.0	29566	28476	6.50	6.50	
772	36	भगूर	26.4	27271	36080	7.00	7—	
750	69	रामनगर	11.0	32861	52867	7.05	7.0	
6865	40	नि-हाळे	30.0	18277	16421	7.05	7.0	
8993	32	खापसाळे	13.3	28822	50490	7.10	7.10	
7104	2	नाशिक	31.3	23602	66550	7.30	7.30	वडझिरे
8879	57	कोनांबे	12.1	25890	61364	7.30	7.20	
8875	51	चांदोरी	27.7	33944	52704	7.30	7.30	
4847	24	रामनगर	11.0	33772	31795	7.30	7.40	
	97	नाशिक	31.3		—	7.45		
386	43	मेंढी	24.3	29566	28476	7.50	7.50	
9051	27	औदेवाडी	18.4	6558	29877	7.45	7.4	
9208	47	देवठाण	38.9	33061	63077	7.50	7.50	
7898	29	गुळवंच	17.4	2500	48511	8.00	8.00	
1332	34	अकोले	42.7	22700	88191	8.00	8—	
9104	55	M.I.D.C.	6.8	34372	93752	8.00	8—	
6834	59	औदेवाडी	22.6	27405	70894	8.15	8.15	
7983	38	स-अकोले	59.7	30936	83128	8.00	8—	
929	105	SMBT	36.3	34270	95700	8.00	8.00	
	122	नाशिक	31.3			8.00		
750	69	व-पिंगळा	24.0	32861	52867	8.15	8.15	
8993	32	सुळेवाडी	39.0	28822	50490	8.15	8	
8574	57	खापसाळे	8.0	25890	61364	8.30		

येणारी वाहने

वाहन क्र.	कर्तव्य क्र.	चालक क्र.	वाहक क्र.	वाहन कोठून आले	मुक्कामी प्रत्यक्ष वेळ	मुक्कामी वेळ	क्षेत्र
9671	43	29566	28476	ठाणगांव	6.45	6.4	
772	36	27271	36080	औदेवाडी	6.55	6.55	
750	69	32861	52867	सोमठाणे	6.55	6.55	
6865	40	18277	16421	दहिवडी	7.00	7—	
8993	32	28822	50490	ता. वाडी	7.05	7.0	
8835	51	33944	52704	आडवाडी	7.15	7.15	
7104	2	23602	66550	शिर्डी	7.15	7.1	
8879	57	25890	61364	पिंपळे	7.20	7.1	
929	105	34270	95700	कोकणवाडी	7.30	7.30	
484	24	33772	31795	अकोले	7.25	7.2	
	97			ताहाकारी	7.35		
386	43	29566	28476	वडझिरे	7.45	7.4	
9051	27	6558	29877	नळवाडी	7.40	7.40	
	122			खेडला	7.45		
1332	34	22700	88191	नि-हाळे	7.40	7.40	
	47	33061	63077	करंजी	7.45	7.45	
7983	38	30936	83128	सांगवी	7.45	7.45	
7898	29	2500	48511	खिरविरे	7.50	7.50	
9104	55	34372	93752	भगूर	7.50	7.50	
6834	59	27405	70894	नाशिक	8.00	8.00	
750	69	32861	52867	रामनगर	8.00	800	
8993	32	28822	50490	खापसाळे	8.10	8.10	
9104	55	34372	93752	M.I.D.C.	8.20	8.20	
8574	57	25890	61364	कोनांबे	8.25		

Figure 6.4: Crew duty

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Chapter 7

Summary

MSRTC is one of the essential services providing means for socio-economic development for rural Maharashtra. But the means of data analysis are archaic and need updation. Plenty of precious manpower is wasted in manual data analysis efforts, where these efforts can be outsourced and the manpower be utilized somewhere more useful.

We tried to automate the geolocaion of bus stands for creation of GIS data, but had to stop due to the ambiguity in the names and difficulty in confirming the location of that data.

We created certain parameters like consistency and ridership for better daily analysis of the traffic and bus transportation system. We looked into the data comprehensiveness of Form4, Master, ETIM and ABC data and found the inconsistencies among them. We also analysed the traffic issue patterns and punctuality of the buses across the month of July for Shahapur taluka.

In preparation for covid-19, we created a timetable connecting 75% of the bus stops to the PHCs of Sinnar taluka. This was done in order to provide medical care access to the people of Sinnar in times of a pandemic.

7.1 Future Work

We can implement timewise analysis on weekly basis for the talukas for an insight on weekly traffic patterns and generate future trips accordingly. The metrics can be replicated for all the taluka for Maharashtra for better insight into traffic analysis. This data, when combined with GIS data will give answers to societal and enterprise concerns like PHCs, schools and industry integration on the MSRTC bus route paths.

Appendix A
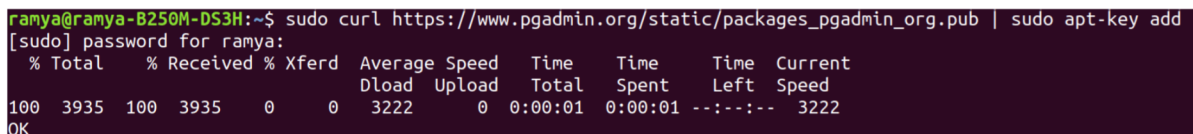
Setting up the environment

A.1 pgAdmin 4

PgAdmin is a free open source tool for postgreSQL, which is a object-relational database system. This section shows how to install pgAdmin 4 on ubuntu .

    i. Firstly, the public key for the repo needs to be installed:

```
$sudo curl https://www.pgadmin.org/static/packages_pgadmin_org
.pub | sudo apt-key add
```


Figure A.1: Installing public key

    ii. Then, the repo config file needs to be created:

```
$sudo sh -c 'echo "deb https://ftp.postgresql.org/pub/pgadmin
/pgadmin4/apt/$(lsb_release -cs) pgadmin4 main" > /etc/apt
```

```
/sources.list.d/pgadmin4.list && apt update'
```


Figure A.2: Creating repository

iii. Finally, install pgAdmin 4:

```
$sudo apt install pgadmin4
```
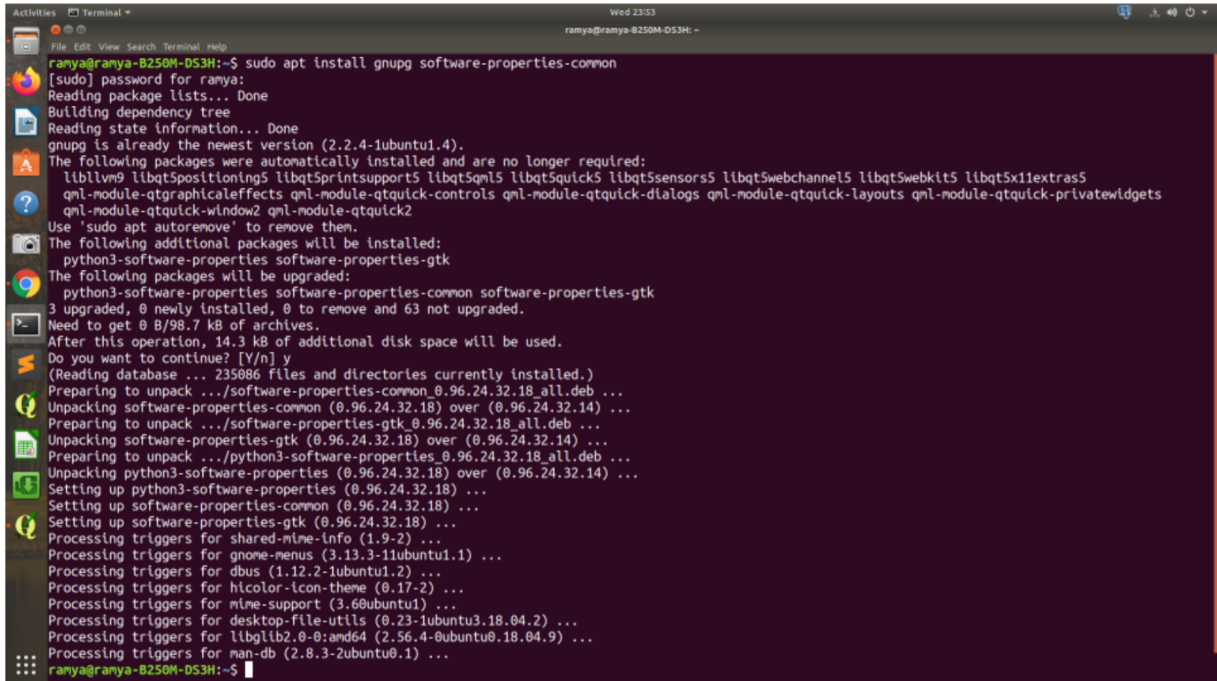

Figure A.3: Installing pgAdmin 4

A.2 QGIS

QGIS is a free and open source GIS software used for viewing, editing and analysing the GIS data. It can be installed from the following website: QGIS for ubuntu

i. To install QGIS, some tools have to be installed. The tools can be installed by executing following command as shown in figure A.4:

```
$sudo apt install gnupg software-properties-common
```


Figure A.4: Installing the prerequisites for QGIS

ii. In the next step, the QGIS signing key has to be installed so that the QGIS soft-
ware can be trusted and installed from the QGIS repo:

```
$wget -qO - https://qgis.org/downloads/qgis-2021.gpg.key | sudo gpg
--no-default-keyring --keyring gnupg-ring:/etc/apt/trusted.gpg.d
/qgis-archive.gpg --import
$sudo chmod a+r /etc/apt/trusted.gpg.d/qgis-archive.gpg
```


Figure A.5: Installing the key(1)

iii. Now add the QGIS repo:

Figure A.6: Installing the key(2)

```
$sudo add-apt-repository "deb https://qgis.org/ubuntu$(lsb_release
-c -s) main"
```


Figure A.7: Add QGIS repo

iv. Update the repository information:

```
$sudo apt update
```

v. Finally, install QGIS:

```
$sudo apt install qgis qgis-plugin-grass
```

A.3   Data and Code

The data and code can be accessed here.

Figure A.8: Install QGIS

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Website Arogya. Government of maharashtra public health department.
    URL `https://arogya.maharashtra.gov.in/1035/`

Website Guidance Document. Guidance document on appropriate management of suspect/confirmed cases of covid-19.
    URL `https://www.mohfw.gov.in/pdf/FinalGuidanceonMangaementofCovidcasesve pdf`

Website History of MSRTC. History of msrtc.
    URL `msrtc.maharashtra.gov.in`.

Website MSRTC ppt. Research at iit bombay on msrtc operations.
    URL `https://www.cse.iitb.ac.in/~sohoni/msrtc/MSRTCpptJuly2019. pdf`

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