GIS framework for Taluka Bus Transportation Analysis and Provisioning

under guidance of

Prof. Milind A. Sohoni

Presented by

Sudhanshu Kulkarni

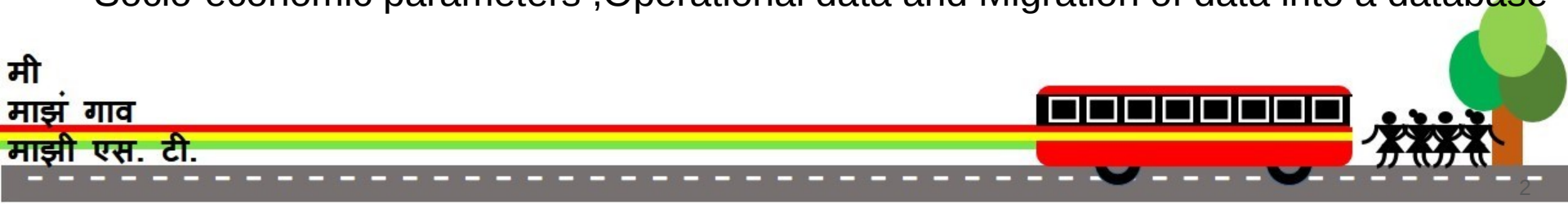
(173350006)

Contents

- **Development Analysis:**
  MSRTC and Other service providers
  Understanding the working of PRI and People's expectation
  ICT based interventions for Transportation

- **Framework Development**
  Digital Geography, Methodology for its creation and Integration with Census

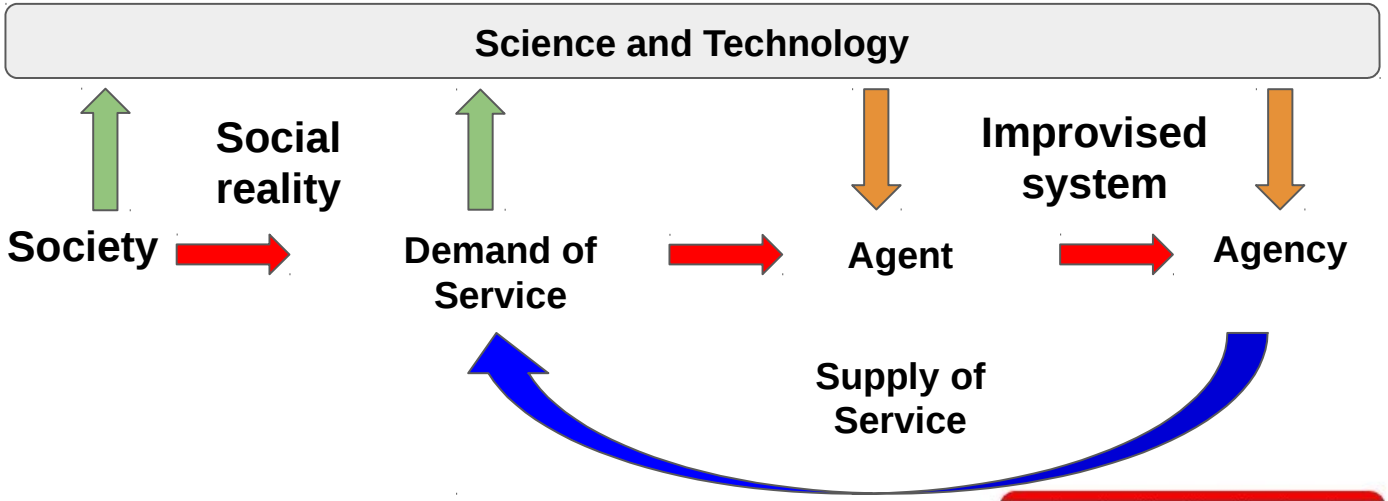
- **Analytic Tools**
  Socio-economic parameters ,Operational data and Migration of data into a database



Transportation as a Carrier of Development

What is Development?

- Development" can be defined roughly as "an event constituting a new stage in a changing situation" implicitly a positive/ desirable event[1]
- *Sadak, Bijli, Pani* for all with high predictability, reliability, high accessibility for all
- Highly interdisciplinary, transdisciplinary



[1] [Development and Development Paradigms-FAO]

Maharashtra State Road Transport Corporation

महाराष्ट्र राज्य मार्ग परिवहन महामंडळ

- State Transportation Undertaking with 18710 Buses, 609 bus stands and 250 Bus depots[2]
- Motto ‘जनसामान्यांसाठी ... रस्ता तिथे एस. टी.’
- 31 divisional offices
- Depot-wise, Division-wise, Region-wise information analysis [3]:

  i) Geographical Information System
  ii) Graphical Reports
  iii) Vehicle Monitoring System
  iv) 20 Point and Budget
  v) Daily Report

[3]Administration Report 2016-17 Government of Maharashtra

मी
माझं गाव
माझी एस. टी.

MSRTC counts its losses

TNN | Mar 28, 2017, 05:43 IST

A- A+

KOLHAPUR: The state transport corporation is finding it difficult to stay on course with a cumulative net loss of Rs 2712 crore in last five years.

The Maharashtra State Road Transport Corporation (MSRTC) is one of the largest public

hindustantimes

Monday, Oct 15, 2018

india world htls cricket cities opinion entertainment lifestyle education sports photos videos ind v wi

PUC panel reports points out MSRTC's losses, blames e-ticketing system

The report was filed by a legislative committee led by Bhartiya Janata Party MLA Sunil Deshmukh.

MUMBAI Updated: Dec 26, 2017 00:50 IST

Surendra P Gangan
Hindustan Times

Rising fuel costs compels corporation to increasing MSRTC bus fares by 18%

MUMBAI

Waive taxes for MSRTC, Transport Minister urges CM

STAFF REPORTER

MUMBAI, MAY 29, 2018 00:41 IST
UPDATED: MAY 29, 2018 00:41 IST

State Transport Minister Diwakar Raote on Monday urged Chief Minister Devendra Fadnavis to waive State taxes on diesel for the Maharashtra State Road Transport Corporation (MSRTC).

Mr. Raote said the steady rise in the prices of diesel had severely affected the MSRTC and has threatened to affect the payment of salaries of its employees. Mr. Raote in his letter to the Chief Minister said that the rising fuel prices had increased the financial burden on MSRTC by ₹400 crore every year.

Fare hike on cards

He said that the MSRTC was also mulling over hiking the fares to tackle the increasing cost of fuel. Abhijit Bhosale, spokesperson for MSRTC, said the details of the fare hike were yet to be worked out.

MSRTC officials said diesel prices were at ₹58.02 per litre in May 2017, but have now increased to an average of ₹68.39 per litre across the State. The officials said that they would also have to factor in a wage revision for the MSRTC's one lakh employees.

Rising fuel prices has increased the MSRTC's budget by at least Rs 460 crore annually. A salary hike offered to its employees also put a burden of Rs 4849 crores on the corporation.

मी
माझ
माझ

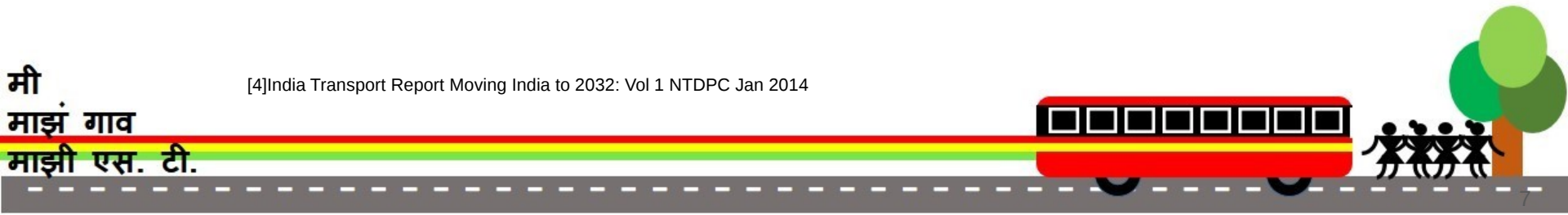
Source: *http://www.sify.com/finance/rising-fuel-costs-compels-corporation-to-increasing-msrtc-bus-fares-by-18-news-commodities-sghlOzdgghbei.html*

National Transport Development Policy Report[4]

Information and Communication Technology (ICT) in the road transportation sector to mitigate with the following challenges:

1. Good quality data to support evidence-based policy making
2. Increase in efficiency of the road transport system and satisfaction of its users
3. Management of safety and care of the injured

[4]India Transport Report Moving India to 2032: Vol 1 NTDPC Jan 2014



Shahapur Taluka Bus Depot

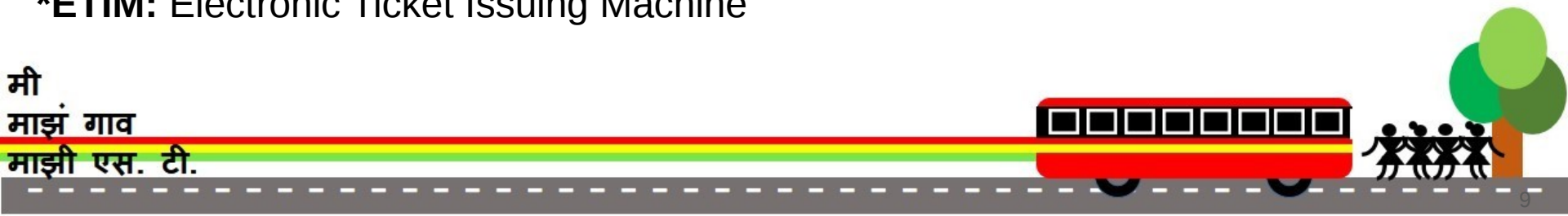
- ~65 buses on 270 routes with a crew size of ~220 for 80 villages in Taluka
- The lowest load factor (.63) in Thane Division as per 2017 reports

मी
माझं गाव
माझी एस. टी.

Shahapur Taluka Bus Depot

- **Form 4:** Official schedule of buses prepared at Division Level with the help of Depot manager
- **Monthly Operational form or *ABC*:** Official document prepared at Depot level by the traffic controller with the help of ETIM* data and Data from Cashier's office
- Grading paradigm followed **A:** Good, **B:** Needs Improvement, **C:** Poor

***ETIM:** Electronic Ticket Issuing Machine



Understanding Form 4

A form 4 is an official document that is essentially the bus schedule

Terminus: First or last bus stop of a bus service

Service: A bus service is a trip between terminals with ***arrival time, departure time***

Schedule: A schedule is a set of services in such a way that the bus is not changed

Additionally **Crew duty** is a set of services such that the crew is not changed

An operational form 4 for any month is considered as **ABC form**

Form 4 Screenshot

शहापुर आगार

वेळापत्रक तक्ता क्र.4 सन :-2017 - 2018

नियत		कामगिरी	फेरीचा				वेळ			शेरा	थांबे
क्र.		क्र.	सांकेतिक क्र.			अंतर	सुटते	पोहचते			
			झटल सेवा								
1	0	C-1	S-S1482	SHAHAPUR	MURBAD	42.7	5.45	7.15	KINHAVALI	विश्रांती	
1		C-1	S-S1483	MURBAD	SHAHAPUR	42.7	7.45	9.15	KINHAVALI	मार्ग:- किन्हवली.	
1		C-1	S-S1484	SHAHAPUR	MURBAD	42.7	9.45	11.15	KINHAVALI	मार्ग:- किन्हवली.	
1	0	C-1	S-S1485	MURBAD	SHAHAPUR	42.7	11.45	13.15	KINHAVALI	मार्ग:- किन्हवली.	
1	0			चा/चा बदल							
1	0	C-2	S-S1486	SHAHAPUR	MURBAD	42.7	13.45	15.15	KINHAVALI	मार्ग:- किन्हवली.	
1		C-2	S-S1487	MURBAD	SHAHAPUR	42.7	15.45	17.15	KINHAVALI	विश्रांती	
1		C-2	S-S1488	SHAHAPUR	MURBAD	42.7	17.45	19.15	KINHAVALI	मार्ग:- किन्हवली.	
1	0	C-2	S-S1489	MURBAD	SHAHAPUR	42.7	19.45	21.15	KINHAVALI	मार्ग:- किन्हवली.	
	0					वाहन देखभाल वेळ21.15 ते 5.45 .					

ABC TABLE

- An ABC table consists of the **passenger load data, various earnings** by <u>any service of the schedule</u>
- Every service is graded on **EPKM (E**ffective **P**assenger **K**ilo**M**etres**)**
- If EPKM >= 43.32 Grade **A**
- If EPKM >= 22.1 && EPKM < 43.32 Grade **B**
- If EPKM < 22.1 Grade **C**

ABC Operational Form

=(M12*0.07053)

senior citizen	From	To	Seating Capacity	Deparute Time	service tax Of	Distance	Fare	Trips Optd.	Effective Kms.	Tray Earning + Advance Booking
18										
951										
2416	3	4	6	7	8	9	10	11	12.0	13
3529										
2433	HPR	murbad	44	5.30	7.00	42.7	54	31	1324	13486
	urbad	SHPR	44	7.30	9.00	42.7	54	31	1324	34255
3086	HPR	murbad	44	9.10	6.40	42.7	54	29	1238	50034
4242	urbad	SHPR	44	11.00	12.30	42.7	54	29	1238	34491
2562	HPR	murbad	44	13.00	14.30	42.7	54	31	1324	44580
1692	urbad	SHPR	44	15.00	16.30	42.7	54	31	1324	61280
	HPR	murbad	44	17.00	18.30	42.7	54	31	1324	37019
	urbad	SHPR	44	19.00	20.30	42.7	54	31	1324	24438

Date	RIP	Time passenger earnig
19	1	474
20	1	508
21	1	770
22	1	573
23	1	522
24	1	501
25	1	212
26	1	696
27	1	297
28	1	1511
29	1	253
30	1	733
31	1	243
	31	13486

Problems identified

- Lack of convergence of Transportation, GIS and Demographics data
- Drudgery in preparing ABC operational Data
- Lack of synchronisation between Form4, ABC and even ETIM data as well
- Lack of GIS data at Taluka Level
- Absence of unified database for Demand estimation and service provisioning

Research Question

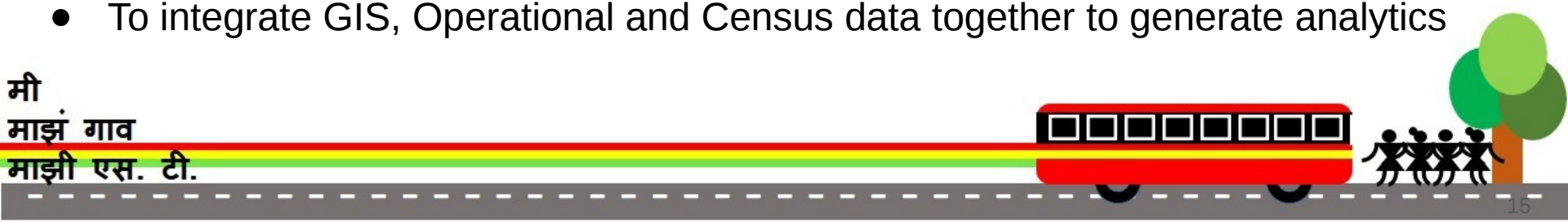
Broad Societal Concern

“Poor Public transportation service provisioning in rural areas of Maharashtra”

DRQ. 1 What ICT tools can be developed for a rural public transportation system?

Research Objectives

- To define a model of Taluka public transportation based on graph theory
- To generate GIS data of transportation maps with points of importance, routes etc.
- To map Form 4 and Operational Data in GIS
- To integrate GIS, Operational and Census data together to generate analytics



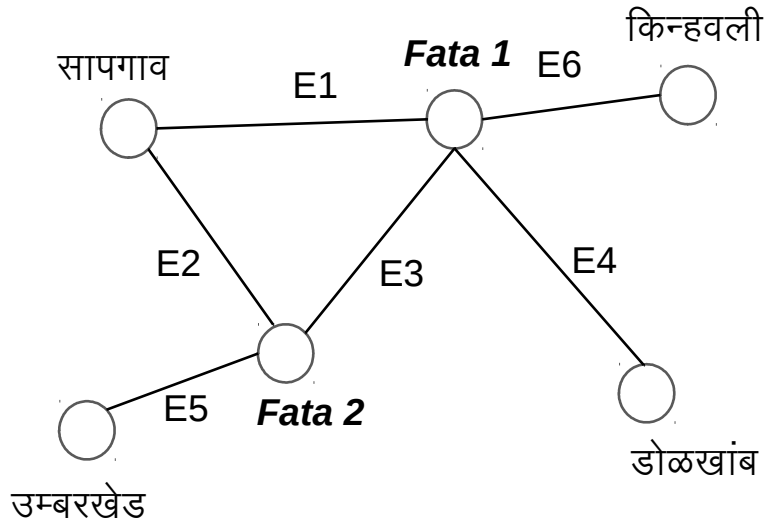
Scope of the Project

- The field of study was in Shahapur Taluka, Thane District
- Only *lalpari* or Ordinary buses and bus-services are considered
- Data considered is based primarily on Form 4 data
- Non-MSRTC service providers data was collected through field surveys
- No Inter-city Bus services were considered

DIGITAL GEOGRAPHY

Graph theory

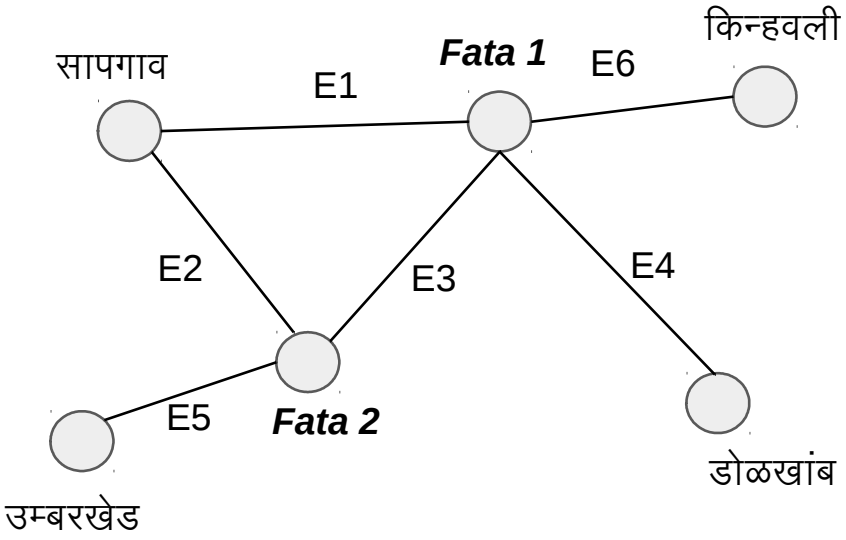
- A Graph **G** is a data structure consisting of a set of Edges(**E**) and Vertices(**V**)
- Represented as **G(V,E)**
- Railway network, Stream network of watershed, Drinking water distribution lines etc.



E = *{E1, E2, E3, E4, E5, E6}*
V = *{* सापगाव, डोळखांब, उम्बरखेड, किन्हवली, *fata1, fata2 }*

मी
माझं गाव
माझी एस. टी.

Graph Theory in Real life



Decision to choose path depends upon:

my requirement and who am I?

A Depot manager: routes with max coverage, shortest routes, routes with high profitability.

Tourist: monsoon season let's explore scenic beauty on the way to डोळखांब

Bus networks as Graphs

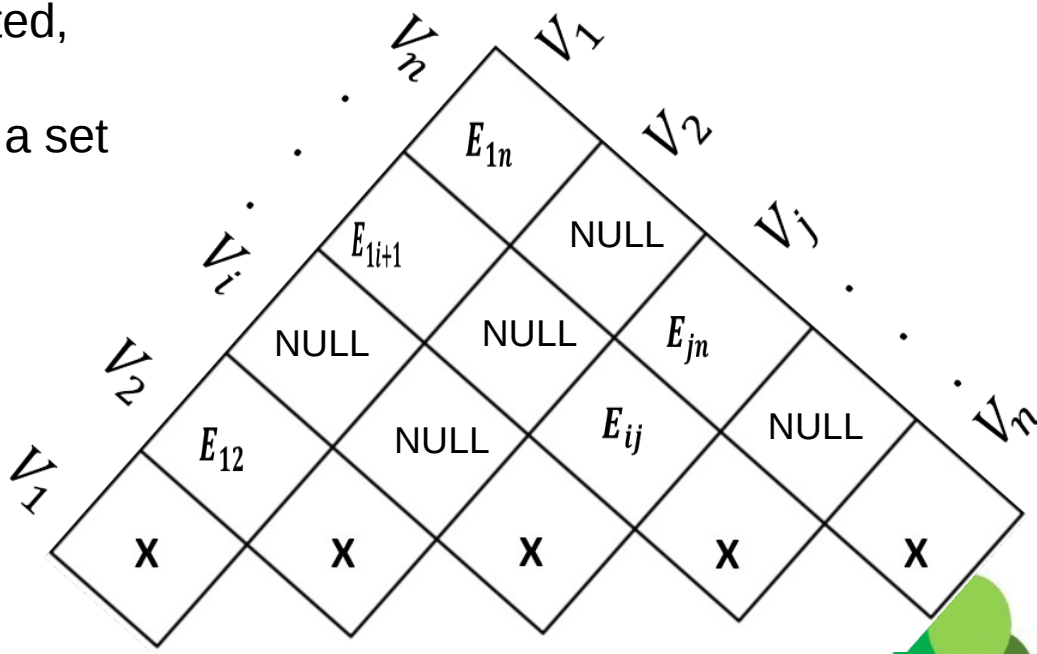
- Derrible and Kenned (2010) to redraw metro networks into graphs G(V, E) by removing the intermediate vertices and considering the end and transfer edges

  V = V*t* + V*e* where,V*t*: Transfer station, V*e*: End station

- V*t*: Stations where it is possible to change routes without leaving the network
- V*e*: Stations which form the beginning/end of a route segment

Digital Geography

- A digital geography is an undirected, planar graph **G(V, E)**
- where: **V** is a set of vertices, **E** is a set of edges
- Each member of **V** and **E** have geographical and geometrical properties



Definitions

- **Vertex(V): A vertex is a point geometry that stores the lat-long**

in our system vertices are identified by

$$V = T \cup F \text{ where}$$

Terminal (T): End stations

***Fata* / Fork/ Junction (F):** Transfer stations, Vertices with degree > 2

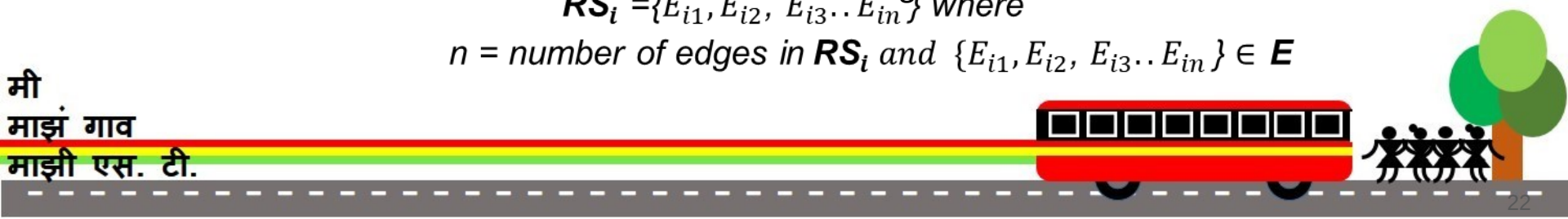
- **Edge(E):** A polyline between two vertices in such a way that there is no intermediate
- **Route Segment (RS):** Ordered set of Edges

$$= \{, \} \text{ where}$$

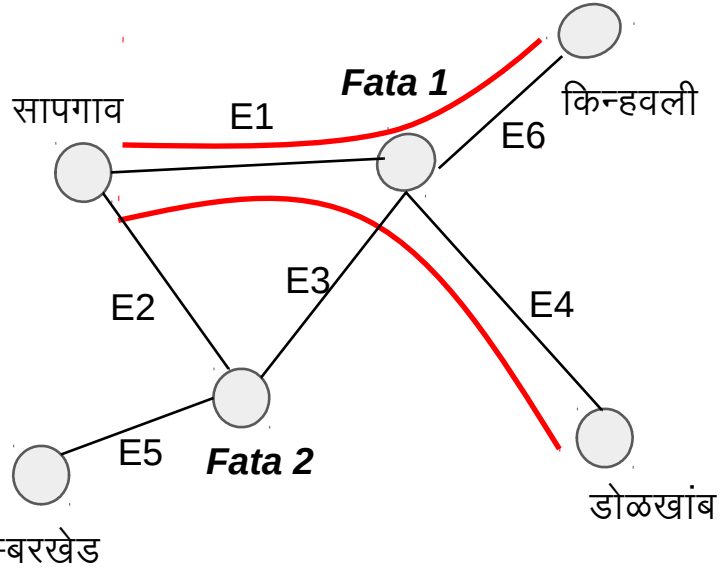
$$n = \text{number of edges in } \boldsymbol{E}$$

$$\boldsymbol{RS_i} = \{E_{i1}, E_{i2}, E_{i3}..E_{in}\} \text{ where}$$

$$n = \text{number of edges in } \boldsymbol{RS_i} \text{ and } \{E_{i1}, E_{i2}, E_{i3}..E_{in}\} \in \boldsymbol{E}$$



Route Segments contd.



So let's assume we have the following routes:

we have two route segments
from सापगाव to डोळखांब and सापगाव to किन्हवली

then we have

π1: (E1,E4) and π2: (E1,E6)

π1 ∩ π2 = {E1}

Overlapping vertices will be {सापगाव, fata1}

Implementation of Digital Geography by Google

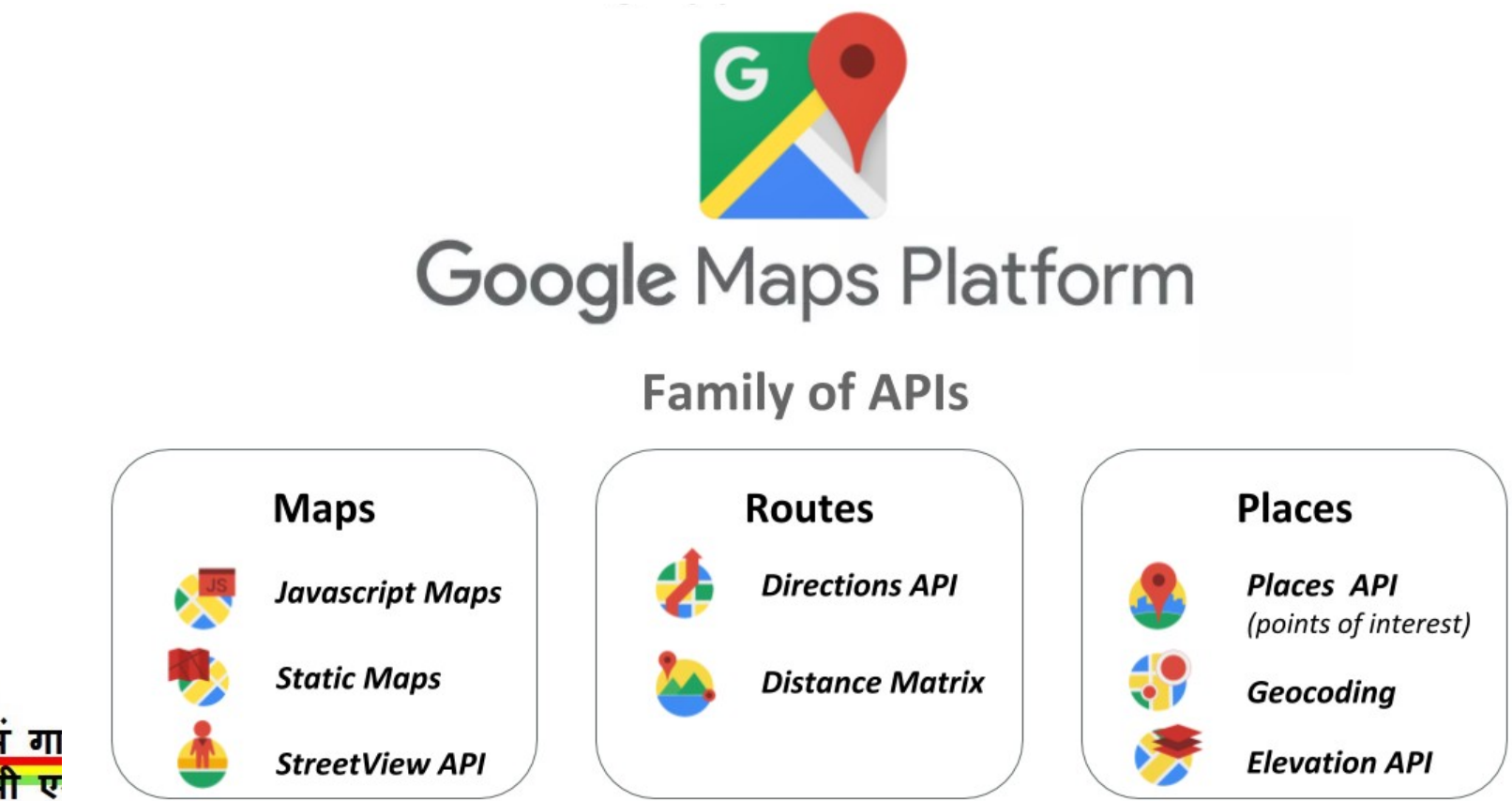


Image Source: https://www.t-sciences.com/wp-content/uploads/2018/06/GCP-Layout-Images-2.png

IMPLEMENTATION OF DIGITAL GEOGRAPHY

Pre-Requisites

- Taluka Polygon File with Census data
- Form 4 and ABC form, Field data for determining the combinatorics of Termini
- Road network
- Google APIs to ascertain lat-long of termini
- Zila parishad schools data

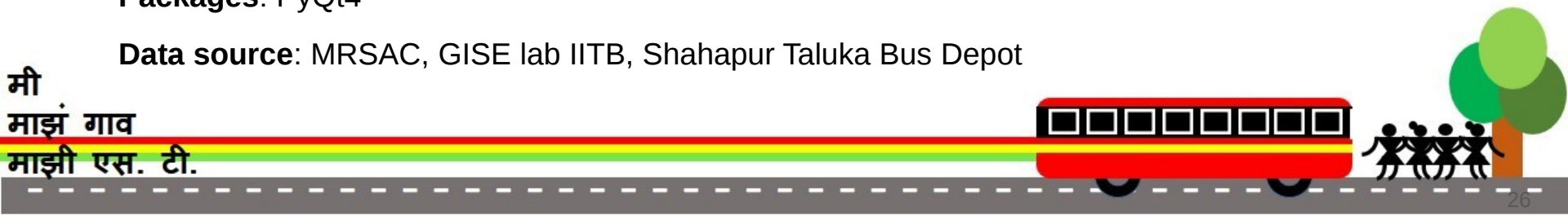
Tool : QGIS 2.18 las palmas, pgAdmin4

DBMS : postgresql , PostGIS

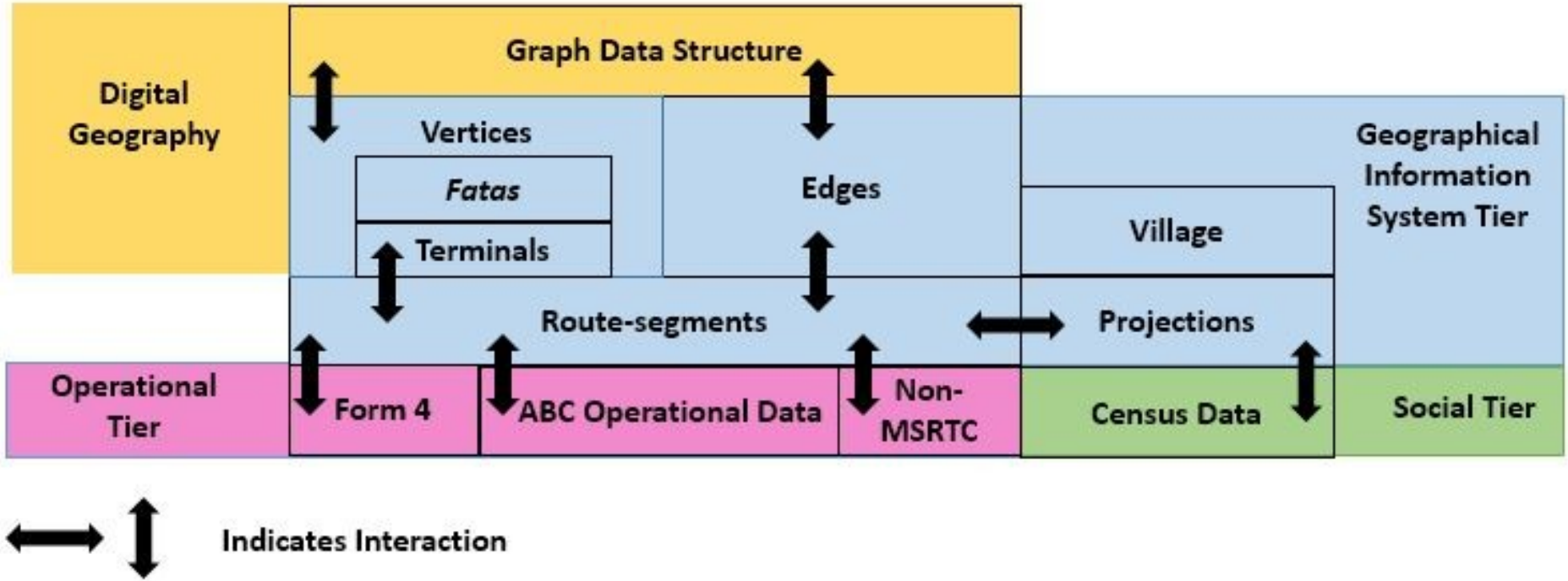
Scripting : python 2.7

Packages: PyQt4

Data source: MRSAC, GISE lab IITB, Shahapur Taluka Bus Depot



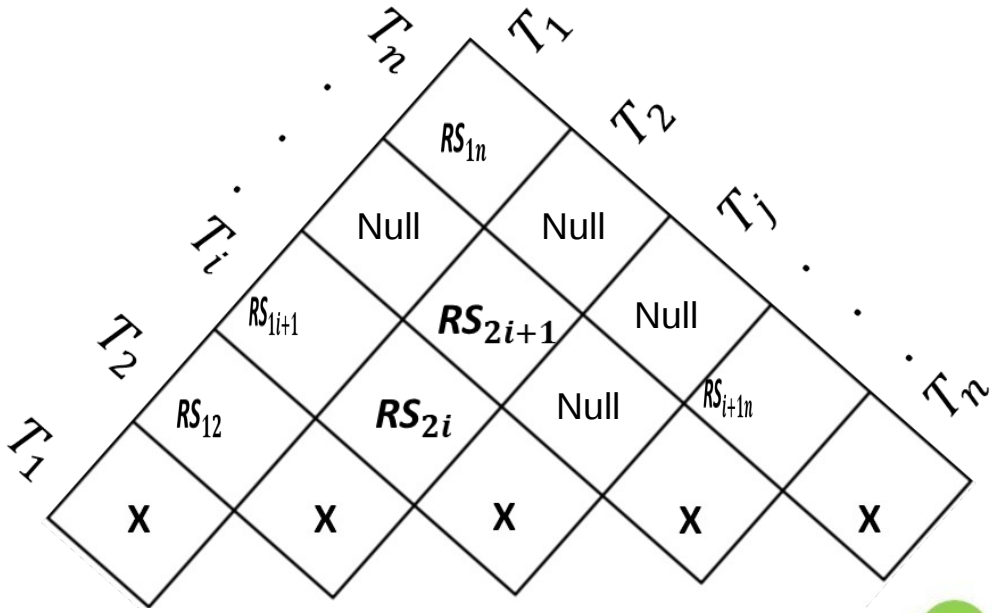
SYSTEM ARCHITECTURE



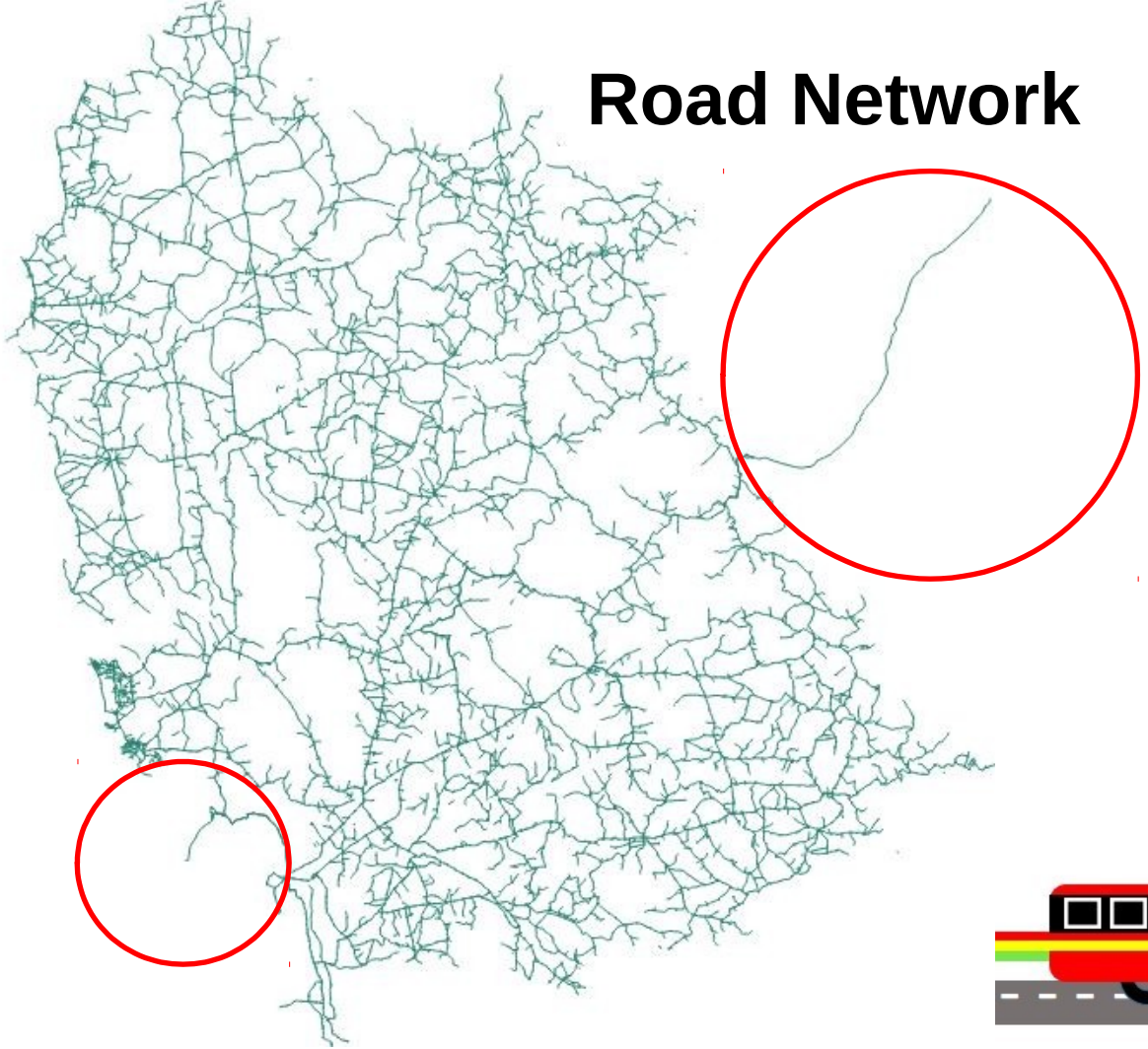
मी
माझं गाव
माझी एस. टी.

Route Segment Combinatorics

A route segment is a polyline between any two distinct termini i.e. $RS \subseteq \binom{T}{2}$,
Please note that we are not having any data of Edges till this step



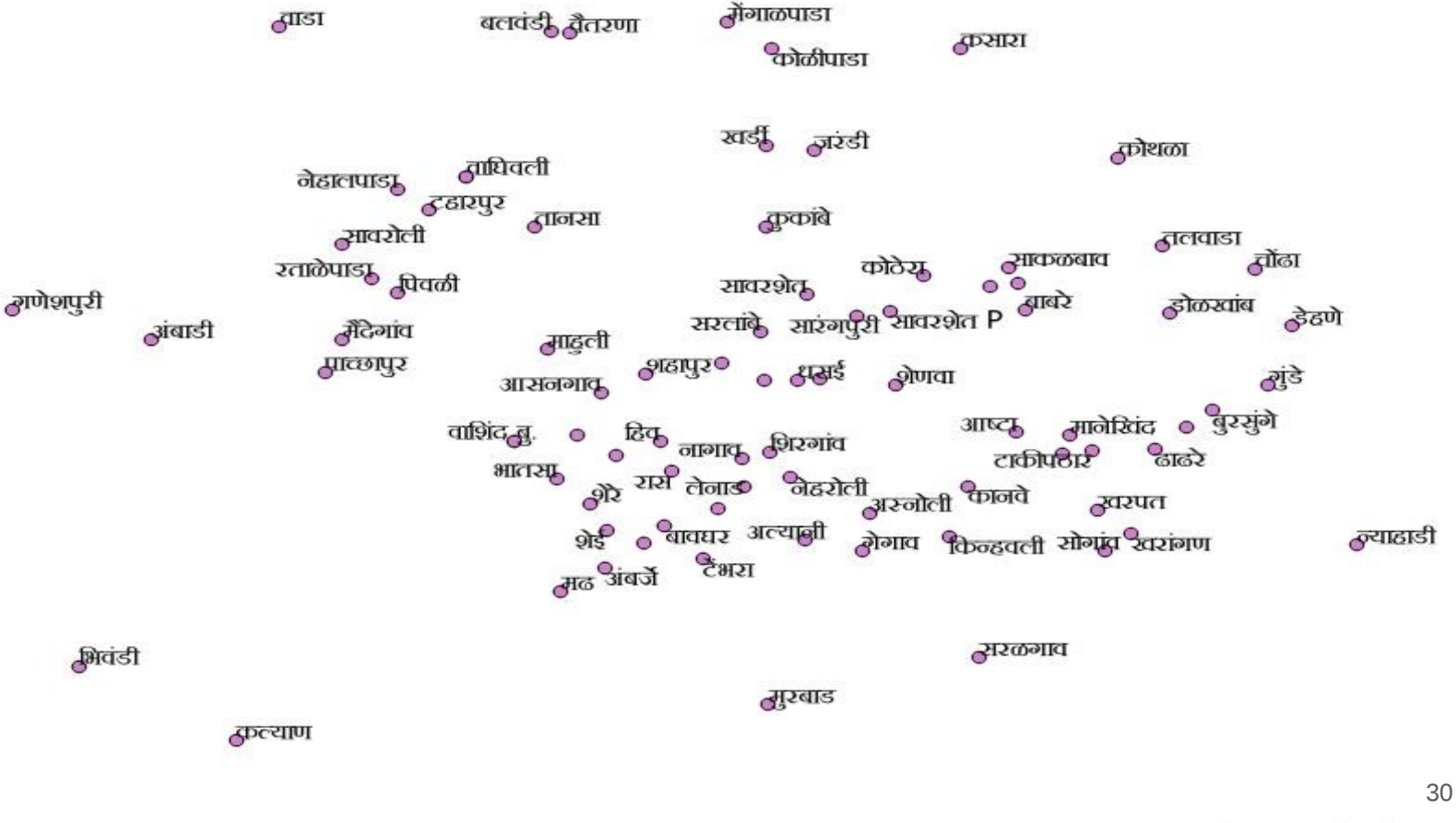
Road Network



These polylines were generated using Google earth as we didn't have MRSAC's roads data of Nashik District and Mumbai Suburbs

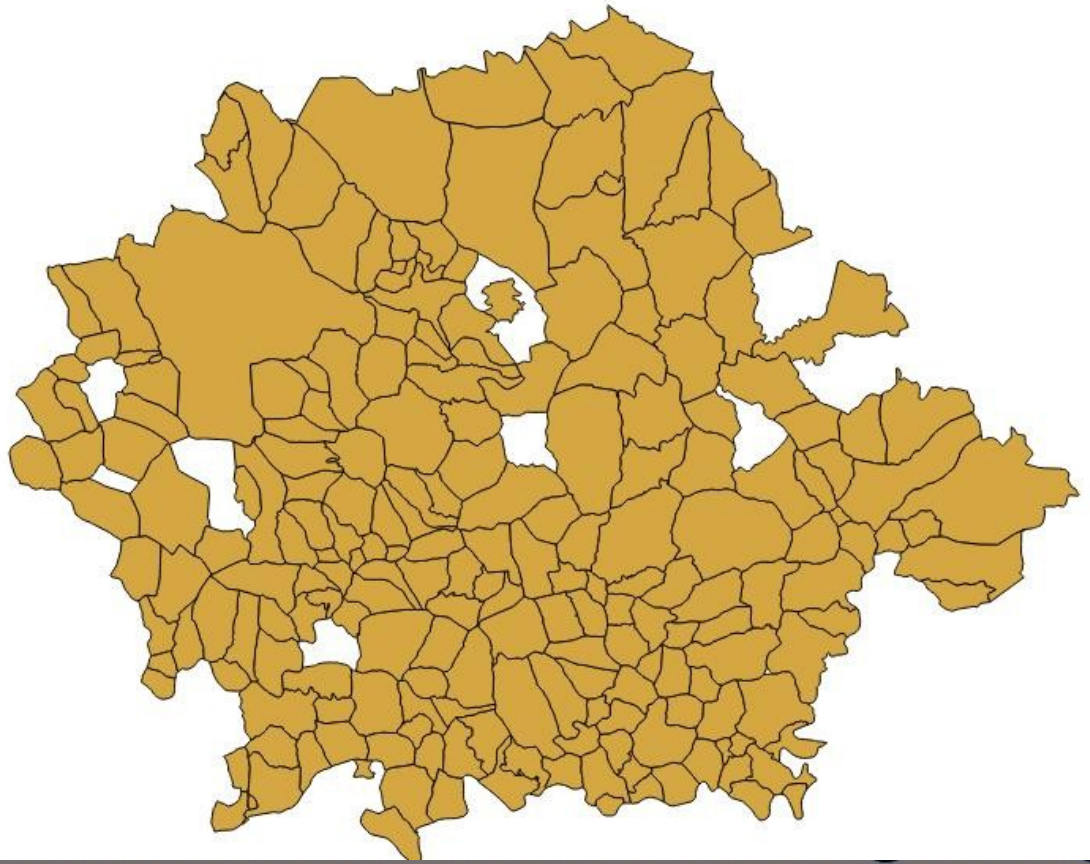
मी
माझं गाव
माझी एस.

Terminals

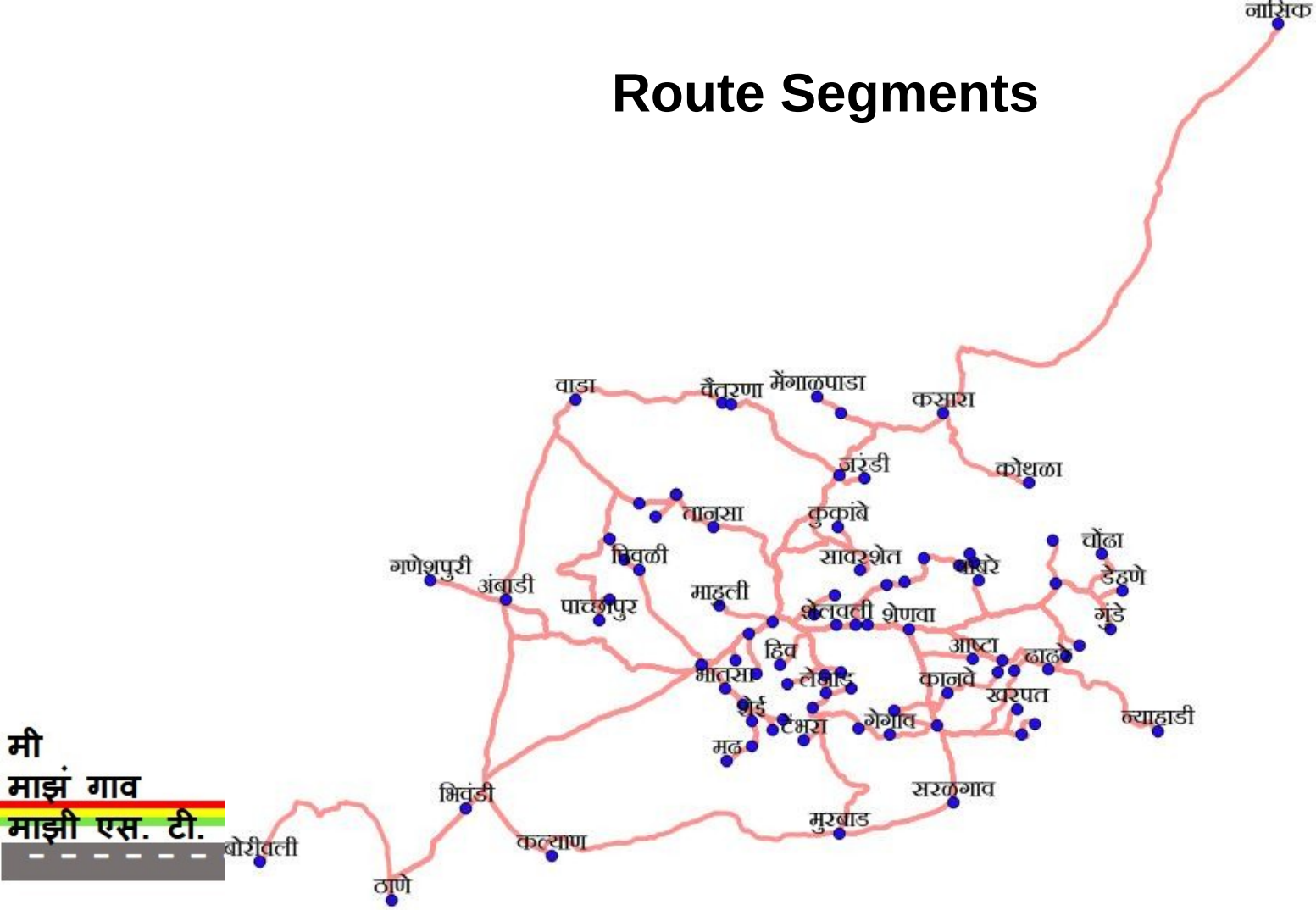


मी
माझं गाव
माझी एस.

Taluka Boundary



Route Segments

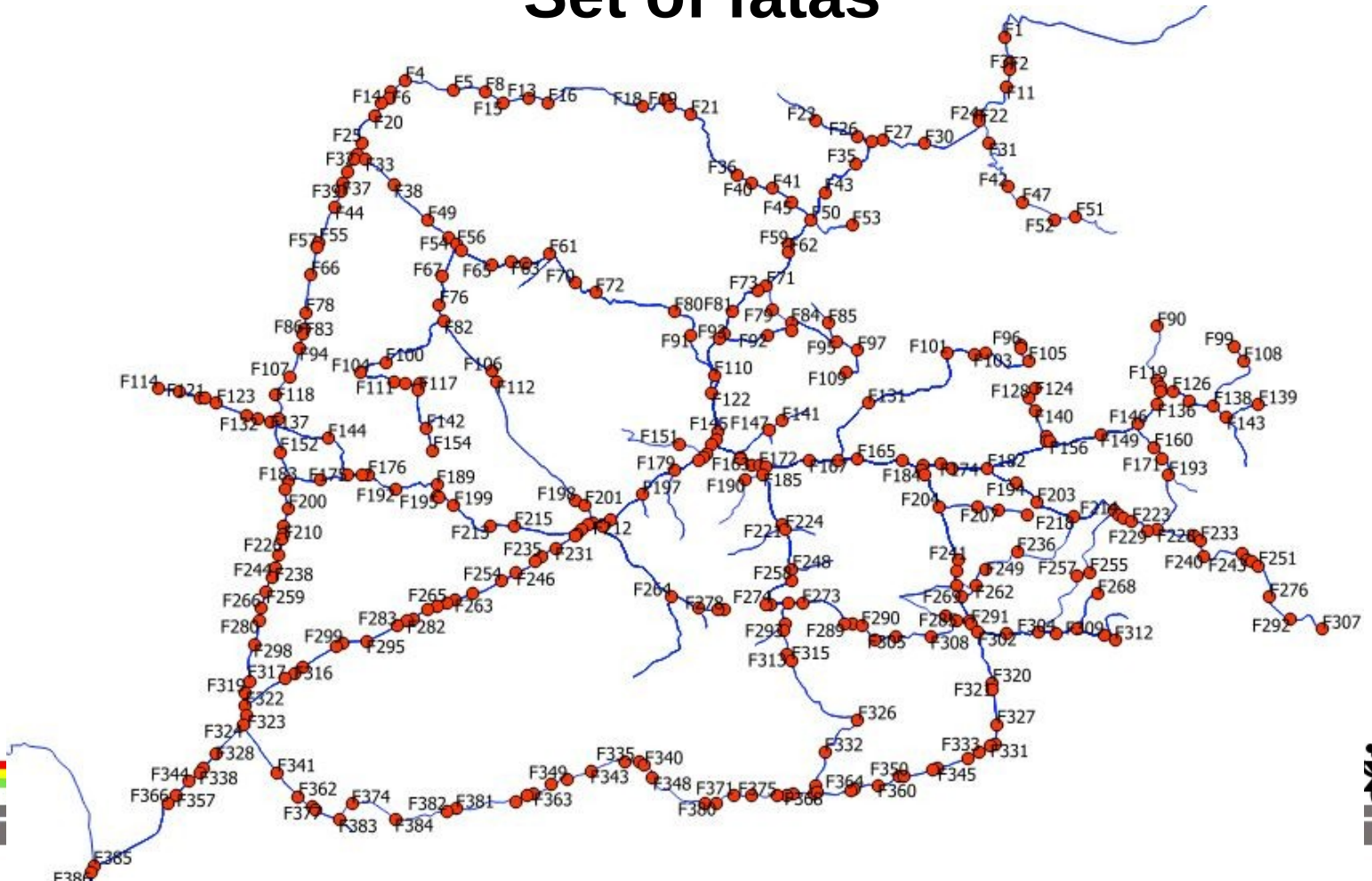


मी
माझं गाव
माझी एस. टी.

Fatas / Forks / Junctions

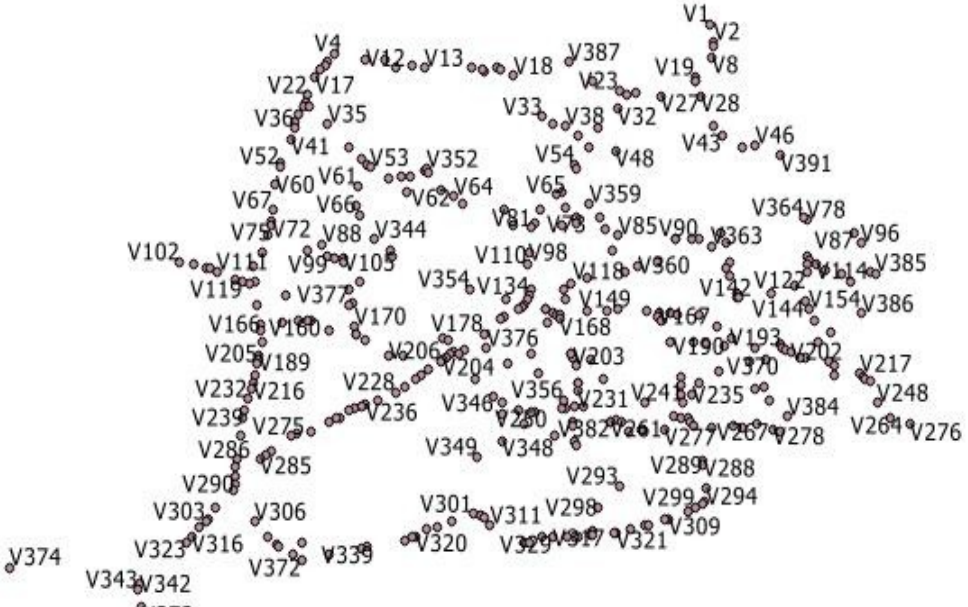
- *Fatas* of ST bus road network and *fatas* of Road network

Set of fatas



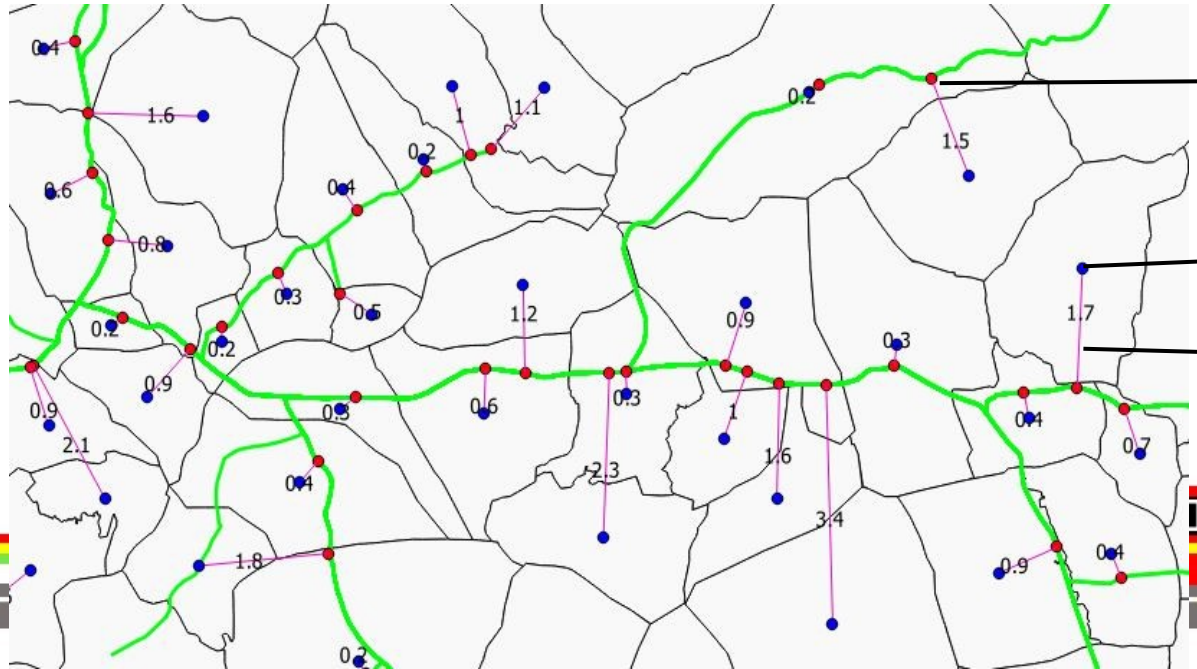
Vertices

- ***V*** = ***T*** ∪ ***F***
- **Data cleaning:** postgres query to find the distance between two vertices, the vertices which were <250 meters of distance were deleted
- Function used: ST_DistanceSphere(geom1, geom2)



Additional Definitions

- **Projections (P):** Point of shortest distance from village centroid
- **Hub distance:** Euclidian distance from village centroid to nearest route segment

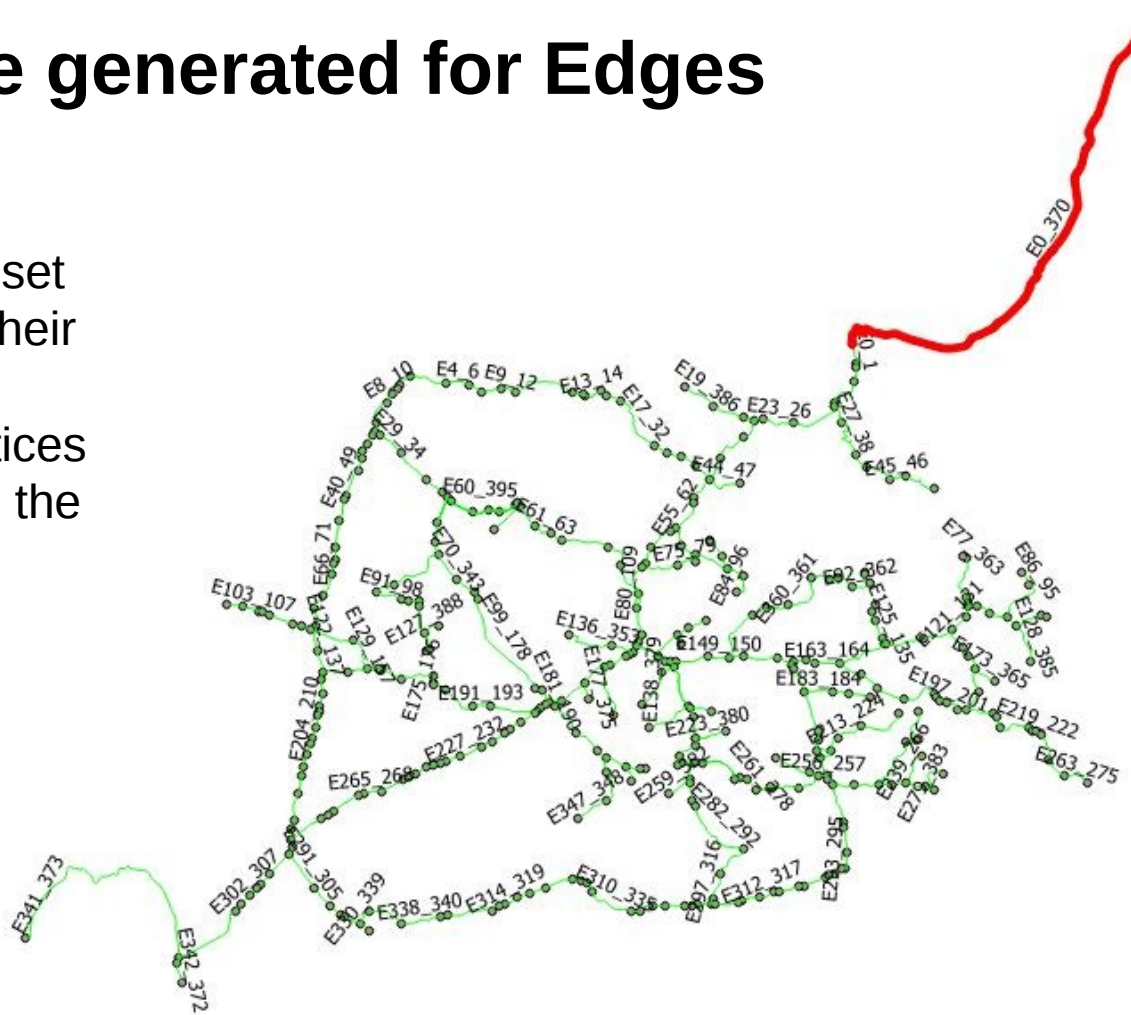


मी
माझं गाव
माझी एस. टी.

Shapefile generated for Edges

Steps to find edges:

1. Find V intersection RS set
2. Order the vertices wrt their route segment
3. For every adjacent vertices in a route-segment find the shortest-path



मी
माझं गाव
माझी एस. टी.

Limitations of current methodology

- Roads were considered bidirectional and single lane
- The system works well with Single part geometries
- System doesn’t consider gradient in terrain (given Shahapur is a hilly area)

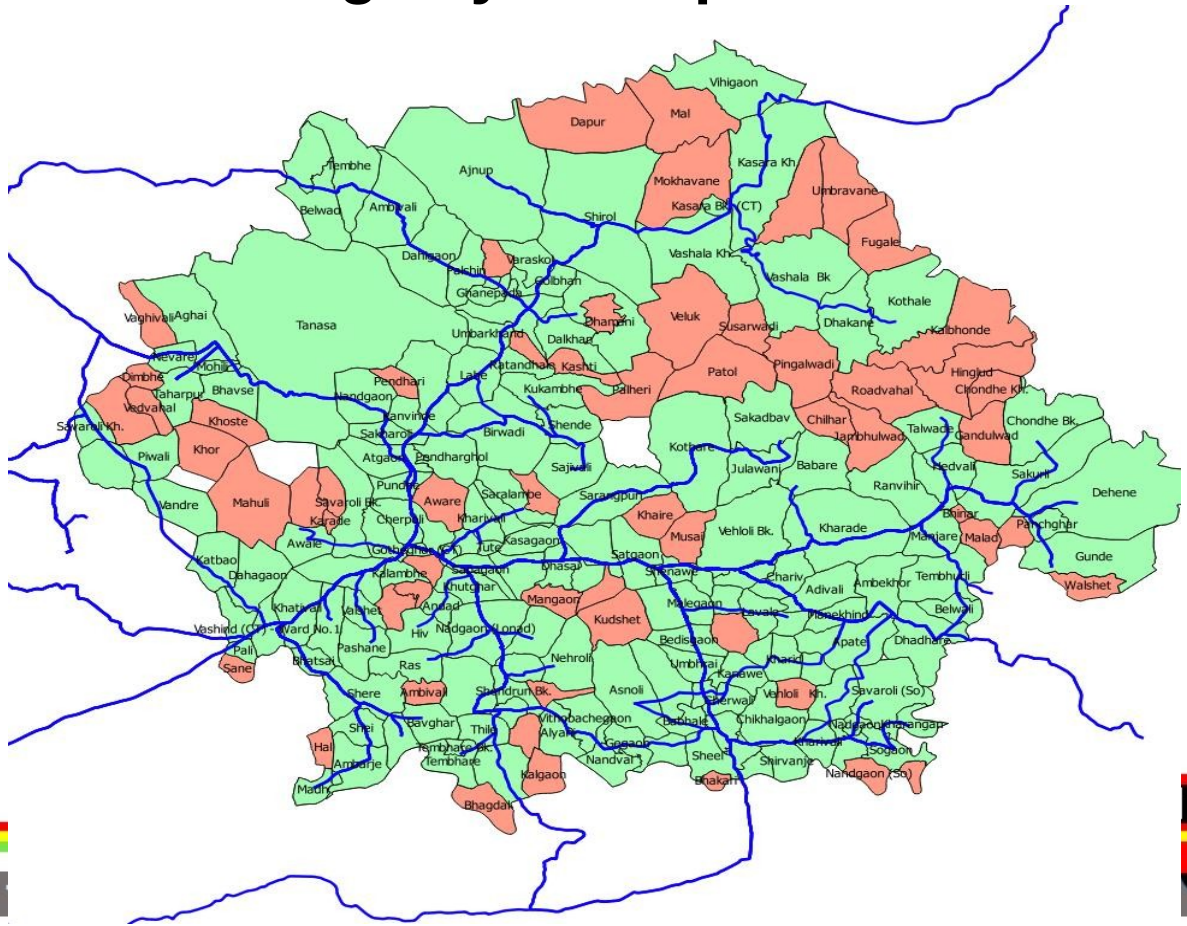
ADDING OPERATIONAL AND CENSUS DATA

Data Cleanup and Migration done for ABC data and form4

- **Duplicacy** in bus service-ids
- Consistent names of Termini
- Arrival departure values which were previously not in timestamp data-type that was rectified
- Missing values of timings were extrapolated and fixed
- Migration of ABC table from excel format to postgresql

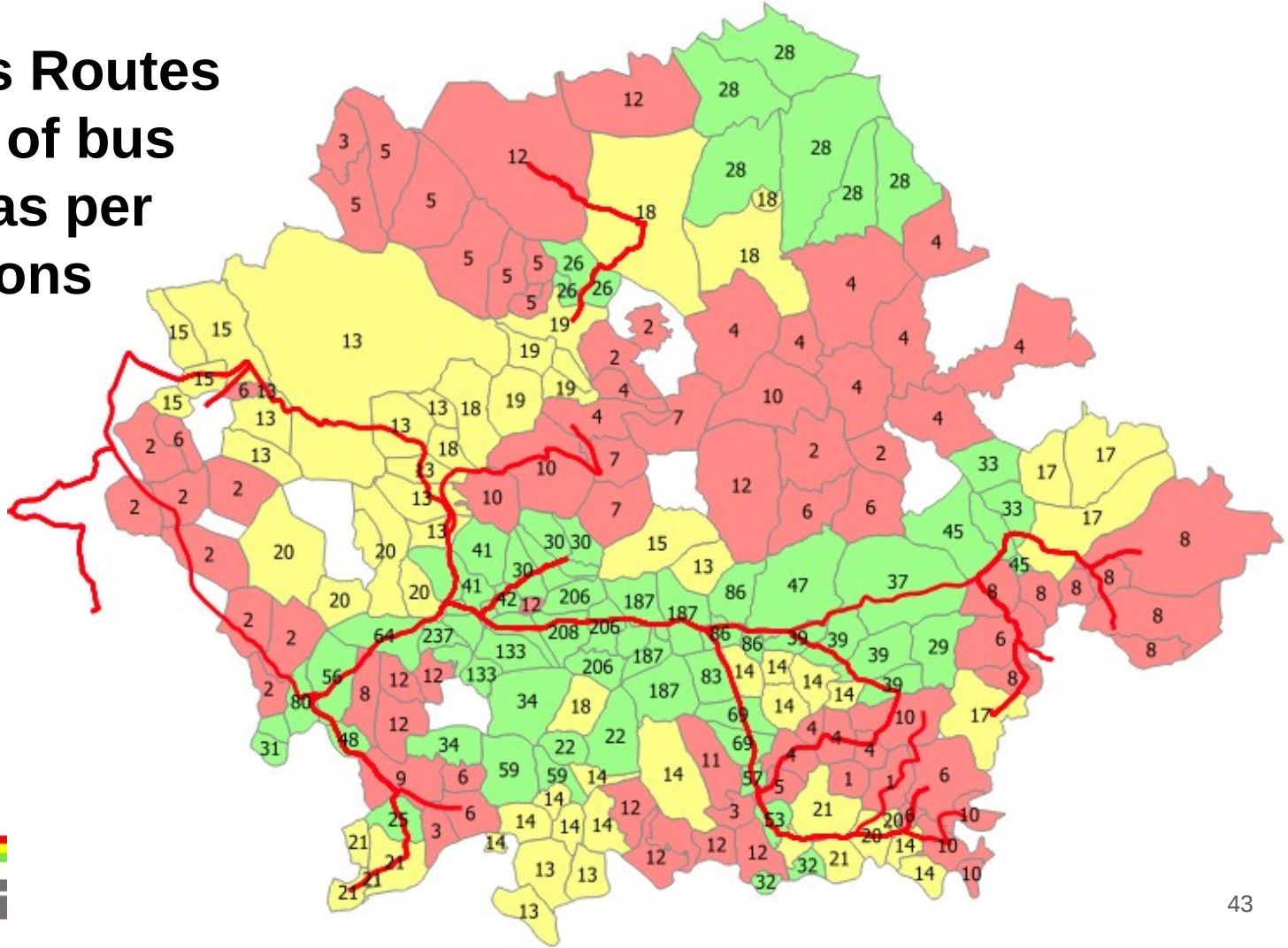
OUTPUTS

Coverage by Transportation



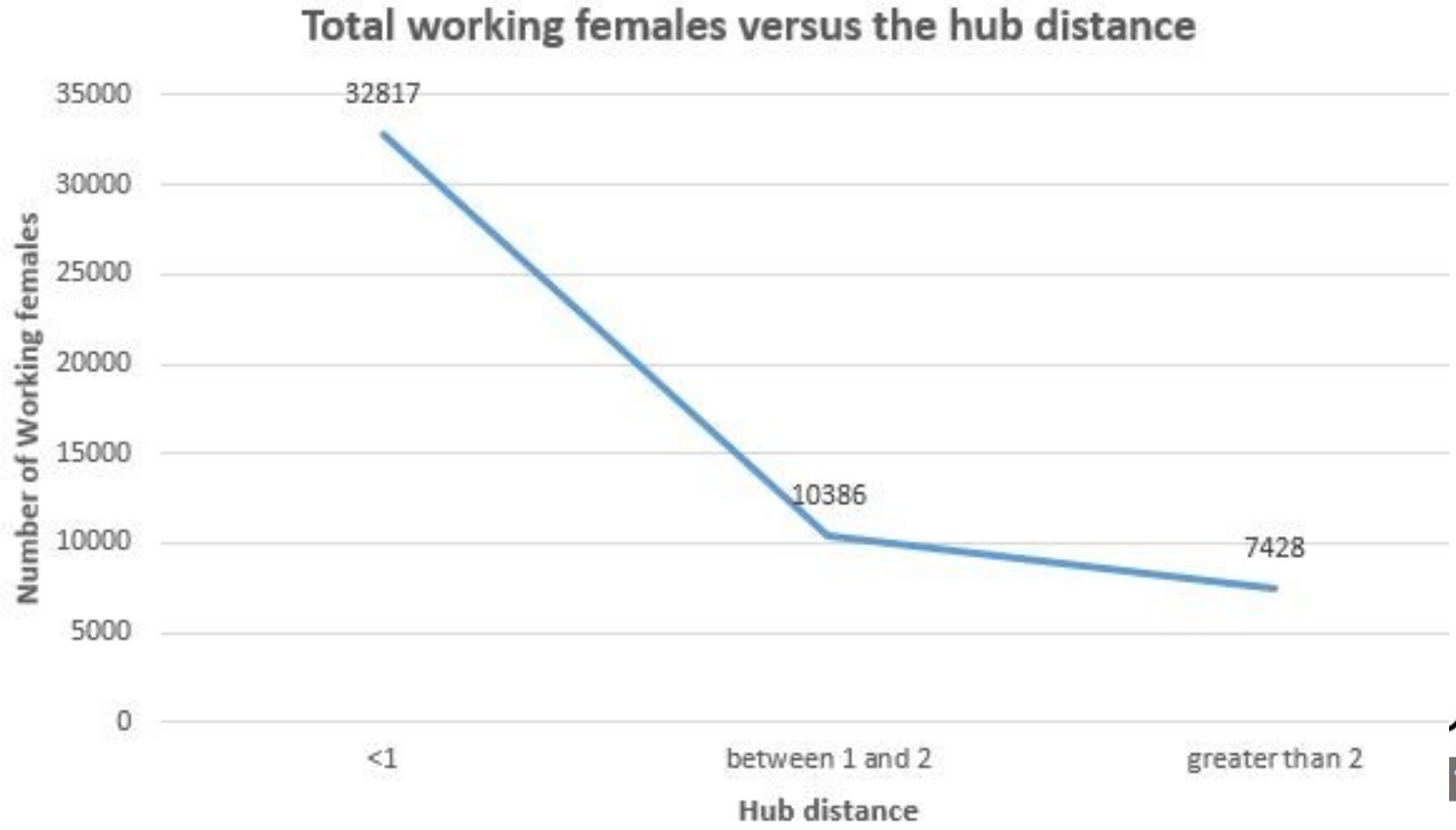
मी
माझं गाव
माझी एस. टी.

Manav Vikas Routes and count of bus services as per projections



मी
माझं गाव
माझी एस. टी.

Working Female population versus hub-distance in Shahapur Taluka



Field work at a glance

Duration and frequency

- 8 (1 day per visit) Visits to Shahapur Taluka depot
- One particular 3-day stay in Taluka to understand the daily schedule of traffic dept., depot manager
- 6 (1 day per visit) Visits to MSRTC Mumbai Central Office
- 2 (1 day per visit) Visits to Thane Division Office Traffic department

Agenda

- To understand the working of a bus-depot
- To collect relevant data and formats
- To understand the daily schedule/job roles in a depot
- To interview and survey non-MSRTC service providers

Conclusion

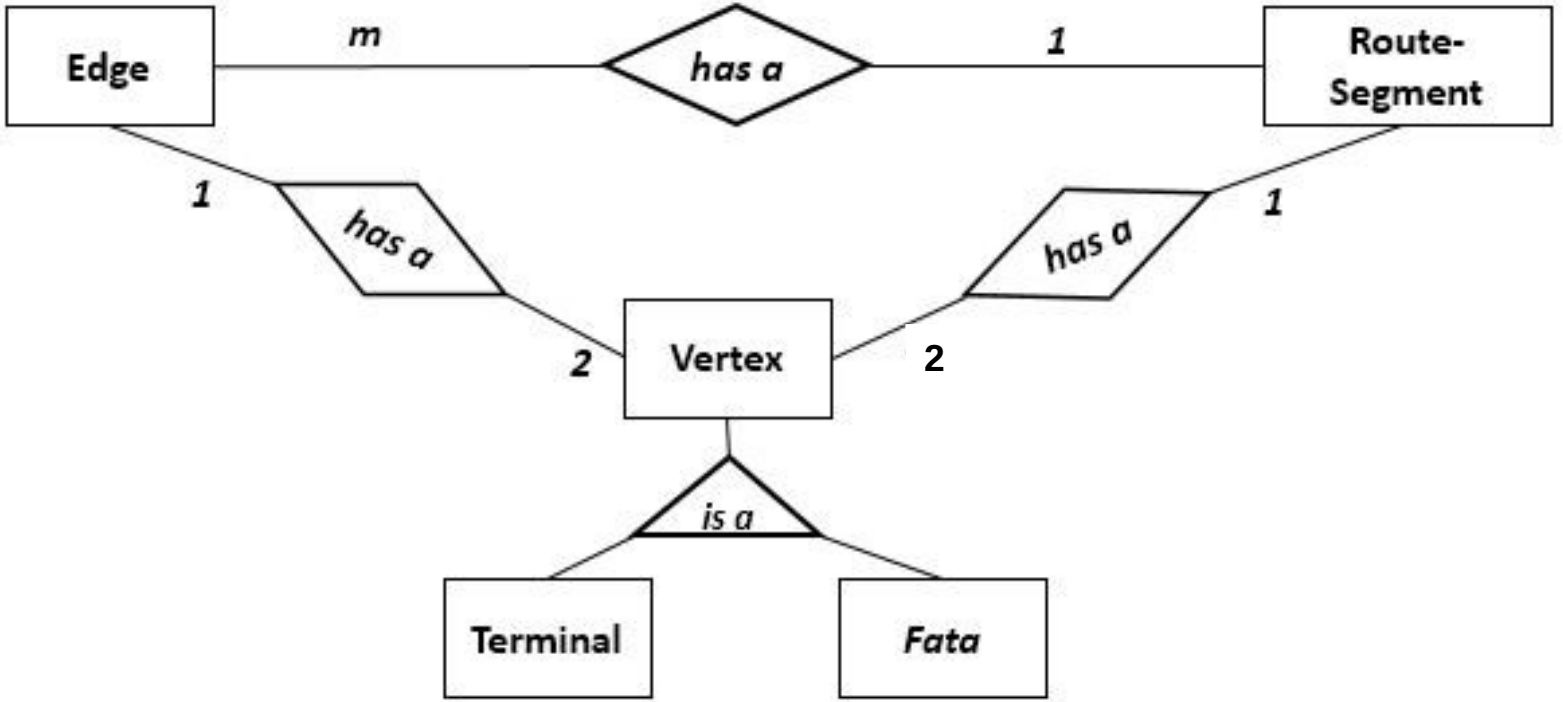
- Identification of ICT as a key ingredient in bus service provisioning
- Our system tries propose a methodology for converting given road network of MRSAC into Digital Geography
- This data should be given by default by MRSAC to MSRTC
- Digital Geography will help in strengthening our Taluka depots with better decision support systems so that Regional Transportation Development plan can be developed

Future scope

- Analysis of Punctuality data with profitability
- Rescheduling the bus services on the basis of network model
- Deeper analysis of multi-modal transportation in Shahapur Taluka
- **Testing the methodology in 3 talukas with different geographies and demographics**
- **Inter-city transportation analysis for tackling bus-bunching problem**
- **Identification of routes with maximum coverage, minimum distance and high profitability**

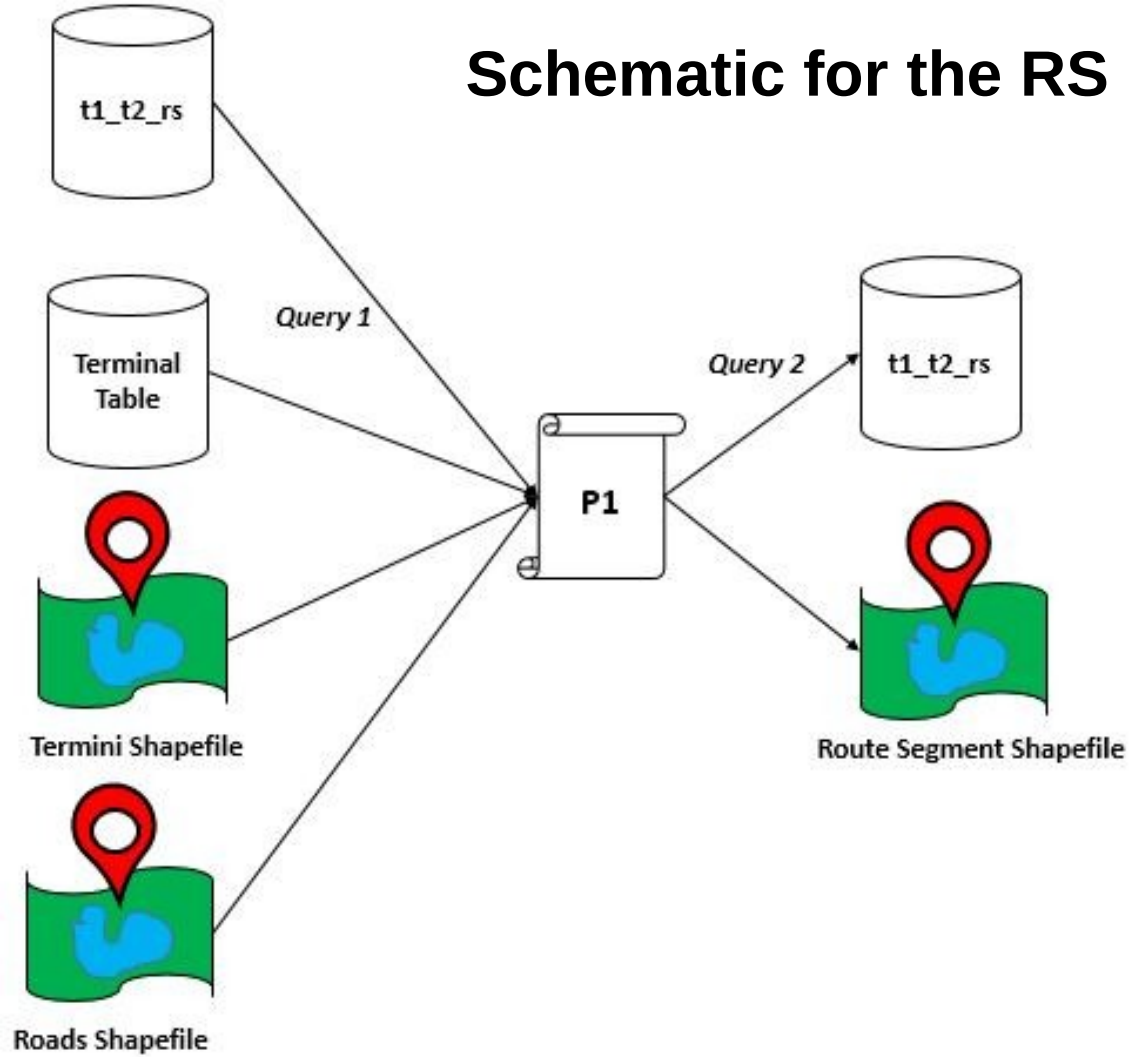
Thank you!

DATABASE DESIGN 1.0



मी
माझं गाव
माझी एस. टी.

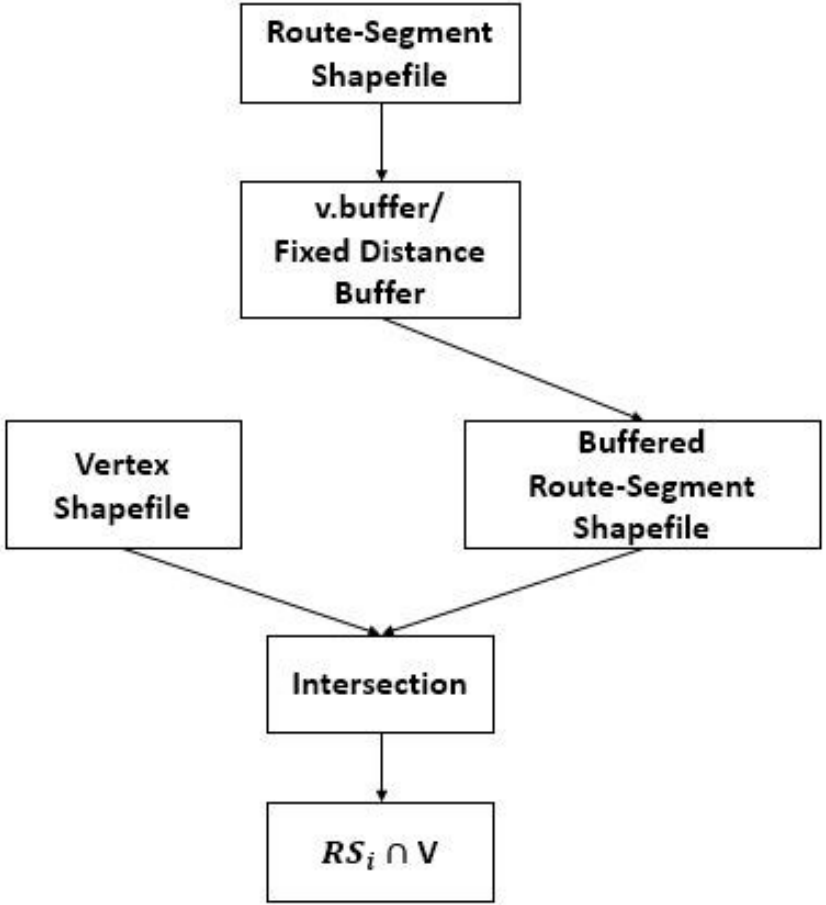
Schematic for the RS generation

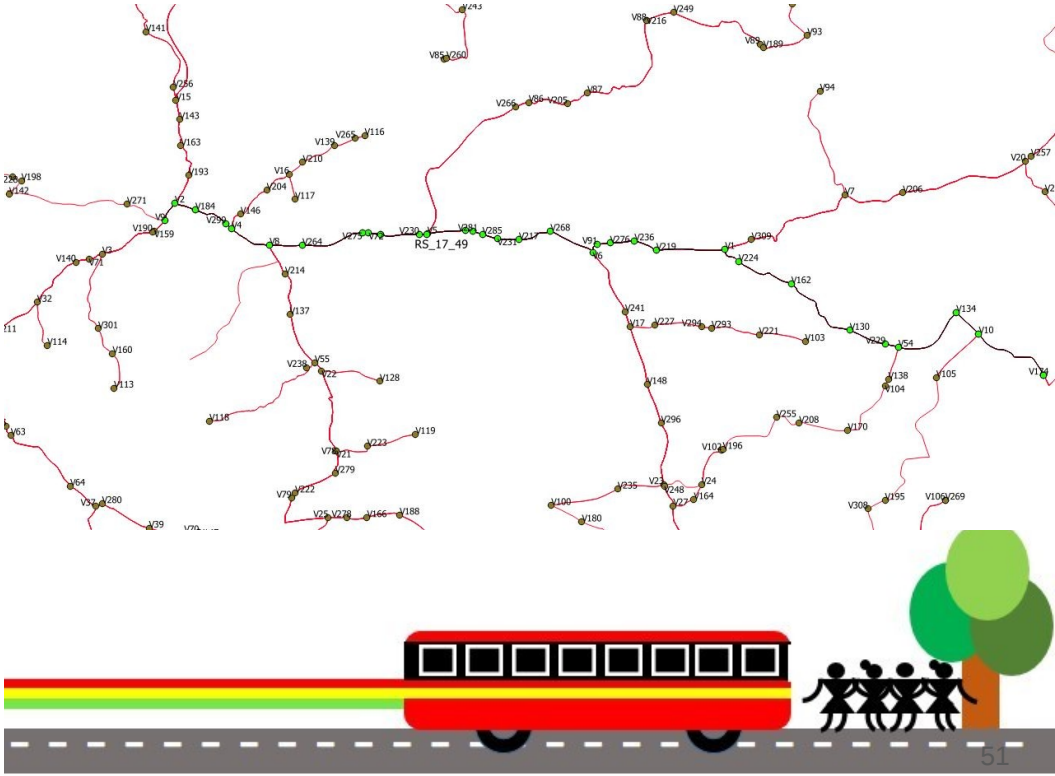


Here,
t1_t2_rs: Table consisting of combinations of termini
Termini table: Table consisting of geometries corresponding to termini
Query1: Inner join query that joins the two tables above
P1: python script that takes in the combinations of termini along with their lat-long; generates the shortest-path between them based on MRSAC data; generates the **route-segment id** and updates the geometry to **RS shapefile**

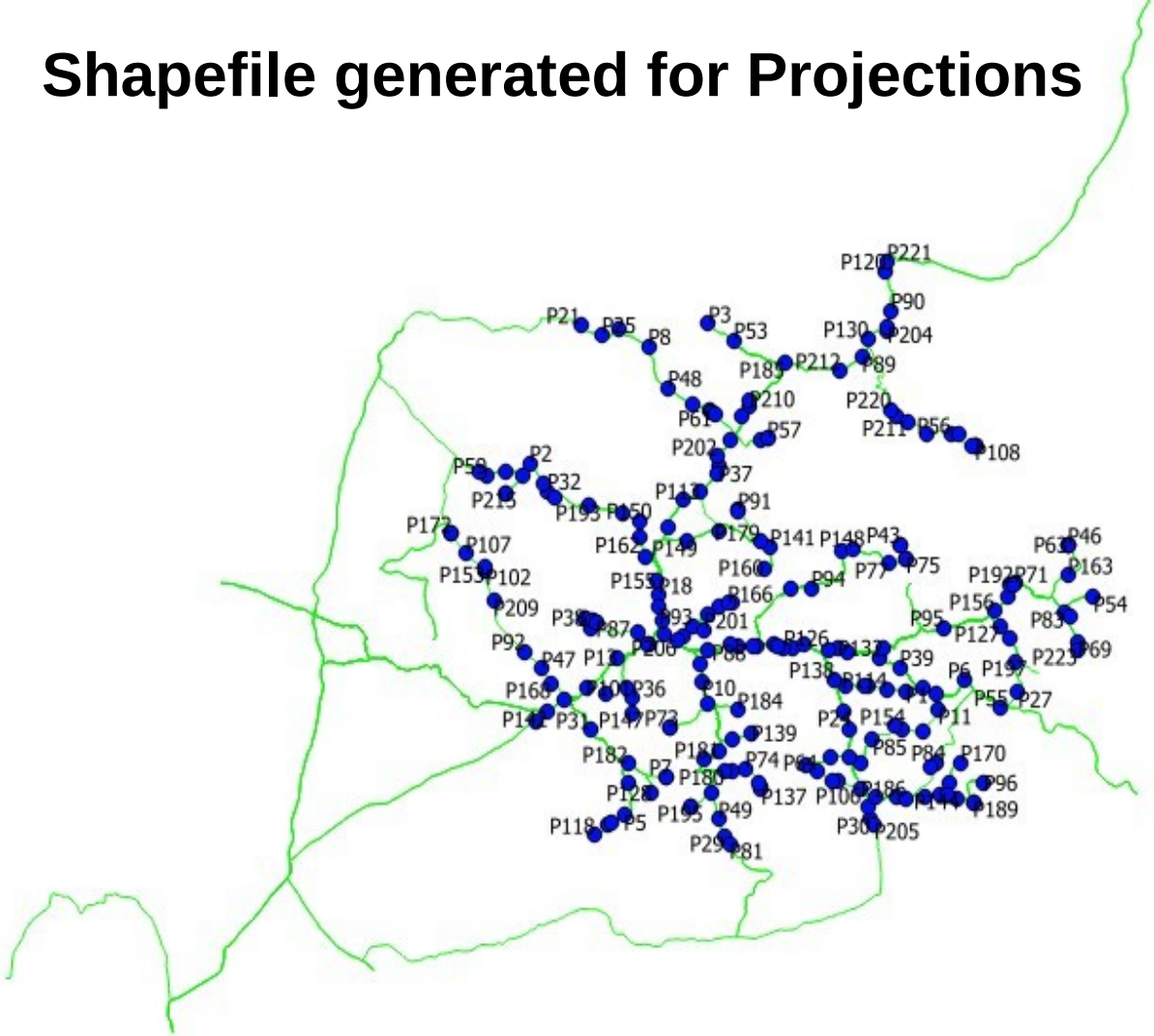
Query2: Update query to update **RS_id in t1_t2_rs**

Schematic V intersects RS



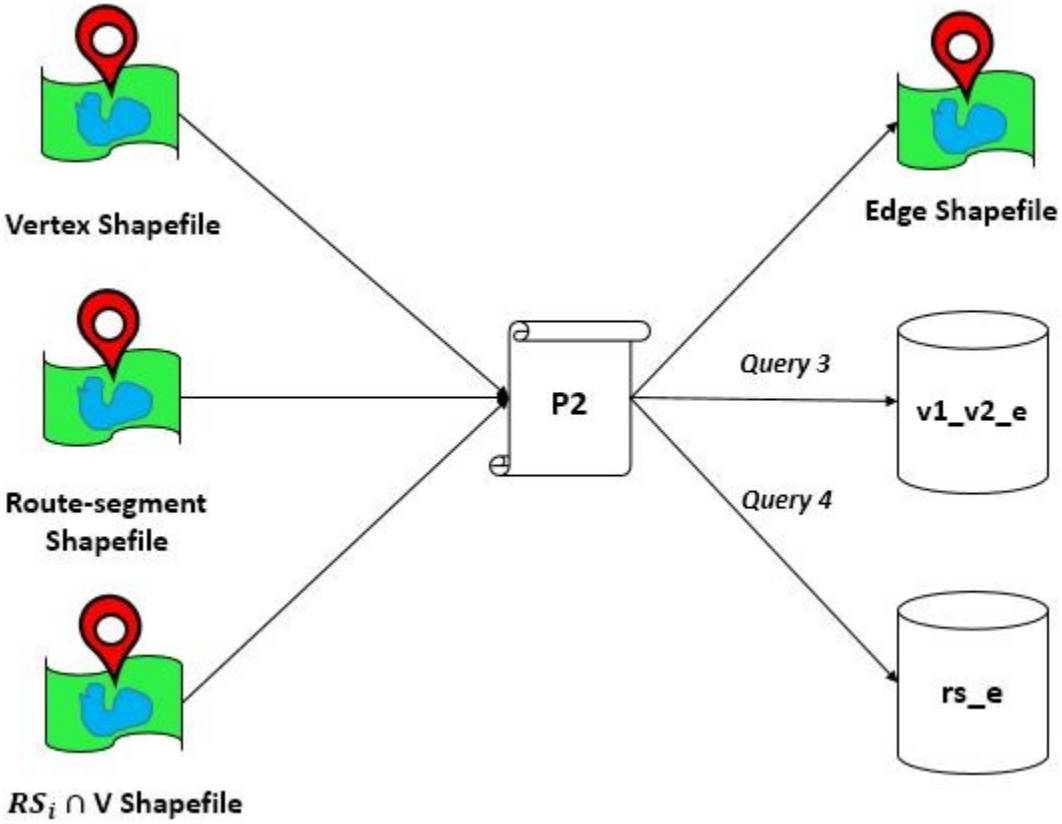


Shapefile generated for Projections



मी
माझं गाव
माझी एस. टी.

Schematic for Edge creation



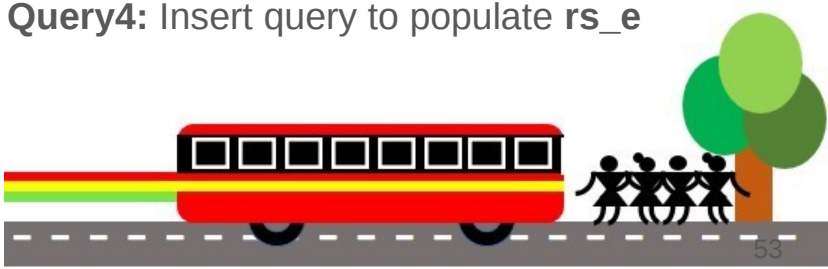
P2: fetches the geometries from the three shapefiles, creates **Edge Shapefile,** updates **v1_v2_e** with **Query 3,** updates **rs_e** with the ordered set of edges for each RS

v1_v2_e: table that stores the combinatorics of vertices wrt edges

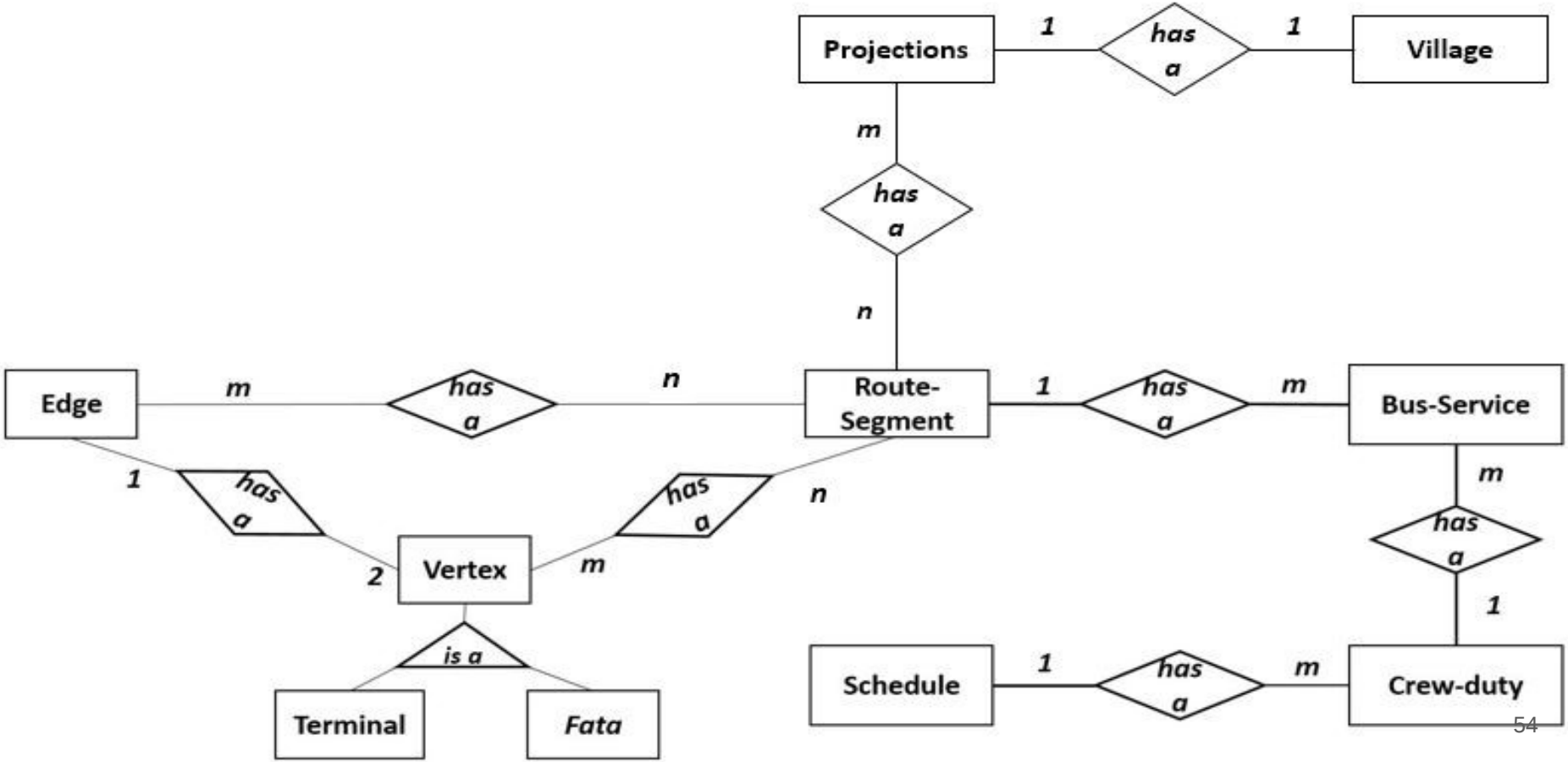
rs_e: table that stores the ordered set of edges for each RS

Query3: Insert query to populate **v1_v2_e**

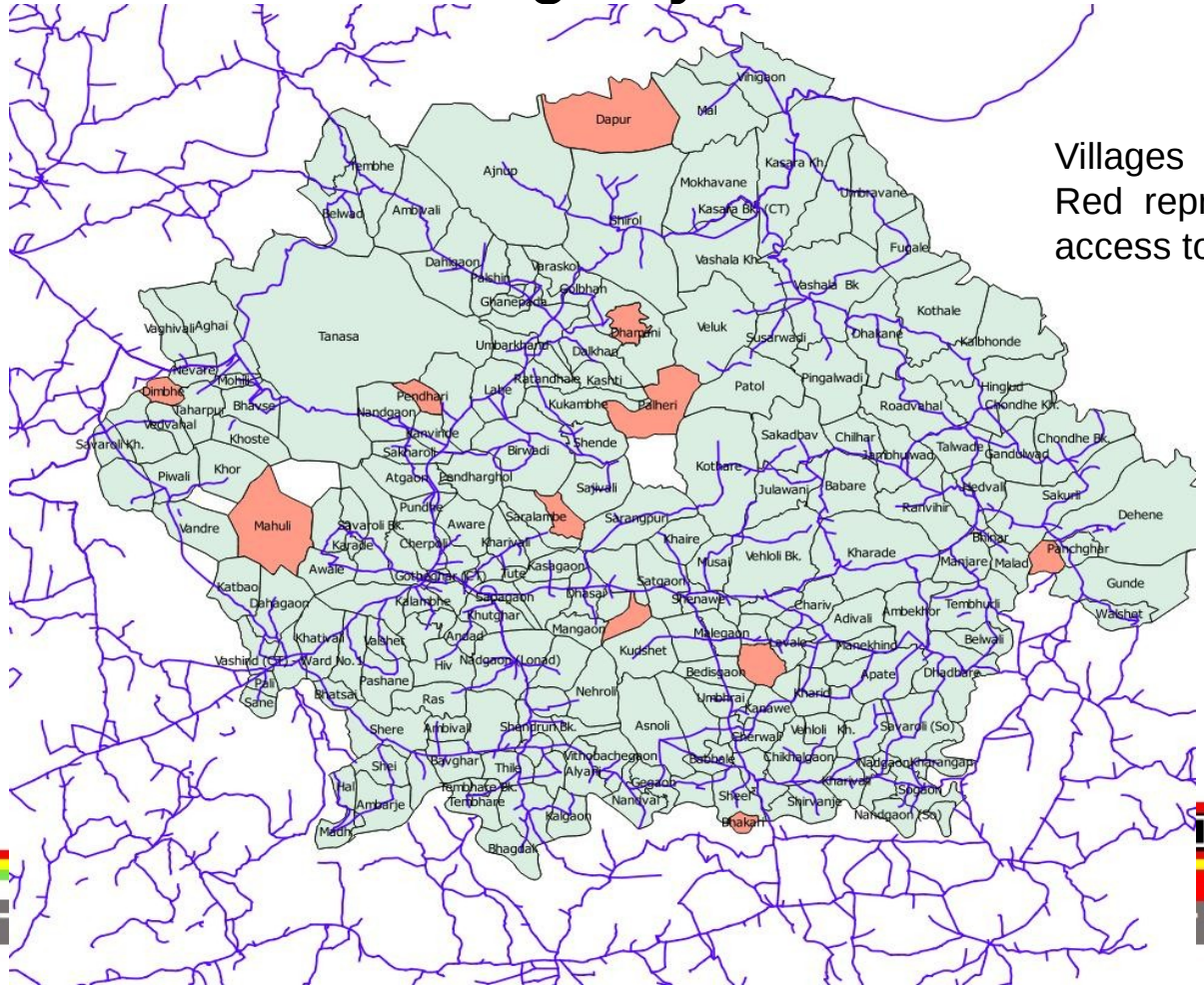
Query4: Insert query to populate **rs_e**



DATABASE DESIGN 1.2

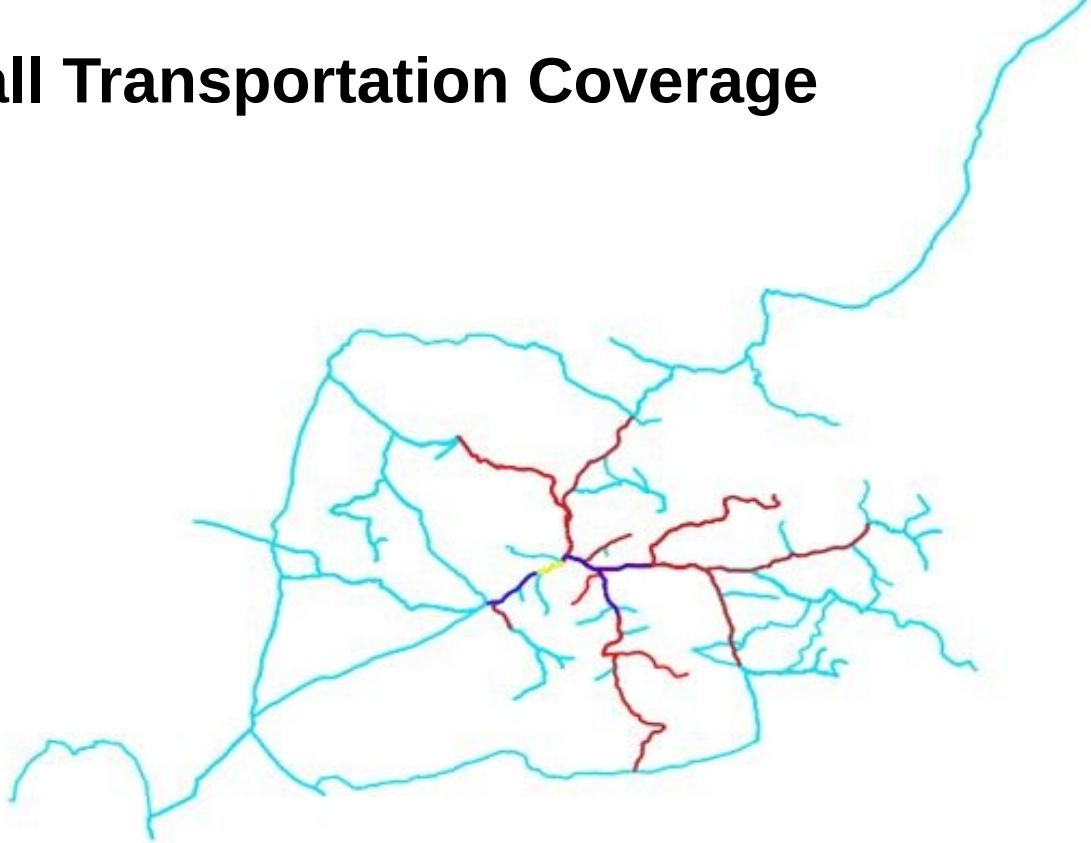


Coverage By Roads



Villages highlighted in Red represents no direct access to roads .

Overall Transportation Coverage

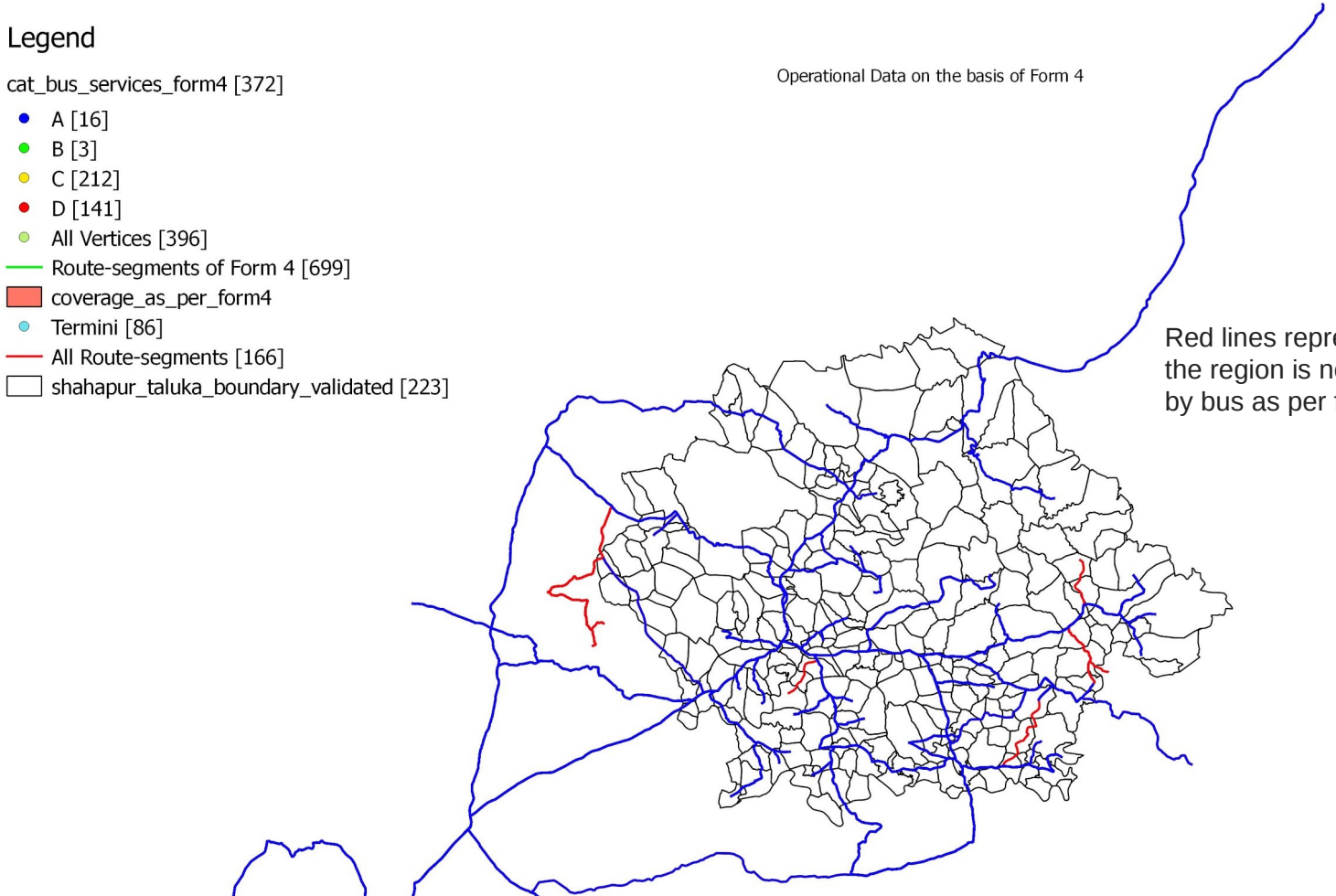


Legend:

- ST bus network
- Jeep network
- Minidor network
- Shared Auto-rickshaw network

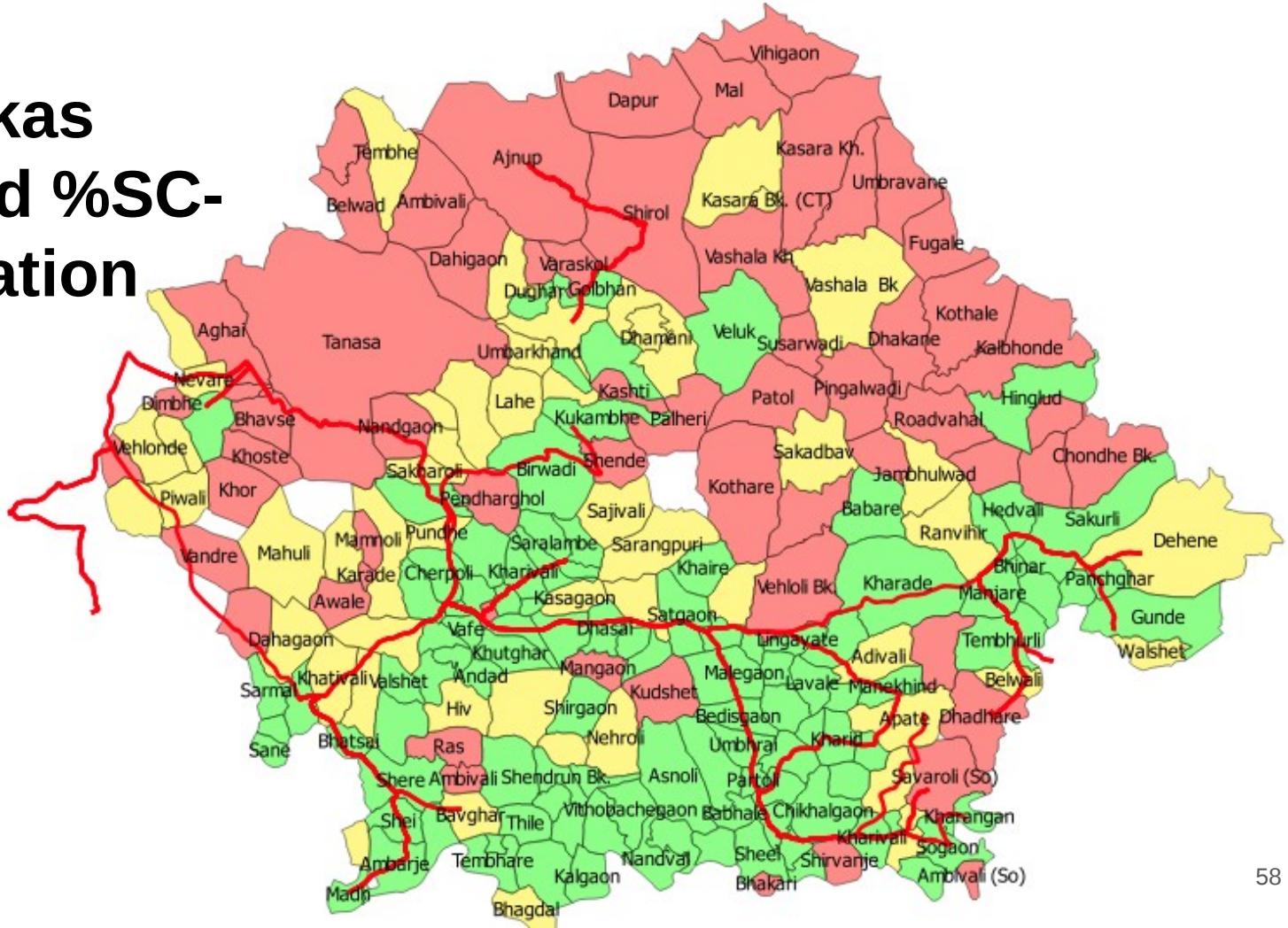
मी
माझं गाव
माझी एस. टी.

Operational Data of Form 4



Red lines represent that the region is not covered by bus as per form 4.

Manav-Vikas routes and %SC-ST Population



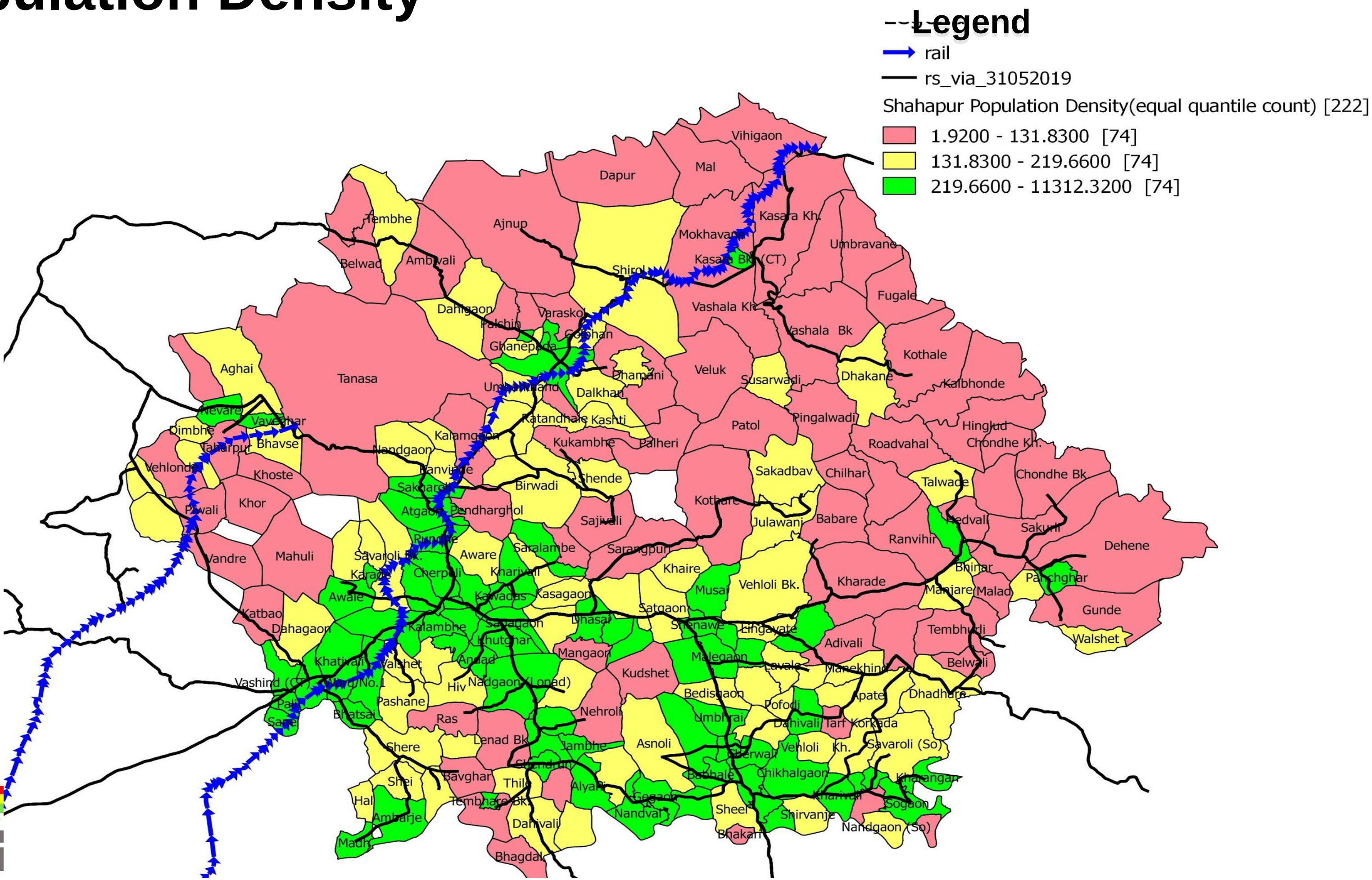
0 - 33

33 - 67

67 - 100

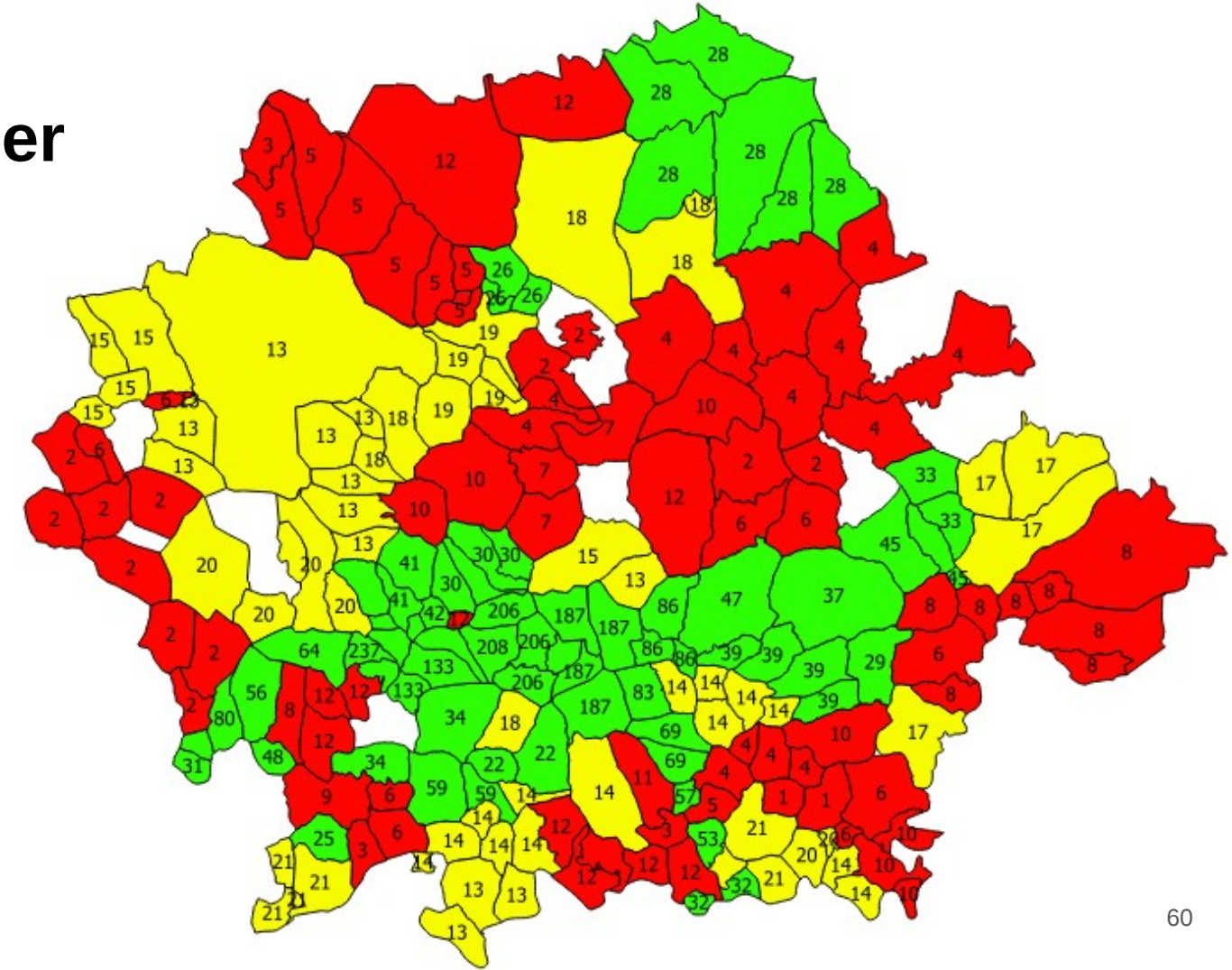
मी
माझं गाव
माझी एस. टी.

Population Density



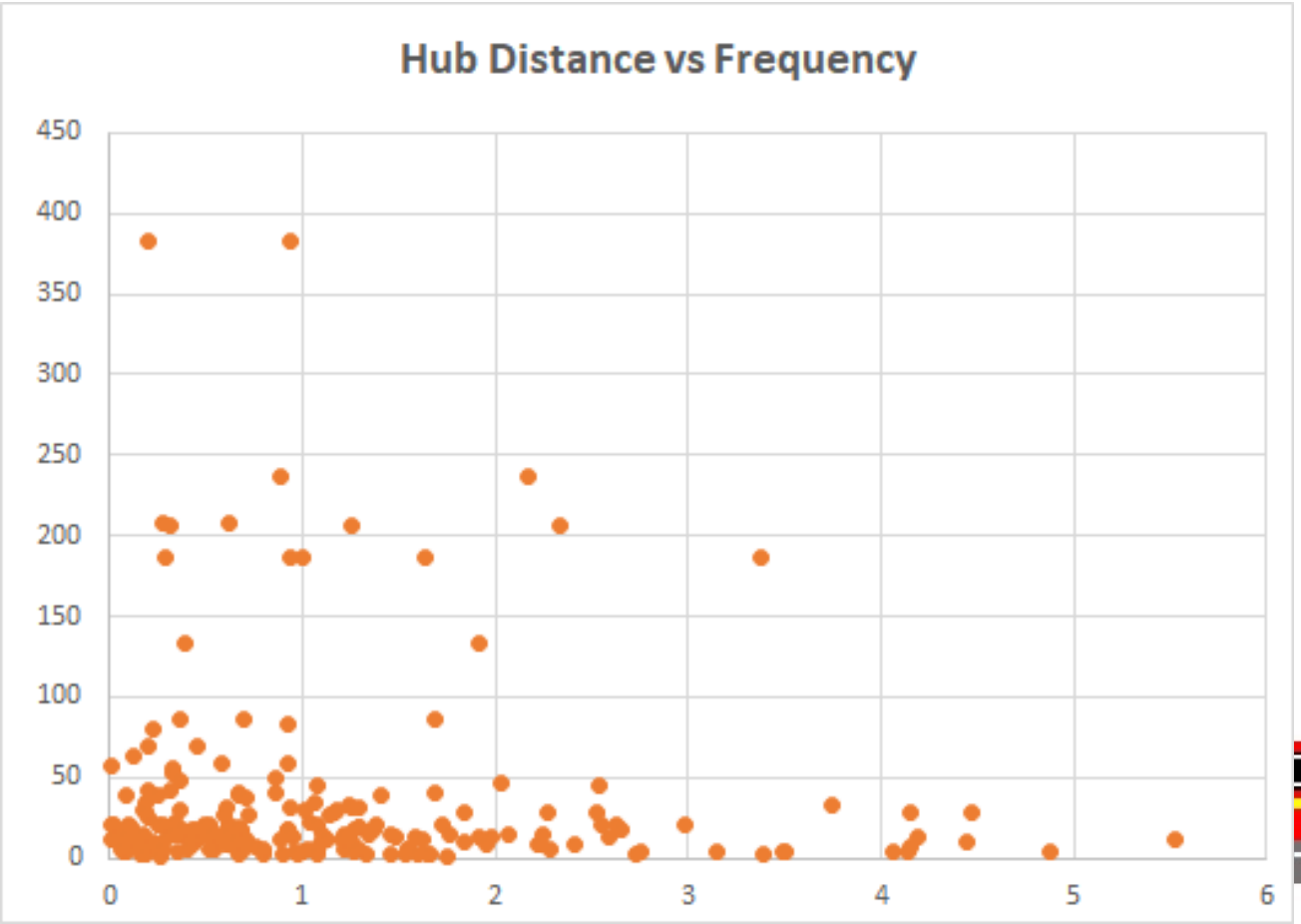
मी
माझं गाव
माझी एस.

Count of bus services as per form 4



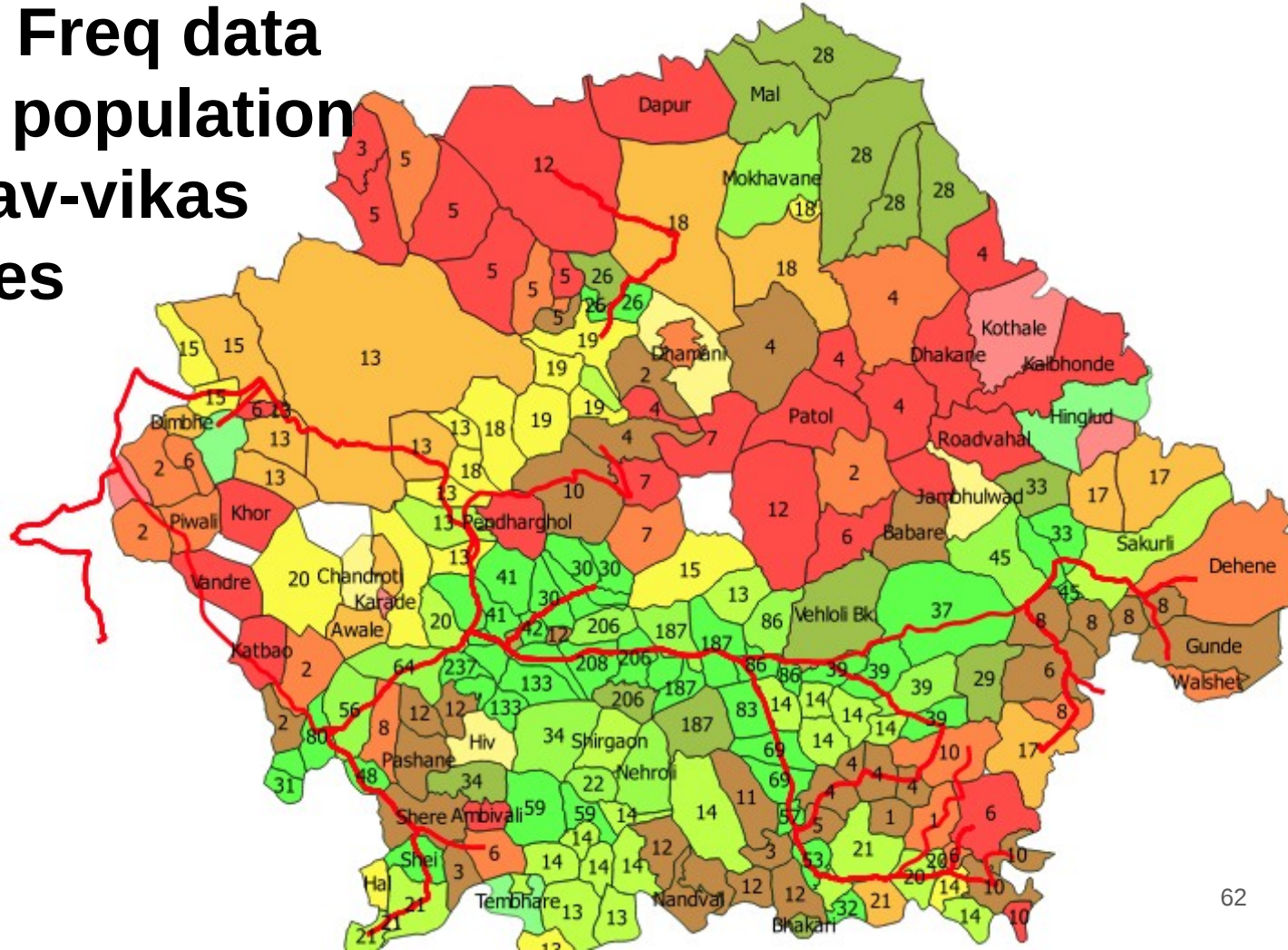
मी
माझं गाव
माझी एस. टी.

Hub Distance vs Frequency



	>10	<10
<1	186418	51374
>1	26555	29904

Overlapping Freq data over %SC-ST population Over Manav-vikas routes



मी
माझं गाव
माझी एस. टी.

Basic Crew Duty analysis of Form 4

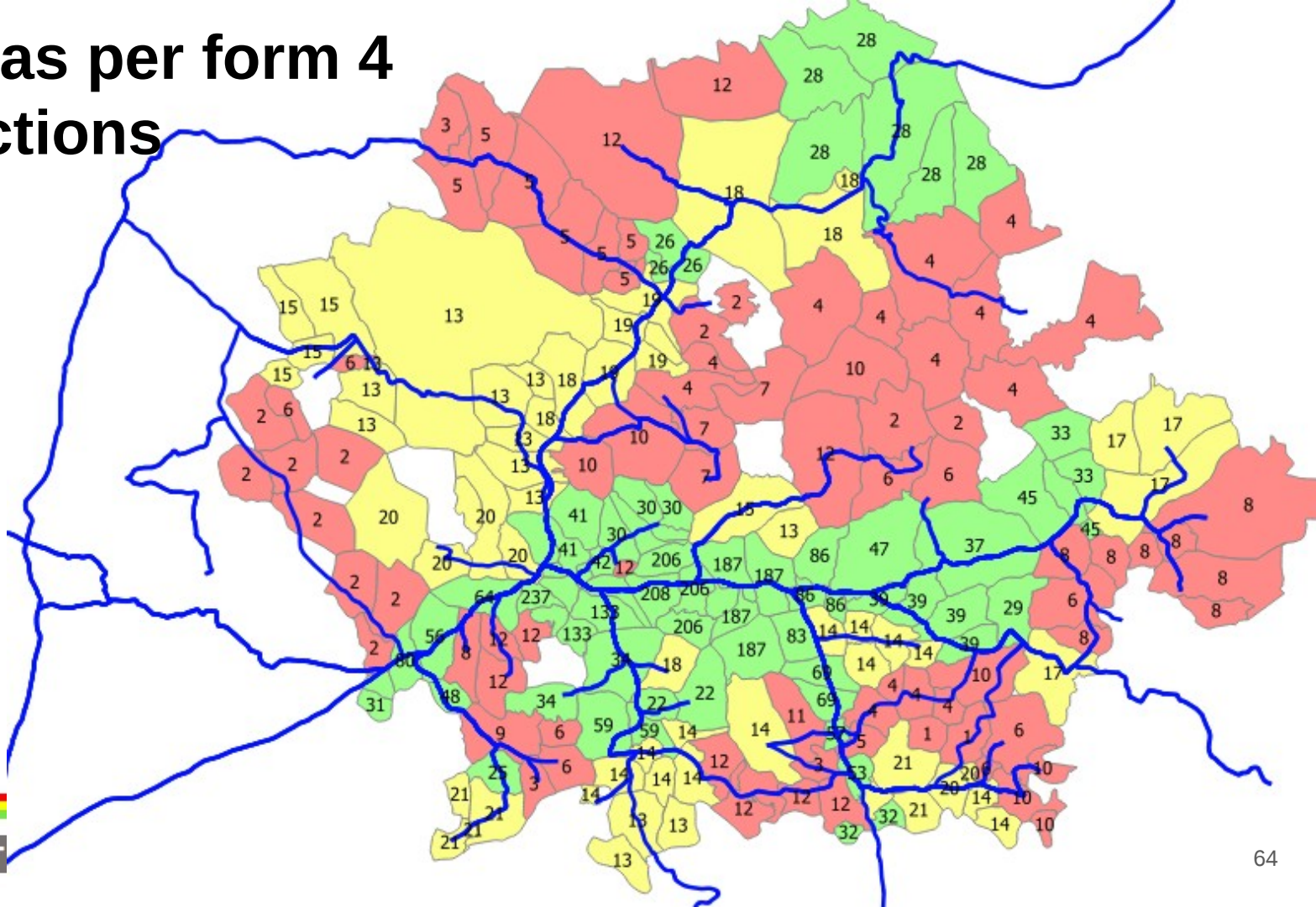
Total Schedules : 56

Total Crew Duties : 108

Total Duty Hours : 874 hours 25 mins

Total Occupied Hours : 637 hours

Coverage as per form 4 and projections



मी
माझं गाव
माझी एस. टी.