GIS-based Enterprise-level Decision Support framework for State Public Bus Transportation, Maharashtra, India (MSRTC)

under guidance of

Prof. Milind A. Sohoni

Presented by

Anshul kumar

(183350002)

Broad Societal Concern

- *“Poor Technological competence of State Public Bus Transportation Maharashtra, India”*

Problems with existing System (MSRTC)

- <u>Lack of convergence of Transportation, GIS-</u>
  - VTS System- Used for real-time tracking of Bus vehicles

  For last two years, one VTS system is being run at MSRTC, for 1 st year it run its trail in Nashik district, From Second year it is being replicated to complete Maharashtra. Apart from VTS, GIS interface is not being used by MSRTC in operations at Taluka level.

Research Output:

- GIS-based framework (digital geography) for Sinnar Taluka.
- Illustrating the Applications of proposed GIS-based framework.
- Benefits of GIS interface for MSRTC.
- Sinnar PHC Bus Scheduling in COVID-19 Epidemic time
- 3 QGIS plugin demonstrating GIS based framework meeting needs of stakeholders at MSRTC (Divisional Traffic officer)

Research Objectives

- To validate the GIS-based framework (digital geography) of shahapur by replicating on Sinnar as a proof of concept.

Research Question

DRQ. 1 What are the applications of the proposed GIS-based framework (Digital geography)? How is it beneficial in transportation?

DRQ. 2 What are the MSRTC stakeholders (Divisional Traffic Officer (DTO) and Bus Depot Manager) requirements from the proposed GIS framework?

Sinnar Taluka

Location- Nashik, Maharashtra

Area: 1,353 km² (census 2011)

Population: 346,390 (census 2011)

Load factor of Sinnar bus depot -

- 54-58% (without concession)
- 70% during the wedding season.
- 65% (with concession)

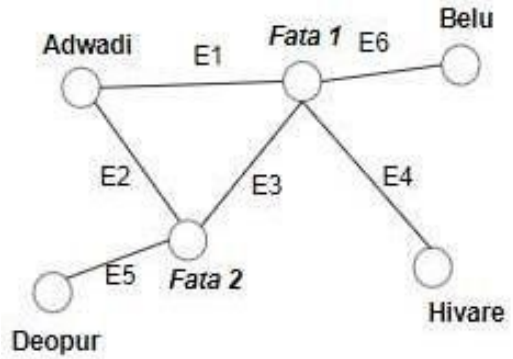
Sinnar Taluka *(Source: Wikipedia)*

Transportation Infrastructure-

- Proximity with Nearest Railway Station. Devlali railway station is about 25 km away from Sinnar depot.
- Proximity to Highways- Two highways pass through the Sinnar Taluka.

Digital Geography[1]

Technically, A digital geography is an undirected, planar graph G= (V, E) where:
V is a set of vertices.
E is a set of edges.



A Sample Graph *[1]*

Properties of a Vertex

1. Each vertex is a Point geometry.
2. Each vertex has a latitude and longitude.

Properties of an Edge

1. Each edge is a Polyline geometry.
2. Each edge e is an ordered set of vertices (v_i ,v_j) such that v_i and v_j ε Vertices.

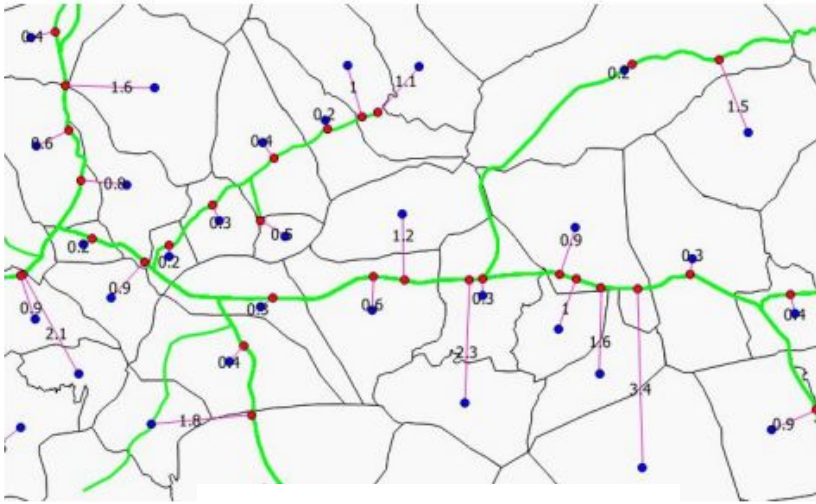
[1] Mr. Sudhanshu Kulkarni (2019), GIS Framework for Taluka Bus Transportation Analysis and Provisioning, Centre for Technology alteratives for rural area, IIT Bombay

MSRTC Bus Network on Digital Geography [1]

- In simple words, Mapping of a region's demographics with MSRTC operational data on GIS interface.

Elements-

- Sinnar Villages
- Sinnar Road Network
- ST Route Network / ST Roads (Roads on which ST buses runs).
- ST Fatas (Point where bus passenger can switch ST buses for changing bus route).
- Village Projections (Point where a village is projected on ST route network)



Village Projections

[1] Mr. Sudanshu Kulkarni (2019), GIS Framework for Taluka Bus Transportation Analysis and Provisioning, Centre for Technology alteratives for rural area, IIT Bombay

ABC Analysis (Profitability Analysis)

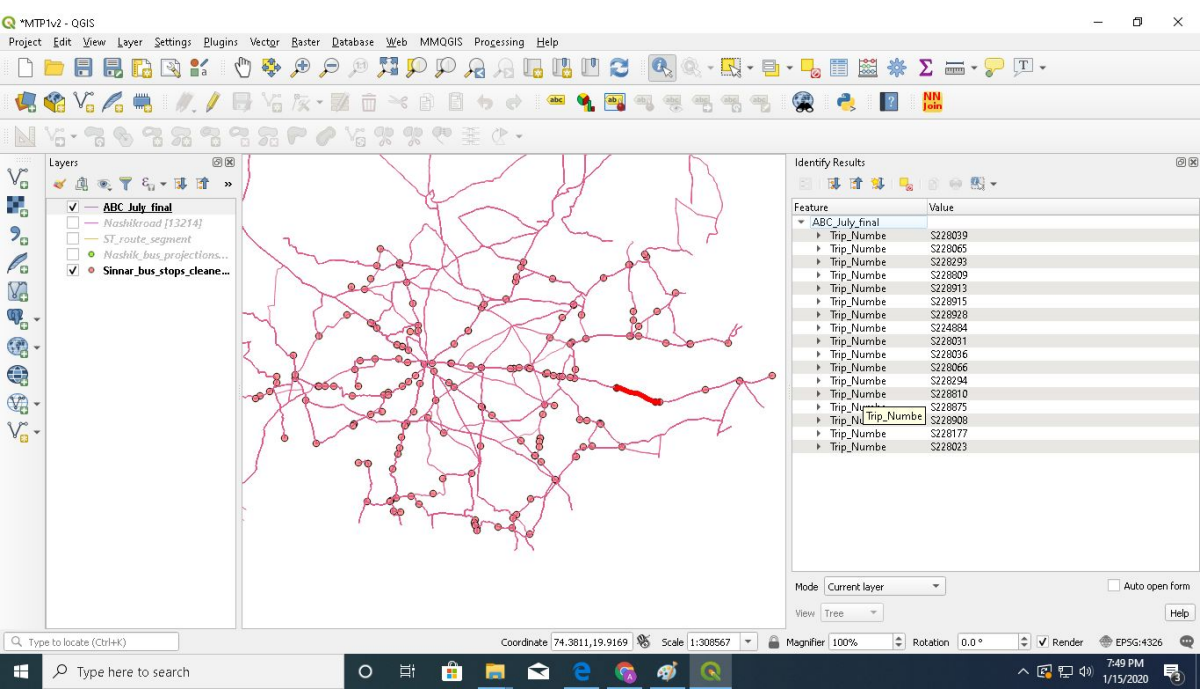
Total number of Trips in for Sinnar July 2019=680
No. of Trips having ABC_Status=”A”=36
No. of Trips having ABC_Status=”B”=263
No. of Trips having ABC_Status=”C”=381

Physical Meaning-
“A” Trips are Profitable having EPKM > Rs. 43.32 / km
“B” Trips are having EPKM between Rs. 43.32 and Rs. 22.1 /km
“C” Trips are in loss having EPKM< 22.1 /km.

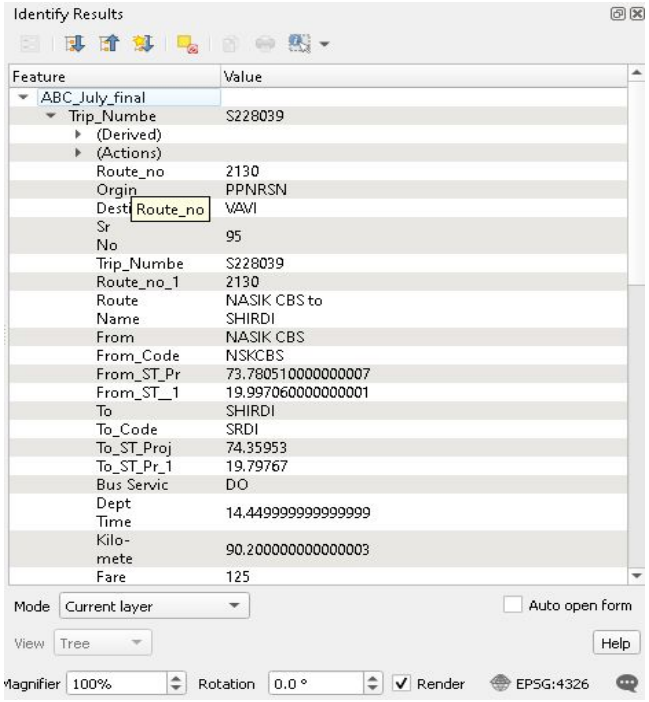
Conclusion- “C” status trips needs more attention. Further there are very few trips which are profitable.

*EPKM- Earning Per Kilometer

ABC Analysis Representation on Digital Geography



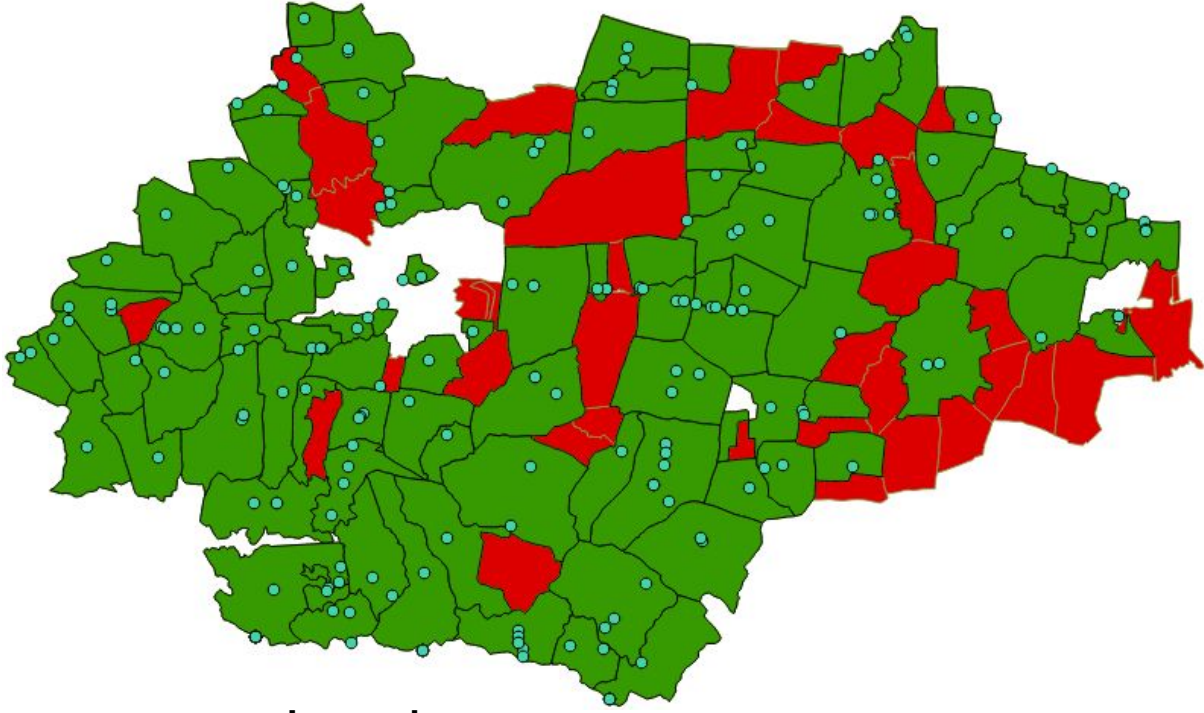
Click on any route Segment, All the Trip passing through the route segment will appear right



ABC details of Bus Trip S228039 by clicking on ‘S228039;

Applications of Digital Geography-

Analysis: Villages having Bus Stops



Total No. of villages in Sinnar -128 (As per census 2011)

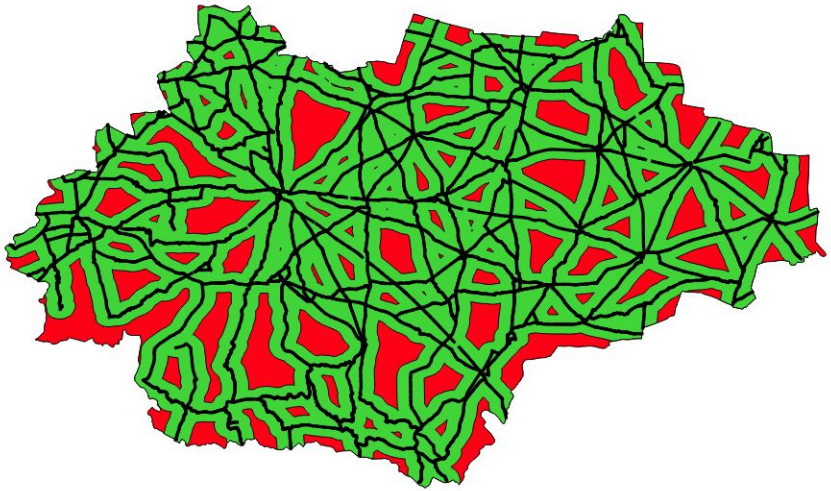
No. of villages having Bus Stops- 98

Percentage of village having Bus Stops- 75.4%

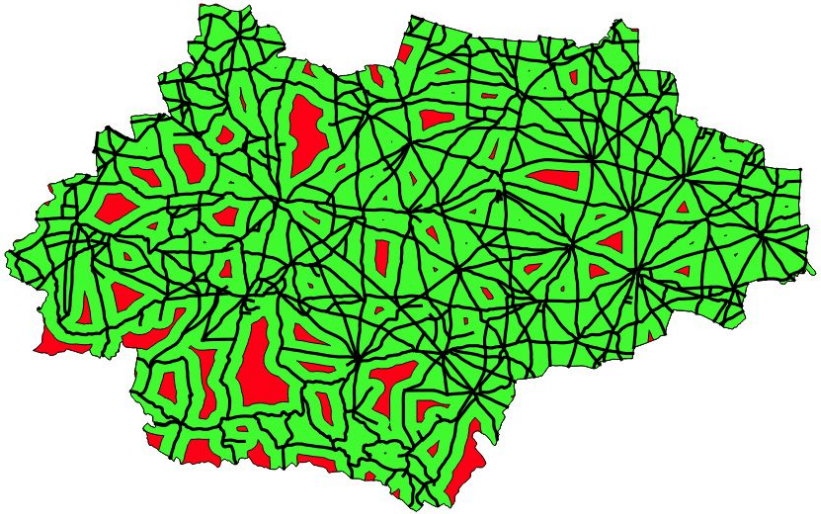
Legends-
Blue dots representing Bus Stops
Green region representing villages having Bus Stop
Red region representing villages having Bus Stop

Sinnar ST Route Coverage:

Here ST road coverage has been calculated considering coverage area as 1 Km within ST road reach. Similarly Sinnar Road Network coverage has been calculated. Green region representing area within 1 km reach of ST road. Red region beyond 1 Km

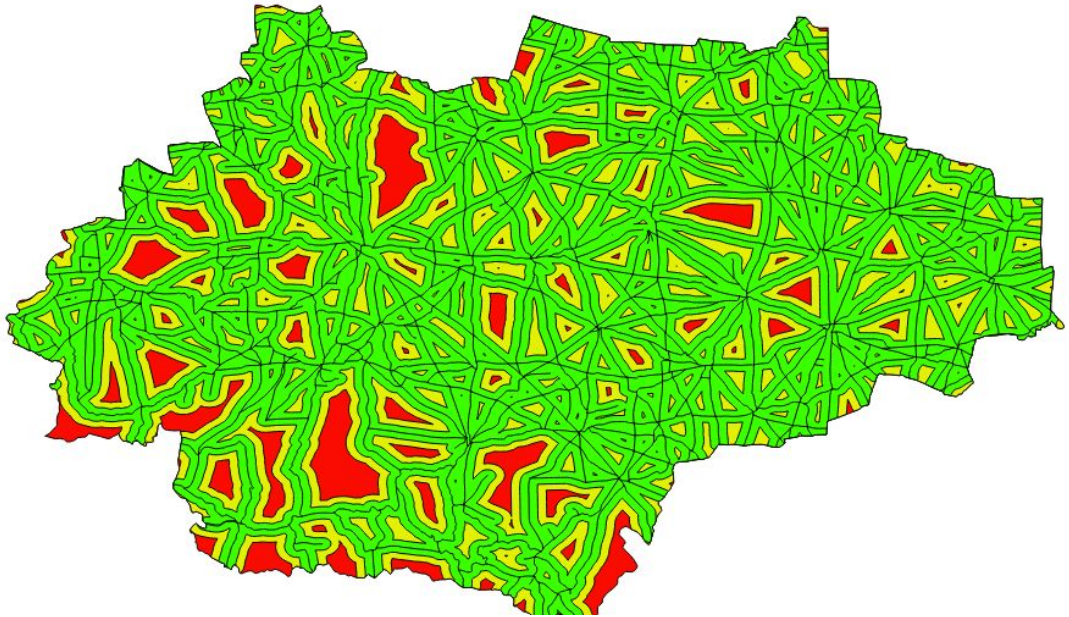


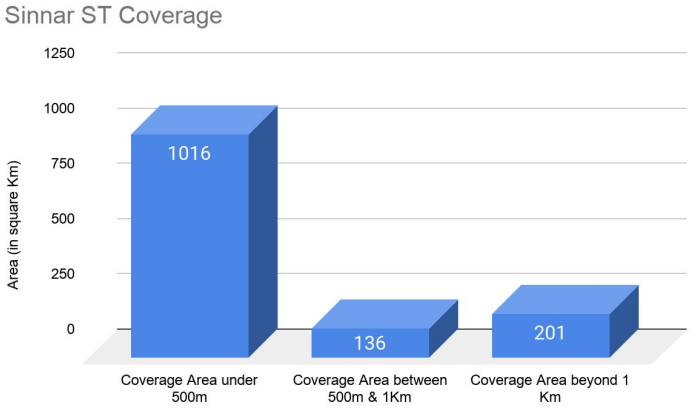
Sinnar ST Route coverage area 80.07%

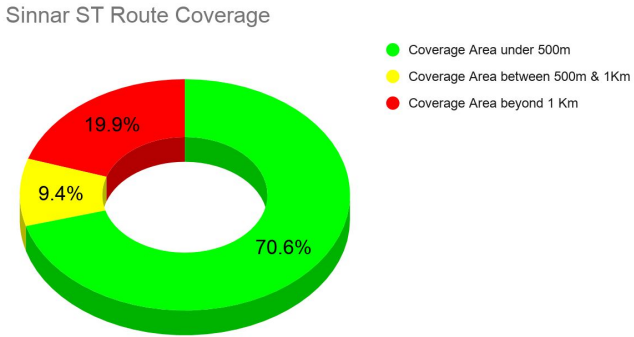


Sinnar Road coverage area 91.55%

Sinnar ST Route Mulitiple range Coverage Analysis-



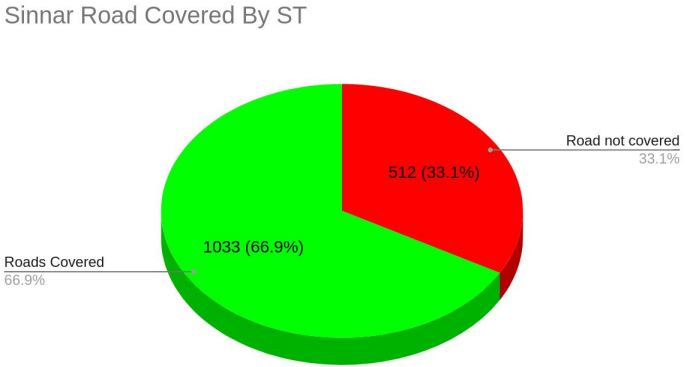




Physical Significance- Red Regions are those which are beyond 1.5 Km from ST Route. So, needs special attention.

Sinnar Road Coverage Analysis-

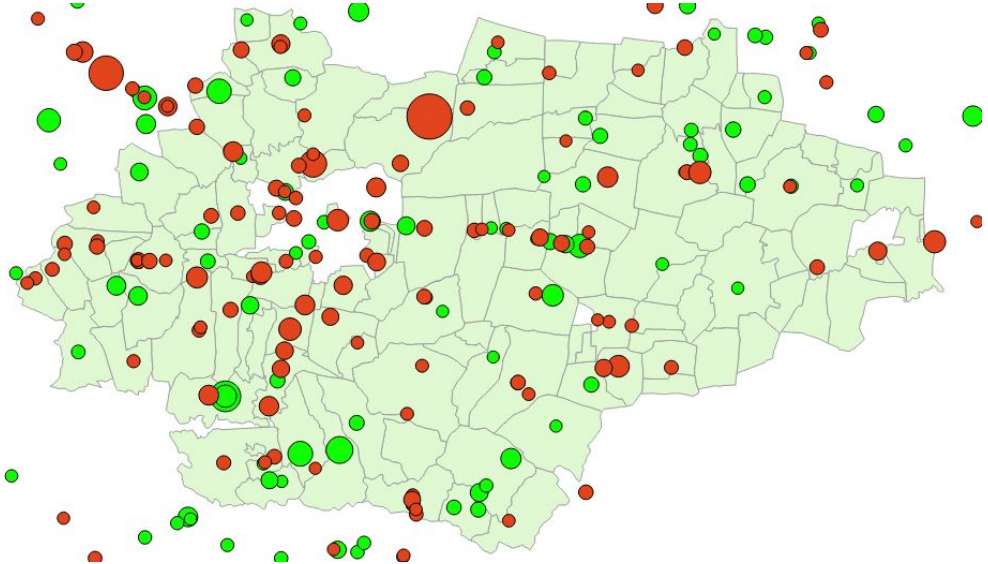
Sinnar ST road Coverage by ST-66.91%



Legend:
Green Lines representing Roads covered by ST
Red Lines representing Roads not covered by ST

Physical Significance-
Red lines are those where ST buses don't run. To improve coverage of an area, ST can try to run buses on these roads.

Bus Stop Dependency Analysis-



This Analysis shows the imbalance of incoming passenger and outgoing passenger on a bus stop based on tickets issued.

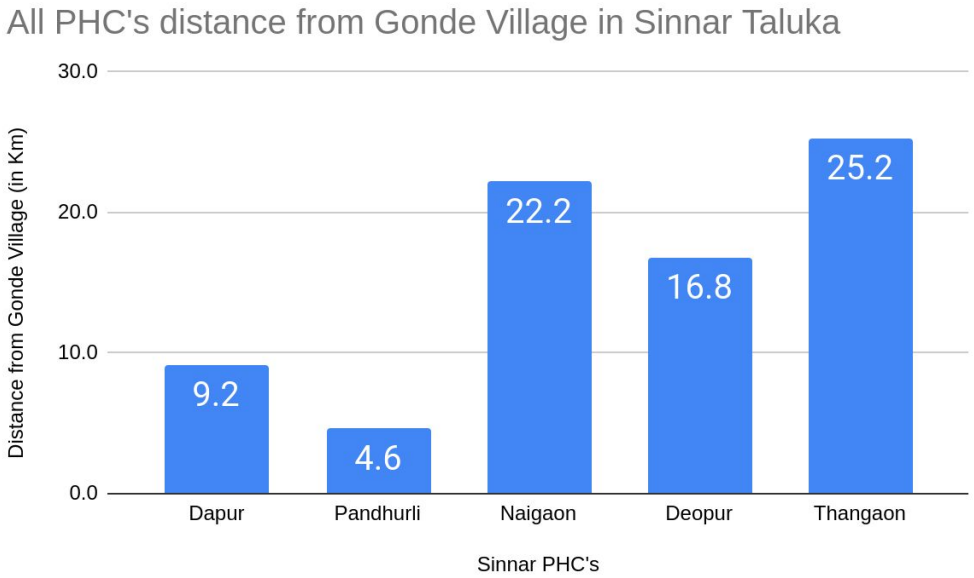
Greater the circle, greater is the imbalance.

This analysis has been done on Sinnar July 2019 ETIM data, Similar can be replicated for 1 year for better accuracy.

Legends:
Green circles represents Incoming passengers are greater then outgoing passengers and
Red circles vice versa.

Physical Significance-
Imbalance in incoming and outgoing passengers denotes use of other means of transport like private transportation services, etc for going or coming in villages. Larger the circle means availability of other means of transportation.
* Reason hasn't validated through field survey

Sinnar Village to PHC distance via road

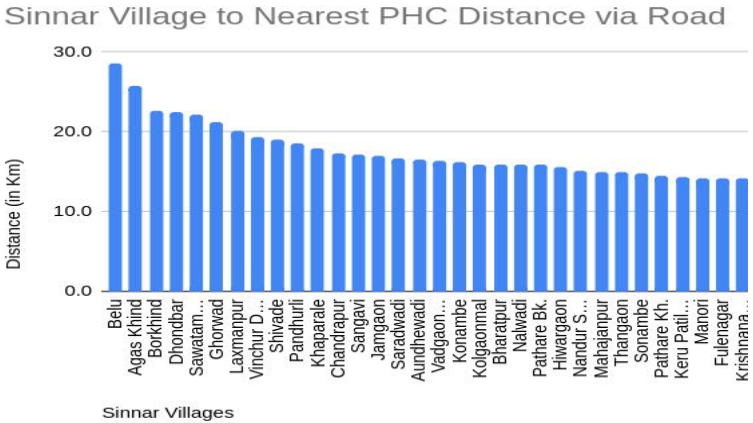


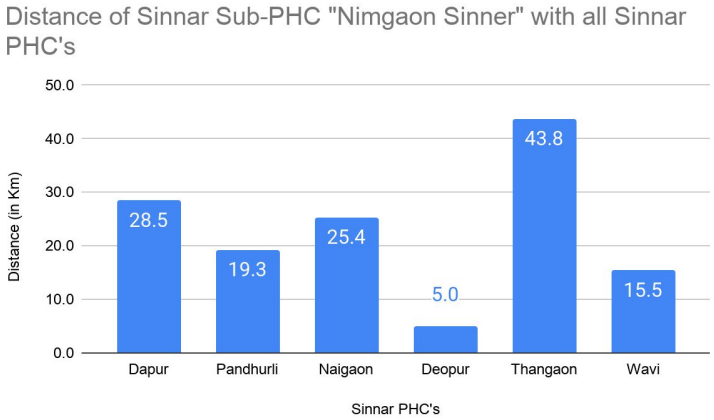
Village Name	PHC	Distance (in km)
Gonde	Dapur	9.2
Gonde	Pandhurli	4.6
Gonde	Naigaon	22.2
Gonde	Deopur	16.8
Gonde	Thangaon	25.2

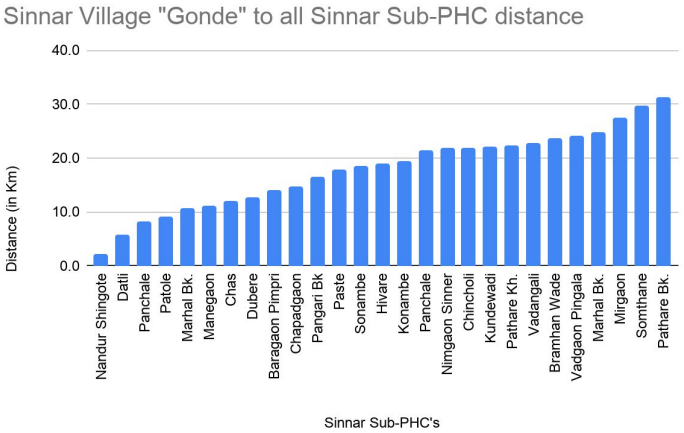
Sinnar Village (Gonde) to All Sinnar PHC distance

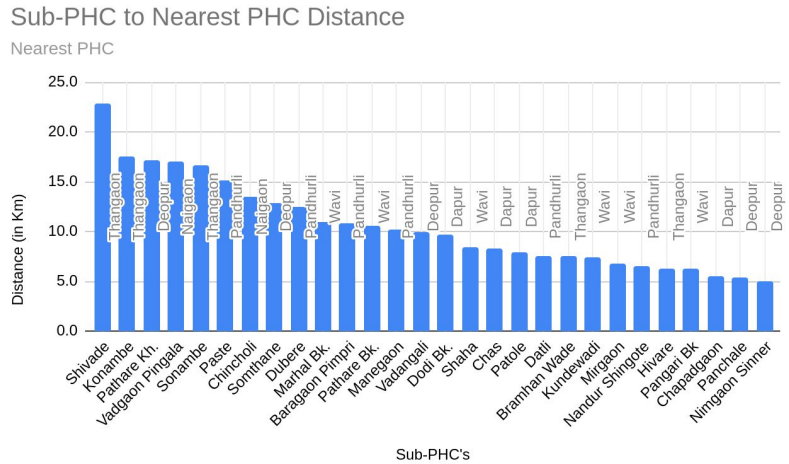
Physical Significance-

Through Digital geography, one can easily calculate distance of all Sinnar PHC from a village. So in case of any seasonal connectivity of road or disconnectivity via road to any PHC, one can know what other possible nearest PHC can be there.

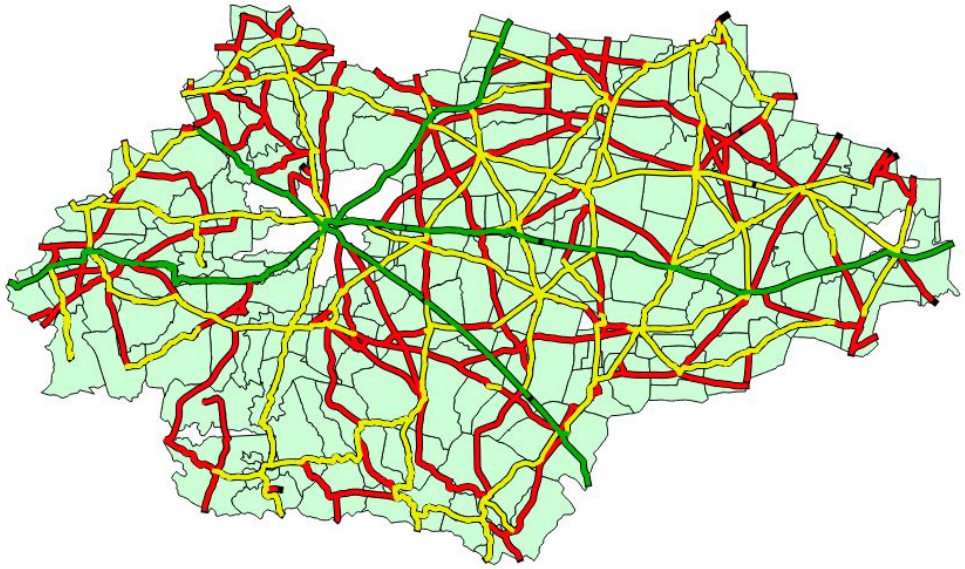

Sinnar Village to Nearest PHC Distance via Road
Distance (in Km)
30.0
20.0
10.0
0.0
Belu
Agas Khind
Borkhind
Dhondbar
Sawatam...
Ghorwad
Laxmanpur
Vinchur D...
Shivade
Pandhurli
Khaparale
Chandrapur
Sangavi
Jamgaon
Saradwadi
Aundhewadi
Vadgaon...
Konambe
Kolgaonmal
Bharatpur
Nalwadi
Pathare Bk.
Hiwargaon
Nandur S...
Mahajanpur
Thangaon
Sonambe
Pathare Kh.
Keru Patil...
Manori
Fulenagar
Krishnana...
Sinnar Villages

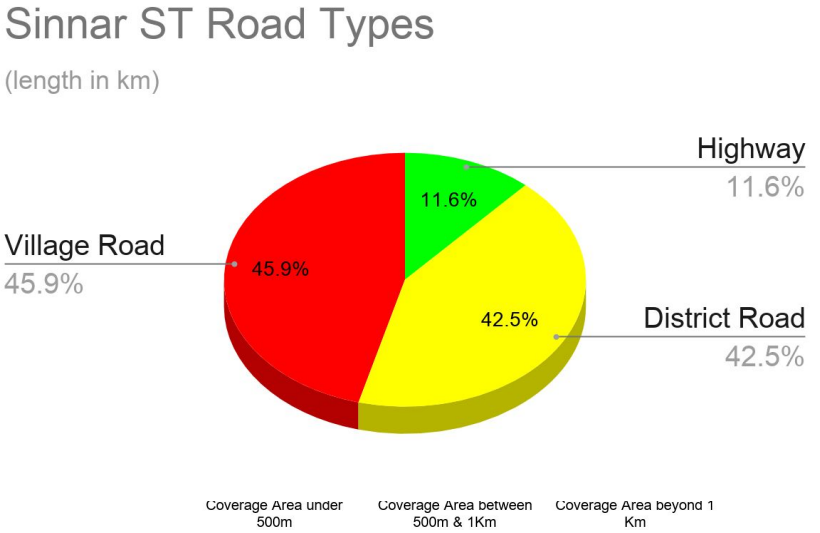

Distance of Sinnar Sub-PHC "Nimgaon Sinner" with all Sinnar PHC's
Distance (in Km)
50.0
40.0
30.0
20.0
10.0
0.0
28.5
19.3
25.4
5.0
43.8
15.5
Dapur
Pandhurli
Naigaon
Deopur
Thangaon
Wavi
Sinnar PHC's


Sinnar Village "Gonde" to all Sinnar Sub-PHC distance
Distance (in Km)
40.0
30.0
20.0
10.0
0.0
Nandur Shingote
Datti
Panchale
Patole
Marnal Bk.
Manegaon
Chas
Dubere
Baragaon Pimpri
Chapadgaon
Pangari Bk
Paste
Sonambe
Hivare
Konambe
Panchale
Nimgaon Sinner
Chincholi
Kundewadi
Pathare Kh.
Vadangali
Bramhan Wade
Vadgaon Pingala
Marnal Bk.
Mirgaon
Somthane
Pathare Bk.
Sinnar Sub-PHC's


Sub-PHC to Nearest PHC Distance
Nearest PHC
Distance (in Km)
25.0
20.0
15.0
10.0
5.0
0.0
Thangaon
Thangaon
Deopur
Naigaon
Thangaon
Pandhurli
Naigaon
Deopur
Pandhurli
Wavi
Pandhurli
Wavi
Pandhurli
Deopur
Dapur
Wavi
Dapur
Dapur
Pandhurli
Thangaon
Wavi
Wavi
Pandhurli
Thangaon
Wavi
Dapur
Deopur
Deopur
Shivade
Konambe
Pathare Kh.
Vadgaon Pingala
Sonambe
Paste
Chincholi
Somthane
Dubere
Marnal Bk.
Baragaon Pimpri
Pathare Bk.
Manegaon
Vadangali
Dodi Bk.
Shaha
Chas
Patole
Datti
Bramhan Wade
Kundewadi
Mirgaon
Nandur Shingote
Hivare
Pangari Bk
Chapadgaon
Panchale
Nimgaon Sinner
Sub-PHC's

Road Type Analysis





Type of Road	Length (in km)
Highway	118
District Road	432
Village Road	466

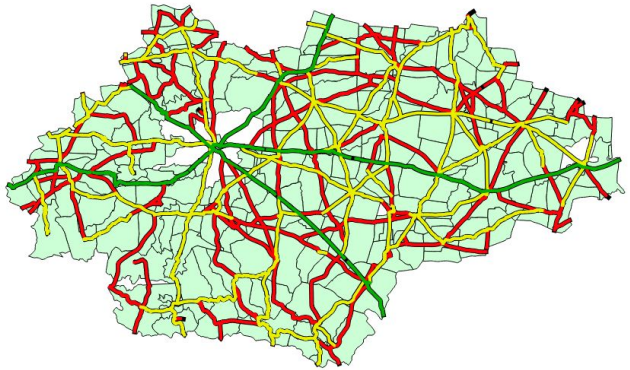
Sinnar ST Roads types length

Physical Significance- Green, yellow, red lines lines are representing Highways, District Roads, Village Roads etc. Running Speed is higher at green roads and lowest at yellow roads. This type of analysis can help in preliminary designing a **new Bus routes creation** where ST just need to maximize the green path as much as possible. Later can be validated through usual process .

Benefits of proposed GIS interface for MSRTC

1) New Route Creation-

- Road Quality/Suitability Check
- Estimate Arrival time on bus stops



Sinnar Road type Map

Pros-

- Time Saving, Faster Decision Making.
- Cost Saving (Fuel and Manpower) on running bus trials & can be used in increasing number of bus trips in taluka.

Typical Activities in Route Creation	Assumed Time
Proposal of New Route by Bus Depot Manager and report to DTO	1 Day
Approval of DTO for running the bus trial on the proposed route	1 Day
10 Bus Trials on Proposed new route (Forward & Reverse Route)	10 Day
Report to DTO and Bus Depot Manager for Quality or suitability of road	1 Day

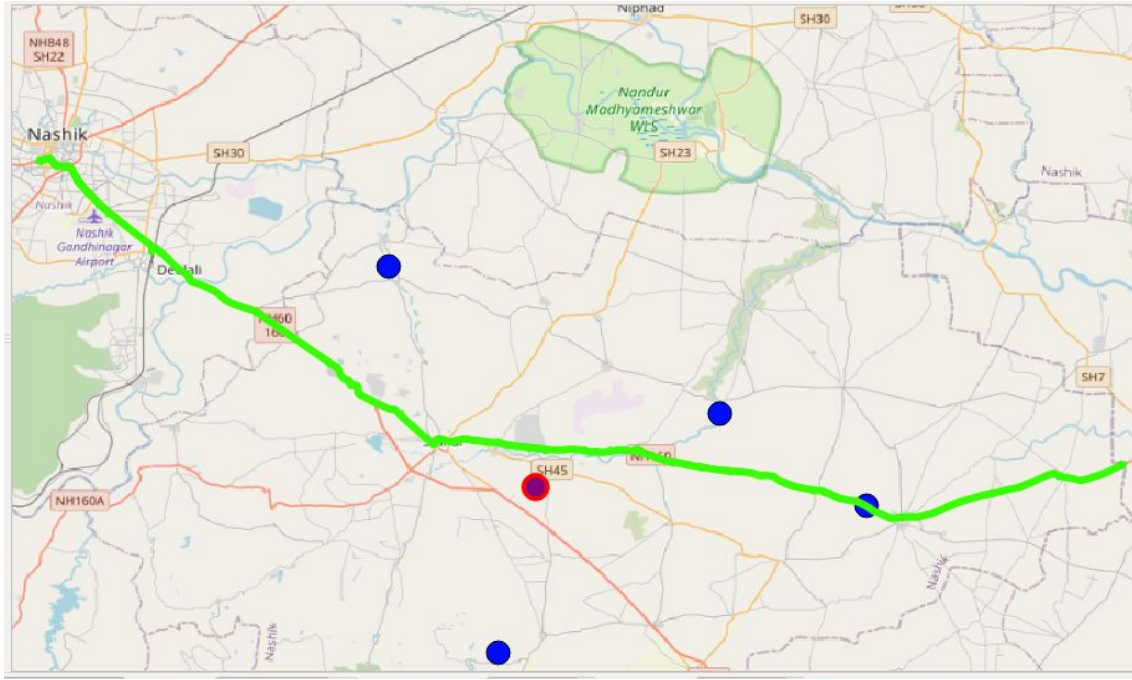
2) Routing:

Utility-

‘B’ and ‘C’ Category Bus trips can be routed through nearby important locations to increase bus traffic hence profitability.

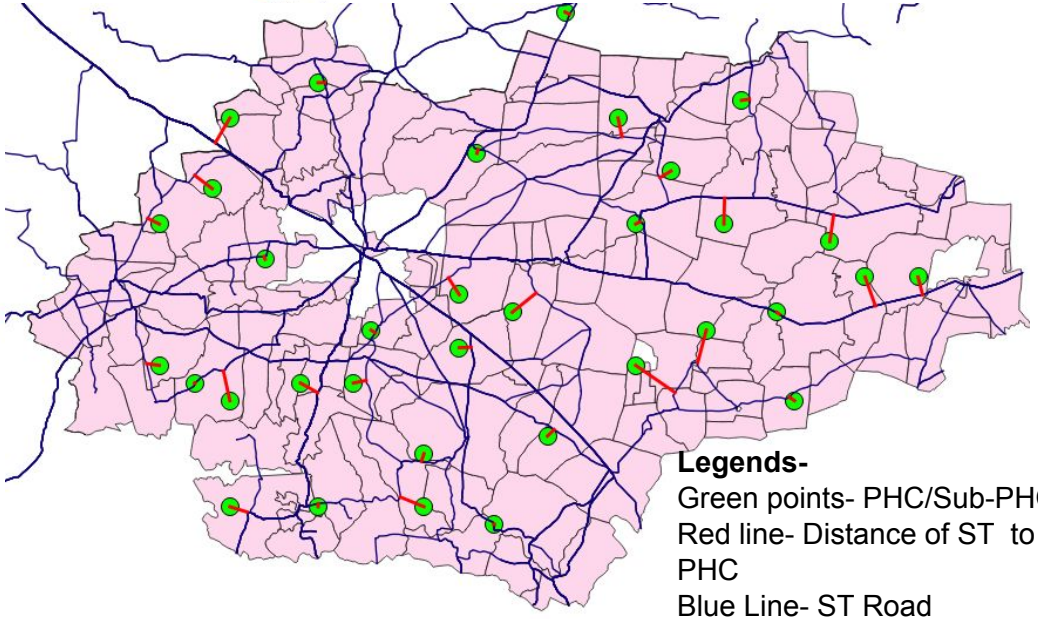
Example-

Routing of Bus route (Green path) through a School (Red point)

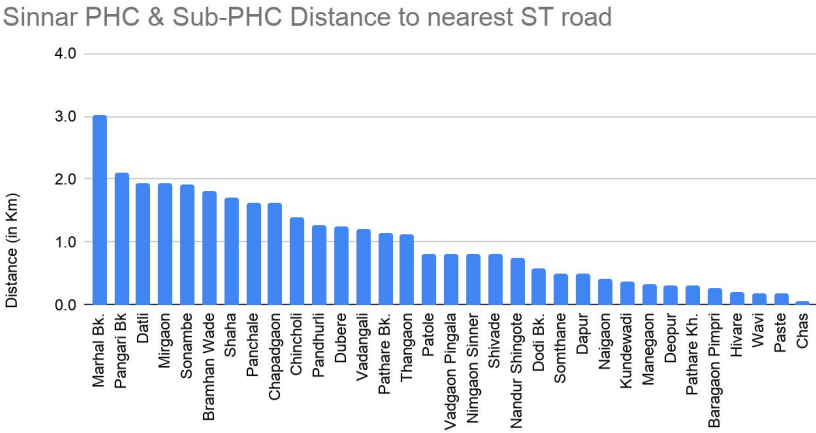


Legends-
Blue dots and Red point representing important locations like School, PHC, economic place like industry etc.
Green path representing Bus Route

3) Need for Feeder Bus-



Legends-
Green points- PHC/Sub-PHC
Red line- Distance of ST to PHC
Blue Line- ST Road



PHC or Sub-PHC village	Distance(in Km)
Marhal Bk.	3.0
Pangari Bk	2.1
Datli	1.9
Mirgaon	1.9
Sonambe	1.9

Top 5 Farthest Sinnar PHC or Sub-PHC

Utility- Green points representing Sub-PHC or PHC, Red lines denoting distance to ST route represented in blue lines. Farthest a distance of a PHC or Sub-PHC from ST road, greater is the need for feeder bus. Same methodology can be applicable for schools etc

Sinnar PHC TimeTable Creation

Create Bus schedules providing access to villages from PHC and vice versa.

Assumptions-

- Selection of routes covering min, 75% bus stops in min. number of routes.
- Estimating Bus Traffic load to be 0.1% population from every village to PHC daily.
- Scheduling number of trips based on traffic load (in morning- from village and in evening- from PHC to village)

Result:
Village Covered: 93.75% i.e. (120 out of 128) considering 3 KM as coverage.
Predicted Load Factor:

Route Number	Forward Trip	Reverse Trip
2130	27.02%	23.67%
6891	25.81%	27.60%
7100	19.16%	27.33%
7102	20.48%	28.68%
7103	15.91%	17.00%

**Low Load Factor due to Strict social distancing*

Sample Output: Sinnar PHC Time Table

Form 4

	A	B	C	D	E	F
1	ROUTE_NO	Trip Type	Departure Time	from	till	Expected Arrival Time
2	2130	Forward	8:15	CHINCHOLI FATA	DARDE FATA	10:35
3	2130	Return	7:30	DARDE FATA	CHINCHOLI FATA	9:50
4	6891	Forward	7:43	SINNAR	DARDE FATA	9:39
5	6891	Return	8:26	DARDE FATA	SINNAR	10:22
6	7100	Forward	8:16	SINNAR	CHAS/NANDUR SHINGOTE FATA	9:31
7	7100	Return	8:34	CHAS/NANDUR SHINGOTE FATA	SINNAR	9:49
8	7103	Forward	7:54	SINNAR	AADWADI (LAST)	9:27
9	7103	Return	8:38	AADWADI (LAST)	SINNAR	10:11
10	7118	Forward	7:47	SINNAR	DEOPUR VILLEGE	8:58
11	7118	Return	9:07	DEOPUR VILLEGE	SINNAR	10:18
12	7161	Forward	8:01	SINNAR	JAKHORI FATA	9:31
13	7161	Return	8:34	JAKHORI FATA	SINNAR	10:05
14	7165	Forward	8:41	SINNAR	DATTA NAGAR	10:46
15	7165	Return	7:19	DATTA NAGAR	SINNAR	9:24
16	85886	Forward	8:40	SINNAR	NALWADI	10:31
17	85886	Return	7:34	NALWADI	SINNAR	9:25
18	7102	Forward	7:41	SINNAR	AUNDHEWADI	8:42
19	7102	Return	6:09	AUNDHEWADI	SINNAR	7:11
20	7107	Forward	7:41	SINNAR	BELU VILLEGE	8:54
21	7107	Return	5:58	BELU VILLEGE	SINNAR	7:11
22	7130	Forward	7:41	SINNAR	KHAPRALE	8:15
23	7130	Return	6:36	KHAPRALE	SINNAR	7:11
24	7131	Forward	7:41	SINNAR	SAYKHEDA FATA	8:35
25	7131	Return	6:16	SAYKHEDA FATA	SINNAR	7:11
26	7139	Forward	7:41	SINNAR	VHIGANWADI	9:33
27	7139	Return	5:18	VHIGANWADI	SINNAR	7:11
28	7147	Forward	7:41	SINNAR	NIRHALE	9:02

Sinnar PHC Bus Timetable

	A	B	C	D	E	F	G	H	I	J
1	ROUTE_NO	BUS_STOP_CD	BUS_STOP_NM	STOP_SEQ	KM	Departure Time	Arrival Time	Halt Time	Trip Type	Route Type
2	2130	CHOFS	CHINCHOLI FATA	1	0	8:15	8:13	2	Forward	PHC
3	2130	MEARI	MEHADARI	2	3.2	8:23	8:21	2	Forward	PHC
4	2130	MLANF	MALGAON FATA	3	5.9	8:31	8:29	2	Forward	PHC
5	2130	SNNR	SINNAR	4	11.3	8:44	8:42	2	Forward	PHC
6	2130	MUSON	MUSALGAON	5	18.3	9:07	8:58	10	Forward	PHC
7	2130	MSLSNK	MUSALGAON (MIDC)	6	17.1	9:07	9:05	2	Forward	PHC
8	2130	MSLSN	MUSALGAON FATA	7	18.7	9:12	9:10	2	Forward	PHC
9	2130	DTL	DATELI	8	21.9	9:21	9:19	2	Forward	PHC
10	2130	KPDH	KOPADI KHURD	9	23.7	9:26	9:24	2	Forward	PHC
11	2130	KADIBD	KHOPADI BUDRUK	10	24.3	9:30	9:28	2	Forward	PHC
12	2130	SISN	DATTA MANDIR	11	25.6	9:34	9:32	2	Forward	PHC
13	2130	BOASNK	BHOKANI FATA	12	26.2	9:37	9:35	2	Forward	PHC
14	2130	DVURFT	DEVPUR FATA	13	29	9:45	9:43	2	Forward	PHC
15	2130	PPNRSN	PANGRI	14	33.9	9:57	9:55	2	Forward	PHC
16	2130	VAVI	VAVI	15	39.3	10:10	10:08	2	Forward	PHC
17	2130	SYFT	SAYALE FATA	16	40.2	10:13	10:11	2	Forward	PHC
18	2130	PATRE	PATHARE	17	48.5	10:32	10:30	2	Forward	PHC
19	2130	DREKA	DARDE FATA	18	49.8	10:37	10:35	2	Forward	PHC
20	2130	DREKA	DARDE FATA	1	0	7:30	7:29	2	Return	PHC
21	2130	PATRE	PATHARE	2	1.3	7:35	7:33	2	Return	PHC
22	2130	SYFT	SAYALE FATA	3	9.6	7:54	7:52	2	Return	PHC
23	2130	VAVI	VAVI	4	10.5	7:57	7:55	2	Return	PHC
24	2130	PPNRSN	PANGRI	5	15.9	8:10	8:08	2	Return	PHC
25	2130	DVURFT	DEVPUR FATA	6	20.8	8:22	8:20	2	Return	PHC
26	2130	BOASNK	BHOKANI FATA	7	23.6	8:30	8:28	2	Return	PHC
27	2130	SISN	DATTA MANDIR	8	24.2	8:33	8:31	2	Return	PHC
28	2130	KADIBD	KHOPADI BUDRUK	9	25.5	8:37	8:35	2	Return	PHC

Load on PHC's-

PHC Bus Stop Code	Load as a %age to Population
DOPUIA	11.2%
DULWIA	17.0%
JGN	13.6%
MUSON	28.3%
TTAGSN	15.8%
VAVIK	14.1%

Sample Passenger Load Table Route No. 7100, Forward Trip

BUS STOP NAME	KM	ROUTE NO	STOP SEQ	Population being served	Expected population being served	Expected Traffic at each bus stop considering traffic =0.1%	No. of Bus Services required considering bus Capacity max=25
GUREWADI	5.1	7100	1	5615	5615	6	1
GONDE FATA	8.4	7100	2	3324	8939	9	1
DAPUR	14.8	7100	3	5902	14841	15	1
DHULWAD FATA (PHC)	16.8	7100	4	3791	2306	2	1
CHAPADGAON	19.7	7100	5	2306	0	0	1

Plugin Development:

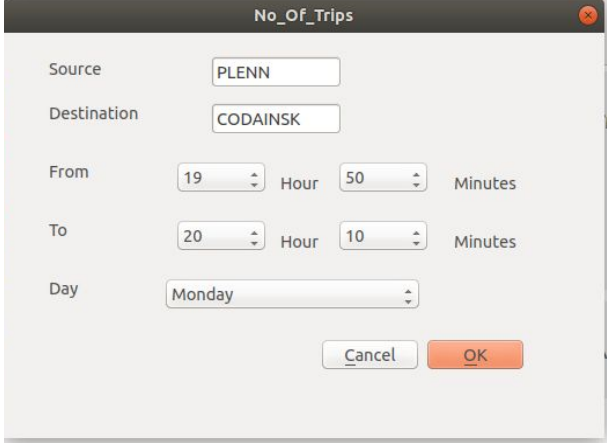
Plugins are made to customize Digital Geography as per the need proposed by MSRTC employees (Divisional Traffic Officer,i.e, DTO)

One of the Requirement Proposed by DTO-

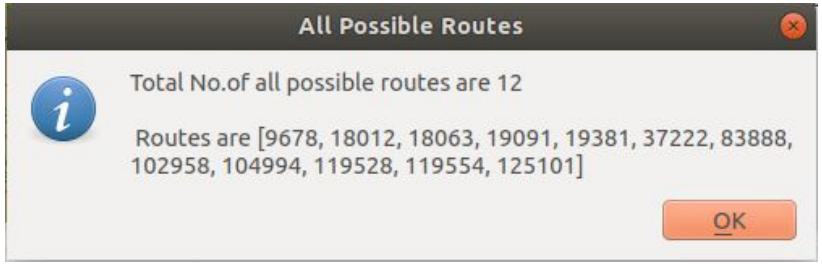
Sometimes local people approach DTO, why a certain bus trip is cancelled by a Bus Depot, So to get the ABC analysis from a bus stop to some other bus stop at a given time and representing on GIS interface**.**

Plugin 1 Objective: To provide details of cancelled trip

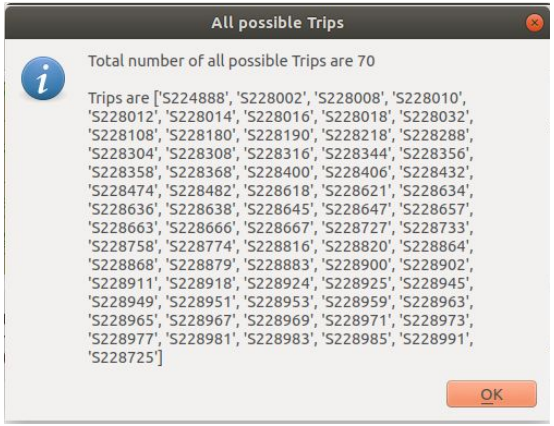
Made for Divisional Traffic Officer (DTO), Nashik



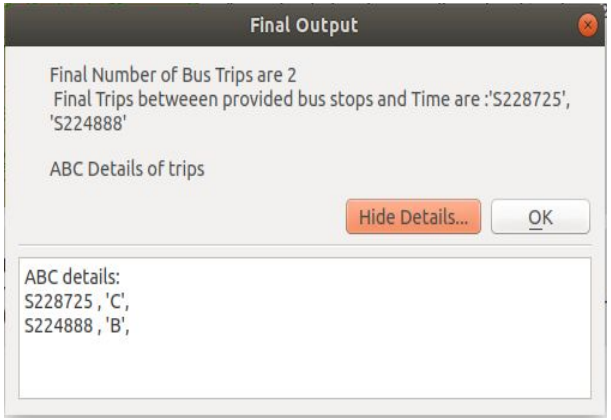
Plugin 1 Inputs



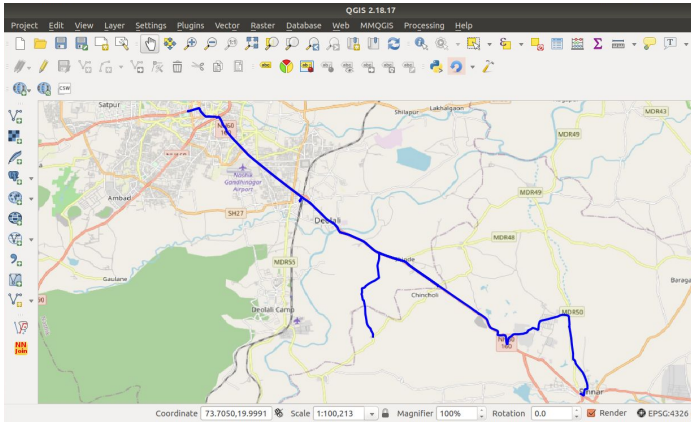
Output (1): All routes passing through Source and destination



Output (2): All bus trips passing through Source and destination irrespective of time



Output (3): All bus trips passing through Source and destination within provided time range



Output (4): Bus Trip Route on GIS interface to display nearby affected region because of trip cancellation

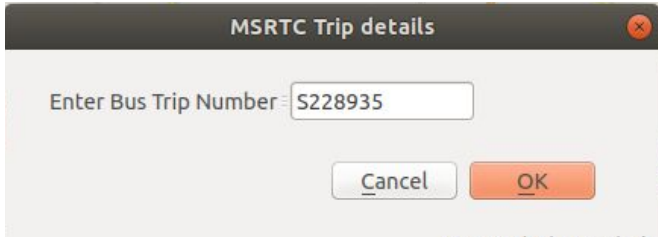
Plugin 2- MSRTC Trip Detail (Extension of Plugin 1):

Use- To get the path of any particular bus Trip along with ABC details.

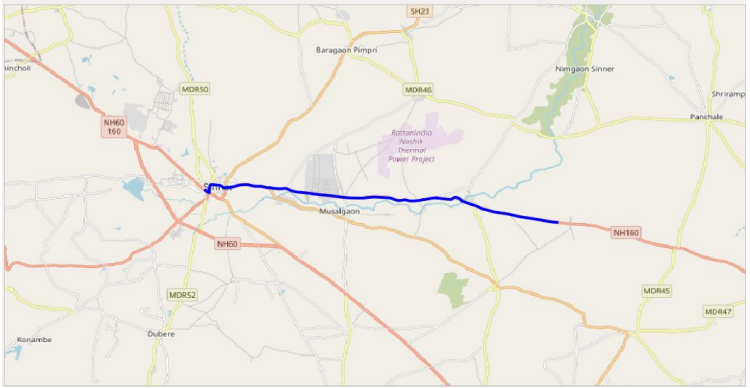
- Can be used as an extension after plugin 1 to get details of about any particular Bus Trip.

Physical Significance-

If a bus Trip is cancelled, then which areas are affected can be visualize from this Plugin



User Inputs for Plugin 2



Displays the path of the Bus Trip

Plugin 3: MSRTC PHC TimeTable Creator

(*Not in Report, developed later after report submission)

Use-

To create PHC Time Table for a Taluka

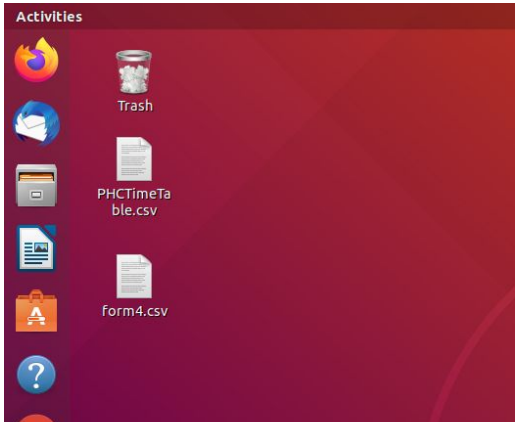
Data Required:

- Digital Geography of Taluka
- PHC Lat-Long.
- Village Population data.

Future Scope:

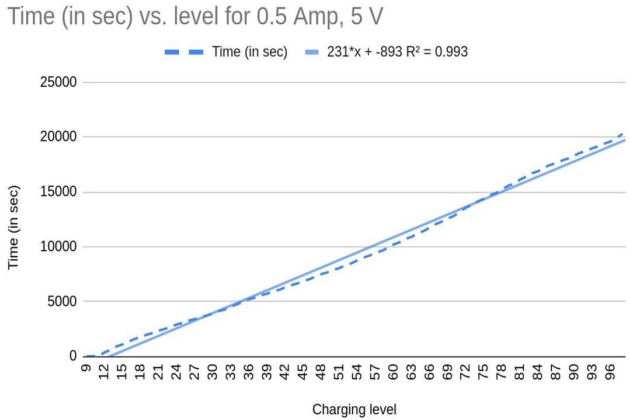
- Same methodology can be replicated to schools.

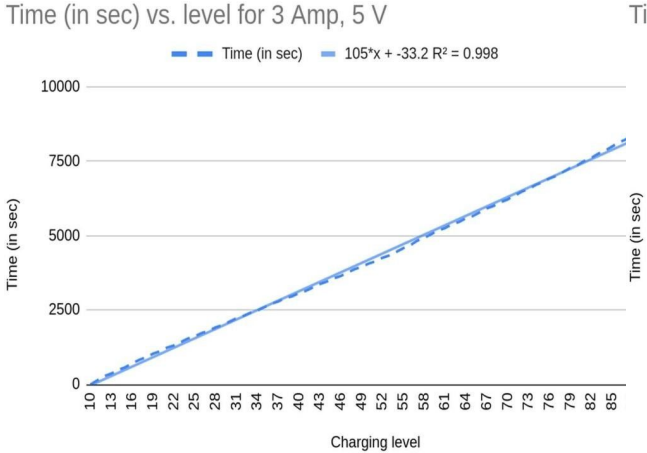
User Interface for Plugin 3

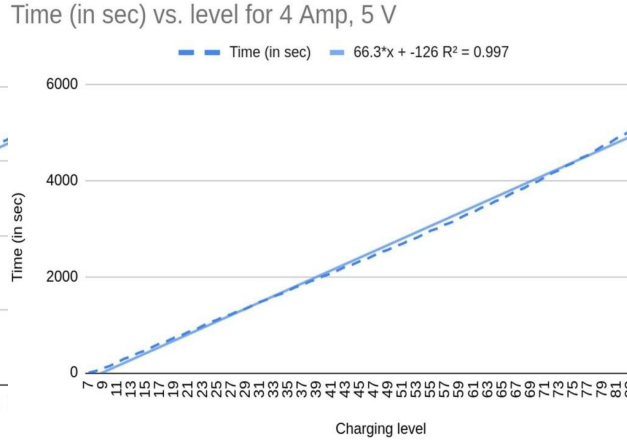


***Output:** Creates Form4.csv and PHCTimeTable.csv at Dekstop*

Additional Work: Trimax Electronic Ticket Issuing Machine (ETIM) slow Charging Problem







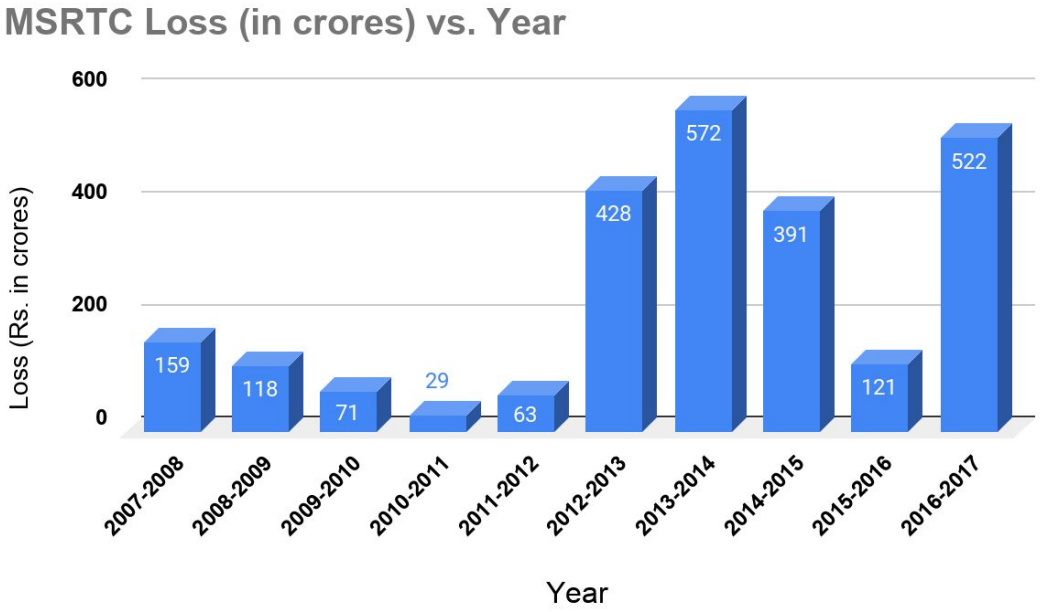
Summary:

Charging Power	Charging speed of Mobile Phone
0.5 Amp, 5 Volt	231 seconds /charging 1%
3 Amp, 5 Volt	105 seconds /charging 1%
5 Amp, 5 Volt	66.3 seconds/charging 1 %

Conclusion: Current ETIM machine takes about 10-12 hrs. to complete full charging for running 8 hours. Strong power charger can be tried to increase charging speed.

Conclusion:

Currently MSRTC is in losses. Technical Interventions like GIS can help reduce losses and increase operational efficiency which directly and indirectly can benefits rural population .



MSRTC Loss over the years

Future Scope:

- Study of Interaction with other modes of transport like railway station, nearby airport, private transportation like rickshaw, jeep etc.
- Field visits and interviews with MSRTC people to validate the work done.
- Development of GIS Interface for MSRTC.

Thank you!